The OCP and the Calculation of Identity

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Abstract

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The Obligatory Contour Principle (Ocp) has generated much literature in phonology, however its history includes unjustified extensions. While applications of the Ocp involve calculating segmental identity, the formulation of the Ocp itself obfuscates the notion of segmental identity, thus allows unprincipled analysis. Alternative to the appeal to the Ocp, two attempts have been made to tackle identity calculation. Feature Algebra by Reiss (2003) introduces quantificational statements in structural descriptions, enabling phonology to refer to arbitrarily similar segments. Baković's (2005) Optimality theoretic constraint dynamics focuses on the interaction between NoGem and Agree and treats partial/sufficient identity to be an emergent property.

Baković's model makes a typological prediction that languages that exhibit avoidance of partial geminates must have independent assimilation processes with respect to the features that are irrelevant to segmental identity. However, this predication is shown to be untenable. Formalization of NoGem brings to light that quantificational statements will be required in effect for the calculation of segmental identity.

Acknowledgement

First and foremost, my sincere gratitude goes to my supervisors, Mark Hale, Charles Reiss and Dana Isac. Charles and Dana were very caring and extremely patient with me; without their encouragement and guidance on academic as well as personal matters, I wouldn't have made it this far. Discussions with Mark (rather, Mark's talking to me) about "big issues" and his comments on the choice of words in my writing were truly instructive. He taught me what is difficult but important is to find an interesting problem that really matters to the theory of language as a property of human mind, and to choose the right approach to the problem. I hope I was able to address and discuss one of such interesting problems in this thesis.

Working as a teaching assistant to Alan Bale has a big impact on my training. Alan's clear explanations of scientific methodology and of foundational ideas in modern linguistics kept me from derailing when writing this thesis.

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Chapter 1

The OCP: an overview

1.1 Introduction

The Obligatory Contour Principle (OCP) is one of the most discussed, putatively universal principles in generative phonology. The OCP was originally conceived in tonal phonology (Leben 1973) to explain the observation that in many tone languages, tonal sequences can be reduced to alternating patterns (e.g. LHL as opposed to LLHL, LHHL). The essential idea of the original conception of the OCP is that the tonal melody, represented independently of the tone-bearing segments, must not be flat, and thus adjacent tones must not be identical. This idea to prohibit adjacent identical *tones* was later extended to the prohibition of adjacent identical *elements* through the autosegmental analysis of Semitic morphophonology (McCarthy 1981, 1986). Combined with consonant-vowel segregation and the theory of autosegmental spreading, the OCP was argued to operate on the consonantal tier and constrain the possible forms of consonantal verbal roots in Arabic, providing an explanation why the form $C_iVC_iVC_j$ (e.g. *sasam*) is non-existent as opposed to $C_jVC_iVC_i$ (e.g. *samam*) in Arabic verbal stems. Autosegmental, or geometric representation of features allowed the OCP to apply not only to *segments* in the traditional notion but also to *autosegments* — the nodes on individual featural tiers or on class tiers. For instance, the OCP can be used as an explanation for apparent avoidance of consecutive nasal consonants, or of adjacent homorganic consonants.

The OCP, extended from tones to segments to features or a set of features, is considered to define a type of "ill-formed" phonological structure, and to function as a trigger or a blocker of certain phonological rules to avoid the ill-formed structures. For example, it can trigger a rule to insert a vowel between adjacent (completely or partially) identical segments, or block the deletion of a vowel when the deletion results in adjacent (completely or partially) identical segments. While 'antigemination' just described is reasoned to be an effect of the OCP, the same constraint is also said to explain geminate integrity. Geminates that are resistant to epenthesis or deletion are argued to be one and the same segment underlyingly, exhibiting the obedience to the OCP.

On the one hand, some consider this extension to be a theoretical advantage, providing "an elegant solution" for an ample amount of commonly observed phenomena. On the other hand, the extension from tones to segments to features/autosegments seems to have sacrificed the definitional rigor in the formulation of the OCP. Since the OCP could apply to adjacent *elements* on any autosegmental tier, what counts as 'identical' or 'adjacent' becomes obfuscated: Are two segments identical if they share only some autosegmentalized feature? Are they adjacent if intervening segments have no specification on the relevant tiers? What exactly is the segment identity that is subject to the OCP, and how does phonological grammar calculate it? Despite the lack of precision and explicitness in its formulation (or rather, because of that), the OCP has generated much literature, whereas little attempt has been made to investigate the fundamental question as to how the grammar refers to segmental identity.

This thesis examines the history of the OCP and its rather unjustified extension from tonal phonology to segmental phonology. It discusses two approaches to the issue of identity reference in phonology. One approach by Reiss (2003) aims to model a formal representational system of identity reference utilizing quantificational logic that enables phonological grammar to refer to an arbitrary subset of features. The other, an Optimality Theoretic approach by Baković (2005), aspires to dispense with the OCP and to explain apparent partial identity between segments by appealing to the interaction between two independent constraints, NOGEM and AGREE. I will show that Boković's model of constraint interaction does not hold for all cases of the avoidance of partially identical adjacent segments typically attributed to the OCP. A formal statement of an OT constraint NOGEM will further reveal that the phonological grammar would need quantificational machinery for the calculation of segmental identity.

This thesis is organized as follows. The rest of this chapter re-examines the development of the OCP. The chapter 2 recapitulates Odden's (1986, 1988) convincing arguments against the OCP and Reiss' Feature Algebraic approach to the reference to identity of segments. The chapter 3 discusses Backović's scheme of constraint interaction and presents a counter-example to it, and the chapter 4 attempts to formalize NOGEM.

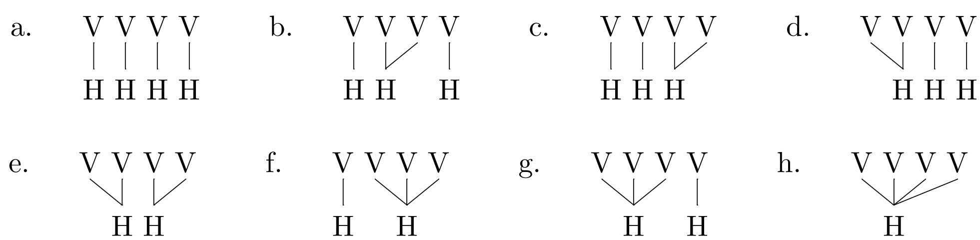
1.2 A History of the OCP

This section reviews the development of the OCP in phonological literature. First suggested in Leben (1973), then formulated by Goldsmith (1976), the idea of "no adjacent identical tones" extended its domain of application from tonal melodies to segments through McCarthy's influential work on Semitic morphophonology (McCarthy 1981, 1986). Autosegmental representations of features allowed the OCP to apply to virtually any "(auto)segment." Yip (1988) is a representative of many analyses that employ the OCP with specific descriptions as to which featural tier the constraint operates on. Such extension, however, seems to come with a cost of obscuring the definition of segmental "identity" and "adjacency." The OCP was further extended into the Optimality theoretic analysis. Its lack of rigor in the definition has led Rose (2000) to postulate two distinct OT constraints: NOGEM that disfavours long consonants, and OCP that applies exclusively on "adjacent" consonants regardless of intervening vowels.

1.2.1 The OCP in tonal phonology

The idea that forms a foundation for the OCP is first conceived in tonal phonology. The basic tenet of this idea is that at the morphemic level, adjacent identical tones must be collapsed into one tone. Autosegmental analysis of tones, which posits the tonal tier distinct from the segmental tier, will allow multiple analysis of tone-to-segment mapping as discussed in Odden (1986). (1.1) is the possible tone-to-segment mappings of consecutive four H-toned segments.

(1.1)



When presented with a sequence of four H tones, a learner is faced with a task of choosing one representation out of 8. Assuming that all four segments belong to the same morpheme, the idea that adjacent identical tone must be collapsed to one will automatically eliminate (1.1a-g) and allow only (1.1h) to be the legitimate representation of the tone-to-segment mapping.

This idea is first suggested in Leben (1973). Leben's suggestion (though not explicit) is based on the suprasegmental analysis of tonal patterns in Mende. Mende is a language with two tones, H and L, and Mende nouns consist of one, two or three syllables. Leben observes that the tonal melodies of Mende nouns can be reduced to 5 patterns at the underlying level (H, L, HL, LH, LHL) and that the pattern such as HHL and LLH do not occur. Mende words such as *pɛ́lɛ́* , in which the identical H tone occurs in sequence, and *nyàhâ* , in which the last syllable carries a contour (HL) tone, can be accounted for by positing underlying H and LHL tone melodies respectively and the tone mapping rule of Mende. The tone mapping rule also explains non-occurence of LLH and HHL patterns.

(1.2) Mende tone mapping rule (Leben 1973: 44)

a. If the number of level tone in the pattern is equal to or less than the number of vowels in the word possessing the pattern, put the first tone on the first vowel, the second on the second, and so on; any remaining vowels receve a copy of the last tone in the pattern.

b. If the number of level tones in the pattern is greater than the number of vowels in the word possesing the pattern, put the first tone on the first vowel, the second on the second, and so on; remaining tones are expressed as a sequence on the last vowel available.

Leben (1978) formalizes his earlier insight as a "convention on tone melodies" and claims that, at the supresegmental level where tones are separated and abstracted from tone-bearing segments, HH is non-distinct from H since they describe the same tonal melody.

(1.3) Convention on tone melodies (Leben 1978: 181)

$[\alpha \mathrm{H}][\alpha \mathrm{H}] \rightarrow [\alpha \mathrm{H}]\emptyset$

He also claims that this convention "limits the inventory of tonal patterns that can be expressed in a given language" (181 fn.). This claim implies a potential universality of the convention in that a learner equipped with this convention will be disburdened in learning representations of tone-to-segment mappings. Note, however, that Leben does not explicitly state that this is a grammatical principle.

Goldsmith (1976) is the first to state Leben's suggestion as a grammatical principle, named as the OCP.

(1.4) Obligatory Contour Principle (Goldsmith 1976: 63)

> At the melodic level of the grammar, any two adjacent tonemes must be distinct. Thus HHL is not a possible melodic pattern; it automatically simplified to HL.

Goldsmith (1973) in fact argues against (1.4) and proposes to revise the OCP as applying to the surface, phonetic level. His proposal is based on the tonal patterns in Etung. Goldsmith presents 7 (out of 10) tonal pattern classes in Etung: L, LH, H, LHL, LLH HHL and HLH. Goldsmith argues that the patterns LLH and HHL may not be reducible to LH and HL underlyingly, as Leben's convention would suggest. The words that carry LLH and HHL tones are shown in (1.5), together with the words with LHL pattern. In (1.5) the last two tones of the pattern LHL is realized as a contour tone on the second syllable in the 2-syllable word. This indicates that the tone mapping in Etung proceeds from left to right. Similarly, the last two tones of LLH and HHL are realized as contour tones on the second syllable in the 2-syllable words. This is unexpected if LLH and HHL are underlyingly LH and HL respectively. Furthermore, LLH and HHL patterns realized in 3-syllable words indicate that the tones are mapped straightforwardly one-to-one from left to right. These forms are again unexpected if LLH and HHL are reducible to LH and HL and tones are mapped from left to right.

(1.5) Etung

		2-syllable	3-syllable
a.	LLH	èbǐn ‘farm’	òròbé ‘beam’
b.	HHL	érôp ‘spear’	ésébè ‘sand’
c.	LHL	òbô ‘arm’	m̀bútà ‘rain’

cf. ǹsí ‘fish’; bìsóé ‘spoon’; égòm ‘jaundice’; ákùpà ‘money’

Even if LLH and HHL may not be reduced to LH and HL at the underlying level, Goldsmith claims that there is no reason to posit two separate yet identical tones at the *phonetic* level. If the phonetic level characterizes perception and articulation, there need not be two consecutive instances of the phonetic representation of L tones in *òròbé* (there need not be two articulatory instructions for the adjacent L tones, for example). Thus, the *phonetic* representation of *òròbé* will be (1.6).

(1.6) Phonetic representation of ‘òròbé’

o robe
L H

Goldsmith argues that the cases in which the OCP is seemingly applied to underlying forms are in fact the reflections of the corresponding phonetic representations and of the way underlying forms are learned. In phonetic representations, adjacent identical tones need not be represented twice (or more). Underlying forms are learned based on phonetic representations, and a learner will posit underlying forms that transparently match the surface phonetic forms unless there is a need to do otherwise. An Etung learner will posit the underlying tonal form for *m̀bútà* straightforwardly from its phonetic form, but he/she will be forced to posit the underlying tonal form for *òròbé* different from its phonetic form LH, since the left-to-right tone mapping rule does not generate the correct output from LH.

Goldsmith revises the OCP that the adjacent identical (auto)segments (i.e. tones in this case) are collapsed to one at the phonetic level, the effect of which may be carried through to the "deeper level," i.e. to the tonal tier, as the unmarked situation.(272) Goldsmith's analysis of Etung indicates that the OCP is not a universal constraint that would apply to underlying representations.

1.2.2 The OCP in segmental phonology

Despite Goldsmith's argument against the status of the OCP as a universal constraint on underlying forms, the status of the OCP in the theory of UG is not closely examined in the subsequent literature. Instead, the putatively universal principle OCP is extended from phonology of tones to segmental phonology, through the autosegmental analysis of Arabic verbal morphology by McCarthy (1981, 1986). In Arabic, verbal forms are analysed into root consonants, vowel patterns and affixal consonants. The consonantal root carries a semantic meaning, and with a certain vowel pattern (and affixal consonants) forms an actual verb. For example, the forms below are derived from the consonantal root [ktb].

(1.7) a. katab 'write'

b. kattab 'cause to write'

c. kaatab 'correspond'

d. takaatab 'write to each other'

Since the consonantal root behaves as a morphological unit, McCarthy assigns the consonantal root an autosegmental tier distinct from the vowel tier.

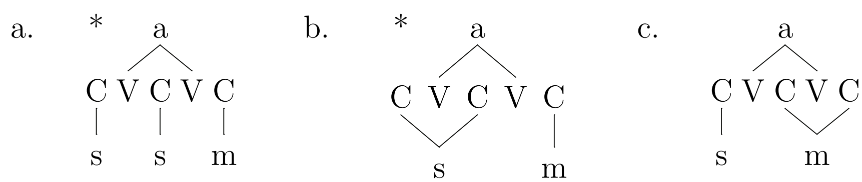
In Arabic and other semitic languages, verbal stems with identical second and third consonants ($C_iVC_jVC_j$, e.g. *samam*) are quite common, while there is no stem with identical first and second consonants ($C_iVC_iVC_j$, **sasam*). To account for this restrictive pattern, McCarthy generalises Leben's version of the OCP (1.4) and attributes the Arabic verbal stem pattern to the newly defined OCP applying to the root consonant tier.

(1.8) Obligatory Contour Principle (McCarthy 1986)

At the melodic level, adjacent identical elements are prohibited.

McCarthy argues that apparent triliteral root like *smm* is formally represented as biliteral *sm* and explains the non-existance of the root *ssm* by left-to-right spreading of the consonantal root to the CV tier. In Arabic, consonants are mapped to the CV tier in one-to-one manner from left to right (McCarthy 1981, 1986), hence only the rightmost consonant of the roots can spread. Thus, the correct representation of the mapping of the root *sm* to CV tier is (1.9c); (1.9a) violates the OCP and (1.9b) violates the rightward mapping/spreading rule.

(1.9)



McCarthy's argument for the OCP extended to segmental phonology is thus far in line with the argument for the OCP made in tonal phonology. In tonal phonology, the stability (a tone remains even when the tone-bearing segment is deleted) and the existence of floating tones are argued as evidence for the independence of tones from segments. The tonal OCP is postulated as a constraint applying to the tonal tier. McCarthy has made a similar line of argument. In Arabic verbal morphology, the consonants and the vowels function differently, which argues for the segregation of consonants and vowels into distinct tiers. The OCP formulated as (1.8) applies to the consonantal tier and constrains the lexical representation of Arabic verbal roots.

McCarthy goes on to argue that the OCP is not only a constraint on the lexical representation but also applies throughout the derivation, and that the effect of the OCP is observed as *antigemination* by blocking syncope. In Afar, for example, the rule of deleting an unstressed vowel fails to apply when the result of deletion is a sequence of adjacent identical segments (geminates).

(1.10) Afar Syncope

i. V → ∅ / #CVC ___ CV

a.	digib-t-é	digb-é	‘she/I married’	
	wager-n-é	wagr-é	‘we/he reconciled’	
b.	aḍaḍ-é		‘I/he trembled’	*aḍḍ-é
	danan-é		‘I/he was hurt’	*dann-é

McCarthy explains that in Afar, even though distantly related to Arabic, the majority of verbal and nominal roots are not decomposable into separate consonant and vowel tiers, thus the representation of *danan-é* is (1.11a). The syncope rule applied to (1.11a) will create geminates as in (1.11b), in which two *n*’s are each associated to adjacent C slots. This form (so-called a “fake/apprent” geminate) violates the OCP. Hence the OCP is interpreted as a constraint on “phonological well-formedness” that has an effect of a “negative filter” over derived forms.

(1.11)

```
a.             e       b.            e
               |                     |
   C V C V C-V           *CV C C-V
   | | | | |              | | | |
   d a n a n              d a n n
```

The analysis of the failure of applying syncope in Afar raises a question: what would happen with the Semitic-type languages in which consonants and vowels are segregated into separate tiers? Since consonants and vowels are on separate tiers, adjacent identical segments can be explained by spreading of a single segment to multiple C slots, and the OCP effect would not be observed except as constraining an underlying morpheme structure. McCarthy proposes a process called ‘Tier Conflation’ in which segments on separate consonant and vowel tiers are linearized onto a single tier, and argues that the OCP effect such as antigemination is observed even in Semitic-type languages. For example, the Tiberian Hebrew schwa deletion rule fails to apply when consonants flanking schwa are identical.

