

Long-distance major place harmony*

Nick Danis

Washington University in St. Louis

nsdanis@wustl.edu

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Abstract

In previous surveys of long-distance consonant harmony, the major place features [labial], [dorsal], and [coronal] are conspicuously absent from the set of possible harmonizing features (Hansson 2010; Rose and Walker 2004; Bennett 2015). Ngbaka (Atlantic-Congo, Democratic Republic of the Congo, [nga]) contains major place harmony between labial-velar segments and simple labials and velars, thus filling this empirical gap. The presence of complex segments, those with multiple place, is crucial to seeing this harmony pattern clearly. These patterns are best handled in the Agreement by Correspondence framework with an active CC-IDENT.PLACE constraint. Other analyses either cannot capture the pattern at all or require fundamental changes elsewhere in phonological theory. The data are supported by a new digitization and statistical analysis of a Ngbaka dictionary (Maes 1959).

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1 Introduction

In all previous surveys of long-distance agreement processes, the feature for which segments agree has never been found to crucially be any of the major place features [labial], [coronal], or [dorsal]. In terms of Agreement by Correspondence (ABC, Rose and Walker 2004; Hansson 2010; Bennett 2015 a.o.), where segments that are similar for some feature(s) [F] correspond, and agree for some other feature(s) [G], it is the feature [G] that is never a major place feature. This work presents such a case.

Ngbaka ([nga], 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 a distinct pattern from cases previously modeled via spreading of a major place feature, which are more properly cases of *minor* place harmony, or harmony for features *dependent* on some major place feature (such as anteriority harmony among coronals, or velar/uvular harmony among dorsals, see e.g. Shaw 1991; Clements and Hume 1995; Hansson 2010).

The major place harmony patterns interact with a voicing agreement pattern where homorganic voiced and voiceless stops cannot co-occur. These generalizations all naturally fit the schema of ABC, and are supported by a new statistical analysis of Ngbaka data. While there are no active, morphological alternations in the data, robust static restrictions like the ones analyzed here crucially inform phonological theory in general (see e.g. Pierrehumbert 1993, McCarthy 1994, Frisch 2011, and references therein), and the Ngbaka pattern thus fills gaps in Hansson (2010), Rose and Walker (2004), and Bennett (2015) with respect to place harmony.

Additionally, while major place harmony is a natural prediction of ABC, the nature of place features makes other approaches, such as spreading or co-occurrence constraints, especially problematic. Using co-occurrence constraints (e.g. Sagey 1986; Suzuki 1998; Alderete 1997; Stanton 2017) is untenable without changes to either the assumed logical power of constraints or the representation of place features; assuming place features are privative, markedness constraints as usually defined cannot distinguish between simple and complex place as needed. Long-distance transvocalic spreading, such as in Clements and Hume (1995), requires treating consonant harmony parallel to vowel harmony, which is empirically problematic (e.g. Casali 1995). Even though this is a static distribution in

the language, cross-linguistic and statistical evidence is given that this should be treated as assimilation, not dissimilation. For these reasons, capturing the patterns in Ngbaka requires an active CC-IDENT.PLACE constraint in the ABC framework to mediate long-distance agreement of major place.

2 Language background

The language investigated in this work is Ngbaka (or Ngbaka Minagende, Democratic Republic of the Congo, [nga]), which is in the Gbaya-Manza-Ngbaka subfamily of Atlantic Congo (Simons and Fennig 2018). Dictionary data is from Maes (1959), and all cited page numbers refer to this work. The language described in Thomas (1963), and subsequently analyzed by Sagey (1986), Mester (1986), and Rose and Walker (2004) (a.o.), is Ngbaka Ma’bo (Central African Republic, [nbm]), a distinct language 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.¹ Ngbaka Minagende is spoken by roughly one million speakers, while Ngbaka Ma’bo is spoken by roughly 88,000 (Simons and Fennig 2018). The remainder of this article discusses Ngbaka [nga] of the Gbaya-Manza-Ngbaka subfamily, and will refer to this language simply as Ngbaka. Wherever relevant, Ngbaka Ma’bo [nbm] will refer to the language of Thomas (1963) and Sagey (1986).

The Ngbaka consonant inventory as described in the introduction to Maes (1959) is given in Table 1.

Table 1: Ngbaka consonant inventory based on Maes (1959)

| | Labial | Coronal | Palatal | Velar | Glottal | Labial-Velar |
|------------|-------------------|-------------------|---------|-------------------|---------|-----------------|
| Plosives | b p ^{mb} | t d nd | | k g ^{ng} | | |
| Implosives | ɓ | ɗ | | | | kp̄ gb̄ ŋm̄ gb̄ |
| Fricatives | f v | s z ^{nz} | | | h | |
| Nasals | m | n | ɲ | ŋ | | ŋm̄ |
| Liquids | | l r | | | | |

Maes groups the labial-velar stops with the other implosives, though it is not clear if this is based on the phonetic realization or phonological patterning. I follow this for the table above, but the phonological representation of airstream features on the labial-velars is not crucial for the present analysis. Maes (1959) also lists “vw” and “nw” as segments, but

these were not present in the wordlist used for this analysis.

3 Co-occurrence restrictions in Ngbaka

Primary evidence for the Ngbaka patterns comes from a statistical analysis of the Ngbaka dictionary. The data provide evidence for a static pattern, but not necessarily a *process* in the sense of active morphophonological alternations. However, even as a static restriction or morpheme structure constraint, any analysis must account for why roots cannot have disharmonic patterns on the surface. In terms of Optimality Theory (OT, Prince and Smolensky 1993), this is due to the necessity of illicit inputs being realized as grammatical outputs, stemming from Richness of the Base, as is assumed here. The same conflation of static restrictions and active processes follows other surveys, as well (Hansson (2010: 153), Rose and Walker (2004: 477), Bennett (2015: 326), see also Kenstowicz and Kisseberth (1977: 136)). In the analysis to follow, the restriction may be discussed as a *process* in terms of abstract inputs and outputs, while the data as a whole gives evidence for a harmony *pattern*. Further, the term *harmony* is agnostic towards an assimilatory or dissimilatory analysis; both are possible, and both require an active CC-IDENT.PLACE constraint, though indirect evidence is given towards assimilation in Section 4.2.1.

The dictionary analyzed, Maes (1959), 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 12), 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.² The Ngbaka consonants and vowels were checked for accuracy, but there still may be discrepancies in the tone and nasality diacritics, and in the raw text for the definitions (though all forms presented here are correct).

From the entire dictionary data, all bi-consonantal (CVCV) words were extracted ($n = 880$). In addition to this being the minimum number of consonants necessary to see a *co-occurrence* restriction (in that a form with a single consonant doesn't shed light on any consonant co-occurrence restrictions), it also rules out most larger polymorphemic forms. The original generalizations for Ngbaka Ma'bo hold within roots only (Thomas 1963), and this is assumed for Ngbaka as well. However, there may be longer bona fide roots that are excluded in this filtering procedure.

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.³ The analysis here uses O/E values to find *categorical* restrictions only. The baseline for a categorical restriction is determined by both the O/E value in conjunction with its statistical significance, as indicated in (1).

The significance of these values are calculated with Fisher’s exact test via a series of 2×2 contingency tables, described in detail in the appendix. The p-value that results from a 2×2 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, one test for each semihomorganic pair as well as for each homorganic pair).⁴ For present purposes, the following apply:

- (1) Interpretation of results:
 - a. p is not significant: no grammatical restriction
 - b. $O/E < 1$ and p is significant: grammatical restriction
 - c. $O/E > 1$ and p is significant: form is the output of a phonological process

The relevant segments, all oral and nasal stops, are sorted based on the following place definitions. All stops and nasals are included for a particular place. This includes implosives and prenasals, as indicated below.

(2) Place Definitions

- cor = {n, ⁿd, d, t, d’}
- dor = {ŋ, ^ŋg, g, k}
- lab = {m, ^mb, b, p, b’}
- lab-dor = {^ŋm, ^ŋm^gb, ^gb, k^p}

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 2, Expected values in Table 3, and their ratios in Table 4. The row and column labeled Total contain the marginal totals for items in that position; for example, there are 160 coronal consonants in C1 position, as indicated by the rightmost column.

Table 2: Observed values for all Ngbaka oral and nasal stops by place

| | cor | dor | lab | lab-dor | other | Total 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 |
| Total C2 | 156 | 171 | 93 | 37 | 423 | 880 |

Table 3: Expected values for all Ngbaka oral and nasal stops by place

| | cor | dor | lab | lab-dor | other | Total 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 |
| Total C2 | 156 | 171 | 93 | 37 | 423 | 880 |

Table 4: O/E ratios for all Ngbaka oral and nasal stops by place

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

* $p < 0.00625$. Italic cells are untested for significance.

