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COMPLEX PLACE AND PLACE IDENTITY

By

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ABSTRACT OF THE DISSERTATION

Complex Place and Place Identity

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This dissertation proposes a unified theory of Place Identity to model interactions of phonological place features along local, long-distance, and input/output dimensions. Empirical support comes from reduction and agreement processes involving complex, or multiple, place on a single segment—processes previously reported to be unattested. Identity constraints (IDENT and AGREE) are those that demand two segments be alike with respect to the presence or value of some feature, and are constructed here following a schema of Generalized Identity. The resulting constraints vary both in the relation of the segments in question (input/output correspondence, surface correspondence, or strict adjacency) and in the location of place features in the geometry (within-category or cross-category). Sets of stringently-defined constraints are built via Constraint Summation, a constraint-building operation that sums the violation profiles of the original constraints. The resulting system of place identity captures partial class effects (based on Padgett 2002) of place along all identity dimensions, while augmenting the observations in de Lacy 2006 on markedness reduction and inventory structure with respect to complex segments.

Empirical investigation of complex segments reveals place behavior unattested with simple stops. In Ngbaka, place co-occurrence restrictions are an example of long-distance major place harmony, which requires place identity over surface correspondence in the Agreement by Correspondence framework (Rose & Walker 2004, a.o.). The patterns are supported by a statistical analysis of a newly-digitized Ngbaka dictionary. Additionally,

in Vietnamese and Aghem, a back, round vowel causes a change in consonantal place on an adjacent consonant, forming a labial-velar stop in both instances. This otherwise unattested type of cross-category interaction provides additional evidence for a unified theory of place features (following Clements & Hume 1995), to which place identity constraints crucially refer. Lastly, complex segments shed a place feature when undergoing markedness reduction instead of reducing to the least marked place (cf. de Lacy 2006). These processes are supported by an empirical survey, and show that place identity must count each place disparity. The resulting grammatical system is powerful enough to determine targets of reduction for complex segments without additional representational devices while restrictive enough to not overgenerate patterns for simple place reduction.

Dedication

For my family.

A voice cannot carry the tongue and the lips that gave it wings.
Alone it must seek the ether.

– Kahlil Gibran, *The Prophet*

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Not everyone's cut out to be a businessman.
For example, curly-haired men and people who need glasses.

– Jack Donaghy, *30 Rock*

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List of Abbreviations

ABC	Agreement by Correspondence
APP	Abstract Primary Place
CC	Consonant/Consonant
CDL	Constraint Definition Language
E	Expected value
ERC	Elementary Ranking Condition
FCT	Feature Class Theory
GIST	Generalized Identity + Summation Theory
GP	Gapped Inventories
IO	Input/Output
MIB	Most Informative Basis
NCC	No Crossing Constraint
O	Observed value
PAD	Place Agreement on Dorsals
PAL	Place Agreement on Labials
PoA	Place of Articulation
PR	Partial Reduction of Complex Place
TR	Total Reduction of Simple Place
TSL	Tier-based Strictly Local
UMH	Universal PoA Markedness Hierarchy
VA	Voicing Agreement

1 Introduction

Why build one, when you can have two at twice the price?

– S.R. Hadden, *Contact*

Phonologically, all of the supraglottal region is divided into three parts, one of which is [dorsal], [coronal] another, and [labial], the third. Segments produced in this region often involve a single articulation at one of these places. However, a number of segments involve two, near-simultaneous articulations: complex segments. Labial-velar doubly-articulated stops like [k͡p] and [g͡b], which are extremely common in West Africa and the Pacific, are phonologically both [labial] and [dorsal]. Empirically, these segments participate in a number of interactions not seen among only simple segments. This dissertation proposes a theory of place identity constraints that capture processes involving both simple and complex segments.

Generally, Identity refers to the class of constraints that assign violations for feature disparities between two segments related in some way. For instance, IO-IDENT constraints from McCarthy & Prince 1995 enforce identity along segments in input-output correspondence, as well as BR-IDENT for for base-reduplicant (BR) correspondence. The same general schema is also used for surface (CC) correspondence (Rose & Walker 2004, Hansson 2010, Bennett 2013) to capture long-distance interactions. Though not traditionally referred to as IDENT constraints, the AGREE constraints of Lombardi 1999, Bakovic 2000 a.o. are effectively IDENT constraints operating on a surface adjacency relation instead of correspondence.[1]

The behavior of place features requires refined formulations of Identity constraints for two main reasons: segments can have multiple place, and place features can differ in their category—whether they are vocalic (V-) or consonantal (C-) place features. The evaluation

[1] As also noted by Bakovic 2000: 10, citing also McCarthy & Prince 1995, Krämer 1995, McCarthy 1995.

of segments in some relation must take into account all of these types of disparities.

This dissertation proposes a unified theory for Place Identity within Optimality Theory. The relevant relations along which Place identity is defined are Input/Output Correspondence (McCarthy & Prince 1995), Surface Correspondence (Hansson 2010, Rose & Walker 2004), and adjacency (AGREE constraints). Additionally, this dissertation argues for a unified place feature theory: vowels and consonants share place features, but differ on their place in the geometry, following Clements 1991, Clements & Hume 1995. The main support for this comes from cross-category interactions: when C-place and V-place interact along any or several of these Identity dimensions. Specifically, consonants agree with vowels in place in Vietnamese and Aghem.

This introductory chapter largely mirrors the structure of the dissertation itself. Chapter 2 introduces and defines the theory. Chapters 3 and 4 focus on case studies of Ngbaka and Vietnamese, respectively. Finally, Chapter 5 presents an empirical survey of reduction processes involving complex place, and formally showing how the constraints can account for this while preserving attested behavior for simple segments.

1.1 Background on complex segments

Complex segments, in this dissertation, refer to any segments with multiple, unordered place features (Sagey 1986). These include labial-velar (or labial-dorsal) stops, which can be voiceless [k͡p], voiced [g͡b], or nasal [ŋ͡m]. Additionally, labial-coronal stops like [t͡p] and clicks are also complex segments (although both with some controversy, see e.g. Bennett 2014). This dissertation focuses mainly on the behavior of labial-velar stops, as they are the most attested and best studied complex segment.

1.1.1 Distribution of labial-velars

In the World Atlas of Linguistic Structure (WALS), 45 of the 556 entries investigated are marked as containing labial-velars (Maddieson 2013). In a recent survey, Cahill 2017 esti-

mates that at least 12% of the world's languages contain contrastive labial-velars, in some form: 848 cases are compiled, the majority in Africa, with "at least 60 languages of the Pacific, and a handful of cases elsewhere" (Cahill 2017: 13).

1.1.2 Phonetics of labial-velars

Labial-velars involve two articulations of equal stricture. While these articulations are often described as simultaneous, close instrumental studies have shown a slight offset between both the closures and the releases of the two articulations. Ladefoged & Maddieson 1996: 339 estimate, for example, that the offset between closures in [k͡p] for an Ewe speaker is 10ms, while the offset between releases is 26ms. These measurements were obtained using electromagnetic articulography. More recently, 4D ultrasound techniques have been used to record labial-velars in Gengbe (Lotven et al. 2017, Berkson et al. 2017).

The durations of labial-velars usually fall between the durations of simple stops—[k] and [p] individually—and clusters. In Yoruba, Ladefoged & Maddieson 1996: 333 report that [g͡b] averaged a duration of 132 ms, while [b] averaged 128 ms, which was not a significant difference. When the duration of a labial-velar is longer than a simple segment, Ladefoged & Maddieson 1996: 339 suggest that the duration might be "the sum of the duration of [p], measured as about 138 ms, plus the amount of time by which the velar articulation leads the labial one", estimated at 20 ms. However, Connell 1994: 457 states based on cross-linguistic measurements that there is likely "a language-specific element in the relation between the double and single stops."

Ladefoged 1968 describes three basic airstream mechanisms for labial-velars in the languages surveyed therein:

(1) a. Pulmonic egressive

b. Velaric ingressive + pulmonic egressive

c. Velaric ingressive + glottalic ingressive + pulmonic egressive

It is worth noting that each combination does include the pulmonic egressive airstream mechanism. The phonological status of the others are less clear; Ladefoged 1968: 9 notes that one Bini speaker produced all three types in the course of a single utterance. Additionally, Mackenzie 2009 (and Hansson 2010) argues that even though Bumo Izon has an implosive labial-velar, it does not participate in implosive harmony along with the simple implosive stops; in other words, it is not phonologically [+constricted glottis].

1.2 Overview of the theory

The range of place disparities involves differences in the number of place, and in the category of place. If a labial-velar segment [k͡p] is compared to a simple labial segment [p], it is strictly neither homorganic nor heterorganic; while both segments share a [labial], one segment is [dorsal] while the other is not. This is called here a *semihomorganic* relation, in that the set of place features of one segment is a (non-empty) proper subset of the other. (See (82) for full definition.)

In a input/output mapping involving a complex input, the semihomorganic output segments must be more faithful than the fully heterorganic output segments. Such processes are surveyed and analyzed in Chapter 5, but one clear case is Amele, where [g͡b] is realized as [p] in final position. While this is a type of reduction process, the mapping of /g͡b/ → [p] must be more faithful than /g͡b/ → [t] in terms of place.

(2)

	/k͡p/	M_1	F	M_2	Comment
a.	k͡p	**		**	Faithful, most marked
b.	p	*	*	*	Semihomorganic, intermediately marked
c.	t	*	***		Heterorganic, least marked

In this simplified tableau, M_x and F are dummy markedness and faithfulness constraints; the full theory of place markedness is developed in Chapter 5. F is a place identity constraint for all place features. Note that the faithfulness violations assigned to /k͡p/ → [p] must be

strictly less than the violations assigned to /k͡p/ → [t]. If these two outputs were equally unfaithful, [t] would be the target of reduction. Likewise, if /k͡p/ → [k͡p] and /k͡p/ → [p] were equally faithful, the target of reduction would be [p], yet contrast between [p] and [k͡p] could not be preserved where desired; markedness would always prefer [p]. It therefore must be the case that place identity (F in (2)) must count individual place feature disparities. This type of reduction is an instance of *partial class behavior* (Padgett 1995, 2002) along the input/output dimension.

Additionally, a homorganic relation can satisfy place identity even when between consonantal and vocalic place features, a cross-categorical homorganic relation. Cross-category versions of place identity judge these to be faithful, while within-category versions are still independently necessary. Vowel-consonant agreement in Vietnamese (/ok/ → [ok͡p]) and k͡p~k^{w} alternations in Mumuye require cross-category place identity. These segments are homorganic in the number and type of place features, but differ in their category (their location with respect to C-place and V-place nodes).

Due to these processes and others surveyed in this dissertation (summarized in Section 1.3), place identity must have the following characteristics:

1. It must mediate long-distance, local, and input/output interactions.
2. There exist versions sensitive and not sensitive to position of place in the geometry (C-place vs. V-place).
3. It must count individual feature disparities.
4. It is based on a universal markedness hierarchy.

McCarthy & Prince 1995 first define IDENT(ity) constraints based on the Correspondence relation, and use these constraints for input/output and base/reduplicant interactions. Local identity refers to the AGREE family of constraints (Lombardi 1999, Bakovic 2000, a.o.). Long-distance place identity is more controversial: Rose & Walker 2004 find no instances of long-distance major place harmony even though a CCIDENT [place] constraint

is predicted in the Agreement by Correspondence (ABC) framework, and Gallagher 2008 argue that such a constraint should not exist at all. Bennett 2013 argues that the lack of major place harmony is an accidental gap. This dissertation shows that the processes does exist in Ngbaka and that a long-distance place identity constraint is crucial for capturing it.

To account for the range of processes involving place, constraints are based on a Generalized Identity schema, which is given below:

(3) **Generalized Identity**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R} \bullet_2)$ $\wedge$ $(\mathcal{S}(\bullet_1, [\text{F}]) \oplus \mathcal{S}(\bullet_2, [\text{F}]))$

—

Assign a violation for each pair of segments $\langle \bullet_1, \bullet_2 \rangle$ such that the two segments are in some relation $\mathfrak{R}$, and the structural relation of $\bullet_1$ and some place feature [F] does not equal the structural relation of $\bullet_2$ and the same place feature [F].

The exact definition of the Constraint Definition Language (CDL) is given in Chapter 2. The English paraphrase is given as well. The choice of segmental relation allows the same schema to mediate local, long-distance, and input/output interactions. The reference to a specific structural relation between feature and root node, opposed to simply a reference to a binary value, allows the constraint to target place features in a specific geometric configuration, or to ignore this configuration altogether.

How, for example, might dorsal faithfulness for consonants be defined under this definition? Following McCarthy & Prince 1995, faithfulness between inputs and outputs is mediated by a correspondence relation $\mathfrak{R}_{\text{io}}$. Additionally, the constraint will check if either segment, input or output, contains a C-place feature [dorsal]. If [dorsal] is a C-place feature in one segment, but not the other, a violation is assessed. This is exemplified in (25).

The Generalized Identity schema is combined with Summation Theory to form the actual constraints in CON. Summation Theory consists of the constraint summation operation, and constraint-building algorithms utilizing it. The algorithms also use a universal place markedness hierarchy, based on de Lacy 2002, 2006, Prince & Smolensky 1993, Lombardi

2001, among others. The definition for constraint summation is given below.

(4) **Constraint Summation**

Given a set of constraints $\{C_1, \ldots, C_n\}$ and a set of candidates $\{x | x = \langle i, o, \Re \rangle\}$, a constraint C_Σ can be formed such that: $\forall x C_\Sigma(x) = C_1(x) + \ldots + C_n(x)$

In short, constraint summation takes a set of constraints, and returns a new constraint whose violation profile is equal to the sum of the original constraints. If constraint C_1 assigns 1 violation to candidate x, and constraint C_2 assigns 2 violations to candidate x, then constraint C_Σ, the summation, assigns 3 violations to candidate x.

(5)

	C_1	C_2	C_Σ	Comment
x	*	**	***	$1 + 2 = 3$

Through building constraints via summation, we derive constraints that capture the class behavior of place while also being sensitive to individual feature disparities (following Feature Class Theory of Padgett 1995, 2002). The summation operation also allows straightforward building of stringently-related constraints, following Prince 1997, de Lacy 2002, 2006.

1.3 Processes involving complex place

Complex segments participate in a number of processes previously thought to be unattested. Part of the reason why complex segments are illuminating for processes involving place is because they can have multiple place. The major place features [coronal], [dorsal], and [coronal] are often considered together as a class called Place (Sagey 1986 et seq.), and many processes are described in terms of this class rather than in terms of the individual features. This is because, with simple stops, if segment A assimilates to segment B in terms of place, multiple feature values change. English nasal place assimilation results in map-

pings of /ng/ → [ŋg]. Should this be considered a process where [coronal] is lost, or where [dorsal] is gained, or both, simultaneously?

Place interactions are categorized along two dimensions: the relation of segments to each other, and the relative positions of the place features in the feature geometry between the two segments. The first dimension differs in whether an interaction is long-distance, local (strictly adjacent), or between input and output. The second differs along whether the place features interaction within-category (either both are C-place, or both are V-place), or cross-category (when one is C-place and the other V-place). Example processes are summarized in the table below.

Table 1.1: Summary of place processes

Segments	Place	Example	Language
Long-distance	Cross-category	—	—
	Within-C	*p…k͡p	Ngbaka
	Within-V	*p…p^{w}	Pohnpeian
Local	Cross-category	/ok/ → [ok͡p]	Vietnamese
	Within-C	/inp/ → [imp]	English
	Within-V	/ot/ → [ot^{w}]	Aghem
Input/output	Cross-category	/k͡p/ → [k^{w}]	Mumuye
	Within-C	/k͡p/ → [k]	Amele
	Within-V	/ot/ → [ot^{w}]	Aghem

Processes are found on nearly all dimensions of category and segmental relation.[2]

1.3.1 Long-distance processes

Long-distance processes are those phonological interactions between two non-adjacent segments. In the case of Ngbaka, two consonants agree for place and voice through an intervening vowel. Specifically, two labials in a word must have matching specifications for

[2]The apparent lack of long-distance cross-category processes is likely an accidental gap exacerbated by the fact that long-distance processes are usually predicated on either the consonant dimension or the vowel dimension. Thus, cross-category processes would be limited to those on the consonant dimension where one consonant has vocalic place. Such a process is certainly possible, but the fact that one is not yet found is likely due to the fact that the possible space is restricted in this way.

all places, and likewise with initial dorsals and medial labial-dorsals. In surveys of long-distance consonant interactions, featural interactions involving laryngeal quality, nasality, manner, and minor place (such as anteriority) are common, yet those involving major place features are strikingly absent (Hansson 2010, Rose & Walker 2004, Bennett 2013).

In Ngbaka, this process is captured with an active surface correspondence identity constraint, id-cc.KPT, illustrated in the following tableau. This tableau contains both possible optima for the input /k͡p-p/.

(6)

	Input	Winner	Loser	Corr.P	id-cc.KPT	id-io.KPT	m.KPT
a.	k͡p-p	p_1ap_1a k_1ap_2a	$\widehat{kp}_1ap_2a$	W		L	W
b.	k͡p-p	p_1ap_1a k_1ap_2a	$\widehat{kp}_1ap_1a$		W	L	W
c.	k͡p-t	$\widehat{kp}_1at_2a$	k_1at_2a p_1at_2a			W	L

The surface generalization of avoiding combinations of labials and labial-velars is met through via the id-cc.KPT constraint: either the optimum is in correspondence with place-identical segments (p_1ap_1a) or the optimum is not in correspondence and satisfies place identity just as well (k_1ap_2a). This chapter also argues that alternative approaches, such as co-occurrence constraints, are not possible without first changing either assumptions about the privative representation of place or the logical power of markedness constraints.

The patterns in Ngbaka, though a static distribution, are shown to be stastically robust following an analysis of a dictionary, Maes 1959.

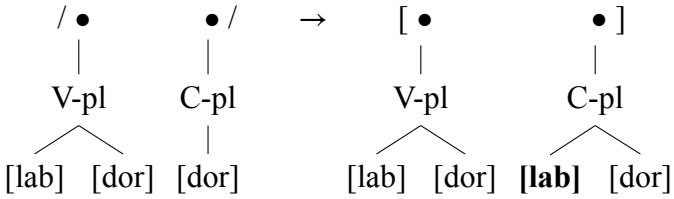
1.3.2 Local cross-category interaction

Cross-category interactions are those where a vocalic or V-place feature interacts in some way with a consonantal or C-place feature. While there are such interactions, as shown by Sagey 1986, Halle et al. 2000, Ní Chiosáin & Padgett 1993, Padgett 2011, interactions where a vowel causes consonantal place on a consonant are rare if nonexistent outside of palatalization.

In Vietnamese, a back, round vowel causes consonantal labial stricture on a dorsal coda consonant, resulting in a labial-dorsal stop:

(7) **Cross-category agreement in Vietnamese**

/ok/ → [o͡kp]



In the above representation, the bolded [labial] place feature on the output consonant appears to satisfy a cross-category agreement constraint id-agr.KPT$_X$. This is shown in the violation tableau below, along with the within-category agreement constraints id-agr.KPT$_C$ and id-agr.KPT$_V$.

(8)

/ok/	id-agr.KPT$_X$	id-agr.KPT$_C$	id-agr.KPT$_V$	•$_1$ place	•$_2$ place
a. ok	*	*	**	V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [dor]
b. ok^w		*	*	V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [dor], V-Pl ↓ [lab]
c. o͡kp		**	**	V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab], C-Pl ↓ [dor]

The faithful candidate in (8a) does not fully satisfy any agreement constraint: the consonant is not [labial] in any way, and the vowel (naturally) lacks any C-place features. The

two candidates in (8b) and (8c), however, both *fully satisfy* the cross-category agreement constraint id-agr.KPT$_X$. This is because both segments, ignoring intermediate place nodes, are both [labial] and [dorsal]. While the rounding candidate [ok^w] does do better on id-agr.KPT$_V$ than the faithful candidate, the double-articulation candidate [o$\widehat{kp}$] does worse on both within-category agreement constraints than [ok^w]. The specific choice of target for agreement is further defined by independent markedness and faithfulness constraints for that language. In the case of Vietnamese, the constraint id-agr.KPT$_X$ is crucial in obtaining a ranking where /ok/ → [o$\widehat{kp}$], capturing the attested cross-category agreement process.

1.3.3 Markedness reduction

Markedness reduction refers to a process that causes segments to surface unfaithfully to a lesser marked segment, outside of assimilation/dissimilation processes. Complex segments satisfy markedness conditions by shedding a place feature: a labial-dorsal stop /$\widehat{kp}$/ can be realized as either [k] or [p] instead of reducing to the least marked place. This *partial reduction* is only possible with complex place. The scaled markedness and faithfulness constraints in this chapter capture both partial reduction of complex place and total reduction of simple place. A typological survey provides crosslinguistic support.

In de Lacy's 2006 survey, reduction among simple segments is always to either glottal or coronal place, depending on other factors. These two places are the least marked on the universal markedness hierarchy argued for there and assumed here as well. While patterns for simple place are preserved here, partial of reduction crucially relies on a definition of input/output place identity which counts individual place disparities between segments. This faithfulness constraint is crucial in capturing the patterns for complex place.

Two systems of stringent markedness and faithfulness constraints are analyzed: one that captures the basic reduction patterns of both complex and simple stops (the Basic Place Reduction System), and the second that generalizes this system over strong and weak prosodic positions (the Extended Place Reduction System), whose predicted languages are supported

by the empirical survey. The typologies of these languages are analyzed in Property Theory (Alber & Prince 2017 a.o.), providing proofs of certain mappings.

1.4 Structure of the dissertation

Chapter 2 gives the main theoretical assumptions and conclusions for the remainder of the dissertation, including segmental representation, constraint definitions and constraint building. Chapter 3 argues that long-distance major place harmony is empirically attested and that an IDENT constraint operating for place between segments in surface correspondence is necessary. Chapter 4 argues that cross-category agreement exists where the place of a vowel causes consonantal place on a consonant is attested in Aghem and Vietnamese. To capture this process, there must be an IDENTconstraint operating on adjacent segments (i.e. an AGREE constraint), and it must be blind to the specific C- and V-place specifications of the segments in question. Chapter 5 presents an empirical survey of reduction processes involving complex segments. These processes result in a semihomorganic simple stop, showing that faithfulness must evaluate each place disparity between segments in question. These processes are analyzed in a system utilizing stringent markedness and faithfulness constraints.

2 Theory

How is place identity defined? While *place* refers to a related set of features, is reference to the individual features themselves necessary, or is place identity simply strict equality of place features between segments? For example, in a mapping like /k/ → [t], is it relevant that both /k/ is [dorsal] but not [coronal], and that [t] is [coronal] but not [dorsal]? Or is it simply enough to say that place identity is satisfied when two segments have the same place, and not otherwise? When segment mappings involve solely simple-to-simple place, these questions are difficult, if not impossible to answer. However, the structure of place identity reveals itself through interactions involving complex place.

When complex segments undergo certain processes, like markedness reduction, it must be the case that /k͡p/ → [p] or /k͡p/ → [k], where there is still a shared place between input and output, are judged to be *more faithful* than mappings where the segments share no place features, such as /k͡p/ → [t]. Thus, place identity cannot simply be strict equality.

This dissertation proposes a unified structure for place identity, and models interactions of complex place along three dimensions: input/output faithfulness, long-distance agreement, and local agreement. These interactions are captured via sets of Identity constraints, defined along input/output, surface correspondence, and strict adjacency, respectively. The versions based on strict adjacency are AGREE-type constraints (Bakovic 2000, Lombardi 1999). The basic identity constraints are based on a schema of Generalized Identity, defined in Section 2.3. Sets of constraints are built from this general schema using via Summation Theory, defined in Section 2.4. Together, these constraints capture desired mappings for relations involving both simple and complex place.

Additionally, the resulting set of constraints captures both *within-category* and *cross-category* interactions along all dimensions. Within-category interactions are those where C-place interacts with C-place, and V-place with V-place. An example is the roundedness

on a vowel such as [o] causing rounding on a consonant, such as [k^{w}]. Cross-category interactions involve V-place in interaction with C-place, or vice versa. An example is the roundness of a vowel [o] causing consonantal stricture on a consonant, resulting in [k͡p]. These patterns are evidence for a unified feature theory for place, where both vowels and consonants share place features (Clements 1991, Hume 1994, Clements & Hume 1995).

A note on naming conventions: the general family of constraints are identity constraints, which consist of the IDENT and AGREE subfamilies. Even though they are both based here on the same schema, I will follow existing conventions and call any constraint based on some form of correspondence an IDENT constraint, and those based on adjacency/locality an AGREE constraint.

2.1 The GIST: Generalized Identity and Summation Theory

The structure of the constraints are based on the following:

(9) **Generalized Identity + Summation Theory (GIST)**:

a. The Generalized Identity schema (defined in (15))

b. Summation Theory

i. Summation Operation (defined in (37))

ii. Constraint Building Algorithms (defined in (43), (45), (46))

Summation Theory consists of two parts: the constraint summation operation, and its specific implementation in constraint-building algorithms. The utility of Summation Theory is that it preserves effects of partial class behavior (following Feature Class Theory (FCT) of Padgett 1995, 2002) while allowing constraints to be defined stringently based on a universal scale (following de Lacy 2002, 2006).

The empirical motivation for Summation Theory arises in interactions of complex place. Padgett 1995 discusses partial class behavior of labial-velars in nasal assimilation cases:

nasals sometimes assimilate to only one place of an adjacent complex segment (e.g. [ŋg͡b vs. ŋ͡mg͡b]).

(10) Padgett 1995: (17)

/N + g͡b/	*CompSeg	Npa
a. ŋ͡mg͡b	**!	
b. ŋg͡b	*	*
c. Ng͡b	*	**!

Npa is a constraint defined in Feature Class Theory (FCT) such that a violation is assigned for each unassimilated place feature in a nasal-consonant sequence. The fully assimilated form [ŋ͡mg͡b] fully satisfies Npa, but at the behest of *CompSeg. The winner in this simple illustration is [ŋg͡b]: better on *CompSeg than the fully assimilated candidate, and better on Npa than the heterorganic combination in [Ng͡b]. This is partial class behavior because the class of place features has only *partially* assimilated. (In this dissertation, the summed markedness constraint m.KPT does the work of *CompSeg; see Chapter 5.)

Chapter 5 offers a typology of partial class behavior over the input-output dimension: labial-velars such as k͡p and g͡b that reduce to a semihomorganic place, either labial or dorsal. The summation operation allows faithfulness violations of individual features to accrue in the evaluation of forms just like constraints on spreading in FCT (so that /k͡p/ → [k] or [p] is more faithful than /k͡p/ → [t]), and rankings of the stringent set of markedness and faithfulness constraints determine the target of reduction, whether it is labial or dorsal. This type of reduction, where the target is still partially faithful, is not found among reduction patterns of simple-to-simple place mappings. In those cases, faithfulness plays no role in the target of reduction (de Lacy 2006).

The implementation of Summation Theory utilizes a generalized schema for place identity: Ident constraints that operate along input/output correspondence and surface correspondence, and those on strict adjacency (i.e. Agree constraints). These are defined in first-order logic in the following sections. The generalized identity schema allows constraints to

not only vary on what relation they operate over, but also the exact type of identity, be it cross-category (consonants and vowels interacting) or within-category.

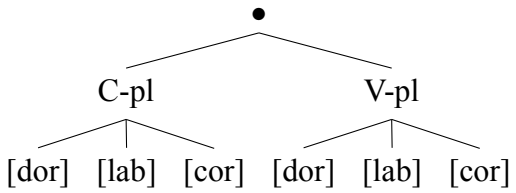
2.2 The representation of place

This dissertation argues for a unified theory of consonant and vowel place, following Clements 1991, Clements & Hume 1995.[1] In such a theory, vocalic place and consonantal place are the same features, but differ in their place in the geometry. I assume separate C-place and V-place nodes, but am agnostic as to the relation of these nodes to each other. Here, the nodes are assumed to be siblings, as this is the simplest structure maintaining separate V- and C-place nodes (see also Prince & Smolensky 1993: (279)). The analyses of local assimilation in Chapter 4 utilize a local AGREE framework, which essentially is feature-changing and not feature-spreading. Thus, it is not obvious how any autosegmental arguments for the positions of the place nodes themselves translate. For simplicity, I simply assume that each place node branches directly from the root node. This also simplifies the constraint definitions to follow. A fully-articulated structure for place is shown below.

(11) **Major Place Features**

The set of major place features is [labial], [coronal], [dorsal].

(12) **Fully-articulated place geometry**



For visual brevity, the major place features are abbreviated [lab], [cor], and [dor] in diagrams and definitions, and as P, T, and K in constraint names. The use of intermediate nodes to differentiate C-place and V-place is not strictly crucial, either. What is necessary is some

[1] Clements & Hume 1995 call this a constriction-based theory, but I adopt the terminology of Padgett 2011 in calling it a unified theory.

form of marking of stricture for a particular feature. This could also be dependent stricture features (Padgett 1994) or simply some sort of diacritic on the place features themselves. The use of intermediate nodes here keeps the basic representational assumptions in line with others that assume a unified theory of place features, and allows easy reference to consonant and vocalic place in the constraint definitions.

Additionally, place features [radical], [pharyngeal], or [glottal] are sometimes included in the set of major place features, to define sounds in the pharygneal and subpharyngeal region. I follow Lombardi 2001, de Lacy 2002, 2006 in assuming that [glottal] is also a major place feature, and that it is the lowest member of the universal markedness hierarchy. However, for simplicity, in this dissertation I focus on the three oral place features [dorsal], [coronal], and [labial].

2.2.1 The primacy of place

Primary and *secondary articulations* are terms often used to refer to the closure that has the most consonantal stricture in the realization of the segment. Primacy of place is then a phonetic property of segments, or full representations, not of individual features. Thus, in a segment like [k^w], the segment contains two major place features: [dorsal] and [labial]. The segment has primary place of [dorsal], as this is a stop closure, and a secondary place of [labial], as this is realized as a vocalic stricture.

(13) **Secondary Articulation**

> "[A] secondary articulation is a gesture with a lesser degree of closure occurring at the same time as another (primary) gesture." (Ladefoged 2006: 229)

However, it has also been used in an abstract, or phonological sense, to pick out a single place articulation in a complex segment that has equal phonetic stricture to the other. Anderson 1976 discusses a number of reasons why this should be the case, stating that the notion of primary place "[does] not reveal [itself] directly in the phonetic substance, but only inferentially through the relation of a sound to others in the system of the language

in which it plays a part" (Anderson 1976: 17). A definition of primary place that is based on phonological patterns, not phonetic characteristics of the segment, is referred to here as Abstract Primary Place (APP). This dissertation rejects the idea of APP.

(14) **Abstract Primary Place (APP)**

The property of a particular place in a complex segment having a special structural status when there is no phonetic difference in stricture between the two place articulations.

Sagey 1986 uses a pointer device in the structure to pick out *major articulators* and *minor articulators*[2], which in her theory is a member of the set of coronal, dorsal, and labial place class nodes. In addition to the pointer device assigning stricture to a particular place feature, the pointer device also serves as a method of defining abstract primary place.

This dissertation rejects an abstract notion of primary place, and the term has no theoretical significance in the following analyses or theory. The primacy of place is defined purely on phonetic grounds. The intended result of this definition, and a major claim of this dissertation, is that a segment with two place articulations (from the result of two major place features) which have equal consonantal phonetic stricture has two primary places. A labial-velar segment [k͡p] has two place features, which are realized as two articulations of equal phonetic stricture—both as full stop closures. Therefore, this segment has two primary place features. There is no representational device that distinguishes one feature from the other, other than their inherent definitions as [labial] and [dorsal]. In terms of Clements & Hume 1995, this means that [k͡p] has both [labial] and [dorsal] C-place.

[2]The terms major and minor articulator should not be confused with the terms major and minor place. Major and minor articulators are always any of [labial], [dorsal], or [coronal], which are the major place features. Minor place refers to distinctions within a single major place, such as dental vs. alveolar for coronal, or velar vs. uvular for dorsal.

2.3 Generalized Identity schema

The Generalized Identity schema is given below:

(15) Generalized Identity

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R} \bullet_2)$ $\wedge$ $(\mathcal{S}(\bullet_1, [\text{F}]) \oplus \mathcal{S}(\bullet_2, [\text{F}]))$

—

Assign a violation for each pair of segments $\langle \bullet_1, \bullet_2 \rangle$ such that the two segments are in some relation $\mathfrak{R}$, and the structural relation of $\bullet_1$ and some place feature [F] does not equal the structural relation of $\bullet_2$ and the same place feature [F].

The content to the left of the slash (/) is the locus of violation; in this case, a pair of segments. A violation is assigned for each locus where the expression on the right side of the slash evaluates to True (building off McCarthy 2003, Hyde 2012, Jurgec 2011, see (17)). This expression takes three arguments: a relation between root nodes $\mathfrak{R}$, a relation $\mathcal{S}$ between a root node and a feature, and a feature [F]. The specific structural relation is identical between both root nodes in the given relation, which results in the specific type of identity being enforced.

In plain English, the constraint breaks down as follows:

(16) Assign a violation for each pair of root nodes $\langle \bullet_1, \bullet_2 \rangle$ such that:

a.	The root nodes are in some relation $\mathfrak{R}$	$(\bullet_1 \mathfrak{R} \bullet_2)$
b.	and	$\wedge$
c.	the truth value of some structural relation $\mathcal{S}$ between root node $\bullet_1$ and feature [F]	$\mathcal{S}(\bullet_1, [\text{F}])$
d.	does not equal	$\oplus$
e.	the truth value of that same structural relation $\mathcal{S}$ between root node $\bullet_2$ and feature [F]	$\mathcal{S}(\bullet_2, [\text{F}])$

The expression containing the exclusive or operator $\oplus$ ensures that the constraint is satisfied (does not assign a violation) either when $\mathcal{S}(\bullet_1, [\text{F}])$ is true for both root nodes, or

when it is false for both root nodes; it is not saying that a root node must be in that specific relation. This is illustrated further in (25).

The key to Generalized Identity is both the exclusive or operator and the the matching structural descriptions on either side of it. In the definition, this description is generalized as $S(\bullet_1, [\text{F}])$. Not only must both root nodes be in the same configuration for some feature, it must be for the *same* feature as well. This captures the fact that IDENT and AGREE constraints operate on separate values of the same feature, but the assumptions here are crucial when dealing with processes with phonologically separate but phonetically related features, such as [labial] and [+round] (see Section 4.5.4). It is impossible to define an AGREE or IDENT constraint to mediate between occurrences of disparate features. Further, the extension of Identity to refer to some structural configuration, instead of the value of a binary feature, allows the constraint to mediate not only privative features such as place, but also the specific location of those place features within a geometry.

The general constraint form follows the general schema from McCarthy 2003 (see also Hyde 2012), and the symbols • representing a root node and ↓ representing the domination relation come from the constraint definition language of de Lacy 2011. Constraints assign a single violation for each unique instance of the locus λ in the configuration C:

(17) λ / C ≡ For any λ satisfying condition C, assign a violation-mark.
(McCarthy 2003: (1))

Specifically, in the constraints here, a violation is assigned for every locus λ such that condition C evaluates to True. The following symbols are used in the constraint definitions.

(18) a. • = The root node of a segment.
b. $x \downarrow y$ = True iff x dominates y.
c. $x \mathfrak{R} y$ = True iff x and y are in relation $\mathfrak{R}$.
d. $\oplus$ = Boolean XOR
e. $\neg, \wedge, \vee$ = Boolean NOT, AND, OR, respectively

The place identity constraints are defined in the following section.

2.3.1 Evaluating identity for place

In the case of generalized identity, each pair of segments are evaluated, and if the condition of the constraint is true, a violation is assigned. For privative place features, there is no feature value to compare. Instead, the absence or presence of the features themselves result in varying truth values based on the structural description at hand. In addition to mere presence or absence, the location of the place features is crucial for certain place identity constraints as well. The Cross-category Identity simply checks if a particular place feature is present *somewhere* in the geometry of both segments. The consonantal and vocalic within-category definitions look specifically for matching C-place and V-place specifications, respectively. These are defined below.

(19) Types of Place Identity

$S(\bullet, [\text{F}]) =$

a. $\bullet \downarrow [\text{F}]$ — Cross-category Ident (XC)

b. $\bullet \downarrow$ C-place $\downarrow [\text{F}]$ — Consonantal Within-Category Ident (WCC)

c. $\bullet \downarrow$ V-place $\downarrow [\text{F}]$ — Vocalic Within-Category Ident (WCV)

where $[\text{F}] \in$ {[coronal], [dorsal], [labial]}

In the above definitions, $\downarrow$ stands for general dominance: $\alpha \downarrow \beta$ is true iff α dominates β. When appearing in a sequence, such as $\alpha \downarrow \beta \downarrow \gamma$, this expression is true iff $\alpha \downarrow \beta$ and $\beta \downarrow \gamma$. Because the relation is general dominance, not strict dominance, it is transitive; if $\alpha \downarrow \beta \downarrow \gamma$, then $\alpha \downarrow \gamma$. The use of general dominance is key to capturing cross-category interactions.

The three types of IDENT listed in (19) are found across all three possible relations, shown in the table below. There are thus six different IDENT constraint forms for each place feature.

Table 2.1: Summary of place processes

Segments	Place	Example	Language
Long-distance	Cross-category	—	—
	Within-C	*p…k͡p	Ngbaka
	Within-V	*p…p^{w}	Pohnpeian
Local	Cross-category	/ok/ → [ok͡p]	Vietnamese
	Within-C	/inp/ → [imp]	English
	Within-V	/ot/ → [ot^{w}]	Aghem
Input/output	Cross-category	/k͡p/ → [k^{w}]	Mumuye
	Within-C	/k͡p/ → [k]	Amele
	Within-V	/ot/ → [ot^{w}]	Aghem

In the Mumuye example, the mapping of /k͡p/ → [k^{w}] is faithful in the sense that both the input and the output contain both [dorsal] and [labial] features, yet they differ in their place in the geometry. While the within-category IDENT constraints will assign violations against this mapping, the cross-category definition will not: in each case, the root node dominates both [dorsal] and [labial]. This is explained in detail in Section 5.6.2.

Each of the constraint schemas above is used in the constraint building algorithms defined in (43–46) to result in the set of actual constraints in CON.

To see how these definitions count violations, a constraint for the feature [dorsal] is given below, for each schema. The counting is the same regardless of the relation chosen, but for the purpose of this example the $\mathfrak{R}_{io}$ relation is used.[3]

(20) **Cross-category Identity**

id-agr.K_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \ \wedge \ ((\bullet_1 \downarrow [\text{dor}]) \oplus (\bullet_2 \downarrow [\text{dor}]))$

[3]A further note on the naming conventions for the constraints themselves: all identity constraints begin with a prefix 'id' followed by any of 'io', 'cc', or 'agr', which represents the segmental relation on which the constraint operates. This is separated with a period from place features for that constraint, and finally a subscripted $_X$, $_C$, or $_V$ indicates whether the constraint is cross- or within-category for C-place or V-place, respectively. All markedness constraints begin with the prefix 'm', and Corr constraints with 'Corr'.

(21) **Within-category C-place Identity**

id-io.K_C

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2)$ $\wedge$ $((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{dor}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{dor}]))$

(22) **Within-category V-place Identity**

id-io.K_V

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2)$ $\wedge$ $((\bullet_1 \downarrow \text{V-pl} \downarrow [\text{dor}]) \oplus (\bullet_2 \downarrow \text{V-pl} \downarrow [\text{dor}]))$

In all constraint definitions to follow, a subscript $_X$ after the constraint indicates that this is a cross-category constraint: it is not sensitive to the specific V- or C-place nodes. Likewise, $_C$ and $_V$ indicate that the constraint is only sensitive to those specific place nodes indicated. The annotated violation tableau in (25) illustrates the basic way these constraints count violations. Two types of potential input/output disparities, promotion and demotion, are defined below.

(23) **Promotion**

A place feature present in V-place in the input appears in C-place in the output.

e.g. /k^w/ → [$\widehat{kp}$]

(24) **Demotion**

A place feature present in C-place in the input appears as V-place in the output.

e.g. /$\widehat{kp}$/ → [k^w]

In each case, there is a change in both V- and C-place features, yet the overall set of place features for each segment remains constant. Violation counting for demotion is shown in the tableau below.

(25) Demotion of [dorsal] C-place:

$\bullet_1$ / C-pl / [dor]	id-io.K_X	id-io.K_C	id-io.K_V
a. $\bullet_2$ / C-pl / [dor]	$\bullet_1 \downarrow$ [dor] = True $\bullet_2 \downarrow$ [dor] = True Violations: 0	$\bullet_1 \downarrow$ C-pl $\downarrow$ [dor] = True $\bullet_2 \downarrow$ C-pl $\downarrow$ [dor] = True Violations: 0	$\bullet_1 \downarrow$ V-pl $\downarrow$ [dor] = False $\bullet_2 \downarrow$ V-pl $\downarrow$ [dor] = False Violations: 0
b. $\bullet_2$ / V-pl / [dor]	$\bullet_1 \downarrow$ [dor] = True $\bullet_2 \downarrow$ [dor] = True Violations: 0	$\bullet_1 \downarrow$ C-pl $\downarrow$ [dor] = True $\bullet_2 \downarrow$ C-pl $\downarrow$ [dor] = False Violations: 1	$\bullet_1 \downarrow$ V-pl $\downarrow$ [dor] = False $\bullet_2 \downarrow$ V-pl $\downarrow$ [dor] = True Violations: 1

The input root node dominates a C-place node which dominates a [dorsal] feature. Candidate (a) is fully faithful. For each of the constraints, the structural condition in the input holds the same as it does in the output. It does not matter whether the condition is True or False, only that it be identical.

For candidate (b), C-pl $\downarrow$ [dor] is True for the input and False for the output, so there is one violation of id-io.K_C. Likewise for id-io.K_V, V-pl $\downarrow$ [dor] is False for the input but True for the output.

Through ignoring the specific V- or C-place nodes themselves, the cross-category constraint is satisfied as long as the same place feature is *somewhere* in the geometry. Also note that if the above relation were not input/output but two adjacent segments, cross-category agreement would be satisfied by a [dorsal] vowel adjacent to a [dorsal] consonant, and likewise for other features and their respective constraints.

Three additional potential processes are defined below.[4]

[4]While these are defined specifically along the input/output dimensions, there are parallel disparities along surface correspondence and adjacency dimensions. These are described generally as *semohomorganic* pairs (defined in Chapter 3) in that the place of one segment is a subset of the place of the other.

(26) **Sprouting**

A place feature absent from a segment in the input appears on that segment in the output.

e.g. /k/ → [k͡p], /k/ → [k^{w}]

(27) **Shedding**

A place feature absent from a segment in the output appears on that segment in the input.

e.g. /k͡p/ → [k], /k^{w}/ → [k]

(28) **Displacement**

Shedding + sprouting of different place features.

e.g. /k/ → [t]

Sprouting is the addition of a place feature, and shedding is the removal of one. While these can be thought of as similar to place deletion and epenthesis, the IDENT constraints defined here have as their locus root nodes, not the features themselves. Identity is evaluated on whether root nodes stay in constant relations with the relevant place features. However, the connection between privative place identity and epenthesis/deletion is noted in McCarthy & Prince 1995: fn. 49. Identity defined for privative place features is also crucially defined in Pater 1999 and Lombardi 2001. It is stressed that in the theory of this dissertation, the correspondence relationship (whether $\mathfrak{R}_{io}$ or $\mathfrak{R}_{cc}$) operates between root nodes (segments) only, *not* between individual features.

