

# **A Typology of Consonant Agreement as Correspondence**

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1. INTRODUCTION. The action at a distance that is characteristic of ‘consonant harmonies’ stands as a pivotal problem to be addressed by phonological theory. Consider the nasal alternations in the Bantu language, Kikongo (Meinhof 1932, Dereau 1955, Webb 1965, Ao 1991, Odden 1994, Piggott 1996). In this language, the voiced stop in the suffix *-idi* in (1a) is realized as [ini] in (1b) when preceded by a nasal consonant at any distance in the stem, consisting of root and suffixes.

- |     |    |  |    |   |
|-----|----|--|----|---|
| (1) | a. | m-[bud-idi] <sub>stem</sub> ‘I hit’    | b. | tu-[kun-ini] <sub>stem</sub> ‘we planted’ |
|     |    | n-[suk-idi] <sub>stem</sub> ‘I washed’ |    | tu-[nik-ini] <sub>stem</sub> ‘we ground’  |

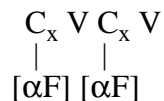
In addition to the alternation in (1), there are no Kikongo roots containing a nasal followed by a voiced stop, confirming that nasal harmony or ‘agreement’, as we will term it, also holds at the root level as a morpheme structure constraint (MSC). In fact, MSCs which require that consonants match for features can also be considered examples of consonant harmony (see also Shaw 1991), but within a more restricted domain. In the Semitic language, Chaha, coronal and velar oral stops in roots match for laryngeal features (Leslau 1979, Banksira 2000). Stops are either voiceless (2a), voiced (2b) or ejectives (2c):

- |     |    |   |    |  |
|-----|----|---|----|--|
| (2) | a. | ji-kətf                    ‘he hashes (meat)’ | c. | ji-t’ək’ir                ‘he hides’   |
|     |    | ji-kəft                    ‘he opens’         |    | ji-t’əβk’                ‘it is tight’ |
|     | b. | ji-dəg(i)s                ‘he gives a feast’  |    |  |
|     |    | ji-dərg                    ‘he hits, fights’  |    |  |

Data such as those in (1-2) are crucial to the debate on mechanisms of feature agreement and their locality, because they display agreement across strings of apparently unaffected neutral material. In the case of Kikongo, intervening consonants and vowels are not nasalized. Likewise in Chaha, intervening vowels in (2a) are not voiceless, and in (2c) intervening segments are not glottalized. Such phenomena, which we term Long Distance Consonant Agreement (LDCA), raise two fundamental questions: (i) what determines the participating segments in LDCA for a given feature? and (ii) how is the neutrality of intervening segments to be obtained? These issues have stimulated various proposals in the literature on nonlinear phonology that involve linking the agreeing feature between participating consonants; however, we will argue that these accounts are unsatisfactory on the basis of explanatory and theoretical considerations.

The aim of this paper is twofold. First, we present a typology of LDCA that includes not only familiar cases of coronal sibilant agreement (i.e. Chumash; see Beeler 1970, Applegate 1972, Poser 1982, Shaw 1991, Gafos 1996[1999]), but also a range of other types, including the examples in (1) and (2). The typology we assemble comprises both alternations and MSCs. Second, we develop an alternative analytical proposal whereby LDCA is brokered via a correspondence-theoretic relation established between the participant segments (extending ideas discussed in Walker 2000a,b, 2001a). We term this approach Agreement by Correspondence (ABC). A chief assertion of the ABC proposal is that agreement is determined by Identity constraints which check feature matching in corresponding consonants, thereby obviating representations in which feature linkage skips over spans of neutral segments. The ABC configuration is shown in (3). In this structure a correspondence relation has been established between two consonants, as indicated by coindexing.

(3) ABC configuration



Another key claim is that similarity plays a decisive role in identifying which segments stand in correspondence.

This paper is organized as follows. §2 presents a crosslinguistic typology of LDCA and discusses our findings that (i) participant consonants share a considerable degree of similarity to each other, and (ii) intervening segments are neutral. In §3 we establish the principles of the ABC approach in connection with the descriptive generalizations that our typology determines. §§4-5 demonstrate aspects of the depth and breadth of this model's application through case studies in long-distance laryngeal agreement and nasal agreement. In §6, we provide a critique of previous research that posits distance featural agreement as the outcome of linkage or spreading. Finally, in §7 we discuss some issues for further study and present the conclusion.

## 2. A TYPOLOGY OF LONG-DISTANCE CONSONANT AGREEMENT

2.1 CROSS-LINGUISTIC OVERVIEW. We begin our survey by defining Long Distance Consonant Agreement (LDCA):

- (4) **Long Distance Consonant Agreement (LDCA):** Agreement for an articulatory or acoustic property that holds between consonants separated by another segment.

LDCA may involve consonants separated by a single vowel, or by larger distances. Although this description excludes patterns limited to root adjacent assimilations, our formal analysis allows for their inclusion, but only as a subset of agreement at a greater distance, as discussed in §3.2.

LDCA encompasses both MSCs and alternations. Every language we have examined that has long-distance alternations also appears to have root structure constraints for the same features. This confluence may in fact have a diachronic explanation under the assumption that MSCs were original and subsequently extended to alternations. In languages with only MSCs, there are often lexical exceptions, suggesting either that lexical diffusion is incomplete or that loanwords are unincorporated. Nevertheless, this does not mean that MSCs are not synchronically part of the grammar (Frisch & Zawaydeh 2000, Ussishkin & Wedel 2003). Despite the historical origins, the parallel strongly points to treating MSCs and alternations synchronically with a unified analysis: they differ in their morphological domain of operation. Such a conflation has the further advantage of avoiding the *duplication* problem (Kenstowicz & Kisseberth 1977, see also Shibatani 1973, Clayton 1976, Hooper 1976). MSCs were originally conceived as static rules that applied to lexical entries before the application of any phonological (and/or morphological) rules (Chomsky & Halle 1968). Subsequent phonological rules applying at the word level had the potential to duplicate the work of MSCs, as they were formally distinct. The architecture of Optimality Theory (OT), in which our analysis is couched, eliminates the duplication problem by articulating MSCs in terms of constraints on the output, a consequence of the Principle of Richness of the Base, which prohibits constraints on inputs (Prince & Smolensky 1993). Both will be analyzed as output constraints; MSCs operate within a smaller subset domain than that of alternations.

What we call LDCA is not coextensive with what is often called ‘consonant harmony’. While many cases of LDCA fall under this label in the literature, it has also been used to refer to other phenomena. Some harmonies involving consonants also operate over a distance in that they do not terminate at the immediately adjacent segment; however, they are local in that they affect a contiguous string of segments, including vowels. Such patterns are witnessed, for example, with the feature [nasal] and in the phenomenon known as emphasis spread. We reserve the term ‘harmony’ to describe these cases. They stand in contrast to the nonlocal nature of LDCA, which has the capacity to skip certain intervening segments. Dissimilation also does not fall within our

survey (cf. Shaw 1991), although we note that it shows certain similarities to agreement. For a recent overview of dissimilation, see Suzuki (1998).

Other uses of the term ‘consonant harmony’ have included sound symbolism alternations (Nichols 1971, Cole 1987) and morphological harmonies such as Salish glottalization (Reichard 1938, Cole 1987) or Chaha labialization (Leslau 1967).<sup>1</sup> We do not address these in this paper for two reasons. First, they do not form a cohesive class. For example, some morphological harmonies arose from vowel-consonant interaction, which would fall outside the scope of consonant agreement. Second, many such cases are morphological rather than phonological, in the sense that a series of consonants alternates to convey morphological information, but not necessarily with an overt triggering element. This is particularly true of diminutive consonant symbolism in Native American languages, which show alternations that are not always triggered by an overt affix, and even if they do, do not show a consistent featural relationship. For example, in Wiyot (Teeter 1964) the diminutive suffixes *-ic*, *-oc* and *-oč* cooccur with stem alternations not only from /s/ to [š], but also from /l/ to [r]. In Luiseño (Kroeber & Grace 1960), the diminutive suffix *-mal* triggers shift of /š/ to [s] and sometimes /r/ to [ð]. It is not clear what featural relationship these shifts share. Nichols (1971:838) further notes that ‘symbolic shifts are never duplicated in regular phonological rules of a single language’, reinforcing that they have a morphological symbolic function only. In contrast, consonant agreement is a phonological restriction operating between two or more output consonants. Due to these reasons, we prefer to be conservative in this paper and exclude morphological harmonies and sound symbolism from the typological survey. See Cole (1987), Akinlabi (1996), Rose (1997), Zoll (1998) and Kurisu (2001) for further discussion.