In Table 4, the bolded cells are those tested for significance, and the italic cells are untested. The combinations between a labial and a labial-dorsal, in either order, are significantly underrepresented, as are combinations of a dorsal followed by a labial-dorsal. Forms with two labial-dorsals are significantly *over*-represented.

The restrictions active in Ngbaka are schematized and discussed below. In discussing the patterns with respect to place, the usual terms *homorganic* and *heterorganic* become

insufficient. The crucial pairs here, those involving a complex stop (e.g. $[\widehat{KP}]$) and a simple stop of one of those two places (e.g. $[K]$ or $[P]$), contain both shared and unshared place features. These pairs are referred to as *semihomorganic*, as defined below, for this reason.

- (3) a. **Homorganic**: segments have identical place features
 $P...P, K...K, \widehat{KP}... \widehat{KP}$, etc.
- b. **Semihomorganic**: one segment has a subset of place features of the other
 $\widehat{KP}...P, \widehat{KP}...K$, etc.
- c. **Heterorganic**: segments have no shared place features
 $P...T, K...P, \widehat{KP}...T$, etc.

The first and most robust evidence for place harmony, Place Agreement on Labials (PAL), is the absence of semihomorganic labial pairs.

(4) **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. $*P... \widehat{KP}$
- b. $*\widehat{KP}...P$
- c. $\checkmark P...P$
- d. $\checkmark \widehat{KP}... \widehat{KP}$

The generalizations for PAL are based on the behavior of labials and labial-dorsals, as given in Tables 2–4. The relevant information is repeated and reorganized into Table 5.

Table 5: Evidence for Place Agreement on Labials

| Combination | O | E | O/E | Significance | Result |
|--------------------------------|----|-------|------|---------------|------------------|
| $P...P$ | 12 | 16.06 | 0.75 | $p = 0.31$ | As expected |
| $\widehat{KP}... \widehat{KP}$ | 11 | 3.62 | 3.04 | $p < 0.00625$ | Overrepresented |
| $P... \widehat{KP}$ | 0 | 6.39 | 0.00 | $p < 0.00625$ | Underrepresented |
| $\widehat{KP}...P$ | 2 | 9.09 | 0.22 | $p < 0.00625$ | Underrepresented |

The restriction applies regardless of the voicing or (pre)nasality of the segments in question:

- (5) a. *bakpa
 b. *gbama
 c. *paŋma
 d. ...

While labial consonants in a root must agree for other place features and for [voice], this is not an instance of *total* identity (MacEachern 1999, Gallagher and Coon 2009, Hansson 2010: 132, Bennett 2015: 198). In cases of total identity, two segments specified for some feature [F] can co-occur *only if they are identical for all other features*. One way to frame PAL as a potential case of total harmony is to say that labials can co-occur only if they are identical. However, this is not the case, as simple labials can differ in implosiveness, nasality, and prenasality, as the data below show.

- | | | | | | |
|-----|----|-----------------------|------|---|----------|
| (6) | a. | ɓama | (v.) | to tighten, pinch | (p. 46) |
| | b. | bà ^m bú | (n.) | wide waistline after birth | (p. 46) |
| | c. | ɓomɔ | (v.) | to tighten, pinch | (p. 53) |
| | d. | ^m báɓó | (n.) | pit for taking animals | (p. 122) |
| | e. | ^m bóbì | (n.) | rattan for tying | (p. 125) |
| | f. | pu ^m bu | (v.) | to be empty or hollow | (p. 155) |
| | g. | gbà ^{ŋm} gbà | (n.) | fall for animals, trap or litter | (p. 79) |
| | h. | gbò ^{ŋm} gbò | (n.) | laugh | (p. 81) |
| | i. | kpò ^{ŋm} gbò | (n.) | type of stool | (p. 111) |
| | j. | ^{ŋm} gbámù | (n.) | black antelope with black dorsal stripe | (p. 142) |
| | k. | gbò ^m bè | (n.) | marabou | (p. 81) |

Examples (6a–f) show non-identical simple labial pairs, while examples (6g–i) show non-identical labial-dorsal pairs. It should be noted, however, that forms (6k) and (6j) are counter-examples to PAL, though their presence is not significant. Because non-identical labials can co-occur, place agreement in Ngbaka cannot be classified under the label of total identity on empirical grounds, and therefore cannot be modeled by approaches designed to restrict consonant harmony in this way (e.g. Gallagher and Coon 2009).

Parallel to PAL, there is place agreement among certain semihomorganic dorsal pairs as well. This is the only long-distance pattern in Ngbaka found to be directional.

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

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

- a. *K... $\widehat{K\text{P}}$
- b. $\sqrt{\widehat{K\text{P}}}$...K
- c. ($\sqrt{}$)K...K
- d. $\sqrt{\widehat{K\text{P}}}$... $\widehat{K\text{P}}$

Table 6: Evidence for Place Agreement on Dorsals

| Combination | O | E | O/E | Significance | Result |
|--|----|-------|------|---------------|-------------------|
| K...K | 26 | 39.25 | 0.66 | $p = 0.00630$ | Underrepresented? |
| $\widehat{K\text{P}}...$ $\widehat{K\text{P}}$ | 11 | 3.62 | 3.04 | $p < 0.00625$ | Overrepresented |
| K... $\widehat{K\text{P}}$ | 1 | 8.49 | 0.12 | $p < 0.00625$ | Underrepresented |
| $\widehat{K\text{P}}...$ K | 13 | 16.71 | 0.78 | $p = 0.32$ | As expected |

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 (8a–b) show. The full list of attested $\widehat{K\text{P}}...$ K forms is given in the appendix.

- (8) a. $\widehat{g\text{b}aka}$ (v.) ‘help, rescue’ (p. 77)
- b. $\widehat{g\text{b}ák\acute{o}-}$ (n.) ‘tree branch’ (p. 77)

Additionally, although 26 observed K...K roots are attested in the dictionary, this is likely significantly underrepresented, as shown in Table 6 ($O = 26, E = 39.25, p = 0.00630$). The p value of 0.00630 for dorsal pairs is just above significance. The alpha of 0.00625 is the result of the Bonferroni correction, which is known to be conservative (see e.g. Sharpe 2015). However, while categorical bans were assumed on the other significantly underrepresented pairs, the homorganic dorsal pairs appear much more often, even if underrepresented. The grammaticality of these combinations is assumed for the present analysis for two general reasons: the constraints as defined cannot capture a ban on K...K pairs, and the absolute number of these forms attested might suggest that a gradient well-formedness account might be better suited (e.g. Coetzee and Pater 2008; Hayes and Wilson 2008; Frisch et al. 2004). Further, the low occurrence of dorsal pairs within a word relate more generally to the phenomenon of Similar Place Avoidance as discussed in

Pozdniakov and Segerer (2007), where languages in general (and especially Proto-Gbaya, the family of Ngbaka) disprefer homorganic segments within a word. Yet, the question still remains why this would only apply to simple dorsal pairs for Ngbaka, and not any others.⁵

Finally, all purely homorganic stops pairs must agree in voicing. The pattern here is parallel to that analyzed by Walker (2001) for Ngbaka Ma’bo.

(9) **Voicing Agreement (VA):**

Homorganic⁶ segments must agree in voicing.

- a. *T...D
- b. *D...T
- c. ✓T...T
- d. ✓D...D

This is supported by the fact that homorganic forms that disagree in voicing are unattested in the dictionary, which is significant. This, as well as other potential co-occurrence restrictions, is shown in Table 7.

Table 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 | $p < 0.01$ | 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 |

Voicing Agreement is the only non-place pattern tested that was found to be significant. (One form found in the dictionary is alternatively pronounced [g...k]: [gòkò]/[gògò] ‘tooth’ (p. 85). If this disharmonic form is included in the totals (so $O = 1$), Voicing Agreement is still significant at $p < 0.05$.) It’s worth noting that there was found to be no co-occurrence restriction between nasals and prenasalized stops (N...^ND, ^ND...N), yet this is the harmony pattern that is analyzed extensively for Ngbaka Ma’bo in Mester (1986), Sagey (1986), van de Weijer (1994), and Rose and Walker (2004), a.o. Despite the fact that these are indeed different languages, as discussed in Section 2, only 2.32 forms of this type are expected, and only one was found. So, while only a single form is attested in the dictionary, and the O/E ratio is less than 1, the difference was not statistically

significant. An analysis of a larger dictionary might yield a more robust finding to indicate a ban on these sequences; I take the current result to show no evidence either way.