In place shedding, there is an input place, either dominated by V- or C-place, that does not exist in the output (or rather, is not associated with the root node in question). In the mapping /k͡p/ → [k], the input root node dominates a [labial] C-place feature, but the output root node dominates no [labial] feature at all. Shedding processes violate both the XC version of the constraint, and the within-category constraint for the category of the place feature that has shed (in this case, C-place). Sprouting is parallel to shedding, except a feature is added instead of removed. Displacement is a combination of shedding and sprouting, for

different features. The following hypothetical candidate sheds a [dorsal] feature and sprouts a [coronal] one; an example of displacement.

(29) a. Input:

$\bullet_1$
|
C-place
|
[dorsal]

b. Output:

$\bullet_2$
|
C-place
|
[coronal]

c. Correspondence:

$\bullet_1 \mathfrak{R}_{io} \bullet_2$

(30) [dorsal] shedding:

a. $\bullet_1 \downarrow$ [dor] = True

b. $\bullet_2 \downarrow$ [dor] = False

(31) [coronal] sprouting:

a. $\bullet_1 \downarrow$ [cor] = False

b. $\bullet_2 \downarrow$ [cor] = True

(32) Evaluation of id-io.K_C:

a. $\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge (\bullet_1 \downarrow$ C-pl $\downarrow$ [dor] $\oplus \bullet_2 \downarrow$ C-pl $\downarrow$ [dor])

b. $\langle \bullet_1, \bullet_2 \rangle$ / **True** $\wedge$ $(\bullet_1 \downarrow$ C-pl $\downarrow$ [dor] $\oplus \bullet_2 \downarrow$ C-pl $\downarrow$ [dor]) 29c

c. $\langle \bullet_1, \bullet_2 \rangle$ / True $\wedge$ (**True** $\oplus \bullet_2 \downarrow$ C-pl $\downarrow$ [dor]) 30a

d. $\langle \bullet_1, \bullet_2 \rangle$ / True $\wedge$ (True $\oplus$ **False**) 30b

e. $\langle \bullet_1, \bullet_2 \rangle$ / True $\wedge$ **True** def. $\oplus$

f. $\langle \bullet_1, \bullet_2 \rangle$ / **True** def. $\wedge$

Recall that in the definition of the general constraint formulation, a violation is assigned for each locus that meets some structural condition (see 17). Because this condition has evaluated to True, a violation is assigned. Violation counting works the same regardless of the relation at hand.

In addition to varying the structural relation of root node to feature $\mathcal{S}$, the constraints also vary in their relation between root nodes, or segments, $\mathfrak{R}$. The full list of individual Identity constraints are given in (33–35). Note that this is **not** the list of constraints that are in CON. The constraints in CON are the results of constraint building algorithms based on the summation operation, defined in the next section.

(33) Input/Output Identity

a. id-io.$[\text{F}]_{\text{X}}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{\text{io}} \bullet_2) \wedge ((\bullet_1 \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow [\text{F}]))$

—

Assign a violation for all disparities in [F] between input and output correspondents.

b. id-io.$[\text{F}]_{\text{C}}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{\text{io}} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{F}]))$

—

Assign a violation for C-place disparities in [F] between input and output correspondents.

c. id-io.$[\text{F}]_{\text{V}}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{\text{io}} \bullet_2) \wedge ((\bullet_1 \downarrow \text{V-pl} \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow \text{V-pl} \downarrow [\text{F}]))$

—

Assign a violation for V-place disparities in [F] between input and output correspondents.

The input/output correspondence relation $\mathfrak{R}_{\text{io}}$ is a relation over $\mathbb{I} \times \mathbb{O}$, where $\mathbb{I}$ is the set of input segments and $\mathbb{O}$ the set of output segments. It is assumed to be intransitive, irreflexive, and asymmetric. Because it is a relation from input to output, in the identity definitions here, $\bullet_1$ always refers to the input root node.

(34) Surface Correspondence Identity

a. id-cc.$[\text{F}]_{\text{X}}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{\text{cc}} \bullet_2) \wedge ((\bullet_1 \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow [\text{F}]))$

—

Assign a violation for all disparities in [F] between surface correspondents.

b. id-cc.$[\text{F}]_{\text{C}}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{\text{cc}} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{F}]))$

—

Assign a violation for C-place disparities in [F] between surface correspondents.

c. id-cc.$[\text{F}]_{\text{V}}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{\text{cc}} \bullet_2) \wedge ((\bullet_1 \downarrow \text{V-pl} \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow \text{V-pl} \downarrow [\text{F}]))$

—

Assign a violation for V-place disparities in [F] between surface correspondents.

The surface correspondence relation $\mathfrak{R}_{\text{cc}}$ is a relation over $\mathbb{O} \times \mathbb{O}$. Following the formulation in Bennett 2013, it is an equivalence relation: transitive, symmetric, and reflexive. The specific cases of surface correspondence identity analyzed here (in Chapter 3) involve only pairs of segments, either in correspondence or not. When identity is evaluated for pairs in correspondence, the constraint treats the locus as a set of segments, not an ordered pair. In other words, for each place-disparity-containing correspondence pair C1 and C2, one violation is assigned per the set of 2 segments, *not* one for each of $\langle \text{C1}, \text{C2} \rangle$ *and* $\langle \text{C2}, \text{C1} \rangle$.

(35) Local Agree Identity

a. id-agr.$[\text{F}]_{\text{X}}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{\text{adj}} \bullet_2) \wedge ((\bullet_1 \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow [\text{F}]))$

—

Assign a violation for all disparities in [F] between adjacent segments.

b. id-agr.[F]$_{C}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{F}]))$

—

Assign a violation for C-place disparities in [F] between adjacent segments.

c. id-agr.[F]$_{V}$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow \text{V-pl} \downarrow [\text{F}]) \oplus (\bullet_2 \downarrow \text{V-pl} \downarrow [\text{F}]))$

—

Assign a violation for V-place disparities in [F] between adjacent segments.

All root nodes are linearly ordered. The adjacency relation $\mathfrak{R}_{adj}$ is defined over $\mathbb{O} \times \mathbb{O}$ and contains all pairs of adjacent root nodes, respecting the linear order. It is intransitive, irreflexive, and asymmetric; essentially a successor relation. As noted by Bakovic 2000, the AGREE-style constraints are very similar in function to IDENT constraints. Here, this similarity is exploited to the point of AGREE constraints being based on the same schema as Ident. The modular definitions here mean that the AGREE constraints differ from the IDENT constraints only in the relation over which they operate.

2.3.2 Identity for binary features

The original IDENT schema from McCarthy & Prince 1995 is based on binary features (with discussion on extension to privative features). Here, the IDENT schema uses specific structural relations, not feature values, to calculate identity between segments. However, if the feature is binary, the corresponding constraint can be defined with the following schema:

(36) Binary Feature Identity

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R} \bullet_2) \wedge ((\bullet_1 \downarrow [\alpha \text{F}]) \oplus (\bullet_2 \downarrow [\alpha \text{F}]))$

The symbol α is a variable that ranges over feature values $\{+, -\}$. Its use in the above definition ensures that the feature associated with either segment must have the same value; if not, the constraint assigns a violation. For example, if the constraint mediates a binary-

valued [voice] feature, the constraint checks for equal truth values of • ↓ [αvoice] with respect to each root node. Further refinement would be needed with ternary- or multi-valued features as well as with underspecification; in this dissertation, place features are assumed to be privative and all others binary.

2.4 Building Constraints via Constraint Summation

The individual constraints defined in the previous section are built into the sets of constraints based on a universal markedness hierarchy via algorithms defined in this section. The general set of constraints are scaled; these constraints are stringently-defined constraints built via Constraint Summation based on a universal hierarchy. Constraint summation is defined in (37).

(37) **Constraint Summation**

Given a set of constraints $\{C_1, \ldots, C_n\}$ and a set of candidates $\{x | x = \langle i, o, R \rangle\}$, a constraint C_Σ can be formed such that: $\forall x C_\Sigma(x) = C_1(x) + \ldots + C_n(x)$

For example, consider the following two markedness constraints that violate against [dorsal] C-place and [labial] C-place respectively.

(38) $m.K_C$

• / • ↓ C-place ↓ [dorsal]

(39) $m.P_C$

• / • ↓ C-place ↓ [labial]

The summation of these two constraints is defined below. The summation operation is indicated with a plus sign (+) in the constraint definition.

(40) $m.KP_C$

• / • ↓ C-place ↓ [dorsal] +

• / • ↓ C-place ↓ [labial]

The evaluation counts all root nodes that dominate [dorsal] C-place, and then all root nodes that dominate [labial] C-place (this notation is fully defined in the next section). The resulting effect is shown in the VT below.

(41)

	$m.K_C$	$m.P_C$	$m.KP_C$
k	1	0	1 (1+0)
p	0	1	1 (0+1)
k͡p	1	1	2 (1+1)

This is the basic operation that will build constraints relating to place markedness and identity on all dimensions. The set of constraints present in CON is built from following algorithms in addition to the constraint schemas defined in the next section.

All constraints defined here are based, on some way, on the following universal markedness hierarchy for Place of Articulation (PoA).

(42) **Universal PoA Markedness Hierarchy (UMH)**

[dorsal] ≻ [labial] ≻ [coronal] (≻ [gottal])

The hierarchy here is taken from de Lacy 2006: 35, which in turn is based on previous implementations in Prince & Smolensky 1993, Lombardi 2001, de Lacy 2002, among others. Glottal place is included in the heirarchy, but in parentheses as I abstract away from glottal place for simplicity in the systems discussed in this dissertation. This dissertation assumes a 3-point scale ending with [coronal] to both keep candidate sets and constraint sets confined to focus on the relevant place interactions for labial-velars, clicks, and simple oral stops. However, certain claims about markedness rely on every segment having a place feature, and there being a markedness constraint that refers to all place features. This is discussed further in Chapter 5.

This hierarchy also differs from de Lacy 2006 in that the UMH here is an ordering of place features, while in de Lacy 2006, it is an ordering of feature *values* for a single, multi-valued place of articulation feature. Referring to individual features in the hierarchy

is assumed here as it makes the representation of complex place in general straightforward, following Sagey 1986: complex segments have multiple place features. In a theory where place of articulation is represented by a single, mult-valued place feature (one value for dorsals, one for labials, etc.), it is not clear how complex, double-articulations are represented.

Taking both the markedness hierarchy in (42) and the constraint schemas in (33–35) as arguments, the following algorithms build the sets of constraints in CON.

(43) **Scaled Constraint Building Algorithm**

1. Given a constraint schema C and hierarchy H, construct a constraint C(f) for each f on H
2. Apply Constraint Summation from the largest set S of constraints such that:
   a) The constraint C(f) where f is the highest member on H is included
   b) All constraints C(f) in S are based on features f that are contiguous on H
   c) The resulting constraint is not already in CON
3. Add the result of 2 to CON.
4. Go to 2. If 2 fails, end.

This is based on de Lacy 2006: Ch. 2, specifically The Marked Reference Hypothesis in (7), and the hierarchy conditions in (9) and (11). The relationship between a formal hierarchy and a set of constraints is expressed here as an explicit constraint building algorithm, but it is not necessarily the case that this algorithm itself has any active cognitive reality—it is simply meant to describe a set of constraints equal to the ones assumed in UG.

To see how this algorithm works, the set of scaled constraints for cross-category IO identity (33) is built from the hierarchy in (42):

(44) Scaled Constraint Building Algorithm, $\mathfrak{R}_{io}$, Cross-category

1. $\{\text{id-io.K}_X, \text{id-io.P}_X, \text{id-io.T}_X\}$ Individual constraints built based on UMH.
2. id-io.KPT_X Apply summation to largest set.
3. $\text{id-io.KPT}_X \in \text{CON}$ Add result to CON.

4. Go to 2.

2′. id-io.KP_X Apply summation to largest set not yet created.

3′. id-io.$KP_X \in$ CON Add result to CON.

4′. Go to 2.

2″. id-io.K_X Apply summation largest set not yet created.

3″. id-io.$K_X \in$ CON Add result to CON.

4″. Go to 2.

2‴. ∅. End.

After this pass of the algorithm, CON = {id-io.KPT_X, id-io.KP_X, id-io.K_X}. Note that even though the constraints id-io.P_X and id-io.T_X are created in Step 1, they are never added to CON, and thus do not exist in constraints in the system as a result of this algorithm. In broader terms, the existence of a summed constraint does not necessarily entail its individual constraints.

The following two algorithms are for reference. When the typology does not demand scaled constraints, one of the two algorithms will be assumed for simplicity.

(45) **Summed Constraint Building Algorithm**

1. Given a constraint schema C and hierarchy H, construct a constraint C(f) for each f on H
2. Apply Constraint Summation from the entire set S above
3. Add the result of 2 to CON. End.

The result of the Summed Constraint Building Algorithm is referred to an omnibus constraint: one mediating all place features in a given class or hierarchy.

(46) **Individual Constraint Building Algorithm**

1. Given a constraint schema C and hierarchy H, construct a constraint C(f) for each f on H
2. Add the result of 1 to CON. End.

C-Place markedness and faithfulness, as well as agreement, are argued to be stringently defined via the Scaled Constraint Building Algorithm. The other two algorithms are included for simplicity; due lack of strong cross-linguistic examples for long-distance identity, for instance, there isn't direct evidence for a set of scaled CCIDENT constraints, so a single constraint is used. Likewise for V-place markedness; individual constraints for each feature are used in Chapter 4, but only as a stand-in as the locus of investigation is not the full interaction of V-place directly.

2.4.1 Comparison with local conjunction and disjunction

Constraint Summation is a process on constraints that is distinct from both local constraint conjunction and local constraint disjunction. Constraint summation is a non-Boolean operation, so violation marks can accrue; this is desired. Faithfulness constraints that are the result of Summation, for instance, evaluate semihomorganic mappings such as /k͡p/→[K] to be less unfaithful than purely heteroganic ones such as /k͡p/→[T]. Further, complex segments are more marked than those with a single place, as they would receive two violations from markedness constraints, rather than just one.

Local conjunction through itself can differentiate between simple and complex place, while disjunction itself cannot.

(47) Markedness of summation compared with hypothetical conjunction and disjunction

output	m.KP	m.K&P	m.K∨P
k	1	0	1
p	1	0	1
k͡p	2	1	1

The disjunction constraint m.K∨P assigns 1 violation to each candidate, as each is [dorsal] *or* [labial]. The summed constraint m.KP and the conjoined constraint m.K&P are effectively identical in this small candidate set: both differentiate between simple and complex place only. However, with the conjoined constraint, the marks are 0 vs. 1, while in the

summed version it's 1 vs. 2. In sum, constraints defined via conjunction can differentiate simple vs. complex place, while those defined via disjunction cannot.

What connective, then, should be used for scaling constraints? Ignoring summation for the moment, disjunction is the better choice for scaling constraints, as the following two tableaux demonstrate.

(48) Hypothetical Scaled Markedness defined via Local Disjunction

Disjunction	mK∨P∨T	mK∨P	mK
k	1	1	1
p	1	1	0
t	1	0	0
t͡p	1	1	0
k͡t	1	1	1
k͡p	1	1	1

The constraints defined via disjunction show the intended effects of more marked segments (in terms of the UMH) having more violation marks overall than the lessor-marked segments. The simple stops here also align with the violation profiles given in de Lacy 2006: 50, reproduced below.

(49) 'Quasi-tableau showing stringency', from de Lacy 2006: Ch. 2 (10)

	*{dors}	*{dors, lab}	*{dors, lab, cor}	*{dors, lab, cor, gl}
k	*	*	*	*
p		*	*	*
t			*	*
ʔ				*

The violation marks for [k p t] parallel those for disjunction in (48). However, de Lacy does not consider complex place, so the specific constraints define there are ambiguous with respect to complex segments.

Scaled constraints based on disjunction also differ from a corresponding constraint set defined via Local Constraint Conjunction. Assume such a constraint m.K&m.P. This constraint assigns a violation for every segment that is dorsal and labial. This would assign violations to labial-velars such as k͡p and g͡b but not to simple segments. While it still has

utility with respect to complex place, a different theory of constraint building would need to be assumed.

(50) Hypothetical Scaled Markedness defined via Local Conjunction

Conjunction	mK&P&T	mK&P	mK
k	0	0	1
p	0	0	0
t	0	0	0
t͡p	0	0	0
k͡t	0	0	1
k͡p	0	1	1

This tableau assumes the conjunction operation is substituted wholesale into the Scaled Constraint Building Algorithm. While this results in a constraint set of little utility, conjunction does have a more general use with respect to complex place. If we assume a conjunction for every possible combination of place features, we end up with a set of constraints that target each possible complex segment individually:

(51) Hypothetical conjoined constraints for each place combination

	m.K&P	m.T&P	m.K&T
k͡p	*		
t͡p		*	
c			*
k			
p			
t			

Complex stops are now differentiated from simple stops. This could be combined with disjunction to give both a set of constraints that capture stringency relations between segments (as in (48)); however, this requires two algorithms and two connectives. Constraint summation can do both as a single connective with one algorithm.

(52) Scaled Markedness defined via Summation

Summation	m.KPT	m.KP	m.K
k	1	1	1
p	1	1	0
t	1	0	0
t͡p	2	1	0
k͡t	2	1	1
k͡p	2	2	1

Like disjunction, the summation approach shows stringency effects with respect to place markedness. Like conjunction, summation can also differentiate between simple and complex place, as the result is a sum of violations and not a boolean value as with disjunction. The theory in this dissertation utilizes summation for this reason.

2.5 Parasitic Identity

Parasitic identity is an extension of the generalized identity schema that restricts identity between root nodes when one or both segments also meet some other specified condition. This is necessary to differentiate V-place faithfulness between vowels and consonants, and it is used to restrict agreement patterns in the analyses of Vietnamese and Aghem in Chapter 4.

For example, in Vietnamese, agreement between a vowel and a consonant occurs only if the consonant is [dorsal]. The standard AGREE constraint is given below.

(53) id-agr.KPT$_X$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge (\bullet_1 \downarrow [dor]) \oplus (\bullet_2 \downarrow [dor])$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge (\bullet_1 \downarrow [lab]) \oplus (\bullet_2 \downarrow [lab])$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge (\bullet_1 \downarrow [cor]) \oplus (\bullet_2 \downarrow [cor])$

The parasitic version of the constraint is defined with the stipulation that $\bullet_2$ is [dorsal], limiting its effect to those sequences. This part of the definition is underlined for reference.

(54) id-agr.KPT$_X$/K

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) $\wedge$ ($\bullet_1 \downarrow$ [dor]) $\oplus$ ($\bullet_2 \downarrow$ [dor]) $\underline{\wedge \bullet_2 \downarrow \text{C-pl} \downarrow \text{[dor]}}$ +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) $\wedge$ ($\bullet_1 \downarrow$ [lab]) $\oplus$ ($\bullet_2 \downarrow$ [lab]) $\underline{\wedge \bullet_2 \downarrow \text{C-pl} \downarrow \text{[dor]}}$ +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) $\wedge$ ($\bullet_1 \downarrow$ [cor]) $\oplus$ ($\bullet_2 \downarrow$ [cor]) $\underline{\wedge \bullet_2 \downarrow \text{C-pl} \downarrow \text{[dor]}}$

This is similar in spirit to conjoining the AGREE constraint with a markedness constraint against [dorsal] C-place, such as m.K$_C$.[5] However, because AGREE is effectively non-categorical, the conjunction must occur with each individual part of Agree-place, as shown:

(55) Agree-place & m.K$_C$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) $\wedge$ ($\bullet_1 \downarrow$ [dor]) $\oplus$ ($\bullet_2 \downarrow$ [dor]) & $\bullet$ / $\bullet \downarrow$ C-pl $\downarrow$ [dor] +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) $\wedge$ ($\bullet_1 \downarrow$ [lab]) $\oplus$ ($\bullet_2 \downarrow$ [lab]) & $\bullet$ / $\bullet \downarrow$ C-pl $\downarrow$ [dor] +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) $\wedge$ ($\bullet_1 \downarrow$ [cor]) $\oplus$ ($\bullet_2 \downarrow$ [cor]) & $\bullet$ / $\bullet \downarrow$ C-pl $\downarrow$ [dor]

Logically, the ampersand & in the constraint definition is functionally equivalent to $\wedge$, but it is used to indicate that the definition is the result of a local constraint conjunction. However, there are remaining issues as well: in local constraint conjunction, the two constraints must share a locus of violation. In the case above, the locus for AGREE is a segment pair, while for markedness it is a single root node. Even though the single root node is a member of the pair for agree, they are not identical. Further, there are additional questions of how, if at all, two summed constraints can be conjoined. Putting these questions aside, I assume that parasitic identity is captured by altering the definition as needed and not via an additional operation of constraint conjunction on summed constraints.[6]

In addition to the Vietnamese patterns, V-place IO faithfulness for consonants and vowels is also defined as parasitic ident, for the feature [±consonantal]. In Chapter 4, certain patterns require forms to have unfaithful secondary articulation (V-place on consonants), while vowels remain faithful (V-place on vowels). Thus, there are two forms of V-place identity, one for each value of [±consonantal].

[5] See also the discussion of formulating positional faithfulness constraints generally as local conjunctions in Tesar 2013: 129.

[6] Thanks to Bruce Tesar for discussion on these points.

(56) id-io.KPT$_V$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor])) $\wedge$ $(\bullet_1 \downarrow$ [+cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [lab])) $\wedge$ $(\bullet_1 \downarrow$ [+cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [cor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [cor])) $\wedge$ $(\bullet_1 \downarrow$ [+cons])

—

"Assign a violation for each pair of [+cons] segments in IO correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place, and for each with a disparity in coronal V-place."

(57) id-io.EAO

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor])) $\wedge$ $(\bullet_1 \downarrow$ [−cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [lab])) $\wedge$ $(\bullet_1 \downarrow$ [−cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [cor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [cor])) $\wedge$ $(\bullet_1 \downarrow$ [−cons])

—

"Assign a violation for each pair of [−cons] segments in IO correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place, and for each with a disparity in coronal V-place."

While both constraints police V-place disparities, the split between − and [+cons] splits the work between consonants and vowels:

(58)

input	output	id-io.EAO	id-io.KPT$_V$	Sprouted V-pl	Shedded V-pl
a	o	*		[lab]	
e	a	**		[dor]	[cor]
e	o	***		[lab], [dor]	[cor]
C	C$^{\gamma}$		*	[dor]	
C^{w}	C		*		[lab]
C^{j}	C^{w}		**	[lab]	[cor]

2.6 Summary of constraint types

Table (2.2) below summarizes each general constraint type discussed. The Locus column refers to the size and type of the locus of violation. Here, the locus is always either a single root node or an ordered pair of root nodes. The Rel column refers to what structural relations are used in the definition of the constraint.

Table 2.2: Summary of constraint types

Schema	Example	Locus	Rel	Ident	Output	Input	Mark	Faith
Output Structure	m.K	$\bullet$	$\downarrow$		✓		✓	
AGREE	id-agr.K	$\langle\bullet,\bullet\rangle$	$\downarrow, \mathfrak{R}_{adj}$	✓	✓		✓	
IOIDENT	id-io.K	$\langle\bullet,\bullet\rangle$	$\downarrow, \mathfrak{R}_{io}$	✓	✓	✓		✓
CCIDENT	id-cc.K	$\langle\bullet,\bullet\rangle$	$\downarrow, \mathfrak{R}_{cc}$	✓	✓		✓?	
Similarity	Corr.K	$\langle\bullet,\bullet\rangle$	$\downarrow, \mathfrak{R}_{cc}$		✓		✓?	

(59) Unary relations:

a. $\mathbb{O}$ = set of output segments (root nodes)

b. $\mathbb{I}$ = set of input segments (root nodes)

In the table above, the Rel column refers to what relations the constraint definition refers to. The IDENT column marks whether the constraint is based on the Identity schema. The Output column refers to whether the constraint refers to the output. (All constraints refer to the output.) The Input column marks whether the constraint refers to the input. The last to columns, Mark and Faith, are informally there to show what types of constraints are traditionally referred to as a Markedness or a Faithfulness constraint. With the addition of surface correspondence constraints, which are based on traditional faithfulness constraints but refer only to the output, the term Faithfulness becomes cloudy. This is not a new observation: McCarthy & Prince 1995 differentiate Faithfulness from Identity, as Identity operates along both the base-reduplicant dimension and input-output dimension. Bakovic 2000 also makes note of the parallels between IDENT constraints and AGREE constraints.

In the system here, all three of IO Identity, CC Identity, and AGREE are based explicitly on the same constraint schema, with the only difference being the exact binary relation the constraint operates on.

2.7 Additional constraint schemas

2.7.1 Similarity Schema

The similarity, or Corr, constraints, are necessary for encouraging surface correspondence in the Agreement by Correspondence framework (Rose & Walker 2004, Hansson 2010, Bennett 2013). Together with CC and IO IDENT constraints, long-distance agreement (and dissimilation) are captured.

(60) Corr.[F]

$\langle \bullet_1, \bullet_2 \rangle$ / $\neg(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge \mathbb{O}(\bullet_{1,2}) \wedge \bullet_1 \downarrow$ C-pl $\downarrow$ [F] $\wedge \bullet_2 \downarrow$ C-pl $\downarrow$ [F]

Assign a violation for each pair of output [F] consonants that are not in surface correspondence.

(61) a. $\mathbb{O}(\bullet)$ is True iff $\bullet$ is in the output

b. $\mathbb{O}(\bullet_{1,2}) = \mathbb{O}(\bullet_1) \wedge \mathbb{O}(\bullet_2)$

In the analysis of Ngbaka in Chapter 3, individual constraints are assumed: Corr.K, Corr.P, and Corr.T.

2.7.2 Output Structure Constraints

Output structure constraints are a subset of what are traditionally considered markedness constraints. In this dissertation, they are markedness constraints that refer only to segmental structure: in other words, the only relation used in the definition is the domination ($\downarrow$) relation. This type of constraint is also called a horizontally context-free markedness constraint in de Lacy 2006, due to the fact that it doe not refer to other root nodes, but may refer to

higher or lower prosodic nodes. Output Structure constraints are understood to operate only on the set of output segments $\mathbb{O}$; this is implicit in their definition.

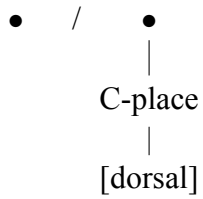
In all constraint definitions, the bullet • represents a segmental root node, and the down arrow ↓ represents domination. This notation is following de Lacy 2011. Multiple instances of the ↓ relation in a row, such as $x \downarrow y \downarrow z$, is equivalent to $x \downarrow y \wedge y \downarrow z$. Also crucial is that this does not refer to *immediate* domination; this is exploited in the definition of the within-category identity constraints versus the cross-category identity constraints.

(62) $m.K_C$

• / • ↓ C-place ↓ [dorsal]

This is equivalent to having the full tree structure in the definition of the constraint:

(63) $m.K_C$



The set of C-place constraints is scaled:

(64) a. $m.KPT_C$

b. $m.KP_C$

c. $m.K_C$

Having both scaled markedness and faithfulness constraints captures the effects explored in de Lacy 2006, where simple stops always reduce to the least marked place on the scale, while also capturing gaps in segmental inventories. In addition, it allows the target of reduction for a complex stop to be either semihomorganic place. The typology of these interactions are surveyed and analyzed in Chapter 5.

V-place markedness on consonants is assumed to be individual constraints. This captures the intended effects in Aghem, but keeps the ranking interactions simple. This is discussed more in Chapter 4.

(65) a. $m.K_V$

b. $m.P_V$

c. $m.T_V$

In a larger study of the cross-linguistic patterns of vocalic place on consonant, there might be evidence to use the same scaled constraints as with C-place features. Individual constraints are assumed here for simplicity.

2.8 Additional assumptions about segmental structure

I assume that the feature [consonantal] separates consonants and glides from vowels. While this is a common assumption, there are other ways to make this distinction as well, such reference to a projected mora, or related features such as [vocoid] or [syllabic]. The analysis does not crucially rely on the use of [consonantal] itself; most if not all theories will have some way to make the same distinction either featurally or structurally. The motivation here is so certain constraints can differentiate between V-place on consonants and V-place on vowels, and to separate the glide [w] from a back round vowel like [o]. The feature specifications for common segments discussed in this dissertation are given below.

(66)

	[consonantal]	C-place	V-place
t	+	[cor]	
p	+	[lab]	
k	+	[dor]	
k͡p	+	[lab], [dor]	
t͡p	+	[lab], [cor]	
c	+	[cor], [dor]	
k^w	+	[dor]	[lab]
t^w	+	[cor]	[lab]
w	+		[lab], [dor]
o	−		[lab], [dor]
a	−		[dor]
e	−		[cor]

For other features, such as [voice] or [nasal], I do not make specific arguments about their place in the geometry and for simplicity I assume a basic bottlebrush representation following again Padgett 2002, where each feature connects directly to the root node as behavior of non-place feature classes are not crucially discussed.

It is important to note that the C- and V-place nodes cannot be reduced to representation-external definitions as the rest of the class nodes are in Feature Class Theory, as the position of features within these nodes is a segment-specific property. In other words, while [voice] is always a laryngeal feature and thus can be defined as one outside of the structure of a particular segment, place features such as [coronal] are *either* C-place or V-place (or both), depending on that particular segment. As a result, the nodes must be included in the geometry itself.

2.8.1 Airstream

In addition to the major place features and their standard definitions, other relevant features are [voice] for voiced segments, and [lingual] for click segments—those with the lingual airstream mechanism, following Miller 2007.

(67) **[lingual] Condition on GEN**

A segment is [+lingual] only if the C-place of the segment is [dorsal] AND either [labial] or [coronal]

Similar to how [+distributed] and [+anterior] are only possible with [coronal] place, [+lingual] is dependent on both [dorsal] place and one other place feature. Depending on the exact definition of [+lingual], segments that have this feature but do not meet the requirements stated for place fall into the realm of phonetically impossible segments (see Walker & Pullum 1999 for general discussion). The lingual, or velaric, airstream mechanism requires full closure both with the tongue dorsum and at either the lips or tongue tip in order for negative pressure to be achieved in this cavity for the ingressive airflow. Such segments could perhaps be repaired somehow by the phonetic implementation, but for the purposes of this dissertation they are assumed to not be generated as candidates. Phonologically, this means there are no [+lingual] simple stops nor are there [+lingual] labial-coronals. The typological effect of this is explored in Chapter 5.

(68) Place and lingual dependencies

	coronal	labial	dorsal	lingual
t	✓			–
p		✓		–
k			✓	–
t͡p	✓	✓		–
c	✓		✓	–
k͡p		✓	✓	–
!, ǀ, ǁ, ǂ	✓		✓	+
ʘ		✓	✓	+

For labial-velar and labial-coronal stops, there is not assumed to be any phonological representation of airstream different from simple stops. Cite Ladefoged 1968 about implosion, etc.

2.9 Differences between GIST and de Lacy 2006

The general conception of scaled markedness and faithfulness constraints here builds on de Lacy 2006. For simple segments, the reasoning and empirical coverage is the same (detailed in Chapter 5). However, with the inclusion of both complex place in the representation and the interaction of these segments in the grammar, there are a number of key differences in the formalisms here versus in de Lacy's 2006 *Markedness* (henceforth dLM).

2.9.1 Representation of place

Instead of representing a segments place of articulation with binary or privative features, a single multi-valued feature is used. The value of the feature is defined with the regular expression *x*o**, with a string length of 3 for place. Place of articulation is represented as follows:

(69) Multi-valued place of articulation features (dLM: (15))

[*xxx*Place]	dorsal
[*xxo*Place]	labial
[*xoo*Place]	coronal
[*ooo*Place]	glottal

The main utility of this representation is that the content of a universal markedness hierarchy is represented in the feature values themselves: dorsal place is the most marked, as its feature value has the longest substring of *x*'s; less marked is labial with correspondingly fewer *x*'s, and so on. However, an additional assumption of this model is that each segment has only a single place feature. It is thus not clear how complex place is represented. A natural extension would be to assume two multi-valued features for segments such as labial-velars and other complex segments:

(70) Multiple multi-valued place of articulation features for complex segments

[*xxx*Place], [*xxo*Place]	labial-dorsal
[*xxo*Place], [*xoo*Place]	labial-coronal
[*xxx*Place], [*xoo*Place]	coronal-dorsal

However, these segmental representations do not automatically translate to the same violation profiles argued to be required here.

2.9.2 Structure of constraints

The dLM definition for faithfulness (Ident) constraints based on this theory of features is given below.

(71) Subsegmental hierarchy-related faithfulness constraint definition (dLM: (20))
IDENT[*υ*F] $=_{\text{def}}$ Incur a violation for every segment S that is [*w*F] while its correspondent S′ is [*z*F], where $z \neq w$
(i) *w* is a substring of *υ*
(ii) *w* does not contain *o* elements

Essentially, the constraint assigns a violation when the *x*-containing substring of the input feature value is not strictly equal to the *x*-containing substring of the output feature value. If the input is dorsal, its feature value is *xxx*, and a violation is assigned if the output segment's place feature value is not *xxx*. Once we consider complex place, an ambiguity arises in the definition regarding what *is* is. If we assign an existential interpretation to the definition, the it will be satisfied when the input is *xxx* and there is a feature on the output segment that is also *xxx* (e.g. /k/ → [k] but also /k/ → [k͡p]). If we assume a universal interpretation, then if the input segment is *xxx*, then all place features on the output segment must also be *xxx* else a violation is assigned (e.g. only /k/ → [k]).

(72) Existential dLM IDENT
Assign a violation if S is [*w*F] and there does not exist [*w*F] in its correspondent S′.

(73) Universal dLM IDENT

Assign a violation if S is [wF] and not all of the features in its correspondent S′ are [wF]

(74) Existential and Universal interpretations of dLM IDENT constraints

	Existential			Universal		
/k͡p/	IDENT[xPlace]	IDENT[xxPlace]	IDENT[xxxPlace]	IDENT[xPlace]	IDENT[xxPlace]	IDENT[xxxPlace]
k͡p	0	0	0	0	0	1
k	0	0	0	1	1	0
p	0	0	1	1	1	1
t	1	1	1	1	1	1

In either case, mapping to a semihomorganic segment is either the same as being completely faithful, or the same as being completely unfaithful—the intermediate level of unfaithfulness is not captured as it is with Constraint Summation or Feature Class Theory. The place feature system in dLM is designed to operate over simple place, and its wholesale adaption to complex place is not possible without refinement. While dLM encorporates the content of the universal markedness hierarchy into the feature values themselves, the hierarchy itself must be a separate, abstract ordering in the model here that the constraint building mechanisms make reference to.

2.10 Chapter Summary

This dissertation proposes that place identity is based on a general identity schema which allows within- and cross-category interactions along io correspondence, surface correspondence, and adjacent segments. Following a unified theory of place, vowels and consonants

can not only agree directly for place features, as is the case in several languages. Stringent sets of constraints are built based on summation theory, which involves the summation operation and specific constraint-building algorithms. This allows partial class behavior to be captured along all relational dimensions, while also accounting for facts about reduction and inventory structure with respect to both simple and complex place.

3 Long-distance major place harmony

3.1 Introduction

Within the framework of Agreement by Correspondence (ABC) (Rose & Walker 2004, Hansson 2010, Bennett 2013 a.o.), segments that are similar for some feature(s) [F] correspond, and agree for some other feature(s) [G]. This is the basic schema to capture long-distance harmony (and dissimilation, Bennett 2013) processes. In all previous surveys of long-distance agreement processes, the agreeing feature [G] has never been found to crucially be any major place feature (labial, coronal, or dorsal). This chapter presents such a case. Ngbaka (Atlantic-Congo, Democratic Republic of the Congo) contains co-occurrence restrictions with labials, dorsals, and labial-dorsals that are best characterized as follows: labial (and certain dorsal) segments correspond, and agree for major place. This is in addition to a voicing agreement process where homorganic voiced and voiceless stops cannot co-occur.

(75) Central claims of this chapter:

a. Ngbaka co-occurrence patterns are instances of long-distance major place harmony, which is otherwise unattested.

b. These patterns are best analyzed within the Agreement by Correspondence framework (ABC, Hansson 2010, Rose & Walker 2004, Bennett 2013 a.o.), and require the existence of a surface correspondence constraint for place identity.

c. The co-occurrence patterns are statistically significant, based on an analysis of Maes 1959.

d. Complex place crucially differentiates place similarity from place identity, allowing these patterns to be detectible.

3.2 Language background

Ngbaka is related to but distinct from Ngbaka Ma'bo, which was described in Thomas 1963 and analyzed in Sagey 1986, Mester 1986, Rose & Walker 2004. The language investigated in this chapter, with data from Maes 1959, is Ngbaka (iso: nga), which is in the Gbaya-Manza-Ngbaka subfamily of Atlantic Congo. The language described in Thomas 1963, and subsequently analyzed by Sagey 1986 and Mester 1986, is Ngbaka Ma'bo (iso: nbm), in the Adamawa-Ubangi subfamily of Atlantic Congo (Hammarström et al. 2016), even though this language is often referred to as just Ngbaka as well. Henrix et al. 2007 describes part of the difference in the following quote:

> Pour se distinguer des Ngbaka ma'bo du groupe linguistique Mondjombo - Kpala - Gbanziri ils se disent Ngbaka minagende. Les deux qualificatifs "mi na ge nde" et "ma 'bo" correspondent à une phrase introduisant un discours: "je (dis) que". Nous nous en tiendrons au seul nom Ngbaka, l'ethnonyme utilisé par leurs voisins. (Henrix et al. 2007: 4)

> To distinguish it from Ngbaka ma'bo, from the language family Mondjombo-Kpala-Gbanziri, they say Ngbaka minagende. The two qualifiers "mi na ge nde" and "ma' bo" correspond to a sentence introducing speech: "I (say) that". We will stick to the single name Ngbaka, the ethnonym used by their neighbors.

The difference in classification is shown in Figure 3.1, and their general geographical locations are shown in Figure 3.2.

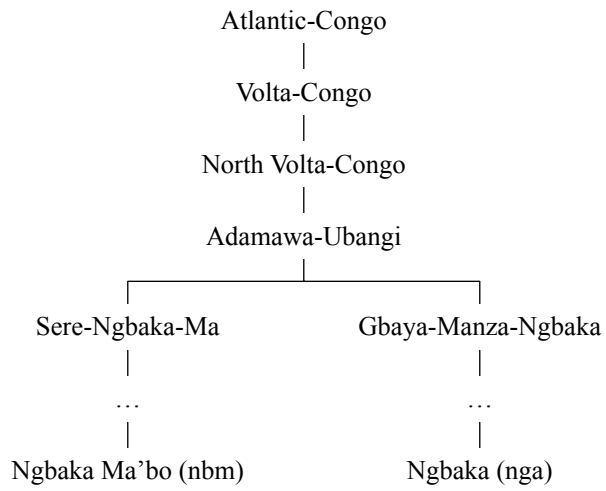


Figure 3.1: Ngbaka and Ngbaka Ma'bo language relation, from Lewis 2009

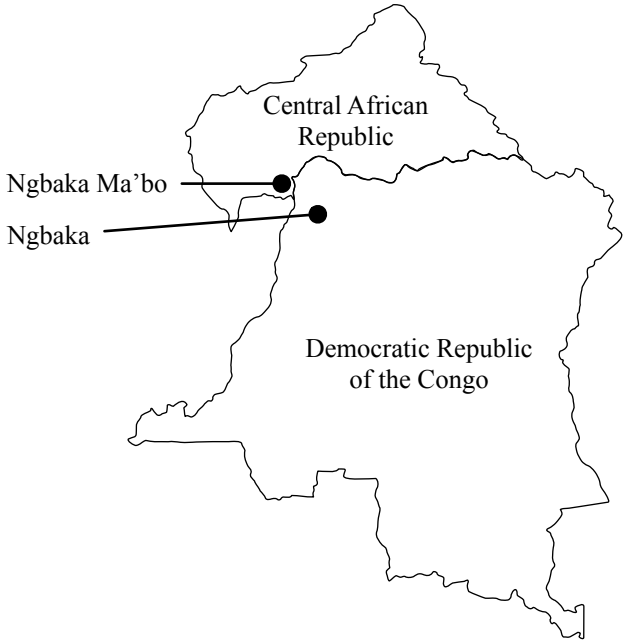


Figure 3.2: Map of Ngbaka and Ngbaka Ma'bo, based on Hammarström et al. 2016

Building on the analyses of Sagey 1986 and Mester 1986, van de Weijer 1996 cites searches of additional primary sources of both Ngbaka and Ngbaka Ma'bo, adding to the confusion. As this chapter will show, despite being different languages, Ngbaka and Ngbaka Ma'bo show extremely similar surface phonotactics with respect to consonant co-

occurrence restrictions, with some key differences. With respect to the core theoretical claim of this chapter, that long-distance place interactions exist, the argument remains the same between the two languages. The remainder of this chapter discusses Ngbaka of the Gbaya-Manza-Ngbaka subfamily, and will refer to this language simply as Ngbaka. Wherever relevant, Ngbaka Ma'bo will refer to the language of Thomas 1963 and Sagey 1986. As this chapter shows, the two languages do contain extremely similar surface phonotactics with respect to labial-velars and voicing.

3.2.1 Consonant inventory

The Ngbaka consonant inventory as described in the introduction to Maes 1959 is given in Table 3.1.

Table 3.1: Ngbaka consonant inventory based on Maes 1959

	Labial	Coronal	Palatal	Velar	Glottal	Labial-Velar
Plosives	b p ^{m}b	t d ^{n}d		k g ^{ŋ}g		
Implosives	ɓ	ɗ				k͡p g͡b ^{ŋm}g͡b
Fricatives	f v	s z ^{n}z				
Nasals	m	n	ɳ	ŋ		ŋ͡m
Liquids		l r				

Maes groups the labial-velar stops with the other implosives. I follow this for the table above, but I do not assume any phonological difference, such as an implosive feature like [+c.g.] in the representation of labial-velars. Maes 1959 also lists "vw" and "nw" as segments, but these were not present in the wordlist used for this analysis.

3.3 Co-occurrence restrictions in Ngbaka

Ngbaka contains the following co-occurrence restrictions in terms of place and voicing. The following tables show a summary of the statistical analysis of the Ngbaka dictionary. The table contains the Observed value (O) and Expected value (E) for each combination in

addition to their significance, calculated via Fisher's exact test. The full results are discussed in detail in Section 3.8.

Table 3.2: Summary of place restrictions for all homorganic and semihomorganic pairs

Combination	O	E	O/E	Significance	Result
T…T	28	28.36	0.99	$p = 1$	As expected
P…P	12	16.06	0.75	$p = 0.31$	As expected
K…K	26	39.25	0.66	$p = 0.00630$	Underrepresented?
K͡P…K͡P	11	3.62	3.04	$p < 0.00625$	Overrepresented
P…K͡P	0	6.39	0.00	$p < 0.00625$	Underrepresented
K͡P…P	2	9.09	0.22	$p < 0.00625$	Underrepresented
K…K͡P	1	8.49	0.12	$p < 0.00625$	Underrepresented
K͡P…K	13	16.71	0.78	$p = 0.32$	As expected

Table 3.3: Summary of voicing and nasal restrictions for all homorganic pairs

Combination	O	E	O/E	Significance	Result
T…D, D…T	0	5.10	0.00	$p < 0.0167$	Underrepresented
N…^{N}D, ^{N}D…N	1	2.32	0.43	$p = 0.47$	As expected
D…^{N}D, ^{N}D…D	8	7.19	1.11	$p = 0.67$	As expected

The restrictions active in Ngbaka are schematized and discussed below.