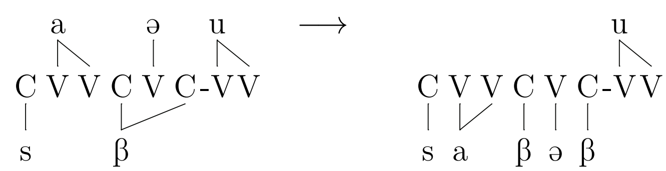
(1.12) Tiberian Hebrew Schwa Deletion

i. ə→ ∅ / VC ___ CV

a.	zaaχrúu	‘they recalled’	saaβəβúu	‘they surrounded’
	haalχúu	‘they walked’	daaləlúu	‘they hung’
b.	malχê	‘kings of’	harərê	‘mountains of’
	qiβrê	‘graves of’	ʕaməmê	‘people of’

(1.13) shows the representations of *saaβəβúu* before and after Tier Conflation. The schwa deletion rule, applying after Tier Conflation, is blocked since the application of the rule will yield *saaββúu*, which violates the OCP.

(1.13)



before Tier Conflation   after Tier Conflation

By introducing Tier Conflation, McCarthy shows that the OCP is a universal constraint in segmental phonology, constraining underlying morpheme structures as well as derived forms, applying equally to languages with non-concatenative and concatenative morphology. This move, however, might make the OCP too promiscuous. In the tonal phonology, the OCP is conceived as a constraint applying exclusively to the tonal tier. In McCarthy (1981), the OCP is considered to apply to the consonantal root tier and restricts the possible representation of the morpheme roots. Arguing that the OCP also applies after Tier Conflation, that is, to a linearized string of consonants and vowels, McCarthy obscures the arguments made for the independence of the consonantal root tier. McCarthy's formulation of the OCP in (1.8) is in fact criticised by Odden (1988) that what constitutes a ‘melodic level’ is not explicitly defined. It is clear, from the examples of Arabic roots and Tiberian Hebrew, that for McCarthy both the consonantal root tier and the linearized CV sequences are ‘melodic levels’. Considering that, in autosegmental analysis, tones form an independent tier just like the Arabic consonantal root tier, it seems that anything that can constitute an autosegmental tier can also be a ‘melodic level’, be it a single feature, a set of some features, segments (i.e. a set of all features) or tones.

Borowsky’s analysis of the spirantisation (more precisely, the failure to apply the spirantisation rule) and the allomorphy of the plural, genitive and past tense suffixes in English as antigemination effect of the OCP reflects such a view that the OCP could apply to any ‘tier’ (Borowsky 1987). Borowsky analyses that, when preceded by [s], the spriantisation of [t] is blocked due to the OCP applying to the manner and the primary (but not secondary) place tiers. She posits underlying forms of the plural and the genitive suffixes as /-Vz/ and of the regular past tense suffix as /-Vd/, and attributes the failure to delete the vowel when preceded by a coronal segment to the OCP applied also to the manner and the primary place tiers. The derivation with the plural and past tense suffixes is exemplified below, where V-deletion fails to apply when the plural suffix (which is [+CONT, +COR]) is preceded by a [+CONT, +COR] segment and the past tense suffix (which is [−CONT, +COR]) is preceded by a [−CONT, +COR] segment.[1]

[1]The following are Borowsky’s rules for spirantization (i) and inflectional vowel deletion (ii).

(i) $[+\text{cor}] \rightarrow [+\text{cont}]$ / ___ y

(ii) $V \rightarrow \emptyset$ / ___ $C_{[\alpha\text{cont},\ +\text{cor}]}$

She states that the left environment needs not be mentioned because the condition is supplied by the OCP.

(1.14) English plural and past tense suffixation

	books	bushes	loved	padded
suffixation	buk -Vz	buʃ-Vz	lʌv -Vd	pæd -Vd
V-deletion	buk -∅z	—	lʌv -∅d	—
voice assimilation	buk -s	n/a	n/a	n/a
	buks	buʃəz	lʌvd	pædəd
		*buʃs		*padd

If we posit the underlying forms of the plural and the genitive suffixes as /-z/ and of the past tense suffix as /-d/, as standardly assumed, Borowsky's analysis could be interpreted as the OCP triggering the application of the vowel insertion rule.

Yip (1988) in fact argues that the OCP not only blocks rule applications but also triggers them. Yip discusses the deletion of a glottal stop in Seri. Seri deletes a glottal stop if it is preceded by another glottal stop in the same syllable. Yip explains that this is not a restriction on the coda position, as a glottal stop in coda is acceptable if not preceded by another glottal stop (e.g. *koʔpanšX* 'Run like him!').

(1.15) Seri glottal deletion

a. ʔa-a:ʔ-sanx → ʔa-a:-sanx 'who was carried'

b. ʔi-ʔa:ʔ-kašni → ʔi-ʔa:-kašni 'my being bitten'

Yip argues that this is not a simple deletion rule but is a *degemination* rule triggered by the OCP applied to the laryngeal tier. Phenomena in which one of two adjacent identical segments deletes are called degemination, and it is considered to be one of the ways to 'fix' the structure that violates the OCP. In (1.15), two glottal stops are separated by a vowel, thus they are not exactly 'adjacent.' However, Yip states that laryngeal features are known to form an autosegmental tier and that laryngeal features are not specified for any segment except *ʔ* in Seri, hence two glottal stops *are* adjacent on the laryngeal tier, with no intervening laryngeal nodes in between.

In her statement of the rules, Yip specifies the *domain* and the *tier* to which the rule applies, and the *change* that in a sense provides the instruction as to how to 'fix' the ill-formed structure. In the case of Seri, the *domain* is a syllable, the *tier* is the laryngeal tire, and the *change* is to delete the second occurrence of the laryngeal segment. The environment that triggers the rule is not mentioned, as the trigger is the (supposedly) universal constraint, the OCP.[2]

In addition to Seri glottal degemination, Yip provides three examples of the rules triggered by the OCP (voicing assimilation in Berber, coronal harmony in Chumash and labial dissimilation in Cantonese). For each rule, Yip specifies the domain, the tier and the change. The domain could be a word, a morpheme or a syllable, and the tier could be Coronal, Strident, Labial or Laryngeal. This suggests that as long as we could analyse segments to be 'adjacent' in some arbitrary domain, and be 'identical' in some arbitrary ways, we could employ the OCP as a rule trigger or a rule blocker. This would be problematic for the conception of the OCP as a constraint. There seems to be no principled way to constrain the domain and the tier that are subject to the OCP, that is, there is no principled way to define the notions of (segment) adjacency and (segment) identity.[3] Furthermore, if we need to specify a domain and a tier for every rule triggered or blocked by the OCP, the OCP begins to look more like a normal phonological rule in which the structural description specifies the precise environment for the rule's application, and the claim of its universality loses an appeal.

[2] Yip's rule statement for Seri glottal degemination is as follows:

Domain: Syllable

Tier: Laryngeal

Trigger:

Change: Delete second

[3] For example, are two labial consonants with an intervening non-labial segment (e.g. *bim*, *brm*) considered to be 'identical' and 'adjacent'? What if they position across a morpheme boundary?

Note that the conception of the Ocp as a negative filter over output forms departs from the original reason for the attractiveness of the constraint. Recall that in tonal phonology, the Ocp restricts the possible tone-to-vowel mappings, thus makes the learning task easier (a learner equipped with the Ocp may not need to entertain the mapping possibilities (1.1a-g), for example). The same can be said to learning of underlying morpheme structures in Arabic-type languages. As a negative filter, the Ocp does not restrict possible underlying forms, nor even output forms in a sense that the grammar would need to "look ahead" and "know" the output of the application of a certain rule in order to block or trigger that rule. One might say that, while the Ocp in its original conception is in line with modeling an explanatorily adequate grammar, the extension of the function of the Ocp adds to a grammar more descriptive power. It seems, however, that the descriptive power has been added by giving up precise definitions of segment identity and adjacency. Furthermore, the Ocp does not seem to mitigate the tasks of a learner. Within a language, the Ocp can apply to a certain tier but not others, and in a certain domain but not others. Thus a learner must learn to suppress this putatively universal constraint on appropriate tiers and domains.

1.2.3 The Ocp in Optimality Theory

Yip argues that the Ocp defines the ill-formed structures that need to be 'fixed'. The structure defined by the Ocp necessarily involves two 'identical' elements, while the specific ways to fix the structure can vary across languages. In this sense, the Ocp "separates out condition and cure" (74). This separation of 'phonological pathology' and 'cure' would apply to the role of the Ocp in Optimality Theory. In the rule-based approach, the Ocp is argued to filter out the derived structures that are ill-formed, and a specific rule will function as a 'cure' to change the ill-formed structures. In OT, the Ocp functions as a markedness constraint that penalizes a ill-formed structure (i.e. adjacent 'identical' segments) and the 'cure' emerges from the ranking of other constraints relative to the OCP. If, for example, the OCP is ranked higher than the faithfulness constraint MAX, deletion of a segment may emerge as a strategy to fix the ill-formed structure.

Rose (2000) is an example of employing the OCP as an OT constraint. Unlike McCarthy who considers antigemination to be an OCP effect, Rose takes a non-standard view that the OCP penalizes identical consonants that are separated only by vowels (e.g. C_iVC_i). She proposes to include this configuration in the typology of adjacency and calls it "consonant adjacency". According to Rose, geminates (C_iC_i) do not violate the OCP but instead violate another constraint NOGEM. Antigemination is thus an effect of highly ranked NOGEM and not of the OCP. Rose bases her claim on data from Ethiopian semitic languages, Tigre and Tigrinya. Tigrinya imperfective forms require gemination of a root consonant, as in (1.16a-b). However, as (1.16c) shows, guttural (pharyngeal, laryngeal, uvular) consonants do not geminate.

(1.16) Tigrinya Imperfective

	Imperfective	Passive Imperf.	Causative Imperf.	
a.	yɨ-gərrɨf	yɨ-gɨrrəf	yɨ-gɨrrɨf	'whip'
b.	yɨ-bɨddɨl	yɨ-bɨddəl	yɨ-bəddɨl	'hurt'
c.	yɨ-sɨħɨb	yɨ-ssaħab	yə-sħɨb	'pull'
	(*yɨ-sɨħħɨb)	(*yɨ-saħħab)	(*yə-saħħɨb)	

The gemination of root consonants indicates that those geminates form a doubly-associated structure. Guttural consonants' resistance to gemination can be explained by a constraint that penalizes doubly-linked gutturals. Such a constraint, however, does not account for the data from Tigre. Tigre plural prefix /*ʔa-*/ does not attach to nouns whose initial consonant is a guttural.

(1.17) Tigre Plural

	Singular	Plural	
a.	kəbɨd	ʔa-kbud	'belly'
b.	bɨħar	ʔa-bħur	'sea'
c.	ʔɨkɨl	ʔakal (*ʔa-ʔkul)	'corn, crop'
d.	ħabɨl	ħabɨllɨt (*ʔa-ħbul)	'rope'

Since the two gutturals belong to separate morphemes, they do not form a doubly-linked structure. After Tier Conflation (i.e. segments belonging to separate tiers are folded into one tier) the two gutturals are separated by a vowel, hence the constraint that prohibits guttural geminates in Tigrinya can not explain the Tigre plural data. What seems to be prohibited is a sequence of two gutturals separated by a vowel, as indicated in the parentheses in (1.17c-d). The plural form in (1.17b) in fact shows that the separation by a vowel, not by a consonant, is the key. Tigre data can be explained by a constraint that penalizes "consonant adjacency" of gutturals. These observations lead Rose to postulate two distinct constraints, Ocp and NoGem. She formulates the two constraints as follows:[4]

(1.18) a. NoGem: Long consonants are disallowed.

b. Ocp: A sequence of adjacent identical segments is disallowed (under consonant adjacency).

Employing these constraints, Rose provides an OT account for the case of syncope in Afar. Recall that in Afar, deletion of an unstressed vowel fails to apply when flank-

[4]These constraints formulated by Rose refer to *surface* sequences, not to association structures, even though the reason to posit the constraint Ocp distinct from NoGem is that the doubly-associated structure can not account for the data in Tigre. Rose mentions that, with regards to Semetic roots, doubling of the final consonant (e.g. *samam*) should be analyzed as reduplication instead of double association. Although she does not provide an analysis of her own, geminates in Tigrinya imperfective forms can also be analyzed as reduplication with syncope applying between identical non-guttural consonants (e.g. *yɨ-gərɨrɨf* → *yɨ-gərrɨf*). In this case, the sequence *rr* forms a fake geminates. Rose's point is, it seems, that NoGem penalizes geminates whether they are true or fake. Later in her paper, Rose attributes different behaviours between true and fake geminates to different domains in which Ocp applies.

ing consonants are identical (see (1.10)). McCarthy argues that this antigemination is an OCP effect. According to Rose, the Afar example is accounted for by NOGEM being ranked higher than the OCP. The constraint MAX$_{IO}$ requires maximal correspondence between input and output forms, while DELETE penalizes "adjacent light open syllables" (104).

(1.19) Tableau for Afar

digbe 'he married'

/digib-e/	NOGEM	DELETE	MAX$_{IO}$	OCP
digibe		*!		
☞ digbe			*	

danane 'he was hurt'

/danan-e/	NOGEM	DELETE	MAX$_{IO}$	OCP
☞ danane		*		*
danne	*!		*	

If the ranking of NOGEM higher than OCP (NOGEM $\gg$ OCP) explains the failure of syncope between identical consonants, the opposite ranking would account for syncope applying only between identical consonants. Rose discusses Classical Arabic as an example exhibiting such a case. In Classical Arabic regular Form I, a vowel syncopates between identical consonants.

(1.20) Classical Arabic syncope

a. katab-a 'he wrote'

b. samm-a 'he prisoned'

c. madd-a ' he stretched'

In McCarthey's (1986) analysis, the sequences *mm* and *dd* are the second consonant of the biliteral roots doubly associated to the C slots, and hence are not subject to the OCP. According to Rose, the data above is accounted for by the OCP ranked higher than NoGem. $\textsc{Max}_{IO}$ must also outrank NoGem (but be ranked below the Ocp) to account for non-occurenece of syncope between non-identical consonants (1.20a).

(1.21) Tableau for Classical Arabic

kataba 'he wrote'

/katab-a/	Ocp	$\textsc{Max}_{IO}$	NoGem
☞ kataba			
katba		*!	

madda 'he stretched'

/madad-a/	Ocp	$\textsc{Max}_{IO}$	NoGem
madada	*!		
☞ madda		*	*

In the above examples, Ocp penalizes completely identical consonants separated by a vowel. Recall that Tigre, on which Rose's formulation of Ocp is based, exhibits the avoidance of only guttural consonants separated by a vowel; whether or not the consonants are completely identical does not seem to matter. This begs a question: Can Ocp apply to individual features? Rose argues that the Tigre data clearly indicates that "the restriction should operate at the level of a featural node such as Pharyngeal" (94). Furthermore, she discusses the fact that there is no verb with final double gutturals (e.g. *saʔaʔ*) in Tigre or in Tigrinya but verbs like *gəfəf* do exist in these languages, and attributes this fact to relative ranking of Ocp constraints with tier specifications (Ocp/pharyngeal $\gg$ Ocp/labial). This is in line with Yip's approach to the Ocp in that the OT constraint Ocp may need to be specified with a specific tier it applies to, be it a featural tier or a tier for the surface sequence.

Rose also indicates that Ocp applies to different domains. Tigre and Tigrinya have similar restrictions on the distribution of gutturals internal to verbal stems, but unlike Tigre (1.17), Tigrinya allows the plural prefix *ʔa-* to attach to nouns with initial guttural consonants.

(1.22) Tigrinya Plural[5]

Singular	Plural	
ħəwi	ʔaħ^{a}wat	'brother'
ʔɨgri	ʔaʔ^{a}gar	'foot'

Rose argues that the contrast between Tigre and Tigrinya is explained by the different domains in which Ocp applies in two languages: In Tigre the domain for Ocp/pharyngeal is a word, while in Tigrinya it is a stem.

Rose's analysis suggests that Ocp may need to be specified with both the tier and the domain, just like Yip's rule statements for the Ocp that have specifications for the tier, the domain and the change. The OT constraint Ocp should then be defined not as a single constraint but as a set of constraints, each of which refers to a different tier/domain specification (for example, Ocp/pharyngeal:word, Ocp/pahryngeal:stem, and so on). Considering the possible combination of tier/domain specifications, Ocp as a set of constraints will considerably increase the volume of the universal constraint inventory Con.