4 Analysis

The analysis here models Place Agreement on Labials (PAL), Place Agreement on Dorsals (PAD), and Voicing Agreement (VA) in the ABC framework (Hansson 2010; Rose and Walker 2004; Bennett 2015). Utilized here are the CORR and IDENT constraints common in ABC, with their usual behavior and effects (with refinements noted). The definitions of the place-specific constraints are given in detail due to the fact that place features are privative and behave as a class (following Sagey 1986 a.o.). Segments are specified for the feature $[\pm\text{voice}]$ as well as for major place features, in the following combinations (for simplicity, labial-dorsals are the only complex segments considered).⁷

(10) Segmental representations

| | place | [voice] |
|---|--------------|---------|
| t / d | [cor] | - / + |
| p / b | [lab] | - / + |
| k / g | [dor] | - / + |
| $\widehat{\text{kp}} / \widehat{\text{gb}}$ | [lab], [dor] | - / + |

There is no phonological, structural distinction between the two place features of the labial-dorsal segment. This follows from the fact that doubly-articulated stops in general have two places of equal phonetic stricture (see Ladefoged 1968; Connell 1994; Ladefoged and Maddieson 1996, a.o.). Sagey (1986) uses a pointer device to single out the labial place feature as an instantiation of *abstract primary place* (see van de Weijer 2011), in order to capture the generalization that in Ngbaka Ma’bo, there is only PAL (and thus only a restriction between “primary articulators”). Here, such machinery is no longer empirically sufficient or theoretically necessary. This not only simplifies the representation and therefore the candidate space, but also uses independent mechanisms (constraint ranking) to replace the work of specific devices meant to model abstract primary place.

All inputs and candidates are indicated via pairs of segments. Surface correspondence is indicated via subscripted indices, as is standard. Candidates are given as dummy $[\text{C}_x\text{aC}_{x/y}\text{a}]$ forms, where $[\text{C}]$ is any of the segments in (10). With only two segments, there are only two possible surface correspondence configurations: they are either in

correspondence, or not in correspondence. The exact definition of surface correspondence therefore is not crucial (whether it is a pairwise chain following e.g. Shih and Inkelas 2019 or an equivalence relation following Bennett 2015).

4.1 Constraints

All constraint definitions are given in a Constraint Definition Language (CDL) that is based on de Lacy (2011), McCarthy (2003), and Hyde (2012), along with an informal paraphrase. For all correspondence-referring constraints (**IDENT** and **CORR**), the locus is a pair of root nodes (segments), indicated as bullets (\bullet). The condition of the constraint uses the operators \wedge and \neg , with their usual definitions, as well as exclusive-or \oplus . Predicates of the form $[F](\bullet)$ are true iff segment \bullet is associated with feature $[F]$. A violation is assigned for each locus making the constraint condition be true, following McCarthy (2003).

4.1.1 Identity

The evaluation of place identity, whether over input/output or surface correspondence, is crucial to capturing the intended effects of semihomorganicity. Each disparity is counted by an omnibus constraint for all of the major place features [labial], [dorsal] and [coronal]. There is a single **CC-IDENT.PLACE** constraint operating over surface correspondence, and two directional faithfulness constraints over input/output correspondence: **IO-IDENT.PLACE** and **OI-IDENT.PLACE**. Each of these polices the removal or addition of place features from input to output, respectively. The exclusive-or operator \oplus ensures that a violation will be assigned when the values of the two segments for that feature are different.

To preserve class behavior of place, **IDENT** constraints for all three place features are defined via constraint summation (---): the violation profile of **IDENT.PLACE** is essentially the sum of the violation profiles of the (hypothetical) constraints **IDENT.[dorsal]**, **IDENT.[coronal]**, and **IDENT.[labial]**. This is indicated in constraint definitions with multiple instances of the basic schema separated by the addition operator $+$. This definition follows the spirit of Feature Class Theory (FCT, Padgett 1995, 2002). Further extensions of constraint summation and this general definition of identity are explored in Danis (2017).

(11) **CC-IDENT.PLACE**

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

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

—
 “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.”

The following faithfulness constraints assign violations for features that are removed or added between input and output. The constraint IO-IDENT.PLACE only assigns violations for place disparities where the input place feature is present, and likewise OI-IDENT.PLACE only assigns violations when the input place feature is absent. This is based on directional IDENT constraints for nasality in Pater (1999) (see also Rose and Walker 2004: 492). Additionally, McCarthy and Prince (1995) discuss the MAX- and DEP-ness of IDENT constraints in its original formulation. The violations assigned by these constraints are discussed in detail in (20) for the analysis of PAL.

(12) **IO-IDENT.PLACE**

$$\begin{aligned} &\langle \bullet_1, \bullet_2 \rangle / (\bullet_1 \mathfrak{X}_{io} \bullet_2) \wedge ([\text{dor}](\bullet_1) \wedge \neg[\text{dor}](\bullet_2)) + \\ &\langle \bullet_1, \bullet_2 \rangle / (\bullet_1 \mathfrak{X}_{io} \bullet_2) \wedge ([\text{lab}](\bullet_1) \wedge \neg[\text{lab}](\bullet_2)) + \\ &\langle \bullet_1, \bullet_2 \rangle / (\bullet_1 \mathfrak{X}_{io} \bullet_2) \wedge ([\text{cor}](\bullet_1) \wedge \neg[\text{cor}](\bullet_2)) \end{aligned}$$

—
 “Assign a violation for each pair of segments in IO correspondence that loses a dorsal place, and for each that loses labial place, and for each that loses a coronal place.”

(13) **OI-IDENT.PLACE**

$$\begin{aligned} &\langle \bullet_1, \bullet_2 \rangle / (\bullet_1 \mathfrak{X}_{io} \bullet_2) \wedge (\neg[\text{dor}](\bullet_1) \wedge [\text{dor}](\bullet_2)) + \\ &\langle \bullet_1, \bullet_2 \rangle / (\bullet_1 \mathfrak{X}_{io} \bullet_2) \wedge (\neg[\text{lab}](\bullet_1) \wedge [\text{lab}](\bullet_2)) + \\ &\langle \bullet_1, \bullet_2 \rangle / (\bullet_1 \mathfrak{X}_{io} \bullet_2) \wedge (\neg[\text{cor}](\bullet_1) \wedge [\text{cor}](\bullet_2)) \end{aligned}$$

—
 “Assign a violation for each pair of segments in IO correspondence that gains a dorsal place, and for each that gains labial place, and for each that gains a coronal place.”

There are both faithfulness and surface correspondence constraints for $[\pm\text{voice}]$ as well: IO/OI-IDENT.[voice] and CC-IDENT.[voice]. There is no assumed IO and OI split of

faithfulness for voice, although one could be assumed if there the output of Voicing Agreement were shown to be D...D. The input/output constraints are equivalent to the standard IDENT constraints for binary features, following McCarthy and Prince (1995), and likewise for the surface correspondence versions following Rose and Walker (2004), Bennett (2015), and Hansson (2010) .

4.1.2 Similarity

Similarity (CORR) constraints are those that encourage segments sharing a value for some feature to be in surface correspondence. These constraints are crucially defined here over *each* of the individual place features to capture the place asymmetries in the generalizations. The constraints are based on individual place features (following Bennett 2015) instead of a similarity scale based on homorganicity (such as in Rose and 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 (e.g. CORR.PLACE); in the final Ngbaka ranking, members of this set crucially dominate one another. The full definition for CORR.[dor] is below; those for CORR.[lab] and CORR.[cor] are defined in a parallel fashion.

(14) **CORR.[dor]**

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

—

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

In addition to CORR.[cor], CORR.[dor], and CORR.[lab], a local conjunction between CORR.[dor] and a positional markedness constraint KP-mi defined in (15) is necessary to capture the asymmetry of PAD. This constraint enforces correspondence between disharmonic pairs [K... $\widehat{\text{KP}}$], but not [$\widehat{\text{KP}}$...K]. This is shown in (16).

(15) **KP-mi**

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

(Assign a violation for every non-initial labial-dorsal segment.)

(16) CORR.[dor]&KP-mi as local constraint conjunction:

| output | CORR.[dor] | KP-mi | CORR.[dor]&KP-mi |
|---------------------------------------|------------|-------|------------------|
| k ₁ ak ₂ a | 1 | 0 | 0 |
| \widehat{kp}_1 ak ₂ a | 1 | 0 | 0 |
| k ₁ a \widehat{kp}_2 a | 1 | 1 | 1 |
| \widehat{kp}_1 a \widehat{kp}_2 a | 1 | 1 | 1 |
| k ₁ a \widehat{kp}_1 a | 0 | 1 | 0 |

The constraint assigns a subset of violations of CORR.[dor]. Defining the constraint in this way grounds it in the cross-linguistic tendency for labial-velars to disprefer word-internal positions, as surveyed by Cahill (2000) (see also Beckman 1998). Though, conjunction itself is not strictly necessary; the constraint can be defined without this connective (see Danis 2017).