2.1.1 AGREEMENT TYPES. The typology of LDCA includes nasal agreement, liquid agreement, laryngeal agreement and coronal and dorsal agreement. We present each case in turn and point out two key characteristics that unite them: the similarity of the interacting consonants and the neutrality of the intervening segments. We list only certain representative languages – for a more extensive list, we refer the reader to Hansson (2001).<sup>2</sup>

2.1.1.1 NASAL. Nasal agreement across intervening vowels and consonants is found in Kikongo (Ao 1991, Odden 1994, Piggott 1996) and Yaka (Hyman 1995, Walker 2000b). Nasal

agreement in the Adamawa-Ubangi language, Ngbaka (Thomas 1963, Wescott 1965, Mester 1986, van de Weijer 1994), presents a case outside of Bantu. The key property of nasal agreement that distinguishes it from the pattern that we call nasal harmony (Piggott 1992, 1996, Walker 1998[2000]) is that intervening vowels (and other consonants) are not nasalized.

Examples of nasal agreement in the Kikongo perfective active suffix following a nasal consonant in the stem domain are repeated in (5) from (1). The suffix consonant phoneme is variably realized as [d] or [l] when oral, as we elaborate in §5.

- (5) a. m-[bud-idi]<sub>stem</sub> 'I hit'                      b. tu-[kun-ini]<sub>stem</sub> 'we planted'  
       n-[suk-idi]<sub>stem</sub> 'I washed'                      tu-[nik-ini]<sub>stem</sub> 'we ground'

The segments that interact with a nasal in the suffix alternation are voiced stops and oral sonorant consonants. In addition, Kikongo has an MSC wherein these consonants do not appear after a nasal. In the case of Ngbaka, nasals do not cooccur with prenasal stops of the same place of articulation in the root.

In Ndonga (Viljoen 1973), suffixal /l/, as in (6a), shows nasal agreement when a nasal occurs in an adjacent (open) syllable, as seen in (6b-c) (vowel height in the suffix is controlled by harmony). If more than a vowel intervenes, agreement does not obtain (6d).

- (6) a. pep-el-a 'blow towards'                      c. kun-in-a 'sow for'  
       b. kam-en-a 'press for'                         d. nik-il-a 'season for'

Other Bantu languages such as Bemba (Hyman 1995) and Lamba (Doke 1938, Odden 1994, Piggott 1996) also show agreement only over an intervening vowel. These cases are also considered long-distance, but they operate over a shorter span due to an independent proximity restriction, which we discuss in §3.

Among the consonants that participate in nasal agreement, approximant consonants and nasals share the property of being sonorants, and voiced stops and nasals share the property of being voiced noncontinuants. In some languages, nasal agreement is extended to include voiceless consonants as well, although this is less common. In Ganda, nasal agreement affects homorganic voiceless stops following a nasal within a lexical root (Bantu; Katamba & Hyman 1991, Hansson 2001). The structures in (7a-b) are well-formed in Ganda, while those in (7c-d) are disallowed. N, D and T symbolize a homorganic nasal, voiced stop and voiceless stop, respectively

- (7) a. NVN -nónà ‘fetch’ c. \*NVD, \*DVN  
 b. TVN -tana ‘go septic’ d. \*NVT

Tiene (Bantu) also presents a case. Voiceless consonants – as well as voiced – participate in nasal agreement within the ‘prosodic trough’ (Hyman 1996, Hyman & Inkelas 1997, Hansson 2001).<sup>3</sup>

2.1.1.2 LIQUID. LDCA also affects liquids, although interaction among liquids is more commonly dissimilatory in nature (e.g. Latin (Jensen 1974, Steriade 1987), Georgian (Fallon 1993, Odden 1994, Sundanese (Cohn 1992)). In the Bantu language, Bukusu, /l/ in the benefactive suffix /-ila/, shown in (8a), becomes [r] after a stem containing [r] in (8b) (Odden 1994). The quality of the suffix front vowel is regulated by height harmony.

- (8) a. teex-ela ‘cook for’ b. kar-ira ‘twist’  
 lim-ila ‘cultivate for’ reeb-era ‘ask for’  
 iil-ila ‘send thing’ resj-era ‘retrieve for’

Liquid agreement operates over intervening vowels and nonliquid consonants. The segments are highly similar, differing in Bukusu only for the alternating feature [lateral].

Liquid agreement is also found in the Austronesian language, Ponapean (Rehg 1981, Hansson 2001), and in the Chadic language, Hausa, with the retroflex flap and /l/ (Newman 2000, Hansson 2001). In the Bantu language, Kipare (Odden 1994), the glide /j/ of the perfective suffix /-ije/ and applied suffix /-ija/ is realized as [r] following [r] and as [l] following [l] in the immediately preceding syllable. Again, the interacting segments are all sonorant approximants.<sup>4</sup>

2.1.1.3 LARYNGEAL. The laryngeal features that we assume are [voice], [spread glottis] ([sg]) and [constricted glottis] ([cg]) (Lombardi 1991). The feature [sg] characterizes aspirated segments and [cg] marks ejectives, implosives and other glottalized segments. All these features show LDCA effects among oral stops. In some cases, a homorganicity restriction is imposed.

VOICE. In Kera, a Chadic language, voiceless velar stops in prefixes and suffixes are voiced if the stem contains voiced oral stops and affricates; other voiced segments do not trigger the voicing agreement (Ebert 1979, Odden 1994, Walker 2000a).

- (9) a. /kV-gàr/ → [gə̀gà̀r] ‘knee’  
 b. /dʒà̀r-ká/ → [dʒà̀rgá] ‘colorful’ (fem.)

- c. /kV-màanə/ → [kəmàanə] \*[gəmàanə] ‘woman’  
 d. /kV-sár-káj/ → [kəsárkáj] \*[gəsárgáj] ‘black’ (coll.)

As mentioned in §1, in Chaha, a Semitic language, stops in a root agree for voicing (Banksira 2000). Fricatives do not participate in the restriction, and we find roots with a mix of voiced and voiceless obstruents such as /sdβ/ ‘curse’, /kzβ/ ‘become inferior.’<sup>5</sup> Voicing restrictions on stops also hold in Ngbaka stems (Thomas 1963, Wescott 1965, Mester 1986, van de Weijer 1994, Walker 2000a), with an additional caveat that the stops be homorganic. Finally, Proto-Indo-European is reported to have a voicing agreement between stops in roots under the Glottalic Theory (Gamkredlidze & Ivanov 1973, Hopper 1973, Salmons 1993). In summary, voicing agreement generally holds between oral stops only.<sup>6</sup> Hansson (2001) points out the case of Ngizim, a Chadic language (Schuh 1978, 1997), in which nonimplosive obstruents in a root agree for voicing.<sup>7</sup>

SPREAD GLOTTIS AND CONSTRICTED GLOTTIS. The other laryngeal features, [sg] and [cg] demonstrate MSCs, but we have found no active alternations in affixes.<sup>8</sup> These constraints, which require that oral stops match for [cg] or [sg], may hold over homorganic stops or stops in general.

In Yucatec Mayan (Straight 1976, Yip 1989) homorganic stops and affricates must match for [cg] to cooccur in a root. Roots such as \*k’Vk are ruled out. If both consonants are [cg], they must be identical, so \*t’Vk’ is impossible. MacEachern (1997[1999]) documents several cases of laryngeal constraints requiring agreement among homorganic stops in roots. For example, in ‘Bolivian’ Aymara,<sup>9</sup> Hausa and the Mayan language, Tzujutil, stops are not required to agree for place, but if they do, then they must match for [sg] or [cg] specifications. This restriction holds over stops separated by both vowels and consonants. Other languages have no restrictions on the homorganic nature of stops. In Kalabari Ijo (Ijoid; Jenewari 1989, Hansson 2001), voiced stops must agree for [cg], being either implosive or plain voiced. In Chaha (Banksira 2000), stops in a root display a restriction that they not differ in laryngeal specification, being either ejectives or voiced, as we saw above in (2). The Bolivian Aymara and Chaha cases are analyzed further in §4.