(76) **Place Agreement on Labials (PAL)**:

Labials cannot co-occur in the same root as labial-velars, in any order, regardless of voicing or nasality. Any pair of labial segments must agree in their full place specification.

a. *P…K͡P

b. *K͡P…P

c. ✓P…P

d. ✓K͡P…K͡P

(77) a. *bak͡pa

b. *g͡bama

c. *paŋ͡ma

d. …

Parallel to Place Agreement on Labials (PAL), there is place agreement among certain dorsal pairs as well. This is the only long-distance process in Ngbaka found to be directional.

(78) **Place Agreement on Dorsals (PAD)**:

Initial simple dorsal stops cannot co-occur with a medial labial-dorsal stops, regardless of voicing or nasality.

a. *K…K͡P

b. ✓K͡P…K

c. (✓)K…K[1]

d. ✓K͡P…K͡P

A labial-dorsal stop can appear with a simple dorsal stop only when the labial-dorsal is in root-initial position. When an initial labial-dorsal appears with a medial dorsal, they can disagree in voicing, as (79a–79b) show.

(79) a. g͡baka ‘help, rescue’ (p. 77)

b. g͡bákɔ̀- ‘tree branch’ (p. 77)

Finally, all purely homorganic stops pairs must agree in voicing.

(80) **Voicing Agreement (VA)**:

Homorganic segments must agree in voicing.

a. *T…D

b. *D…T

c. ✓T…T

d. ✓D…D

[1]Simple dorsal-dorsal combinations are likely underrepresented, but for the analysis here they are assumed to be grammatical. See also the note in Section 3.8.2.1.5.

3.4 ABC Analysis

The analysis here accounts for the place co-occurrence restrictions in Ngbaka within the Agreement by Correspondence framework. There is a Corr constraint for each individual place feature, following Bennett 2013, compared to the similarity scales used in Rose & Walker 2004. Crucially, each place feature [labial], [dorsal] and [coronal] has its own Corr constraint. There are general place identity constraints for both Input/Output (IO) correspondence and for Consonant/Consonant (CC) surface correspondence. The correspondence relation is assumed to be transitive, symmetric, and reflexive, following Bennett 2013. However, due to the restrictions on candidate size (2 consonants), the transitivity property will not come into play. The assumption that correspondence is symmetric, however, is crucial for capturing the directionality of Place Agreement on Dorsals (PAD).

The processes, and specific targets for the analysis, are given below.[2]

(81) **Targets for Ngbaka analysis**:

a. *Unfaithful mappings:*

Input		Result	Process	Pair Description
/P-K͡P/	→	¬/P-K͡P/	PAL	Initial labial and medial labial-velar
/K͡P-P/	→	¬/K͡P-P/	PAL	Initial labial-velar and medial labial
/K-K͡P/	→	¬/K-K͡P/	PAD	Initial velar and medial labial-velar
/T-D/	→	¬/T-D/	VA	Homorganic voiced and voiceless

b. *Faithful mappings:*

[2]Throughout this chapter, KP, K, and P stand for all labial-dorsals, dorsals, and labials, regardless of manner or voice, respectively. T and D together stand for voiceless and voiceless stops, regardless of place, that are homorganic (e.g. t-d, p-b, k-g, etc.). (To avoid confusion, there is no abbreviation for the class of plain coronals, regardless of voice or nasality.)

Input		Result	Pair Description
/$\widehat{\text{KP}}$-K/	→	/$\widehat{\text{KP}}$-K/	Initial labial-velar and medial velar
/N-$^{\text{N}}$D/	→	/N-$^{\text{N}}$D/	Homorganic nasal and prenasal
/D-$^{\text{N}}$D/	→	/D-$^{\text{N}}$D/	Homorganic voiced and prenasal
/$\widehat{\text{KP}}$-G/	→	/$\widehat{\text{KP}}$-G/	Semihomorganic dorsal voiced and voiceless

Because the restrictions in Ngbaka are static, there is little evidence as to what the actual mappings are for the illicit consonant pairs. The analysis will simply aim to prevent fully faithful occurrences of these pairs. However, for PAL and PAD, Section 3.7.1 gives indirect evidence that this process results in complex place agreement (i.e. /$\widehat{\text{kp}}$…p/→[$\widehat{\text{kp}}$…$\widehat{\text{kp}}$]). Semihomorganicity is defined below.

(82) **Semihomorganicity**

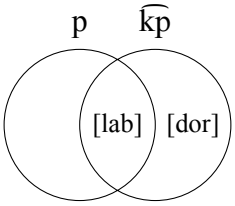
Two segments are *semihomorganic* if the set of place features of one segment is a non-empty proper subset of the set of place features of the other segment.

a. Place(S1) ⊊ Place(S2)

b. Place(S1) ≠ ∅

The definition crucially uses the proper subset, as segments with equal sets of place features are simply homorganic. Even though it is assumed that every segment is specified for place, the definition stipulates non-empty to avoid trivial semihomorganicity if glottals, for instance, are assumed to be placeless and therefore automatically contain a proper subset of an oral stop's place features. Thus, P and KP are semihomorganic, as are K and KP. This is shown visually in the Venn digram below.

(83) Segments [p] and [k͡p] are semihomorganic:



More specifically, the pair K and K͡P are referred to as a semihomorganic dorsal pair, while P and K͡P as a semihomorganic labial pair.

This definition contrasts with the more familiar notions of homorganicity and heterorganicity, which can be defined in the same set-theoretic terms below:

(84) **Homorganicity**

Two segments are homorganic if they have equal place features.

a. Place(S1) = Place(S2)

(85) **Heterorganicity**

Two segments are heterorganic if they have no shared place features.

a. Place(S1) ∩ Place(S2) = ∅

There is an additional relation, defined below, when both segments have shared and unshared place features (e.g. k͡p~t͡p).

(86) **Semiheterorganicity**

Two segments are semiheterorganic if each has shared and unshared place features.

a. Place(S1) \ Place(S2) ≠ ∅

b. Place(S2) \ Place(S1) ≠ ∅

c. Place(S1) ∩ Place(S2) ≠ ∅

A possible semiheteroganic mapping (e.g. t͡p~k͡p) is discussed for Dagbani in Chapter 4 Section 4.6.3.

3.4.1 Representation

Each segment is represented with any of the place feature combinations listed in (87) as well as full specifications for [voice], [sonorant], and [nasal]. Only interactions along the C-place dimension are considered here, to keep the interactions simple.

The treatment of place requires that labial-velars have two major place feature specifications, [labial] and [dorsal] (Sagey 1986, Clements & Hume 1995, a.o.). Beyond this, no representational devices, such as a pointer device (Sagey 1986), government (van de Weijer 1996), or abstract C-place vs. V-place distinctions (Clements & Hume 1995, Cahill 1999) are necessary.

Phonetic prenasals are assumed to be phonologically non-nasal sonorants. This follows arguments in Rice 1993, and in Rose & Walker 2004 about Ngbaka specifically, but it is not crucial for the overall argument. Representational assumptions about prenasals do affect the analysis of any potential nasal-prenasal interaction; however, in the dictionary analyzed here, there were found to be no such interactions.

(87) Feature representation

	c-place	voice	sonorant	nasal
n	[cor]	+	+	+
^{n}d	[cor]	+	+	−
d	[cor]	+	−	−
t	[cor]	−	−	−
m	[lab]	+	+	+
^{m}b	[lab]	+	+	−
b	[lab]	+	−	−
p	[lab]	−	−	−
ŋ	[dor]	+	+	+
^{ŋ}g	[dor]	+	+	−
g	[dor]	+	−	−
k	[dor]	−	−	−
$\widehat{ŋm}$	[lab], [dor]	+	+	+
$\widehat{^{ŋm}gb}$	[lab], [dor]	+	+	−
$\widehat{gb}$	[lab], [dor]	+	−	−
$\widehat{kp}$	[lab], [dor]	−	−	−

Place features are assumed to be privative, as is normally assumed in most representational theories (Sagey 1986, Clements & Hume 1995, Halle 1995, Halle et al. 2000). The ABC analysis does not crucially require privative place features, as the Ident constraints that refer to place could also be defined over binary place features. However, in Section 3.5.1, situations where the representation of place features crucially matters are discussed. Only labial-dorsals are assumed for simplicity in candidate generation and constraint interaction. Chapter 5 shows how scaled constraints can also reduce inventories to only containing labial-dorsal segments.

The values for [voice] for nasals and prenasals are assumed to be positive, but it is not crucial. The realization of the sonorant feature entails phonetic voicing, so the value for [voice] might not be necessary. Whether the value for [voice] is positive or negative, it is crucially one of these values, and not underspecified, which would act as a third value (see Steriade 1995 for a discussion). The choice of a voicing value does have implications

for how nasals and prenasals behave in Voicing Assimilation. With these caveats, in the analysis that follows, nasals and prenasals are assumed to be [+voice].

In the candidates in the analysis, each segment is paired with another, either in surface correspondence (indicated with subscripts: [p_1ap_1a]) or not in correspondence ([k_1ap_2a]). All consonant pairs are considered as inputs as well.

3.4.2 Constraints

3.4.2.1 Identity

The evaluation of place identity, whether over Input/Output (IO) or Consonant/Consonant (CC) correspondence, is crucial to capturing the intended effects of semihomorganicity. Each disparity is counted by a single constraint for each of the major place features [labial], [dorsal] and [coronal].

(88) **id-io.KPT**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{dor}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{dor}]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{lab}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{lab}]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{cor}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{cor}]))$

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place, and for each with a disparity in coronal C-place."

(89) **id-cc.KPT**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{dor}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{dor}]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{lab}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{lab}]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{cor}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{cor}]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a

disparity in dorsal C-place, and for each with a disparity in labial C-place, and for each with a disparity in coronal C-place."

Note that the above definitions define *two* constraints based on the same schema, but along both the CC and IO correspondence relation.[3] Based on the violations assigned by these constraints, a [k͡p] in correspondence with [p] or [k] is *more identical* than a [k] being in correspondence with [p], or any other purely heterorganic combination. This constraint is the summation of three different individual ident constraints, as explained in Chapter 2. While three individual constraints would also capture the desired process for Ngbaka, the single constraint us used here as it will later be defined as part of a set of stringent constraints, which are necessary over the individual constraints for typological purposes. Additionally, the single constraint here simplifies the ranking arguments for Ngbaka.

The above definition is also similar in spirit to Feature Class Theory (Padgett 1995, 2002), in that the evaluation of the place class of features is gradiently evaluated (in that individual disparities add up for a single constraint).

(90) Violation profile for id-cc.KPT and id-io.KPT where S_1 and S_2 are segments in IO or CC correspondence

S_1	S_2	id:KPT	Comment
k	k͡p	1	[labial] disparity
k	p	2	[labial] and [dorsal] disparity
t	k͡p	3	[labial], [coronal], and [dorsal] disparity

There are both IO and CC Ident constraints for the remaining features as well:

[3]The constraints defined are based on the within-category C-place ident definitions; however, the cross-category definition could be used as well. In Ngbaka, there are no secondary articulations on the surface, so the cross-category constraints would still yield consonantal place. However, to stress that this is consonant harmony, I use the definitions that explicitly include the C-place node.

(91) **id-io.[nasal]**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [\alpha\text{nasal}]) \oplus (\bullet_2 \downarrow [\alpha\text{nasal}]))$

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in [±nasal]."

(92) **id-io.[sonorant]**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [\alpha\text{sonorant}]) \oplus (\bullet_2 \downarrow [\alpha\text{sonorant}]))$

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in [±sonorant]."

(93) **id-io.[voice]**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [\alpha\text{voice}]) \oplus (\bullet_2 \downarrow [\alpha\text{voice}]))$

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in [±voice]."

(94) **id-cc.[nasal]**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [\alpha\text{nasal}]) \oplus (\bullet_2 \downarrow [\alpha\text{nasal}]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in [±nasal]."

(95) **id-cc.[sonorant]**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [\alpha\text{sonorant}]) \oplus (\bullet_2 \downarrow [\alpha\text{sonorant}]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in [±sonorant]."

(96) **id-cc.[voice]**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [\alpha\text{voice}]) \oplus (\bullet_2 \downarrow [\alpha\text{voice}]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in [±voice]."

These three IO constraints are equivalent to the standard Ident constraints for binary features, following McCarthy & Prince 1995, and likewise for the CC versions following Rose & Walker 2004, Bennett 2013. Alpha-notation is used, where α is a variable ranging over + and −. If a voice feature differs in its specification, for instance, between input and output root nodes, a violation is assigned.

3.4.2.2 Similarity

Similarity constraints are those that encourage segments sharing a value for some feature to be in correspondence. Abbreviated Corr, these constraints are crucially defined over individual place features to capture the place asymmetries in the generalizations. The constraints are based on individual place features (following Bennett 2013) instead of a similarity scale based on homorganicity (such as in Rose & Walker 2004), as it is the very notion of homorganicity that is at play. Further, a single constraint cannot be used that encompasses all features below; in the final Ngbaka ranking, members of this set crucially dominate one another. They are defined below in the Constraint Definition Language (CDL) developed in Chapter 2.

(97) **Corr.K**

$\langle \bullet_1, \bullet_2 \rangle$ / $\neg(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \ \wedge \ \mathbb{O}(\bullet_{1,2}) \wedge \ \bullet_1 \downarrow$ C-pl $\downarrow$ [dor] $\wedge \ \bullet_2 \downarrow$ C-pl $\downarrow$ [dor]

—

"Assign a violation for each pair of output segments that have dorsal C-place and are not in CC correspondence."

(98) **Corr.P**

$\langle \bullet_1, \bullet_2 \rangle$ / $\neg(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge \mathbb{O}(\bullet_{1,2}) \wedge \bullet_1 \downarrow$ C-pl $\downarrow$ [lab] $\wedge \bullet_2 \downarrow$ C-pl $\downarrow$ [lab]

—

"Assign a violation for each pair of output segments that have labial C-place and are not in CC correspondence."

(99) **Corr.T**

$\langle \bullet_1, \bullet_2 \rangle$ / $\neg(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge \mathbb{O}(\bullet_{1,2}) \wedge \bullet_1 \downarrow$ C-pl $\downarrow$ [cor] $\wedge \bullet_2 \downarrow$ C-pl $\downarrow$ [cor]

—

"Assign a violation for each pair of output segments that have coronal C-place and are not in CC correspondence."

Additionally, the following constraint Corr.K/C2=P is needed to capture the asymmetry of PAD.

(100) **Corr.K/C2=P**

$\langle \bullet_1, \bullet_2 \rangle$ / $\neg(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge \mathbb{O}(\bullet_{1,2}) \wedge \bullet_1 \downarrow$ C-pl $\downarrow$ [dor] $\wedge \bullet_2 \downarrow$ C-pl $\downarrow$ [dor]
$\wedge \bullet_2 \downarrow$ [lab] $\wedge \neg$initial($\bullet_2$)

—

"Assign a violation for each pair of output segments that have dorsal C-place and are not in CC correspondence and the non-initial segment also has labial C-place."

This is an ad hoc constraint that enforces correspondence between pairs [K…$\widehat{\text{KP}}$], but not [$\widehat{\text{KP}}$…K]. The predicate initial(•) is true iff • is in a root-initial position. Its violation profile is given below.

(101) Violation profile for Corr.K vs. Corr.K/C2=P:

output	Corr.K	Corr.K/C2=P	Comment
k_1ak_2a	1	0	C2 is not labial
$\widehat{kp}_1ak_2a$	1	0	C2 is not labial
$k_1a\widehat{kp}_2a$	1	1	C2 is labial
$\widehat{kp}_1a\widehat{kp}_2a$	1	1	C2 is labial
$k_1a\widehat{kp}_1a$	0	0	C1 and C2 are in correspondence

The constraint assigns a subset of violations of Corr.K. While the constraint is ad hoc, it does have grounding in the cross-linguistic tendency for labial-velars to disprefer word-internal positions, as surveyed by Cahill 2000 (see also Beckman 1998). Below is a positional markedness constraint from this analysis:

(102) **KP-mi**

Labial-velars are licensed only morpheme-initially (Cahill 2000: 85)

Assuming this constraint assigns a violation for every medial labial-velar, the definition in (100) can be reformulated as a local constraint conjunction between Corr.K and KP-mi. This would result in an identical violation profile as in (101).

(103) Corr.K/C2=P as local constraint conjunction:

output	Corr.K	KP-mi	[Corr.K & KP-mi]	Corr.K/C2=P
k_1ak_2a	1	0	0	0
$\widehat{kp}_1ak_2a$	1	0	0	0
$k_1a\widehat{kp}_2a$	1	1	1	1
$\widehat{kp}_1a\widehat{kp}_2a$	1	1	1	1
$k_1a\widehat{kp}_1a$	0	1	0	0

This formulation recasts the ad hoc constraint in terms of existing cross-linguistic tendencies and shows that it can be defined using existing machinery. Chapter 5 uses a slightly

different theory of markedness constraints for both simple and complex place, based on those of Cahill 2000.

3.4.2.3 Segmental Markedness

Segmental markedness is evaluated per place feature of the segment: complex segments like [k͡p] receive 2 violations, while all other (simple) segments receive 1 violation. Voicing markedness is similarly evaluated, except for [+voice] segments only.

(104) **m.KPT**

• / • ↓ C-pl ↓ [dor] +

• / • ↓ C-pl ↓ [lab] +

• / • ↓ C-pl ↓ [cor]

—

"Assign a violation for each root node that has dorsal C-place, and for each that has labial C-place, and for each that has coronal C-place."

(105) **m.KPT/[+voice]**

• / • ↓ C-pl ↓ [dor] ∧ • ↓ [+voice] +

• / • ↓ C-pl ↓ [lab] ∧ • ↓ [+voice] +

• / • ↓ C-pl ↓ [cor] ∧ • ↓ [+voice]

—

"Assign a violation for each root node that has dorsal C-place and is [+voice], and for each that has labial C-place and is [+voice], and for each that has coronal C-place and is [+voice]."

(106) VT for m.KPT and m.KPT/[+voice]

output	m.KPT	m.KPT/[+voice]
t	1	0
p	1	0
k	1	0
k͡p	2	0
d	1	1
b	1	1
g	1	1
g͡b	2	2

While m.KPT/[+voice] assigns two violations to the voiced labial-velar [g͡b], this is due to the constraint definition, not to the structure of the representation itself. The segment [g͡b] still only has a single specification for [+voice], but the constraint m.KPT/[+voice] counts place/[+voice] pairs, which results in the two violations. There are two reasons for this constraint, and both are typological: this allows for voicing distinctions in complex segments to be determined independently of the distinctions in simple stops (see Danis 2014 and Section 5.6.1 here). For the argument of this chapter, neither of these reasons are crucial. A more common *[+voice] constraint would work just as well. The constraint m.KPT/[+voice] is used instead for consistency within the dissertation.

3.4.3 Ranking and support

With the constraint set and representations defined in the previous section, the final ranking for Ngbaka is given in Figure 3.3. All ranking calculations are done in Prince, Tesar, et al. 2016.

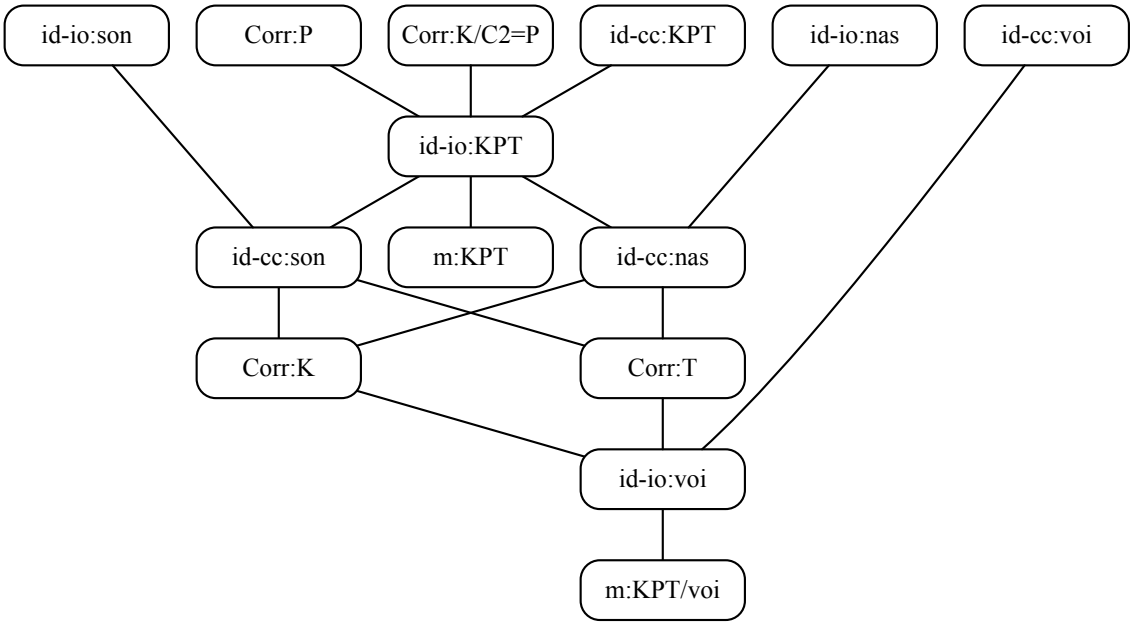


Figure 3.3: Ngbaka ranking

The targets for this analysis are determined by which linguistically relevant combinations of consonants are significantly underrepresented as determined in Section 3.8. In the cases where no significance was found or where it was investigated, the outputs are assumed to be faithful when possible. There are certain candidate sets whose optima are determined due to rankings required to get the desired optima from other candidate sets. In all tableaux in this chapter, candidates are based on a hypothetical form of CaCa, where C is any of the consonants in question. Surface correspondence is indicated via subscripted indices on these consonants.

Table 3.4: Full support for Ngbaka

	Input	Winner	Loser	Id-cc.[voice]	Corr.P	Id-cc.KPT	Id-io.[nasal]	Id-io.[sonorant]	Corr.K/C2=P	Id-io.KPT	m.KPT	Id-cc.[nasal]	Id-cc.[sonorant]	Corr.K	Corr.T	Id-io.[voice]	m.KPT/[+voice]
a.	^{m}b-p	^{m}b$_1$ab$_1$a	^{m}b$_1$ap$_1$a	W												L	L
b.	^{m}b-$^{\widetilde{nm}}$gb	^{m}b$_1$aŋg$_2$a mb$_1$amb$_1$a	mb$_1$a$\widetilde{\text{ŋm}}$gb$_2$a		W					L	W						W
c.	^{m}b-$^{\widetilde{nm}}$gb	^{m}b$_1$a$^{\eta}$g$_2$a mb$_1$amb$_1$a	mb$_1$a$\widetilde{\text{ŋm}}$gb$_1$a			W				L	W						W
d.	^{m}b-m	^{m}b$_1$am$_1$a	^{m}b$_1$a^{m}b$_1$a m$_1$am$_1$a				W					L					
e.	^{m}b-b	^{m}b$_1$ab$_1$a	^{m}b$_1$a^{m}b$_1$a b$_1$ab$_1$a					W					L				
f.	$^{\eta}$g-$\widetilde{\text{ŋm}}$gb	$^{\eta}$g$_1$amb$_2$a $^{\eta}$g$_1$a$^{\eta}$g$_1$a	$^{\eta}$g$_1$a$^{\widetilde{nm}}$gb$_2$a						W	L	W			W			W
g.	^{m}b-m	^{m}b$_1$am$_1$a	^{m}b$_1$an$_2$a ^{m}b$_1$an$_2$a ^{n}d$_1$am$_2$a $^{\eta}$g$_1$am$_2$a							W		L					
h.	^{m}b-b	^{m}b$_1$ab$_1$a	^{m}b$_1$ad$_2$a ^{m}b$_1$ag$_2$a ^{n}d$_1$ab$_2$a $^{\eta}$g$_1$ab$_2$a							W		L					
i.	^{n}d-$\widetilde{\text{ŋm}}$gb	^{n}d$_1$aŋmgb$_2$a	^{n}d$_1$a^{m}b$_2$a ^{n}d$_1$a$^{\eta}$g$_2$a							W	L					L	
j.	^{n}d-n	^{n}d$_1$an$_2$a	^{n}d$_1$an$_1$a									W			L		
k.	$^{\eta}$g-ŋ	$^{\eta}$g$_1$aŋ$_2$a	$^{\eta}$g$_1$aŋ$_1$a									W		L			
l.	^{n}d-d	^{n}d$_1$ad$_2$a	^{n}d$_1$ad$_1$a										W		L		
m.	$^{\eta}$g-g	$^{\eta}$g$_1$ag$_2$a	$^{\eta}$g$_1$ag$_1$a										W	L			
n.	g-k	k$_1$ak$_1$a	g$_1$ak$_2$a											W		L	W
o.	d-t	t$_1$at$_1$a	d$_1$at$_2$a												W	L	W
p.	^{m}b-d	^{m}b$_1$ad$_2$a	^{m}b$_1$at$_2$a													W	L

Table 3.5: Most Informative Basis (MIB) for Ngbaka

ERC	id-cc.[voice]	Corr.P	id-cc.KPT	id-io.[nasal]	id-io.[sonorant]	Corr.K/C2=P	id-io.KPT	m.KPT	id-cc.[nasal]	id-cc.[sonorant]	Corr.K	Corr.T	id-io.[voice]	m.KPT/[+voice]
a.	W												L	L
b.		W					L	L	L	L	L	L	L	L
c.			W				L	L	L	L	L	L	L	L
d.				W					L		L	L	L	L
e.					W					L	L	L	L	L
f.						W	L	L	L	L	L	L	L	L
g.							W	L	L	L	L	L	L	L
h.									W		L	L	L	L
i.										W	L	L	L	L
j.											W		L	L
k.												W	L	L
l.													W	L

Table 3.4.3 contains the Most Informative Basis (MIB) for Ngbaka, which is calculated in OT Workplace (Prince, Tesar, et al. 2016) following the Fusional Reduction algorithm (FRed) from Brasoveanu & Prince 2011. The MIB contains the same ranking information as the support in Table 3.4, yet with as many L-valued Elementary Ranking Condition (ERC) coordinates as possible. Thus, for any constraint, it is immediately clear which and all other constraints this must dominate in the full ranking—representing both immediate and general dominance.

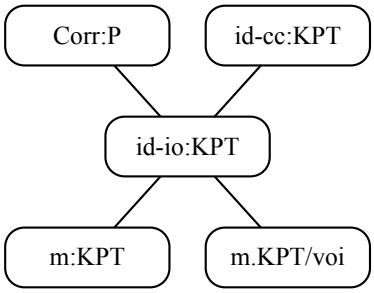
3.4.3.1 Place Agreement on Labials

To capture PAL, both id-cc.KPT and Corr.P must dominate id-io.KPT.

(107) Sub-MIB for PAL

ERC	**Corr.P**	**id-cc.KPT**	**id-io.KPT**	**m.KPT**	id-cc.[nasal]	id-cc.[sonorant]	Corr.K	Corr.T	id-io.[voice]	**m.KPT/[+voice]**
b.	**W**		**L**	**L**	L	L	L	L	L	**L**
c.		**W**	**L**	**L**	L	L	L	L	L	**L**
g.			**W**	**L**	L	L	L	L	L	**L**

(108) Subranking for PAL



The table in (107) contains a subset of the ERCs from the MIB in 3.4.3 showing the ranking information for the constraints relevant for PAL. These are bolded in the table. (These constraints also interact with the other constraints in the table, but these interactions are not crucial for the place interactions for PAL.) The specific rankings are shown in the sub-Hasse diagram in (108). Note that this is not new ranking information presented; all information here is a subset of the overall support/MIB, simply extracted for focus on a particular process.

The interactions can be partially seen in the ERC for the candidate set for the input /k͡p-p/, shown below.

(109) CT for /k͡p-p/

ERC	Input	Winner	Loser	Corr.P	id-cc.KPT	id-io.KPT	m.KPT
a.	k͡p-p	p_1ap_1a k_1ap_2a	$\widehat{kp}_1ap_2a$	W		L	W
b.	k͡p-p	p_1ap_1a k_1ap_2a	$\widehat{kp}_1ap_1a$		W	L	W

In this system, the optima for the input /pak͡pa/ are $[p_1ak_2a]$ and $[p_1ap_1a]$. These are tied. Both satisfy the surface condition that no two labials may be in correspondence with non-identical place values. Output $[p_1ak_2a]$ satisfies this by not being in correspondence, and $[p_1ap_1a]$ by having non-identical place. In essence, $[p_1ak_2a]$ is the dissimilation candidate following Bennett 2013, while $[p_1ap_1a]$ is the agreeing candidate. Because this is a static co-occurrence restriction, it is not obvious what the actual output is. A third option, $[\widehat{kp}_1a\widehat{kp}_1a]$, is discussed in Section 3.7.1.

Despite these uncertainties about the actual output, there is a clear interaction of place here. As Bennett 2013 shows, both dissimilation and agreement require a certain ranking schema, which is present here: the CC Ident constraint must dominate the IO Ident constraint for the harmonizing feature(s). Further refinement of the choice relies on standard IO and markedness constraints. What I am calling long-distance place harmony is simply a processes determined by this specific ranking schema, whether or not the actual output is an agreeing one. This is still theoretically relevant, as in the discussion of Rose & Walker 2004, no cases were found where Ident-IO-[place] (here id-io.KPT) is crucially dominated by Ident-CC-[place] (here id-cc.KPT). This is one such case.

3.4.3.2 Place Agreement on Dorsals

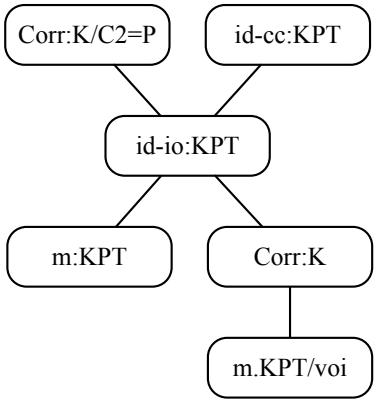
The ranking for PAD is parallel to that of PAL, with the exception of the relevant similarity constraint. Because only a subset of semihomorganic dorsal pairs are in correspondence, the

special constraint Corr.K/C2=P is necessary, instead of a basic Corr.K constraint (Corr.K is still necessary for capturing the homorganicity effects of voicing agreement, however, as the next section shows). The sub-MIB and subranking are shown below.

(110) Sub-MIB for PAD

ERC	**id-cc.KPT**	**Corr.K/C2=P**	**id-io.KPT**	**m.KPT**	id-cc.[nasal]	id-cc.[sonorant]	**Corr.K**	Corr.T	id-io.[voice]	**m.KPT/[+voice]**
c.	**W**		**L**	**L**	L	L	**L**	L	L	**L**
f.		**W**	**L**	**L**	L	L	**L**	L	L	**L**
g.			**W**	**L**	L	L	**L**	L	L	**L**
j.							**W**		L	**L**

(111) Subranking for PAD



Semihomorganic dorsal pairs with a medial labial-dorsal are sensitive to the constraint Corr.K/C2=P, so these forms are subject to PAD. This is shown in the CT below for the input /k-k͡p/.

(112) CT for /k-k͡p/

ERC	Input	Winner	Loser	id-cc.KPT	Corr.K/C2=P	id-io.KPT	m.KPT	Corr.K
a.	k-k͡p	k_1ap_2a k_1ak_1a	$k_1ak͡p_1a$	W		L	W	
b.	k-k͡p	k_1ap_2a k_1ak_1a	$k_1ak͡p_2a$		W	L	W	W

Here, both id-cc.KPT and Corr.K/C2=P must dominate id-io.KPT. The constraint Corr.K/C2=P demands correspondence from pairs such as [ka͡kpa], but not [k͡paka]. As the dictionary analysis shows, [k͡paka] must be allowed to surface faithfully. Thus, while Corr.K/C2=P must dominate id-io.KPT, id-io.KPT must dominate the standard Corr.K constraint.

(113) CT for /k͡p-k/

ERC	Input	Winner	Loser	id-cc.KPT	id-io.KPT	m.KPT	Corr.K
a.	k͡p-k	$k͡p_1ak_2a$	$k͡p_1ak_1a$	W			L
b.	k͡p-k	$k͡p_1ak_2a$	p_1ak_2a k_1ak_1a		W	L	L

Additionally, not only can initial labial-velars surface faithfully with medial dorsals, but they can also disagree in voicing. Thus, semihomorganic dorsal pairs pattern with purely heterorganic stops rather than with purely homorganic stops.

(114) Attested K͡P-K forms:

a. g͡baka ‘help, rescue’ (p. 77)
b. g͡bákɔ́- ‘tree branch’ (p. 77)
c. g͡baŋa ‘be afraid’ (p. 78–79)
d. g͡bàᵑgà ‘door leaf’ (p. 79)

e. k͡pá^{ŋ}gà ‘cassava bread’ (p. 109)
f. k͡pɛ̀kà ‘knife for tattoos’ (p. 110)
g. k͡pɛ̀kà ‘click of a trap’ (p. 110)
h. k͡pɛ̀^{ŋ}gȧ ‘iron blade or weapon’ (p. 110)
i. ^{ŋm}g͡bàkà ‘Ngbaka people or language’ (p. 142)
j. ^{ŋm}g͡bà^{ŋ}gà ‘dispute case’ (p. 143)
k. ^{ŋm}g͡bà^{ŋ}gá- ‘combat leader’ (p. 143)
l. ^{ŋm}g͡bókó- ‘knee pain’ (p. 144)
m. ^{ŋm}g͡bù^{ŋ}gà ‘main rope of a trap’ (p. 145)

(115) CT for /k͡p-g/

ERC	Input	Winner	Loser	id-cc.[voice]	id-cc.KPT	id-io.KPT	m.KPT	Corr.K	id-io.[voice]	m.KPT/[+voice]
a.	k͡p-g	k͡p$_1$ag$_2$a	k͡p$_1$ag$_1$a	W	W			L		
b.	k͡p-g	k͡p$_1$ag$_2$a	k͡p$_1$ak$_1$a		W			L	W	L
c.	k͡p-g	k͡p$_1$ag$_2$a	p$_1$ak$_2$a k$_1$ak$_1$a			W	L	L	W	L
d.	k͡p-g	k͡p$_1$ag$_2$a	p$_1$ag$_2$a			W	L	L		
e.	k͡p-g	k͡p$_1$ag$_2$a	k͡p$_1$ak$_2$a						W	L

In (113), the reason KP-K forms can surface faithfully is that the consonants are not in surface correspondence. Note that this is a very different statement than saying the forms can surface faithfully because they are in correspondence but not in agreement. This is supported by the fact that the Ngbaka data does not include a significantly underrepresented number of semihomorganic dorsal forms that disagree in voicing (see Section 3.8.2.3); these forms occur as expected assuming no restriction. In other words, if [k͡paka] were in correspondence but perhaps subject to *directional* place agreement, then we would assume it is still also subject to voicing agreement. However, forms like [k͡paga] surface faithfully.

Additionally, the fact that a labial-velar survives in initial position is not surprising cross-linguistically (Beckman 1998, Cahill 2000. One other solution might be to relate this to an active, positional faithfulness constraint that preserves place in this initial position, superseding the harmony subsystem. However, without the directional Corr constraint Corr.K/C2=P, again, forms like [k͡paga] would still be in a surface correspondence relation, and thus be susceptible to voicing agreement, which empirically they are not.

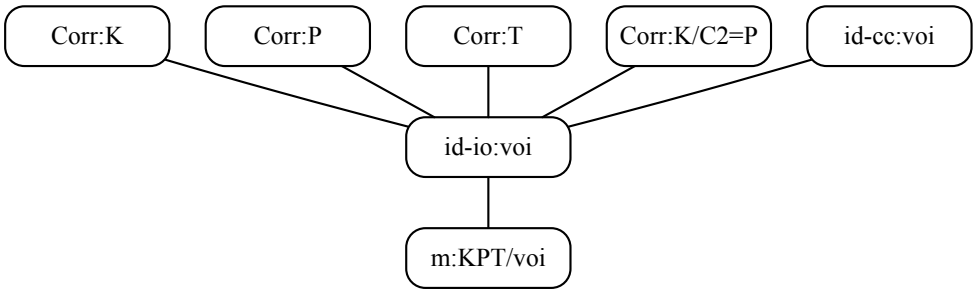
ERC (115a.) shows how the losing candidate that is fully faithful but in correspondence loses to the non-corresponding candidate, as this winner trivially obeys all id-cc constraints on voice and place (by virtue of not being in correspondence). ERC (115e.) shows that id-io.[voice] must dominate m.KPT/[+voice], as voicing distinctions are preserved. Likewise, ERC (115d.) states that id-io.KPT must dominate both m.KPT and Corr.K as place distinctions (specifically, the presence of labial-velars) is preserved in this form. This also means Corr.K is violated, as the removal of the dorsal feature from [k͡p] in this form would also trivially satisfy Corr.K, as then the segments would not be both dorsal. Additionally, ERC (115d.) resolves the disjunction in ERCs (112a-b.), as id-io.KPT must dominate m.KPT, therefore id-cc.KPT and Corr.K/C2=P both must dominate id-io.KPT, instead of either of m.KPT or Corr.K.

3.4.3.3 Voicing Agreement

(116) Sub-MIB for VA

ERC	**id-cc.[voice]**	**Corr:P**	**Corr:K/C2=P**	id-io.KPT	m.KPT	id-cc.[nasal]	id-cc.[sonorant]	**Corr:K**	**Corr:T**	**id-io.[voice]**	**m.KPT/[+voice]**
a.	**W**									**L**	**L**
b.		**W**		L	L	L	L	**L**	**L**	**L**	**L**
f.			**W**	L	L	L	L	**L**	**L**	**L**	**L**
j.								**W**		**L**	**L**
k.									**W**	**L**	**L**
l.										**W**	**L**

(117) Subranking for VA



The following CT combines the candidate sets for all homorganic pairs that disagree in voicing: /t-d/, /p-b/, and /k-g/. The ERCs have been sorted to show related constraint interactions among candidate sets.

(118) CT for VA

ERC	Input	Winner	Loser	Corr.P	Corr.K	Corr.T	id-cc.[voice]	id-io.KPT	id-io.[voice]	m.KPT/[+voice]
a.	p-b	p_1ap_1a	p_1ab_2a	W					L	W
b.	k-g	k_1ak_1a	k_1ag_2a		W				L	W
c.	t-d	t_1at_1a	t_1ad_2a			W			L	W
d.	p-b	p_1ap_1a	p_1ab_1a				W		L	W
e.	t-d	t_1at_1a	t_1ad_1a				W		L	W
f.	k-g	k_1ak_1a	k_1ag_1a				W		L	W
g.	p-b	p_1ap_1a	p_1ad_2a p_1ag_2a t_1ab_2a k_1ab_2a					W	L	W
h.	t-d	t_1at_1a	p_1ad_2a t_1ab_2a t_1ag_2a k_1ad_2a					W	L	W
i.	k-g	k_1ak_1a	p_1ag_2a t_1ag_2a k_1ab_2a k_1ad_2a					W	L	W

ERCs 118a–c show that each Corr constraint, Corr.P, Corr.K, and Corr.T all dominate id-io.[voice]. This accounts for the fact that Voicing Agreement (VA) applies to all homorganic stops. However, VA does not apply to semihomorganic pairs, such as KP-K, which is discussed in Section 3.4.3.2. ERCs 118g–i show that the place dissimilation candidates lose.

Each of these losers is actually a number of tied candidates, as the system of place markedness is not articulated enough to distinguish between segments of different simple place. Detailed analysis of how the stringent markedness and faithfulness constraints control for reduction targets is given in Chapter 5.

3.4.3.4 Faithful nasal and prenasal combinations

Combinations with homorganic nasal-prenasal combinations surface faithfully in this system. This is supported by these pairs not being significantly underrepresented in the dictionary data. It is stressed that this assumption is due to the lack of significance of a small number of observed forms. While there is a small number of N-^{N}D combinations observed in the dictionary, this number is not different enough from the expected value for it to be significant. See Section 3.8.2.2.2 for details. A study of a larger dictionary may yield different results.

(119) CT for (lack of) Nasal Agreement, labials

ERC	Input	Winner	Loser	id-cc.[voice]	Corr.P	id-io.[nasal]	id-io.[sonorant]	id-io.KPT	id-cc.[nasal]	id-cc.[sonorant]	id-io.[voice]	m.KPT/[+voice]
a.	m-^{m}b	$m_1a^{m}b_1a$	m_1ap_1a	W			W			W	W	L
b.	m-^{m}b	$m_1a^{m}b_1a$	m_1ap_2a		W		W		L		W	L
c.	m-^{m}b	$m_1a^{m}b_1a$	$m_1a^{m}b_2a$		W				L			
d.	m-^{m}b	$m_1a^{m}b_1a$	p_1ap_1a			W	W		L		W	L
e.	m-^{m}b	$m_1a^{m}b_1a$	$^{m}b_1a^{m}b_1a$ m_1am_1a			W			L			
f.	m-^{m}b	$m_1a^{m}b_1a$	m_1at_2a m_1ak_2a n_1ap_2a $ŋ_1ap_2a$				W	W	L		W	L
g.	m-^{m}b	$m_1a^{m}b_1a$	$m_1a^{n}d_2a$ m_1aNg_2a n_1amb_2a $ŋ_1a^{m}b_2a$					W	L			

The CT in (119) shows the rankings for faithful realization of labial nasal-prenasal pairs. Due to ranking requirements of Corr.P from PAL, the outputs for NA are in correspondence. This is otherwise undetectable on the surface. Additionally, as nasals and prenasals were assumed to be [+voice] in (87), the outputs must obey Voicing Agreement as well.

The comparisons in ERCs 119a–b show that the prenasalized stop [^{m}b] cannot be realized as [p]. In both cases, this is a violation of both id-io.[voice] and id-io.[sonorant]. Additionally, because the segments are in correspondence in ERC 119a and nasals and prenasals are both specified for voice, id-cc.[voice] and id-cc.[sonorant] both prefer the winner m_1amb_1a, as it contains two segments in correspondence which are both [+voice]

and [+sonorant].

ERC 119c shows that Corr.P must dominate id-cc.[nasal]; in other words, labials being in correspondence is more important for segments to agree in nasality.

3.5 Problems with alternative analyses

This section describes problems with alternative analyses of the Ngbaka data. Co-occurrence restrictions fall victim to the superstructure problem. A linking approach (e.g. Gallagher & Coon 2009) is unfeasible because this is not a case of a complete identity effect, and spreading is problematic because of assumptions about which place appears on vowels and consonants.

3.5.1 Using co-occurrence constraints

There is a fatal problem with co-occurrence constraint analyses, such as the analysis in Sagey 1986. I consider any analysis that uses co-occurrence constraints of the form *X...Y to be of this type, where X and Y are feature specifications that may or may not be identical (see also Alderete 1997, Suzuki 1998, Pulleyblank 2002 a.o.). The overall framework that these constraints are utilized in, whether they are language-specific inviolable autosegmental constraints such as in Sagey 1986 or rankable and violable constraints such as in Suzuki 1998, is not crucial. The only crucial assumptions are about the nature of the representation of place and complex segments, and the nature of evaluation of these constraints. These are all defined below.

The argument is as follows: assuming place feature privativity and standard assumptions about constraints on structure, listed in (120), any constraint that targets simple segments of place α will also ban complex segments containing α. This is an instance of the superstructure problem as defined in Jardine 2016. The case here with place features is parallel also to cases of rules targeting short segments but not geminates as discussed in Hayes 1986a,b.[4]

[4]Thanks to Paul de Lacy for pointing this out.