The purpose of this constraint is to capture the directionality of PAD through the restriction of the correspondence relation itself. While directionality in ABC can also be captured using either positional faithfulness constraints or directional CC-IDENT constraints, these make the wrong predictions with respect to the interaction of PAD and VA, as discussed in Section 4.2.2.

4.1.3 Segmental Markedness

Segmental markedness is evaluated per place feature of the segment: complex segments like \widehat{kp} receive 2 violations, while all other (simple) segments receive 1 violation. As all segments in this system are specified for at least one place feature, the distinction in the constraint violations is 1 versus 2, or effectively simple versus complex. Voicing markedness *[+voice] has its usual effect, following Lombardi (1999), a.o.

(17) a. VT for *PLACE

| output | *PLACE |
|---------------------------------|--------|
| t, p, k, d, b, g | 1 |
| \widehat{kp} , \widehat{gb} | 2 |

b. VT for *[+voice]

| output | *[+voice] |
|-------------------------|-----------|
| t, p, k, \widehat{kp} | 0 |
| d, b, g, \widehat{gb} | 1 |

4.2 Ranking

The full Ngbaka support is shown in (18).⁸ All ranking information is shown in Comparative Tableaux (CTs), following Prince (2002). Each row of a CT contains an

Elementary Ranking Condition (ERC), where a constraint preferring the winning candidate (W) must dominate all constraints preferring the losing candidate (L). Blank cells indicate the constraint does not make a differentiation.⁹

(18) Full support for Ngbaka

| Input | Winner | Loser | IO-IDENT.PLACE | CC-IDENT.[voice] | CORR.[lab] | CORR.[cor] | CC-IDENT.PLACE | CORR.[dor]&KP-mi | *PLACE | OI-IDENT.PLACE | CORR.[dor] | IO/OI-IDENT.[voice] | *[+voice] |
|----------------------|----------------------------------|----------------------------------|----------------|------------------|------------|------------|----------------|------------------|--------|----------------|------------|---------------------|-----------|
| a. k- \widehat{kp} | $\widehat{kp}_1ak\widehat{p}_1a$ | k_1ap_2a k_1ak_1a | W | | | | | | L | L | | | |
| b. k-g | k_1ak_1a | k_1ag_1a | | W | | | | | | | | L | W |
| c. p- \widehat{kp} | $\widehat{kp}_1ak\widehat{p}_1a$ | $p_1ak\widehat{p}_2a$ | | | W | | | | L | L | | | |
| d. t-d | t_1at_1a | t_1ad_2a | | | | W | | | | | | L | W |
| e. k- \widehat{kp} | $\widehat{kp}_1ak\widehat{p}_1a$ | $k_1ak\widehat{p}_1a$ | | | | | W | | L | L | | | |
| f. k- \widehat{kp} | $\widehat{kp}_1ak\widehat{p}_1a$ | $k_1ak\widehat{p}_2a$ | | | | | | W | L | L | W | | |
| g. \widehat{kp} -k | \widehat{kp}_1ak_2a | $\widehat{kp}_1ak\widehat{p}_1a$ | | | | | | | W | W | L | | |
| h. k-g | k_1ak_1a | k_1ag_2a | | | | | | | | | W | L | W |
| i. k-b | k_1ab_2a | k_1ap_2a | | | | | | | | | | W | L |

Detailed rankings for each process are discussed in the following sections. Note that there is one irreducible disjunction in the full ranking: ERC 18g. For \widehat{kp} -k/ to surface faithfully and not be in correspondence, it must be preferred to $[\widehat{kp}_1ak\widehat{p}_1a]$, which is unfaithful but in correspondence. The winner is better both in terms of markedness (*PLACE) and in not adding place features to the output (OI-IDENT.PLACE), so one of these constraints must dominate CORR.[dor]. This disjunction is similar in spirit to the larger discussion of DEP and markedness constraints; see Gouskova (2007) for a summary.

4.2.1 Place Agreement on Labials

The ranking necessary for Place Agreement on Labials is shown below.

(19) CT for \widehat{kp} -p/

| Input | Winner | Loser | IO-IDENT.PLACE | CORR.[lab] | CC-IDENT.PLACE | *PLACE | OI-IDENT.PLACE |
|----------------------|-------------------------------------|--------------------------------|----------------|------------|----------------|--------|----------------|
| a. \widehat{kp} -p | $\widehat{kp}_1 a \widehat{kp}_1 a$ | $k_1 a p_2 a$ $p_1 a p_1 a$ | W | | | L | L |
| b. \widehat{kp} -p | $\widehat{kp}_1 a \widehat{kp}_1 a$ | $\widehat{kp}_1 a p_2 a$ | | W | | L | L |
| c. \widehat{kp} -p | $\widehat{kp}_1 a \widehat{kp}_1 a$ | $\widehat{kp}_1 a p_1 a$ | | | W | L | L |

Following the basic ABC schema for long-distance interaction, ERC 19b demands CORR.[lab] dominate both place markedness *PLACE and faithfulness OI-IDENT.PLACE, as CORR.[lab] prefers the winner where the consonants are in correspondence. All labial pairs, including those with labial-dorsals, correspond. In ERC 19c, CC-IDENT.PLACE must dominate both *PLACE and OI-IDENT.PLACE as well, as identity of surface segments is more important than removing place features from the input (OI-IDENT.PLACE) or being more marked (*PLACE).

PAL in Ngbaka is a static restriction, so there are no active alternations to show what the actual mappings are. The winning candidate is assumed to be $[\widehat{kp}_1 a \widehat{kp}_1 a]$, where [dorsal] place is added to the output to satisfy CC-IDENT.PLACE. This candidate is possible because it satisfies IO-IDENT.PLACE through not removing any place features, although it does add one (violating OI-IDENT.PLACE) and is more marked than the faithful candidate. This is expressed in ERC 19a, where the losing candidate is actually a tie between the dissimilation candidate $[k_1 a p_2 a]$ and the simple agreement candidate $[p_1 a p_1 a]$, where surface identity is satisfied through removing a place feature. The choice of possible agreement and dissimilation optima are summarized in the following table:

(20)

| | /k ₁ p ₂ a/ | IO-IDENT.PLACE | *PLACE | OI-IDENT.PLACE | Disparity | Process |
|----|---|----------------|--------|----------------|--------------|-------------------|
| a. | k ₁ a p ₂ a | 1 | 2 | 0 | [labial] → ∅ | Dissimilation |
| b. | p ₁ a p ₁ a | 1 | 2 | 0 | [dorsal] → ∅ | Simple agreement |
| c. | k ₁ p ₁ a k ₁ p ₁ a | 0 | 4 | 1 | ∅ → [dorsal] | Complex agreement |

The input mapping to any of these choices is still a kind of major place long-distance interaction, whether it's dissimilation (a) or agreement (b or c). As Bennett (2015) demonstrates, most static long-distance interactions have either an agreement or dissimilation analysis, both caused by the same basic ABC ranking schema where correspondence is demanded of feature [F] and agreement demanded for feature [G]. Faithfulness rankings for [F] and [G] determine whether it is agreement or dissimilation. It should be noted here that features [F] and [G], which are both major place features, are controlled by the same faithfulness constraints. The dissimilation candidate in (a) and the simple agreement candidate in (b) can only be differentiated by a more articulated theory of markedness.

There are, however, three reasons why [k₁p₁a k₁p₁a], the complex agreement candidate, is assumed to be the optimum:

- (21)
- K₁P...K₁P pairs are significantly overrepresented in the dictionary data.
 - Agreement processes cross-linguistically agree for the more marked feature value (Steriade 1995 and references therein; see Iacoponi 2016 for long-distance processes specifically).
 - Kinematic studies of speech errors (e.g. Goldstein et al. 2007) show that gestural intrusion errors (the addition of an articulation) are much more common than gestural reduction errors (the removal of an articulation) (following also Rose and Walker 2004: 519).