In all of these languages, [sg] and [cg] are characteristic of stops/affricates only. While glottalized fricatives are possible, they are rare and are often realized phonetically as affricates. Fricatives are not aspirated, although Vaux (1998) has argued that [sg] can characterize plain voiceless fricatives (see also Kingston 1990, Stevens 1998). Yet, we know of no agreement effects

obtaining between fricatives and aspirated stops. We also found no agreement between glottalized sonorants and obstruents.

2.1.1.4 CORONAL. There are three types of coronal LDCA: sibilant agreement, dental agreement and retroflex agreement. All involve features that refer to the tongue tip/blade (Gafos 1996[1999]) and are therefore only relevant to coronals.

SIBILANT. The most common type operates among sibilant fricatives and affricates, producing alternations such as [s]/[ʃ]. This has previously been termed ‘*sibilant* harmony’. (The term ‘sibilant’ is strictly inaccurate, since at least in Tahltan, harmony involves interdental nonsibilant fricatives.) This type of agreement is documented in many Native American languages, including the Athapaskan languages Navajo (Hojier 1945, Sapir & Hoijer 1967, Kari 1976, McDonough 1990, 1991), Tahltan (Hardwick 1984, Nater 1989, Shaw 1991, Clements 2001), Chilcotin (Cook 1983, 1993), Chiricahua Apache (Hojier 1939, 1946) and Kiowa Apache (Bittle 1963), Uto-Aztecan Southern Paiute (Sapir 1931, Harms 1966), and Mayan languages such as Tzutujil (Dayley 1985) and Tzeltal (Kaufman 1971). It is also found in Basque (Hualde 1991, Trask 1997, Clements 2001), Imdlawn Tashlhiyt Berber (Elmedlaoui 1992), Moroccan Arabic (Heath 1987), Bantu languages such as Kinyarwanda (Kimenyi 1979) and Kirundi (Ntahirageza 1993), and Omotic languages such as Aari (Hayward 1990) and Maale (Amha 2001). The key characteristic of sibilant agreement is that it holds between coronal fricatives and affricates, but oral stops (coronal and noncoronal) and all other consonants and vowels are transparent.

An example from Aari (Hayward 1990) is given in (10) with the causative suffix /-sis/, which is realized as [ʃiʃ] when palatoalveolar affricates or fricatives occur anywhere in the preceding stem (10b). Note that the initial suffix consonant is voiced adjacent to a voiced obstruent.

- |      |    |         |                        |             |                        |
|------|----|---------|------------------------|-------------|------------------------|
| (10) | a. | giʔ-    | ‘hit’                  | giʔ-sis-    | ‘cause to hit’         |
|      |    | duuk-   | ‘bury’                 | duuk-sis-   | ‘cause to bury’        |
|      |    | sug-    | ‘push’                 | sug-zis-    | ‘cause to push’        |
|      | b. | naʃ-    | ‘like, love’           | naʃ-ʃiʃ-    | ‘cause to like’        |
|      |    | tʃʰaaq- | ‘curse, swear an oath’ | tʃʰaaq-ʃiʃ- | ‘cause to curse, etc.’ |
|      |    | ʃaan-   | ‘urinate’              | ʃaan-ʃiʃ-   | ‘cause to urinate’     |
|      |    | ʒaaq-   | ‘sew’                  | ʒaaq-ʒiʃ-   | ‘cause to sew’         |

In Kinyarwanda (Kimenyi 1979:43) sibilant agreement operates in the opposite direction: alveolar fricatives in the root become palatoalveolar when preceding a palatoalveolar fricative in a suffix:

- (11) a. /ku-sas-a/            [gusasa]            ‘to make bed’  
           /ku-sas-iiʃ-a/        [guʃaʃiiʃa]        ‘to cause to make the bed’  
       b. /ku-soonz-a/        [gusoonza]        ‘to get hungry’  
           /ku-soonz-iiʃ-a/      [guʃoonʒeeʃa]    ‘to cause to make get hungry’

In many languages, directional sibilant agreement occurs irrespective of affix/root affiliation of the sounds and may produce an assimilation pattern that converts, for example, /s/ to [ʃ] and /ʃ/ to [s]. Although sibilant agreement is most commonly regressive, the Aari case shows that regressive directionality is not a fixed property. In Aari, the morphological root controls changes in the suffix.

DENTAL. The second type of coronal LDCA operates among stops and is found in languages with alveolar-dental contrasts. It is particularly prevalent in Nilotic languages, such as Mayak (Andersen 1999), Shilluk (Gilley 1992), Anywa (Reh 1996), Paeri (Andersen 1988) and (Dho)Luo (Stafford 1967, Yip 1989, Tucker 1994). In most of these languages, agreement is found strictly as an MSC holding over the cooccurrence of alveolar and dental stops. In languages that allow dental nasals, the constraints also hold of nasal stops. In Anywa (Reh 1996), there is no cooccurrence of dental and alveolar stops in a root. In addition, a root final [l] or [r] is realized as a voiced alveolar stop with the patient-deleting suffix /-o/, as in (12a). If following a root initial dental stop, however, it must be dental as in (12b). A similar process is found in Paeri (Andersen 1988).<sup>10</sup>

- (12) a. dāl      dūdò ‘to fold something’                      b. ḍīr      ḍīḍò ‘to jostle’  
           nūr      nūdó ‘to press something down’                      ṭōr      ṭòḍò ‘to finish’  
           līer      líedó ‘to hang’

Since roots are of the shape CV(V)C, there are no intervening consonants that can be examined for transparency or opacity to the agreement.

In Mayak, alternations are found in the affixes themselves, and unlike Anywa, agreement converts a dental stop to alveolar rather than alveolar to dental. The singulative suffixes /-ɛṭ/ and /-ʌṭ/ and the suffix /-iṭ/ may optionally be realized with an alveolar [t] when the root contains an alveolar stop, including the implosive stop [ɖ] (13b). The alveolars /l/ and /n/ fail to initiate LDCA as shown

in (13a). They also do not block agreement, as seen in (13b). Only oral stops show the dental/alveolar contrast, and it is only among these consonants that agreement operates.

(13)	a.	bəɛl-ɛ̄t̚	‘cane’	b.	d̄im-ɛ̄t̚	~	d̄im-ɛt	‘bird’
		ŋaj-ɪ̄t̚	‘snail’		kɛt-m-ɛ̄t̚	~	kɛt-m-ɛt	‘star’
		ʔim-ʌ̄t̚	‘intestine’		tid-ʌ̄t̚	~	tid-ʌt	‘doctor’
					tuy-ɪ̄t̚	~	tuy-it	‘back of head’

RETROFLEX. The third type of coronal agreement involves retroflexion. Breeze (1990:10) reports that in Gimira (Benchnon), an Omotic language of Ethiopia, ‘no two palatoalveolar fricatives or affricates within a root morpheme can differ in the feature of retroflexion’.<sup>11</sup> Gimira has a series of plain coronal obstruents [t ts tʃ tʃ̣ s z ʃ ʒ] and retroflex [tʂ tʂ̣ ʂ ẓ]. Roots such as the following are attested. The numbers indicate tone levels.

(14)	ʂaʂ 3	‘vein’	ʃatʃ 4	‘stretcher’
	tʂ̣ʊtʂ̣ 4	‘louse’	tʃ̣ʌʃt 4	‘be pierced’

The causative affix /-s/ shown in (15a) undergoes retroflex and palatoalveolar agreement with preceding root segments, as in (15b). A final root segment is often dropped; single final alveolar stops fuse with the suffix to form an affricate:

(15)	<b>Stem</b>		<b>Causative</b>
a.	mak 2	‘say’	mas 2 ‘cause to say’
	dub 4	‘dance’	dus 4 ‘cause to dance’
	kit 1	‘draw water’	kits 1 ‘cause to draw water’
b.	zert 1	‘be red’	zertʂ 1 ‘make red’
	ʂup 3	‘slaughter’	ʂuʂ 3 ‘cause to slaughter’
	tʂ̣ʊdʊ	‘spit’	tʂ̣ʊtʂ̣ ‘cause to spit’
	ʃid 3	‘remain’	ʃitʃ 3 ‘cause to leave’

Some Australian languages also present tongue tip orientation contrasts among coronal stops, but few effects of consonant agreement are attested. There are retroflexion alternations discussed in McGregor (1990) and Hamilton (1993) involving apical consonants. In Gaagudju, a word-initial apical alveolar stop is realized as retroflex preceding a retroflex consonant across an intervening vowel. Evans (1995) states that in Mayali, apical stops and nasals (but not retroflex /ɹ/) separated by

only a vowel agree in retroflexion. Sanskrit retroflexion is an oft-cited case of retroflex harmony, but it shows certain characteristics that set it apart from the others. We address it in §6.3.