This chapter reviewed the development of the Ocp in phonological theories. The Ocp as originally conceived in tonal phonology proposed an explanatory adequate model of phonological grammar in that the principle restricts possible underlying tone-to-segment mappings, although its universality was questioned by Goldsmith (1976). With its status in the theory of UG left unexamined, the Ocp has been extended into the analysis in segmental phonology through the autosegmental model of Semitic morphophonology (McCarthy 1981, 1986). McCarthy's analysis with Tier Conflation allows the Ocp to apply not only as a constraint restricting possible underlying representations, but also as a negative filter over derived structures, blocking

[5]Gutturals in coda position is prohibited in Tigrinya, and an epenthetic vowel *a* is inserted after coda gutturals.

or triggering rules in order to avoid ill-formed geminates. Applying to autosegmental representations, the OCP has the potential to refer to any autosegmental tier, be it a feature tier, a root tier, or a tonal tier. Applying to both underlying and derived representations, the OCP also has a potential to operate on a specific domain, be it a morpheme or a word. This necessitates any OCP blocked or triggered rule to be specified with the tier and the domain to which it applies (Yip 1988). Although the OCP continues to be considered as a universal principle, there seems to be no principled way to constrain on which tier and at which point of derivation the OCP operates. This makes it difficult to establish a precise definition of segment adjacency and identity. The OCP is further carried through to the Optimality theoretic analysis. Rose's (2000) analysis indicates that the OCP can operate on a featural tier or a root tier, and can apply to specific domains. This further suggests that the OCP should be considered as a set of constraints, each of which bans adjacent elements that are treated as identical on a specific tier in a specific domain. Either in the rule-based or in the Optimality theoretic approaches, the OCP basically can refer to any tier and domain, thus this principle/constraint could be used quite opportunistically in the analysis. It seems that, as the researchers extended the application of the OCP from tones to segments and from underlying representations to representations including derived ones, the status of the OCP as a 'principle' has become dubious. In the next two chapters, I will discuss two alternative approaches to the OCP from two different theoretical perspectives.

Chapter 2

Against the OCP and calculating identity

The OCP has been extended from a constraint that restricts possible representations of tonal melodies to a constraint that defines 'ill-formed' phonological structures in general. As such, the OCP is also considered to function as a trigger or a block of phonological rules. The extension from tones to segments, however, comes with auxiliary assumptions such as consonant-vowel segregation and Tier Conflation. Application of the OCP to featural levels (as in Yip 1988) requires, as a premise, autosegmental representation of segments. In other words, an analysis that employs the OCP as a rule trigger or blocker has to have a particular set of assumptions as to whether consonants and vowels are segregated and how features are autosegmentally organized, for example. Such additional (yet necessary) assumptions obscure the definition of segmental identity and adjacency. Odden (1986, 1988) convincingly argues against employing the OCP as a universal constraint, from both logical and empirical perspectives. He points out that it is the fact that what counts as 'identical' is idiosyncratic among languages, and encourages one to establish a formal system to account for varying identity references. Following Odden, Reiss (2003) aims to build a formal model for calculating segmental identity that utilizes quantificational logic. This chapter recapitulates Odden's arguments and summarizes Reiss' algebraic model of identity reference.

2.1 Odden 1986

Odden (1986) makes strong arguments against the OCP as a universal principle of a phonological grammar. He first proposes a plausible alternative to Goldsmith's analysis of the underlying forms in Etung. Odden points out that the distinct LLH and LH (HHL and HL) tonal melodies in Etung at the underlying level can be collapsed to LH (HL) if one allows tones and vowels to be associated in the lexicon. In Goldsmith's approach, tones and vowels are stored separately (i.e. unassociated) and the association between the two autosegmental levels is part of phonological derivation. Hence, *òròbé* can not be derived from LH and the left-to-right tone mapping rule. However, if tones and vowels are stored in associated forms, LLH can be reduced to LH in the lexicon, as in (2.1), and therefore, Odden argues, Goldsmith's analysis does not constitute a genuine counterexample to the OCP applying at the underlying level.

```
(2.1)    o ro be     bi so e
         |/    |      |   \|
         L     H      L    H
```

Odden (1986) further provides examples from Shona that seemingly supports the OCP as a constraint on tonal patterns in the lexicon. In Shona, high tones of a noun are lowered after the associative prefix which bears a high tone. This is explained by the Associative Lowering Rule. (In (2.2-2.6) high tones are indicated with acute accents, and no accent indicates a low tone.)

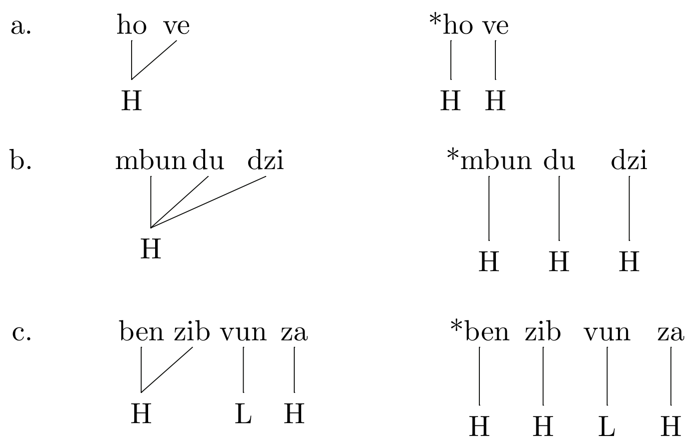
(2.2) Shona Associative Lowering

i. $H \rightarrow L \ / \ H_{[+assoc]} \ \_\_\_$

a.	hóvé	'fish'	né-hove
b.	mbúndúdzí	'army worms'	né-mbundudzi
c.	bénzíbvunzá	'inquisitive fool'	né-benzibvunzá

If, on the one hand, each vowel of a noun separately bears a high tone, the rule (2.2i) would lower only the first vowel, as the second (and the subsequent) vowel is no longer in the environment for the rule to apply. On the other hand, if the consecutive high tones are underlyingly represented as one high tone spreading to multiple vowels, lowering of all the neighbouring high tones will easily be explained. (2.2c) further confirms the spreading analysis. In (2.2c) the high tone on the final vowel is not lowered because of the low tone on the penult vowel which blocks spreading. The underlying lexical tones of Shona nouns in (2.2) are thus represented as follows.

(2.3) Lexical representation of Shona nouns



The representation in (2.3) obeys the OCP stated in (1.4): on the tonal tier, adjacent identical tones are prohibited.

Nonetheless, Odden goes on to show that the OCP is neither a derivational constraint nor a constraint that applies to the underlying (lexical) forms. His argument comes from "downstep" in Kishambaa. In Kishambaa, downstep (indicated as $^!$) applies between two contiguous H tones where the pitch of the second H is lower than that of the first.

(2.4) Kishambaa Downstep

kúi 'dog'

níꜝkúi 'It is a dog'

If the H's in *ní* and *kúi* are collapsed to one when the two morphemes are concatenated, downstep would not occur as there is putatively only one H. This argues against the OCP applying to derived forms.

(2.5)

```
ni  kui        *ni  kui
|    |            \  /
H    H             H
```

Odden shows that Kishambaa makes a contrast between two adjacent H tones and a multiple-associated H tone at the lexical (underlying) level. Consider the two (monomorohemic) nouns in (2.6). The downstep in *ngóꜝtó* indicates that there are underlyingly two H's, each is associated to one vowel. If there were undelyingly only one H, the downstep would not occur. This is indicated in *nyóká* , in which no downstep occurs. The contrast between the two nouns counter-exemplifies the OCP as a constraint at the lexical level.

(2.6)

```
ngóꜝtó 'sheep'      nyóká 'snake'

ngo  to              nyo  ka
 |    |                \  /
 H    H                 H
```

Although Odden refutes the status of the OCP as a universal constraint, he also acknowledges that the obedience to the OCP is in fact observed in various languages and thus it "does some work for us" (378). He attributes the observed effects of the OCP to a preferred, principled way of learning underlying forms from phonetic sequences of adjacent identical tones. The OCP restricts possible representations of a surface sequence of the same tone, as as shown in (1.1). If any of the 8 possible representations is compatible with the data available to a learner, that is, there is no evidence to determine one representation over the others, a learner will presumably have a principled way to choose one representation as being correct. The mappings in (1.1b-g) seem ad hoc, hence plausible "principled" ways to choose a representation would be to assume either (I) a phonetic sequence of the same tone is represented as one tone associated with multiple vowels (multiple association, (1.1h)), or (II) a phonetic sequence of the same tone is represented as a sequence of identical tones, each associated with one vowel (one-to-one association, (1.1a)). Odden argues that (I) is preferred, as it complies with the Well Formedness Condition, a condition that dictates the association between tones and vowels in autosegmental phonology.

(2.7) Well Formedness Condition (Goldsmith 1976: 44, 1990: 319)

a. All vowels are associated with at least one tone.

b. All tones are associated with at least one vowel.

c. Association lines do not cross.

What the WFC indicates is that any unassociated vowel becomes associated with available tones, which further indicates that association of a tone with multiple vowels is a normal case. (II) on the other hand is in conflict with the WFC, since it implies that one-to-one association is the norm, and thus a learner will need additional evidence that a tone can be associated with multiple vowels. Everything else being equal, a learner will prefer (I) which is in accordance with the WFC and needs no extra evidence for a multiply-associated tone. Odden comes to a conclusion similar to Goldsmith (1976) that the observed effects attributed to the OCP in fact come from the way to solve a learning problem. He states that "the OCP deserves no special theoretical status in phonological theory" and that "some effects of the OCP is to be attributed to the fact that children learning a language must make some principled decision regarding the correct representation of adjacent identical tones" (380).

2.2 Odden 1988

Odden (1988) argues, even more strongly, against the OCP employed in the analyses of segmental/non-tonal phonology. Odden criticizes the formulation of the OCP by McCarthy (1986)[1] for being unclear about what constitutes a "melodic level", and argues that the lack of clarity in defining the organization of features and the "precise unit" the OCP constrains makes it difficult to test the universality of the OCP.

Odden points out that the majority of non-tonal OCP effects discussed in the literature deals with adjacent consonants, and that apparent OCP effects on adjacent identical vowels are rare. If the OCP is universal, it should also constrain vowel sequences and one would expect to observe similar 'antigemination' phenomena (blocking consonant deletion, for example) between identical vowels. Estonian has a rule to delete unaspirated consonants between vowels in so-called "strong" forms (e.g. genitive, 1st person singular) as shown in the alternation *tegu* (nom.) $\sim$ *teo* (gen.) 'deed'.[2] Consonant deletion does happen even when flanking vowels are identical, forming geminate vowels (or long vowels), contrary to the prediction one would make if the OCP constrains vowel sequences.

(2.8) Estonian Consonant Deletion

Nominative	Genitive	
lugu	loo	'story'
sugu	soo	'tribe'
kubu	koo	'arm of grain'

Regarding McCarthy's analysis of Arabic verbal roots, Odden points out that homoroganicity, not total identity, of consonats better explains the restriction on the root structure. Recall that non-occurence of verbs like **sasam* as opposed to *samam* is accounted for by the rightward spreading of biliteral consonantal roots and the OCP

[1] (1.8), repeated here: "At the melodic level, adjacent identical elements are prohibited."

[2] *u* is lowered in a vowel cluster subsequent to consonant deletion.

operating over the root structure (1.9). Odden, citing Greenberg (1950), remarks that the triconsonantal verbal roots with homoroganic first and second consonants, such as *bmC* and *gkC*, are also prohibited. If the ban on the roots such as *ssC*, *bmC* and *gkC* is dictated by the OCP, the OCP clearly ignores voicing and nasal features. The accepted verbal forms like *saxiṭa* 'be annoyed', *ḍaɣaṭa* 'press' and *manaṭ* 'way' confirm that it is homorganicity (identical place features) that matters, and that the features [± continuant], [±voice] and [± nasal] are not subject to the OCP with regards to Arabic verbal root structure. The lack of explicitness in the definition of "melodic levels" allows one to employ the OCP in the analyses of almost any kind of 'antigemination' (e.g. ban on completely identical geminates like **ssC* or partially identical geminates like **bmC*, **gkC*), but such a formulation fails to explain why the OCP is seemingly unoperational with respect to vowel sequences or certain consonantal features.[3]

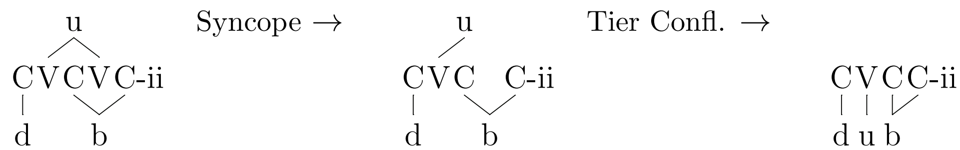
Odden also questions the claim that antigemination constitutes an evidence for the OCP. Antigemination phenomena are considered to be the effects of the OCP at work. If antigemination is dictated by the OCP and the OCP is universal, then antigemination must be universally observed. This is not the case, however: Geminate vowels are widely accepted as shown in the Estonian example. Odden is careful to mention that "the considerable degree of freedom" given to the analyses of antigemination might make it difficult to disprove the universality of the phenomena. One example of such "freedom" is given by the introduction of Tier Conflation and the postulation of consonant-vowel segregation.[4] McCarthy (1986) argues that the geminate consonants as a result of syncope in Akkadian (e.g. *dububii* → *dubbii* 'speak! (f. sg.)'; *šakikat* → *šakkat* 'it(f.) was harrowed') do not violate the OCP as these geminates are doubly-linked root consonants and the syncope rule applies *before* Tier

[3]To quote Chomsky and Halle (Chomsky & Halle 1968: 60), "[A]ny ambiguity or inexplicitness in the statement of rules must in principle be eliminated, since the receiver of the instructions is assumed to be incapable of using intelligence to fill in gaps or to correct errors. To the extent that the rules do not meet this standard of explicitness and precision, they fail to express the linguistic facts."

[4]Another factor Odden mentions is Phonetic Implementation Rules (McCarthy 1986, 5.2).

Conflation.

(2.9) Akkadian Syncope



Recall that the obedience to the OCP in Afar syncope is reasoned that consonant and vowels are not segregated into separate tiers in Afar (1.10). An alternative to this analysis would be to postulate C-V segregation and order the syncope rule *after* Tier Conflation.[5]

(2.10) Afar Syncope (alternative)

Note that, if the syncope is ordered after Tier Conflation or C-V segregation is not supported in Akkadian, the data above will be interpreted as a counter-example to the OCP. Introducing C-V segregation and Tier Conflation into the analysis has a significant consequence: Tier Conflation allows rules like syncope to be ordered either before or after it. By ordering syncope after Tier Conflation, on the one hand, the failure to apply syncope (e.g. Afar) is argued to be the obedience to the OCP. On the other hand, ordering syncope before Tier Conflation explains the application of syncope as obeying the OCP (e.g. Akkadian), since resulting geminate consonants are in fact one and the same consonant on the consonantal tier (true geminates). McCarthy's analytic apparatus has a potential to interpret counter-examples to antigemination ('antiantigemination') as examples of antigemination,

[5]Rose (2000: 99) points out that "[T]hose languages that resist syncope, like Afar, either must apply syncope after Tier Conflation or must not have vocalic and consonantal segregation in the first place. Those languages that allow syncope between identical consonants would apply the rule before Tier Conflation when the identical consonants form a geminate."

and vice versa. This will make it vacuous to argue that antigemination is evidence favouring the OCP.

Odden also comments that antigemination is not uniform in that what determines segment identity varies among languages. Odden gives examples of languages that epenthesize a vowel between 'identical' consonants.

(2.11) Antigemination by Epenthesis

(i) Tondano inserts a schwa between word-internal identical consonants.
/wuʔuk-ku/ → [wuʔukəku] 'my hair'

(ii) Modern Hebrew inserts *e* between stem final *t* or *d* and the suffix-initial *t*.
/yalad-ti/ → [yaladeti]; /kišat-ti/ → [kišateti]

(iii) English epenthesize a schwa between coronal stridents and the plural and the genitive suffixes /-s/, and between coronal stops and the regular past tense suffix /-d/.

While Tondano requires complete identity of adjacent consonants, only partial identity (specifically the identity of place features) seems sufficient for epenthesis to apply in Modern Hebrew and in English. Apart from the question whether the above examples of epenthesis are cases of (total or partial) antigemination triggered by the OCP, it is clear that some kind of identity statements is required for a grammar to correctly calculate the environment in which epenthesis applies.

The same situation holds for 'antiantigemination'. Odden provides examples where syncope applies *only* when flanking consonants are 'identical.' These examples are especially problematic for the claimed universality of the OCP, as the result of the rule application is promoting the creation of total or partial geminates.

(2.12) Antiantigemination by Syncope

(i) Koya deletes a word final vowel if preceding and following consonants are identical, ignoring retroflexion.

/na:ki # ka:va:li/ → [na:kka:va:li] ‘to me it is necessary’

/verka:ḍi # digte/ → [verka:ḍdigte] ‘the cat got down’

(ii) In Telugu, a short vowel is deleted between homoroganic consonants, both within and between words.[6]

/gulābi # mogga/ → [gulābmogga] ‘rose bud’

/pāta # ceppu/ → [pācceppu] ‘old sandal’

/cerku-gaḍa/ → [cerggaḍa] ‘sugarcane stick’

(iii) Intensive reduplication in Nukuoro reduplicates the first two syllables (CVCV) and deletes the second V if flanking consonants are identical.

balavini → balabalavini ‘awkward’

bobo → bobbobo ‘rotten’

(iv) Yapese deletes a vowel between homorganic consonants if the first consonant is postvocalic or word initial.

/ba # puw/ → [bpuw] ‘it’s a bamboo’

/ni # te;l/ → [ntel] ‘take it’

/rada:n/ → [rda:n] ‘its width’

/qalaee-g(u)/ → [qalae:gu] ‘my headache’

For syncope to apply, Nukuoro requires complete identity of flanking consonants, Koya requires partial identity, ignoring retroflexion. Telugu only requires identity in place features, but minor place features are ignored. Homorganicity is sufficient in Yapese as well, with a positional requirement in the first consonant.