As shown in Table 5, [K₁P...K₁P] pairs are significantly overrepresented on the surface. This is taken as evidence that inputs other than /K₁P...K₁P/ are mapping to [K₁P...K₁P], such as the relevant semihomorganic pairs shown below.¹⁰

$$(22) \begin{array}{l} /K\widehat{P}\dots\widehat{K}P/ \\ /K\widehat{P}\dots P/ \\ /P\dots\widehat{K}P/ \\ /K\dots\widehat{K}P/ \end{array} \begin{array}{l} \searrow \\ \searrow \\ \searrow \\ \searrow \end{array} [\widehat{K}P\dots\widehat{K}P]$$

In the analysis given here, these disharmonic, semihomorganic pairs all neutralize to the complex agreement output.¹¹

Additionally, Iacoponi (2016) discusses a cross-linguistic generalization where “in dominant-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 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), agreement to complex place fits the generalization in Iacoponi (2016). This line of reasoning also follows theories of underspecification (see e.g. Steriade 1995; Archangeli 2011), where it is impossible for the unmarked or default value of some feature to cause agreement as it is presumably absent from the representation at that stage.

Lastly, kinematic studies of speech error production, specifically Goldstein et al. (2007), show that so-called *gestural intrusion errors* are decidedly more frequent than *gestural reduction errors*. Essentially, when tasked with repeating a phrase like *cop top*, there is more likely to be an additional dorsal gesture on the [t] than there is a reduced coronal gesture. This follows the same line of reasoning as Rose and Walker—citing parallel findings in Pouplier et al. (1999)—who state 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 and Walker 2004: 520). Ngbaka, then, is a case where complex segments *are* allowed and place agreement *is* detectible.

For the three reasons outlined above, the Ngbaka patterns are analyzed as a case of complex agreement in terms of (20). It is important to note, however, that even if Ngbaka does not contain long-distance place *agreement*, but rather dissimilation, these patterns are still caused by an active CC-IDENT.PLACE constraint.

4.2.2 Place Agreement on Dorsals

Place Agreement on Dorsals (PAD) is the only directional process found in the Ngbaka data. It only applies to forms with an initial dorsal and a medial labial-dorsal: $K\dots\widehat{KP}$.

(23) CT for /k- \widehat{kp} /

| Input | Winner | Loser | IO-IDENT.PLACE | CC-IDENT.PLACE | CORR.[dor]&KP-mi | *PLACE | OI-IDENT.PLACE | CORR.[dor] |
|----------------------|----------------------------------|--------------------------|----------------|----------------|------------------|--------|----------------|------------|
| a. k- \widehat{kp} | $\widehat{kp}_1ak\widehat{p}_1a$ | k_1ap_2a k_1ak_1a | W | | | L | L | |
| b. k- \widehat{kp} | $\widehat{kp}_1ak\widehat{p}_1a$ | $k_1ak\widehat{p}_1a$ | | W | | L | L | |
| c. k- \widehat{kp} | $\widehat{kp}_1ak\widehat{p}_1a$ | $k_1ak\widehat{p}_2a$ | | | W | L | L | W |

Again, the winning candidate is assumed to be $[\widehat{kp}_1ak\widehat{p}_1a]$, following the reasons in (21). To capture the asymmetry between semihomorganic dorsal pairs, the constraint CORR.[dor]&KP-mi demands correspondence from forms where both consonants are [dorsal] but the second is also [labial]. While both CORR.[dor]&KP-mi and CORR.[dor] prefer the winning candidate in ERC 23c, the next tableau shows that CORR.[dor] cannot dominate both *PLACE and OI-IDENT.PLACE:

(24) CT for / \widehat{kp} -k/

| Input | Winner | Loser | IO-IDENT.PLACE | CC-IDENT.PLACE | CORR.[dor]&KP-mi | *PLACE | OI-IDENT.PLACE | CORR.[dor] |
|----------------------|-----------------------|----------------------------------|----------------|----------------|------------------|--------|----------------|------------|
| a. \widehat{kp} -k | \widehat{kp}_1ak_2a | k_1ak_1a p_1ak_2a | W | | | L | | L |
| b. \widehat{kp} -k | \widehat{kp}_1ak_2a | \widehat{kp}_1ak_1a | | W | | | | L |
| c. \widehat{kp} -k | \widehat{kp}_1ak_2a | $\widehat{kp}_1ak\widehat{p}_1a$ | | | | W | W | L |

In order for $[\widehat{kp}$ -k/ to surface faithfully, it must *not* be in correspondence. If it were, it

would be subject to PAD. The optimum is indeed not in correspondence: [k̄p₁ak₂a]. The constraint CORR.[dor]&KP-mi does not differentiate between any of the candidates in this candidate set, as none of them are of the form K...K̄P.

The fact that K̄P...K forms avoid surface correspondence to escape PAL means these forms should escape Voicing Agreement as well. This prediction is borne out.

- (25) a. ḡbaka (v.) ‘help, rescue’ (p. 77)
 b. ḡbákò- (n.) ‘tree branch’ (p. 77)

If the optimum to /k̄p-k/ in (24) were in correspondence, then we should expect VA to apply as well. However, this is not the case. Dorsal semihomorganic forms that disagree in voicing, such as those in (25), surface faithfully both in terms of place and voice.

(26) CT for /ḡb-k/

| Input | Winner | Loser | CC-IDENT.[voice] | CC-IDENT.PLACE | *PLACE | OI-IDENT.PLACE | CORR.[dor] | IO/OI-IDENT.[voice] | *[+voice] | Loser Comment |
|---------|-----------------------------------|--------------------------------------|------------------|----------------|--------|----------------|------------|---------------------|-----------|---------------------------|
| a. ḡb-k | ḡb ₁ ak ₂ a | ḡb ₁ ak ₁ a | W | W | | | L | | | Faithful, in corr. |
| b. ḡb-k | ḡb ₁ ak ₂ a | ḡb ₁ ak̄p ₁ a | W | | W | W | L | | | Place agreement |
| c. ḡb-k | ḡb ₁ ak ₂ a | k̄p ₁ ak ₁ a | | W | | | L | W | L | Voicing agreement |
| d. ḡb-k | ḡb ₁ ak ₂ a | k̄p ₁ ak̄p ₁ a | | | W | W | L | W | L | Place & voicing agreement |

In ERC 26a, the loser is faithful and in correspondence, and therefore violates both CC-IDENT.[voice] and CC-IDENT.PLACE. Both CC-IDENT constraints prefer the doubly-disharmonic winner as it trivially satisfies surface correspondence identity through lack of correspondence; even though [ḡb₁ak₂a] has two segments that disagree in voicing, they are not in correspondence, so CC-IDENT.[voice] is satisfied.

Failure of VA to apply here is the reason why the absence of place agreement on [K̄P...K] forms must be due to non-correspondence. If place agreement were directional, either with directional versions of CC-IDENT.PLACE or through positional faithfulness, then the optimum [k̄p₁ak₁a] would be in correspondence, but not susceptible to this new,

directional place harmony. For instance, an IDENT constraint sensitive only to onsets would preserve place in $[\widehat{kp}_1ak_1a]$, but the optimum would also be susceptible to *other*, non-directional agreement, as there is a single correspondence relationship that holds between segments. Because these forms are not subject to voicing agreement, the lack of place agreement must be due to the lack of correspondence.

4.2.3 Voicing Agreement

Voicing Agreement holds between homorganic consonants, and demands that they agree in voicing. (See also Walker 2001 for Ngbaka Ma’bo.)

(27) CT for Voicing Agreement

| Input | Winner | Loser | IO-IDENT.PLACE | CC-IDENT.[voice] | CORR.[lab] | CORR.[cor] | OI-IDENT.PLACE | CORR.[dor] | IO/OI-IDENT.[voice] | *[+voice] |
|--------|------------|-------------------|----------------|------------------|------------|------------|----------------|------------|---------------------|-----------|
| a. k-g | k_1ak_1a | k_1ab_2a ... | W | | | | W | | L | W |
| b. k-g | k_1ak_1a | k_1ag_1a | | W | | | | | L | W |
| c. p-b | p_1ap_1a | p_1ab_2a | | | W | | | | L | W |
| d. t-d | t_1at_1a | t_1ad_2a | | | | W | | | L | W |
| e. k-g | k_1ak_1a | k_1ag_2a | | | | | | W | L | W |

VA applies to all homorganic pairs—all of CORR.[dor], CORR.[cor], and CORR.[lab] dominate IO/OI-IDENT.[voice], as does CC-IDENT.[voice] (ERCs 27c–e). Faithful voicing violates CC-IDENT.[voice] (ERC 27b), and the place dissimilation candidate loses to the voicing agreement candidate (ERC 27a). Note that even though CORR.[lab] dominates CORR.[dor] because of PAD, both constraints still dominate the relevant constraints for VA. While all the ERCs in (27) are disjunctive, IO/OI-IDENT.[voice] must dominate *[+voice], as ERC 18i shows.