All three coronal agreement cases show alternation for features that refer to the tongue tip or tongue blade; Gafos (1996[1999]) argues that coronal harmonies involve either the feature [tongue tip constriction area] ([TTCA]) or the feature [tongue tip constriction orientation] ([TTCO]). Segments that participate in sibilant agreement are highly similar in that only fricatives and affricates are involved to the exclusion of stops. The dental/alveolar alternation involves only stops. Finally, retroflexion involves either oral stops or fricatives/affricates. It may also include nasals and rhotics if the language contains alveolar and retroflex sonorants.

2.1.1.5 DORSAL. The final type we consider is Dorsal agreement. Our discussion is based on examples identified in Hansson (2001). Dorsal agreement involves alternations or restrictions between velar and uvular articulations. These segments are distinguished by the feature [high] (Chomsky & Halle 1968) or [retracted tongue root] ([RTR]) (Czaykowska-Higgins 1987, Goad 1989), and in feature geometric models, are characterized with a Dorsal node.

In the Totonacan language, Tlachichilco Tepehua (Watters 1988), /k/ in a derivational prefix, such as /ʔuks-/ (16a), is realized as uvular if a uvular follows in the stem (16b):

- (16) a. /ʔuks-k'atsa:/            ʔuksk'atsa:            'feel, experience sensation'  
       b. /ʔuks-laqts'-in/            ʔoqslaqts'in            'look at Y across surface'

Dorsal agreement takes place across intervening vowels and consonants. Although high vowels may be lowered when adjacent to uvulars (note the lowering of /ʔuks-/ to [ʔoqs-] in (16b)), this only occurs in a strictly local environment and does not interfere with dorsal agreement. This underscores that dorsal agreement cannot be analyzed as extension of a feature to all segments in the domain; otherwise nonlocal vowel lowering should result. Hansson (2001:94) points out that when intervening high vowels are not adjacent to one of the two agreeing uvular consonants, they do not lower. In the example /lak-pu:tiq'i-ni-j/ → [laqpu:teʔenij] 'X recounted it to them', /i/ lowers to [e] directly preceding the uvular (the [q'] debuccalizes to [ʔ]), but /u:/ located between the agreeing dorsal consonants fails to lower to [o:]. Other cases of dorsal agreement are found in Misanla Totonac (MacKay 1999), Aymara (De Lucca 1987, MacEachern 1997), Ineseño Chumash (Applegate 1972) and the Dravidian language, Malto (Mahapatra 1979).

In conclusion, there are five main types of consonant agreement: nasal, liquid, laryngeal, coronal and dorsal, along with various sub-types.<sup>12</sup> Several key properties of LDCA emerged from the discussion. First, the typology includes both MSCs and active alternations. Second, the agreeing consonants share a high degree of similarity. Third, segments intervening between the agreeing consonants are unaffected by the agreeing feature, and do not block agreement. In the next two sections, we will elaborate on the similarity and blocking characteristics of LDCA.

2.2 SIMILARITY. LDCA phenomena share the general property that the interacting segments bear a high level of ‘similarity’. We view similarity as determined by shared features, and our typology reveals that in terms of features, [sonorant], [continuant] and place features are the most important in identifying classes of similar segments. Segments within these classes are differentiated by one or more minor features such as [lateral] or [voice]. The following table summarizes our similarity findings with respect to LDCA, and lists one example language for each type:

(17)

TYPE	SUB-TYPE	EXAMPLE LANGUAGE	INTERACTING SEGMENTS
Laryngeal	voice	Kera (Ebert 1979) Ngizim (Schuh 1978, 1997)	Oral stops <i>or</i> obstruents
	constricted glottis	Chaha (Leslau 1979)	Oral stops
	spread glottis	Aymara (MacEachern 1997[1999])	Oral stops
Nasal		Kikongo (Meinhof 1932, Ao 1991, etc.)	(Voiced) stops <i>or</i> consonantal approximants
Liquid	rhotic	Bukusu (Odden 1994)	Liquids
	lateral	Kipare (Odden 1994)	Approximants
Coronal	sibilant	Aari (Hayward 1990)	Fricatives & affricates
	retroflex	Gimira (Breeze 1990) Mayali (Evans 1995)	Fricatives & affricates <i>or</i> Stops & affricates
	dental	Mayak (Andersen 1999)	Stops (affricates)
Dorsal	retracted tongue root	Tlachichilco Tepehua (Watters 1988) Malto (Mahapatra 1979)	Stops <i>or</i> obstruents

Homorganicity is an independent requirement that may be imposed on laryngeal and nasal agreement. We also note that laryngeal specifications do not usually impact Coronal or Dorsal agreement. For example, sibilant agreement may obtain regardless of the [cg] or [voice] features of the interacting consonants, as seen with the Aari example in (10). Similarly, dental and retroflex agreement operates between stops regardless of voicing. The major Place nodes, Labial, Dorsal, Coronal and Pharyngeal do not show long-distance agreement. We discuss possible reasons for

their exclusion in §7.

The notion of ‘similarity’ in MSCs has previously been noted by Pierrehumbert (1993), van der Weijer (1994), Broe (1996), Frisch (1996), Frisch *et al.* (in press) and MacEachern (1997 [1999]), although most of these works focus primarily on dissimilatory constraints (but Frisch *et al.* in press discuss possible extensions to harmony systems). The metric for computing similarity proposed by Frisch *et al.* (in press) relies on feature classes, groups of segments characterized by a set of distinctive features. Similarity is obtained by calculating the shared feature classes of two segments in a given language inventory and dividing it by the number of shared feature classes plus non-shared feature classes. The similarity metric is based on individual language inventories, but the method uses universal features and natural classes. Therefore, even though a particular pair of consonants will not have the exact same similarity rating in different languages, its position as more or less similar with respect to another consonant pair will be maintained. Although it was developed for other phenomena, this method of computing similarity is successful in establishing relevant hierarchies between sets of consonants found in consonant agreement, and we adopt it here. For example, homorganic consonants are computed as more similar than heterorganic, and nasal stops are more similar to voiced stops than to voiceless stops, a pattern found in nasal agreement (see §5 for more details). Although it cannot predict precisely which consonant agreement patterns a given language has, it provides general guidelines concerning which consonants are more likely to participate in different agreement patterns. In addition, Frisch *et al.* (in press) point out their metric might be further refined by adjusting the weight features carry, in particular they suggest that major manner features, such as [sonorant], might be weighted more heavily in computing similarity, and this is consistent with our observations about LDCA.

The similarity requirement on agreeing segments in LDCA is not systematically found in other kinds of assimilatory systems involving consonants, and this sets LDCA apart. We claim that the interacting segments in harmony systems are driven by satisfaction of alignment or spreading rules/constraints. Participant segments are those contained within the domain of spreading that are sufficiently phonetically compatible with the spreading feature (Cole & Kisseberth 1995, Walker 1998[2000], but see Piggott 1992 on nasal harmony); for example, nasal harmony regularly affects vowels, which are relatively compatible with superimposed nasalization, but vowels do not interact

with nasals in LDCA. On the other hand, if specific targets are apparently singled out in harmonies, one proposal (Gafos 1996[1999]) maintains that it is the contrastive nature of the segments that determines their perceptible participation as targets or triggers of harmony. While this may be true of many cases of consonant agreement, it is not a reliable predictive factor in compelling participation. For example, Chaha voice agreement, discussed in §2.1.1.3 and in §4, singles out stops for agreement, but fricatives do not participate despite a contrast between /s/ and /z/. In Anywa, discussed in §6, nasal stops participate in dental agreement even though there is no phonemic contrast between nasal dental and alveolar stops.

2.3 BLOCKING EFFECTS. The other main characteristic of consonant agreement systems that we have identified is that intervening segments do not block agreement, and they are unaffected by the agreeing feature, that is, they are ‘skipped’.<sup>13</sup> Long-distance assimilations in which consonants play a role and which show blocking effects, such as nasal harmony, emphasis harmony or labial harmony, show other properties that set them apart from the LDCA typology. Most notably, they affect contiguous strings of segments, i.e. they are local, and the assimilation does not hold between consonants alone; vowels may trigger the assimilation and be audibly affected themselves. Moreover, the set of interacting segments are not regularly those that are most similar. There are two main sources of blocking in these systems: blocking by segments incompatible with the harmonic feature and blocking by segments specified for the feature.