[6] Minor place features on coronals such as [±distributed] is ignored. The ignored features and the voicing feature regressively assimilate.

Whether they create or break up geminates, the rules illustrated in (2.11, 2.12) require reference to segment identity, and what makes segments 'identical' differs across languages. Odden further provides a following typological classification concerning rules that either create or separate geminates (Odden's (a,c,d,f): 462).

(2.13) a. Delete a vowel unless flanking consonants are identical.

b. Delete a vowel only if flanking consonants are identical.

c. Insert a vowel unless flanking consonants are identical.

d. Insert a vowel only if flanking consonants are identical.

The examples in (2.11), where (total or partial) geminates are separated by epenthesis, are the cases of (2.13d), and such epenthesis rules are argued to be triggered by the OCP (Yip 1988). (2.13a) represents the putative 'blocking' effect of the OCP. The application of rules of the type (2.13c) will preserve geminates, which can be accounted for by 'geminate integrity' (true geminates do not split). The examples in (2.12), where (total or partial) geminates are created by syncope, are the cases of (2.13b) that raise a question on the universality of the OCP.

Independently of the results of their applications (whether they create or separate geminates) the types of rules in (2.13) require reference to segmental identity, and what counts as identical varies across languages as exemplified in (2.11) and (2.12). Odden argues that, independently of antigemination (or antiantigemination), and of the OCP, phonological grammar needs a system to correctly describe varying instances of segment 'identity'.

2.3 Feature Geometry and Feature Algebra, Reiss (2003)

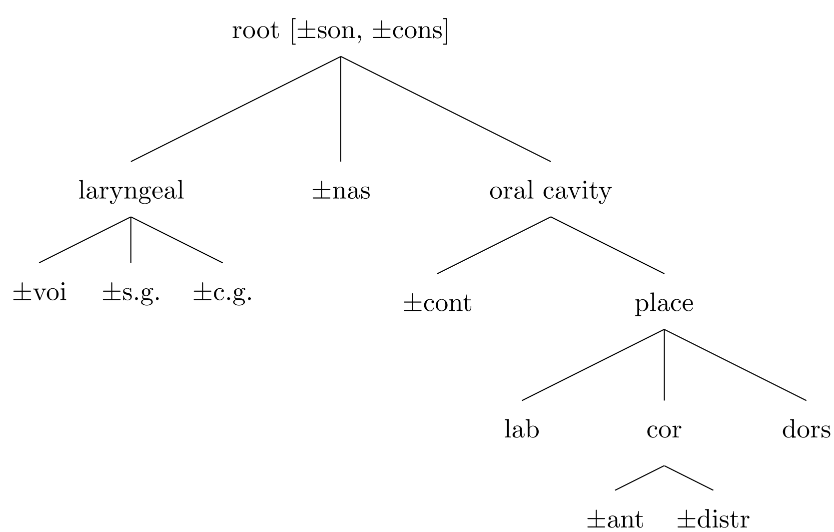
Odden convincingly argued that a theory of phonological grammar needs "an adequate formal account of identity references" (461). What kind of formal apparatus is required depends on how features are organized: Are features arranged into separate tiers as proposed in autosegmenal phonology? Do they form Feature Geometric representations with hierarchical structures, or are they simply matrices with no hierarchy? Responding to Odden, Reiss (2003) proposes an algebraic model of identity calculation and argues that Feature Geometrical representation is not powerful enough (or too restrictive) to describe the identity references required in the rules in Odden's examples. Before proceeding to Reiss' algebraic model, I will recapitulate Feature Geometry.

2.3.1 Feature Geometry

It is a well-supported, widely accepted hypothesis that a speech segment is composed of a set of phonological features. Theories diverge as to how these features are organized. One approach to the theories of feature organization is Feature Geometry (FG), independent of but emanating from Autosegmental Phonology. In Autosegmental Phonology, features are distributed, or "autosegmentalized" into separate tiers in the way that each feature appears on no more than one tier. Specified features are placed as nodes (or "autosegments") on their appropriate tiers. The relation among tiers are represented as association lines between nodes, and featural changes are analyzed as deletion, addition or rearrangement of association lines regulated by the Well Formedness Condition (2.7). One of the motivations for the autosegmental approach is to capture the fact that certain features "behave together" when phonological rules are applied. The autosegmental theory accounts for this "harmonic" behaviour of features by organizing harmonic features into an autosegmental tier.

FG builds on this notion of harmonic features and proposes a hierarchically organized model of feature representation. In FG, a group of features that "regularly function together" form a 'constituent' and represented as an intermediate node, or a 'class node' (Clements & Hume 1996, Goldsmith & Noske 2006). Individual features each form its own tier, and valued features are represented as terminal nodes on those tiers. A constituent/class node dominates featural nodes or other constituents. The highest node is called a 'root node,' representing a speech segment itself. A typical feature geometric representation of a consonantal segment is shown below (adopted from Clements & Hume 1996: 292, and Yip 1988: 70, with modifications).[7]

(2.14)

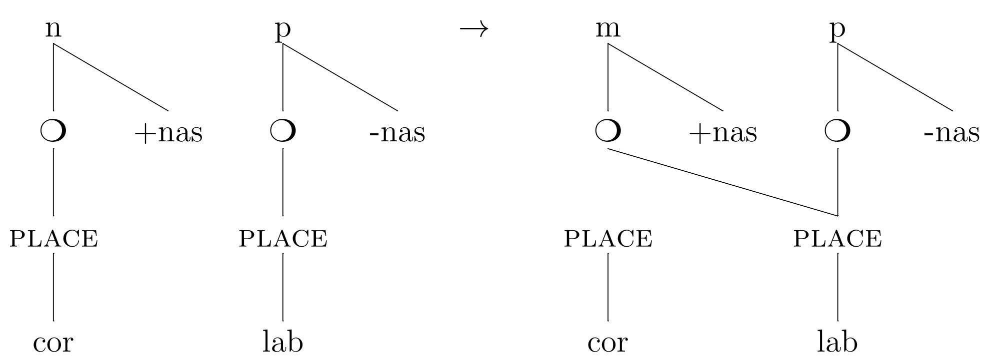


When segments are sequenced linearly, a tier and the tier immediately dominating it form a 'plane'. The branches that indicate dominance relation among nodes can be interpreted as association lines drawn on the planes. Just as in Autosegmental Phonology, featural change is understood as reorganizing the association lines (that is, changing dominance relations) on the condition that the WFC is respected. An

[7] In this representation, the features [±sonorant] and [±consonantal] are directly attributed to the root node. The place features, [labial], [coronal] and [dorsal], are considered to be privative instead of binary (Clements & Hume 1995, Hall 2007). The coronal node has its feature specification but also works as a class node.

advantage of hierarchically organizing features is that such an organization can simplify the statements of phonological rules. Consider, for example, place assimilation rules. If features are unorganized on the one hand, a rule describing place assimilation would have to refer to all the place features such as [labial], [coronal], [±distributed] and so forth. If features are hierarchically organized on the other hand, place assimilation is understood as spreading of a place node and the assimilation rule needs not mention individual place features, as features dominated by the place node will "behave together."

(2.15) Place assimilation: $np \to mp$[8]



Note that (2.15) indicates the partial identity (identity of place features) of the two segments *m* and *p*. In general, feature geometric representation expresses identity relation as association relation between the nodes on one tier and the nodes on the higher tier. The configuration in which one node on a featural tier is associated with two nodes on a dominating tier indicates the identity in terms of the feature represented on the featural tier. Partial identity, as illustrated above, will be characterized by this configuration holding among some (but not all) nodes/tiers lower than the root tier. One of the configurations for total identity of two segments will be the configuration in which one root node connects to two slots on the CV skeltal tier. A grammar with feature geometric representation will calculate identity relation

[8] The de-linked nodes are assumed to be deleted.

between two segments by "scanning" over the geometric structure composed of nodes and association lines among them.[9]

It is in fact imperative that the features dominated by the same class node behave together. One consequence of hierarchical feature organization is that when a rule makes reference to a class feature such as 'place' and instruct to change that class feature, individual features dominated by that class node must follow the rule and undergo a featural change as stated in the rule. Features under the place node such as [±distr] can not escape the change. If an assimilation rule targets a root node, total assimilation must result. As a corollary to this, it is hypothesized that "only feature sets which form constituents may function together in phonological rules" (Clements & Hume 1996: 250). That is, if a language exhibits assimilation in both voicing and place features with the exclusion of nasality, voicing and place assimilation must be stated in two separate rules.

Note that what it means by "to behave" or "to function" is not clear here. Are only features that undergo a change due to one phonological rule considered to "behave" together? What about features that together describe an environment in which a rule applies (that is, features in the rule's structural description)? Let us assume that the features in the structural description of a rule "function together" just as the features that are subject to change due to a phonological rule. This assumption will be justified considering that, whether they describe the target or the environment of a rule, both types of features are crucial in the statement of a rule; a rule statement does not establish without one or the other, and there is no principle to decide which type of features are "functioning" or "not functioning" in a rule.[10] Together with this assumption, FG makes a prediction as to what kind of phonological rules is

[9]However, more on identity calculation in Ch. 4.

[10]Yip (1988) attempts to eliminate the environment from rule statements, by attributing the environment to the OCP. It is nonetheless misleading to claim that the environment is eliminated. Note that in Yip's degemination/antigemination rules, the target of the rule is also the environment. Inclusion of the tier specification in the rule statements serves as a description of the environment.

impossible, namely that a rule that involves, in the description of either the target or the environment, features that do not form a constituent is impossible. In other words, phonological rules do not allow one to refer to arbitrary sets of features that are not members of a class/constituent.

Reiss (2003) however demonstrates that this prediction is untenable and that FG is too restrictive to accurately describe identity references.

2.3.2 Feature Algebra

Reiss (2003) aims to develop a system that accurately describes identity references attested in languages, and proposes a model, Feature Algebra (FA), that employs in rules' structural descriptions (SD) algebraic notation with the use of quantifiers and variables. Recall that what counts as "identical" segments differs across languages — for a rule to apply, some language requires complete identity of segments in the environment while others require only partial identity with respect to some set of features — as illustrated in Odden (1988). Reiss argues that phonological grammar must include an apparatus capable of calculating varying instances of "identity" references, and demonstrates how FA has a capacity to do so.

FA assumes that segments are simply feature bundles/matrices with no internal organization, and that a grammar can thus refer to an arbitrary set of features within the bundles. This assumtion is based on "substance free" approach to phonology. Substance free phonology claims that the phonological grammar has no access to phonetic information. The representations computed over in the phonological module are necessarily of a different type from the representations in the articulatory or perceptual modules. Standing strictly on the modularity hypothesis of the architecture of human grammar, it argues that there is no reason for articulatory organizations to be represented in the phonology, hence there is no articulator-based dominance relation among individual phonological features.

Providing that segments are unorganized bundles of features, the identity between two segments boils down to the identity of the values of the features that comprise each segment. The identity between two segments C_1 and C_2 in terms of an arbitrary single feature F_i is expressed in FA as follows.

(2.16) Identity between C_1 and C_2 w.r.t a single feature

$[\ (\alpha F_i)_1\ ] = [\ (\beta F_i)_2\ ]$

For some feature F_i, the segments C_1 and C_2 have the same value.

The Greek letters are variables ranging over the set of binary values $\{+, -\}$. The numeral subscripts indicate which of the two segments the feature belongs to — or more precisely, which of the two bundles the feature is a member of.

The identity between two segments C_1 and C_2 in terms of a set of features is expressed by introducing set notations and the universal quantifier.

(2.17) Identity w.r.t a set of features

Let $\mathbf{F}$ be a set of all features that comprise a segment, and $\mathbf{G}$ be a subset of $\mathbf{F}$: $\mathbf{G} \subseteq \mathbf{F}$. Let F_i be an arbitrary member of $\mathbf{G}$. The segments C_1 and C_2 are identical with respect to a set of features $\mathbf{G}$ when the following holds:

$\forall\ F_i \in \mathbf{G}$ such that $[\ (\alpha F_i)_1\ ] = [\ (\beta F_i)_2\ ]$

For every feature in some specified subset of features, C_1 and C_2 have the same value.

When $\mathbf{G} \subseteq \mathbf{F}$, the formula in (2.17) expresses a partial identity of C_1 and C_2. The total identity is expressed when $\mathbf{G} = \mathbf{F}$.

Using the formula in (2.17) in the SD, we can now formally state the syncope rule in Koya. Koya deletes word final vowels between identical consonants (2.12-i).

(2.18) Koya Syncope (Reiss 2003: 320)

a. $V \longrightarrow \emptyset \ / \ C_1\underline{\quad}\#C_2$

if $\forall$ $F_i \in \mathbf{G}$ such that $[\ (\alpha F_i)_1\ ] = [\ (\beta F_i)_2\ ]$

where $\mathbf{G}$={[cor], [lab], [dors], [s.g.], [son], [nas], [lat], [voi]}

b. /na:ki # ka:va:li/ → [na:kka:va:li] ‘to me it is necessary’

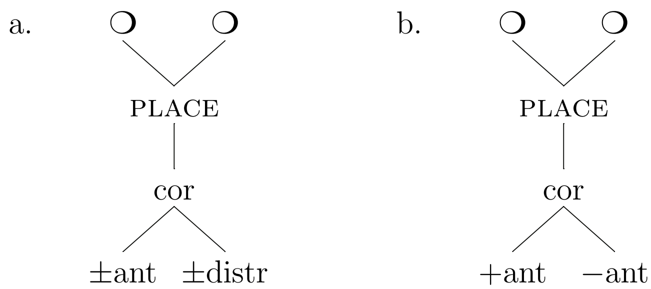
/verka:ḍi # digte/ → [verka:ḍdigte] ‘the cat got down’

Reiss remarks (321) that (2.18a) is “not particularly pretty” but is a correct formalization of the syncope rule and its environment.

Note that FG is incapable of referring to the partial identity required in Koya syncope. Koya ignores in the identity calculation the features specifying retroflexion, but requires the two flanking consonants C_1 and C_2 to have the identical value for all other features, including place features. In feature geometric terms, the identity of place features between two adjacent consonants is expressed as the configuration in which one place node is ultimately associated to two adjacent slots on the CV skeletal tier (2.19a). The place node dominates the coronal node, and the coronal node in turn dominates the nodes representing the features [distributed] and [anterior] which are the features necessary to specify (non-)retroflexion. Referring to the place features entails the reference to the presence or absence of the coronal node. If the coronal node is present, the reference to the place features entails the reference to the features [±distr] and [±ant]. That is, if the coronal feature is present, it is impossible to refer to the place features with the exclusion of retroflexion. Furthermore, it is illicit for two nodes on the CV skeletal tier to share the same coronal node yet be linked to two different nodes on the lower featural tires (2.19b). Since nodes on different tiers are not ordered with respect to each other, FG has no mechanism to determine which consonantal slot [+ant] and [−ant] are each associated to in (2.19b).[11]

[11] Representations in which one root node dominates two nodes of the same feature with conflicting

(2.19)



In short, FG is "insufficiently powerful" to capture the identity requirement attested in Koya.

Koya is a representative of Odden's rule type (2.13b) where syncope applies *only if* flanking consonants are identical. Rules of the types (2.13b,d) can be stated using the identity conditions in (2.17). How, then, would FA deal with the types (2.13a,c) where a rule applies *unless* flanking consonants are identical? Noting the logical equivalence between the expressions *unless* and *if not*, Reiss points out that the references to identity in Odden's typological classification can be restated in terms of references to identity and to non-identity. Reiss reformulates Odden's classification as follows.

(2.20) a. Delete a vowel only if flanking consonants are non-identical.

b. Delete a vowel only if flanking consonants are identical.

c. Insert a vowel only if flanking consonants are non-identical.

d. Insert a vowel only if flanking consonants are identical.

Non-identity between segments can be expressed as difference in the value of at least one feature among a set of features that comprise a segment. For example, *b* and *p* are non-identical in terms of the value of the single feature [voi], while *b* and *m* are non-identical in terms of two features [nas] and [son]. However, the three consonants

values are proposed for contour segments such as affricates and prenasalized stops. Reiss suggests that one could assume a default order for contour segments ([−cont] is ordered first for affricates, [+nas] is ordered first for prenasalized stops). In the case of Koya, however, the order between retroflex and non-retroflex segments are not fixed, hence it is impossible to assume a default order for the features [anterior] and [distributed].

b, p, m will not be treated as non-identical if the features relevant to the identity calculation are [lab], [cor] and [dors].

Non-identity of some arbitrary feature F_i is expressed in FA as follows.[12]

(2.21) Non-dentity of an arbitrary feature F_i

$[\ (\alpha F_i)_1\ ] \neq [\ (\beta F_i)_2\ ]$

For some feature F_i, the segments C_1 and C_2 have different values.

Non-identity of segments C_1 and C_2 is expressed with the existential quantifier.[13]

(2.22) Non-identity of segments

Let **F** be a set of all features that comprise a segment, and **G** be a subset of **F**: $\mathbf{G} \subseteq \mathbf{F}$. Let F_i be an arbitrary member of **G**. The segments C_1 and C_2 are non-identical with respect to a set of features **G** when the following holds:

$\exists\ F_i \in \mathbf{G}$ such that $[\ (\alpha F_i)_1\ ] \neq [\ (\beta F_i)_2\ ]$

For some specified subset of features, there is at least one feature for which the segments C_1 and C_2 have different values.