5 Problems with alternative analyses

This section describes problems with two alternative analyses of the Ngbaka data: co-occurrence constraints and spreading. When using a pure markedness approach, with constraints of the form $*X...Y$, the illicit semihomorganic pairs (such as $P...K̄P$) cannot be targeted without also targeting the licit $K̄P...K̄P$ pairs; this is an instance of the *superstructure problem* as defined by Jardine (2016) and in the following section. Additionally, modeling this processes as a case of transvocalic spreading *is* possible assuming the representations of Clements and Hume (1995); however, this conflates the treatment of long-distance consonant spreading with vowel spreading, making incorrect cross-linguistic predictions (following Casali 1995).

5.1 Using co-occurrence constraints

Analyses using co-occurrence constraints, such as that in Sagey (1986), cannot actually capture the observed Ngbaka patterns without altering certain nontrivial but standard assumptions about phonological theory. These are defined below:

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

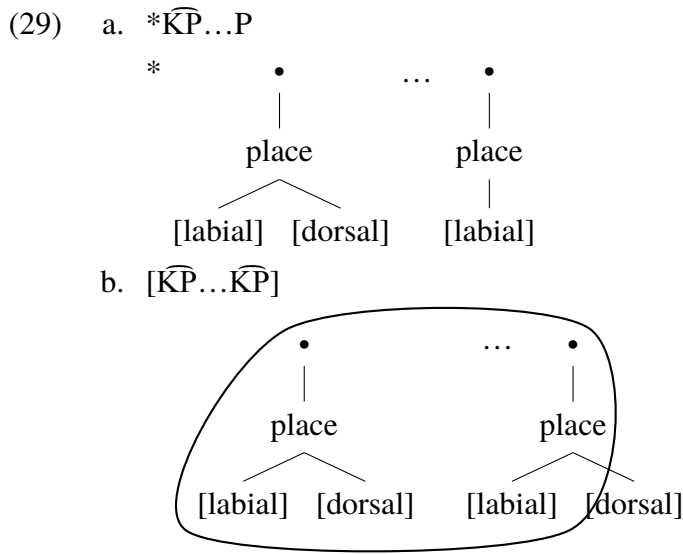
Place features are privative. (Sagey 1986; Yip 1989; Clements and Hume 1995; Halle 1995; Halle et al. 2000 a.o.)

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

Constraints are negative and can only target structure present in the specified representation. (Jardine 2016; de Lacy 2006; McCarthy 2003; Jardine and Heinz 2016 a.o.)

The argument is as follows: assuming that place features are privative and markedness constraints are negative, defined in (28), any constraint that targets simple segments of place α will also target complex segments *containing* α . In this case, we want to allow the complex homorganic forms of the shape $K̄P...K̄P$, but ban semihomorganic forms $K...K̄P$, $P...K̄P$, and $K̄P...P$. Each of those banned forms contains a substructure of the allowed $K̄P...K̄P$.¹²

To demonstrate this explicitly, a simplified version of the co-occurrence restriction used in Sagey (1986: 265) is given in (29a).¹³ This constraint will undesirably target the form in (29b), indicated by the circled structure.



This is an instance of the *superstructure problem*, which is where “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). The constraint in (29a) has no way of detecting the presence of an additional [dorsal] feature (as there is in (29b)) 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 (28) must be abandoned.¹⁴ However, there is nontrivial evidence that each of these assumptions must be upheld. These are discussed in the following sections.

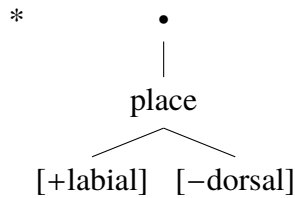
Any analysis that uses co-occurrence constraints of the form $*X\dots Y$ is affected by this problem, where X and Y are feature specifications that may or may not be identical (see also Alderete 1997; Suzuki 1998; Pulleyblank 2002; Stanton 2017 a.o.). The overall framework that these constraints are implemented in, whether they are language-specific inviolable autosegmental or morpheme structure 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, as defined above. The following sections discuss the consequences of abandoning either one of these assumptions.

5.1.1 Making place features binary

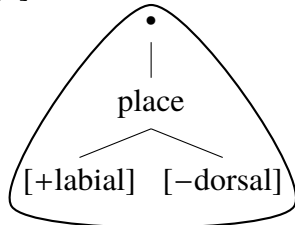
By eschewing PiP, simple labials can be marked as [+labial –dorsal] (and presumably [–coronal], along with any other relevant specifications). This feature specification is no

longer a substructure of labial-dorsals, which would be [+labial +dorsal].

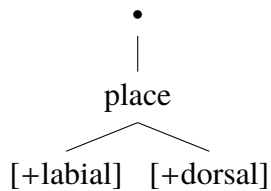
(30) *P with binary features:



(31) [P] is banned:



(32) [\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 (30) can now explicitly detect the absence of a dorsal articulation accompanying a labial one due to the presence of the negative value of [dorsal].

Jardine, in treating tonal patterns, 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.¹⁵

However, Clements and Hume (1995: 252) explain: “Unlike most other features, [labial], [coronal], and [dorsal] are treated as privative (one-valued), rather than binary. *This is because phonological rules do not appear to operate on the negative values of these categories* (emphasis mine).” 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 *does* refer to a negative feature value of a place feature. However, this goes against a general consensus in the literature about place features, since, notably, Sagey (1986). As Clements and Hume (1995) state above, most if not all patterns of place behavior are modeled without reference to the negative value of a feature. If binary place features are assumed for Ngbaka, the crosslinguistic predictions are unsubstantiated.¹⁶

Formal language-theoretic methods avoid the superstructure problem by computing over strings of segments and thus eschewing feature representations altogether. In the Strictly Piecewise grammars of Heinz (2010) or the Tier-based Strictly Local (TSL) grammars of Heinz et al. (2011) (see also McMullin and Hansson 2016), the pairs $p\widehat{kp}$, \widehat{kpp} , and $kk\widehat{p}$ can be targeted without fear of the superstructure problem surfacing because there is no structure below the level of the segment; the symbols for p and \widehat{kp} can essentially be replaced with α and β . Because there is no subsegmental structure, however, the structural affinity between simple segments like $[p]$ and their complex counterparts like $[\widehat{kp}]$ is lost.

While the TSL languages begin to incorporate featural information through tier projection, their focus is on the structural characterization of the pattern in terms of the ordering relation necessary to capture it. The goal in the present analysis is not incompatible, but is more precisely to explain why certain sounds interact in this way, using feature-geometric structure that is more standard in the literature. In essence, while TSL grammars have a general method of projecting certain segments to their own tier, there is currently no established method for representing structural similarities between segments (or, *why* certain segments should pattern together on a tier).

5.1.2 *Increasing the power of the constraint logic*

To avoid a representation with negative feature values, the logical power of the constraint itself must be increased. Instead a negative literal as defined by Jardine and Heinz (2016), the restriction can be defined in terms of first-order logic (FO). A constraint that bans $[P]$ without banning $[\widehat{KP}]$ operating over privative features can then be defined as follows:

$$(33) \quad \forall x, y[\bullet(x) \wedge [1ab](y) \wedge x \downarrow y] \rightarrow \exists z[[dor](z) \wedge x \downarrow z]$$

—

“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 (assuming the same structures as in (29)). However, [\widehat{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, Jardine and Heinz (2016) argue that FO is too powerful for natural language markedness constraints, and a more restrictive form of logic is required for markedness.

The analysis presented here uses ABC, with the caveat that constraints operating on the correspondence relation use a stronger form of logic than negative literals. While they do not discuss surface correspondence, Potts and Pullum (2002) show that standard OT faithfulness constraints (such as IDENT) can be defined in modal logic, which is less expressive than first-order logic (Potts and Pullum 2002: 364). Surface identity constraints like CC-IDENT.PLACE have a clear isomorphism with input/output IDENT constraints like IO/OI-IDENT.PLACE, by design (see e.g. Rose and Walker 2004: 493). In short, while Jardine and Heinz (2016) argue that *markedness* constraints should be defined as negative literals, they explicitly do not discuss faithfulness constraints or the correspondence relation in general. The analysis here preserves PiP and NTWR with the allowance of a more powerful logic for *correspondence* constraints, but not for other non-correspondence markedness constraints.

5.2 Spreading

A general alternative to long-distance processes is to assume that they are caused by spreading. Two general types of spreading have been proposed: iterative (strictly local) spreading, and transvocalic (spreading under relativized locality). This section will show how only transvocalic spreading, as defined in Clements and Hume (1995), can capture the Ngbaka patterns, but also how this formulation has since been criticized on both empirical and theoretical grounds.