In nasal harmony, obstruents often block assimilation of [nasal]. In Ijo (Kwa) (Williamson 1965, 1969, 1987, Walker 1998[2000]), leftward nasal harmony issues from a nasal consonant or nasal vowel (18a), but obstruents block the assimilation (18b).

- |      |    |      |           |    |        |        |
|------|----|------|-----------|----|--------|--------|
| (18) | a. | ãnda | ‘wrestle’ | b. | izõngo | ‘jug’  |
|      |    | ĩãĩ  | ‘shake’   |    | abãmu  | ‘loft’ |

Obstruents are the least likely segments to participate in nasal harmony systems. This stands in contrast to nasal consonant agreement, where voiced stops are often targets, and other obstruents, which often remain unaffected, do not interfere with the agreement. A comparable blocking effect is found in emphasis harmony in some dialects of Arabic, which may be halted by high vowels and palatal consonants (Hoberman 1989, Davis 1995, Shahin 1997). Archangeli & Pulleyblank (1994) and Davis (1995) argue that the feature [RTR], which requires retraction of the tongue root, is

antagonistic to segments that require a contradictory gesture, raising of the tongue body. In Dorsal agreement, however, consonants agree for the feature [RTR] despite the presence of intervening high vowels, which do not lower and do not block. Nasal harmony and emphasis harmony have been analyzed in terms of feature spreading between contiguous segments (e.g. Davis 1995, Walker 1998[2000]), and we believe that is correct. In cases where the spreading feature reaches a segment with which it is incompatible, the spreading is ended.

Harmony may also be blocked when an intervening segment is specified for the assimilating feature. An example is found in Nawuri labial harmony (Casali 1995), in which round vowels and glides cause a high vowel in an immediately preceding syllable to become round (19a). The assimilation is blocked by intervening plain labial consonants (in careful speech) (19b). The alternations shown here involve a singular noun class prefix /gI-/, where /I/ represents a high vowel whose roundness and ATR qualities are determined by the following vowel.

- |      |    |           |              |    |           |           |
|------|----|-----------|--------------|----|-----------|-----------|
| (19) | a. | gɪ-sɪbɪta | ‘sandal’     | b. | gi-mu     | ‘heat’    |
|      |    | gi-ke:li: | ‘kapok tree’ |    | gi-fufuli | ‘white’   |
|      |    | gɔ-sɔ     | ‘ear’        |    | gi-pula   | ‘burial’  |
|      |    | gu-jo     | ‘yam’        |    | gi-bo:to: | ‘leprosy’ |

Casali (1995) analyzes this assimilation as spreading of [labial] from a [-consonantal] segment. He obtains the blocking by labial consonants through a feature geometry in which the Place node and its dependent features (e.g. [labial], [coronal], etc.) occupy the same tier in consonants and vowels. Labial consonants therefore block rounding harmony because their [labial] feature prevents [labial] spreading from a neighboring vocoid via a prohibition on line crossing (Goldsmith 1976).

Once again, the blocking phenomenon has been treated in terms of the mechanics of (local) feature spreading. Like the nasal and emphasis harmonies, the Nawuri data are compatible with an analysis under which continuous strings of segments are affected. Ní Chiosáin and Padgett (1997) have argued that the consonants which intervene between assimilating vowels also undergo harmony themselves, though frequently not audibly so. We return to this issue in §6. These harmony cases stand in stark contrast to the LDCA cases outlined in 2.1, which show no blocking either due to featural incompatibility or to specification with the agreeing feature. The approach we take to LDCA treats it separately from spreading-based phenomena. In the next section, we turn to the formal

treatment of LDCA that we propose and its underpinnings.

### 3. LONG-DISTANCE AGREEMENT BY CORRESPONDENCE

3.1 SIMILARITY INSTIGATES SOUND RELATIONS. Our typology reveals a correlation between LDCA and similarity between the agreeing consonants. Building on Walker (2000a,b, 2001a), we propose that similarity forms the basis for establishing a formal relation between the interacting segments. We hypothesize that LDCA patterns have their functional origins in language production, in particular, the phonological planning of speech (i.e. organization and sequencing of abstract units) and its execution (i.e. motor controls that accomplish the ‘plan’). Considerable psycholinguistic evidence shows that speakers form connections between similar segments and that similar but different segments pose problems in speech production. By rendering similar sounds identical in some property, LDCA thus has the potential to facilitate production. As we outline below, we suggest that LDCA may arise through production-based pressures in diachronic change but may also operate as an active constraint in a synchronic grammar. We leave open the possibility that perception-based factors might also play a role, but focus chiefly on the production basis here.

Language production studies have firmly established that the production of a given consonant primes or activates other consonants in the word or phrase that share a large number of features. This is apparent in patterns of speech errors, for which it has been widely established that consonants sharing greater similarity have an increased likelihood to participate in a slip of the tongue (Nooteboom 1967, MacKay 1970, Fromkin 1971, Shattuck-Hufnagel & Klatt 1979, Kupin 1982, Stemberger 1982, Levitt & Healy 1985, Frisch 1996, Vousden *et al.* 2000). It is observed that near-identical sounds often shift to identical ones. Representative examples include mispronunciation of the phrase *subjects show* as *shubjects show* (Shattuck-Hufnagel & Klatt 1979), and misproducing *yellow* in the tongue twister *red lorry, yellow lorry* as *yerow* or *yeyow*. Priming among similar segments within words is also made evident by phonologically-based analogical pressure. Zuraw (2000) observes that segments in similar syllables are often rendered identical, English examples include *pompon* -> *pompom*, *sherbet* -> *sherbert*.<sup>14</sup>

Although speech errors of this kind are often described in terms of segment substitution, several studies have now shown that an individual articulatory gesture or feature may be mistakenly repeated in a similar sound while another gesture or feature does not carry over (Mowrey & MacKay 1990,

Frisch & Wright 1996-1997, 2002, Pouplier *et al.* 1999). This parallels the pattern of LDCA. Moreover, work by Pouplier *et al.* (1999) reveals that erroneous (partial) carryover of a gesture from one segment to another may take place without producing audible consequences for the listener. This suggests the occurrence of errors in speech production is considerably higher than indicated by counts of perceived errors. Errorful productions would therefore seem to present a greater problem for speakers than previously conceived. In addition, the sources of production errors between similar sounds might well be richer than assumed under traditional planning-based scenarios. A study by Pouplier & Goldstein (2002) finds that not all speech errors manipulate static abstract units alone: they can be gradient and produce segments that are not phonotactically well-formed in the language. This, they argue, suggests that errors may arise not only from miscoordination of planning, but also through dynamically-based miscoordination in execution.

In the aggregate, the speech error research suggests that the occurrence of similar but different consonants in an utterance presents production difficulties that are mitigated by a shift towards identity. This point has been addressed in spreading activation models of language production processing (e.g. Dell & Reich 1980, Dell 1984, 1986, Stemberger 1985, MacKay 1987). The most relevant aspect of this modeling is that each of the featural or gestural properties of a consonant causes the associated processing nodes to become ‘activated’. In a word containing two consonants that have only a small degree of difference, there is a significant overlap in the nodes that receive activation. The production-based difficulty for consonants that are near-identical thus arises in coordinating their few separate properties and keeping the similar segments distinct. As seen in natural speech errors and errors associated with tongue twisters and certain other elicitation techniques, the tendency is to improve ease of production-related processing by overriding differences between the consonants and making some or all of their properties match.

We suggest that LDCA is a phonologized means of accomplishing such matching for individual features. We speculate that this may arise in a language first in the form of an MSC (see Walker *et al.* 2002). Morphemes containing combinations of consonants that are more prone to interact in a speech error would be excluded from the lexicon. This could emerge in diachronic language change, occurring gradually until the exclusion is systematic, and/or it could operate as an active synchronic condition. For example, one can observe the historical origins of Chaha laryngeal agreement

discussed in §4 by comparing it with related languages, such as Amharic, which lack the agreement, ex. Amharic [widək'] / Chaha [wit'ək'] 'fall' (Banksira 2000). In circumstances where affixation forms words containing consonant combinations excluded within morphemes, the condition could be extended by analogy to the entire word. This will produce alternations in affix consonants, such that they change to agree with some featural property of a root segment. The grammatical reflexes of MSCs versus alternations in a synchronic grammar would be the domains over which the relevant phonological constraints operate, i.e. morpheme or word.