(120) a. **Place is Privative (PiP)**

Place features are privative. (Sagey 1986 et seq.)

b. **No Taxation Without Representation (NTWR)**

Constraints are negative and can only target structure present in the specified autosegmental structure. (Jardine 2016, de Lacy 2006, McCarthy 2003, Jardine & Heinz to appear)

As mentioned, PiP is standard in the phonological literature (Sagey 1986, Clements & Hume 1995, Halle 1995, Halle et al. 2000). NTWR is also fairly standard, but usually assumed tacitly. The idea of sticking to negative constraints is discussed in de Lacy 2002, 2006, McCarthy 2003 and formalized in Jardine 2016, Jardine & Heinz n.d. The Superstructure Problem, as defined by Jardine, is where "banned subgraph constraints cannot describe a pattern in which a grammatical substructure—i.e., a substructure that we want to allow in the pattern—is a superstructure of a banned substructure" (Jardine 2016: 255). In this case, we want to allow KP-KP, but ban K-$\widehat{\text{KP}}$, P-$\widehat{\text{KP}}$, and $\widehat{\text{KP}}$-P. Each of those banned forms contains a substructure of the allowed $\widehat{\text{KP}}$-$\widehat{\text{KP}}$. This is under the assumption that the constraints are interpreted as *X bans any structure containing X.

(121) Constraint: *X

(122) Structures violating *X:

a. X

b. Y
   |
   X

c. X
   / \
  Z   W

d. …

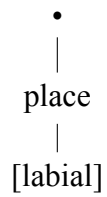
If a language bans the structure in (122a) but allows those in (122b) or (122c), or a number of other structures containing X, then this is an example of the superstructure problem.

To see how this is relevant for place features, assume (a simplified) version of a constraint intended to assign violations to simple labial segments.

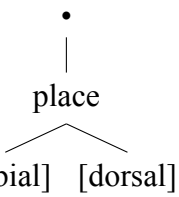
(123) Constraint:

(124) Structures violating constraint:

a.

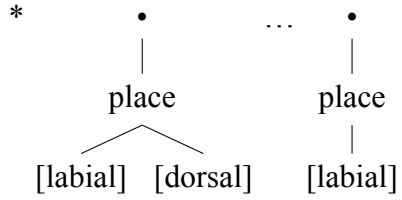


b.



In this case, the structure in (124a) is a substructure of that in (124b); both will violate the unconstraint, which is undesired. A simplified version of the co-occurrence constraint used in Sagey 1986 is given below. (The full version is given in 130.)

(125)



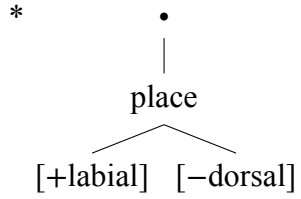
The above constraint falls victim to the superstructure problem for the same reason that (123) does: the constraint has no way of detecting the presence of an additional [dorsal] feature when it is not explicitly violating against it. To use co-occurrence constraints to describe the Ngbaka patterns, either one or both of the assumptions in (120) must be abandoned.

3.5.1.1 Making place features binary

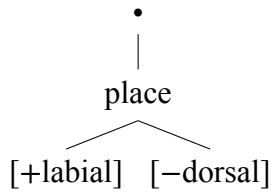
Clements & Hume 1995: 252 explain: "Unlike most other features, [labial], [coronal], and [dorsal] are treated as privative (one-valued), rather than binary. This is because phono-

logical rules do not appear to operate on the negative values of these categories." If a co-occurrence constraint model of Ngbaka were to be upheld, it could be argued to indeed be a case where a phonological rule (in this case, a constraint) crucially refers to a negative feature value of a place feature. By eschewing the PiP assumption, simple labials would be marked as [+labial −dorsal] (and presumably [−coronal], along with any other relevant specifications). This feature specification is no longer a substructure of labial-dorsals, which would be [+labial +dorsal].

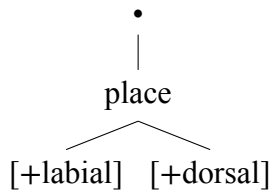
(126) Constraint:



(127) [P] is banned:



(128) [$\widehat{KP}$] is licit:



With this representation, the structure of [P] (and [K]) is no longer a substructure of [$\widehat{KP}$], and the substructure problem is avoided. The constraint in (126) can now explicitly detect the absence of a dorsal articulation accompanying a labial one due to the presence of the negative value of [dorsal].

The use of negative feature values is parallel to the treatment of tonal patterns: Jardine proposes a solution to "enrich autosegmental representations to include information about local associations which do not occur" (Jardine 2016: 255). This allows unassociated tone-

bearing units (TBUs) to be targeted by constraints which would otherwise target all TBUs. Negative feature values are essentially information about which features do not occur.

3.5.1.2 Increasing the power of the constraint logic

However, the analyst might be unconvinced that the present evidence is sufficient to change the arity of place features. To avoid a representation with negative feature values, the power of the constraint itself must be increased. Instead of a constraint on structure—a negative literal as defined by Jardine & Heinz (to appear)—the restriction can be defined in terms of first order logic (FO).

A constraint that bans [P] without banning [$\widehat{\text{KP}}$] can then be defined as follows:

(129) $\forall x, y[\bullet(x) \wedge [lab](y) \wedge x \downarrow y] \rightarrow \exists z[[dor](z) \wedge x \downarrow z]$

—

"For all root nodes x that dominate a [labial] feature y, it must also dominate a [dorsal] feature$z$."

For [P], the root node dominates [labial], but does not dominate [dorsal], so the structure is banned. However, [$\widehat{\text{KP}}$] satisfies the conditional, and the structure is licit. Notice the "positive" nature of the constraint, in that if you are [labial], then you *must also be* [dorsal]. First order logic is powerful enough to capture the patterns here, however, its power is also its downfall. Jardine & Heinz argue that FO is too powerful for natural language markedness constraints, and a more restrictive form of logic is required for markedness constraints.

The analysis presented here uses ABC, assuming both that markedness constraints are negative and that place is privative. However, the moniker of markedness constraint is muddied in theories of surface correspondence, such as ABC. The constraints Corr.K, Corr.P, id-cc.KPT, etc., are constraints that only reference the output, and could be considered markedness constraints by a simple definition. However, the definitions of these constraints, especially id-cc.KPT, are based on input/output correspondence constraints. The definition of id-cc.KPT here does indeed use first order logic in its definition. The caveat is that the

bifurcation of traditional markedness and faithfulness is no longer maintained in this definition: instead, both id-cc.KPT and id-io.KPT are *relational* constraints based on the Ident schema, as these constraints evaluate pairs of segments in some sort of formal relation. A constraint like *P would be considered an *output-referring non-relational constraint*, as it evaluates only a single piece of (sub)structure in the output. This is essentially the type of constraint argued to be negative literals in Jardine and Heinz, as they do not discuss faithfulness constraints (or correspondence in general). In summary, the ABC analysis can make use of privative features because the key constraints in the analysis are more like traditional faithfulness constraints than they are like traditional markedness constraints.

There is also recent work that argues specifically for a co-occurrence-constraint approach over a correspondence one. Heinz 2010 argues that many long-distance interactions are best captured through constraints over the precedence set on strings in language patterns. McMullin & Hansson 2016 makes similar arguments, except over Tier-Strictly Local representations. In both of these frameworks, constraints are defined over items in a string, with each item representing an individual speech segment. In other words, segments are the atomic units; they do not decompose into features. Because of this, the superstructure problem is avoided in both instances.

In the Precedence Grammar of Heinz 2010, long-distance phonotactics are captured by a set of illegal precedence pairs in the language. For Ngbaka, this means that any precedence pairs p…k͡p or k͡p…p are disallowed, but p…p and k͡p…k͡p are licit, as these pairs are absent from the restricted set. Because there is no inherent similarity between the symbols p and k͡p, as there is in a featural analysis, there is no sub- or superstructure relation between the two sounds. In other words, a labial-dorsal stop could be represented with the arbitrary symbol α, and simple labials with β, making it clear that they are distinct.

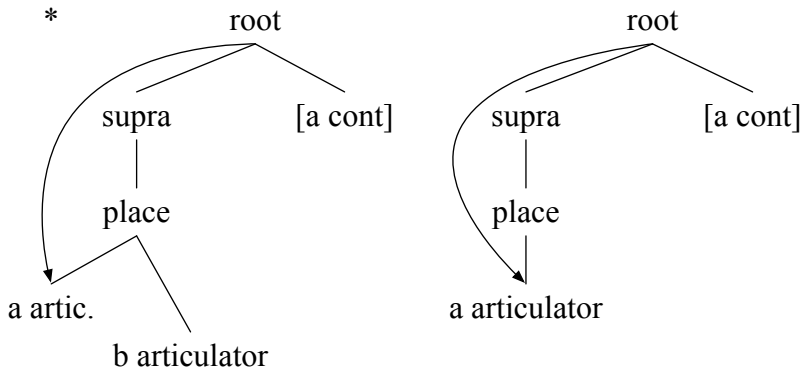
While featural information is not included directly in Heinz 2010, the Tier-based Strictly Local (TSL) languages begin to include this information in the representations (Heinz et al. 2011). In this framework, all elements in a string that are externally defined to have

some property, such as *voiced* or *labial*, project to form a new sub-string. All constraints, based now on strict succession rather than precedence, are evaluated against this substring. For Ngbaka, we can imagine constraints *p͡kp and *k͡pp active on the labial teir. For a hypothetical word pa͡kpa, the substring projects p͡kp, and this is ruled illegal by the TSL constraint *p͡kp. Again, forms like papa and k͡pa͡kpa are correctly ruled licit as the constraints operate on items in a string, not on featural/autosegmental relationships. In essence, the precedence grammar of Heinz 2010 and the TSL grammar of Heinz et al. 2011, McMullin & Hansson 2016 avoid the substructure problem by abandoned privative place features, in that all features have been abandoned in the segmental representation.

3.5.1.3 Additional problem with Sagey's constraint

An additional minor problem with Sagey's analysis specifically is that in the description of Ngbaka Ma'bo, the restriction applies only between "major articulators", which is an implementation of Abstract Primary Place (APP). The original constraint is shown below.

(130) Sagey 1986: (109):



The intention of this constraint is to ban (in either order) combinations of a complex segment (one with two articulatory features) with a simple segment, where the articulator of the simple segment is the same as the major articulator (the one receiving the pointer) of the complex segment. Additionally, the labial articulation of [k͡p] is assumed to be major, meaning all K͡P-P combinations are banned, but K͡P-K is not. This is desired and is con-

sidered an advantage of abstract primary place: the restriction is given in terms of major articulators only instead of specific features.

However, due to the discovery of K-KP also being banned in Ngbaka, reference to abstract primary place is no longer advantageous. Still assuming that [labial] is the primary articulator of [k͡p], a constraint banning K-K͡P sequences would then need to make reference to specific place features themselves. This is not a fatal problem, it simply means more constraints need to be defined: those for PAL and those for PAD.

3.5.2 Partial identity

Gallagher & Coon 2009 argue for a theory of Complete Identity Effects (CIE) to explain co-occurrence restrictions. Here, a monolithic Ident constraint polices all surface identity—it assigns a violation if two segments are not identical, and it is satisfied if two segments are identical. One reported advantage this theory has over the standard ABC account of using Ident constraints for individual features is that it does not predict the occurrence of major place harmony. The standard ABC account, in modeling CIEs, involves Ident constraints for every relevant feature, including place. However, a separate ranking, where Ident-Place is the only active CC constraint, predicts major place harmony. Because this pattern, they argue, is unattested, this is undesirable. However, the present analysis is indeed a case of major place harmony. One question that remains is: can Ngbaka instead be modeled as a complete identity effect, and therefore utilize the system of Gallagher & Coon 2009?

For a pattern to be a complete identity effect, it must meet the following generalization: for all segments in some domain (say, word) that share the feature value F must be identical. In Chol, all [+c.g.] segments must be identical. For Ngbaka, the generalization is as follows.

(131) Ngbaka as a complete identity effect:

All [labial] segments within a root must be identical.

However, this generalization is not met. While [labial] segments cannot differ for [dorsal] or [voice], they can differ in (pre)nasality and implosiveness:

(132)

a.	’bama	(v.)	to tighten, pinch
b.	bà^{m}bú	(n.)	wide waistline after birth
c.	’bɔmɔ	(v.)	to tighten, pinch
d.	^{m}bá’bó	(n.)	pit for taking animals
e.	^{m}bɔ́bì	(n.)	rattan for tying
f.	pu^{m}bu	(v.)	to be empty or hollow
g.	g͡bà$^{ŋ͡m}$g͡bà	(n.)	fall for animals, trap or litter
h.	g͡bò^{m}bè	(n.)	marabou
i.	g͡bɔ̀$^{ŋ͡m}$g͡bɔ̀	(n.)	laugh
j.	k͡pò$^{ŋ͡m}$g͡bò	(n.)	type of stool
k.	$^{ŋ͡m}$g͡bámù	(n.)	black antelope with black dorsal stripe

Examples (132a–f) show non-identical simple labial pairs, while examples (132g–k) show non-identical labial-dorsal pairs. It should be noted however that forms (132h) and (132k) are counter-examples to PAL, which are also discussed in (150). These counterexamples are not stastically significant, as discussed in sections 3.8.2.2.2 and 3.8.2.2.3.

3.5.3 Spreading

A general alternative to long-distance processes is to assume that they are caused by spreading, either local and iterative or long-distance (skipping transparent segments). However, the features are usually manner features such as nasal, which are phonetically realized on the surface of all intervening segments, or features like anterior which are not phonetically realized due to a stipulation that not all phonological segments can have a phonetic realization of the feature anterior. However, the argument for major place features, such as dorsal and labial in the case here, is more troublesome: presumably, all intervening segments will have some phonetic realization of these features, yet they are not realized phonetically in the segments (vowels, and possible consonants) that intervene between two harmonizing consonants.

Assuming a wholesale adoption of the representation and tier assumptions from Clements & Hume 1995, there still remain several issues on major place feature spreading. Most importantly, in a unified theory of place, where consonants and vowels share features, how do the presence of intervening vowel features affect spreading of place from consonant to consonant?

Spreading of consonantal C-place is only possible according to the No Crossing Constraint as defined in Clements & Hume 1995. Spreading is blocked when the No-Crossing Constraint is violated:

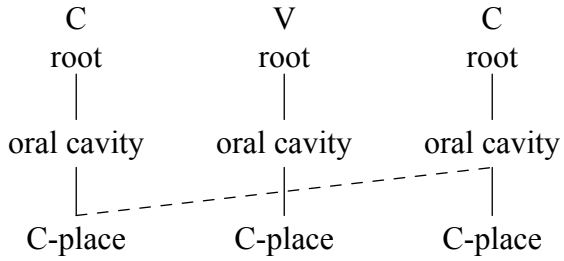
(133) **No Crossing Constraint (NCC)** (Clements & Hume 1995: (27))

Association lines linking two elements on tier *j* to two elements on tier *k* may not cross.

In their model, transvocalic spreading of the C-place node itself is blocked because vowels also bear a C-place node:

> "The assimilation of all consonantal place features as a unit can only be expressed as the spreading of the C-place node. If vowels also bear a C-place node, the C-place node of consonants cannot spread across them without violating the NCC (27), as shown below:"

(134) Spreading is blocked by the NCC: (Clements & Hume 1995: (59)):



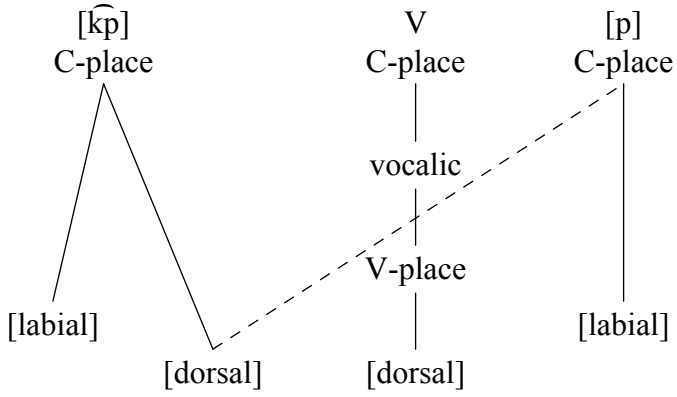
Because the C-place node that intervenes is on the same tier as the C-place node that spreads (tier *j*), and the oral cavity nodes of the spreading and intervening consonant are both on the same tier (tier *k*), the structure above violates the NCC. This is by design, as they state:

> "It is a striking crosslinguistic generalization that consonantal place features do not appear to be able to spread as a unit from one consonant to another across vowels." (Clements & Hume 1995: 288)

However, this is spreading of the entire C-place node. Another possibility for the Ng-baka patterns is that the relevant place features, [labial] for PAD and [dorsal] for PAL, spread individually. Such transvocalic spreading of consonantal C-place features should be possible: "[f]or example, many languages have rules of coronal assimilation in which the coronal node spreads from consonant to consonant across vowels and certain consonants." (Clements & Hume 1995: 289)

Under these same assumptions, such spreading would still require that the spreading place feature not be blocked by any other place features on the same tier. Yet, elsewhere, they argue that similar place features ([dorsal], etc.) are on the same tier regardless of whether they are C-place or V-place, in the context of Korean CV OCP effects (Clements & Hume 1995: (44)). If this is the case, then a [dorsal] feature spreading from C_1 to C_2 in a C_1VC_2 can spread across a dorsal vowel.

(135) Intervening vowels don't block spreading: (cf. Clements & Hume 1995: (68))



In the above diagram, all [dorsal] features are on a tier (*j*). One [dorsal] node is linked to a C-place node, on one tier (*k*). The other [dorsal] node is linked to a V-place node, which is neither on tier *k* or *j*. Because of this, the NCC is not violated, as it is defined in (133), meaning individual C-place can spread across intervening vowels, even those of the same

place. However, the notion of tier as used in Clements & Hume 1995 has been challenged: "[Unified Feature Theory] leaves C-Place and V-Place in an indeterminate state where they remain on separate tiers but interact as if on the same tier as needed" (Halle et al. 2000: 412).[5]

While the Clements & Hume 1995 model allows individual C-place features (but not the C-place node itself) to spread past vowels, necessary definitions of tier and the NCC have been criticized. Another approach to long-distance interactions is via iterative spreading. Hansson summarizes this approach as such: "all spreading is taken to be strictly local at the segmental level, such that nothing is ever 'skipped': all segments within a spreading domain are participants, targeted by (and hence carrying) the spreading feature" (Hansson 2010: 20).

If place agreement in Ngbaka is satisfied via iterative spreading, vowels will also bear that feature, and should show a phonetic realization of it. However, intervening vowels appear to be unrestricted in this position. In the K͡PVK͡P forms in Maes 1959, we find [a], [o], [ɔ], and [e].

(136)	a.	g͡bàg͡bà	(sg.)	bridge	x
	b.	g͡bó͡ŋ͡mg͡bó	(sg.)	laugh	x
	c.	k͡pɔ̀k͡pɔ̀	(sg.)	shoes	x
	d.	ŋ͡mg͡bém͡ŋg͡bé	(sg.)	small bell made of coiled iron	x

Either place features are not actually spreading iteratively past a vowel, or the place features have spread but are not phonetically realized on the vowel. However, the potential spreading of a consonantal gesture affecting vowel quality is a generous interpretation of iterative spreading. A more strict definition of iterative spreading, e.g. from Gafos 1999, means it is impossible to continue the articulatory gesture of the consonant through the vowel, as they are fundamentally incompatible.

[5]Or as Akin calls it in Phonology 1, "A trick!"

3.6 Related processes and the significance of complex place

The similarity and identity constraints crucial for the analysis here both refer to major place features. When dealing with only simple segments, such interactions do not occur. For instance, assume there is a consonant pair [k…k]. Corr.K prefers these segments to be in correspondence. However, because each segment is dorsal and only dorsal, they automatically satisfy place identity id-cc.KPT as well, as they are homorganic.

Semihomorganic consonant pairs share a feature, so they are similar enough to be subject to Corr constraints based on place. However, once these segments are in correspondence, they are not *identical* in place, and so the corresponding semihomorganic pair violates id-cc.KPT. Note that all homorganic combinations, by the definition of homorganicity, also satisfy id-cc.KPT. In other words, all identical pairs of segments are also by definition similar for some feature [G], but all pairs that share a value for some feature [G] are not necessarily identical. This is exactly the status of semihomorganic pairs with respect to major place features.

(137)

	Pair	**Identical for C-place**	**Similar for [lab]**
a. *Homorganic*	P…P	Yes	Yes
b. *Heterorganic*	P…K	No	No
c. *Semihomorganic*	P…K͡P	No	Yes

3.6.1 Luganda

Place similarity isn't the only option, however. Constraints can prefer that segment pairs be in correspondence whose features match for nasal, manner, and voice features as well. Such a case would be where all voiced segments correspond, and agree for major place. While this has also been argued to be largely unattested, one possible case is described in Katamba & Hyman 1991 for Luganda (a.k.a. Ganda, Bantu, Uganda, [lug]), as discussed also in Hansson 2010: 129. One of the co-occurrence restrictions for verb roots is that two heterorganic nasals cannot co-occur:

(138) *N_1VN_2 (where N_1 and N_2 are nonhomorganic) (Katamba & Hyman 1991: (8c))

(139) Luganda nasal restrictions (simplified, see Katamba & Hyman 1991: 206–7)

a. *nVm, *mVn

b. nVn, mVm

A preliminary generalization of the Luganda patterns in terms of ABC are that nasals correspond, and agree for place; this also requires a constraint like id-cc.KPT for place agreement on surface correspondents. This is a potential case of long-distance place harmony outside of complex place.

3.6.2 Ponapean

Pohnpeian (Oceanic, Caroline Islands, [pon], also called Ponapean) contains co-occurrence restrictions between simple labials [p, m] and velarized labials [p^{γ}, m^{γ}] (Rehg & Sohl 1981, Hansson 2010, Bennett 2013). Bennett analyzes this pattern as harmony of a [labial-velar] feature, but assuming Clements & Hume 1995, the harmony is between V-place [dorsal] features. As Ngbaka is harmony between C-place features and thus within-category for consonants, Pohnpeian is within-category harmony for V-place features.

3.7 Discussion

3.7.1 On the output of illegal semihomorganic pairs

If a combination of [pa$\widehat{kp}$a], in either order, is prohibited from surfacing faithfully, there are at least 3 possible mappings:

(140) VT for place realization

	/pakpa/	m.KPT	id-io.KPT	Comment
a.	p_1ak_2a	2	1	Dissimilation
b.	p_1ap_1a	2	1	Simple agreement
c.	$\widehat{kp}_1a\widehat{kp}_1a$	4	1	Complex agreement

The system in the previous section had tied optima between (140a.) and (140b.)—it does not differentiate between dissimilation and simple agreement. The candidate $\widehat{kp}_1a\widehat{kp}_1a$ is harmonically bounded because it has equal violations of id-io.KPT as (140a–b.), but is worse on markedness. This is because id-io.KPT counts all place disparities in both directions: sprouting and shedding.

However, there is reason to believe that the actual optimum for Ngbaka might be [kp_1akp_1a], the complex agreement candidate.[6] This evidence is listed below:

(141) Evidence for complex agreement:

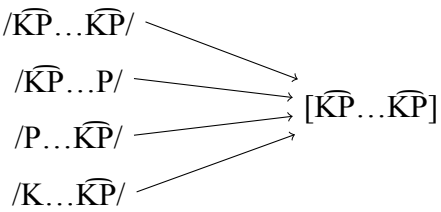
a. $\widehat{KP}$-$\widehat{KP}$ pairs are significantly overrepresented in the Ngbaka dictionary data

b. Rose & Walker 2004 cite experimental evidence that suggests it is more likely for a place feature to be added than replaced

c. Other agreement processes seem to always agree to the more marked feature value (cite Luca)

In the dictionary data, there are 11 observed instances of $\widehat{KP}$…$\widehat{KP}$ forms, while only 3.61 were expected; this difference is significant (see 3.6). This suggests that inputs other than /$\widehat{KP}$…$\widehat{KP}$/ are mapping to [$\widehat{KP}$…$\widehat{KP}$], such as the relevant semihomorganic pairs shown below.

(142)



Additionally, Iacoponi 2016 discusses a cross-linguistic generalization where "in dominent-recessive consonant harmony, the target is always the marked feature". In the cases surveyed there, voicing assimilation always maps to [+voice], nasal assimilation to [+nasal], and dorsal assimilation to [+high], with several other cases as well. Since the presence of a

[6] Thanks to Luca Iacoponi and Sharon Rose for discussion on this point.

place feature is usually assumed to be more marked than the absence of one (either due to place being privative or in explicit theories of place markedness theories in OT), agreement to complex place would fit in with the generalization in Iacoponi 2016.

Lastly, Rose & Walker cite Pouplier et al. 1999 as evidence that "[t]here is no coarticulation impetus for place gestures to be reduced, and accordingly, it appears that retention of place features is favored." (Rose & Walker 2004: 519). They go on to state: "We suggest that the additive property of speech errors with place is mirrored in consonantal agreement in the respect that place articulations can be added but not removed. Place agreement is avoided, because complex stops are generally dispreferred." (Rose & Walker 2004: 520). Ngbaka, then, is a case where complex segments are allowed and place agreement is detectible. It is important to note that even if Ngbaka does not contain long-distance place *agreement*, but rather dissimilation, these patterns are still caused by an active id-cc.KPT dominating some io place faithfulness.

For the complex agreement candidate [$\widehat{\text{KP}}$…$\widehat{\text{KP}}$] to win, it must be evaluated better by some constraint not currently in the system. This is unlikely to be a segmental markedness constraint, as markedness violates against all place features.

Instead, the IO faithfulness id-io.KPT can be split into i→o and o→i variants. This follows the definition for directional Ident constraints utilized by Pater 1999, among others. Either the generalized identity schema would need to be changed, or directionality can be thought of as a version of parasitic identity: identity only applies if one root node already has a specific place property.

(143) id-io.KPT/+

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{dor}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{dor}])) \wedge \bullet_1 \downarrow [\text{dor}]$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{lab}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{lab}])) \wedge \bullet_1 \downarrow [\text{lab}]$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [\text{cor}]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [\text{cor}])) \wedge \bullet_1 \downarrow [\text{cor}]$

This constraint assigns a violation for every place disparity *as long as that place is present in the input*. Essentially, this constraint assigns violations to place shedding, but not sprouting.

(When a place feature is sprouted, it is by definition not in the input.)

Likewise, a constraint against place sprouting is defined parallel, but on the condition that the output root node ($\bullet_2$) is specified for a place feature.

(144) id-io.KPT/−

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [dor])) ∧ $\bullet_2$ ↓ [dor] +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [lab])) ∧ $\bullet_2$ ↓ [lab] +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [cor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [cor])) ∧ $\bullet_2$ ↓ [cor]

The constraint id-io.KPT/+ only assigns violations for place disparities where the input place feature is present, and likewise id-io.KPT/− only assigns violations when the input place feature is absent. This is similar to nasal ident in Pater 1999, and Tesar 2013 discusses these constraints as (expand)

(145) VT for place realization

/pakpa/	m.KPT	id-io.KPT/+	id-io.KPT/−	Disparity
a. p_1ak_2a	2	1	0	[labial] → ∅
b. p_1ap_1a	2	1	0	[dorsal] → ∅
c. $\widehat{kp}_1a\widehat{kp}_1a$	4	0	1	∅ → [dorsal]

With this split, the ranking id-io.KPT/+ ≫ id-io.KPT/− now favors the complex agreement candidate [$\widehat{kp}_1a\widehat{kp}_1a$] over the simple agreement and dissimilation candidate, as both of those two involve a place feature that was positively-valued in the input being realized as negatively-valued in the output. Working this into the overall Ngbaka ranking would result in the complex agreement candidate as the output for PAD. For a ranking of the Ngbaka data with the complex agreement candidate $\widehat{kp}_1a\widehat{kp}_1a$ as optimum, see Danis 2017a.

3.7.2 Capturing the asymmetry in the place generalizations

The asymmetry in PAD is captured here through restricting the correspondence of certain dorsal pairs. However, another option is through restricting *agreement* of place.

(146) Capturing Asymmetry

a. KP-K is not in correspondence, but K-KP is.

b. KP-K and K-KP are both in correspondence, but place agreement is directional.

The reason (146a) is chosen over (146b) is due to semihomorganic dorsal forms with mismatched voicing, such as those in (115). If forms like [k͡paga] were in correspondence, then they would also be subject to voicing agreement. However, semihomorganic dorsal forms with mismatched are not only present in the data, but they are significantly overrepresented (see Section 3.8.2.3). This is strong evidence against [k͡paga] forms being subject to Voicing Agreement (which does indeed apply in both directions). The general strategy in (146a) is concluded, and implemented with the ad hoc constraint Corr.K/C2=P.

3.7.3 Interim summary

The place and voicing co-occurrence restrictions are captured naturally via standard ABC assumptions. Labials correspond, and agree for place. Dorsal pairs correspond when the medial consonant is also labial, and agree for place. Additionally, all homorganic stops correspond and agree in voicing. Other theories, such as co-occurrence constraints, spreading, or Complete Identity, either cannot capture the full set of generalizations, or require other changes to our phonological assumptions (such as privative versus binary place).

3.8 Statistical analysis of a Ngbaka dictionary

As an empirical basis for the central claims of this chapter, a previously undigitized dictionary, Maes 1959, is searched for the relevant place combinations. It is found that words containing labials and labial-dorsals in any order are significantly underrepresented, corresponding to the description of Ngbaka Ma'bo in Thomas 1963. Additionally, the combination of initial dorsals with medial labial-dorsals is significantly underrepresented as well. This section goes over these findings in detail.

Table 3.6: Summary of place restrictions for all homorganic and semihomorganic pairs

Combination	O	E	O/E	Significance	Result
T…T	28	28.36	0.99	$p = 1$	As expected
P…P	12	16.06	0.75	$p = 0.31$	As expected
K…K	26	39.25	0.66	$p = 0.00630$	Underrepresented?
$\widehat{\text{KP}}$…$\widehat{\text{KP}}$	11	3.62	3.04	$p < 0.00625$	Overrepresented
P…$\widehat{\text{KP}}$	0	6.39	0.00	$p < 0.00625$	Underrepresented
$\widehat{\text{KP}}$…P	2	9.09	0.22	$p < 0.00625$	Underrepresented
K…$\widehat{\text{KP}}$	1	8.49	0.12	$p < 0.00625$	Underrepresented
$\widehat{\text{KP}}$…K	13	16.71	0.78	$p = 0.32$	As expected

Table 3.7: Summary of voicing and nasal restrictions for all homorganic pairs

Combination	O	E	O/E	Significance	Result
T…D, D…T	0	5.10	0.00	$p < 0.0167$	Underrepresented
N…$^{\text{N}}$D, $^{\text{N}}$D…N	1	2.32	0.43	$p = 0.47$	As expected
D…$^{\text{N}}$D, $^{\text{N}}$D…D	8	7.19	1.11	$p = 0.67$	As expected

3.8.1 Methodology

The dictionary chosen for analysis is Maes 1959. This dictionary has Ngbaka headwords first, which makes eventual parsing much easier, and has transcriptions in (near) IPA.

The dictionary was scanned and run through OCR software (Abbyy FineReader), looking for French, Dutch, and specially-trained IPA characters. This resulted in a rich-text document, which was manually checked word-for-word against the original dictionary by a research assistant.[7] The Ngbaka consonants and vowels were checked for accuracy, but there still may be discrepancies in the tone and nasality diacritics.

From the entire dictionary data, all bi-consonantal words were extracted. In addition to this being the minimum number of consonants necessary to see a co-occurrence restriction, it also rules out most compounds and reduplicated forms. The original generalizations hold for within roots only for Ngbaka Ma'bo (Thomas 1963), and this is assumed for Ngbaka

[7]Thanks to Dana Matarlo for her assistance with this part.

as well. However, there may be longer bona fide roots that are excluded in this filtering processes.

To find evidence of co-occurrence restrictions, O/E ratios, as used by Pierrehumbert 1993, are calculated for all stops sorted by place of articulation. O is the observed number of forms for some combination in the lexicon, and E is the expected number of forms expected in a lexicon of a specific size assuming free combination of consonants. E is calculated with the formula below, taken from Frisch 2011:

(147) Definitions for O and E

$$O = \text{observed } (C_1, C_2) \text{ forms in lexicon}$$
$$E = \frac{Obs(C_1) \times Obs(C_2)}{Total}$$

If a combination appears exactly as many times as is expected assuming free combination, the ratio of O to E will equal 1. As a certain combination appears less than expected, its O/E value will approach 0. Values of O/E near or equal to 0 imply a grammatical ban on that combination. Additionally, an O/E value significantly higher than 1 indicates that combination appears more often than expected. While these values have been extended to stochastic or weighted grammars to show both gradient preferences and dispreferences for certain combinations, the analysis here uses O/E values to find *categorical* restrictions only. The significance of these values were calculated with Fisher's exact test via a series of 2x2 contingency tables, described in detail in Section 3.8.2.1. Fisher's exact test is chosen over a χ^2 (chi-squared) test, as it is more accurate with a smaller sample size (such as the current one) (Agresti 2007: 45).

For present purposes, the following apply:

(148) Interpretation of results:

a. p is not significant: no grammatical restriction

b. $O/E < 1$ and p is significant: grammatical restriction

It's worth emphasizing that the O/E values for consonant co-occurrences take into account the type frequency of the individual consonants themselves. If the observed combinations of a form are low, it could either be due to the harmony subsystem (as developed previously in this chapter), or due to other, independent forces on the general phonotactics and frequency of the lexicon. For example, there are fewer nasal/prenasal combinations (N…^{N}D, ^{N}D…N) than there are labial/velar-labial combinations (K͡PP…P), yet the the analysis only treats the latter as ungrammatical. This is because of the significance of the difference between the observed and expected values. There may be other grammatical or extragrammatical forces that influence the frequency of nasals and prenasals independently, but their low attestation is not assumed to be caused by the subsystem of the grammar dealing with harmony/co-occurrence restrictions, which is why they are treated as licit by the present analysis.

3.8.2 Results

The following sections show the results of the dictionary analysis for both place and voice/nasality co-occurrence restrictions.

3.8.2.1 Place co-occurrence restrictions

The relevant segments, all oral and nasal stops, are sorted based on the following place definitions. While implosives are not included in the original analysis by Sagey 1986, they are included here because they also seem to obey the co-occurrence restrictions.

(149) Place Definitions[8]

cor = {n, ⁿd, d, t, ɗ}

dor (K) = {ŋ, ᵑg, g, k}

lab (P) = {m, ᵐb, b, p, ɓ}

lab-dor (KP) = {$\widehat{ŋm}$, $\widehat{ᵑᵐgb}$, $\widehat{gb}$, $\widehat{kp}$}

The label "other" encompasses all other segments, such as liquids and fricatives of all places of articulation. Based on this definition, Observed values are given in Table 3.8, Expected values in Table 3.9, and their ratios in Table 3.10.

Table 3.8: Observed values for all Ngbaka oral and nasal stops by place (Definition 2)

	cor	dor	lab	lab-dor	other	Mar C1
cor	28	34	17	11	70	160
dor	43	26	27	1	105	202
lab	33	31	12	0	76	152
lab-dor	15	13	2	11	45	86
other	37	67	35	14	127	280
Mar C2	156	171	93	37	423	880

Table 3.9: Expected values for all Ngbaka oral and nasal stops by place

	cor	dor	lab	lab-dor	other	Mar C1
cor	28.36	31.09	16.91	6.73	76.91	160
dor	35.81	39.25	21.35	8.49	97.10	202
lab	26.95	29.54	16.06	6.39	73.06	152
lab-dor	15.25	16.71	9.09	3.62	41.34	86
other	49.64	54.41	29.59	11.77	134.59	280
Mar C2	156	171	93	37	423	880

[8]Where it improves readability, the dorsals, labials, and labial-dorsals are abbreviated as K, P, and $\widehat{KP}$, respectively.

Table 3.10: O/E ratios for all Ngbaka oral and nasal stops by place

	cor	dor	lab	lab-dor	other
cor	**0.99**	*1.09*	*1.01*	*1.64*	*0.91*
dor	*1.20*	**0.66**(*)	*1.26*	**0.12***	*1.08*
lab	*1.22*	*1.05*	**0.75**	**0.00***	*1.04*
lab-dor	*0.98*	**0.78**	**0.22***	**3.04***	*1.09*
other	*0.75*	*1.23*	*1.18*	*1.19*	*0.94*

Starred cells indicate significance. Italic cells are untested for significance.

The values for all semihomorganic pairs are repeated in Table 3.11 , with their significance. The p-value that results from a 2x2 Fisher's exact test is compared to an alpha of 0.00625, which is the standard value of 0.05 adjusted for 8 tests (Bonferroni correction, the other 4 tests being all homorganic pairs). [9]

Table 3.11: O/E and significance for all semihomorganic pairs ($\alpha = 0.00625$)

C1	C2	O	E	O/E	p
lab	lab-dor	0	6.39	0.00	0.0013
lab-dor	lab	2	9.09	0.22	0.0051
dor	lab-dor	1	8.49	0.12	0.0011
lab-dor	dor	13	16.71	0.78	0.3185

All combinations except for the last, KP-K, are statistically significant—these combinations are significantly underrepresented in the Ngbaka dictionary data. This is the basis for assuming a categorical ban on these combinations in the analysis. The combination of an initial labial-dorsal with a medial dorsal has a $p > 0.00625$, so it is assumed that this combination occurs as we would expect via free combination—it is not significantly over- or underrepresented.

The P-KP and KP-P combinations were reported as ungrammatical by Thomas 1963 for Ngbaka Ma'bo, and this is the generalization assumed by Sagey 1986. However, the K-KP combination has not been reported to be banned in the previous literature; this is a

[9] Much thanks to Adam Chong for assistance with the statistics in this section.

new generalization discovered here. Each of these combinations is discussed in detail in the following sections.

3.8.2.1.1 P-KP combinations

P-KP combinations are significantly underrepresented in the Ngbaka dictionary data. There are 0 observed pairs, which is significant. This is shown in Table 3.12.

Table 3.12: P-KP 2x2 contingency table

		lab-dor	other
lab	*O*	0	152
	E	6.39	145.61
	O/E	**0.00**	1.04
other	*O*	37	691
	E	30.61	697.39
	O/E	1.21	0.99

Significant, $p < 0.00625$

This coincides with the description of Ngbaka Ma'bo in Thomas 1963.

3.8.2.1.2 KP-P combinations

KP-P combinations are significantly underrepresented in the Ngbaka dictionary data. There are 2 observed pairs, which is significant. This is shown in Table 3.13.

Table 3.13: KP-P 2x2 contingency table

		lab	other
lab-dor	*O*	2	84
	E	9.09	76.91
	O/E	**0.22**	1.09
other	*O*	91	703
	E	83.91	710.09
	O/E	1.08	0.99

Significant, $p < 0.00625$

While there are two counter-examples, the O/E value is still below 1 and $p < 0.00625$, so these combinations are significantly underrepresented. The two counterexamples are given below.

(150) KP-P counterexamples:

a. g͡bòᵐbè (n.) ‘marabou’ (p. 81)

b. ŋ͡mg͡bámù (n.) antelope sp. (*Cephalophus dorsalis*) (p. 142)

Both are fauna, which might be relevant as specialized vocabulary might survive with otherwise illicit phonotactics.[10]

3.8.2.1.3 K-KP combinations

KP-P combinations are significantly underrepresented in the Ngbaka dictionary data. There is 1 observed pair, which is significant. This is shown in Table 3.14.

Table 3.14: K-KP 2x2 contingency table

		labdor	other
dor	*O*	1	201
	E	8.49	193.51
	O/E	**0.12**	1.04
other	*O*	36	642
	E	28.51	649.49
	O/E	1.26	0.99

Significant, $p < 0.00625$

The single counterexample is given below.

(151) K-KP counterexamples:

a. kù ŋ͡mg͡bà (n.) ‘large mortar for pounding corn’ (p. 144)

[10] Thanks to Laura McPherson for pointing this out.

3.8.2.1.4 KP-K combinations

Table 3.15: KP-K 2x2 contingency table

		dor	other
lab-dor	*O*	13	73
	E	16.71	69.29
	O/E	**0.78**	1.05
other	*O*	158	636
	E	154.29	639.71
	O/E	1.02	0.99

Not significant, $p = 0.32$

There are 13 observed forms with initial labial-velars and a medial dorsal, of an expected 16.71. While this O/E ratio is below 1, it is not significant, so it is assumed that these forms appear exactly as expected. The observed forms are listed below:

(152) Attested k͡p-K forms:

a. g͡baka ‘help, rescue’ (p. 77)
b. g͡bákɔ́- ‘tree branch’ (p. 77)
c. g͡baŋa ‘be afraid’ (p. 78–79)
d. g͡bàᵑgà ‘door leaf’ (p. 79)
e. k͡páᵑgà ‘cassava bread’ (p. 109)
f. k͡pɛ̀kà ‘knife for tattoos’ (p. 110)
g. k͡pɛ̀kà ‘click of a trap’ (p. 110)
h. k͡pɛ̀ᵑgȧ ‘iron blade or weapon’ (p. 110)
i. ᵑ͡mg͡bàkà ‘Ngbaka people or language’ (p. 142)
j. ᵑ͡mg͡bàᵑgà ‘dispute case’ (p. 143)
k. ᵑ͡mg͡bàᵑgá- ‘combat leader’ (p. 143)
l. ᵑ͡mg͡bókó- ‘knee pain’ (p. 144)
m. ᵑ͡mg͡bùᵑgà ‘main rope of a trap’ (p. 145)

3.8.2.1.5 Homorganic combinations

Among the homorganic combinations, labial pairs and coronal pairs both appear exactly as expected. Dorsal pairs are likely significantly underrepresented, and labial-dorsal pairs are

significantly over-represented.

While the *p* value for dorsal pairs is not below 0.00625, it is very nearly there. Additionally, the alpha of 0.00625 is the result of the Bonferroni correction, which is known to be conservative 35 (see e.g. Sharpe 2015). Thus, it is likely that dorsal pairs are significantly underrepresented. However, while categorical bans were assumed on the significantly underrepresented pairs, the homorganic dorsal pairs appear much more often, even if underrepresented.

3.8.2.2 Voicing and nasality restrictions

To test for significance of the voicing and nasality restrictions, consonant pairs were sorted into either homorganic or non-homorganic (heterorganic and semihomorganic) on one dimension, and voiced stop-voiceless stop, nasal-prenasal, and voiced stop-prenasal, and all other pairs on the other dimension. The *p* value is compared against an alpha of 0.0167, as this is 0.05 adjusted for 3 tests.

Table 3.16: Summary of voicing and nasal restrictions

Combination	Result	O	E	O/E	Significance
T-D	Banned	0	5.10	0.00	$p < 0.0167$
N-ND	Allowed	1	2.32	0.43	$p = 0.47$
D-ND	Allowed	8	7.19	1.11	$p = 0.67$

Stop consonants were first sorted based on the following groups:

(153) Stops

Voiceless stops (T) = {t, p, k, k͡p}

Voiced stops (D) = {d, b, g, g͡b}

Nasals (N) = {n, m, ŋ, ŋ͡m}

Prenasalized stops (ND) = {nd, mb, ŋg, ŋ͡mg͡b}

3.8.2.2.1 Voicing Agreement

This section shows that homorganic pairs containing voiced and voiceless stops together are significantly underrepresented.[11]

Table 3.17: Voicing agreement

		homorganic	other
T-D	*O*	0	22
	E	5.10	16.90
	O/E	**0.00**	1.30
other	*O*	204	654
	E	198.90	659.10
	O/E	1.03	0.99

Significant, $p = 0.00402659$

Between 5 and 6 forms are expected to occur with homorganic stops with a mismatch in voicing, yet 0 occur. This is significant. The conclusion is that there is a grammatical ban on homorganic stops that disagree in voice.