In the model of Clements and Hume (1995), individual C-place features (but not the C-place node itself) *are* able to spread past intervening vowels, due to how the No-Crossing Constraint is defined (repeated in (34)). Such an allowance is made for so-called cases of the feature [coronal] spreading, which has been well-documented: “[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

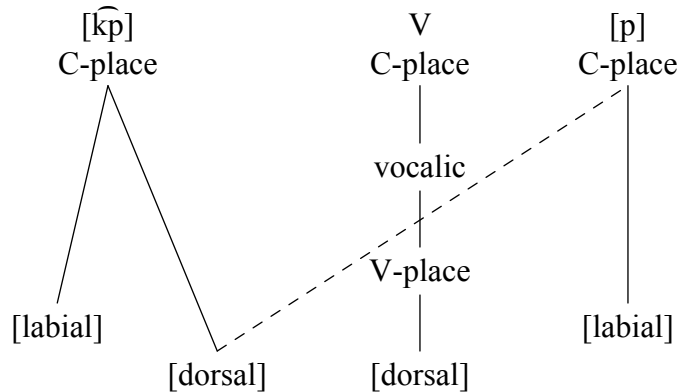
and Hume 1995: 289, see also Shaw 1991). However, these cases, while analyzed as a [coronal] node spreading past intervening segments, do *not* constitute cases of major place harmony as defined here. These analyses involve a [coronal] feature spreading to another segment already with a [coronal] feature; in essence, [coronal] spreading is used as a vehicle for [anterior] and [distributed] spreading, features assumed to be subordinate to the [coronal] feature (see also Odden 1994). In terms of ABC, this would involve [coronal] segments to be in correspondence, and for harmony to occur for the features [anterior] directly. Nevertheless, the representations as defined can also account for certain Ngbaka patterns.

The figure below shows how transvocalic spreading can be accomplished based on the specific definition of the No-Crossing Constraint and the geometry argued for by Clements and Hume (1995) to model PAL in Ngbaka.

(34) **No Crossing Constraint (NCC)** (Clements and Hume 1995: 266)

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

(35) Intervening vowels don't block spreading: (cf. Clements and Hume (1995: 297))



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 (34), meaning individual C-place can spread across intervening vowels, even those of the same place.

While the Clements and Hume (1995) model allows individual C-place features to spread past vowels, its predictions and formulations have been criticized. Empirically, Casali

(1995) argues that the transparency of an intervening segment of the same place as the spreading feature should not be universally encoded in the model: vocalic spreading of a [labial] feature across a consonant in Nawuri is blocked if the intervening consonant is a plain [labial], such as [m]. Modeling vocalic spreading in Nawuri requires a single place tier for consonants and vowels, Casali argues, yet such a structure would make the spreading in (35) impossible. Additionally, Rose and Walker (2004: 487) take the general existence of such blocking effects in vowel harmony, and their alleged absence in consonant harmony, as evidence that the latter is formally distinct from the former; one is spreading, the other is agreement.

Theoretically, the notion of tier as used in Clements and 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). The specific issue at hand is that all place *features* occupy the same tier, but their immediately dominating nodes, C-place and V-place, occupy different tiers.

Under theories of strictly local *iterative* spreading, features of segment X can spread to segment Y as long as those features also spread to every segment between X and Y. However, the features assumed to spread this way 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 (see e.g. Shaw 1991; Gafos 1999). In fact, part of the motivation for iterative spreading is the general assumption that consonant place features do *not* spread: “In particular, strict locality (along with other basic assumptions) explains why vocalic place features spread long-distance, while consonantal place features do not” (Ní Chiosáin and Padgett 1997: 2). Iterative spreading is—by design—not a viable option to capture the Ngbaka patterns here.

6 Typological significance

It is not a coincidence that major place harmony presented here involves segments with complex place. Cases of consonant harmony are characterized by the fact that the two harmonizing segments are already similar in some way. In Ngbaka, place harmony is predicated on place similarity. Semihomorganic consonant pairs (such as [kp...p]) share a place feature, so they are subject to CORR constraints based on that place feature. However, though these segments are in correspondence, they are not *identical* in place, and so the

corresponding semihomorganic pair thus violates CC-IDENT.PLACE.

| | | | |
|------|----------------|-------------------------------|---------------------------------|
| (36) | | <i>Similar for some place</i> | <i>Identical for all places</i> |
| a. | Homorganic | P...P | Yes |
| b. | Heterorganic | P...K | No |
| c. | Semihomorganic | P... \widehat{KP} | Yes |

Place harmony predicated on place similarity can only occur between semihomorganic segments, as these are the only pairs where place similarity (sharing one feature) does not entail place identity (sharing all features). Note that all homorganic combinations, by the definition of homorganicity, also satisfy CC-IDENT.PLACE. In other words, semihomorganic pairs are the only segments that would be in correspondence due to a constraint like CORR.[lab], while also not satisfying CC-IDENT.PLACE, which polices all place features. Therefore, only languages with a phonologically complex segment can potentially exhibit this “place-on-place” harmony.

Clements (2000) actually describes the place restrictions in Ngbaka in terms of a harmony process, stating in passing that “in this language, a rule of consonant harmony requires any two [labial] consonants in a simple word to have the same characterisation for [dorsal]” (p. 129). However, in discussing the nasal harmony of Ngbaka Ma’bo, Rose and Walker (2004: fn. 26) assume (following Sagey (1986)) that labial-velars are primarily [labial], abstracting away from complex place and any potential place harmony process. As is shown here, the notion of abstract primary place is not actually advantageous in describing the restrictions due to the discovery of Place Agreement on Dorsals, and both place restrictions are best analyzed in terms of a harmony process.

Other potential cases are reported in Cahill (2006), who cites Ngbaka Ma’bo as well as Kukú (Nilotic, South Sudan/Uganda, dialect of Bari [bfa]) and Kaanse (or Kaansa, Gur, Burkina Fasso, [gna]) as other languages that ban labials and labial-velars from co-occurring, but in these other languages the ban is on labials generally co-occurring within the same morpheme. (It is also worth noting here that the existence of PAD goes against the generalization in Cahill 2006 that co-occurrence restrictions with labial-velars are always between other labials.)

The following sections discuss two possible patterns that are potentially further cases of place harmony, but do *not* involve labial-velar doubly-articulated stops.

6.1 *Luganda*

While complex segments are necessary to detect place-on-place harmony, harmony can operate on factors other than place similarity. Similarity conditions for surface correspondence can be based on nasal, manner, and voicing features as well. Such a case would be where all nasal segments correspond, and agree for major place. While this has also been argued to be largely unattested, one possible case is described in Katamba and 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:¹⁷

(37) *N₁ VN₂ (where N₁ and N₂ are nonhomorganic) (Katamba and Hyman 1991: 179)

(38) Luganda nasal restrictions (simplified, see Katamba and Hyman 1991: 206–7)

a. *n...m, *m...n

b. n...n, m...m

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 CC-IDENT.PLACE for place agreement on surface correspondence. There are a number of other interacting restrictions, all described in Katamba and Hyman (1991).

One confound with this pattern is to ensure that this is not simply an instance of a total harmony, which would subsume place agreement (as Hansson 2010: 219 also discusses). The total harmony generalization for Luganda would be formulated as, if a root contains two nasals, those nasals are completely identical. One reason why it is difficult to separate total harmony from true major place harmony in this case is that if a segment is a nasal, the rest of its (non-place) features are largely predictable: it is usually voiced, sonorant, and so on. To differentiate total harmony from major place harmony for corresponding nasals, a language would need segment pairs that are both nasal, but differ in some non-place feature, such as [voice]. If a voiceless nasal could co-occur with another homorganic nasal, then this is evidence against total harmony and for major place harmony. Due to the rarity of voiceless nasals, however, true major place harmony is difficult to see in these conditions. Even other phonetically nasal segments like prenasals are sometimes argued to be phonologically non-[nasal] (e.g. Rice 1993). The Luganda

pattern, however, is a potential case of long-distance place harmony outside of complex place and place similarity.

6.2 Ponapean

Ponapean (Oceanic, Caroline Islands, [pon], also called Pohnpeian) contains co-occurrence restrictions between simple labials [p, m] and (labio-)velarized labials [p^y, m^y] (Rehg and Sohl 1981; Hansson 2010; Bennett 2015).¹⁸ We can call this SAL, or *secondary (place) agreement on labials*, to stress its similarity to PAL in Ngbaka.