Our hypothesized grounding of LDCA in speech production provokes the question whether errors and LDCA show a true parallel with respect to similarity, that is whether the same groupings of similar consonants are witnessed across these phenomena. A study by Walker *et al.* (2002) suggests an answer in the affirmative. They examined errors involving nasals [m, n] and oral stops in English elicited using the SLIPS error induction technique (Baars & Motley 1974). The stop consonant inventory of English is roughly comparable to that of certain Bantu languages showing nasal agreement (e.g. Kikongo, which affects homorganic/heterorganic stops, and Ganda, which affects homorganic stops only). Their results show that for the consonant pairs under scrutiny, those more likely to interact in long-distance nasal agreement parallel those participating in more errors. Specifically, there were more errors between nasals and voiced stops vs. nasals and voiceless stops, and more errors between nasals and homorganic stops vs. nasals and heterorganic stops.

Our suggested basis in language production is further strengthened by Hansson's (2001) typological finding that LDCA is predominantly regressive in cases where it is not root/stem controlled. Hansson points out that this directionality correlates with a tendency for speech errors involving near-identical segments to involve the early pronunciation ('anticipation') of a property of a segment sequenced later in the word or utterance. It should be noted, however, that regressivity in LDCA stands as a crosslinguistic tendency rather than an absolute – for instance, certain patterns of nasal agreement are progressive, as will be discussed in §5. The occurrence of anticipatory errors in speech rather than perseveratory ones likewise stands as a tendency.<sup>15</sup>

In sum, the interaction observed among near-identical sounds in speech production provides support for our claim that speakers construct a formal relation between similar segments. Furthermore, the parallels between speech error patterns and distance agreement lead to our

supposition that LDCA is a grammaticized avoidance of consonant combinations that may present production difficulties, resolved via matching of subsegmental properties.

Finally, the similarity basis for interaction is not limited to consonants, and we envision the potential for extension to other kinds of agreement patterns. Similar vowels are also observed to have increased likelihood of participation in speech errors (Shattuck-Hufnagel 1986), and certain vowel harmonies might be amenable to an account utilizing a similarity-based relation between vocalic segments. For example, Kaun (1995) has observed that vowels matching in height are more prone to participate in round harmony. Moreover, similarity has been observed to form a basis for relations established between constituents at levels higher than the segment, for instance, between words, producing analogical or paradigmatic effects (see Burzio 1999, 2000 on the notion of Gradient Attraction). We identify some additional cases in the next section.

3.2 THEORETICAL ASSUMPTIONS. We frame our analysis in Optimality Theory (Prince & Smolensky 1993) and adopt the Correspondence approach to faithfulness (McCarthy & Prince 1995, 1999). We assume familiarity with the core assumptions of this framework.

As anticipated in §1, we formalize the relation between consonants that interact in LDCA in terms of correspondence. Following the definition given by McCarthy & Prince (1995:262), two structures are in correspondence if a relation is established between their component elements. Correspondence constraints determine faithfulness of mapping between related structures by requiring identity of their structure and content.

In general, we posit that similarity is a source of correspondence between structures, that is, structures that are recognized as alike in many ways are prone to be associated together, and this connection may be grammaticized in terms of a correspondence relation. Similarity (which includes identity at its extreme) may be morphological and/or phonological in basis, and we suggest that both kinds of similarity may contribute to the occurrence of correspondence between structures. Consider the familiar examples of correspondence between input-output, stem-affixed stem and base-reduplicant. The occurrence of a correspondence relation in the first two cases is attributable to the morphological similarity/identity of the structures, and in the latter case it is the result of a morphological requirement that the reduplicant be phonologically similar to its base. In the case of Agreement by Correspondence (ABC), we suggest that correspondence between consonants in the

output arises from their phonological similarity.

Correspondence attributable to phonological similarity has been previously identified at higher levels of organization. On the basis of pseudo-reduplication phenomena, Zuraw (2000) has argued for a violable constraint requiring that syllables in a word stand in correspondence, and Suzuki's (1999) study of onset identity effects has accrued evidence for a constraint enforcing correspondence between onsets of adjacent syllables. Our proposal also connects to a broad range of other research identifying linguistic requirements that phonological elements in a word be repeated or copied outside of morphological reduplication (see Goad 1996, MacEachern 1997[1999], Rose 1997, Yip 1997, Kitto & De Lacy 1999, Ussishkin 1999, Clements 2001, Feng 2001, Krämer 2001, Pater 2003).

The requirement that a correspondence relation be established between similar segments in the output is expressed as a violable constraint, building on Walker (2000a,b, 2001a). The generalized schema for this type of constraint is given in (20).

- (20) **CORR-C $\leftrightarrow$ C**: Let  $S$  be an output string of segments and let  $C_i, C_j$  be segments that share a specified set of features  $F$ . If  $C_i, C_j \in S$ , then  $C_i$  is in a relation with  $C_j$ , that is,  $C_i$  and  $C_j$  are correspondents of one another.

We regard the schema in (20) as providing a framework for constraints requiring correspondence between any pair of segments belonging to the output, be they consonants or otherwise. In view of our present focus on consonant agreement, we adopt Walker's **CORR-C $\leftrightarrow$ C** label. Nevertheless, we allow that a more general **CORR-Seg $\leftrightarrow$ Seg** label would have utility in agreement phenomena not limited exclusively to consonants. In cases of consonant agreement, the restriction of **CORR-Seg $\leftrightarrow$ Seg** constraints to consonants will follow from their similarity. This is illustrated in the definition of the constraint that we label **CORR-T $\leftrightarrow$ D** in (21). This constraint requires that a correspondence relation be established between stops in the output that agree in place, i.e. pairs that are *at least* as similar as [t] and [d] (e.g. [...p...b...], [...d...t...], [...k...k...]).

- (21) **CORR-T $\leftrightarrow$ D**: Let  $S$  be an output string of segments and let  $X$  and  $Y$  be segments specified [-sonorant, -continuant,  $\alpha$ Place]. If  $X, Y \in S$ , then  $X$  is in a relation with  $Y$ , that is,  $X$  and  $Y$  are correspondents of one another.

To accommodate the gradient nature of similarity, we array individual **CORR-C $\leftrightarrow$ C** constraints in

a fixed hierarchy – a familiar implementation of scalar phenomena in the theory (see, e.g., Prince & Smolensky 1993, Kenstowicz 1994, Walker 1998[2000], Crosswhite 1999[2001]). The hierarchy is organized such that the more similar the pair of consonants, the higher ranked the requirement that they correspond. The portion of the correspondence hierarchy relevant for voicing agreement among stops is given in (22) (drawing on Walker 2000a). We note that the ranking of these constraints need not be stipulated, but is an expositional convenience. The implications follow from superset relations between constraints encompassing increasingly less similar segments.

(22) **Similarity-based correspondence hierarchy:**

CORR-T↔T	>>	CORR-T↔D	>>	CORR-K↔T	>>	CORR-K↔D
“identical stops”		“same place”		“same voicing”		“any oral stops”

The constraints in (22) are interpreted as follows. CORR-T↔T requires that a correspondence relation be established between stops that agree in place and voicing (e.g. [...t...t...], [...b...b...]). CORR-T↔D expresses the same requirement for the superset of stop pairs that match in place. CORR-K↔T encompasses any pair that agrees in voicing, including heterorganic pairs, and CORR-K↔D expands to any pair of oral stops.

We suppose that correspondence constraints exist only for segment pairs exceeding a certain threshold of similarity. In this study, we will use the similarity scales resulting from the method of computation proposed by Frisch *et al.* (in press) – which function as our basis for relative similarity – together with our survey of attested LDCA patterns as a guide to this threshold.

A schema of the relevant correspondence relations operating in a hypothetical form is given in (23). Faith-IO constraints enforce faithfulness between input and output. Within the output, CORR-C↔C constraints can produce correspondence between similar consonants. Constraints that we label Faith-CC (or Faith-SegSeg under more general circumstances) require identity of structure and content between these segments.