3.8.2.2.2 Nasal Agreement

While only 1 observed form appears in the data that contains a homorganic nasal-prenasal pair, only between 2 and 3 are expected. This is not significantly under or over-represented, so no grammatical ban on homorganic nasal-prenasal pairs is assumed. While previous analyses assume a ban on N-ND sequences, the fact that the data here does not support this could be due to the size of the wordlist. The O/E ratio is less than 1, but only very few actual examples are expected. In a longer wordlist, it might be the case that this underrepresentation is significant. However, for the purposes of this chapter, no ban on N-ND sequences is assumed.

[11] There was one form [g…g] found in the dictionary with an alternative [g…k] pronunciation. If this form is included in the totals (so $O = 1$), it is significant at $p = 0.025$.

Table 3.18: Nasal agreement

		homorganic	other
N-ND	*O*	1	9
	E	2.32	7.68
	O/E	**0.43**	1.17
other	*O*	203	667
	E	201.68	668.32
	O/E	1.01	1.00

Not significant, $p = 0.4680881$

3.8.2.2.3 Sonorant Agreement

Sonorant Agreement is the term used here to describe possible agreement in the feature [sonorant] between homorganic stops, namely, voiced stops and prenasalized stops. In the representational theory assumed here, these stops differ only in their value for the feature [sonorant].

Table 3.19: Sonorant agreement

		homorganic	other
D-ND	*O*	8	23
	E	7.19	23.81
	O/E	**1.11**	0.97
other	*O*	196	653
	E	196.81	652.19
	O/E	1.00	1.00

Not significant, $p = 0.6700866$

The observed voiced-prenasal forms are given below.

(154) a. bàmbú (s.) ‘wide waistband of mothers after childbirth’ (p. 46)

b. dɔ̀ndɔ̀ (s.) ‘slippery surface’ (p. 62)

c. gàŋgá (s.) ‘hook, barb’ (p. 75)

d. gbàŋbà (s.) ‘trap for animals’ (p. 79)

e. gbɔ́ŋbɔ́ (s.) ‘laugh’ (p. 81)

f. gɔ̀ŋgɔ̀ (s.) ‘basket with long bottom with two corners’ (p. 87)

g. mbɔ́bì (s.) ‘rattan for tying’ (p. 125)

h. dándèà (s.) ‘small black swallow (Psalidoprocne sp.)’ (p. 56)

3.8.2.3 Semihomorganic KP-K patterns with heterorganic pairs

The pairs P…KP, KP…P, and K…KP are all significantly underrepresented in the Ngbaka dictionary data, as Section 3.8.2.1 shows. The pair KP…K is appears as expected assuming free combination. The question that remains is, does KP…K pattern like purely homorganic pairs or like purely heterorganic pairs with respect to Voicing Agreement? The number of attested KP-K pairs that show a mismatch in voicing among oral stops is significantly *over*represented. Because the number of voicing mismatches among oral stops in KP-K pairs is not significantly underrepresented, it patterns more like heterorganic pairs.

Table 3.20: Semihomorganic KP-K and Voicing Agreement

		KP-K	other
T-D	*O*	2	21
	E	0.34	22.66
	O/E	**5.89**	0.93
other	*O*	11	846
	E	12.66	844.34
	O/E	0.87	1.00
Significant, $p = 0.04280122$			

The observed forms are given below.

(155) Attested semihomorganic dorsal pairs that differ in voicing:

a. g͡baka ‘help, rescue’ (p. 77)

b. g͡bákɔ̀- ‘tree branch’ (p. 77)

Table 3.20 shows that the O/E value of 5.89 for KP-K pairs of oral stops that differ in voicing is significantly overrepresented at $p = 0.04$. However, it is not crucial for the

argument that these pairs be overrepresented, simply that they are not significantly underrepresented. So, while the *p* value is only slightly less than an alpha of 0.05, the conclusion would be the same with a *p* of greater than 0.05, as long as the O/E value is near or greater than 1. If the O/E value were less than 1 *and* the *p* value were less than 0.05, then the conclusion would be that KP-K pairs pattern like purely homorganic stops. However, this is not the case. This is the empirical basis for assuming that KP-K pairs are not in correspondence in the ABC analysis.

3.8.3 Summary

Through a statistical analysis of Maes 1959, semihomorganic labial pairs, and semihomorganic dorsal pairs with medial labial-dorsals, are found to be significantly underrepresented. Additionally, homorganic pairs of voiced and voiceless stops are significantly underrepresented. Homorganic labial-dorsal pairs are significantly overrepresented.

3.9 Chapter Summary

This chapter presents an ABC analysis with statistically significant empirical support of long-distance major place harmony, a process previously claimed to be unattested. Co-occurrence restrictions in Ngbaka are best accounted for via ABC constraints referring to major place identity. Consonant combinations of P…$\widehat{\text{KP}}$, $\widehat{\text{KP}}$…P, and K…$\widehat{\text{KP}}$ are all significantly underrepresented in the Ngbaka data, leading to the generalization that labial pairs, and certain dorsal pairs, correspond, and agree for major place. The existence of complex place is crucial to seeing the effects of major place agreement, as semihomorganic pairs are similar enough to correspond based on Corr constraints referring to individual features, but are not identical based on a constraint that evaluates all place features.

4 Cross-category vowel-consonant agreement

Vietnamese and Aghem display cross-categorical C-to-V interactions: the place feature of a vowel is realized on a consonant as a consonantal place. For this to be possible, two things must be the case: consonants and vowels share place features, and there is an Agree-type constraint that forces agreement between these place features, but is agnostic to the fact that certain features determine vocalic place and others consonantal place. In other words, in the segmental structure defined in Chapter 2, this Agree constraint does not care whether a place feature, such as [labial], is dominated by C-place or V-place in a consonant when it is adjacent to a [labial] vowel.

Cross-linguistically, previous attested cases of cross-category C-to-V agreement only involved types of palatalization, and representational theories have been developed to model this restriction (e.g. Ní Chiosáin & Padgett 1993). Here, the cases of cross-category agreement are generalized to involve interaction with all place features.

The processes in Vietnamese and Aghem are described, with a focus on Vietnamese. The general Agree constraint fits into the framework of the dissertation as an instance of the Identity schema, defined in Chapter 2.

4.1 The argument

In Vietnamese, dorsals in the syllable rhyme show a restricted distribution. Palatal stops appear only after front vowels, and labial-velars appear only after back, round vowels. Plain velars appear after central vowels.

(156) Vietnamese rhyme agreement patterns:

a. /OK/ → [O$\widehat{\text{KP}}$]

b. /AK/ → [AK]

c. /EK/ → [EC]

(157)

a.	ʔuk͡p	‘Australia’	(Phạm 2006: 115)
b.	duŋ͡m	‘to be correct’	(Phạm 2006: 115)
c.	coŋ͡m	‘husband’	(Phạm 2006: 115)
d.	ɔŋ͡m	‘bee’	(Phạm 2006: 115)
e.	xɔk͡p	‘to cry’	(Phạm 2006: 115)
f.	*ok		
g.	*ak͡p, *ek͡p		

These are all instances of the vowel place influencing the place of the consonant. The pattern in (156a) is significant because it is perhaps the only case where vocalic place (in this case, [labial]) from a vowel appears as consonantal place on a consonant, outside of palatalization.

This is part of a larger place agreement process discussed in Section 4.3. The labial place on the resulting labial-velar is consonantal, and therefore this is a case of cross-category V-to-C agreement, which is typologically rare if not non-existent (Ní Chiosáin & Padgett 1993, Padgett 2011, Halle et al. 2000, a.o.).

This chapter argues that consonants and vowels must share place features, following Clements 1991, Clements & Hume 1995. These features are subject to Agree constraints within the schemas defined in this dissertation. Cross-category agreement occurs when Agree constraints blind to specific C- and V-place nodes are active and remaining marked-ness and faithfulness constraints allow the agreeing outputs to surface. Both instances of cross-category agreement investigated here, Vietnamese and Aghem, have as targets labial-dorsal segments k͡p (and g͡b).

To complete the argument that this is C-to-V interaction, the main piece of evidence that Vietnamese contains consonants agreeing to the vowels, and not vice versa, is the comple-mentary distribution of the targets of agreement: [c], [k], [k͡p]. These segments, [c] and [k͡p], are restricted to the rhyme after certain vowels. If vowels were assimilating to consonants,

we would expect to see the targets of agreement in all positions. Because we don't see [k͡p] outside of agreement, it is safe to assume that it results only from a consonant agreeing with a vowel.

4.2 Summary of vowel-consonant interactions

Padgett 2011 categorizes interactions between consonants and vowels along two dimensions: cross-category versus within-category, and C-to-V versus V-to-C. These are defined below.

(158) **Within-category** (WC):

"'Within-category' interactions are those between a vowel and another (semi)-vocalic element, whether the latter is a secondary articulation or a primary one (a glide)." (Padgett 2011: 1762)

(159) **Cross-category** (XC):

"…C–V interactions in which the primary articulation of a [+consonantal] segment appears to interact with the place of a vowel." (Padgett 2011: 1764)

For whatever representational split is assumed between the place features on vowels and the place features of consonants, whether it is a unified theory with distinct C- and V-place nodes, or one with a disjoint set of features (e.g. [labial] and [±round]), a cross-category interaction where some vowel place interacts with some consonantal place. Interactions in this sense also depend on the theory of the grammar, whether it is autosegmental spreading or separate feature instances mediated by Agree constraints.

In within-category interactions, vocalic place in a consonant interacts with vocalic place on vowels; thus a rounded consonant like [kʷ] might cause a vowel to be rounded, or a round vowel might cause simple [k] to become [kʷ]. Cross-category interactions involve the consonantal place on a consonant to interact with the vowel place on a vowel. For instance, a simple [p] might cause an unrounded vowel to become rounded.

The direction of the interaction can also vary:

(160) **V-to-C** (VC):

The vowel assimilates to the consonant.

(161) **C-to-V** (CV):

The consonant assimilates to the vowel.

In either XC or WC interactions, the underlying place of one segment, the consonant or the vowel, affects the realization of the other. If the underlying place of the consonant spreads or causes agreement, the interaction is V-to-C (as the **v**owel assimilates **to** the **c**onsonant), and it is C-to-V if the vowel place influences the consonant. These interactions are summarized in the following table, with empirical examples from Padgett 2011:

Table 4.1: Typology of Padgett 2011

	Within-category (WC)	Cross-category (XC)
V-to-C (VC)	✓/e/ → [u] / _ w (Kabardian)	✓/ɨ/ → [u] / p, m_ (Mapila Malayalam)
C-to-V (CV)	✓/T/ → [T^{j}] / _ i, e (Russian)	✓/k/ → [tʃ] / _ i (Slovak) */k/ → [p] / _ u (Unattested)

In the attested typology of such interactions, cross-category C-to-V (XCCV) interactions are found to be extremely rare if not non-existent. The only attested cases are of palatalization, where a front vowel affects a velar or coronal segment. In the case of Slovak cited above, a velar [k] fronts to an alveo-palatal affricate. Phonetically, this does involve a change in the place of articulation of the consonant. The remaining question is what *phonological* change has occurred.

However, there are no clear synchronic cases of cross-category interactions outside of palatalization processes. Why might this be? They are the only kind of interaction in the above table that involves the addition or removal of C-place on a consonant. If removal of C place is universally bad or extremely rare, then the only possible XCCV interactions are ones that create a complex segment. However, removal of C-place from a consonant

cannot be universally bad, as it occurs in the reduction processes analyzed in Chapter 5, and in other cases of consonant assimilation (e.g. /np/ → [mp]) crosslinguistically. It is only when the trigger is a vowel is it not seen. This is remains an open question. Padgett's formulation does not take into account the possibility of complex segments as outputs of an assimilation process. This is the pattern seen in Vietnamese, and the typology is thus annotated below.

Table 4.2: **Augmented** typology of Padgett 2011

	Within-category (WC)	Cross-category (XC)
V-to-C (VC)	✓/e/ → [u] / _ w (Kabardian)	✓/ɨ/ → [u] / p, m_ (Mapila Malayalam)
C-to-V (CV)	✓/T/ → [T^{j}] / _ i, e (Russian)	✓/k/ → [tʃ] / _ i (Slovak) */k/ → [p] / _ u (Unattested) ✓/k/ → [k͡p] / u _ (Vietnamese)

In Vietnamese, as is argued in this chapter, the roundedness of the vowel is realized as phonological consonantal stricture, making the interaction cross-category. Additionally, the vowel does not change place, so the interaction is C-to-V.

4.3 Background on Vietnamese

This chapter will focus on the Hanoi dialect, but the Saigon dialect also contains a similar process with respect to labial-velars (see Phạm 2006 for a comparative study and also Thompson 1965). The rest of this chapter will focus on the Hanoi dialect, unless otherwise specified. The full set of consonants that appear in initial position is given in Table 4.3.

Table 4.3: Vietnamese consonant inventory - onsets (Kirby 2011: 382)

	Labial	Labio-dental	Dental	Alveolar	Palatal	Velar	Glottal
Plosive	ɓ		t t^{h}	ɗ	tɕ	k	ʔ
Nasal	m		n		ɲ	ŋ	
Fricative		f v		s z		x ɣ	h
Approximant	w						
Lateral approximant			l				

While there is a palatal segment in initial position, its phonetic description differentiates it from the palatal segment in coda position, transcribed here as [c]. Kirby states that "this segment is consistently realized as an affricate [tɕ]", opposed to an unaffricated palatal stop [c] (Kirby 2011: 382) in coda position. See also Hall 1997 for a detailed discussion on the different kinds of palatal segments and their representations.

In coda position, Vietnamese has the following inventory.

Table 4.4: Vietnamese consonant inventory - codas (Kirby 2011: 382)

	Labial	Alveolar	Palatal	Velar	Labial-velar
Plosive	p	t	c*	k*	k͡p*
Nasal	m	n	ɲ*	ŋ*	ŋ͡m*
Approximants			j		w

The starred forms in Table 4.4 indicate that these segments have a distribution further limited by the immediately proceeding vowel inside the syllable rhyme. While coronals and labials can appear after any vowel, the set of palatal, velar, and labial-velar segments can only appear after front, central, or back-round vowels, respectively. These restrictions are summarized in the following table, reproduced from Kang et al. 2016:

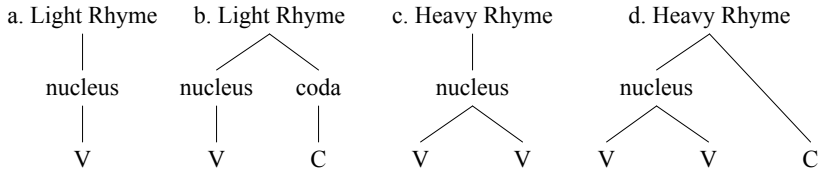
(162) Rhyme restrictions, reproduced from Kang et al. 2016: (5):

Vowel	IPA	[c ɲ]	[k ŋ]	[k͡p ŋ͡m]
Front	i	✓		
	e	✓		
	ɛ	✓		
	ɛː		(✓)	
Central	ɯ		✓	
	ɤ			
	ɤ̆		✓	
	ă		✓	
	a		✓	
Back round	u			✓
	o			✓
	ɔ			✓
	ɔː		(✓)	

In Vietnamese, all back vowels are round and all round vowels are back. Plain dorsals can occur after all long vowels. The restriction only occurs after short vowels; when a long vowel is present, it is assumed that the coda consonant is no longer part of the domain of agreement. This is following the analysis in Phạm 2006, shown below.

Phạm 2006 analyzes Vietnamese as a nucleus-weight language "...in which a light rhyme, i.e. a monomoraic rhyme with a short vowel and a final consonant as in Fig. 2b, is the domain of feature sharing and centralization of the vowel" (Phạm 2006: 110).

(163) Types of rhyme configurations for Vietnamese (Phạm 2006: Fig. 3):



Assuming these structures, the consonant after a VV or Vː is outside the scope of agreement.

Vietnamese contains the labial-velars [k͡p ŋ͡m] in coda position following the back, round vowels [u o ɔ] (Kirby 2011, see also Kang et al. 2016, Hajek 2009).

(164)	a.	uŋ͡m˧˥	'tumor'	(Kirby 2011: 383)
	b.	oŋ͡m˧˥	'grandfather'	(Kirby 2011: 383)
	c.	ɔŋ͡m˧˥	'bee'	(Kirby 2011: 383)
	d.	uk͡p˧˥	'Australia'	(Kirby 2011: 383)
	e.	ok͡p˧˥	'snail'	(Kirby 2011: 383)
	f.	ɔk͡p˧˥	'mind, brain'	(Kirby 2011: 383)
	g.	duŋ͡m	'to be correct'	(Phạm 2006: 115)
	h.	coŋ͡m	'husband'	(Phạm 2006: 115)
	i.	xɔk͡p	'to cry'	(Phạm 2006: 115)
	j.	*ak͡p		
	k.	*ek͡p		

Labial-velars in coda position contrast with simple labials:

(165) a. su͡kpˀ ‘to scoop’ (Kirby 2011: 383)
b. supˀ ‘soup’
c. ho͡ŋmˀ ‘hip’
d. homˀ ‘day’
e. hɔ͡kpˬ ‘to study’
f. hɔpˬ ‘to meet’
g. sɔ͡ŋmˬ ‘wave’
h. sɔmˬ ‘hamlet’

Labial-dorsals do not contrast with simple dorsals in coda position, nor do simple dorsals contrast with palatals in this position:

> Labiodorsals and plain dorsals are in complementary distribution: the former occur after the three short back rounded vowels [u, o, ɔ]; the latter occur elsewhere except after [iː] and [əː]. Dorsals do not occur after long back vowels. Palatalized and plain dorsals are in complementary distribution except after [a]. (Phạm 2006: 114)

Simple dorsal codas become labial velars after back, round vowels. There is a full labial closure present, as Kirby 2011 states that “[t]his articulation is sometimes accompanied by a visible puffing of the cheeks as air becomes thrapped in the oral cavity.” (Kirby 2011: 383)

Phonetically, there are varying descriptions of the fronted dorsal that appears after front vowels in complementary distribution with velars. Phạm 2006 transcribes it as both [c] and [ʲk], while Kirby 2011 describes it as a pre-velar segment, with no alveolar contact. This segment is thus different from the palatal consonant that appears in initial positions, which has both frication and alveolar contact. The segment in final position is a stop, but also Kirby states “conditioning vowels tend to be shortened and centralized, and may be produced with a noticeable palatal offglide.” (Kirby 2011: 383). The remainder of this chapter will refer to these fronted velars as simply palatals, and will transcribe them as C.

The restrictions for short vowels are summarized in the table below:

(166) Rhyme restrictions in Vietnamese:

	E	A	O	Comment
T	✓	✓	✓	Coronals occur freely
P	✓	✓	✓	Labials occur freely
C	✓	*	*	
K	*	✓	*	Dorsals agree
K͡P	*	*	✓	
T͡P	*	*	*	No labial-coronals

(167) Onset restrictions in Vietnamese:

	E	A	O	Comment
T	✓	✓	✓	Coronals occur freely
P	✓	✓	✓	Labials occur freely
K	✓	✓	✓	Dorsals occur freely
C	*	*	*	No palatal stops
K͡P	*	*	*	No labial-dorsals
T͡P	*	*	*	No labial-coronals

In this table, E, A, and O stand for front, central, and back vowels. E is phonological [coronal], while both A and O are [dorsal]. The round vowel O is additionally [labial]. The consonants T, P, and K and [coronal], [labial], and [dorsal], respectively. The labial-velar segment K͡P is both [labial] and [dorsal]. The fronted velar, or palatal, segment C is treated here as phonologically both [dorsal] and [coronal]. Its phonetic implementation is not as a double-articulation but rather as a stop with a single articulation with a palatal closure.

4.4 Proposal for cross-category agreement

In order for cross-category agreement to occur, as it must in Vietnamese, V-place and C-place are susceptible to the same Agree constraint. The definition is below, repeated from (54):

(168) id-agr.KPT$_X$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [dor]) ⊕ ($\bullet_2$ ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [lab]) ⊕ ($\bullet_2$ ↓ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [cor]) ⊕ ($\bullet_2$ ↓ [cor]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal place, and for each with a disparity in labial place, and for each with a disparity in coronal place."

Recall that the crucial property of this constraint is that it does not reference the C-place or V-place nodes in the structure. The sequences [op$^{\text{ɣ}}$] and [o$\widehat{\text{kp}}$] are thus evaluated identically by this constraint:

(169)

	id-agr.KPT$_X$	$\bullet_1$ place	$\bullet_2$ place
op	*	V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab]
op$^{\text{ɣ}}$		V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab], V-Pl ↓ [dor]
o$\widehat{\text{kp}}$		V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab], C-Pl ↓ [dor]

The type of agreement in the languages analyzed here, whether it is cross-category agreement or within-category agreement, then depends on the ranking of the markedness and faithfulness constraints for the relevant C- and V-place features. Below, the cross-category candidate [o$\widehat{\text{kp}}$] and the within-candidate candidate [op$^{\text{ɣ}}$] are differentiated by V- and C-place markedness for the feature [dorsal].

The agreement constraints based on the cross-category schema then do not specifically enforce cross-category agreement; they are simply satisfied by it. However, they are also satisfied by within-category agreement as well. The remaining constraint interactions determine the exact type of agreement in the language. In Vietnamese, there is cross-category agreement, while in Aghem, there is cross-category agreement for the feature [dorsal], and within-category agreement for the feature [labial].

(170) Controlling for type of agreement via markedness

	id-agr.KPT$_X$	m.K$_V$	m.K$_C$	$\bullet_1$ place	$\bullet_2$ place
op	*			V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab]
op$^{\text{ʏ}}$		*		V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab], V-Pl ↓ [dor]
o$\widehat{\text{kp}}$			*	V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab], C-Pl ↓ [dor]

(171) Controlling for type of agreement via faithfulness

/op/	id-agr.KPT$_X$	id-io.K$_C$	id-io.K$_C$	$\bullet_1$ place	$\bullet_2$ place
op	*			V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab]
op$^{\text{ʏ}}$		*		V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab], V-Pl ↓ [dor]
o$\widehat{\text{kp}}$			*	V-Pl ↓ [lab], V-Pl ↓ [dor]	C-Pl ↓ [lab], C-Pl ↓ [dor]

It will be seen that in Aghem, faithfulness crucially determines the type of agreement, WC over XC. It must be faithfulness that decides for Aghem, as [$\widehat{\text{kp}}$] is phonotactically licit in underived environments and in the mapping /op/ → [o$\widehat{\text{kp}}$], yet agreement from /ok/ results in [ok$^{\text{ʍ}}$], due to demands on labial faithfulness.

4.4.1 Constraints

The analysis uses the following constraints. The scaled markedness and faithfulness constraints are the same as those in Chapter 5, but are explicitly marked as violating against C-place.

(172) *Cross-category agreement*

a. **id-agr.KPT$_X$/VC**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [dor]) ⊕ ($\bullet_2$ ↓ [dor])) ∧ (Rh ↓ $\bullet_1, \bullet_2$) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [lab]) ⊕ ($\bullet_2$ ↓ [lab])) ∧ (Rh ↓ $\bullet_1, \bullet_2$) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [cor]) ⊕ ($\bullet_2$ ↓ [cor])) ∧ (Rh ↓ $\bullet_1, \bullet_2$)

—

"Assign a violation for each pair of adjacent segments in the syllable rhyme that have a disparity in dorsal place, and for each with a disparity in labial place, and for each with a disparity in coronal place."

b. **id-agr.KP$_X$/VC**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [dor]) ⊕ ($\bullet_2$ ↓ [dor])) ∧ (Rh ↓ $\bullet_1, \bullet_2$) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [lab]) ⊕ ($\bullet_2$ ↓ [lab])) ∧ (Rh ↓ $\bullet_1, \bullet_2$)

—

"Assign a violation for each pair of adjacent segments in the syllable rhyme that have a disparity in dorsal place, and for each with a disparity in labial place."

c. **id-agr.K$_X$/VC**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{adj} \bullet_2$) ∧ (($\bullet_1$ ↓ [dor]) ⊕ ($\bullet_2$ ↓ [dor])) ∧ (Rh ↓ $\bullet_1, \bullet_2$)

—

"Assign a violation for each pair of adjacent segments in the syllable rhyme that have a disparity in dorsal place."

In Vietnamese and Aghem, agreement is limited to VC contexts. In Vietnamese, agreement occurs within the light rhyme of a syllable (see 163). Following Phạm 2006, the agreement process is restricted to after short vowels; for simplicity it is assumed that the Rh node in the constraint definition refers to light rhymes only; those coda consonants dominated by a heavy rhyme are thus outside the scope of the agreement constraint.

In Aghem, agreement occurs after a prefix vowel on the first consonant of the root. In the analysis that follows, the Agree constraints ignore all CV forms.

(173) *C-place markedness*

a. **m.KPT$_C$**

• / • ↓ C-pl ↓ [dor] +

• / • ↓ C-pl ↓ [lab] +

• / • ↓ C-pl ↓ [cor]

—

"Assign a violation for each root node that has dorsal C-place, and for each that has labial C-place, and for each that has coronal C-place."

b. **m.KP$_{C}$**

• / • ↓ C-pl ↓ [dor] +

• / • ↓ C-pl ↓ [lab]

—

"Assign a violation for each root node that has dorsal C-place, and for each that has labial C-place."

c. **m.K$_{C}$**

• / • ↓ C-pl ↓ [dor]

—

"Assign a violation for each root node that has dorsal C-place."

(174) *C-place faithfulness*

a. **id-io.KPT$_{C}$**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [cor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [cor]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place, and for each with a disparity in coronal C-place."

b. **id-io.KP$_{C}$**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [lab]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place."

c. **id-io.K_C**

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ C-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ C-pl $\downarrow$ [dor]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place."

These are the basic scaled C-place markedness and faithfulness constraints based on de Lacy 2006 and whose typology is analyzed in detail in Chapter 5.

For V-place markedness for consonants, individual constraints are assumed (following (46)). The cross-linguistic generalizations and implications for V-place on consonants is not the primary focus of this dissertation. The individual constraints allow the necessary mappings here without adding additional ranking complexity, though they likely overpredict cross-linguistically. Because V-place features can appear on both consonants and vowels, the V-place markedness and faithfulness constraints are further defined to target [+cons] and [−cons] segments, respectively.

(175) V-place markedness for consonants

a. **m.K_V**

$\bullet$ / $\bullet \downarrow$ V-pl $\downarrow$ [dor] $\wedge$ $\bullet \downarrow$ [+cons]

—

"Assign a violation for each [+cons] root node that has dorsal C-place"

b. **m.P_V**

$\bullet$ / $\bullet \downarrow$ V-pl $\downarrow$ [lab] $\wedge$ $\bullet \downarrow$ [+cons]

—

"Assign a violation for each [+cons] root node that has labial C-place"

c. **m.T_V**

• / • ↓ V-pl ↓ [cor] ∧ • ↓ [+cons]

—

"Assign a violation for each [+cons] root node that has coronal C-place"

For V-place markedness on vowels, the omnibus markedness constraint is assumed (following (45)), again to simplify constraint interactions. In the mappings for Vietnamese and Aghem, the vowel is always faithful (as it is a C-to-V process).

(176) V-place markedness for vowels

a. **m.EAO**

• / • ↓ V-pl ↓ [dor] ∧ • ↓ [−cons] +

• / • ↓ V-pl ↓ [lab] ∧ • ↓ [−cons] +

• / • ↓ V-pl ↓ [cor] ∧ • ↓ [−cons]

—

"Assign a violation for each [−cons] root node that has dorsal V-place, and for each that has labial V-place, and for each that has coronal V-place."

The behavior of the V-place markedness constraints is illustrated in the tableau below.

(177)

	m.EAO	m.K_V	m.P_V	m.T_V	V-place	[cons]
e	*				[cor]	−
a	*				[dor]	−
o	**				[lab], [dor]	−
C^{γ}		*			[dor]	+
C^{w}			*		[lab]	+
C^{j}				*	[cor]	+

Again, because both vowels and consonants can house V-place features, faithfulness must not only point to the V-place node, but also to the specific [±cons] feature also part

of that segment. The following faithfulness constraints check the input root node and apply only if it dominates a [±cons] feature of a specific value.

(178) **id-io.KPT$_{V}$**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [dor])) ∧ ($\bullet_1$ ↓ [+cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [lab])) ∧ ($\bullet_1$ ↓ [+cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [cor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [cor])) ∧ ($\bullet_1$ ↓ [+cons])

—

"Assign a violation for each pair of [+cons] segments in IO correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place, and for each with a disparity in coronal V-place."

(179) **id-io.EAO**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [dor])) ∧ ($\bullet_1$ ↓ [−cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [lab])) ∧ ($\bullet_1$ ↓ [−cons]) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [cor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [cor])) ∧ ($\bullet_1$ ↓ [−cons])

—

"Assign a violation for each pair of [−cons] segments in IO correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place, and for each with a disparity in coronal V-place."

The behavior of these two constraints is illustrated in the tableau below.

(180)

input	output	id-io.EAO	id-io.KPT_V	Sprouted V-pl	Shedded V-pl
a	o	*		[lab]	
e	a	**		[dor]	[cor]
e	o	***		[lab], [dor]	[cor]
C	C^{γ}		*	[dor]	
C^{w}	C		*		[lab]
C^{j}	C^{w}		**	[lab]	[cor]

There is a further generalization in Vietnamese that the rhymal cross-category only occurs if the consonant in question is dorsal. This is captured with a constraint that has the content of id-agr.KPT_X but only applies if the consonant has [dor] C-place. This could be thought of as a local conjunction between id-agr.KPT_X and m.K_C, as the following tableau shows.

(181)

	id-agr.KPT_X	m.K_C	[id-agr.KPT_X & m.K_C]
ok	*	*	*
o$\widehat{kp}$		*	
ek	**	*	**
ec	*	*	*
op	*		
ot	***		
ep	**		
et			

However, Chapter 2 discusses the issues with conjoining two constraints with different types of violation loci (ordered pair vs. individual). The crucial constraints are instead formulated as parasitic identity on place agreement.

(182) Two conjunctions: Agree & C-place markedness

a. **id-agr.KPT$_X$&m.K$_C$**

b. **id-agr.K$_X$&m.KP$_C$**

This is crucial to capture the generalization that only dorsal rhyme consonants agree. This is a *different* generalization than saying only the feature [dorsal] agrees; when a dorsal [k] becomes [k͡p], for instance, it is the [labial] feature that agrees, and likewise for palatalization after front vowels with respect to the feature [coronal].

The conjunction of an atomic constraint with a summed constraint is defined as the sum of each summand constraint locally conjoined with the atomic constraint. This is because the resulting constraint summation can result in non-boolean values (in other words, gradient violations, see Padgett 2002, McCarthy 2003). It can also be defined as a parasitic identity constraint, as discussed in Chapter 2.

There are two, separate issues at hand for the definition of agreement in Vietnamese: the evaluation of agreement between features itself, and the limiting of agreement to the proper domain. The crucial argument is that the evaluation is cross-categorical, as in id-agr.KPT$_X$. The fact that this constraint must police agreement in the syllable rhyme and only when the consonant is dorsal is a separate issue. The strategy here is to simply work the domain of agreement into the definition of the constraint itself, with the relevant relation based on adjacency. Other options might involve extended the surface correspondence relationship to operate on adjacent segments, such as the ones here. This strategy is left unexplored but it is a possibility. However, under this type of analysis, the relevant identity constraint will still require C-place and V-place features to agree.

4.4.2 Candidates under consideration

For the following analysis, candidates consist of CV and VC sequences of segments. Consonants differ in the following possible C- and V-place combinations.

(183) **CV forms**: Consonantal C-place × Consonantal V-place

$$\left\{\begin{array}{ll} \text{t} & \text{[cor]} \\ \text{p} & \text{[lab]} \\ \text{k} & \text{[dor]} \\ \widehat{\text{tp}} & \text{[cor], [lab]} \\ \text{c} & \text{[cor], [dor]} \\ \widehat{\text{kp}} & \text{[lab], [dor]} \end{array}\right\} \times \left\{\begin{array}{ll} \text{ʲ} & \text{[cor]} \\ \text{ʷ} & \text{[lab]} \\ \text{ɣ} & \text{[dor]} \\ \varnothing & \end{array}\right\} \times \left\{\begin{array}{ll} \text{e} & \text{[cor]} \\ \text{a} & \text{[dor]} \\ \text{o} & \text{[lab], [dor]} \end{array}\right\}$$

(184) **VC forms**: Vowel V-place × Consonantal C-place × Consonantal V-place

$$\left\{\begin{array}{ll} \text{e} & \text{[cor]} \\ \text{a} & \text{[dor]} \\ \text{o} & \text{[lab], [dor]} \end{array}\right\} \times \left\{\begin{array}{ll} \text{t} & \text{[cor]} \\ \text{p} & \text{[lab]} \\ \text{k} & \text{[dor]} \\ \widehat{\text{tp}} & \text{[cor], [lab]} \\ \text{c} & \text{[cor], [dor]} \\ \widehat{\text{kp}} & \text{[lab], [dor]} \end{array}\right\} \times \left\{\begin{array}{ll} \text{ʲ} & \text{[cor]} \\ \text{ʷ} & \text{[lab]} \\ \text{ɣ} & \text{[dor]} \\ \varnothing & \end{array}\right\}$$

All possible C-place combinations are tested, with a minimum of 1 and maximum of 2 per segment. Note that the palatal stop [c] has both [dor] and [cor] C-place. Additionally, each feature can appear as a secondary articulation on a consonant, or a consonant can have no secondary articulation. The front vowel [e] is [cor], the mid central vowel [a] is [dor], and the back, round vowel [o] is [lab] and [dor].

This results in 24 different possible consonants and 3 different vowels. There are then 72 CV forms and 72 VC forms. Each CV and VC form is considered as an input for a total of 144 candidate sets, and each candidate set consists of all 72 forms for that segment sequence (the order of the consonant and vowel is fixed per candidate set). This results in 10,368 total possible candidates. The list of inputs, as well as their specific mappings for Vietnamese, are shown in Figure 4.2. All candidate and candidate set generation was automated with a Python script.

4.4.3 Ranking and Support

The ranking and full support for Vietnamese are given in Figure 4.1 and Table 4.5. The complete mappings of this system are given in Figure 4.2. All constraint evaluation and ranking calculates are done in OT Workplace (Prince, Tesar, et al. 2016).

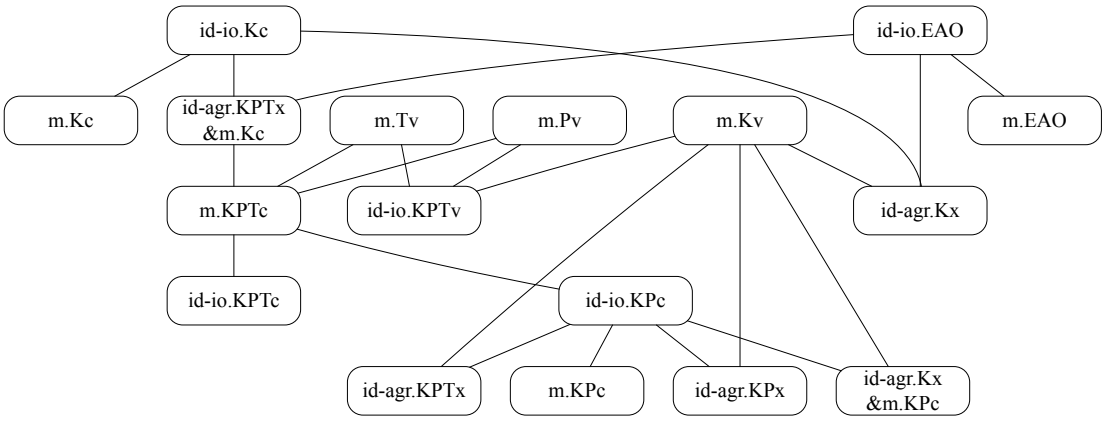


Figure 4.1: Vietnamese ranking

Cross-category agreement can be satisfied in a number of ways. Either the vowel can change its place features to match the consonant, or the consonant can change its place features. For a consonant to change its features, it can either sprout or shed C- or V-place. In the case of Vietnamese, dorsal consonants sprout a C-place in order to satisfy cross-category agree. Other options are ruled out via V-place markedness and faithfulness constraints.

(185) V-place markedness and faithfulness prevent agreement via secondary articulation

Input	Winner	Loser	$m.P_V$	$id\text{-}io.KPT_V$	$m.KPT_C$	$id\text{-}io.KP_C$	$id\text{-}io.KPT_C$	$m.KP_C$
a. ok	o$\widehat{\text{kp}}$	$o k^w$	W	W	L	L	L	L

The loser ok^w is preferred by a number of constraints, specifically those that refer to both [labial] C-place markedness and faithfulness, as this form only has [labial] V-place. However, the winner o$\widehat{\text{kp}}$ is preferred by those constraints that refer to [labial] V-place markedness and faithfulness: $m.P_V$ and $id\text{-}io.KPT_V$. Either one of these must dominate all of

Table 4.5: Full Vietnamese support

Input	Winner	Loser	$m.P_V$	$m.T_V$	$m.K_V$	id-io.K_C	id-io.EAO	m.EAO	id-agr.K_X	$m.K_C$	id-io.KPT_V	id-agr.KPT_X&m.K_C	$m.KPT_C$	id-io.KP_C	id-io.KPT_C	id-agr.KPT_X	$m.KP_C$	id-agr.K_X&m.KP_C
a. ok^w	o$\widehat{\text{kp}}$	ok^w	W								L		L	L	L		L	
b. k^{j}e	ke	k^{j}e		W							L							
c. ek^w	ec	ek^j		W							W		L		L			
d. k^{ɣ}e	ke	k^{ɣ}e			W						L							
e. op^w	op	op^ɣ			W				L		W				L	L		L
f. ek^w	ec	et				W			L	L		L	L	W	L	L	L	L
g. k^{w}o	ko	ka					W	L										
h. ek^w	ec	ak					W		L			L	L		L	L		L
i. ek^w	ec	ek										W	L		L			
j. k$\widehat{\text{p}}^w$e	ke	k$\widehat{\text{p}}$e											W	L	L	W		
k. etp^w	ep	et												W		L	L	
l. otp^w	op	ot												W		W	W	L

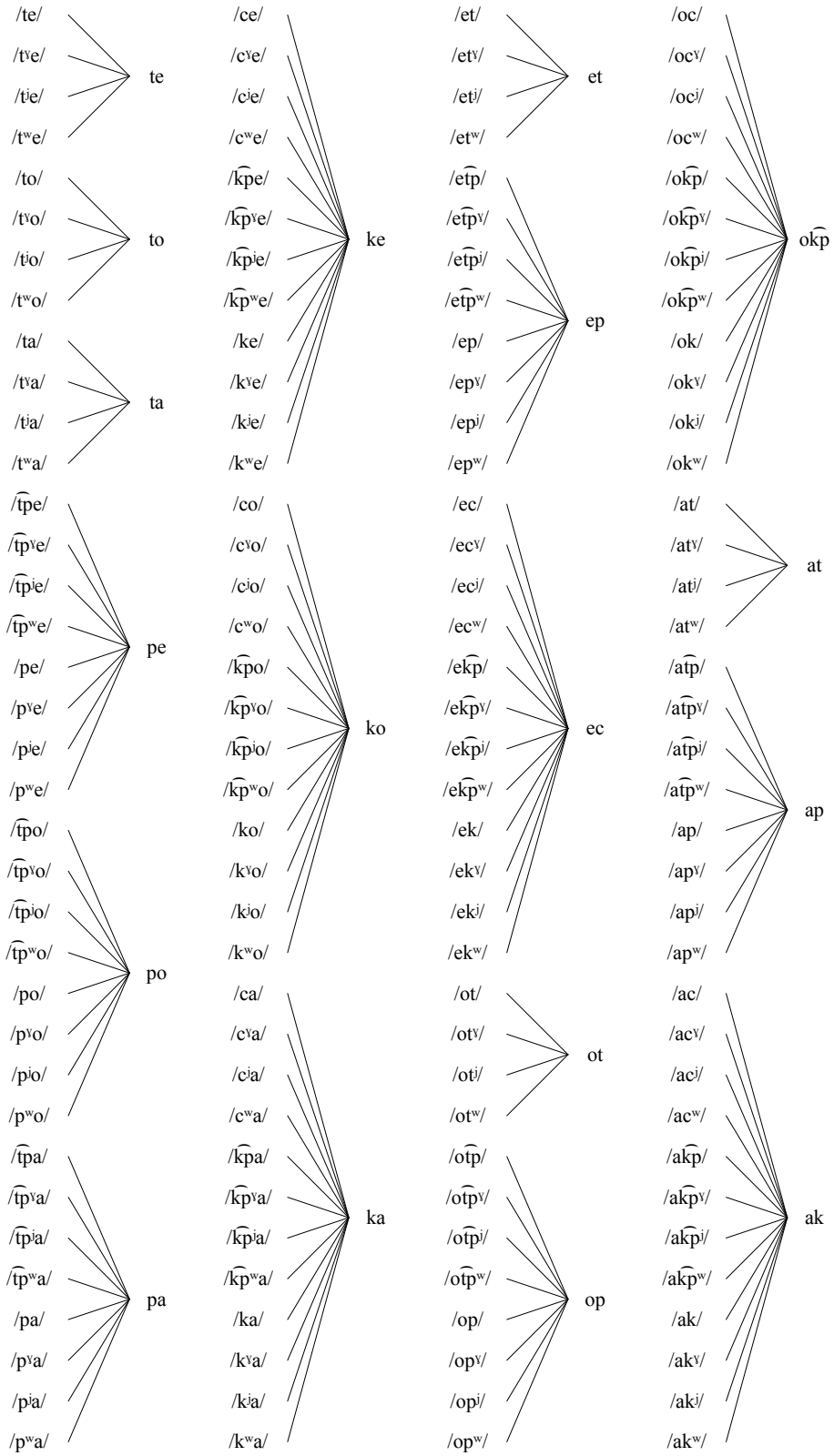


Figure 4.2: Complete mappings for Vietnamese

m.KPT$_C$, m.KP$_C$, id-io.KPT$_C$, and id-io.KP$_C$. The sprouting of a C-place feature is preferred to the sprouting of a V-place feature to satisfy cross-category agreement.

Both the winner and loser in (185) satisfy id-agr.KPT$_X$&m.K$_C$, so this constraint does not make a distinction between them. This is not the case for the faithful candidate.

(186) Faithful candidate doesn't satisfy Agree

Input	Winner	Loser	id-agr.KPT$_X$&m.K$_C$	m.KPT$_C$	id-io.KP$_C$	id-io.KPT$_C$	id-agr.KPT$_X$	id-agr.KP$_X$	m.KP$_C$
a. ok	o͡kp	ok	W	L	L	L	W	W	L

While the faithful loser is better across all [labial] C-place markedness and faithfulness, it crucially does not satisfy id-agr.KPT$_X$&m.K$_C$(nor does it satisfy the other [labial]-referring cross-category agree constraints), as the vowel is [labial] but the consonant is not.

Additionally, changing the vowel to a completely dorsal vowel [a] will satisfy agree, but this is ruled out due to faithfulness of V-place features on vowels.