An example of rules of the types (2.13a,c)=(2.20a,c) that makes reference to non-identity of flanking consonants is Afar. Afar deletes an unstressed vowel between consonants *unless* the consonants are completely identical, that is, only if the consonants are non-identical. In feature algebraic terms, the Afar syncope rule is stated as follows.

[12] F is a variable for features, and a subscripted F (e.g. F_i) designate a particular feature.

[13] The formula in (2.22) is of course equivalent to

(i) $\neg\forall\ F_i \in \mathbf{G}$ such that $[\ (\alpha F_i)_1\ ] = [\ (\beta F_i)_2\ ]$
It is not the case that for some specified subset of features, C_1 and C_2 have the same value.

(2.23) Afar Syncope (Reiss 2003: 319)

a. $V_{[-stress]} \longrightarrow \emptyset$ / #CVC$_1$___#C$_2$

if $\exists$ F$_i \in$ **F** such that [$(\alpha F_i)_1$] $\neq$ [$(\beta F_i)_2$]

b.

digibté	digbé
danané	(*danné)

Recall that Afar syncope example is argued to support the Ocp, as it is a case of antigemination by blocking syncope between identical consonants. Furthermore, Odden's (2.13c), logically equivalent to Reiss' (2.20c), is also considered to represent the cases of the obedience to the Ocp: epenthesizing a vowel only between non-identical consonants will preserve existing geminates, the preservation of geminates is accounted for by the integrity of true geminates, and true geminates obey the Ocp. Reiss' reformulation of Odden's rule typology clarifies that the putative Ocp effects can be obtained by referring to non-identity of segments, that is, without invoking the Ocp.[14]

Reiss acknowledges that the model he proposes is capable of (non-)identity statements that are unattested.

(2.24) Unattested Identity Conditions

a. Complete Non-identity

$\forall$ F$_i \in$ **G** such that [$(\alpha F_i)_1$] $\neq$ [$(\beta F_i)_2$]

For every feature in some specified subset of features, the segment C_1 and C_2 have different values.[15]

[14] Reiss points out that the rules of the type (2.20a) are precisely the kind of rule statements Yip (1988) rejects for being ad hoc.

[15] Reiss clarifies that when **G** is a singleton set, the complete non-identity is extensionally equivalent to the non-identity.

b. Variable Partial Identity

$\exists$ $F_i \in \mathbf{G}$ such that $[\ (\alpha F_i)_1\ ] = [\ (\beta F_i)_2\ ]$

For some specified subset of features, there is at least one feature for which the segment C_1 and C_2 have the same value.

Does this capability for unattested (non-)identity statements necessarily make FA too powerful to be "an adequate formal account for identity references," and hence to be included as an apparatus of phonological grammar? Reiss argues that the phonological patterns attested in world's languages constitute only a subset of the patterns that the human phonological system could possibly generate, and that the gap between the generative capacity of FA and the patterns actually attested can be attributed to extra-grammatical factors such as phonetics and sound change. Reiss emphasizes that it is a requirement for a model of human phonological system to at least be able to generate all the attested patterns.

FA introduces (i) a set notation (e.g. **F, G**), (ii) variables that ranges over a set, and (iii) quantifiers that picks either all the members (universal) or at least one member of a set (existential). These elements, together with the assumption that segments are represented as unorganized feature bundles, allows the phonological system to make identity references with respect to an arbitrary set of features. FG, on the other hand, is incapable of doing so by virtue of the hierarchical organizaton of features. It is attested that languages refer to an arbitrary set of features that do not form a "class/constituent" in feature geometric terms. FG hence fails to meet the minimum requirement of generating attested patterns.

Chapter 3

Identity references: a proposal from OT

Baković (2005) is presented as a "response to the claims reasserted by Reiss (2003), following Odden (1988) that every relevant process may essentially stipulate which features can and which features cannot be ignored in the determination of segmental identity" (280). Like Reiss and Odden, Baković is also against the idea of the OCP being a universal constraint. However, as he takes Optimality Theoretic approach to phonology, his argument against the OCP is based on a different ground from that of Odden and Reiss. Odden's criticism of McCarthy's formulation of the OCP is directed to the lack of a rigorous definitions of "melodic levels" and "identity" which in effect allows unprincipled analyses. Odden instead calls attention to the need to develop an "adequate formal account of identity references" (Odden 1988). Following Odden, Reiss (2003) proposes a model for identity references that is capable of describing identity statements attested in languages. One of the pivotal claims of Odden and Reiss is that languages make reference to the identity of two segments according to some arbitrarily defined set of features.

This claim is what Baković responds to. He argues that the phonology does not contain constraints against adjacent segments that are 'identical' with respect to an arbitrary set of features. The OCP, as has been defined and discussed in the literature, has no indication as to what counts as "identical" segments, and leaves room for the interpretation of identity in terms of some arbitrary feature set. Such a constraint, Baković claims, does not exist in CON, the universal constraint inventory. Instead, the OCP could be replaced by a markedness constraint NOGEM, and that constraint's interaction with other constraints independently active in the grammar. Baković focuses on the alleged OCP effect, antigemination, and develops a model of constraint interaction which can account for apparent OCP effect without positing the OCP-type constraints. This model makes a typological predication about possible and impossible languages.

Upon closer examination, however, it becomes clear that Baković's argument against "arbitrariness" of features in identity calculation is orthogonal to the claim made by Odden and Reiss. Furthermore, his typological prediction will be refuted by examining another putative effect of the OCP.

3.1 Lithuanian Partial Antigemination

Baković (2005, 2007 and To appear with Pająk) proposes an attractively restrictive model of CON that would account for the phonological phenomena that involves references to the identity of adjacent segments. Reference to the segmental identity, whether it is total or partial, and regardless of the theoretical framework, has been discussed in relation to a putatively universal constraint, the OCP. Baković attempts to eliminate the OCP from CON and provide an alternative analysis of the presumed OCP effects without resorting to the constraint.

Baković centers his thesis on the examination of the avoidance of adjacent consonants that are 'sufficiently identical,' that is, consonants that "may or may not differ with respect to at most a small subset of specific features" (2005: 279).[1] The

[1] In the preceding chapters, segments that are identical in terms of some subset of features are said to be 'partially' identical. It should be made clear that extensionally speaking, partial identity subsumes complete identity. For example, assume an identity statement where the features relevant to the identity are [cor], [lab], [dors] and [voi] is irrelevant to the identity. The pairs of segments {t,

avoidance of (partially or totally) identical adjacent consonants can be achieved in various ways, for example: (i) epenthesis between the consonants, (ii) failure to apply syncope between the consonants (while syncope applies elsewhere), (iii) dissimilation of the consonants, or (iv) deletion of one of the consonants. (i) and (ii) are the cases of 'antigemination,' assumed to be evidence favouring the OCP. As already discussed in preceding chapters, (i) is said to be triggered by the OCP while (ii) is the blocking effect of the OCP. The last strategy (iv) is referred to as "degemination", and is considered to be triggered by the OCP as discussed in Yip (1988).

Baković concentrates on the analysis of the type (i) "antigemination," that is, breaking up of consonant clusters by inserting a vowel when consonants are 'sufficiently identical'. His claim that the OCP can be dispensable is based on the optimality theoretic analysis of the antigemination by epenthesis, revolving around data from Lithuanian.

In Lithuanian, an epenthetic [i] is inserted between the verbal prefixes */at-/* and */ap-/* and any stem with initial obstruents that are 'sufficiently identical' to the final consonant of the prefix.

(3.1) Lithuanian (from Baković 2005)

at^{j}i-t^{j}eis^{j}t^{j}i	'to adjudicate'	ap^{j}i-put^{j}i	'to grow rotten'
at^{j}i-duot^{j}i	'to give back'	ap^{j}i-b^{j}er^{j}t^{j}i	'to strew all over'
at-ko:p^{j}t^{j}i	'to rise'	ap-kal^{j}b^{j}et^{j}i	'to slander'
at-ras^{j}t^{j}i	'to find'	ap-mo:k^{j}i:t^{j}i	'to train'

In (3.1), *i* epenthesis applies when the prefix-final and the stem-initial consonants are either completely identical (*ap^{j}i-put^{j}i*) or they differ, at most, in voicing (*at^{j}i-duot^{j}i*), or in palatalisation (*at^{j}i-t^{j}eis^{j}t^{j}i*), or in both (*ap^{j}i-b^{j}er^{j}t^{j}i*) but in no other features.[2] For the purpose of *i* epenthesis, the adjacent consonants need not be

d} and {d, d} both are pairs of 'identical' segments in this case, though intuitively {t, d} are partially identical and {d, d} are completely identical. Baković's term 'sufficient identity' may capture this subsumption more appropriately.

[2]The epenthetic *i* triggers palatalization of the prefix-final consonants.

completely identical; they could differ with respect to voicing and palatalization. In other words, voicing and palatalization seem to be ignored for the adjacent consonants to be treated as identical. Baković writes that "McCarthy's basic insight [...] that the presence of a vowel is conditioned by the avoidance of adjacent identical consonants" is applicable to the Lithuanian facts, but that "[T]his insight does not [...] satisfactorily explain why certain features [...] may in some case be ignored in the determination of adjacent consonant identity" (280).

As is clear from Lithuanian (and other languages), segmental identity makes reference to a subset of features, ignoring some features from the complete set of features that comprise a segment. Reiss (2003) takes this as a fact about phonology and proposes to include, for each rule that requires identity reference, an identity statement in the rule's structural description. For Reiss (and for Odden) the question to be investigated concerning identity references is "What kind of representational and computational apparatus is phonology to be equipped with in order to make reference to varying degree of 'identity'?"

Baković approaches to the issue of identity references from a different perspective. He shares the view that current phonological theories are unable to explain what determines segmental identity, and states that this "unfortunate state of affairs [...] can only be improved by exploring independent ways in which to predict the notions 'identical', 'sufficiently identical', 'similar' and so on" (281). In other words, the important question for Baković concerning identity references is "Why may certain features be ignored in the determination of adjacent segment identity? What factors determine which features are relevant and which are irrelevant for identity?"

Baković seeks "the key to answering this question" in the behaviour of the adjacent consonants that do not trigger *i* epenthesis in the same context. When the vowel is not inserted (that is, the adjacent consonants are sufficiently different), the prefix-final consonant regressively assimilates to the stem-initial consonant in voicing and palatalization, as shown in (3.2).

(3.2) Lithuanian assimilation

at-ko:p^{j}t^{j}i	'to rise'	ap-kal^{j}b^{j}et^{j}i	'to slander'
ad-buk^{j}t^{j}i	'to become blunt'	ab-dras^{j}k^{j}i:t^{j}i	'to tear'
at^j-p^{j}aut^{j}i	'to cut off'	ap^j-k^{j}el^{j}aut^{j}i	'to travel through'
ad^j-b^{j}ek^{j}t^{j}i	'to run up'	ab^j-g^{j}i:d^{j}i:t^{j}i	'to heal'

The assimilation in voicing and palatalization is accounted for by the relative ranking of the two types of constraints, Agree and Ident. Agree is a set of markedness constraints that penalize consonant clusters that do not agree with respect to a specified feature, while Ident is a set of faithfulnesss constraints that penalize an output forms that does not share the same value with their corresponding input forms with respect to a specified feature (that is, Ident disfavours feature changes). When assimilation is observed, it indicates that Agree outranks Ident. In Lithuanian the features that under go assimilation is in [voice] and [palatal],[3] hence, Agree[voi] and Agree[pal] must be ranked higher than Ident[voi] and Ident[pal].

Agree[voi], Agree[pal] >> Ident[voi], Ident[pal].

Note that, if this voicing and palatal assimilation happens between 'sufficiently identical' consonants, the result is a sequence of completely identical adjacent consonants, i.e. a geminate, which is ungrammatical.

(3.3) /ap/ + /b^{j}ert^{j}t^j/ → *[ab^j-b^{j}er^{j}t^{j}i]

[ap^{j}i-b^{j}er^{j}t^{j}i] 'to strew all over'

The barring of geminates is accounted for by a markedness constraint NoGem which penalizes completely identical adjacent segments. Based on these observations,

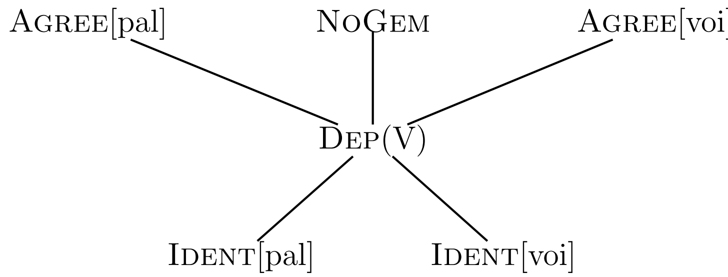
[3]Presumably Baković does not believe palatalization is a feature, however, he glosses over the exact feature specification responsible for palatalization.

Baković analyzes *i* epenthesis between 'sufficiently (and not necessarily completely) identical' consonants in Lithuanian as due to the interaction between the two types of conflicting constraints, NoGem and Agree[voi], Agree[pal]. The epenthesis of a vowel is a particular strategy to 'repair', or to avoid, the ill-formed structures that these constraints penalize.

Let us look at again the examples (3.2) and (3.3). Note that the assimilating feature, [voi] and [pal], are exactly the features ignored in the determination of adjacent consonant identity. On the one hand, assimilation of the ignored features, which satisfies Agree[voi] and Agree[pal], makes the sequence of 'sufficiently identical' adjacent consonant p-b^j into a 'completely identical' geminate b^j-b^j, violating NoGem. On the other hand, satisfying NoGem will inevitably violate at least one of the two Agree constraints. Baković argues that, in order to satisfy these conflicting requirements, Lithuanian employs a strategy to epenthesize a vowel *i*. The vowel insertion is accounted for by the relative ranking of Dep(V), which penalizes any vowel in the output with no corresponding vowel in the input. While neither geminates nor consonant clusters that do not agree in [voi] or [pal] are ever observed, the vowel insertion does sometimes happen. This fact indicates Dep(V) is ranked lower than NoGem, Agree[voi] and Agree[pal]. In turn, Dep(V) must outrank both Ident[voi] and Ident[pal], since the voicing and palatal assimilation, not the vowel insertion, happens when adjacent consonants are sufficiently different. There is, however, no evidence to decide the relative ranking among NoGem, Agree[voi] and Agree[pal]. Although these constraints should in principle be independently ranked, the relative ranking among them is left undecided. What is crucial, however, is that each of these constraints is ranked higher than Dep(V).

Baković proposes the following constraint ranking for Lithuanian (3.4) which correctly predicts the epenthesis and the assimilation patterns as the tableaux in (3.5) demosntrate.

(3.4) Constraint ranking for Lithuanian



(3.5) Tableaux for Lithuanian

at^ji-$duot^ji$

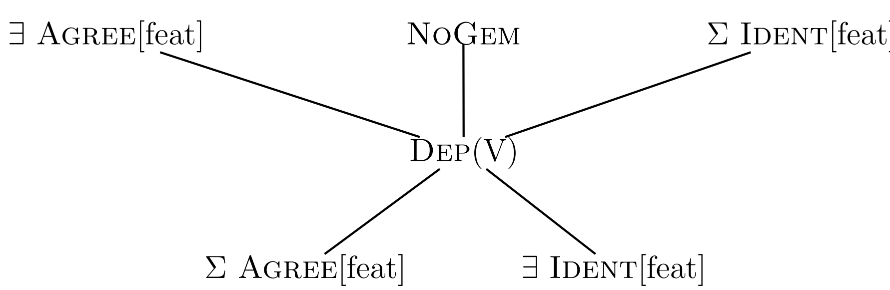
/t+d/	NoGem	Agree[voi]	Agree[pal]	Dep(V)	Ident[voi]	Ident[pal]
td		*!				
☞ tid				*		
dd	*!				*	

ad^j-$b^jek^jt^ji$

/t+b/	NoGem	Agree[voi]	Agree[pal]	Dep(V)	Ident[voi]	Ident[pal]
tb		*!				
tib				*!		
☞ d^jb^j					*	

The constraint ranking in (3.4) could be restated more abstractly to represent any language that exhibit the same type of antigemination phenomena as Lithuanian. Baković provides the following general schema for constraint ranking for a case of antigemination where 'sufficiently identical' segments are broken up by vowel insertion.

(3.6) Insert a vowel only if flanking consonants are sufficiently identical



Here, the notation ∃Agree[feat] and ∃Ident[feat] each means a set of at least one Agree and Ident constraint respectively. Within a single ranking, the set of features referred to by ∃Agree[feat] are the same set referred to by ∃Ident[feat]. ΣAgree[feat] and ΣIdent[feat] refer to the sets of constraints complementary to ∃Agree[feat] and ∃Ident[feat]. Crucially the features referred to by ∃Agree[feat] and ∃Ident[feat] are exactly those features that are *ignored* in the calculation of adjacent segment identity. This in turn means that the features referred to by ΣAgree[feat] and ΣIdent[feat] are the features relevant to the determination of identity. It is also important that ΣIdent[feat] is ranked above Dep(V), and hence aboveΣAgree[feat], to account for the fact that insertion of a vowel, rather than dissimilation of identity-relevant features, occurs between adjacent segments.