(23) Consonantal correspondence model:

Input	/b e p o/	
	⇕	<i>IO Faithfulness</i>
Output	[b e p o]	
	↔ ↗ ↘	<i>CC Faithfulness</i>

A Faith-CC constraint applicable to voicing is given in (24), again with expositional focus on consonants. It requires that if a segment in the output is specified as [voice], any corresponding

segments in the output must match in voicing specification. We assume that laryngeal features are monovalent, but the basic analysis is not altered if binary features are adopted instead.

- (24) **IDENT-CC(voice)**: Let  $C_i$  be a segment in the output and  $C_j$  be any correspondent of  $C_i$  in the output. If  $C_i$  is [voice] then  $C_j$  is [voice].

The constraint in (24) is formulated without reference to segment order. However, the existence in some languages of unidirectional rightward or leftward ABC which is not derivative from morphological structure will necessitate an elaboration in directional terms, as discussed in §5.

Constraints enforcing faithfulness between input and output also play a key role. Drawing on Pater (1999), we assume that IDENT constraints distinguish between the loss and gain of privative feature specifications (an extension also adopted by McCarthy & Prince 1995, 1999 for binary features). Examples are given in (25). IDENT-IO(voice) penalizes the loss of input [voice] specifications, and IDENT-OI(voice) punishes segments that acquire [voice] in the output.

- (25) a. **IDENT-IO(voice)**: Let  $\alpha$  be a segment in the input and  $\beta$  be any correspondent segment of  $\alpha$  in the output. If  $\alpha$  is [voice], then  $\beta$  is [voice].  
 b. **IDENT-OI(voice)**: Let  $\alpha$  be a segment in the input and  $\beta$  be any correspondent segment of  $\alpha$  in the output. If  $\beta$  is [voice], then  $\alpha$  is [voice].

We illustrate the above constraints' evaluation with respect to various candidates in (26). This tableau simply tabulates violations; constraints are unranked here. Subscripted letters notate CC correspondence. We assume that IO relations in the candidates here and in subsequent tableaux are such that segments with matching positions in the input and output strings are in correspondence.

(26) Correspondence among consonants in the output

/bepo/	ID-CC(voi)	ID-IO/OI(voi)	CORR-T↔T	CORR-T↔D	CORR-K↔T	CORR-K↔D
a. $b_x e p_y o$				*		*
b. $b_x e p_x o$	*					
c. $b_x e b_x o$		*(OI)				

Candidates (26a-b) do not display voicing agreement. In (26a) the homorganic consonants are not in correspondence, violating CORR-T↔D, and by implication, CORR-K↔D, as well. In (26b), the consonants are in correspondence, but they do not agree for voicing, incurring a violation of IDENT-CC(voice). Candidate (26c) exemplifies the ABC outcome. The consonants are in correspondence with each other and they agree in their voicing specification.

As (26) illustrates, CC-correspondence automatically favors a relation between segment pairs matching in the specified features whenever they occur in the output. In the preponderance of languages that do not show LDCA, Faith-IO/OI will be sufficiently high-ranked to block changes to segments that would be required to enforce agreement. In order for an LDCA pattern to be active, both the relevant IDENT-CC and CORR-C↔C constraint(s) must supercede an IO/OI faithfulness constraint.

It is also the case that LDCA may be moderated by proximity restrictions, which we formalize via a PROXIMITY constraint. Recall that in some languages, consonants that are relatively close together agree for a given feature, whereas those separated by a greater distance fail to agree. Compare the patterns in Kikongo and Ndonga, repeated here from §2:

(27) a. <b>Kikongo</b>	b. <b>Ndonga</b>
m-[bud-idi] <sub>stem</sub> ‘I hit’	[pep-el-a] <sub>stem</sub> ‘blow towards’
tu-[kun-ini] <sub>stem</sub> ‘we planted’	[kun-in-a] <sub>stem</sub> ‘sow for’
tu-[nik-ini] <sub>stem</sub> ‘we ground’	[nik-il-a] <sub>stem</sub> ‘season for’

In Kikongo, nasal agreement operates in the stem regardless of distance between the nasal and suffix consonant. In Ndonga, nasal agreement fails if the consonants are not in adjacent syllables.

Proximity is an independent requirement that may be imposed on interacting elements. It can be incorporated into our analysis through a proximity constraint:<sup>16</sup>

(28) **PROXIMITY**: Correspondent segments must be within the domain of adjacent syllables.

PROXIMITY is invariably obeyed in Ndonga, but it is violated in words of Kikongo in which nasal agreement holds between consonants separated by multiple segments, as shown in (29). By ranking PROXIMITY over the relevant CORR-C↔C and IDENT-CC constraints in Ndonga, nasal agreement will obtain only among consonants separated by no more than a single vowel, but consonants standing at a greater distance will fail to agree or correspond. When PROXIMITY is ranked lower, agreement obtains regardless of distance between the relevant consonants, as in Kikongo.

(29) <b>Ndonga</b>	PROXIMITY	<b>Kikongo</b>	PROXIMITY
kun <sub>x</sub> in <sub>x</sub> a	✓	tukun <sub>x</sub> in <sub>x</sub> i	✓
n <sub>x</sub> ikil <sub>y</sub> a	✓	tun <sub>x</sub> ikin <sub>x</sub> i	*

One important question is whether local noniterative root-adjacent assimilations might also be

subject to an analysis incorporating agreement through correspondence. In fact, there is nothing in the definition of correspondence that precludes such a situation, since the only restriction CORR-C $\leftrightarrow$ C places on correspondence is the similarity of the interacting segments. Nevertheless, just as CORR-C $\leftrightarrow$ C does not restrict adjacent segments from being in correspondence, it also does not restrict segments at a distance from being in correspondence. Therefore, if root-adjacent ABC occurs in a given language, it is predicted that the language will also exhibit ABC over a longer distance. This occurs in languages with consonant sequences, such as Tahltan (Shaw 1991). In Tahltan /s/ is altered to [ʃ] preceding palatoalveolar fricatives and affricates both in root adjacent contexts, ex. /hudi-s-tʃa/  $\rightarrow$  [hudifʃtʃa] ‘I love them’ and distance contexts, ex. /ya-s-tʃ’etʃ/  $\rightarrow$  [yaʃtʃ’etʃ] ‘I splashed it’. PROXIMITY is a separate constraint that regulates maximal distance between corresponding segments. If PROXIMITY is ranked higher than CORR-C $\leftrightarrow$ C and IDENT-CC, as in Ndonga, then the upper-bound of correspondence is limited to a window of adjacent syllables. If the language allows consonant sequences, root-adjacent agreement may also occur, but again only in addition to agreement within the limits PROXIMITY sets. We have not identified any language which exhibits this situation, since those languages whose LDCA is restricted by PROXIMITY have a limited range of consonant clusters.

Local assimilation is also regulated by factors other than correspondence through similarity, such as phonotactic factors and coarticulation, which by definition entails root adjacency. For example, post-nasal voicing is often attributed to a coarticulation difficulty in terminating voicing following a nasal (Hayes & Stivers 1995, Pater 1999). Prenasal voicing is also attested. In Spanish, /s/ is commonly voiced preceding nasals: ex. *mismo* [mizmo] ‘same’. This does not apply in cases of long-distance interaction, and we know of no cases of long-distance voicing agreement triggered by nasals. We conclude that local assimilations are triggered by separate constraints, and subject to separate pressures that do not apply at greater distances.<sup>17</sup> We return to this matter in §4, where we discuss laryngeal agreement in Chaha and contrast it with a separate case of local laryngeal spreading.

In what follows we explore the application of the ABC approach through two sets of case studies. The first considers laryngeal agreement in Chaha and Bolivian Aymara, and the second investigates nasal agreement in Ngbaka and Kikongo. Both pairs of languages contrast in the

strength of the similarity requirement enforced between agreeing segments, thereby revealing typological parallels across LDCA for different features. In addition, each set of case studies presents different properties that test the capacity of ABC to capture variation within the typology.

#### 4. CASE STUDIES I: LARYNGEAL AGREEMENT

The features [sg] and [cg] are grouped with [voice] to form the family of Laryngeal features. In this section, we examine two cases of laryngeal agreement in detail, showing how languages may differ in their similarity requirements. Chaha (Banksira 2000) has agreement effects in roots pertaining to both [cg] and [voice] in stops. A dialect of Aymara termed ‘Bolivian’ (De Lucca 1987, MacEachern 1997[1999]) shows agreement for [cg] and [sg] in roots for homorganic stops only.