(187) Vowel faithfulness prevents V-to-C agreement

Input	Winner	Loser	id-io.EAO	m.EAO	m.KPT$_C$	id-io.KP$_C$	id-io.KPT$_C$	m.KP$_C$
a. ok	o͡kp	ak	W	L	L	L	L	L

The constraint controlling V-place faithfulness on vowels, id-io.EAO, must dominate all of V-place markedness for vowels (m.EAO), [labial] C-place markedness (m.KPT$_C$, m.KP$_C$) and faithfulness (id-io.KPT$_C$, id-io.KP$_C$). The full CT for the input /ok/ is given in Table 4.6.

Table 4.6: Full ERC set for input /ok/ in Vietnamese

Input	Winner	Loser	m.P$_V$	m.T$_V$	m.K$_V$	id-io.K$_C$	id-io.EAO	m.EAO	id-agr.K$_X$	m.K$_C$	id-io.KPT$_V$	id-agr.KPT$_X$&m.K$_C$	m.KPT$_C$	id-io.KP$_C$	id-io.KPT$_C$	id-agr.KPT$_X$	id-agr.KP$_X$	m.KP$_C$	id-agr.K$_X$&m.KP$_C$
a. ok	o͡kp	ot^w	W			W			W	L	W		L		M	M	M	L	
b. ok	o͡kp	ok^w	W			W					W		L	L	M			L	
c. ok	o͡kp	at^y			W	W	W	L		L	W		L		M	M		L	
d. ok	o͡kp	op^y			W	W				L	W		L	W	M			L	
e. ok	o͡kp	ot^y			W	W				L	W		L		M	M	M	L	
f. ok	o͡kp	at				W	W	L	W	L			L		M	M	M	L	
g. ok	o͡kp	et				W	W	L		L			L		M			L	
h. ok	o͡kp	op				W			W	L			L	W	M	M	M	L	W
i. ok	o͡kp	ot				W			W	L			L		M	M	M	L	
j. ok	o͡kp	ak					W	L					L	L	L			L	
k. ok	o͡kp	ok										W	L	L	L	W	M	L	

Palatalization in Vietnamese also involves cross-category agreement in this analysis. In those cases, plain dorsals [k] become palatal after front vowels. In the analysis here, the dorsals agree for the feature [coronal] of the front vowel while retaining their underlying dorsal specification. I assume that the resulting segment [c] contains the C-place features

[dorsal] and [coronal], and does not contain any secondary articulations as Kirby 2011 describes its realization as an unaffricated palatal stop Kirby 2011: 382. However, as the phonetic descriptions for the target segment are more vague than with the labial-dorsals, this assumption is not crucial to the analysis.

(188) Palatalization is cross-category agreement

Input	Winner	Loser	m.T_V	id-io.KPT_V	m.KPT_C	id-io.KPT_C
a. ek	ec	ek^j	W	W	L	L

Like the case with the labial-dorsals, secondary coronal articulation is ruled our via the V-place markedness and faithfulness constraints m.T_V and id-io.KPT_V. The coronal C-place markedness and faithfulness constraints m.KPT_C and id-io.KPT_C prefer the loser [ek^j] as this form does not sprout or shed any C-place features.

Additionally, with the optimum as [ec], this is also an instance of partial class behavior: while the vowel and consonant agree for [coronal], they disagree for the feature [dorsal]. The perfectly agreeing candidate, [et], is ruled out due to [dorsal] faithfulness.

(189) Dorsal C-place faithfulness prevents total agreement

Input	Winner	Loser	id-io.K_C	id-agr.K_X	m.K_C	id-agr.KPT_X&m.K_C	m.KPT_C	id-io.KP_C	id-io.KPT_C	id-agr.KPT_X	id-agr.KP_X	m.KP_C	id-agr.K_X&m.KP_C
a. ek	ec	et	W	L	L	L	L	W	W	L	L	L	L

The only constraints that do not prefer the loser [et] are those that police [dorsal] C-place markedness: id-io.KPT_C, id-io.KP_C, and id-io.K_C. Specifically, in the complete ranking, id-io.K_C is undominated and dominates id-agr.KPT_X&m.K_C, meaning that the agreement must be faithful to [dorsal] C-place.

(190) Partial class behavior of [ec]:

output	id-agr.KPT$_X$	Comment
et		All features agree
ec	*	[e] is not [dor]
ek	**	[e] is not [dor], [k] is not [cor]

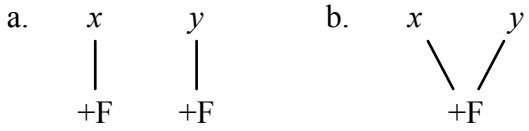
While [ec] is preferred to [ek] because it has fewer violations of id-agr.KPT$_X$, it is also preferred to [et] as it has fewer (read: none) violations of id-io.K$_C$, which dominates both id-agr.KPT$_X$ and id-agr.KPT$_X$&m.K$_C$.

4.5 The significance of segmental structure

What makes cross-category agreement possible here is not only the ranking and definitions of the constraints, but the specific assumptions about representation. The argument here crucially relies on a unified feature theory of representation, following Clements 1991, Clements & Hume 1995. In such a theory, vowels and consonants share place features, and exact realization of stricture is determined by the features' position in the geometry (either under C-place or V-place). They key Agree constraint, id-agr.KPT$_X$, is defined to force agreement for the same features but not necessarily for those features to have the same position in the geometry.

Less crucial is whether assimilation is treated as autosegmental spreading or as feature changing (*see* eg. Hayes 1986a). If agreement is accomplished via autosegmental spreading, then cross-category agreement is only possible if vowels and consonants share the relevant features. In a theory of local Agree, the actual agreement is ambiguous between spreading and feature-changing. Bakovic 2000 explains how through using local agree constraints, the spreading candidate is not differentiated from the non-spreading but agreeing candidate: "A pair of adjacent segments in principle satisfies an AGREE[F] constraint either by bearing separate instances of the same value of [F] …or by autosegmentally sharing a single value of [F] " (Bakovic 2000: 11, see also Beckman 1998: 39).

(191) From Bakovic 2000: (9):



Under spreading analyses, the exact geometry of the representation is crucial in whether consonants and vowels can share place features (see e.g. Clements & Hume 1995, Halle et al. 2000 and Padgett 2011 for a review). However, there is no phonological reason to rule out a representation where a labial vowel is adjacent to a labial consonant and there is no feature sharing (effectively 191a.). These are simply two adjacent segments. The only question is, what makes this specific sequences preferred by the grammar? In the present analysis, the answer there is id-agr.KPT_X.

One question that arises in non-spreading analyses of cross-category agreement is: without explicit feature sharing, must the consonant and vowel have the same feature? In other words, the constraint id-agr.KPT_X is basically Agree-[labial], Agree-[dorsal], and Agree-[coronal], summed into one. For each individual constraint, violations are assigned based on the presence or absence of *the same feature* between consonants and vowels. This is the standard assumption for agree constraints and it is followed here. The answer here is still affirmative, consonants and vowels must still share place features.

4.5.1 Disjoint place theories

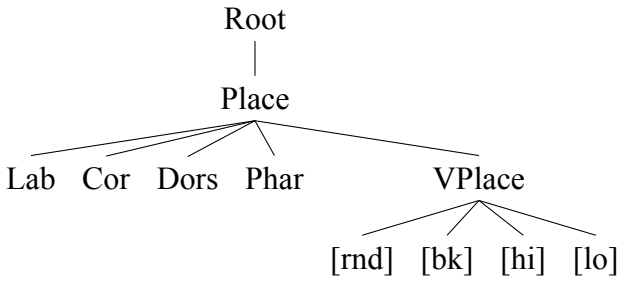
However, not every theory of representation assumes that vowels and consonants share features. I will term these theories *disjoint place theories*, after the fact that the sets of consonantal place features and vocalic place features are largely disjoint. Popular examples are Halle et al. 2000, Padgett 2002, Ní Chiosáin & Padgett 1993. In these theories, the feature causing vowels to be round is different from the feature causing consonants to be labial (e.g. [round] vs. [labial]). However, to capture processes classified as cross-category, there must be some sort of affinity between these two features, such that either the representations or

the rules/constraints treat them in a related way.

4.5.2 Inherent VPlace Theory

Inherent VPlace Theory (IVPT), developed in Ní Chiosáin & Padgett 1993, assumes a split between C-Place (or just Place) features and V-Place features (called there VPlace). However, the set of features possible under each node are crucially disjoint. The basic place geometry is given below (Ní Chiosáin & Padgett 1993: (4)).

(192)



IVPT makes two major claims: First, when secondary articulation is not contrastive in a language, plain stops (such as [p], [t], etc.) are *redundantly specified* for V-Place features ([p] is [round]). Second, all vowel-consonant interactions are interactions of only V-Place features.

For so-called cross-category V-to-C interactions, where a vowel becomes [round] due to a plain labial consonant, it is assumed that the labial consonant includes an inherent, or redundant, specification of [round]. The interaction then is between V-Place and easily captured in the IVPT representation.

However, in the typology discussed there, there are no cases where the place of a vowel changes the place of the consonant, outside of palatalization. Such processes are hard if not impossible to represent in IVPT; indeed, this is the intention: "a major argument for inherent VPlace theory concerns the absence of rules in which a vowel displaces the CPlace feature of a consonant" (Ní Chiosáin & Padgett 1993: 39).

For Vietnamese, it would have to be assumed that the [round] feature of the vowel appears on the dorsal coda, but the result of this interaction is a double-articulation [k͡p] and

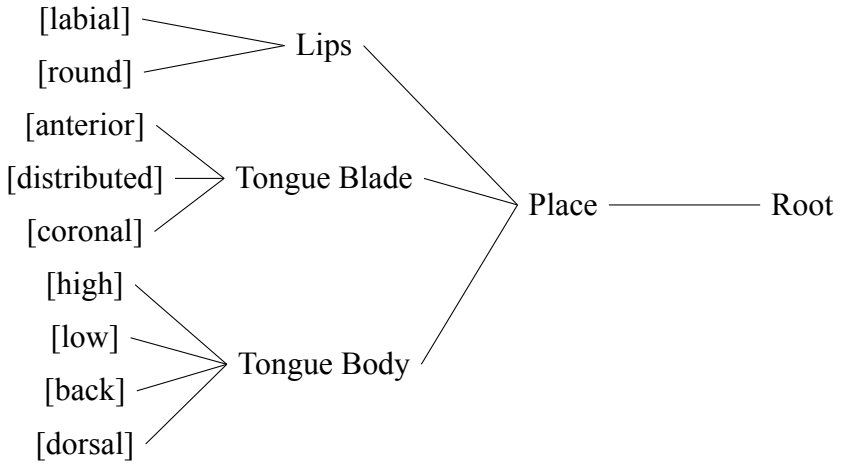
not a rounded velar [k^{w}]. There would need to be a restructuring rule that would add a bona fide labial consonantal place, or it would have to be assumed that the phonetic implementation of a [round], [dorsal] segment in Vietnamese is phonetically [k͡p]. However, this would have to be language specific, as in Aghem the same process results in a rounded velar [k^{w}].

While plain labial consonants can be redundantly specified for [round], [round] consonants cannot be redundantly specified as labial, as in general coronals and dorsals can be [round] as well. An ad hoc restructuring rule would be needed. The fact that it is difficult to represent the interactions of Vietnamese and Aghem in IVPT is essentially by design; it was developed to not predict such C-to-V cross-category agreement.

4.5.3 Revised Articulator Theory

The Revised Articulator Theory (RAT) of Halle et al. 2000 uses features parallel to those in IVPT, such as [round], [back], but does not place them together under a V-Place node. Instead, these features are grouped together in the structure based on what articulator they depend on. They depart from Sagey 1986, though, in that articulator nodes are no longer features; for instance, [labial] is now a terminal feature, sister to [round], both dominated by a Lips node. The full place structure is given below.

(193) Place feature structure of RAT (from Halle et al. 2000: (1))



While IVPT stipulated affinities between VPlace features and the related place feature,

RAT encodes this in the structure itself; [round] shares a dominating node with [labial] and no other place features (called *articulator features* by Halle et al. 2000), [back] shares a dominating node with [dorsal] and no other place features, and so on. However, despite the fact that [+round] and [labial] are both dominated by a Lips node, the features themselves are two different abstract symbols, and would need to be treated as such by a phonological rule or constraint. The Revised Articulator Theory runs into the same problem as IVPT.

4.5.4 Must consonants and vowels still share features even without spreading?

Yes. If we do not assume that affinities between features like [labial] and [round] are captured in the representation directly, such as in Vietnamese, they must be part of a specific rule or constraint. A hypothetical constraint could be defined as such:

(194) **Compromise** (hypothetical, rejected)

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ [+round]) $\oplus$ ($\bullet_2 \downarrow$ [labial]))

—

"Assign a violation for each pair of adjacent segments whose values for [+round] and [labial] do not match."

This assumes that round vowels have no labial feature, but are instead only [+round]. The same sequences of consonants are assigned violations, but the featural assumptions of the segments are different and the constraint refers to two different features, instead of the statuses of a single feature. Because the constraint is outside the standard Agree schema, we can call it a Compromise constraint ("*We can't both be the exact same feature, but I'll be [+round] if you be [labial]*.").

Note that the Compromise schema explicitly rejects the Generalized Identity schema, in that it no longer evaluates the *same* feature or structural description for each segment; the predicates under evaluation can differ on either side of the exclusive or operator.

While I take the cross-category agreement in Vietnamese to be evidence that vowels and consonants do indeed share features (based on Clements & Hume 1995 and others), such

evidence is weakened if the existence of a Compromise constraint like the one in (194) is permitted. However, the existence of Compromise constraints is rejected as an alternative to Agree here based on the theory of constraints employed. As also noted by Bakovic 2000, the Agree constraints have a very similar structure to Ident constraints, and this is made explicit in the constraint language here. The Agree constraint id-agr.KPT_X has the exact same structure as io and cc Ident constraints id-io.KPT_C and id-cc.KPT differing only in the specific relation between segments that is made reference to (strict precedence, io correspondence, cc correspondence). The Compromise constraint defined above references two separate (though phonetically related) features, yet it is difficult to imagine a situation where an IO Ident constraint referencing two different features would be employed. Thus, the Agree schema fits in with the independently necessary Ident schema, while a Compromise constraint would require an ad-hoc definition.

Further, there is no obvious phonological internal bound to what constraints can be referenced in a Compromise constraint; while [+round] and [labial] do have phonetic affinities, constraints referring to unrelated features such as [labial] and [+anterior] would need to be ruled out somehow. The Agree schema accomplishes this through only allowing a single feature to be referenced in the definition.[1]

In summary, an agree constraint that does not look for V- or C-place distinctions is necessary to model the cross-category agreement in Vietnamese, and also fits in with the theory of constraints in the present theory. A complex segment like $\widehat{kp}$ agrees perfectly with the vowel, while rounded consonants like k^w are ruled out via independent markedness or faithulness constraints. Because this is motivated by an agree constraint, the winning candidate does not necessarily contain shared features between the vowel and consonant in an autosegmental sense; rather, the relevant segmental root nodes both dominate the same

[1]Further, the summation operation as implemented here is not a loophole to generate an agree constraint with unrelated features, 1. summing two Agree constraints each for a different feature still does not mediate identity directly between those two features and 2. as the only input to the summation operation involves an independently-motivated feature scale, so the features are related. In this dissertation, it is only those features that are major place features that are scaled and summed.

features. Through using the Agree schema and its structural isomorphism with Ident, this is indeed evidence that vowels and consonants make use of the same place features.

4.6 Similar processes

4.6.1 Aghem

Aghem is a Bantoid language spoken in the South West region of Cameroon (Lewis 2009). The language contains cross-category [dorsal] agreement on labials, and within-category [labial] agreement on coronals and dorsals. The consonant inventory of Aghem is given in Table 4.7.

Table 4.7: Aghem consonant inventory (Hyman 1979: 3)

	Labial	Alveolar	Alveo-palatal	Velar	Labial-velar	Glottal
Stops	p b	t d		k g	k͡p g͡b	ʔ
Fricatives	f v	s z		ʃ ʒ	ɣ	
Affricates	pf bv	ts dz	tʃ dʒ			
Liquid/glides		l	j		w	
Nasals	m	n	ɲ	ŋ	ŋ͡m	

The general agreement patterns are schematized below.

(195) *Type of Agreement*

a. /op/ → [ok͡p] XC [dorsal]

b. /ok/ → [ok^{w}] WC [labial]

c. /ot/ → [ot^{w}] WC [labial]

Like in Vietnamese, we see evidence of multiple place features agreeing: here both [labial] and [dorsal] show agreement, while in Vietnamese it was [labial] and [coronal]. However, unlike in Vietnamese, where cross-category agreement only occurred *on dorsal segments*, the cross-category agreement processes in Aghem occur *only for the feature [dorsal]*, regardless of the place of the target consonant.

This agreement occurs between root-initial consonants and immediately preceding prefix vowels.

(196)

Class 7 (sg.)	Class 8 (pl.)	Gloss
kɨ-ba	o-g͡ba	piece
kɨ-baʔ	o-g͡baʔ	rope
kɨ-bɛ	o-g͡bɛ	fufu

Using the same constraints as for the Vietnamese analysis, this section gives a sketch of the patterns in Aghem.[2] Like Vietnamese, Aghem satisfies agreement through sprouting place features; however, unlike Vietnamese, Aghem sprouts both C- and V-place features, depending on the context.

(197) Cross-category agreement as C-place [dorsal] sprouting

	Input	Winner	Loser	id-agr.K_X&m.KP_C	id-io.KP_C	id-io.KPT_C	id-agr.KPT_X	id-agr.KP_X	id-agr.K_X	m.KPT_C	m.KP_C	m.K_C	id-io.K_C
a.	op	o͡kp	op	W	L	L	W	W	W	L	L	L	L

While the faithful candidate [op] is better for all [dorsal] C-place markedness and faithfulness constraints, the winner [o͡kp] satisfies all [dorsal] cross-category agree constraints.

(198) Dorsal V-place markedness prevents agreement via secondary articulation

	Input	Winner	Loser	m.K_V	id-io.KP_C	id-io.KPT_C	m.KPT_C	m.KP_C	m.K_C	id-io.K_C	id-io.KPT_V
a.	op	o͡kp	op$^{\gamma}$	W	L	L	L	L	L	L	W

Sprouting a [dorsal] V-place feature also satisfies cross-category agree, but this is ruled out through [dorsal] V-place markedness m.K_V.

Interestingly in Aghem, while both [p] and [k] agree with a back, round vowel, they have different targets: [p] becomes a labial-velar, as shown above, while [k] sprouts a V-

[2]Unlike for Vietnamese, not all possible candidate sets are tested, only those relevant for the patterns.

place [labial] feature to become [k^{w}]. Because both [k͡p] and [k^{w}] are possible targets of agreement with [o], there must be some constraint or constraints that differentiate them. Both forms fully satisfy cross-category agree id-agr.KPT$_{X}$.

For Aghem, the within-category instances of agreement are caused by the C-place markedness and faithfulness constraints that refer to the feature [labial].

(199) Within-category labial agreement

	Input	Winner	Loser	id-io.KP$_{C}$	id-io.KPT$_{C}$	m.KPT$_{C}$	m.KP$_{C}$	m.P$_{V}$	id-io.KPT$_{V}$
a.	ok	ok^{w}	ok͡p	W	W	W	W	L	L

Note that both the winner and the loser in the tableau above perfectly satisfy cross-category Agree. All Agree constraints evaluate this winner-loser pair as e which is why the constraints are not shown in the tableau. However, sprouting a V-place [labial] feature is preferred to sprouting a C-place [labial] feature.

4.6.2 Xitsonga

In Xitsonga (Tsonga, Bantu, South Africa, [tso]), root-final round vowels [o] or [u] become the glide [w] before the diminutive suffix [-ana]. If the root also contains an adjacent [m], it dissimilates to [ŋ] to avoid a sequence of two labial consonants, as shown below.

(200) /…mo…/ → […ŋw…] (Lee & Burheni 2014: (7))

	Root	Diminutive	Gloss
a.	nòmò	ʃi-nòŋw-ànà	‘mouth’
b.	nsómó	ʃi-nsóŋw-áná	‘seam’
c.	gòmò	ʃi-gòŋw-ànà	‘forehead’
d.	fómò	ʃi-fóŋw-áná	‘form’
e.	ʃik^{h}ómó	ʃi^{h}óŋw-áná	‘cup handle’

(201) /…mu…/ → […ŋw…] (Lee & Burheni 2014: (8))

	Root	Diminutive	Gloss
a.	nsímú	ʃi-nsíŋw-ánà	‘field’
b.	n̪àmù	ʃi-n̪àŋw-ànà	‘neck’
c.	ɦòmú	ʃi-ɦɔ̀ŋw-ánà	‘cow’
d.	rìsímú	ʃi-síŋw-ánà	‘song’
e.	mùmú	ʃi-múŋw-ánà	‘hot weather’
f.	ʃikòmù	ʃi-kòŋw-ànà	‘hoe’

In Lee & Burheni 2014, this dissimilation is triggered by an OCP-[lab] constraint, which dominates Ident[lab]. Similarly, the vowel becomes a glide due to a constraint marking hiatus, *VV, dominates Ident[cons] (like here, Lee & Burheni 2014 assume [w] is [+consonantal], and vowels are [−consonantal]).

(202) Velarization of [m], from Lee & Burheni 2014: (17)[3]

	/ʃi-nomo-ana/	OCP-[lab]	*VV	Max-V[lab]	Ident[lab]	Ident[cons]
a. →	ʃinoŋwana				*	*
b.	ʃinomoana		W *		L	L
c.	ʃinomwana	W *			L	*
d.	ʃinomana			W *	L	L

This explains the non-labial realization of the nasal, but leaves open the reason why it should realize as velar. However, in the ranking above, a candidate with a coronal nasal, [ʃinonwana], would do just as well as the indicated optimum. The attested form is argued here to be due to cross-category [dorsal] agreement between V-place on the glide [w] and the resulting C-place on the nasal [ŋ]. This rules out the coronal nasal candidate.

[3]The constraints in this tableau are taken directly from Lee & Burheni 2014. As defined there, they are: “OCP-[lab]: Assign a violation mark to labials that are adjacent” (15a). “*VV: Assign a violation mark to vowels that are adjacent” (15b). “Max-V[lab]: Assign a violation mark with a round vowel ([labial]) in the input does not have a correspondent in the output” (14a). “Ident[lab]: Assign a violation mark when corresponding segments in the input and the output do not have identical values for the [labial] feature” (14b). “Ident(cons): Assign a violation mark when corresponding segments in the input and the output do not have identical values for the [consonantal] feature” (14c).

Forgoing a complete analysis, the original CT is augmented with two constraints used in this dissertation: id-agr.K_X and m.K_C. The constraint id-agr.K_X prefers the attested optimum over the coronal nasal candidate, [ʃinonwana]. The markedness constraint m.K_C is also included as a constraint that prefers [ʃinonwana] to the attested form.

(203) Augmented CT from Lee & Burheni 2014

	/ʃi-nomo-ana/	OCP-labial	*VV	Max-V[lab]	**id-agr:K_X**	Ident[lab]	Ident[cons]	**m.K_C**
a. →	ʃinoŋwana					*	*	*
b.	ʃinomoana		W *			L	L	**L**
c.	ʃinomwana	W *			**W** *	L	*	**L**
d.	ʃinomana			W *		L	L	**L**
e.	**ʃinonwana**				**W** *	*	*	**L**

Assuming that the glide [w] has V-place features just as a vowel would, this process fits a definition of cross-category agreement between C-place and V-place. However, consonant-glide agreement is also much more common than just in Xitsonga. In English, for example, *sandwich* becomes [sæmwɪtʃ] in fast speech—with [labial] agreement between the nasal and glide.

4.6.3 Dagbani

In Dagbani (Gur, Ghana, [dag]), labial-velar stops [k͡p] and [g͡b] palatalize before front vowels (Wilson & Bendor-Samuel 1969, Olawsky 1999). This is similar to other palatalization processes with simple segments.

(204) a. /n k͡pi/ n c͡p, n t͡p ‘die’ (v.) (Olawsky 1999: (509))

b. /n g͡bi/ n ɟ͡b, n d͡b ‘dig’ (v.) (Olawsky 1999: (509))

Olawsky 1999 describes the target of the process as either labio-palatal or labial-alveolar. However, the phonetic study of Cahill 2008 finds “significant frication in the

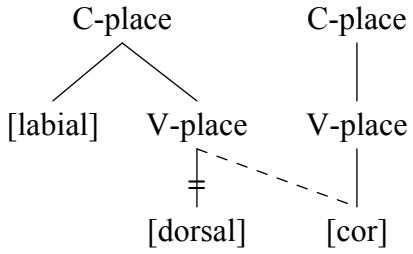
release of the stop", describing the articulation as more properly "palatal closure, labial closure, slow palatal release, labial release, palatal friction." He gives the following narrow transcriptions:

(205) a. /k͡píní/ c͡pʃíní 'guinea fowl' (Cahill 2008: 2a)

b. /g͡bíhí/ ʄ͡bʒíhí 'to sleep' (Cahill 2008: 2d)

Is this a cross-categorical process? Does it involve a displacement of a C-place feature triggered by a vowel (V-place feature)? Cahill 2008 argues that it does. Also assuming the representation of Clements & Hume 1995, he proposes the following assimilation process for Dagbani:

(206) Cahill 2008: (6), /K͡PI/ → [T͡PI]:



This means the result of the palatalization process is a segment with [labial] C-place and [coronal] V-place, treating palatalization as [coronal] spreading. However, there is also a simple labial [p] which undergoes palatalization in the same environment:

(207) a. /píní/ pʲíní 'gifts' (Cahill 2008: 2a)

b. /pè/ pʲè 'to milk' (Cahill 2008: 2c)

While Cahill 2008 does note that palatalization with simple labials is not consistent, giving several forms with no palatalization, Olawsky 1999 notes that simple coronals [t d] palatize before front vowels as well. Additionally, Olawsky 1999: 261 states that all palatalization before front vowels "can be described as (optional) secondary articulation", so it is not clear how different the process involving simple labials is from the other palatalization processes, if at all.

Assuming that all these segments are part of the same general palatalization process (as is also argued by Bennett 2014), the output of /PI/ would be [P^{j}I], or structurally, a segment with labial C-place and coronal V-place—the same structure assumed by Cahill 2008 for [T͡P]. The assumption that labial-dorsals have abstract primary place represented by a C- and V-place asymmetry cannot be true for Dagbani if palatalization is also assumed to be coronal spreading to V-place; the result is two segments with the same place structure but different phonetic implementations.

The pattern in Dagbani is also similar to one in Tampulma (Gur, Ghana, [tpm]). The inventory structure and reduction processes are anaylzed for Tampulma in Chapter 5, but Bergman et al. 1969 also note a palatalization process that affects labial-velars: the segments [g͡b] and [ŋ͡m] occur contrastively in Tampulma, but [g͡b^{j}] and [ŋ͡m^{j}], described as palatalized labial-velars, occur only before the vowel [ɛ] (pp. 22–24). While this is only brief field notes, it suggests a processes of secondary palatalization and not categorical change of the [dorsal] articulation, which might be more in line with the process in Dagbani as well.

4.7 Alternative, derivational approaches

The analysis presented in this chapter assumes that the cross-categorical agreement is an active phonological process that occurs without an intermediate step of rounding on the consonant. However, an alternative proposal might assume a more derivational approach, either synchronically or diachronically, where the velar consonant becomes rounded, and then the roundedness on the consonant becomes a full consonantal closure.[4] This is schematized below.

(208) **Intermediate Rounding analysis:**

ok > ok^{w} > o͡kp

This analysis is split further into two types: synchronic and diachronic. A diachronic

[4]Thanks to Jaye Padgett and Paul de Lacy for discussions on this point.

derivational analysis assumes that the phonotactic patterns seen in Vietnamese are the result of historical change and are not as a whole an active phonological process. It also predicts a stage where the observed output was a rounded velar [k^{w}]. The synchronic derivational analysis involves satisfying agreement via labial V-place sprouting, and then an additional process of labial promotion to C-place. The differences between these two analyses, and between the derivational approach and the parallel approach argued for here, make subtly different predictions. These predictions cannot all be tested here, but this section offers discussion on either their status or how they might eventually be tested.

On the historical source of labial-velars, Hajek 2009 notes:

> The development of doubly articulated allophones in Vietnamese is easily explicable—they result from marked lip-rounding of word-final velars after rounded nuclei, e.g. /huk/ > [hʊk^{w}] > [hʊk͡p] 'to turn into an addict'. Carry-over rounding onto the final velar is then subject to further construction equivalent to that of the velar stop closure. (p. 218)

While this confirms the historical account of how labial-velars first came to be in Vietnamese, the question that remains is, is this the *only* explanation needed for place agreement in Vietnamese, or did this historical change result in an active, synchronic process/phonotactic restriction? For instance, while the process of [e]-epenthesis in sC- clusters in Spanish is well-documented historically, it remains as an active phonotactic generalization in the language (see e.g. Hualde 2011).

Hajek 2009 also notes that while Thompson 1965 cited variability in the realiation of full labial closure in the relevant contexts, more recent descriptions, such as Hajek's own work, find the general pattern of /ok/ → [ok͡p] to be completely regular and not optional, suggesting that "it is possible that this difference reflects the completion of an earlier sound change in progress" (Hajek 2009: 219). Whether this is an active process could be tested with a wug test experiment on native speakers (Berko 1958, see also Kawahara 2011), although this must be left to future work.

The differences between a synchronic derivational analysis and a synchronic parallel analysis (i.e. the analysis argued for here) is more difficult to test, as both would presumably pass the wug test, and ultimately relates to a deeper, more general issue. A serial analysis would at minimum involve a different grammatical framework than parallel OT adopted here, such as Harmonic Serialism (HS) or a rule-based serialism.

One difference is in the cross-linguistic predictions, however. An active cross-category agreement constraint such as id-agr.KPT$_X$, predicts an additional number of possible agreement patterns that are unattested. For example, while this constraint does allow labial V-place to surface as C-place as in Vietnamese, it also predicts cross-category agreement via displacement: for instance, /ot/ → [op]. With such a pattern, cross-category agreement results in a consonant with simple place that agrees with the vowel place in some way. This is possible when the constraint banning complex place is undominated (unlike Vietnamese which allows complex agreement). Over-prediction of cross-categorical agreement patterns is avoided with the exclusion of id-agr.KPT$_X$, yet the patterns that are attested (such as palatalization and vowel-to-consonant interactions) must be captured through other means, such as Inherent V-place Theory, detailed in Section 4.5.2.

Additionally, the synchronic derivational analysis still requires both a cross-categorical identity constraint and a theory of unified place features, for the mapping of [ok^w] → [o$\widehat{kp}$], still assuming a constraint-based framework such as HS. The existence of cross-category faithfulness is also necessary for Mumuye as discussed in Section 5.6.2. Because id-io.KPT$_X$ is necessary both for the synchronic derivational analysis of Vietnamese and for patterns in languages like Mumuye, the present argument for the existence of id-agr.KPT$_X$ is one of theoretical symmetry: the structure of identity constraints is unified so there is a cross-category version along all dimensions. Further support for this is from the fact that there are indeed cross-categorical interactions beyond Vietnamese and Aghem, as detailed in Padgett 2011. The present analysis gives a uniform explanation for all cross-category interactions, with the caveat of overprediction.

In summary, future experiments aimed at testing the activeness of the process can determine whether it is synchronic or diachronic. However, whether it is derivational or parallel would be determined by further investigation of the corss-linguistic typology as well as theory-internal arguments.

4.8 The place of place on labial-velars

This analysis crucially assumes that both place features on a labial-velar are immediately dominated by a C-place node. There are two primary reasons for this: it is the null hypothesis about the C-place node: C-place is intended to represent phonetic consonantal stricture. Additionally abstract V-place is problematic when double articulations contrast with secondary articulations.

This is the null hypothesis, and it allows for a consistent cross-linguistic phonetic implementation for labial-velar segments.

> For example, if a sound is specified as [−consonantal] then [labial] is interpreted as lip rounding. Alternatively, the relevant information is read off feature-geometric structure. Thus Herzallah (1990), Clements (1991), Hume (1994, 1996), and Clements and Hume (1995) **locate [labial], [coronal], [dorsal], and [pharyngeal] under separate C-Place and V-Place nodes, depending on whether a consonantal or vocalic constriction is intended**. (Padgett 2011: 1772, emphasis mine)

Additionally, languages can contrast between double articulation and secondary articulation:

(209) Yele contrast (Henderson 1995)

a. k͡pa: ‘stealing’ (p. 8)

b. kʷɔ ‘stand’ (p. 10)

c. pʲɑ: ‘woman’ (p. 9)

d. t͡pa: ‘turn over’ (p. 9)

e. pʲʷɑ: ‘pandanus’ (c = labial, v = labial, coronal) (p. 9)

f. t͡pʲa: clan name (c = coronal, labial, v = coronal) (p. 9)

In these cases, double articulations contrast with secondary articulations. In (209b), the segment has [dorsal] C-place and [labial] V-place, evidence by the phonetic strictures of the two gestures. Because this segment contrasts with the double-articulation in (209a), k͡p must have a different geometry of place features:

(210) Possibilities for k͡p:

a. C-place: [labial], [dorsal]; V-place: ∅

b. C-place: [labial]; V-place: [dorsal] (see e.g. Cahill 1999, 2006)

In (210a), the phonetic strictures align with phonological C- and V-place. However, (210b) has a phonological V-place feature that is realized with a full consonantal stricture. Assuming (210b) as the structure for [k͡p] requires language-specific phonetic implementation rules for C- and V-place. We cannot assume that (210b) is universally realized as [k͡p], as that would make velarized labials impossible [pˠ]. Neither can we assume that the structure of [k͡p] is always (210b), because in Vietnamese, the C-place of the segment is definitely dorsal as the labial-velar results as the realization of a simple dorsal in certain positions.

Further, double articulations can have additional secondary (tertiary?) articulations:

(211) Yele V-place on complex segments (Henderson 1995)

a. t͡pʲa: clan name (p. 9)

b. k͡pʲɔpʷɔ ‘purse’ (p. 9)

If one of the consonantal strictures were represented with V-place, then the phonetic implementation rules would have to interpret some but not all V-place features as consonantal,

and others as purely vocalic. If there is no phonological need for this complication, it should be avoided, as it is here.

Additionally, the existence of labial demotion in labial-dorsals (/k͡p/ → [k^{w}]), as discussed in Section 5.6.2, makes the assumptions in (210b) problematic: the mapping of /k͡p/ → [k^{w}] would involve a demotion of the labial feature, mirroring the phonetic realization, but also a promotion of the dorsal feature, even though there is consonantal dorsal stricture in both segments. The use of C- and V-place nodes as an ersatz APP distinction leads to unsubstantiated mappings.

4.9 Conclusion

This chapter presents analyses of cases where a vowel directly influences the C-place on a consonant. In both Vietnamese and Aghem, back, round vowels cause certain adjacent segments to become labial-velar stops. In Vietnamese, a dorsal [k] agrees with the vowel for place, causing it to become [k͡p]. In Aghem, labials [p] agree with back, round vowels, also resulting in labial-velars. Such agreement requires an Agree constraint that is satisfied by matching place specifications regardless of the position of the place feature with respect to C- or V-place nodes. The constraint id-agr.KPT$_{X}$, based on the generalized identity schema, does exactly this. Further markedness and faithfulness C- and V-place features further determine the target of agreement. Empirically, the typology of CV interactions in general is expanded, and gaps are filled, under this analysis. Previous surveys of consonant-vowel interactions (e.g. Ní Chiosáin & Padgett 1993, Halle et al. 2000, Padgett 2011) claim that a vowel place never displaces the C-place on a consonant. While this is technically still true, it is indeed the case that a V-place can add a C-place on a consonant, as in Vietnamese and Aghem.

5 Markedness reduction as place shedding

This chapter presents an empirical survey of markedness reduction via shedding: complex segments satisfy markedness requirements by shedding a place feature, rather than by neutralizing to the least marked place on a universal hierarchy. For labial-velars, this means /k͡p/ is realized as either semihomorganic simple stop [k] or [p]. Both are attested. Evidence for shedding comes from either paradigmatic alternations, phonotactic distributions, or patterns of free variation.

While markedness reduction patterns for simple-to-simple mappings, as surveyed and analyzed in de Lacy 2006, always involve the segment in question neutralizing to the lowest member of the universal hierarchy (total reduction), faithfulness prevents complex stop neutralization from doing the same (partial reduction). The relevant constraints must be powerful enough to choose the semihomorganic target of total reduction, e.g. to either place of the complex segment, while preserving the generalization that simple stops always neutralize to the lowest member of the markedness hierarchy.

After presenting the results of the empirical survey, this chapter defines the Basic Place Reduction System (BRS), which demonstrates the basic constraint interaction capturing both the reduction of simple and complex place, as well as gaps in inventories for both simple and complex place. This system is then extended into the Extended Place Reduction System (ERS), which differentiates between strong and weak prosodic positions. This will capture asymmetries between word-initial/onset inventories versus word-final/coda inventories for the languages surveyed.

5.1 Significance and context

The survey of inventory structure and markedness reduction processes in de Lacy 2002, 2006 lead to two targets for the resulting phonological system:

(212) **Total Reduction of Simple Place (TR)**

Simple segments reduce to the least marked place on the universal markedness hierarchy. (Faithfulness does not play a role in simple segment reduction.)

e.g. /k/ → [t], /p/ → [t], /k/ ↛ [p][1]

(213) **Gapped Inventories (GP)**

Surface inventories can contain gaps: "Gapped inventories are those that are missing an element of intermediate markedness" (de Lacy 2006: 163)

e.g. [k t], but not [p]

These targets are based on a universal markedness hierarchy like the one in (42). The description of TR is simplified a bit, as de Lacy 2006 shows how different markedness hierarchies can conflict, and cause the target of reduction to be a segment that is not the least marked on the PoA hierarchy (see de Lacy 2006: 88). However, even in these cases, faithfulness/preservation does not play a role in choosing this target; it is solely markedness. It is also crucial to remember that the hierarchy used in this chapter excludes glottal place for simplicity; any mappings to coronal place discussed in this chapter should be understood intensionally as "reducing to least marked place" rather than as mapping extensionally to coronal place.

Do these same properties apply to complex place, and if not, what is the difference? For complex segments, Total Reduction of Simple Place (TR) does *not* apply; segments shed a single place instead of reducing to the least marked place.

[1] ↛ = never maps to

(214) **Partial Reduction of Complex Place (PR)**

Complex segments reduce to either their more marked or less marked semihomorganic place.

e.g. /k͡p/ → [k], /k͡p/ → [p]

Such an effect is significant because it must be the case that place faithfulness evaluates semihomorganic mappings such as /k͡p/ → [k] or /k͡p/ → [p] as more faithful than TR mappings such as /k͡p/ → [t]. This is explained in detail in Section 5.4.

In the system in de Lacy 2006, there is a one-to-one correspondence from each member on the Universal Markedness Hierarchy to possible place of articulation for a given segment. As dorsal is on the scale, there are dorsal segments, and so forth. It is thus possible to say that dorsal *segments* are more marked than labial *segments* because dorsal *place* is more marked than labial *place*. However, with complex place, the place of articulation of [k͡p], which is both labial *and* dorsal, no longer corresponds to a single spot on the scale. How, then, is the markedness of this segment evaluated with respect to others? In other words, what is considered a gapped inventory once complex segments are involved? As a rough metric, a *markedness score* is calculated for each segment. This markedness score is equal to all markedness violations assigned by the stringent set of constraints for that segment. A segment with a higher markedness score is more marked than a segment with a lower markedness score.

(215) Markedness scores

output	m.K	m.KP	m.KPT	Score
t			*	1
p		*	*	2
k	*	*	*	3
t͡p		*	**	3
k͡p	*	**	**	5

Under this metric, [k͡p] is more marked than [t͡p], which is more marked than [t] and [p] individually (and equally marked to [k]). Thus, an inventory like the following is gapped:

(216) Gapped inventory with complex place:
[t p k k͡p]

This inventory structure is a key empirical target for a system as it represents the vast majority of languages with complex segments: full contrast among simple stops, with labial-dorsals but no labial-coronals.

In summary, while simple segments reduce to the least marked place on a hierarchy (TR), complex segments partially reduce by shedding a single place feature (PR). This is shown in the empirical survey in Section 5.3. Additionally, inventories with gaps (GP) exist in terms of both simple segments and complex segments. The Basic Reduction System in Section 5.4 models these targets.

5.2 Theoretical preliminaries

This chapter crucially makes use of several tools and theories related to Optimality Theory and ERC logic. Specifically, the fusion operation is used to show entailment among ERC sets. Additionally, W-extension and L-retraction show entailment between individual ERC vectors (Prince 2002a,b, Brasoveanu & Prince 2011). This chapter also assumes familiarity with ERCs in general.

The following definitions are taken directly from Prince 2002b, modified slightly for readability.

(217) **W-extension**: e→W (Prince 2002b: (9))
If ERC_1 and ERC_2 are identical, except that the i^{th} coordinate of ERC_1 is e and the i^{th} coordinate of ERC_2 is W, then ERC_1 entails ERC_2.

(218) **L-retraction**: L→e (Prince 2002b: (10))

If ERC_1 and ERC_2 are identical, except that the i^{th} coordinate of ERC_1 is L and the i^{th} coordinate of ERC_2 is e, then ERC_1 entails ERC_2.

A three-coordinate ERC `WeL` states that the constraint corresponding to position 1 of the vector must dominate the constraint corresponding to position 3 of the vector.

(219)

input	C1	C2	C3
winner~loser	W	e	L

Based on the above ERC, C1 must dominate C3. This entails, via W-extension, the ERC `WWL`, which states that C1 *or* C2 must dominate C3.

Additionally, the ERC `WLL` entails both `WeL` and `WLe` via L-retraction.

(220)

input	C1	C2	C3
winner~loser	W	L	L

The original ERC `WLL` states that C1 must dominate *both* C2 *and* C3. This entails that C1 must dominate C2, and that C1 must dominate C3. Full proofs and further explanation of L-retraction and W-extension are given in Prince 2002b.

While L-retraction and W-extension give entailments of single ERCs, the fusion operation gives entailments over a set of ERCs. A set of ERCs {A, B} entails their fusion A∘B. The fusion operation is indicated via the symbol ∘ and it is calculated tritwise over an ERC set following the definition below from Prince 2002b.

(221) **Fusion**. For X = W, L, e, (Prince 2002b: (12))

X ∘ X = X *Idempotence*

X ∘ L = L *Dominance of L*

X ∘ e = X *e is Identity*

To show the utility of the fusion operation, assume two ERCs `WWL` and `WLe`. Their fusion is `WLL`:

(222)

	C1	C2	C3
ERC1	W	W	L
ERC2	W	L	e
ERC1∘ERC2	W	L	L

The fusion clearly states that C1 must dominate C3 (as well as C2); however, this proposition is not entailed directly by either individual ERC. The ERC `WWL` states that C1 *or* C2 dominates C3, while the second ERC `WLe` states C1 must dominate C2. Through their fusion, we get additional ranking information that is jointly entailed by the set of ERCs.

Property Theory is utilized in analyzing the typology of specific OT systems (Alber & Prince 2017, Alber, DelBusso, et al. 2016, Bennett et al. 2016, McManus 2016, and much ongoing work). An OT system S is a particular definition of GEN_S and CON_S. Property Theory expresses the typology of a system as a set of structured binary-valued *properties*; the values of a property P are some ERC and its negative (e.g. `WeL` versus `LeW`). From property theory and the ERC logic toolbox, typological arguments are made based on the entailments of one or more property values for a given defined system.