(39) Labials cannot differ in their velarization:

- a. *p^y...p, *p...p^y
- b. *m^y...m, *m...m^y
- c. *p^y...m, *p...m^y
- d. *m^y...p, *m...p^y

(40) Plain labials can co-occur:

- a. p...p, m...m, p...m,

(41) Velarized labials can co-occur:

- a. p^y...p^y, m^y...m^y, p^y...m^y (Hansson 2010: 82, Bennett 2015: 216)

Bennett analyzes this pattern as harmony where [labial] segments correspond, and agree for a [labial-velar] feature. Bennett uses the ad hoc feature [labial-velar] to abstract away from the exact type of secondary articulation that is at play and to show how schematically it fits into the general characterization of harmony in ABC, though he does cite the similarities between his analysis of backness harmony in Ponapean and the Ngbaka Ma'bo patterns. Additionally, Hansson (2010: 78) discusses Ponapean as a case of secondary-articulation harmony, but again abstracts away from the exact representational structure necessary to capture these patterns.

However, assuming the C- and V-place distinctions of Clements and Hume (1995) and the constraint definitions here, the harmony can be modeled parallel to Ngbaka, except between V-place [dorsal] features. While Ngbaka requires a CC-IDENT.PLACE constraint understood to operate over C-place, a parallel constraint, CC-IDENT.VPLACE, can be easily defined to treat Ponapean harmony in the same fashion. While, like Luganda, Ponapean alone doesn't provide evidence for major place harmony, once major place harmony is

independently attested as in Ngbaka, we can extend the same machinery to capture secondary place harmony as well.

Because Ponapean is a case of secondary articulation harmony, which can be represented with V-place features, [\pm back] features, or some other feature or mechanism, both Bennett (2015) and Hansson (2010) do not strictly treat these patterns as major place harmony. An anonymous reviewer points out an alternative analysis for Ngbaka, where a previous state of the language might have contained a Ponapean-esque secondary articulation harmony, say on sequences like [p^w...p], and over time [p^w] became [kp̄]; this would result in the patterns attested here, without synchronic major place harmony.

It is common historically for labial-velars to derive from sequences of either plain labials or dorsals and back, round vowels, or directly from rounded labials and dorsals:

- (42) a. (Ku >) K^w > K̄P
b. (Pu >) P^w > K̄P (Cahill (1999) and references therein)

However, even if it is the case for labial-velars to have derived from either a Ku or Pu sequence (which is common), for the major place harmony patterns to be the result of historical change, multiple things must have been the case: Ngbaka must have contained *both* secondary articulation harmony on labials *and* on dorsals ([p^w...p] and [k^w...k]); *and* for both [p^w] and [k^w] to have changed to [kp̄]. These assumptions are all speculative, and in the discussion of the historical development of labial-velar double-articulation, neither Cahill (1999) nor Connell (1998) list any languages where *both* of these developments have occurred;¹⁹ languages include either the sound change K^w > K̄P *or* P^w > K̄P (or another derivation). For these reasons, it is *more* speculative to assume that the patterns present in Ngbaka are only the historical remnants of a previous, secondary-articulation harmony than to assume it is an instance of synchronic, major-place harmony. Additionally, synchronic and historical analyses are not mutually exclusive.

7 Summary

This article shows Ngbaka place restrictions are an instance of long-distance major place harmony, filling this empirical gap. The restrictions between segments with simple and complex place (semihomorganic pairs) naturally fit the schema of Agreement by Correspondence via the long-distance agreement constraint for major place features,

CC-IDENT.PLACE. Alternative analyses are either impossible in general or without fundamental changes to phonological theory. Empirically, the data are supported by a new statistical analysis of a Ngbaka dictionary. Even though this is a static distribution, certain combinations are significantly underrepresented to the point of a categorical ban, while overrepresented forms provide indirect evidence for the target of certain mappings, such as place harmony itself. The intuition in Rose and Walker (2004) that place harmony may be unreported not due to its theoretical impossibility but due to its reliance on otherwise rare complex segments is supported. As other languages show similar patterns with respect to labial-velars, the pattern is perhaps not as rare as originally thought.

Notes

1. Thanks to Nicholas Rolle for pointing this out.
2. Thanks to Dana Matarlo for assistance with this part.
3. From Frisch (2011): $E = \frac{Obs(C_1) \times Obs(C_2)}{Total}$
4. Much thanks to Adam Chong for assistance with the statistics in this section.
5. Both Eric Bakovic and an anonymous reviewer point out that in $K...K$ and $K...K\widehat{P}$ pairs, there may be a phonetic proximity effect, as cross-linguistically the dorsal gesture of a labial-velar occurs slightly before the labial one (see e.g. Ladefoged and Maddieson (1996)), and thus the dorsal gestures are “adjacent” across the vowel in each case. This cannot explain all the patterns, however, as in $P...K\widehat{P}$ pairs, there is no adjacency. While this may be an explanation for both the underrepresentation of dorsal pairs and the directionality of PAD, it requires a theory that can handle phonetic proximity effects at a distance, and PAL is still evidence for major place harmony as analyzed here.
6. In the discussion of Voicing Agreement, $x...y$ where $x, y \in \{T, D, N, {}^ND\}$ indicates a homorganic pair for any place of articulation.
7. As interactions involving nasals and prenasals specifically are found to not be significant, they are excluded as possible candidates, to keep the candidate set size manageable.
8. All ranking calculations done in OT Workplace (Prince, Tesar, et al. 2016).

Candidates were generated via a Python script and all constraint evaluation was automated via VBA within OT Workplace directly.

9. In some of the following CTs, constraints that do not differentiate between *any* of the winner/loser pairs are not shown for space considerations; however, no ranking information is lost as the full tableau is recoverable as the complete list of constraints is shown in (18).
10. Thanks to Luca Iaconi and Sharon Rose for discussion on this point.
11. One reviewer points out that the $\widehat{KP} \dots \widehat{KP}$ forms might be overrepresented due to reduplication. This may be the case, but does still not explain why *only* the $\widehat{KP} \dots \widehat{KP}$ forms are overrepresented (and not also simple labial, coronal, and dorsal forms, which may presumably also contain reduplicated forms). The reasons listed here for the overrepresentation of $\widehat{KP} \dots \widehat{KP}$ forms are specific to the fact that a double articulation is involved.
12. The case here with place features is parallel to cases of rules targeting short segments but not geminates, as discussed in Hayes (1986a,b). Thanks to Paul de Lacy for pointing this out.
13. The original version of the restriction as formulated in Sagey (1986) actually makes reference to *major articulators* and *minor articulators*, where the major articulator has special status. Sagey assumes the labial articulation to be major in Ngbaka Ma'bo, and thus the restriction is between major articulators only. This is not possible here, as the presence of both PAD and PAL does not provide evidence that one articulator in a complex segment should be treated differently from another.
14. Elsewhere in the dissertation, Sagey does state, "Since the class nodes just discussed cannot be specified as minus, is impossible to spread a minus value for a class node. It is, however, still possible to refer to the property of not involving a particular class node, just as it is possible to refer to the absence of other structures in phonology" (Sagey 1986: 276). This, then, would imply that a more powerful logic is assumed, as discussed in the next section.
15. The solution to the superstructure problem with respect to tone patterns, as proposed in Jardine (2016) and Jardine and Heinz (2016), is to also include an "anti-association" relation in the representation, so a node that is explicitly *not*

associated to a H tone, for instance, can be targeted by a constraint directly (see also Walker (2014: 511)). This same formalism can be applied here as well, though a formal comparison between that and negative feature values is understudied.

16. An anonymous reviewer points out the fact that the feature [\pm grave], and likewise [\pm coronal] (see e.g. Chomsky and Halle (1968: 303)), are essentially binary place features. While this is technically true, there are two caveats: systems using binary [coronal] (such as in SPE) trifurcate the dorsal, labial, and coronal places with [\pm coronal] and [\pm anterior], rather than using three features. Thus it is not immediately clear how the predictions of using two binary features map to those using three privative features. In other words, an SPE-like system is not a case where the major place features of [coronal], [dorsal], and [labial] are all assumed to be binary rather than privative. Further, certain processes that once referred to the binary value of a place feature can often be reformulated to refer the privative value of a new place feature. I appeal to the literature and take the overall lack of feature systems that crucially define the three major place features as binary (since Sagey) as evidence that this is indeed the case for consonants.
17. However, as Katamba and Hyman point out, palatal nasals do not seem to follow this generalization.
18. The exact nature of the secondary articulation is unclear; Hansson (2010) calls it velarization with lip rounding as a phonetic enhancement. This is followed here, though not crucially.
19. Cahill (p.c.) is not aware of any such language, stating that while it's not impossible, it's unlikely.

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