From the ranking schema above, Baković draws a generalization that answers his question: "Why certain features may be ignored in the determination of adjacent segment identity?" The generalization is that for every instance of avoidance of sufficiently identical adjacent consonants, the features ignored in the computation of identity independently undergo assimilation.[4] The determination of 'sufficient identity' is in fact not arbitrary; just as [voi] and [pal] in Lithuanian, ignored features would be predicted by examining assimilation process in a given language. Apparent 'sufficient identity' observed in antigemination emerges from the interaction between NoGem, which refers to complete identity, and other independent constraints Agree that promotes assimilation of certain features. Baković claims that "constraint against arbitrarily similar adjacent consonant do not exist in Con" (312), and that his model employing only NoGem and Agree (and its counterpart Ident) constraints is sufficient to account for antigemination, without additional constraints such as Ocp (as

[4]McCarthy (1986) also makes similar observation on Damascene in which syncope is blocked when flanking heteromorphemic consonants differ only in voicing and pharyngealization, the features that assimilate in consonant clusters created by the syncope. He writes "The antigemination effect, I claim, applies in a principled way to pairs of consonants that differ in features that regularly assimilate" (243).

in Rose 2000) nor additional stipulations concerning the representation of geminates (true vs. fake geminates).

3.2 On 'arbitrariness'

Reiss, following Odden, make an empirical claim that languages make references to an arbitrary subset of features in the calculation of identity. Baković responds to this by claiming that features that are relevant or irrelevant in the identity calculation are in fact not arbitrarily stipulated, and that one could predict the relevant features by examining assimilation processes independently active in a given language. One should realize, however, that the notion of the word "arbitrary" is quite different between the two authors.[5]

Reiss states that the features relevant to identity calculation is arbitrary in a sense that those features do not form a 'constituent' in feature geometric terms. Recall, for example, that Koya syncope requires identity of adjacent consonants ignoring retroflexion, that is, the set of features relevant for Koya syncope includes all but [distributed] and [anterior]. In FG, however, such a set does not form any coherent class or constituent. Interestingly, the Lithuanian data, from which Baković derives his generalization, in fact supports Reiss' claim about arbitrariness. In Lithuanian, the features relevant to identity are [coronal], [labial], [dorsal], [sonorant], [nasal], [lateral]. In FA, the Lithuanian epenthesis rule is expressed as follows.

(3.7) $\emptyset \longrightarrow \mathrm{i}$ / C_1____C_2

if $\forall\ \mathrm{F}_i \in \mathbf{G}$ such that $[(\alpha\ \mathrm{F}_i)_1] = [(\beta\ \mathrm{F}_i)_2]$

where $\mathbf{G} = \{$[cor], [lab], [dors], [son], [nas], [lat]$\}$

Note that the set **G** that designates a set of identity-relevant features does not form any kind of class according to any feature geometric model. This is also true to

[5] I owe Allison Cameron for the ideas discussed in this section.

the set of identity-irrelevant features {[voi], [pal]}. Assuming that the specification for palatalization involves some kind of place feature, such as [coronal], [labial] and [dorsal] and the features dominated by them, there would be no way to make reference to a set of all place features except one, using feature geometric models. The Lithuanian example provides further evidence that the phonology must be able to refer to arbitrary sets of features.

According to Baković, the set of identity-irrelevant features {[voice], [pal]} is non-arbitrary because it is exactly the set of features that undergo assimilation. As a corollary, the set of identity-relevant features is non-arbitrary because it is the complement set of {[voi], [pal]}. This issue, irrespective of its truth or falsity, is orthogonal to Reiss' claim about arbitrariness. Under Baković's theory, 'sufficient identity' emerges from the interaction between NoGem and Agree, but there is no mechanism that constrain which features can be referred to in ∃Agree and ∃Ident. Even for Baković, the set of features that are relevant for the determination of segmental identity is arbitrary in Reiss's sense.

One should also be careful about the notations Baković utilizes. Baković employs quantifier symbols as "abbreviations" (292). ∃Agree simply means a set of Agree constraints, and there is no quantificational operation involved over the constraint set. It should be noted as well that the notations ∃Agree and ∃Ident are used as if they refer to sets of *features* ignored or relevant to the identity calculation. However, this is misleading considering the basic assumption of Optimality Theory that constraints are independently ranked. An OT grammar could refer to a set of *constraints*, but can not refer directly to a set of *features*; reference to a set of features is only possible when mediated by the reference to a set of constraints. Thus the set such as {[voi], [pal]} is in fact not a real object in Baković's framework.

3.3 Baković's Typological Generalization

Baković's analytical apparatus is constrained and conservative in that it does not make use of the OCP to account for antigemination of 'sufficiently identical' consonant clusters. With the Lithuanian examples, he demonstrated that the putative OCP effect could be explained effectively by "a representationally very inclusive definition of NoGem" (282) with combination with independent Agree constraints. His claim that "constraint against arbitrarily similar adjacent consonant do not exist in Con" (312) argues against Reiss' proposal as Baković, though indirectly, denies the capability in phonology to refer to an arbitrarily defined subset of features.[6] Reiss on the contrary argues for the inclusion of quantificational machinary in phonological grammar that allows such capacity.

Baković's generalization makes a prediction concerning possible and impossible languages. According to his theory, the apparent "sufficient/partial" identity in antigemination is emergent from the interaction between NoGem and Agree. More specifically, segmental identity in 'sufficiently identical' antigemination depends on independent assimilation process dictated by a set of high-ranked Agree constraints, and features ignored in the determination of 'sufficient identity' necessarily undergo assimilation. This claim thus makes the following typological prediction:

(3.8) There can never be a language that avoids sufficiently identical adjacent segments without also assimilating with respect to the features ignored.

[6]However, Baković (Pająk & Baković, To appear) employs in his analysis of Polish a contextual NoGem constraint, NoGem/NVA that penalizes only geminates that are not adjacent to any vowel (NVA stands for "non vowel adjacent"). In so doing, he states that the postulation of contextual NoGem is "analogous" to the postulation of segmental-type NoGem (by Kawahara 2007, for example) and suggests a possibility that NoGem is a family of constraints including constraints NoGem/NVA, NoGemObs and NoGemGlide. The latter two are segmental-type constraints. Although his analysis does not use segmental-type NoGem's, he writes, when defining contextual NoGem constraints, "[...] contextual constraints may need to be more specific [...], incorporating information about word position or combining with segmental type constraints (e.g. NoGemObs/NVA)." Note that constraints like NoGemObs, NoGemGlide are exactly the kind of constraints Baković claims to be non-existent in Con in (Baković 2005), as they do refer to subsets of features with specified feature values.

Consider, for example, a toy language in (3.9).

(3.9) Toy impossible language

/ak-ku/ → [akəku]

/ak-gu/ → [akəgu]

/ak-tu/ → [aktu]

/ak-du/ → [akdu]

The pattern of schwa-epenthesis in this toy language indicates that the features relevant for the segment identity is place features, and that voicing is ignored in the determination of identity. According to Baković's schema (3.6), NoGem and Agree[voice] must outrank Dep(V) to ensure a schwa to epenthesise between two *k*'s and between *k* and *g*. As Agree[voice] is a higher ranked constraint, it is expected that the feature [voice] independently assimilates in the environment where schwa epenthesis does not happen (i.e. adjacent consonants are not homorganic). That is, the ranking Agree[voi] >> Vep(V) must penalize [*akdu*] as suboptimal, as is shown in the tableau in (3.10). Hence this toy language is predicted to be impossible according to Baković's generalization.

(3.10) Tableaux for Toy impossible language

[akəgu]

/k+g/	NoGem	Agree[voice]	DepV	Ident[voice]
kk	*!			*
☞ kəg			*	
kg		*!		

[akdu]

/k+d/	NoGem	Agree[voice]	DepV	Ident[voice]
☛ kt				*
kəd			*!	
kd		*!		

Recall that Reiss' feature algebraic model is able to describe the attested patterns as well as unattested patterns. Reiss argues that why certain patterns are not attested could have extra-grammatical explanation and that the goal of phonology is to describe not only the attested patterns but also *possible* patterns. It is a minimum requirement that a phonological theory be able to describe all the attested patterns. The question then is, is Baković's generalization applicable to other attested patterns? Does his ranking schema predict attested patterns to in fact be possible?

In the following, I will examine whether Baković's typological claim is in fact tenable by extending his ranking schema of antigemination to degenimation.

3.4 Degemination and analysis of Catalan

Baković's generalization is based on the cases of antigemination (specifically, the cases of one type of antigemination — antigemination by epenthesis), however, it should in principle be applicable to the case of other types of the 'avoidance' of sufficiently identical adjacent segments, such as degemination. In antigemination, an intervening segment breaks up a sequence of adjacent identical segments, which can be achieved either by insertion of a vowel or failure of applying syncope. In degemination, on the other hand, an adjacent identical consonant cluster is dissolved by deleting one of the consonants.

Although antigemination and degemination are different processes, both phenomena share the same 'target' or 'goal', namely to avoid sequences of (completely or sufficiently) identical adjacent segments. This separation between 'target' and 'process' is one of the basic tenets of OT, coined as "Homogenity of Target/Heterogenity of Process" (McCarthy 2002, Baković 2007).[7] The idea to separate the 'target' and the 'process' in fact predates OT (e.g. Yip 1988) and is motivated to explain the observed fact that different languages employ different phonological processes to achieve the same structural configuration. In OT, the 'target' is provided by markedness constraints: Markedness constraints define phonologically ill-formed structures that need to be 'avoided' or 'repaired'. In order to achieve this goal (i.e. to avoid or repair ill-formed structures), languages can employ different strategies/processes depending on the interaction (i.e relative ranking) between markedness constraints and faithfulness constraints.

In order to clarify the separation between 'target' and 'process' in Baković's generalization, let us go over the logic behind his analysis of the determination of sufficient identity. The basic assumption of this logic is that there is no constraint against arbitrarily similar adjacent segments and that the only constraint against adjacent identical segments is NoGem that refers to the complete identity of segments. However, apparent 'sufficiently/partially identical' adjacent segments are not identical enough to be penalized by NoGem (3.11a). In order for NoGem to have its effect on such a sequence, there must be other constraints that require 'sufficiently identical' segments to become 'completely identical.' Agree[F_i] is one such constraint; it penalizes adjacent segments that do not agree with respect to the specified feature F_i, hence triggers the assimilation of that feature. When Agree[F_i] works on the sequence of sufficiently identical adjacent segments and forces assimilation of features that are ignored in identity determination, such a sequence will become geminates (3.11b).

[7]Kager (1999) calls it "functional unity of processes" in a sense that different processes serve the unified goal of repairing ill-formed structures.

(3.11) Conflicting requirements: NoGem and Agree

a. NoGem

kk	*
kg	✓

b. Agree[voi]

kk	✓
kg	*

- Satisfy all Agree ⇔ Violate NoGem
- Violate one Agree ⇔ Satisfy NoGem

Obviously, NoGem and Agree are conflicting constraints: satisfying all Agree constraints will create geminates which violates NoGem, while obeying NoGem will inevitably violate at least one Agree constraint. If NoGem and Agree constraints are both ranked high, some lower-ranked constraint would be violated (for the sake of saving higher-ranked constraints) and the effect of the violation would surface as a 'process,' maintaining the adjacent segments as 'sufficiently identical' as they are. It is the dynamics between NoGem and Agree[feat] that 'determines' sufficient identity between segments; without these conflicting forces, the effect of a repair process (i.e. violation of some lower-ranked constraint) would not surface. If there appears to be avoidance of 'sufficiently identical' adjacent segments, there would be the conflict between NoGem and some Agree constraint(s) no matter what the avoidance strategy is. Avoidance of sufficiently identical adjacent segments thus implies some active Agree constraints with respect to the features that are ignored in identity determination. This leads to a prediction that the assimilation of such features would be observed independently of the avoidance process that a given language exhibits.

It is clear that Baković's claim that 'sufficient identity' emerges from the interaction of NoGem and Agree and that no language exhibits avoidance of sufficiently identical adjacent consonants without independent assimilation of the ignored features, is a claim about the 'target'. Whatever process is employed to avoid/repair sequences of 'sufficiently identical' segments, the hypothesis about the emergence of the sufficient identity should maintain itself. The separation between the 'target' and the ‘process’ in OT will thus make it legitimate to apply Baković’s model for antigemination to the cases of degemination.

3.4.1 Catalan

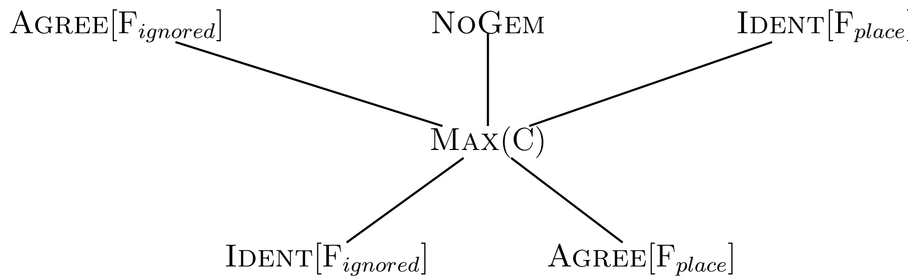
Catalan can be analyzed as a language that exhibit the avoidance of sufficiently identical adjacent segments by means of degemination. In Catalan, word-final obstruents delete when preceded by a homorganic sonorant as in the example (3.12).

(3.12) Catalan (data from Odden 2005)

	Masc sg	Fem sg	
a.	al	altə	‘tall’
	blaŋ	blaŋkə	‘white’
	prufun	prufundə	‘deep’
	kur	kurtə	‘short’
	sor	sorðə	‘deaf’
b.	əskerp	əskerpə	‘shy’
	l^yark	l^yarγə	‘long’

The deletion of the obstruent in coda seems to be triggered by the ‘sufficient/partial’ identity of adjacent segments. Note that the deletion is not due to the constraint against complex coda. A complex coda is allowed in Catalan as exemplified in *əskerp* and *l^yark*. The features involved in the determination of sufficient identity are [coronal] [labial] and [dorsal]; in other words, every feature except place features, for example [sonorant] and [lateral], are ignored in the determination of identity. Following Baković’s schema, we could draw the constraint ranking for Catalan as in (3.13), where [$F_{ignored}$] abbreviates the set of identity-irrelevant features while and [F_{place}] abbreviates the set of identity-relevant features.

(3.13) Constraint ranking for Catalan



Max(C) is a faithfulness constraint that penalizes when the output lacks any consonant that is in the input. The violation of Max(C) will thus surface as consonant deletion. Ranking of Ident[F_{place}] alongside NoGem and Agree[$F_{ignored}$] ensures that the avoidance of sufficiently identical adjacent segments is not realized by dissimilation. This ranking is supported by the data where the obstruent is deleted in the homorganic consonant cluster in coda.

(3.14) Tableau for Catalan

kur - kurtə

/r+t/	NoGem	Agree[son]	Max(C)	Ident[son]
rt		*!		
rr	*!			
☞r			*	

The ranking in (3.13) predicts that, since the assimilation of all non-place features is independently motivated (i.e. Agree[$F_{ignored}$] is ranked high), there will be an independent evidence for the assimilation of features such as [sonorant] when coda clusters are not homorganic. However, recall the alterations *əskerp* $\sim$ *əskerpə* and $l^y ark \sim l^y ar\gamma ə$. There is no assimilation, for example, of the feature [sonorant] in [*rp*] and [*rk*] in coda position. In fact, the ranking in (3.13) would select as optimal the output candidate in which the coda obstruent also deletes, contradictory to the fact.

(3.15) əske**rp** - əskerpə

/r+p/	NoGem	Agree[son]	Max(C)	Ident[son]
rp		*!		
rr	*!			
☛ r			*	

The prediction that there will be an independent evidence of the assimilation of non-place features in Catalan is not borne out as the forms *əskerp* and *l^yark* show. Furthermore, the constraint ranking that accounts for the obstruent deletion does not account for the data where coda obstruents do not delete. Note, however, that the deletion occurs only when a coda obstruent is preceded by a homorganic consonant. We could explore the possibility of assimilation being context-sensitive, that is, assimilation applies only between homorganic consonants. When we replace the context-free Agree[son] with the context-sensitive constraint Agree[place]→Agree[son] and rank the former below Ident[son], the observed data is in fact accounted for.[8]

(3.16) Tableaux for Catalan, using context-sensitive Agree[son]

kur - kurtə

/r+t/	NoGem	Agree[pl] →Agree[son]	Max(C)	Ident[son]	Agree[son]
rt		*!			*
rr	*!				
☞ r			*		

əske**rp** - əskerpə

/r+p/	NoGem	Agree[pl] →Agree[son]	Max(C)	Ident[son]	Agree[son]
☞rp					*
rr	*!		*		
r			*!		

[8]Notational abbreviation here: Agree[place]→Agree[son] is not a single constraint but a set of context-sensitive constraints: {Agree[cor]→Agree[son], Agree[lab]→Agree[son], Agree[dors]→Agree[son]}

The constraint ranking using context-sensitive AGREE[$F_{ignored}$] could account for the fact in Catalan. Nonetheless this analysis has a considerable drawback — it loses the typological prediction in terms of possible and impossible languages. Recall the Toy impossible language from the preceding section.

(3.17) Toy impossible language

/ak-ku/ → [akəku]

/ak-gu/ → [akəgu]

/ak-tu/ → [aktu]

/ak-du/ → [akdu]

In this toy language, schwa-epenthesis happens between homorganic consonants, ignoring the feature [voice]. However, there is no voicing assimilation in [*akdu*]. Baković's original analysis predicts this language to be impossible. Introducing context-senstive constraints in CON, however, would make the toy language a possible language.