5.3 Empirical survey

Evidence for complex segment reduction processes comes in two general forms: distributional disparities between strong and weak prosodic positions, and overt alternations between complex and simple segments. Languages containing complex segments were compiled from four general sources: the UPSID database of Maddieson 1984, the World Atlas of Linguistic Structure (Dryer & Haspelmath 2013), Ladefoged's *Phonetic Study of West African Languages*, and the languages surveyed in Cahill 2009. All languages described to include any complex segment, in most cases a form of the labial-velar stop, were compiled together in a list index to their ISO code from Lewis 2009. The result is a list of 132 languages that are tagged for having complex segments.

From this list, primary sources, in most cases full descriptive grammars and in other cases brief published field notes, were sought out wherever available. At the time of this writing, primary sources for 49 languages were investigated and searched for evidence of markedness reduction processes. The languages with the clearest evidence for markedness reduction of complex segments are summarized in Table 5.1.

Table 5.1: Clear cases of place shedding

Language	Underlying Place		Surface Place	Type of alternation
Amele	[lab], [dor]	→	[lab]	Paradigmatic
Dagbani	[lab], [dor]	→	[lab]	Phonotactic
Lele	[lab], [dor]	→	[lab]	Phonotactic
Tampulma	[lab], [dor]	→	[dor]	Phonotactic
Fwe/Yeyi	[dor], [cor]	→	[dor]	Free variation

In most cases, inventory disparities between onset and coda position yield the most cases of reduction processes. However, in some cases, like Amele, the reduction is described to occur in word-final positions, though there is only one example of a labial-velar appearing in a coda position as part of a word medial cluster. In other cases, like Dagbani, there is a clear onset/coda disparity, while segments in word-final position are restricted even further (see e.g. (228)). In the analysis, differences between onset/coda and word-initial/word-final position are abstracted away from, with only reference to strong prosodic positions (initial) and weak prosodic positions (final).

Amele shows a clear alternation of [g͡b] and [p], as it involves the prosodic parsing of a morphosyntactic morpheme. In other words, there is direct evidence of a /K͡P/ → [P] mapping. In other cases, such as in Dagbani, Lele, and Tampulma, there is a static distribution of segments in strong position versus weak position. These languages are included because in strong position, there is a contrast between /k͡p/, /k/, and /p/, while in weak position this contrast is neutralized to either [k] or [p]. Because only one semihomorganic segment is possible in this position, this is predicted to be the target of reduction for the complex segment.

While the exact ranking conditions for this are explained in detail in Sections 5.4 and 5.5, the argument is summarized as follows: if /k͡p/ is unfaithful (not present in some prosodic position), then it must map to something that is not [k͡p]. If [p] is allowed but [k] is banned in this same position, for instance, then /k͡p/ will never map to [p] over [t]. The segment /k͡p/ will never map to [t] when either semihomorganic segment is available, as this is a more faithful option that also (partially) satisfies markedness conditions. When only one semihomorganic segment is available, this is also then the target for the complex segment. Such is the case for Dagbani, Lele, and Tampulma. In other words, simultaneous mappings of /p/ → [p] (or /k/ → [k]) *and* /k͡p/ → [t] is impossible.

There are a number of other languages that contain complex segments only in strong position, but contain both [p] and [k] in weak position. These languages do contain place shedding, but the target of reduction (i.e. which place actually sheds) is ambiguous. Amele would be this type of language, but as mentioned, contains a morphosyntactic alternation that makes the target clear. In Table 5.2, the languages marked as *Full Simple* contain shedding in weak position, but the target is ambiguous (either [k] or [p]) due to lack of clear phonological alternations.

Table 5.2: Stop inventories in final position for languages surveyed

Type	k͡p	K	P	T	Languages
No Dorsals			✓	✓	Dagbani (Olawsky 1999), Lele (Frajzyngier 2001)
No Labials		✓		✓	Tampulma (Bergman et al. 1969)
Full Simple		✓	✓	✓	Amele (Roberts 1987), Ewondo (Redden 1979), Doyayo (E. Wiering & M. Wiering 1994), Mumuye (Shimizu 1983), Gbaya-Bossangoa (Samarin 1966), Bari (Cohen 2000), Mbum (Hagège 1970)
Full	✓	✓	✓	✓	Efate South (Thieberger 2006)
Nasals only		(✓)	(✓)	(✓)	Kisi Southern Childs 1995, Kalabari (Harry 2004), Dagaare Southern (Bodomo 1997)
No Codas					Yoruba (Bamgbose 2011), Awutu (Obeng 2008), Ma'di (Blackings & Fabb 2003), Owa (Mellow 2014), Sénoufo Cebaara (Mills 1984), Ngiti (Lojenga 1994), Fon (Lefebvre 2002), Nkonya (Reineke 1972), Lelemi (Höftmann 1971), Bora (Thiesen & Weber 2012), Sango (Samarin 1967)

5.3.1 Amele

In Amele (Papuan, Papua New Guinea, [aey]), [k] and [p] contrast in weak position, but /g͡b/ is reduced to [p]. Evidence for this mapping comes from a morphosyntactic alternation explained below. The consonant inventory for Amele is given in Table 5.3.

Table 5.3: Amele consonant inventory (Roberts 1987)

	Labial	Alveolar	Palatal	Velar	Glottal	Labial-velar
Stop	p b	t d		k g	ʔ	g͡b
Nasal	m	n				
Fricatives	f v	s	j̱		h	
Liquids/Approximants	w	l	j			

In Amele, the voiced labial-dorsal stop [g͡b] surfaces as [p] when in word-final position. This is a morphosyntactic alternation. There is a person-number morpheme /og͡b/ that, depending on its order with respect to a tense/aspect morpheme, is either parsed into an onset

position or a word-final position. When /g͡b/ appears in initial (onset) position, it surfaces faithfully, but in final position it neutralizes. The data below are from Roberts (p.c.), also reported in Roberts 1987: 336. This process is also discussed in Cahill 1999, 2000, van de Weijer 2011.

(223) Initial position (person/number + tense/aspect):

a.	/h + og͡b + ona/	→	[hoˈ.g͡bɔ.nə]	‘we are coming’ (present)
b.	/f + og͡b + ona/	→	[foˈ.g͡bɔ.nə]	‘we are seeing’ (present)
c.	/h + og͡b + a/	→	[ˈho.g͡bə]	‘we came’ (today)
d.	/f + og͡b + a/	→	[ˈfo.g͡bə]	‘we saw’ (today)

(224) Final position (tense/aspect + person/number):

a.	/h + ol + og͡b/	→	[hɔˈ.lɔp]	‘we used to come’ (past habitual)
b.	/f + ol + og͡b/	→	[fɔˈ.lɔp]	‘we used to see’ (past habitual)
c.	/h + um + eg͡b/	→	[ˈhu.mɛp]	‘we come and (we) ...’ (SS.sequential)
d.	/f + im + eg͡b/	→	[ˈfi.mɛp]	‘we see and (we) ...’ (SS.sequential)

Because of this alternation, we are sure that the mapping in Amele is /g͡b/ → [p], or more generally, that a labial-dorsal sheds its [dorsal] place and is realized as a simple [labial].

This is part of a more general devoicing processes in the same position:

(225) In final position of polysyllabic words: (Roberts 1987: 346)

/d/	→	[t]
/b/, /g͡b/	→	[p]
/g/	→	[k]

Roberts 1987: 333 notes that [b], [g], and [d] can surface finally in monosyllabic words.

(226)

a.	[sib]	‘rubbish’	(Roberts 1987: 333)
b.	[lig]	‘shrug species’	(Roberts 1987: 335)
c.	[g͡bæːd]	‘cheek’	(Roberts 1987: 335)

It is not clear if [g͡b] can occur finally in monosyllabic words. There are no forms given, but Roberts does give one form with [g͡b] occurring in a word-internal coda, contrasting with [b] in that same position:

(227) a. [tug͡b.dɔʔ] ‘to butcher’ (Roberts 1987: 346)

b. [tub.dɔʔ] ‘to join’ (Roberts 1987: 346)

As Roberts notes, there is some ambiguity as to the exact position where these consonant variations take place. It is at least clear, however, that [g͡b] does reduce in place in the final position of polysyllabic words. Whether the precise position is coda, non-initial coda, or word-final, this is a distinction between a strong prosodic position, and a weak one.

5.3.2 Dagbani

Dagbani (Gur, Ghana, [dag]) contains voiced, voiceless, and nasal labial-velars. The full consonant inventory is given in Table 5.4.

Table 5.4: Dagbani consonant inventory (Olawsky 1999: 251)

	Labial	Alveolar	Palatal	Velar	Glottal	Labial-velar
Stops	p b	t d	tɕ dʑ	k g		k͡p g͡b
Nasals	m	n	ɲ	ŋ		ŋ͡m
Fricatives	f	s z	ʃ ʒ	ɣ	h	
Laterals		l				
Flaps		ɾ				
Glides	ʋ		j			

However, Olawsky gives the following condition for weak positions in Dagbani, repeated below verbatim:

(228) **Coda condition for Dagbani** (Olawsky 1999: (292))

The consonants allowed in coda position in word-internal environments are:

[m, ŋ, n, r, l, b, ɣ]

In word final position, only [m, ŋ] are admitted.

These segments are also shown in Table 5.5.

Table 5.5: Dagbani consonant inventory - codas

	Labial	Alveolar	Velar
Stops	b	t d	
Nasals	m	n	ŋ
Fricatives			ɣ
Laterals		l	
Flaps		ɾ	

While labial-velars, including [g͡b], are allowed in onsets, [b] is the only oral stop allowed in codas, suggesting a mapping of /g͡b/ → [b].

There is another relevant process involving velars: [g]-lenition. The voiced velar stop [g] is in complementary distribution with the voiced velar fricative [ɣ]: [ɣ] occurs after vowels and [g] elsewhere, in monomorphemic words.

(229) [g]-lenition

/g/ → [ɣ] / V _

(230) a. dɔɣte ‘doctor-SG’ (Olawsky 1999: (479))

b. paɣa ‘woman-SG’ (Olawsky 1999: (501))

c. *paga

However, labial-velars appear faithfully in the environment of [g]-lenition:

(231) a. dag͡bana ‘Dagomba-SG’ (Olawsky 1999: (310))

One remaining question is if a /g͡b/ → [ɣ] mapping is possible in coda position. However, for the discussion to follow in the analysis, all cross-manner neutralization is abstracted away from.

5.3.3 Tampulma

Tampulma (Gur, Ghana, [tpm]) contains voiced, voiceless, and nasal labial-velar stops. The full inventory is given in Table 5.6.

Table 5.6: Tampulma consonant inventory (Bergman et al. 1969: 12)

	Labial	Alveolar	Alveo-palatal	Velar	Glottal	Labial-velar
Stops	p b	t d	tʃ dʒ	k g	ʔ	k͡p g͡b
Fricatives	f v	s z			h ʁ	
Nasals	m	n	ɲ	ŋ		ŋ͡m
Laterals		l				
Flaps/Trills		r ɾ				
Approximants	w		j			

Tampulma contains distributional evidence for the reduction of /k͡p/ → [k]: while the complete set of stop segments is allowed in initial position, only the following consonants are allowed in final position:

Table 5.7: Tampulma consonant inventory - codas

	Labial	Alveolar	Velar
Stops			k
Nasals	m	n	ŋ
Laterals		l	
Trills		r	

(232) Tampulma consonants in final position: (Bergman et al. 1969: 31)

[k], [m], [n], [ŋ], [l], [r]

This is the same set of sounds that can occur word-internally as the first member of a consonant cluster (Bergman et al. 1969: 33). Like with Amele, there are restrictions as to the set of sounds that can occur in strong initial positions versus weak final positions.

Assuming that all consonants that do not occur in final position map to a consonant that does occur in final position, [k] is the phonologically closest segment to [k͡p]; if /k͡p/ is to map to anything in this set, it is [k].

5.3.4 Lele

Lele (East Chadic, Chad, [lln]) contains voiced, voiceless, and prenasalized labial-velar stops (Frajzyngier 2001). The complete consonant inventory is shown in Table 5.8

Table 5.8: Lele consonant inventory (Frajzyngier 2001: 8)

	Labial	Alveolar	Palatal	Velar	Labial-velar	Glottal
Stops	p b	t d		k g	k͡p g͡b	
Glottalized Stops	ɓ	ɗ				
Prenasals	ᵐb	ⁿd			ŋ͡ᵐg͡b	
Nasals	m	n	ɲ	ŋ		
Fricatives		s				h
Liquids		r l				
Glides	w		j			

While all stops can occur initially, Frajzyngier lists the following condition on word-final consonants: "Alveolar consonants **j, c, d, s**[2] and velar consonants **g** and **k** cannot occur in word-final position" (p. 11). Although not listed, all labial-velars are also banned from word final position, as well as all prenasalized stops (Frajzyngier 2001: 9). Based on the descriptions of the various consonants, the word-final inventory in Table 5.9 can be extrapolated, even though it is not stated explicitly.

Table 5.9: Lele consonant inventory - word final

	Labial	Alveolar	Palatal	Velar
Stops	p b			
Nasals	m	n		ŋ
Glides	w		j	

While simple velars [k g] cannot occur word-finally, simple labials can.

(233) a. hab 'find' (Frajzyngier 2001: 10)

b. kùb 'mouth' (Frajzyngier 2001: 30)

c. *hag

[2]It is not clear what specific consonants 'c' and 'j' refer to, as neither symbol is given in the consonant chart for the language. However, the relevant part of this list is that velar stops k and g are banned in word-final position. As they are listed as alveolar, and the palatal glide [j] can occur word-finally, 'c' and 'j' here likely refer to [tʃ] and [dʒ], respectively.

Additionally, there are two processes that repair ill-formed words: vowel epenthesis and g-weakening. Vowel epenthesis occurs to prevent [k s d] from final position, while g is weakened to a palatal glide in that same position.

Evidence for vowel epenthesis comes from possessive morphology. While the word for 'body' is [kusu] in isolation, Frajzyngier 2001 argues that the root is actually /kus/, and the final vowel is epenthetic and predictable. One piece of evidence is the first person possessive morpheme. When the root ends in a vowel, the possessive morpheme is [-niŋ]. When the root ends in a consonant, it is [-iŋ]. The form for 'my body' is given below, with the C-final allomorph.

(234) Vowel Epenthesis

a. kus-iŋ 'my body' (Frajzyngier 2001: 14)

b. *kusu-niŋ 'my body'

Additionally, alternations for g-weakening are found in similar cases. When an object pronoun appears on a verb whose root ends in [g], the [g] is realized as a glide if the pronoun is C-initial. Below are two forms involving the verb 'put' /bòg/.

(235) g-weakening

a. bòg-ìŋ put-1SG (Frajzyngier 2001: 19)

b. bòj-dù put-3M-3F (Frajzyngier 2001: 19)

This g-weakening process is similar to the process in Dagbani.

5.3.5 South Efate

South Efate, or Efate South (Oceanic, Vanuatu, [erk]) contains contrastive labials, velars, and labial-velars in both initial and final position (Thieberger 2006). It is cited by Hajek 2009 as the only language with this property, and indeed it is the only language found in the present survey with such a property.[3] The consonant inventory is given in Table 5.10.

[3] Vietnamese does allow labials, velars, and labial-velars in final position, but with a restricted distribution; only labial-velars are only contrastive with labials. See 4.

Table 5.10: South Efate consonant inventory

	Labial-velar	Labiodental	Labial	Palatal	Alveolar	Velar
Stop	k͡p		p		t	k
Fricative		f			s	
Nasal	ŋ͡m		m		n	ŋ
Lateral					l	
Trill					r ^{n}dr	
Glide	w			j		

Here, [^{n}dr] is a prenasalized trill. The following forms show contrast between [p k k͡p] in both initial and final positions:

(236) a. pak ‘to go to’
b. kak ‘mesh formed at base of palmtrees’
c. lap ‘many’
d. nak͡p tree sp.
e. k͡pas ‘to chase’ (Thieberger 2006: 47)

While the segments [k͡p] and [ŋ͡m] are described as phonetically co-articulated, in fluent speech labial-velars “may also be realized as a stop-nasal or a stop-stop combination rather than as a coarticulated segment”, or in extreme cases with one articulation not being realized at all (Thieberger 2006: 49). The following shows different realizations of the [k͡p] in fluent speech:

(237) a. /nak͡pei/ → nak.pei ‘front’
b. /uk͡plim/ → u.k͡plim ‘ceremony after a death’
c. /uk͡plim/ → u.klim ‘ceremony after a death’
d. /uk͡plim/ → u.plim ‘ceremony after a death’ (Thieberger 2006: 49)

It is not clear how this phonetic variation applies across different words and different speakers. However, at first glance it might appear that the segment transcribed as [k͡p] in South Efate is not a “true” labial-velar, due to this phonetic unstability, and instead might be a

cluster that is sometimes realized with phonetic overlap. However, there is phonotactic evidence that this is more segmental than a cluster.

In initial position, South Efate allows heterorganic obstruent consonant clusters. This includes both stop-stop clusters as well as stop-fricative clusters. The labial-velar stop [k͡p] can appear in initial clusters with other obstruents such as [k] or [t] (Thieberger 2006: 59). If [k͡p] were treated phonologically like a cluster in these cases, these forms would be the only cases of a three-consonant cluster that are not formed from the article [n-]: "initial consonant clusters often result form the presence of the article *n*, and the only five initial three-consonant clusters are all /n/-initial" (Thieberger 2006: 58).

Additionally, [k͡p] can appear syllable-finally, while "there are only two syllable-final consonant clusters, /lf/ and /rk/" (Thieberger 2006: 58). In the examples given from fluent speech where [k͡p] is phonetically realized as a cluster, it seems to always be heterosyllabic (as in (237a)). If [k͡p] were phonotactically a cluster, it would be the only such obstruent-obstruent cluster in final position.

With respect to its patterning with respect to syllable phonotactics, [k͡p] in South Efate behaves like a single, complex segment. However, there is still the issue of its irregular phonetic realization. It might be the case that the language is in transition from a cluster to a complex segment; such that [k͡p] behaves more like a segment than a cluster with respect to phonotactics, but phonetically is sometimes realized more like a cluster than a single segment. Regardless, it is the best known case for a language with full preservation of complex and simple place in final position (with respect to labial-velars).

5.3.6 Yeyi and Fwe

Yeyi (Bantu R, Namibia, Botswana, [yey]) contains dental, alveolar, and lateral clicks (Seidel 2008: 41). Clicks are in free variation with non-click egress velar stops: "several items seem to be characterized by a free variation with non-click counterparts, namely /g/ and /k/, or any aspirated or prenasalized combination thereof" (Seidel 2008: 41).

Table 5.11: Yeyi click inventory (Seidel 2008: 41)

	dental	alveolar	lateral
voiceless	ǀ	ǃ	(ǁ)
voiced	ǀ̬	ǃ̬	
voiceless aspirated	ǀʰ	ǃʰ	
voiceless prenasal	ŋǀ	ŋǃ	(nǁ)
voiceless prenasal aspirated	ŋǀʰ	ŋǃʰ	
voiced prenasal	ŋǀ̬	ŋǃ̬	

In the related language Fwe (Bantu K, Namibia, [fwe]), there is a parallel alternation between clicks and simple pulmonic velars (Gunnink n.d.).

(238) Fwe place shedding in clicks:

a. [ǀ] → [k] [kùǀàpùrà] ~ [kùkàpùrà] ‘to tear’ (14)

b. [g͡ǀ] → [g] [mùg͡ǀênè] ~ [mùgênè] ‘thin (person)’ (16)

c. [ŋ͡ǀ] → [ŋ] [ŋ͡ǀórèzà] ~ [ŋórèzà] ‘resin’ (18)

This is a robust alternation, with “the majority of click words…realized both with and without clicks, be it by the same speaker or by different speakers” (Gunnink n.d.: 7) and “all speakers substitute clicks with non-clicks in certain words” (p. 8). Significantly, while all clicks have non-click variants, not all velars have click variants: “the vast majority of words with these phonemes [/k/, /ŋ/, and /ŋk/] do not have a click alternative” (p. 9). This suggests that certain words contain underlying clicks which have a choice of realization (as a click or as a simple velar), while words with an underlying velar stop do not have the choice to be realized as a click. In other words, it is a shedding process from (complex) click to simple velar.

This is supported by the fact that voicing and nasality are preserved in the alternation. Assuming that the click has two place features, one for anterior place and one for posterior place, in addition to values for [voice] and [nasal], the anterior place feature of a click is not realized when the speaker produces the simple pulmonic variant.

5.4 Basic Place Reduction System

The purpose of this system is to show how with the scaled markedness and faithfulness constraints below, the following is achieved:

(239) **Partial Reduction of Complex Place (PR)**

Complex segments reduce to either their more marked or less marked semihomorganic place.

e.g. /k͡p/ → [k], /k͡p/ → [p]

(240) **Total Reduction of Simple Place (TR)**

Simple segments reduce to the least marked place on the universal markedness hierarchy.

e.g. /k/ → [t], /p/ → [t], /k/ ↛ [p][4]

(241) **Gapped Inventories (GP)**

Surface inventories can contain gaps: "Gapped inventories are those that are missing an element of intermediate markedness" (de Lacy 2006: 163)

e.g. [k t], but not [p]; [k p t k͡p] but not [t͡p]

The system (GEN_{BRS}, CON_{BRS}) is defined, and the typology is analyzed in property theory, as defined in Alber, DelBusso, et al. 2016, Bennett et al. 2016, Alber & Prince 2017, McManus 2016, and much ongoing work. A property is a choice between mutually-exclusive ranking values (Alber, DelBusso, et al. 2016: e91), such that given two constraints M and F, one value of the property stipulates that M ≫ F, and the other F ≫ M. Upon a complete property analysis for a system, a choice of all property values will determine all ranking information necessary for that particular grammar of the typology. All possible property choices, minus those ruled our via ranking contradiction or mootness (scope) will determine all possible grammars in the typology.

[4] ↛ = never maps to

5.4.1 CON_{BRS}

This system uses only the following six constraints, listed below.

(242) *Markedness:*

a. **m.KPT**

• / • ↓ C-pl ↓ [dor] +

• / • ↓ C-pl ↓ [lab] +

• / • ↓ C-pl ↓ [cor]

—

"Assign a violation for each root node that has dorsal C-place, and for each that has labial C-place, and for each that has coronal C-place."

b. **m.KP**

• / • ↓ C-pl ↓ [dor] +

• / • ↓ C-pl ↓ [lab]

—

"Assign a violation for each root node that has dorsal C-place, and for each that has labial C-place."

c. **m.K**

• / • ↓ C-pl ↓ [dor]

—

"Assign a violation for each root node that has dorsal C-place."

The markedness constraints are stringently defined following the Scaled Constraint algorithm also defined in Chapter 2. The choice to define markedness stringently this way based on a universal hierarchy is based on Prince & Smolensky 1993, Lombardi 2001, de Lacy 2006, a.o.. Following Prince 1997, de Lacy 2002, 2006, the constraints are stringently defined. This expresses the content of the Universal Markedness Hierarchy in the content of the constraints themselves rather than via a universal ranking of individual constraints.

While de Lacy gives a number of arguments favoring a stringency analysis over a fixed universal ranking, this chapter provides additional arguments in the behavior of complex place. The omnibus markedness constraint differentiates only between simple and complex place when the domain of evaluation is a single segment. This effect is *not* achieved with a universal fixed ranking, nor is it achieved with a set of lenient markedness constraints, in the sense of Gouskova 2003. A set of stringent constraints is lenient if it does not include a constraint that makes reference to the least marked item on the scale (in this case, [coronal] place).

(243) *Faithfulness:*

a. **id-io.KPT$_{\mathbf{C}}$**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) $\wedge$ (($\bullet_1 \downarrow$ C-pl $\downarrow$ [dor]) $\oplus$ ($\bullet_2 \downarrow$ C-pl $\downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) $\wedge$ (($\bullet_1 \downarrow$ C-pl $\downarrow$ [lab]) $\oplus$ ($\bullet_2 \downarrow$ C-pl $\downarrow$ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) $\wedge$ (($\bullet_1 \downarrow$ C-pl $\downarrow$ [cor]) $\oplus$ ($\bullet_2 \downarrow$ C-pl $\downarrow$ [cor]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place, and for each with a disparity in coronal C-place."

a. **id-io.KP$_{\mathbf{C}}$**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) $\wedge$ (($\bullet_1 \downarrow$ C-pl $\downarrow$ [dor]) $\oplus$ ($\bullet_2 \downarrow$ C-pl $\downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) $\wedge$ (($\bullet_1 \downarrow$ C-pl $\downarrow$ [lab]) $\oplus$ ($\bullet_2 \downarrow$ C-pl $\downarrow$ [lab]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place."

a. **id-io.K$_{\mathbf{C}}$**

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) $\wedge$ (($\bullet_1 \downarrow$ C-pl $\downarrow$ [dor]) $\oplus$ ($\bullet_2 \downarrow$ C-pl $\downarrow$ [dor]))

—

> "Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place."

The faithfulness constraints are defined on the generalized identity schema for input/output correspondence using the Scaled Constraint algorithm, as defined in Chapter 2. As the BRS only considers only interactions in consonantal place, the ident constraints can either be defined on the cross-category or within-C-place definitions. However, the definitions given here use the within-C-category definition to emphasize that these are changes in consonantal place.

Further, the faithfulness constraints count each place disparity, such that /k͡p/ → [p] is more faithful than /k͡p/ → [t]. That is to say, place faithfulness is not class equality. It is not unreasonable to consider a definition of place faithfulness that assigns a violation whenever the set of place features for one segment *does not equal* the set of place features for another segment. All unfaithful pairs are assigned a violation, but equally so. This would not capture the partially-faithful semihomorganic mappings attested in this chapter, however.

While the faithfulness constraints are not based on strict equality of the the place features, are they "gradient"? The scare-quotes are used to signify a number of differing definitions of what constraint gradiency refers to. On the most basic level, a constraint is categorical if for each locus of violation, the constraint returns either zero or one violation mark. McCarthy gives the following definition, relevant here: "Gradient constraints can assign multiple violation-marks even when there is just one instance of a marked structure or an unfaithful mapping" (McCarthy 2003: 76). Under this definition, each individual place identity constraint (pre-summation) is categorical: they assign one violation if there is a disparity in place feature F and 0 otherwise. Are the summed versions, then, categorical or gradient?

Summed constraints are identical in violation counting to constraints in Feature Class Theory (FCT, Padgett 1995, 2002), and McCarthy classifies the FCT-style constraints under *collective gradience*:

(244) "Assign violation-marks in proportion to the cardinality of a set. Example (Padgett 1995, 2002): Constraint(Class) ≈ assign one violation-mark for each member of the feature-class Class that does not satisfy CONSTRAINT. E.g. Assim[Place] assigns two marks to [an͡gba], one to [aŋ͡gba] and none to [aŋ͡mg͡b]." (McCarthy 2003: (4c))

The following tableau shows the parallelism between the FCT constraint Assim[place] and the summed version of Agree for place, id-agr.KPT_C.

(245)

	Assim[Place]	id-agr.KPT_C
a. [an͡gba]	**	**
b. [aŋ͡gba]	*	*
c. [aŋ͡mg͡b]		

For collective gradience, there is still a connection between the individual/categorical constraint definitions, as McCarthy points out:

> "For example, the gradient constraints IDENT[color] and SPREAD[color] in Padgett (2002) are superfluous if there are categorical IDENT constraints for each of the vowel-color features [back] and [round]. If CON includes categorical IDENT[round], IDENT[back], SPREAD[round] and SPREAD[back], then gradient IDENT[color] and SPREAD[color] are superfluous because their presence will have no visible effect on the resulting factorial typology" (McCarthy 2003: 85)

In short, this claim is if that Individual constraints are part of a system, then the Summed version will not change the typology. This is true. However, the inverse is *not* true: including *only* the summed version of a constraint results in a more restrictive typology than if *only* the individual constraints are part of a system. This is because the individual constraints will result in the mappings of the summed constraint when they are not crucially ranked with respect to one another. However, the individual constraint system will then on top of that

include the mappings where they *are* crucially ranked with respect to another—mappings impossible with a single summed constraint.

Additionally, including only the scaled versions of the constraints (as in the BRS) is still a less restrictive typology over individual constraints, but more articulated than simple the omnibus summed constraint. This fact is part of the more general arguments for stringency in general. The overall question of whether the faithfulness constraints used here are gradient is relevant because de Lacy points out that a different version of place identity, which is gradient, cannot capture TR.

> "…suppose that faithfulness constraints assigned different violations based on the degree of difference along the hierarchy…[f]or example, [k] and [p] are only one stop away on the PoA hierarchy, so Ident{dorsal} would assign one violation to the mapping /k/ → [p]. Since [t] is two steps away from [k], /k/ → [t] would incur two violations of Ident{dorsal}…" (de Lacy 2006: 115)

In McCarthy's characterization, this is an example of *scalar gradience*. Summation does not result in this type of gradiency, and predictions for simple place reduction are preserved.

5.4.2 GEN_{BRS}

Because the system only considers consonant to consonant mappings, the distinction between cross-category or within-category for C-place is neutralized. The candidate sets considered are for all simple places dorsal, labial, and coronal, as well as labial-dorsals and labial-coronals. Phonological coronal-dorsals (argued to be phonetic palatals in Chapter 4) are not considered as their typology is less understood. A decision is made to focus on the constraint interactions involving labial velars k͡p and labial-coronals t͡p, which are clear double articulations with phonologically complex place. It is important to stress that the exclusion of phonological coronal-dorsals results in a specific system, with specific constraint interaction, analyzed below. The eventual inclusion of coronal-dorsals results in a

new system, whose properties would need to be studied separately (yet there are likely to be affinities between the two systems).

(246) Candidate sets considered:

	Place
k	[dor]
p	[lab]
t	[cor]
k͡p	[lab], [dor]
t͡p	[lab], [cor]

Each input has the full set of segments as possible outputs, and every segment in (246 is considered as an input. All calculations to follow were computed with OT Workplace (Prince, Tesar, et al. 2016).

5.4.3 Factorial Typology

The BRS factorial typology is given in Table 5.12.

Table 5.12: BRS Factorial Typology

Lg.	/k/	/p/	/t/	/k͡p/	/t͡p/	Comment
L01.	k	p	t	k	p	Marked places are preserved in complex segments
L02.	k	p	t	k	t	Marked place is preserved in /k͡p/, reduced in /t͡p/
L03.	k	p	t	p	p	Marked place is reduced in /k͡p/, preserved in /t͡p/
L04.	k	p	t	p	t	Marked place is reduced in both /k͡p/ and /t͡p/
L05.	k	p	t	k͡p	p	[k͡p] surfaces, marked place is preserved in /t͡p/
L06.	k	p	t	k͡p	t͡p	[k͡p] and [t͡p] surface
L07.	k	t	t	k	t	[p] is banned
L08.	t	p	t	p	p	[k] is banned, marked place preserved in /t͡p/
L09.	t	p	t	p	t	[k] is banned, marked place reduced in /t͡p/
L10.	t	p	t	p	t͡p	[k] is banned, [t͡p] surfaces
L11.	t	t	t	t	t	Total reduction to [t]

The inputs are listed along the top row, and each row are those outputs for the given inputs for a particular language. Note that this typology represents mappings, yet from a

surface perspective, many of these languages result in the same surface inventory. For example, L01–L04 all include the same set of surface segments [k p t]. The only difference are the particular mappings of /k͡p/ and /t͡p/. Languages L01–L04 display the four logical possibilities for complex place mapping to their semihomorganic simple places: /k͡p/ can map to either [k] or [p], and /t͡p/ can map to either [t] or [p]. Among these four languages, these choices are independent. These interactions are analyzed in detail in the next section.

5.4.4 Property Analysis

The property definitions of the BRS are listed below, with relevant inputs and mappings. Note that the table does not encode scopal relations between properties as in the tree in 248. Each property is numbered (1–6), and each has a value of A or B. The ERC for a particular value is given, and the ERC for the opposite value is the opposite ERC. The coordinates of each ERC are based on the order of constraints given in the tuple above the table itself.

(247) **BRS Property Definitions**

⟨m.KPT, m.KP, m.K, id-io.KPT, id-io.KP, id-io.K⟩

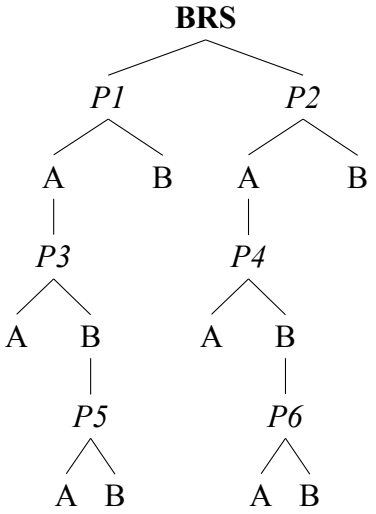
Prop	Input	Value A		Value B	
1	/k/	→ k	eLLWWW	→ t	eWWLLL
2	/p/	→ p	eLeWWe	→ t	eWeLLe
3	/k͡p/	→ k͡p	LLeWWe	→ ¬k͡p	WWeLLe
4	/t͡p/	→ t͡p	LeeWee	→ ¬t͡p	WeeLee
5	/k͡p/	→ k	eeLeeW	→ p	eeWeeL
6	/t͡p/	→ p	eLeeWe	→ t	eWeeLe

In this table, each *property* is associated with a particular input. The value of that property determines the mapping of that input; the resulting output is indicated immediately following the rightwards arrow to the right of the ERC.

With six binary properties, there are 64 logically possible property value combinations. However, the typology itself consists of only 11 languages. The typology is restricted for

two reasons: ranking contradiction and property mootness. Two property values are contradictory if their ERCs fuse to L^+.[5] Mootness refers to properties that are outside the scope of other properties. The scopal relations of the BRS properties are given below:

(248) **BRS Property Relations**



In this system, if P3 takes the value A, then the choice for P5 is *moot*: linear orders of constraints might satisfy one of the ERCs associated with the vales for P5.A and B, but the choice will not yield a distinction in optima.

5.4.4.1 Partial Reduction of Complex Place (PR)

In BRS, complex segments such as k͡p undergo markedness reduction under certain rankings. However, unlike with simple place, they do *not* always reduce to the least marked place. Instead, they reduce to either semihomorganic place. In discussing neutralization of simple segments, de Lacy explains: "[Place of Articulation] preservation is irrelevant in choosing whether /k/ wil turn into [p], [t], or [ʔ], because none of these options preserves the input segment better than any other" (de Lacy 2006: 78). This is still the case in BRS; simple segments always reduce to the least marked place on the scale. However, the statement is in general must be amended: preservation (faithfulness) *does* play a role in choosing

[5]Following Prince 2002a, L^+ is the set of ERCs that contain at least one L coordinate and no W coordinates.

the target of reduction for complex segments like /k͡p/, as both [p] and [k] are more faithful than any heterorganic segment such as [t].

Total Reduction is accomplished via harmonic bounding: any candidate that is not either the faithful candidate or the least marked candidate is harmonically bounded. This is true both for the BRS and in de Lacy's original system. Partial Reduction is due to the summation effects in both certain markedness and faithfulness constraints. The markedness constraint that assigns a violation to all places, m.KPT, acts as a *de facto* ban on complexity when the domain of evaluation is a single segment and all possible places are represented featurally. This is due to the fact that violation marks accrue: segments with complex place receive two violations, while segments with simple place receive one. Thus, even though the constraint marks against all place features, the only differentiation made is between complex and simple stops.

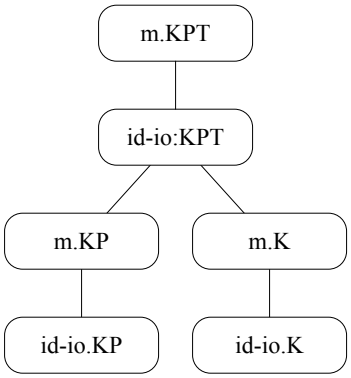
(249)

	m.KPT
t	*
p	*
k	*
t͡p	**
k͡p	**

In languages where k͡p is unfaithful, either m.KPT or m.KP must dominate both id-io.KPT and id-io.KP. What these constraints do is filter complex segments from the candidate set, leaving (certain) simple stops as possible optima. The choice of optima is now between either semihomorganic place. The semihomorganic places are preferred to the least marked place candidate because of the definition of place identity. Each place feature disparity results in a faithfulness violation, such that /k͡p/ → [p] results in fewer faithfulness violations than /k͡p/ → [t].

For a concrete example, the ranking for L04 is given below. In this language, all simple stops are faithful, /k͡p/ → [p] and /t͡p/ → [t].

(250) L04 Ranking



(251) **L04, One possible linear order**

⟨m.KPT, m.KP, m.K, id-io.KPT, id-io.KP, id-io.K⟩

/k͡p/	m.KPT	id-io.KPT	m.K	id-io.K	m.KP	id-io.KP
a. k	*	*	*		*	*
b. p	*	*		*	*	*
c. t	*	***		*		**
d. k͡p	**		*		**	
e. t͡p	**	**		*	*	*

As mentioned, the dominated constraint m.KPT only differentiates between simple and complex place. In this candidate set, the only forms that survive filtration past m.KPT are k, p, and t. The next constraint in this linear order is id-io.KPT, which differentiates between t and k & p. The candidate /k͡p/ → [t] is more unfaithful than either of /k͡p/ → [k] or /k͡p/ → [p] with respect to id-io.KPT. Thus, the least marked form is filtered out of the optimization process by a faithfulness constraint in a case of neutralization.

In simple-to-simple mappings, filtration by markedness constraints prevents realization of the faithful segment. All other remaining segments are equally unfaithful, so markedness

again filters down to the least marked segment. In semihomorganic mappings, filtration by markedness prevents realization of the fully faithful complex segment, but partially faithful semihomorganic stops survive this pass of filtration. Thus, faithfulness can and does determine the target of reduction in these cases.

5.4.4.2 Gaps

First, the faithful realization of the simple stops /k/ and /p/ are independent choices: both can be faithful, either one can be faithful, or neither can be faithful.

(252)

	Both k and p	Only k	Only p	Neither
Prop 1	eLLWWW	eLLWWW	eWWLLL	eWWLLL
Prop 2	eLeWWe	eWeLLe	eLeWWe	eWeLLe
Fusion	eLLWWW	eLLLLW	eLWLLL	eWWLLL
Lgs.	L01–L06	L07	L08–L10	L11

If /k/ is faithful but /p/ is unfaithful, the resulting surface inventory will be gapped: [p] is absent but both more marked and lessor marked segments are present. This is parallel to the original system in de Lacy 2006.

However, with the inclusion of complex segments /k͡p/ and /t͡p/ in the system, there are opportunities for more gaps: languages that include /k͡p/ but lack /t͡p/ have gapped inventories, since [k͡p] is the more marked segment of the two. This type of inventory is possible due to the faithfulness constraint id-io.KP. Undominated, this constraint ensures the faithfulness of all labials, dorsals, and labial-dorsals; labial-coronals can be ruled out independently. This is shown as the fusion of two property values: P3A, /k͡p/ is faithful, and P4B, /t͡p/ is unfaithful.

(253) P3.A LLeWWe

P4.B WeeLee

Fusion LLeLWe

The fusion of the two property values states that id-io.KP must dominate m.KPT, m.KP, and id-io.KPT.

There is exactly one language in BRS that includes [k͡p] but not [t͡p]: L05.

(254) L05 Support

ERC	Input	Winner	Loser	id-io.KP	id-io.K	m.KPT	m.KP	m.K	id-io.KPT	Prop
a.	/k/	k	t	W	W		L	L	W	P1.A
b.	/k͡p/	k͡p	k	W		L	L		W	P3.A
c.	/t͡p/	p	t͡p			W			L	P4.B

The column labeled Prop displays the properties and values reflected in the ERCs of the support. Even though only 3 ERCs are needed for the support, the rest of the property values are either entailed from these, or moot. P1.A is reflected in ERC a. P3.A is satisfied in b, resulting in faithful /k͡p/. These values are compatible with ERC c, which results in unfaithful /t͡p/. Even though labial-coronals are unfaithful in this language, it must be the case that /t͡p/ → [p], or that P6 has the value of A. P6.A is entailed by P3.A and P4.B.

(255) Proof: Faithful /k͡p/ (P3.A) and unfaithful /t͡p/ (P4.B) entails /t͡p/ → [p] (P6.A)

a. `LLeWWe` P3.A

b. `WeeLee` P4.B

c. `LLeLWe` P3.A∘P4.B

d. `eLeeWe` via L-retraction

e. `eLeeWe` P6.A

f. ∴ P3.A and P4.B entails P6.A. QED.

Similarly, P3.A by itself (`LLeWWe`) entails P2.A (`eLeWWe`) via L-retraction. The value for P5 is moot, as it only applies under the scope of P3.B. This accounts for the full range of properties for the BRS.

5.4.4.3 Choice between semihomorganic target of reduction

A significant property of the stringent system defined in de Lacy 2006 was that, among simple segments, the target of markedness reduction is always to the least marked place on the scale. This trait is called Total Reduction of Simple Segments (TR). This trait is found in BRS as well.

While faithfulness does not play a role in deciding the target of reduction for simple stops (when reduction involves displacement), it does for reduction of complex stops (when reduction involves shedding).

If a language has simple labials and dorsals, but not [k͡p], the grammar has a choice between the target of reduction of [k͡p]. It can either reduce to the more marked place [k], or to the lessor marked place [p]. This is Property 5 in the current analysis, and the choice in ranking is between m.K and id-io.K.

(256) Property 5 Value A: /k͡p/ → [k]
id-io.K ≫ m.K

(257) Property 5 Value B: /k͡p/ → [p]
m.K ≫ id-io.K

Note that this distinction in Property 5 is only relevant under the scope of Property 3 Value B, which determines the mapping of /k͡p/, assuming faithful /k/. If, for instance, labials are banned in the language generally (/p/ → [t]), then /k͡p/ can never map to [p]. This can be seen via ranking contradiction of the relevant property values.

It is precisely the existence of these properties which obviates the need for Abstract Primary Place as a mechanism for choosing the target of reduction for complex segments. The grammar (ranking) itself can choose the target, without overpredicting targets for simple stops. In Cahill 2000, individual faithfulness constraints MaxDor and MaxLab are used to determine the target of reduction for languages like Amele. However, the existence of these constraints will then increase the typology of possible simple-to-simple mappings.

If /p/ is unfaithful, then it must be the case that `eWeLLe` (Property 2 Value B). For /k͡p/ to be faithful, it must be the case that `LLeWWe` (Property 3 Value A). These two ERCs cannot be simultaneously satisfied: their fusion is `LLeLLe`. Another way to see this is that the ERC for P2.B entails P3.B via W-extension.

(258) Proof: Unfaithful /p/ (P2.B) entails unfaithful /k͡p/ (P4.B)

a. `eWeLLe` P2.B

b. `WWeLLe` via W-extension

c. `WWeLLe` P3.B

d. ∴ P2.B entails P3.B. QED.

Further, if /p/ is unfaithful (P2.B) but /k/ is faithful (P1.A), then it must be the case that /k͡p/ → [k] (P5.A).

(259) Proof: Unfaithful /p/ (P2.B) and faithful /k/ (P1.A) entails /k͡p/ → [k] (P5.A)

a. `eWeLLe` P2.B

b. `eLLWWW` P1.A

c. `eLLLLW` P2.B∘P1.A

d. `eeLeeW` via L-retraction

e. `eeLeeW` P5.A

f. ∴ P2.B and P1.A entails P5.A. QED.

Likewise, if /k/ is unfaithful (P1.B) but /p/ is faithful (P2.A), then it must be the case that /k͡p/ → [p] (P5.B)

(260) Proof: Unfaithful /k/ (P1.B) and faithful /p/ (P2.A) entails /k͡p/ → [p] (P5.B)

a. `eWWLLL` P1.B

b. `eLeWWe` P2.A

c. `eLWLLL` P1.B∘P2.A

d. `eeWeeL` via L-retraction

e. `eeWeeL` P5.B

f. ∴ P1.B and P2.A entails P5.B. QED.

What this means generally is that the BRS will never allow chain shifts, like the following.

(261) Hypothetical chain shift

/k͡p/ → [p]

/p/ → [t]

In terms of Tesar 2013, BRS is Output-Driven: if the input /k͡p/ maps to [p], then all inputs more similar to [p] than /k͡p/ (e.g. /p/) will also map to [p].

5.4.5 Interim summary

The Basic Reduction System captures three intended goals: total reduction among simple segments, partial reduction for complex segments, and gapped inventories for both complex and simple segments.

5.5 Extended Place Reduction System

The Extended Place Reduction System (ERS) includes reference to strong and weak prosodic positions. Candidates include segments in either position, and there is a set of positional markedness constraints referring specifically to these weak positions. The utilization of strong and weak positions captures asymmetries between certain prosodic positions, whether it be onset/coda asymmetries or word-initial/word-final ones.

5.5.1 GEN_{ERS} and CON_{ERS}

(262) ERS Candidate sets:

	Place	Position
ka	[dor]	Strong
pa	[lab]	Strong
ta	[cor]	Strong
k͡pa	[lab], [dor]	Strong
t͡pa	[lab], [cor]	Strong
ak	[dor]	Weak
ap	[lab]	Weak
at	[cor]	Weak
ak͡p	[lab], [dor]	Weak
at͡p	[lab], [cor]	Weak

The position of the dummy vowel [a] indicates whether the consonant is in a strong or a weak prosodic position, as indicated in (262). Each form in (262) is considered as an input; however, the candidate set for each input includes only those forms with the same prosodic configuration. In other words, [ka] is not a possible candidate for /ak/.

The entirety of CON_{BRS} is included in CON_{ERS}, as well as the following positional markedness constraints.

(263) *Markedness:*

a. **m.KPT/W**

● / ● ↓ C-pl ↓ [dor] ∧ W(●) +

● / ● ↓ C-pl ↓ [lab] ∧ W(●) +

● / ● ↓ C-pl ↓ [cor] ∧ W(●)

—

"Assign a violation for each root node in a weak prosodic position that has

dorsal C-place, and for each that has labial C-place, and for each that has coronal C-place."

b. **m.KP/W**

• / • ↓ C-pl ↓ [dor] ∧ W(•) +

• / • ↓ C-pl ↓ [lab] ∧ W(•)

—

"Assign a violation for each root node in a weak prosodic position that has dorsal C-place, and for each that has labial C-place."

c. **m.K/W**

• / • ↓ C-pl ↓ [dor] ∧ W(•)

—

"Assign a violation for each root node in a weak prosodic position that has dorsal C-place."

In the above definitions, W(•) is a predicate that evaluates to True when • is in a weak prosodic position, be it coda or word-final. For the purposes of this system, this difference is abstracted away from.

The factorial typology for the ERS includes 50 languages. The full list is shown in Table 5.13. The languages in (264) are exactly those that have fully faithful contrasts in strong position. When this is the case, the contrasts in weak position parallel those of BRS exactly, as shown in (264).

Table 5.13: Full ERS Typology

ERS	/ta/	/pa/	/ka/	/k͡pa/	/t͡pa/	/at/	/ap/	/ak/	/ak͡p/	/at͡p/
L1.	ta	pa	ka	ka	pa	at	ap	ak	ak	ap
L2.	ta	pa	ka	ka	pa	at	ap	ak	ak	at
L3.	ta	pa	ka	ka	pa	at	ap	ak	ap	ap
L4.	ta	pa	ka	ka	pa	at	ap	ak	ap	at
L5.	ta	pa	ka	ka	pa	at	at	ak	ak	at
L6.	ta	pa	ka	ka	pa	at	ap	at	ap	ap
L7.	ta	pa	ka	ka	pa	at	ap	at	ap	at
L8.	ta	pa	ka	ka	pa	at	at	at	at	at
L9.	ta	pa	ka	ka	ta	at	ap	ak	ak	at
L10.	ta	pa	ka	ka	ta	at	ap	ak	ap	at
L11.	ta	pa	ka	ka	ta	at	at	ak	ak	at
L12.	ta	pa	ka	ka	ta	at	ap	at	ap	at
L13.	ta	pa	ka	ka	ta	at	at	at	at	at
L14.	ta	pa	ka	pa	pa	at	ap	ak	ap	ap
L15.	ta	pa	ka	pa	pa	at	ap	ak	ap	at
L16.	ta	pa	ka	pa	pa	at	ap	at	ap	ap
L17.	ta	pa	ka	pa	pa	at	ap	at	ap	at
L18.	ta	pa	ka	pa	pa	at	at	at	at	at
L19.	ta	pa	ka	pa	ta	at	ap	ak	ap	at
L20.	ta	pa	ka	pa	ta	at	ap	at	ap	at
L21.	ta	pa	ka	pa	ta	at	at	at	at	at
L22.	ta	pa	ka	k͡pa	pa	at	ap	ak	ak	ap
L23.	ta	pa	ka	k͡pa	pa	at	ap	ak	ap	ap
L24.	ta	pa	ka	k͡pa	pa	at	ap	ak	ak͡p	ap
L25.	ta	pa	ka	k͡pa	pa	at	at	ak	ak	at
L26.	ta	pa	ka	k͡pa	pa	at	ap	at	ap	ap
L27.	ta	pa	ka	k͡pa	pa	at	at	at	at	at
L28.	ta	pa	ka	k͡pa	t͡pa	at	ap	ak	ak	ap
L29.	ta	pa	ka	k͡pa	t͡pa	at	ap	ak	ak	at
L30.	ta	pa	ka	k͡pa	t͡pa	at	ap	ak	ap	ap
L31.	ta	pa	ka	k͡pa	t͡pa	at	ap	ak	ap	at
L32.	ta	pa	ka	k͡pa	t͡pa	at	ap	ak	ak͡p	ap
L33.	ta	pa	ka	k͡pa	t͡pa	at	ap	ak	ak͡p	at͡p
L34.	ta	pa	ka	k͡pa	t͡pa	at	at	ak	ak	at
L35.	ta	pa	ka	k͡pa	t͡pa	at	ap	at	ap	ap
L36.	ta	pa	ka	k͡pa	t͡pa	at	ap	at	ap	at
L37.	ta	pa	ka	k͡pa	t͡pa	at	ap	at	ap	at͡p
L38.	ta	pa	ka	k͡pa	t͡pa	at	at	at	at	at
L39.	ta	ta	ka	ka	ta	at	at	ak	ak	at
L40.	ta	ta	ka	ka	ta	at	at	at	at	at
L41.	ta	pa	ta	pa	pa	at	ap	at	ap	ap
L42.	ta	pa	ta	pa	pa	at	ap	at	ap	at
L43.	ta	pa	ta	pa	pa	at	at	at	at	at
L44.	ta	pa	ta	pa	ta	at	ap	at	ap	at
L45.	ta	pa	ta	pa	ta	at	at	at	at	at
L46.	ta	pa	ta	pa	t͡pa	at	ap	at	ap	ap
L47.	ta	pa	ta	pa	t͡pa	at	ap	at	ap	at
L48.	ta	pa	ta	pa	t͡pa	at	ap	at	ap	at͡p
L49.	ta	pa	ta	pa	t͡pa	at	at	at	at	at
L50.	ta	ta	ta	ta	ta	at	at	at	at	at

(264) ERS Typology - filtered to faithful in strong position

	Faithful in Strong Position					*Full BRS Contrasts in Weak Position*					
ERS	/ka/	/pa/	/ta/	/k͡pa/	/t͡pa/	/ak/	/ap/	/at/	/ak͡p/	/at͡p/	BRS Equiv.
L28.	ka	pa	ta	k͡pa	t͡pa	ak	ap	at	ak	ap	L01
L29.	ka	pa	ta	k͡pa	t͡pa	ak	ap	at	ak	at	L02
L30.	ka	pa	ta	k͡pa	t͡pa	ak	ap	at	ap	ap	L03
L31.	ka	pa	ta	k͡pa	t͡pa	ak	ap	at	ap	at	L04
L32.	ka	pa	ta	k͡pa	t͡pa	ak	ap	at	ak͡p	ap	L05
L33.	ka	pa	ta	k͡pa	t͡pa	ak	ap	at	ak͡p	at͡p	L06
L34.	ka	pa	ta	k͡pa	t͡pa	ak	at	at	ak	at	L07
L35.	ka	pa	ta	k͡pa	t͡pa	at	ap	at	ap	ap	L08
L36.	ka	pa	ta	k͡pa	t͡pa	at	ap	at	ap	at	L09
L37.	ka	pa	ta	k͡pa	t͡pa	at	ap	at	ap	at͡p	L10
L38.	ka	pa	ta	k͡pa	t͡pa	at	at	at	at	at	L11

The following languages are those that contain faithful /ka/, /pa/, and /k͡pa/ but unfaithful /t͡pa/ in strong position.

(265) ERS Typology, filtered to /ka/, /pa/, /k͡pa/, ¬/t͡pa/

Lg.	/ak/	/ap/	/ak͡p/	/at͡p/	Comment
L22.	ak	ap	ak	ap	Ambiguous, likely attested
L23.	ak	ap	ap	ap	Amele-type
L24.	ak	ap	ak͡p	ap	South Efate-type
L25.	ak	at	ak	at	Tampulma-type
L26.	at	ap	ap	ap	Dagbani-type
L27.	at	at	at	at	Total Reduction

The choice to filter to /ka/, /pa/, /k͡pa/, ¬/t͡pa/ in strong position represents the fact that all languages surveyed have this basic inventory structure. For weak position, there are several possibilities. L22 and L23 both have full simple stop contrasts, but are without

labial-dorsals. In these two languages, labial-dorsals have a free choice of reducing to [k] or reducing to [p]. (Labial-coronals /t͡p/ must reduce to [p] under these conditions.) Amele is the one empirical example of L23: Amele preserves place contrasts in word-final position, but there is a clear morphosyntactic alternation showing that /k͡p/ → [p].

L24 is the South Efate-type language, as this is the only case of underived labial-dorsals appearing in coda/word-final position. (Additionally, Amele does have exactly one instance of a labial-dorsal appearing in a word-medial coda position, see (227).) Connell 1994 cites Jaba (Hyam, Niger Congo, Nigeria, [jab]) as one language with labial-dorsals in final position, but lists no examples. Vietnamese does contain labial-velars in coda position, but only as the result of agreement.

5.5.2 Amele-type languages

Amele-type languages are those with a full contrast between simple stops in weak position [k p t], and where /k͡p/ → [p]. Because both /k/ and /p/ are faithful, the choice of reduction for /k͡p/ is due to P5 as extended to weak position: either m.K or m.K/W must dominate id-io.K. Note that the empirical evidence that /k͡p/ maps to [p] is from a morphosyntactic alternation with a person-number morpheme as described in Section 5.3.1.

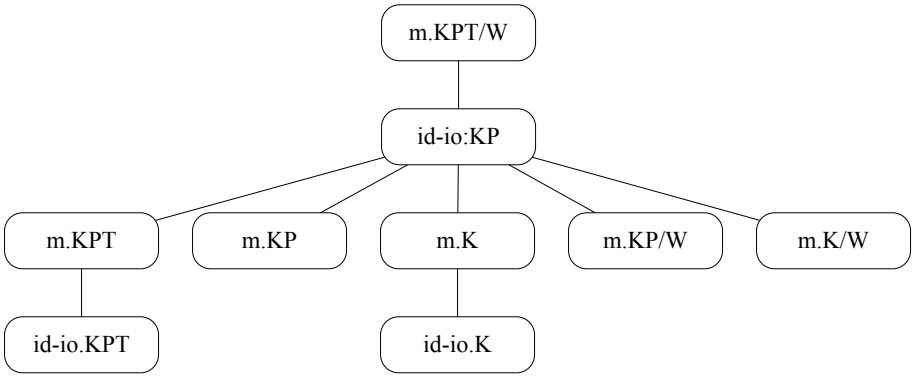
(266) **L23 Support (Amele-type Languages)**

	Input	Winner	Loser	m.KPT/W	id-io.KP	m.KPT	m.KP	m.K	m.KP/W	m.K/W	id-io.KPT	id-io.K
a.	/ak͡p/	ap	ak͡p	W	L	W	W	W	W	W	L	L
b.	/k͡pa/	k͡pa	ka		W	L	L				W	
c.	/ak/	ak	at		W		L	L	L	L	W	W
d.	/t͡pa/	pa	t͡pa			W					L	
e.	/ak͡p/	ap	ak					W		W		L

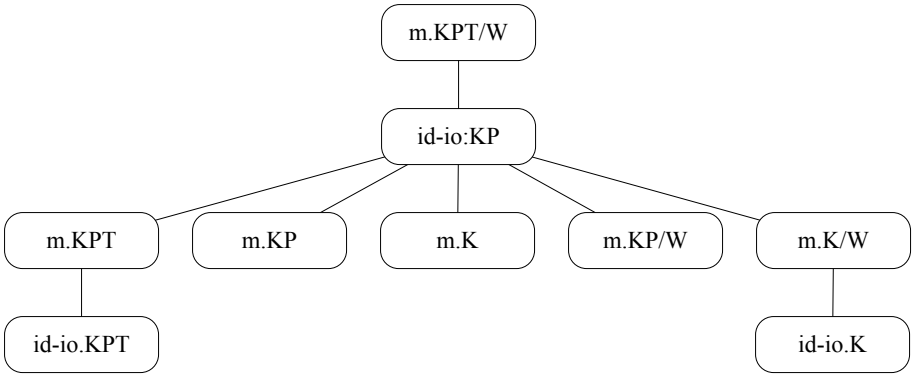
(267) **L23 MIB**

ERC	m.KPT/W	id-io.KP	m.KPT	m.KP	m.K	m.KP/W	m.K/W	id-io.KPT	id-io.K
a.	W	L	L	L	L	L	L	L	L
b.		W	L	L	L	L	L	L	L
c.			W					L	
d.					W		W		L

(268) **L23 Ranking**



or



Because both simple labials and dorsals contrast in weak position, there must be some grammatical mechanism to determine the target of reduction for /k͡p/. It is precisely the reflex of BRS P5.B in the ERS, shown in ERC 266e above. The fact that the grammatical system allows a choice of reduction target for /k͡p/ means this information does not need to be part of the representation itself, as it would in an abstract primary place approach. The

choice of either m.Kor m.K/W dominating id-io.K determins the labial target of reduction for /k͡p/, as is shown in ERC 267d.

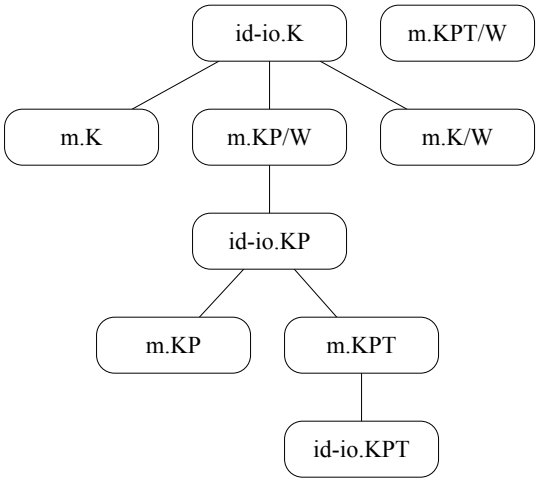
5.5.3 Tampulma-type languages

The next two sections describe languages whose choice of reduction target for /k͡p/ is forced due to independent conditions on the surface inventory. In Tampulma-type languages, all labials are banned from coda position. As a result, it must be the case that /k͡p/ → [k] (see also the proof in (259)).

(269) **L25 Support (Tampulma-type Languages)**

	Input	Winner	Loser	id-io.K	m.KPT/W	m.K	m.KP/W	m.K/W	id-io.KP	m.KPT	m.KP	id-io.KPT
a.	/ak/	ak	at	W		L	L	L	W		L	W
b.	/ap/	at	ap				W		L		W	L
c.	/k͡pa/	k͡pa	ka						W	L	L	W
d.	/t͡pa/	pa	t͡pa							W		L

(270) **L25 Ranking**



5.5.4 Dagbani-type languages

In Dagbani-type languages, all dorsals are banned from weak position. Here, labial-dorsal stops map to labial: /k͡p/ → [p]. However, the specific ranking interactions causing the mapping here differ from those in the Amele-type language, even though the target of reduction is the same.

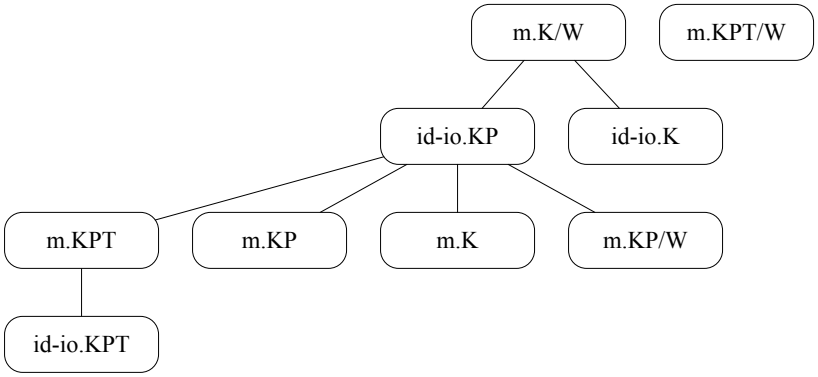
(271) **L26 Support (Dagbani-type Languages)**

Input	Winner	Loser	m.KPT/W	m.K/W	id-io.KP	id-io.K	m.KPT	m.KP	m.K	m.KP/W	id-io.KPT
a. /ak/	at	ak		W	L	L		W	W	W	L
b. /ka/	ka	ta			W	W		L	L		W
c. /k͡pa/	k͡pa	ka			W		L	L			W
d. /ap/	ap	at			W			L		L	W
e. /t͡pa/	pa	t͡pa					W				L

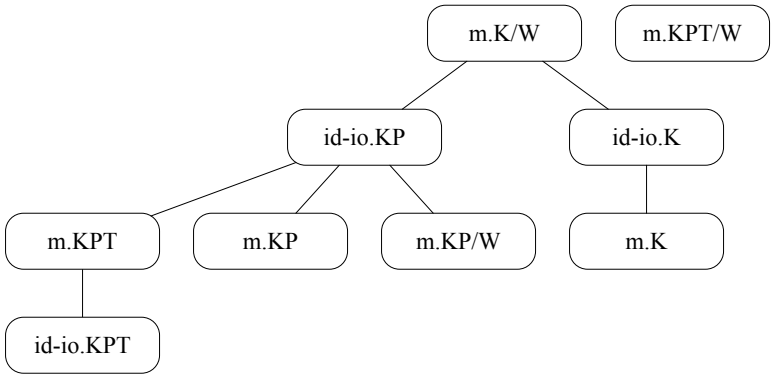
(272) **L26 MIB**

ERC	m.KPT/W	m.K/W	id-io.KP	id-io.K	m.KPT	m.KP	m.K	m.KP/W	id-io.KPT
a.		W	L	L	L	L	L	L	L
b.			W	W	L	L	L	L	L
c.			W		L	L		L	L
d.					W				L

(273) **L26 Ranking**



or



5.5.5 South Efate-type languages

In South Efate-type languages, all non-coronal faithfulness dominates all markedness. In addition, m.KPT dominates id-io.KPT; this ensures that the labial-coronal /t͡p/ is not realized in any position. The rest of the segments, however, are faithful in all positions.

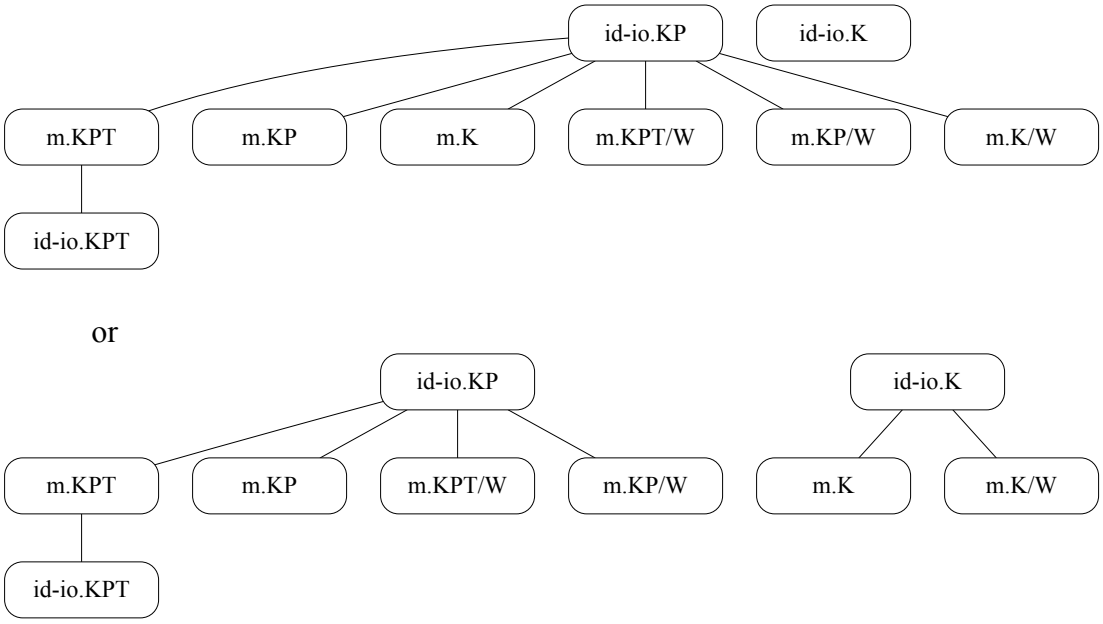
(274) **L24 Support (South Efate-type languages)**

Input	Winner	Loser	id-io.KP	id-io.K	m.KPT	m.KP	m.K	m.KPT/W	m.KP/W	m.K/W	id-io.KPT
a. /ak/	ak	at	W	W		L	L		L	L	W
b. /akp/	akp	ak	W		L	L		L	L		W
c. /tpa/	pa	tpa			W						L

(275) **L24 MIB**

ERC	id-io.KP	id-io.K	m.KPT	m.KP	m.K	m.KPT/W	m.KP/W	m.K/W	id-io.KPT
a.	W	W	L	L	L	L	L	L	L
b.	W		L	L		L	L		L
c.			W						L

(276) **L24 Ranking**



5.6 Interactions beyond C-place

5.6.1 Voicing markedness

As defined in Chapter 3, voicing markedness is tied to place of articulation with the constraint m.KPT/[+voice].

(277) VT for m.KPT and m.KPT/[+voice]

output	m.KPT	m.KPT/[+voice]
t	*	
p	*	
k	*	
t͡p	**	
k͡p	**	
d	*	*
b	*	*
g	*	*
d͡b	**	**
g͡b	**	**

Because this constraint effectively counts [+voice]/place feature pairs, there are two ways for a voiced complex segment to satisfy this constraint: it can devoice, or it can shed a place. This means that if a language preserves voicing contrasts for simple stops, it can neutralize voicing contrasts for complex segments independently. Instead of a voiced complex segment becoming voiceless (e.g. /g͡b/ → [k͡p]), it can satisfy m.KPT/[+voice] through shedding a place, and thus incurring one fewer violation: /g͡b/ → [b]. This is shown in detail in Danis 2014. A number of languages have voicing contrasts among simple stops, but have voiceless [k͡p] as the only complex segment. The surface inventories of these languages, [k p t b d g k͡p], is predicted with a system including m.KPT/[+voice].

5.6.2 Reduction as place demotion

In a number of languages, labial-dorsal stops [k͡p] are in free-variation with labialized dorsal stops [k^{w}]. In Mumuye, for example, “the labial-velar plosive /k͡p/ is optionally weakened to [k^{w}], a labialized velar plosive” (Shimizu 1983: 22). A similar process also occurs in Noni/Noone (Hyman p.c.). Assuming this is also a type of markedness reduction process,

how is the faithfulness of [k^{w}] evaluated with respect to both [$\widehat{kp}$] and semihomorganic simple stops [k] and [p]?

Using the cross-category identity schema, the same used for local agreement for Vietnamese in Chapter 4, we have a cross-category input/output faithfulness constraint id-io.KPT$_X$. While id-io.KPT$_C$ and id-io.KPT$_V$ both assign violations to /$\widehat{kp}$/ → [k^{w}], as there is a change in both C-place and V-place, the constraint id-io.KPT$_X$ assigns zero, as there is no change in place regardless of the position in geometry; both segments are still [labial] and [dorsal].

(278) Cross-category versus within-category faithfulness for /$\widehat{kp}$/

/$\widehat{kp}$/	id-io.KPT$_X$	id-io.KPT$_C$	id-io.KPT$_V$	Comment
a. k^{w}		*	*	[lab] demotion
b. $\widehat{kp}$				faithful
c. p^{y}		*	*	[dor] demotion
d. k	*	*		[lab] shedding
e. p	*	*		[dor] shedding
f. t	***	***		[cor] displacement

When this alternation occurs, it is triggered by a markedness constraint against multiple C-place in a form: m.KP$_C$ or m.KPT$_C$. A ranking for this process is given in the CT below.

(279) Cross-category faithfulness allows place demotion in /$\widehat{kp}$/

input	winner	loser	m.KPT$_C$	m.K$_V$	id-io.KPT$_X$	id-io.KPT$_C$	id-io.KPT$_V$	m.P$_V$	m.KP$_C$
a. /$\widehat{kp}$/	k^{w}	$\widehat{kp}$	W			L	L	L	W
b. /$\widehat{kp}$/	k^{w}	p^{y}		W				L	
c. /$\widehat{kp}$/	k^{w}	k			W		L	L	
d. /$\widehat{kp}$/	k^{w}	p			W		L	L	
e. /$\widehat{kp}$/	k^{w}	t			W	W	L	L	L

Without id-io.KPT$_X$, the candidate [k^w] is harmonically bounded; it is the only constraint that prefers the winner over the simple stops [p] and [k]. However, because such an alternation exists, it must be the case that there is cross-categorical faithfulness just as there is cross-categorical agreement.

Languages that contrast [k͡p] and [k^w] provide evidence that there still must be within-category faithfulness, as well. The basic argument is this: in the above tableau, the reason [k^w] is preferred to [k͡p] is due to markedness. However, if markedness allows both [k͡p] and [k^w] to surface, as it would in a language that contrasts those sounds, then there must be faithfulness constraints specific to each of those sounds as well. This is shown below.

(280) Within-category faithfulness preserve /k͡p/ and /k^w/ contrast

	Input	Winner	Loser	id-io.KPT$_C$	id-io.KPT$_V$	id-io.KPT$_X$	m.K$_V$	m.KPT$_C$	m.P$_V$
a.	k͡p	k͡p	k^w	W	W			L	W
b.	k^w	k^w	k͡p	W	W			W	L

Here, the only constraints that preserve the difference between /k͡p/ and /k^w/ are the within-category faithfulness constraints. The markedness constraints m.KPT$_C$ and m.P$_V$ do also differentiate these candidates, but they cannot allow both to surface at the same time; the markedness constraints are in direct conflict. Without the within-category faithfulness constraints, a language could not contrast between labial-dorsal [k͡p] and labialized dorsal [k^w]. Because such a contrast does exist, these constraints must exist.

5.7 Summary and conclusion

This chapter discusses three general interactions involving both segments with complex place and those with simple place: simple place always undergoes Total Reduction, complex place can undergo Partial Reduction, and inventories have gaps: intermediately-marked segments can be absent from an inventory. The scaled-via-summation constraints capture

the partial reduction of complex segments while preserving the fact that simple segments always totally reduce.

6 Conclusion

This dissertation has proposed a theory of Generalized Identity using Summation Theory to build sets of stringently-related constraints. This theory of place identity accounts for interactions that are long-distance, local, and along the input/output dimension. Place restrictions in Ngbaka require the use of a long-distance place identity constraint. Vietnamese shows that place identity must be satisfied by cross-categorical agreement, with the place of a vowel causing a change of place on a consonant. Place shedding processes show that place identity must count individual place disparities, and that the grammar must allow a complex segment to map to either one of its faithful semihomorganic places. Together these processes fill empirical gaps in the range of processes place was thought to participate in, while unifying the grammatical mechanisms necessary to account for them. Additionally, the structural representation of complex segments is simplified, in that neither place is abstract in a strictly phonological sense, while also providing further evidence for unified place theories where consonants and vowels share features.

6.1 Why complex place?

Empirically, this dissertation presents a number of processes that are not known to exist among simple segments. Why might this be? The type of place-on-place harmony present in Ngbaka can only be detected with the presence of complex place. There, segments must correspond based on some place feature, and must be identical for all place features; this is only a meaningful generalization when the two segments in correspondence contain mismatched place features beyond those that trigger correspondence. However, surface place identity can be active on other types of correspondence not based on place features. A potential example is given in Luganda, where nasals must agree in place (Katamba & Hyman 1991).

For partial reduction, there are also clear reasons why this is only attested among complex segments. Among the possible targets of reduction for a simple stop, all are equally unfaithful; the stringent markedness causes all but the least marked to be harmonically bounded. However, this is not the case for complex inputs: the semihomorganic targets are both less marked than the fully faithful candidate, but more faithful than the fully reduced candidates. Thus, there are rankings where this target is optimal, as shown in Chapter 5.

However, for cross-category consonant-to-vowel (XCCV) agreement, the reasons are less clear.[1] Why might cross-category agreement be attested only when the result is a complex consonant? In other words, why is XCCV agreement attested only via sprouting, but not via displacement? It cannot be the case that only languages that independently allow complex segments allow for XCCV agreement, as Vietnamese does not allow labial-dorsals outside of agreement contexts.

Perhaps we might want to work in a universal condition on GEN, removing the displacement agreement candidates such that place features cannot be removed from a segment in certain agreement contexts. However, this is an untenable position for several reasons. First, place features can be removed from consonants, as is clear from the shedding processes surveyed in Chapter 5. Second, consonants often lose place features in within-category consonantal (WCC) interactions, such as nasal place assimilation often causes such displacement (e.g. /np/ → [mp]). However, the most critical reason why we cannot make this a restriction on GEN is that GEN does not know nor care what types of processes a candidate will be a part of, if any. The displacement XCCV candidates must be a part of the system.

Because displacement occurs in WCC contexts, and XC agreement does occur in general, the position taken here is that this is a gap in the typology. The systems defined here do predict XCCV via displacement, and to change this outcome would change other desired outcomes elsewhere. There may be reasons beyond the factorial typology why this type of process is unattested; this is left for future research.

[1] Thanks to Jaye Padgett for discussion on this topic.

Even if there is no single or clear reason *why* these processes are limited to complex place (if this is really the case), it is clear that once they are observed, a refined theory of place identity must be developed; one that goes beyond strict class equality where place is either categorically faithful or unfaithful. This has been the goal of the present dissertation.

Appendix A

Full Place Identity Definitions

This appendix lists the full definitions for all basic (non-parasitic) place faithfulness as a result of the Scaled Constraint Building Algorithm.

A.1 Input/Output Identity

A.1.1 Within-category C

(281) id-io.KPT$_C$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [cor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [cor]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place, and for each with a disparity in coronal C-place."

(282) id-io.KP$_C$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [lab]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place."

(283) id-io.K$_C$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{io} \bullet_2$) ∧ (($\bullet_1$ ↓ C-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ C-pl ↓ [dor]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal C-place."

A.1.2 Within-category V

(284) id-io.KPT$_V$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [cor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [cor]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place, and for each with a disparity in coronal V-place."

(285) id-io.KP$_V$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [lab]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place."

(286) id-io.K$_V$

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor]))

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal V-place."

A.1.3 Cross-category

(287) id-io.KPT_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [dor]) \oplus (\bullet_2 \downarrow [dor]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [lab]) \oplus (\bullet_2 \downarrow [lab]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [cor]) \oplus (\bullet_2 \downarrow [cor]))$

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal place, and for each with a disparity in labial place, and for each with a disparity in coronal place."

(288) id-io.KP_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [dor]) \oplus (\bullet_2 \downarrow [dor]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [lab]) \oplus (\bullet_2 \downarrow [lab]))$

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal place, and for each with a disparity in labial place."

(289) id-io.K_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{io} \bullet_2) \wedge ((\bullet_1 \downarrow [dor]) \oplus (\bullet_2 \downarrow [dor]))$

—

"Assign a violation for each pair of segments in IO correspondence that have a disparity in dorsal place."

A.2 Local Agreement

A.2.1 Within-category C

(290) id-agr.KPT_C

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow \text{C-pl} \downarrow [dor]) \oplus (\bullet_2 \downarrow \text{C-pl} \downarrow [dor]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ C-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ C-pl $\downarrow$ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ C-pl $\downarrow$ [cor]) $\oplus$ $(\bullet_2 \downarrow$ C-pl $\downarrow$ [cor]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal C-place, and for each with a disparity in labial C-place, and for each with a disparity in coronal C-place."

(291) id-agr.KP_C

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ C-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ C-pl $\downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ C-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ C-pl $\downarrow$ [lab]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal C-place, and for each with a disparity in labial C-place."

(292) id-agr.K_C

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ C-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ C-pl $\downarrow$ [dor]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal C-place."

A.2.2 Within-category V

(293) id-agr.KPT_V

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [cor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [cor]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal V-place, and for each with a disparity in labial V-place, and for each with a disparity in coronal V-place."

(294) id-agr.KP_V

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [lab]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal V-place, and for each with a disparity in labial V-place."

(295) id-agr.K_V

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ V-pl $\downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ V-pl $\downarrow$ [dor]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal V-place."

A.2.3 Cross-category

(296) id-agr.KPT_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ [cor]) $\oplus$ $(\bullet_2 \downarrow$ [cor]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal place, and for each with a disparity in labial place, and for each with a disparity in coronal place."

(297) id-agr.KP_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ [dor]) $\oplus$ $(\bullet_2 \downarrow$ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow$ [lab]) $\oplus$ $(\bullet_2 \downarrow$ [lab]))

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal place, and for each with a disparity in labial place."

(298) id-agr.K_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{adj} \bullet_2) \wedge ((\bullet_1 \downarrow [dor]) \oplus (\bullet_2 \downarrow [dor]))$

—

"Assign a violation for each pair of adjacent segments that have a disparity in dorsal place."

A.3 Surface Correspondence Identity

A.3.1 Within-category C

(299) id-cc.KPT_C

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow C\text{-pl} \downarrow [dor]) \oplus (\bullet_2 \downarrow C\text{-pl} \downarrow [dor]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow C\text{-pl} \downarrow [lab]) \oplus (\bullet_2 \downarrow C\text{-pl} \downarrow [lab]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow C\text{-pl} \downarrow [cor]) \oplus (\bullet_2 \downarrow C\text{-pl} \downarrow [cor]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place, and for each with a disparity in coronal C-place."

(300) id-cc.KP_C

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow C\text{-pl} \downarrow [dor]) \oplus (\bullet_2 \downarrow C\text{-pl} \downarrow [dor]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow C\text{-pl} \downarrow [lab]) \oplus (\bullet_2 \downarrow C\text{-pl} \downarrow [lab]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal C-place, and for each with a disparity in labial C-place."

(301) id-cc.K_C

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow C\text{-pl} \downarrow [dor]) \oplus (\bullet_2 \downarrow C\text{-pl} \downarrow [dor]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal C-place."

A.3.2 Within-category V

(302) id-cc.KPT$_V$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{cc} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{cc} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [lab])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{cc} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [cor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [cor]))

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place, and for each with a disparity in coronal V-place."

(303) id-cc.KP$_V$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{cc} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{cc} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [lab]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [lab]))

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal V-place, and for each with a disparity in labial V-place."

(304) id-cc.K$_V$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{cc} \bullet_2$) ∧ (($\bullet_1$ ↓ V-pl ↓ [dor]) ⊕ ($\bullet_2$ ↓ V-pl ↓ [dor]))

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal V-place."

A.3.3 Cross-category

(305) id-cc.KPT$_X$

$\langle \bullet_1, \bullet_2 \rangle$ / ($\bullet_1 \mathfrak{R}_{cc} \bullet_2$) ∧ (($\bullet_1$ ↓ [dor]) ⊕ ($\bullet_2$ ↓ [dor])) +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [lab]) \oplus (\bullet_2 \downarrow [lab]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [cor]) \oplus (\bullet_2 \downarrow [cor]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal place, and for each with a disparity in labial place, and for each with a disparity in coronal place."

(306) id-cc.KP_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [dor]) \oplus (\bullet_2 \downarrow [dor]))$ +

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [lab]) \oplus (\bullet_2 \downarrow [lab]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal place, and for each with a disparity in labial place."

(307) id-cc.K_X

$\langle \bullet_1, \bullet_2 \rangle$ / $(\bullet_1 \mathfrak{R}_{cc} \bullet_2) \wedge ((\bullet_1 \downarrow [dor]) \oplus (\bullet_2 \downarrow [dor]))$

—

"Assign a violation for each pair of segments in CC correspondence that have a disparity in dorsal place."

Appendix B

Vietnamese Word List

Table B.1: Summary of wordlist totals for vowel consonant co-occurrences

	Front	Central	Back
Coronal	6	13	6
Labial	6	10	6
Fronted Dorsal	14	0	0
Dorsal	0	12	0
Labial-dorsal	0	0	11

NB: This is **not** a random sample of forms, but rather a collection of forms that were originally meant to show this exact distribution. The totals above are simply for reference.

(308) Front Vowel + Coronal Consonant

a.	tin	‘news’	(Kirby 2011: 384)
b.	mit	‘jackfruit’	(Kirby 2011: 384)
c.	len	‘go up’	(Kirby 2011: 385)
d.	met	‘tired’	(Kirby 2011: 385)
e.	xɛn	‘to praise’	(Kirby 2011: 385)
f.	mɛt	‘meter’	(Kirby 2011: 385)

(309) Front Vowel + Fronted Dorsal Consonant

a.	dic	‘target’	(Phạm 2006: 111)
b.	leɲ	‘order’	(Phạm 2006: 111)
c.	ʔiʲk	‘be useful’	(Phạm 2006: 115)
d.	diʲk	‘target’	(Phạm 2006: 115)
e.	liʲŋ	‘soldier’	(Phạm 2006: 115)
f.	ʔeʲk	‘frog’	(Phạm 2006: 115)
g.	beʲŋ	‘disease’	(Phạm 2006: 115)
h.	xaʲk	‘guest’	(Phạm 2006: 115)
i.	keŋ̣	‘channel’	(Kirby 2011: 385)
j.	seḳ	‘slanting’	(Kirby 2011: 385)
k.	sɛŋ̣	‘green’	(Kirby 2011: 385)
l.	sɛḳ	‘book’	(Kirby 2011: 385)
m.	siŋ̣	‘pretty’	(Kirby 2011: 384)
n.	tʰiḳ	‘to like’	(Kirby 2011: 384)

(310) Front Vowel + Labial Consonant

a.	tim	‘heart’	(Kirby 2011: 384)
b.	zip	‘occasion’	(Kirby 2011: 384)
c.	ɗem	‘night’	(Kirby 2011: 385)
d.	sep	‘to sort’	(Kirby 2011: 385)
e.	tɛm	‘stamp’	(Kirby 2011: 385)
f.	zɛp	‘sandals’	(Kirby 2011: 385)

(311) Central Vowel + Coronal Consonant

a.	dɨt	‘be broken’	(Phạm 2006: 111)
b.	dɨt	‘be broken, cut’	(Phạm 2006: 115)
c.	dət	‘land, soil’	(Phạm 2006: 115)
d.	mat	‘eye’	(Phạm 2006: 115)
e.	lan	‘orchid’	(Kirby 2011: 385)
f.	ɓat	‘bowl’	(Kirby 2011: 385)
g.	lɤn	‘big’	(Kirby 2011: 385)
h.	ɓɤt	‘to reduce’	(Kirby 2011: 385)
i.	lɤ̆n	‘time, turn’	(Kirby 2011: 385)
j.	ɓɤ̆t	‘no, none’	(Kirby 2011: 385)
k.	lăn	‘to roll’	(Kirby 2011: 385)
l.	ɓăt	‘to catch’	(Kirby 2011: 385)
m.	mɯt	‘jam’	(Kirby 2011: 384)

(312) Central Vowel + Dorsal Consonant

a.	xac	‘guest’	(Phạm 2006: 111)
b.	xak	‘to engrave’	(Phạm 2006: 111)
c.	dɨk	‘virtue’	(Phạm 2006: 115)
d.	xak	‘to engrave’	(Phạm 2006: 115)
e.	saŋ	‘to cross’	(Kirby 2011: 385)
f.	sak	‘corpse’	(Kirby 2011: 385)
g.	tɤ̆ŋ	‘floor, storey’	(Kirby 2011: 385)
h.	ɲɤ̆k	‘take up, lift’	(Kirby 2011: 385)
i.	săŋ	‘petrol’	(Kirby 2011: 385)
j.	săk	‘sharp’	(Kirby 2011: 385)
k.	sɯŋ	‘to swell’	(Kirby 2011: 384)
l.	sɯk	‘energy’	(Kirby 2011: 384)

(313) Central Vowel + Labial Consonant

a.	kəm	‘mute’	(Phạm 2006: 115)
b.	t^{h}ap	‘to light’	(Phạm 2006: 115)
c.	tam	‘eight’	(Kirby 2011: 385)
d.	sap	‘wax’	(Kirby 2011: 385)
e.	t^{h}ɤm	‘fragrant’	(Kirby 2011: 385)
f.	lɤm	‘class’	(Kirby 2011: 385)
g.	tɤ̆m	‘center’	(Kirby 2011: 385)
h.	lɤ̆p	‘to fill in’	(Kirby 2011: 385)
i.	tăm	‘to bathe’	(Kirby 2011: 385)
j.	săp	‘soon’	(Kirby 2011: 385)

(314) Back Vowel + Coronal Consonant

a.	ɓut	‘pen’	(Kirby 2011: 384)
b.	lun	‘short’	(Kirby 2011: 384)
c.	non	‘to vomit’	(Kirby 2011: 385)
d.	ɓot	‘powder’	(Kirby 2011: 385)
e.	lɔn	‘can’	(Kirby 2011: 385)
f.	ɓɔt	‘foam’	(Kirby 2011: 385)

(315) Back Vowel + Labial Consonant

a.	tum	‘(placename)’	(Kirby 2011: 384)
b.	zup	‘to help’	(Kirby 2011: 384)
c.	tom	‘shrimp’	(Kirby 2011: 385)
d.	hop	‘box’	(Kirby 2011: 385)
e.	tɔm	‘(onmptc.)’	(Kirby 2011: 385)
f.	hɔp	‘to meet’	(Kirby 2011: 385)

(316) Back Vowel + Labial-Dorsal Consonant

a.	ʔu͡kp	‘Australia’	(Phạm 2006: 115)
b.	du͡ŋm	‘to be correct’	(Phạm 2006: 115)
c.	co͡ŋm	‘husband’	(Phạm 2006: 115)
d.	ɔ͡ŋm	‘bee’	(Phạm 2006: 115)
e.	xɔ͡kp	‘to cry’	(Phạm 2006: 115)
f.	so͡ŋm	‘river’	(Kirby 2011: 385)
g.	so͡kp	‘shock’	(Kirby 2011: 385)
h.	sɔ͡ŋm	‘to finish’	(Kirby 2011: 385)
i.	sɔ͡kp	‘squirrel’	(Kirby 2011: 385)
j.	su͡ŋm	‘gun’	(Kirby 2011: 384)
k.	su͡kp	‘to scoop’	(Kirby 2011: 384)

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