(3.18) Tableaux for the Toy impossible language (now possible)

[akəgu]

/k+g/	NOGEM	AGREE[pl] →AGREE[voi]	DEP(V)	IDENT[voi]	AGREE[voi]
kk	*!			*	
☞kəg			*		
kg		*!			*

[akdu]

/k+d/	NOGEM	AGREE[pl] →AGREE[voi]	DEP(V)	IDENT[voi]	AGREE[voi]
kt				*!	*
kəd			*!		
☞ kd					*

With a constrained and conservative model of CON, including no context-sensitive constraints, Baković's hypothesis about 'sufficient identity' of segments is unable to account for the degemination of 'sufficiently identical' consonants in Catalan. Catalan does not exhibit assimilation of the features ignored in the calculation of sufficient segment identity, and Baković's hypothesis predicts the attested output forms to be suboptimal. We could, however, save the hypothesis and account for the Catalan data by introducing context-sensitive constraints in CON. Relaxing of CON nonetheless has a severe consequence: with context-sensitive constraints, Baković's hypothesis predicts the Toy impossible language to be possible, sacrificing the predictive power Baković's original analysis has.

Baković's hypothesis does seem to explain 'sufficient identity' of segments in the cases of antigemination by epenthesis.[9] However, it fails to account for 'sufficient identity' in other attested cases of avoidance of 'sufficiently identical adjacent segments.' One of the indications we could draw from this is that, 'sufficient' identity of segments may not always be calculated from combinations of the references to the set of all features (which, presumably, only NOGEM is capable of) and references to individual features. As mentioned in the section 3.2, reference to some subset of features must be mediated by reference to a set of constraints in OT. It seems, however, that the phonological grammar needs some mechanism to refer directly to a subset of features.[10]

[9] See his analysis of English and Modern Hebrew (Baković 2005) and Polish monoconsonantal proclitics (Pająk & Baković To appear).

[10] In Feature Algebra, Catalan coda obstruent deletion will be expressed as follows:

(i) $C_{2[-son]} \longrightarrow \emptyset$ / CVC_1____#
if $\forall$ $F_i \in \mathbf{G}$ such that $[(\alpha\ F_i)_1] = [(\beta\ F_i)_2]$ where $\mathbf{G} = \{[\text{cor}], [\text{lab}], [\text{dors}]\}$

Additional note on Catalan

In the analysis of Catalan above, we have assumed that the obstruent deletion is not dictated by the constraint against complex coda. However, there is an alternative analysis to this. One could argue that complex codas are generally disfavoured in Catalan and that the language resolves complex codas by means of coalescence rather than deletion.[11]

Suppose that the masculine singular forms in (3.12a.) are realized by the fusion of the homorganic coda segments, precisely, the segment of the lower sonority being fused into the segment of the higher sonority, in order to dissolve ill-formed complex codas. The analysis requires ranking of at least three constraints: a constraint against complex codas (NoComplexCoda); a constraint against fusion of consonants, and a constraint against deletion of consonants (Max(C)). Uniformity (Uni) constraints penalize the output whose element has multiple correspondence in the input (Kager 1999). We assume that the constraint against consonant fusion is Uni(C) which penalizes the output containing a consonant resulting from the fusion of two or more consonants in the input.

We have assumed that, in Catalan, complex codas are dissolved by coalescence of the coda segments, sacrificing Uni(C). This indicates that NoComplexCoda is ranked higher than Uni(C). Furthermore, segmental fusion is a preferred process over deletion for the purpose of 'fixing' complex codas. This indicates that Max(C) must be ranked higher than Uni(C) as well.

- Max(C), NoComplexCoda >> Uni(C)

The fusion, however, does not occur in the forms in (3.12b.) where the place feature of the coda consonants is different. In these forms, complex codas are in fact

[11] This analysis, if successful, needs not to posit NoGem, and thus makes Catalan an irrelevant case for testing Baković's hypothesis.

allowed. This could be attributed to IDENT[pl] that is ranked higher than NOCOMPLEXCODA. When coda consonants are homorganic, they can undergo coalescence and make simplex codas, since the fusion of homorganic clusters does not violate IDENT[pl]. Fusing non-homorganic consonants, on the other hand, requires the change of the place feature of one of the consonants, which violates IDENT[pl].

- IDENT[pl] >> NOCOMPLEXCODA >> UNI(C)

From the data given in (3.12), we are unable to decide relative ranking between MAX(C) and NOCOMPLEXCODA and between MAX(C) and IDENT[pl]. Being inconclusive about these ranking, we could give an analysis to Catalan in terms of coalescence.

(3.19) Catalan Coalescence

kur - kurtə

/r+t/	IDENT[pl]	MAX(C)	NOCOMPLEXCODA	UNI(C)
kurt			!*	
☞kur				*

əskerp - əskerpə

/r+p/	IDENT[pl]	MAX(C)	NOCOMPLEXCODA	UNI(C)
☞əskerp			*	
əsker	*!			*

Coalescence analysis does seem to work. However, consider the following data.

(3.20) Catalan – more data (data from Odden 2005)

Masc sg	Fem sg	
sa	sanə	'healthy'
bo	bonə	'good'
du	durə	'hard'
kla	klarə	'clear'

There are clear instances of consonant deletion, and the higher-ranked Max(C) does not account for this violation.

The data in (3.20) is in fact problematic for any traditional OT analysis where the optimal candidate is selected in 'one shot'. Consider the alternations *kur* ∼ *kurtə*/ *prufun* ∼ *prufundə* verses *du* ∼ *durə*/*sa* ∼ *sanə*. the word final *r* and *n* delete in *du* and *sa*, yet they survive in *kur* and *prufund*. In the rule-based approach, these alternations will be explained by rule ordering (deletion of word final *r* and *n* precedes coda obstruent deletion). In the traditional OT, no constraint ranking would be able to select *kur* on the one hand and *du* on the other in one shot. Some kind of serialism will be required, however, it is beyond the scope of this paper.

3.5 On '(un)attestedness'

The data from Catalan provides an empirical evidence against Baković's claim that avoidance of 'sufficiently identical' adjacent segments must be accompanied by independent assimilation of identity-irrelevant features. This claim, although refuted, is based on the schema of constraint ranking (3.6). What is the status of this schema in OT? It should be noted that the ranking schema (3.6) has a status of something like a 'meta-constraint', a constraint over possible constraint rankings (that is, possible grammars). Suppose that Baković's observation is correct and that every language that exhibits sufficiently identical antigemination by epenthesizing a vowel also exhibits assimilation of identity-irrelevant features. In order to attribute this observation, a (supposedly) true statement about languages, to OT grammar, the ranking schema (3.6) must somehow be built into the system of the grammar. However, the architecture of OT does not have a way to incorporate 'meta-constraints'. None of the components of OT grammar, Gen, Con or Eval, restricts constraint rankings so that the constraints that promote assimilation of identity-irrelevant features (Agree) would rank alongside NoGem. There is no mechanism *inside* the OT architecture that restricts relative rankings of NoGem and Agree.

Baković writes that his model that attributes 'sufficient identity' observed in antigemination to the constraint interaction between NoGem and Agree "suggests an explanation for the unattestedness of the identity conditions identified by Reiss, an explanation [...] that constraints against arbitrarily similar adjacent segments do not exist in Con" (312).[12] Although his attempt to eliminate a constraint like Ocp from Con must be appreciated, his alternative to "constraint against arbitrarily similar adjacent segments," represented as the ranking schema (3.6), has no *grammatical* status inside OT grammar. The schema is in fact a description generalized over descriptions of grammars that generate attested patterns.

Consider language acquisition. Roughly speaking, language acquisition amounts to re-ranking of constraints. At the initial stage of acquisition, all markedness constraints are ranked higher than faithfullness constraints as Smolensky (1996) claims, or alternatively all faithfulness constraints are ranked higher than markedness constraints, as in Hale & Reiss (1998). Whichever is the case, the learner is forced to re-rank constraints when he/she encounters data for which the initial ranking fails to account. During the course of acquisition, the learner continues to change constraint ranking until all the output (i.e. all the optimal candidates) match the available data. The constraint ranking at the final stage of acquisition must reflect the patterns in the data available to the learner.

It is misleading to think that the ranking schema (3.6) is a fact about grammars; it is a fact about data. It is also extraneous to claim, as a criticism, that quantificational machinery employed in Reiss' model predicts unattested identity conditions, hence it is too powerful. The system of OT alone allows one to state constraint rankings (grammars) that generate unattested patterns. It is not solely the contents of a

[12] What Baković means by "arbitrary" here is irrelevant to Reiss' claim, as has been clarified in the section 3.2.

grammar that determine *attested* patterns; it is a combination of the system of a grammar, the nature of language acquisition and the available data that is responsible for attested patterns. We must be cautious in distinguishing what patterns that are attested to be attributed to the grammar and what is due to extra grammatical factors such as availability of the data.

Chapter 4

Formalizing NoGem

4.1 Identity reference in NoGem

Baković aspires to reduce 'sufficient/partial identity' between segments to the dynamics between NoGem and Agree constraints that are independently active in the grammar of a given language. He acknowledges that NoGem is like a segmental level Ocp, and claims that "a representationally very inclusive definition of NoGem" (282) is enough to handle 'sufficient identity' when combined with Agree constraints, dispensing the Ocp. His attempt does not seem to have as wide an applicability as he claims, but it is worthwhile to clarify what he meant by "representationally very inclusive definition of NoGem" and investigate how NoGem would *formally* evaluate output candidates.

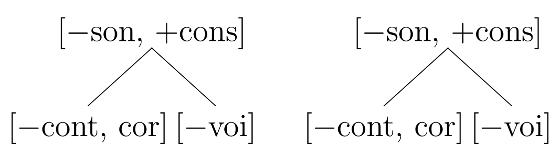
Many of the optimality theoretic constraints have been given only informal definitions. Moreover, the models of segmental representation are often implicit in OT, and there has been little discussion on how in formal terms output forms are evaluated against OT constraints. What does it involve, for example, for an output candidate to receive a violation mark from NoGem? NoGem penalizes completely identical adjacent segments, hence the evaluation process involves reference to complete identity. Linguists doing analysis on transcribed data can easily detect which sequences would receive violation marks due to NoGem: the sequences of two identical IPA symbols. Obviously, phonology does not work this way. Segments are composed of features, and the complete identity of two segments boils down to the identity of the feature values for every feature that comprises each segment. How the identity of features, and ultimately the identity of segments, is checked would depend on the models of segmental representation.

In the following, I will discuss how the markedness constraints NoGem would be stated formally in two different segmental representation models: 1) segments as unorganised feature bundles, as in Feature Algebra; 2) segments as hierarchically organised geometric objects, as in Feature Geometry. For expository purpose, I shall consider only consonantal segments. I will adopt the Feature Geometric tree presented in Chapter 2 (2.14) as a model for representing consonants, and the features represented on that tree as forming a complete set of features.

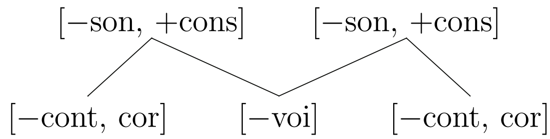
First off, let us clarify what Baković means by stating that his definition of NoGem is "representationally very inclusive." He provides the following four configurations as possible representations that NoGem penalizes (the feature values are based on the geminate *tt*). Although a complete model of segmental representation is not given, it is clear from the configurations in (4.1) that Baković assumes that segments take some form of autosegmental representations. There is thus hierarchical relations among features. For example, a root node representing features [sonorant] and [consonantal] dominates the features [voice], [coronal] and [continuant] in (4.1).

(4.1) Possible configurations for a geminate [tt], all to be penalized by NoGem (Baković's (3))

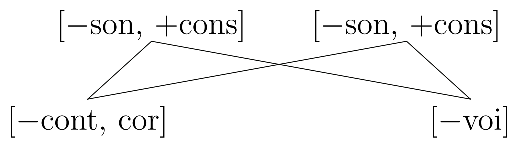
a. Two identical consonants



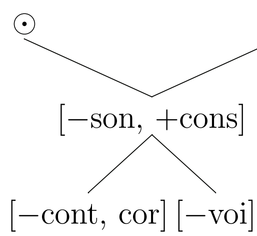
b. Two identical consonants; shared [voice]



c. Two identical consonants; all features shared



d. One consonant; two timing slots[1]



By "a representationally very inclusive definition of NoGem", Baković means that any of these configurations is subject to NoGem and will receive a violation mark. Note that the configuration (4.1d) represents a 'true geminate' while the configurations (4.1a-c) represent a 'fake geminate.' That is, NoGem does not distinguish 'true' from 'fake' geminates, according to Baković's definition of NoGem.

(4.2) a. True geminate b. Fake geminate

The question amounts to, then, what would involve for NoGem to evaluate these two structures?

Before continuing, let us first formalize NoGem in Feature Algebraic terms where such structural difference in (4.2) does not matter.

[1] Baković states that the nature of the timing slots (moras, syllables or subsyllabic constituents) is not at issue, hence using "the non-committal symbol '⊙'." (282 fn.)

4.1.1 Segments as unorganized bundles of features

NoGem penalizes an output form containing a sequence of completely identical adjacent segments (e.g. sequences like *ss*, *mm*, *tt* etc.). In order to evaluate output forms against NoGem, the grammar needs to make reference to the "complete identity" of segments.

Suppose that a segment is represented as an unorganised bundle of features. In order to evaluate output forms against NoGem, the grammar needs to check every feature and its value in the bundle for each of the two adjacent segments.

Assume that in a hypothetical language L_1, consonants are represented using all and only the following binary features.[2]

(4.3) [son, cons, voi, s.g., c.g., nas, cont, lab, cor, dors, ant, distr]

To verify the identity of the consonants of a cluster C_1C_2, the grammar checks the value of each of the 12 features in (4.3) for C_1 and C_2. When the value of every feature is the same between C_1 and C_2, Eval gives a violation mark to an output form containing such C_1C_2. "NoGem" is in fact an abbreviation of (4.4) below.

[2] It is reasonable to assume that not every language utilises the same set of features to represent segments in their grammar. That is, the featural representation of segments is language specific. For example, depending on the inventory of consonants, it is possible that some language does not use the feature [±distr] to distinguish one consonant from another, while in some other language [±distr] is distinctive. Redundant features — features that are not used to represent segments in either the input to or the output of phonological components — may not be stored in the phonological grammar of a language. If this is correct, we may conclude that NoGem in its complete form (i.e. the form immediately usable by Eval) is not universal — which features are included inside the brackets in (4.4) or in **F** in (4.5) must be learned. Unless Con is allowed to provide NoGem in a schematic form, Con must provide multiple NoGem's, each referring to every possible partition of the universal feature set that includes all possible distinctive features.

(4.4) Give a violation mark to a sequence C_1C_2

if

$$C_1 = \begin{bmatrix} \alpha son \\ \gamma cons \\ \epsilon voi \\ \zeta s.g. \\ \theta c.g. \\ \iota nas \\ \lambda cont \\ \nu lab \\ \pi cor \\ \rho dors \\ \sigma ant \\ \phi distr \end{bmatrix} \qquad C_2 = \begin{bmatrix} \beta son \\ \delta cons \\ \varepsilon voi \\ \eta s.g. \\ \vartheta c.g. \\ \kappa nas \\ \mu cont \\ \xi lab \\ \varpi cor \\ \varrho dors \\ \varsigma ant \\ \varphi distr \end{bmatrix}$$

and

$\alpha = \beta, \gamma = \delta, \epsilon = \varepsilon, \zeta = \eta, \theta = \vartheta, \iota = \kappa, \lambda = \mu, \nu = \xi, \pi = \varpi, \rho = \varrho, \sigma = \varsigma, \phi = \varphi$

where $\alpha, \beta, \gamma, \delta, \epsilon, \varepsilon, \zeta, \eta, \theta, \vartheta, \iota, \kappa, \lambda, \mu, \nu, \xi, \pi, \varpi, \rho, \varrho, \sigma, \varsigma, \phi, \varphi \in \{+, -\}$

This rather pedantic notation can be rewritten using the identity condition in the algebraic notation proposed by Reiss (2003).

(4.5) NoGem with Feature Algebra

Give a violation mark to a sequence C_1C_2

if $\forall \mathrm{F}_i \in \mathbf{G} \subseteq \mathbf{F}$ such that $[(\alpha \mathrm{F}_i)_1] = [(\beta \mathrm{F}_i)_2]$

where $\mathbf{G}$ = { son, cons, voi, s.g., c.g., nas, cont, lab, cor, dors, ant, distr}

$\mathbf{F}$ = { son, cons, voi, s.g., c.g., nas, cont, lab, cor, dors, ant, distr}

that is, $\mathbf{G} = \mathbf{F}$

and $\alpha, \beta \in \{+, -\}$

In (4.5), **F** is a set of all the features that comprise a consonant in this language. **G** is any subset of **F**, and in the above case, **G** and **F** happen to denote the same set. F is a variable that takes features as its attributes, hence ranges over the feature set $\mathbf{G} = \mathbf{F}$. (The roman subscript i serves as an index to designate a particular feature in $\mathbf{G} = \mathbf{F}$. That is, F_i denotes a feature in $\mathbf{G} = \mathbf{F}$.) The Greek letters α, β are also variables that takes values $\{+, -\}$ as their attributes. The numeral indices 1 and 2 are each associated to the consonants C_1 and C_2 respectively. Valued features (e.g. $\alpha\mathrm{F}_i$) with the same numeral index belong to the same consonant.

NoGem is defined informally as a constraint that penalizes a sequence of adjacent identical segments. Formally stated, however, the evaluation process of an output sequence of segments against NoGem requires, for each pair of two adjacent segments, checking the identity of the values of all the features comprising each segment, as shown above in (4.4) and (4.5).

4.1.2 Segments as hierarchically organised geometric "trees"

Now let us return to the evaluation of the structures (4.2a,b).

First, consider the structure (4.2a), a so-called "true geminate". When two adjacent nodes/slots on the CV tier are in fact linked to one root node, no issue arises concerning the identity of the two adjacent C's on the CV tier — they are one and the same consonant appearing in two adjacent positions on the CV tier. In this case NoGem will be stated as follows:

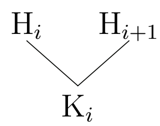
(4.6) NoGem for a "true geminate" (4.2a) with Feature Geometry

Let R be a relation "be associated to". Let $\mathbf{H}$ be a set of nodes on a CV tier and H be a member of $\mathbf{H}$: $\mathrm{H} \in \mathbf{H}$. Assume that the members of $\mathbf{H}$ are totally ordered such that $\mathrm{H}_n \prec \mathrm{H}_{n+1}$.

Let $\mathbf{K}$ be a set of root nodes and K be a member of $\mathbf{K}$: $\mathrm{K} \in \mathbf{K}$. Assume that the members of $\mathbf{K}$ are totally ordered such that $\mathrm{K}_n \prec \mathrm{K}_{n+1}$.

Give a violation mark to a structure in which one root node K_i is multiply associated to two adjacent nodes H_i and H_{i+1}, that is, $\mathrm{K}_i R \mathrm{H}_i$ and $\mathrm{K}_i R \mathrm{H}_{i+1}$.[3]

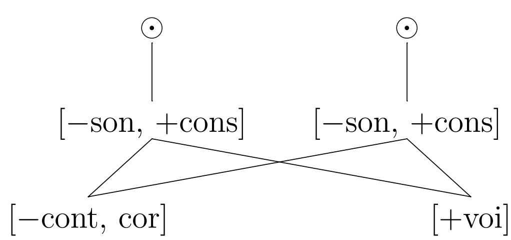
[3] The subscript i will be chosen arbitrarily for H and K. For example, H_i may be the third member of the ordered set $\mathbf{H}$ while K_i may be the second member of the ordered set $\mathbf{K}$.



For "true geminates," the grammar can evaluate the identity of adjacent segments based on their geometric structure, without referring to the identity of feature values.

We shall now consider how the structure for "fake geminates" (4.2b) will be evaluated against NoGem. (4.2b) subsumes Baković's configurations (4.1a-c). Let us begin with examining the configuration (4.1c). I repeat the configuration here, with additional associations to the timing slots.

(4.7) Two identical consonants; all features shared

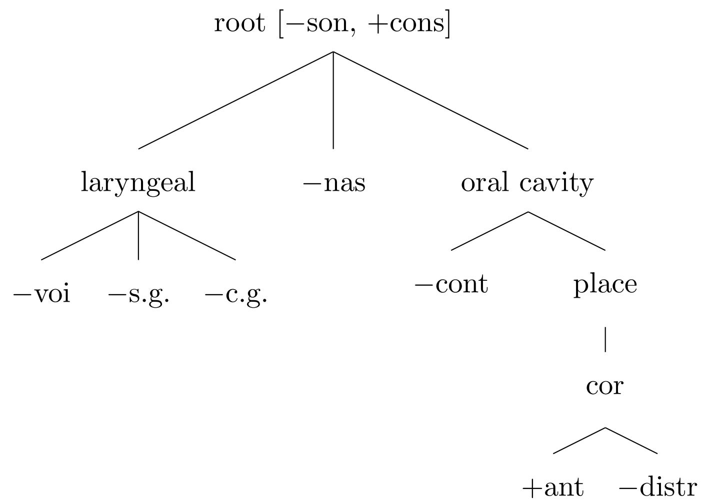


Baković's representational model is different from the model we have adopted in that the features [continuant] and [coronal] form one autosegmental tier and that both [voice] and [cont, cor] tiers are immediately dominated by the root tier.[4]

In our model, (14) in Chapter 2, [cont] and [cor] each forms its own tier, and are not immediately dominated by the root tier: there is an intermediate "oral cavity" (o.c.) tier that dominates [cont] tier and the "place" tier; the "place" tier in turn dominates [cor] tier. The [voi] tier is also dominated by an intermediate "laryngeal" tier which in turn is dominated by the root tier. The representation of the segment *t* according to our model is given below.

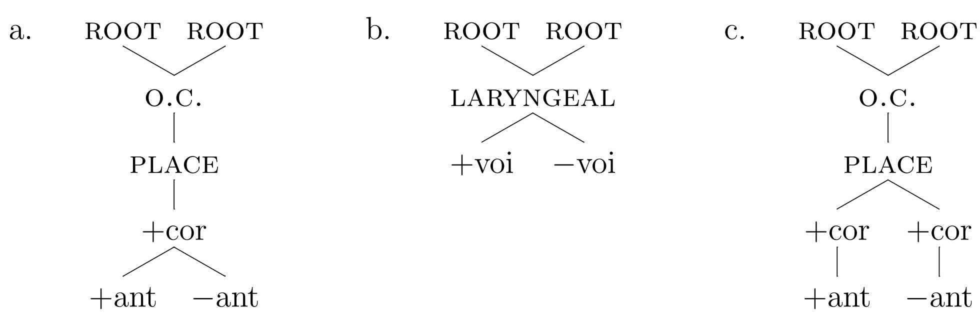
[4] What Baković has in mind might be a "puddle-wheel" representation (Coleman & Local 1991, Archangeli 1985) where each feature forms its own tier and linked to one common CV-skeletal tier. In such an "open book" like representation (Clements & Hume1995, Clements 1999) there is no class node and hence no dominance relation among features. If we assume a "puddle-wheel" or "open-book" representation, where feature nodes are directly linked to the root nodes and the root nodes are in turn linked to CV timing slots, we could rely only on geometric structures to calculate identity as in the text (4.10).

(4.8) Representation of the segment [t]



When we translate the configuration (4.1c)/(4.7) into our model of segmental representation, what “two identical consonants, all features shared” implicates is that there are two separate root nodes yet both of them are ultimately associated to the same node on every featural tier. Recall that association lines also represent dominance relation between nodes, namely that the node on the higher tier dominates the node on the lower tier it associated with. Furthermore, a class/constituent node can not dominate two nodes on the same feature tier that have conflicting feature values.[5] Since dominance relation is transitive and asymmetric, it would make representations like (4.9a-c) illicit.

(4.9) Illicit FG representations



That is, if two root nodes are associated to one and the same node on every tier that are immediately lower than the root tier, it would ensure that the two root tiers

[5]See 2.3.2.

are ultimately associated to the same node on every featural tier. In such a case, the geometric structure will be sufficient for calculating identity between adjacent segments (see fn.4), and NoGem will be stated as follows.

(4.10) NoGem for (4.1c) with Feature Geometry

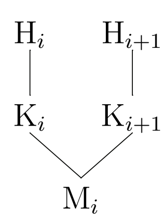
Let R be a relation "be associated to". Let $\mathbf{H}$ be a set of nodes on a CV tier and H be a member of $\mathbf{H}$: $\mathrm{H} \in \mathbf{H}$. Assume that the members of $\mathbf{H}$ are totally ordered such that $\mathrm{H}_n \prec \mathrm{H}_{n+1}$.

Let $\mathbf{K}$ be a set of root nodes and K be a member of $\mathbf{K}$: $\mathrm{K} \in \mathbf{K}$. Assume that the members of $\mathbf{K}$ are totally ordered such that $\mathrm{K}_n \prec \mathrm{K}_{n+1}$.

Let $\mathbf{M}$ be a set of nodes on a tier immediately dominated by the root tier, and M be a member of $\mathbf{M}$: $\mathrm{M} \in \mathbf{M}$. Assume that the members of $\mathbf{M}$ are totally ordered such that $\mathrm{M}_n \prec \mathrm{M}_{n+1}$.

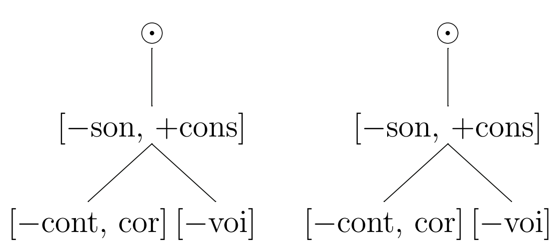
Give a violation mark to a structure in which the following two conditions hold: $\mathrm{K}_i R \mathrm{H}_i$ and $\mathrm{K}_{i+1} R \mathrm{H}_{i+1}$

$\mathrm{M}_i R \mathrm{K}_i$ and $\mathrm{M}_i R \mathrm{K}_{i+1}$

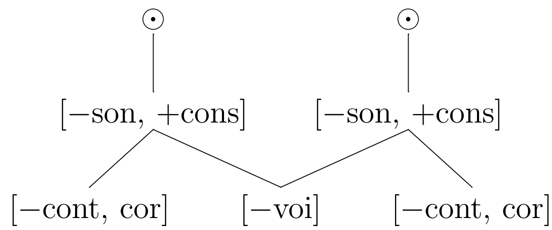


The need for the grammar to refer to every feature and its value becomes obvious when we consider the configurations (4.1a,b), repeated here with additional links to the timing slots.

(4.11) a. Two identical consonants



b. Two identical consonants; shared [voice]



In (4.1b)/(4.11b), only *some* feature is shared by two root nodes, that is, there are association lines that (directly or indirectly) connect two root nodes only on some feature node. All other feature nodes are (directly or indirectly) linked to only one of the two root nodes. The geometric structure would tell nothing about the identity of the features whose representing nodes are not connected to both of the two root nodes in any way. In (4.1a)/(4.11a), two root nodes are represented in complete separation, there is *no* association line that connects two root nodes in any way. In this case the geometric structure provides no indication as to whether the two consonants are identical or not.

Coleman & Local (1991) provide proofs showing that autosegmental representations are graphs; nodes in autosegmental representations correspond to vertices and association lines correspond to edges. Nonetheless, isomorphism between two graphs, representing two segments, does not guarantee that the segments are identical. Graph isomorphism is about the structure of graphs, that is, how vertices relate among each other, not about what kind of objects those vertices are. However, it is the nature of the vertices/nodes that is crucial to calculate the segmental identity. For example, (4.12a, b) are isomorphic, since we could think of a function f such that f(+ant) = −ant, f(−dist) = +dist. (4.12a) may be a part of a graph representing [t], while (4.12b) could be a part of a graph representing [ʃ]. Unless every *valued* feature forms a distinct vertex, evaluating graph isomorphism does not work as a measure to calculate segmental identity.

(4.12)

a.
$$\begin{array}{cc} \multicolumn{2}{c}{\text{cor}} \\ +\text{ant} & -\text{distr} \end{array}$$

b.
$$\begin{array}{cc} \multicolumn{2}{c}{\text{cor}} \\ -\text{ant} & +\text{distr} \end{array}$$

In the case of "fake geminates" (4.2b), which subsumes Baković's possible geminate representations (4.1a-c), the structural similarity serves little for the purpose of calculating the identity of two geometrically represented segments. The grammar is required to 'see' more than the geometric structure and to check every feature and its value represented on the nodes. The calculation of segmental identity then seems to necessitate algebraic representations. NoGem can be stated as in (4.13) so as to penalize "fake geminates."

(4.13) NoGem for "fake geminates" (4.2b) with Feature Geometry (in combination with Feature Algebra)

Let R be a relation "be associated to". Let $\mathbf{H}$ be a set of nodes on a CV tier and H be a member of $\mathbf{H}$: $\mathrm{H} \in \mathbf{H}$. Assume that the members of $\mathbf{H}$ are totally ordered such that $\mathrm{H}_n \prec \mathrm{H}_{n+1}$.

Let $\mathbf{K}$ be a set of root nodes and K be a member of $\mathbf{K}$: $\mathrm{K} \in \mathbf{K}$. Assume that the members of $\mathbf{K}$ are totally ordered such that $\mathrm{K}_n \prec \mathrm{K}_{n+1}$.

Give a violation mark to a structure in which two adjacent root nodes K_i and K_{i+1} are each associated with two adjacent nodes on the CV tier H_i and H_{i+1} respectively:

$\mathrm{K}_i R \mathrm{H}_i$ and $\mathrm{K}_{i+1} R \mathrm{H}_{i+1}$

$$\begin{array}{cc} \mathrm{H}_i & \mathrm{H}_{i+1} \\ | & | \\ \mathrm{K}_i & \mathrm{K}_{i+1} \end{array}$$

if the following conditions hold for K_i and K_{i+1}:

i. Let $\mathbf{F}_i$ be the set of all features represented on K_i and the nodes that K_i

dominates, and $\mathbf{F}_{i+1}$ be the set of all valued features represented on K_{i+1} and the nodes that K_{i+1} dominates. $\mathbf{F}_i = \mathbf{F}_{i+1}$

And

ii. $\forall \mathrm{F}_i \in \mathbf{F}_1 = \mathbf{F}_2$ such that $[(\alpha \mathrm{F}_i)_1] = [(\beta \mathrm{F}_i)_2]$

where $\alpha, \beta \in \{+, -\}$

Baković conceived of NoGem as insensitive to the distinction between 'true' and 'fake' geminates. It is demonstrated above that, if two segments are represented as separate root nodes associated to two adjacent nodes on the CV tier (i.e. the representation for a 'fake geminate'), and if either no feature or only some (but not all) features are shared between the root nodes, the grammar could not rely solely on the geometric representation to calculate segmental identity. The grammar would have to resort to algebraic representation to check the values of the every feature that the two segments consist of.

The informal definition of NoGem that it penalizes adjacent identical segments is intuitively easy to understand and we as linguists can easily pick out the sequences that are penalized by the constraint. However, the informal and intuitive definition of NoGem would not have brought to light what the evaluation process against such a constraint would involve. When formally stated, NoGem involves the calculation of complete identity between adjacent segments. Geometric structures are helpful to calculate the identity of adjacent segments only when the segments are represented as "true geminates," i.e. adjacent two timing slots are linked to one and the same root node, or two root nodes share all the features. If two root nodes share only some or none of the features, reference to complete identity of two segments would require a Feature Algebraic mechanism to form a set of features and universally quantify over that set.

A mechanism to refer to identity relations between segments is required in phonology regardless of one's theoretical framework, i.e. whether one takes a rule-based approach or a constraint-based approach such as OT, and whether one assumes segments to be unorganized feature bundles or to be internally organized geometric objects, phonological grammar needs a formal machinery for identity references. Through the attempt to formalize NoGem by referring to the geminate structures provided by Bković, I wish to have shown that phonology must at least be capable of quantificational statements, independently of theoretical commitment of a researcher.

4.2 Where generalizations come from

This thesis examined the history of the Ocp and the imprecise and informal nature of its formulation that obscures the notion of segment identity. Reiss (2003) proposed a model of algebraic representation that enables phonology to refer to an arbitrary set of features and consequently to to state both complete and partial identity relations between segments. Baković aimed at dispensing with the Ocp and claimed that partial/sufficient identity of segments was emergent from the interaction between NoGem and Agree. The data from Catalan showed that his schema of constraint interaction can not be generalized, and formalization of NoGem, which involves reference to complete identity between adjacent segments, revealed that algebraic representation would in fact be necessary when candidates are evaluated against NoGem. One lesson we could learn from this would be the importance of explicit, precise formulation of rules, constraints or principles. This might be too obvious to re-emphasize but it seems to be often forgotten.

When the idea of the OCP was first conceived, the domain of its application was rather limited — the OCP was thought to be a principle to constrain the underlying representations of tone melodies at the morphemic level. With McCarthy's work on non-concatenative morphology (1981, 1986) the OCP has become to be interpreted as a constraint on adjacent *elements* not only on the tonal tier but also on any autosegmental tier, in a morpheme as well as in derived structures, extending the domain of its application to segmental phonology. It might seem that the OCP has gained more generality, but this generality is in fact illusory: McCarthy and the subsequent researches using the OCP to account for their data needed additional, auxiliary assumptions such as CV segregation and Tier Conflation. Yip's (1988) rule statements show that, in the actual analyses, the apparent generality of the OCP that adjacent *identical elements* are prohibited at *a melodic level* had to be compensated with specifications of the domain and the tier to which the OCP applies. With auxiliary assumptions and specifications, the status of the OCP appears to be the same as any phonological rule or constraint that dictates specific behaviour of specific segments in a specified domain.

We should aim to develop a precise and explicit formulation of a rule (or a constraint) that would account for a specific set of data rather than rush to formulate an imprecise and vague 'principle' that may cover a greater set of data but requires auxiliary assumptions. With explicit and formal statements of rules (or constraints), we would be able to discover what part of the statements can be generalized, as the following quotation from Chomsky (1957) suggests:

> By pushing a precise but inadequate formulation to an unacceptable conclusion, we can often expose the exact source of this inadequacy and, consequently, gain a deeper understanding of the linguistic data. More positively, a formalized theory may automatically provide solutions for many problems other than for which it was explicitly designed. Obscure and intuition-bound notions can neither lead to absurd conclusions nor provide new and correct ones, and hence they fail to be useful in two important respects.

This thesis did not discuss in detail the issue of segment adjacency. I have treated the adjacency in terms of numerical subscripts (e.g. C_1C_2, K_iK_{i+1}), but it would be unlikely that phonology counts the number of segments in an utterance and assign numerical subscripts in increasing order. That is, it is not plausible that phonology computes over representations $C_{16}C_{17}$ for example. More plausible procedure will be that phonology forms ordered pairs over a sequence of segments and calculates identity of each pair. The adjacency relation in terms of ordered pairs must also be included in the identity statements of adjacent segments.

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