4.1 CHAHA. Banksira (2000) reports that in Chaha, a Semitic Gurage dialect of Ethiopia, adjacent oral stops in a root may not differ in laryngeal specification. As this is a Semitic language, Banksira’s use of ‘adjacent’ refers to root adjacent segments, but assessed at the level of the morphological root. In actual stems, consonants will be separated by a templatic vowel in at least the perfective form of the verbal paradigm, producing a nonlocal effect. In accordance with the ABC analysis, agreement is assessed at the level of the output stem, not at the level of the underlying root, so consonants will be separated by an intervening vowel in the verbal paradigm. We will provide additional evidence that the agreement also holds at a distance across intervening consonants.

Stops are ejectives (30a), voiced (30b) or voiceless (30c). In general, the interacting stops are heterorganic, either coronal or velar. Due to Semitic MSCs that prevent consonants of the same place of articulation from cooccurring in roots (Greenberg 1950, Bender & Fulass 1978, Buckley 1997), there are few instances of homorganic stops in a root. We provide conjugations in the 3 ms. imperfective and imperative to illustrate that different vowels may appear between the consonants.<sup>18</sup> The Chaha consonant inventory is /t k t’ k’ d g f s z x m r β w j/ plus palatalized and labialized versions of some of these which may or may not be derived: [k<sup>j</sup> k<sup>j</sup>’ k<sup>w</sup> k<sup>w</sup>’ g<sup>j</sup> g<sup>w</sup> ∫ tʃ tʃ’ ʒ]. /x/ is included as separate from /k/, since, although they alternate in verb paradigms, their distribution is not entirely complementary.<sup>19</sup>

(30)	<b>Imperfective</b>	<b>Imperative</b>	
a.	ji-t'ək'ir	t'ik'ir	'hide!'
	ji-rət'ik'	nit'ik'	'snatch'
	ji-k'ət'ir	k'it'ir	'kill!'
	ji-rək'it'	nik'it'	'kick!'
b.	ji-dəg(i)s	dig(i)s	'give a feast!'
	j-ad(i)g	əd(i)g	'make fall!'
	ji-gədir	gidir	'put to sleep!'
	j-ag(i)d	əg(i)d	'tie!'
c.	ji-kətf	kitf	'hash (meat)!'
	ji-təks	tiks	'set on fire!'
	ji-kətkit	kətkit	'hit with a stick repeatedly!'

There are also numerous verb roots with agreement between stops across intervening consonants:

(31)	<b>Imperfective</b>	<b>Imperative</b>	
a.	ji-k'mət'ir	k'əmt'ir	'amputate'
	ji-t'əβk'	t'ibək'	'be tight'
b.	ji-dərg	dirg	'hit, fight'
	ji-grədf	gərdif	'grind coarsely'
c.	ji-kəft	kift	'open'

The labial stops do not participate in the agreement, either as triggers or targets. Banksira (2000) argues that the only phonemic bilabials in Chaha are the sonorants /m β/. The voiced bilabial stop [b] occurs as an allophone of /β/ word-initially, following nasals, and in certain morphologically-conditioned former gemination sites. The voiceless bilabial stop [p] only appears as a devoiced variant of this latter former geminate. Ejective [p'] does not occur except in a few Amharic loanwords. The restriction of the agreement effect to coronals and velars is a result of the limited distribution of labial stops. Assuming that agreement holds of surface forms, labial stops cannot be targets. The voiceless labial stop [p] is restricted to penultimate root position and will appear only to meet morphological requirements, which outrank laryngeal agreement. As for voiced [b], this

segment is also restricted; it is the sonorant [β] which appears in the paradigm in most instances (ex. [zəbək'ə] 'he daubed' vs. [jizəβk'] 'he daubs'). Since only stops participate in laryngeal agreement, paradigm uniformity would prevent consonant agreement from appearing in a subset of the paradigm. Labial stops also cannot trigger voicing for the same reason. Given these conditions, we limit our attention to the coronals and velars.<sup>20</sup>

Banksira does not mention cases of voiceless stops adjacent (at the level of the morphological root) to either ejectives or voiced stops, but we have found no examples of such roots. In a database of 855 Chaha verb roots including reduplicated forms compiled from Banksira (2000), Leslau (1979) and other sources, there are 117 verb roots with coronal and velar stops. All but 20 of these show laryngeal agreement, a rate of 83%. The 83% agreement rate is found for stops not separated by another consonant or 'adjacent' (58/70 verbs) as well as for those separated by another consonant (39/47 verbs). In our calculations, we treated consonants separated by 'weak' root consonants /j w a/ as being adjacent, since they are not separated by a consonant in the surface form. For example, the consonants /d/ and /k'/ are categorized as adjacent in a verb like [dak'əm] 'laugh', although many analysts would treat this verb as having a root with three segments /dak'/.<sup>21</sup> Based on these figures, we conclude that the laryngeal agreement effect is also active in positions separated by other consonants, but that in both adjacent and non-adjacent positions, the restriction is not absolute. MSCs often show lexical exceptions in this manner.

There are two possible interpretations of such exceptions. One assumes MSCs are no longer synchronically active (Paradis & Prunet 1993). Another recognizes that long-distance processes, be they consonantal MSCs or vowel harmony, tend to exhibit lexical restrictions and fail to adapt loanwords (Ussishkin & Wedel 2003). Either way, analyses utilizing lexically specific rankings or stratified lexicons (Itô & Mester 1995, Pater 2000) or lexically-specified co-phonologies (Inkelas *et al.* 1997) have been proposed to account for these differences. We therefore assume that the small class of words that does not respect the agreement is lexically specified with a higher-ranked IDENT-IO/OI constraint.

Fricatives are not targets of agreement (32a). Nor do fricatives and sonorants trigger agreement (32b):



One might counter that the difference between these two phenomena in Chaha is historical in nature: the LDCA is a lexicalized historical process and local spreading is an active synchronic process. However, this type of synchrony-diachrony dichotomy offers no explanation for the apparent inertness of fricatives in LDCA, even in alternations (as in Kera (see §2.1.1.3)), compared with their participation in local voicing assimilation between obstruents. Combinations of laryngeally mismatched stop-fricative combinations are frequent in roots. Furthermore, as will be discussed in §4.3, laryngeal agreement in Aymara exhibits homorganicity effects, which local voicing also does not display.

4.2. ANALYSIS. As outlined in §3.2, similarity is calculated among stops based on a hierarchy of identical segments ( $T \leftrightarrow T$ ), homorganic segments ( $T \leftrightarrow D$ ), and heterorganic stops ( $K \leftrightarrow T$ ,  $K \leftrightarrow D$ ), as repeated from (22) in (34a) for voicing only. With [cg] adding another dimension, there are further correspondences between homorganic voiceless stops ( $T \leftrightarrow T'$ ), heterorganic voiceless ( $K \leftrightarrow T'$ ), homorganic ( $D \leftrightarrow T'$ ) and heterorganic ( $D \leftrightarrow K'$ ), as shown in (34b).

- (34) a. **[voice]:**  $\text{CORR-}T \leftrightarrow T \gg \text{CORR-}T \leftrightarrow D \gg \text{CORR-}K \leftrightarrow T \gg \text{CORR-}K \leftrightarrow D$   
 b. **[cg]:**  $\text{CORR-}T' \leftrightarrow T' \gg \text{CORR-}T \leftrightarrow T' \gg \text{CORR-}K \leftrightarrow T', \text{CORR-}D \leftrightarrow T' \gg \text{CORR-}D \leftrightarrow K'$

The [voice] agreement hierarchy is familiar from §3.2. The [cg] constraints are interpreted as follows.  $\text{CORR-}T \leftrightarrow T'$  requires correspondence between homorganic voiceless stops, including ejective and plain voiceless.  $\text{CORR-}K \leftrightarrow T'$  holds over the superset of homorganic and heterorganic voiceless stops.  $\text{CORR-}D \leftrightarrow T'$  expands to include homorganic pairs that disagree in [voice] and [cg], and finally  $\text{CORR-}D \leftrightarrow K'$  refers to all stops, including those that disagree in laryngeal features. The similarity between [t'] and [k], which differ for Place and [cg] and between [t'] and [d], which differ for [voice] and [cg], is very close, so we have situated the constraints pertaining to these sound pairs at the same level in the hierarchy. There is only one example of a Chaha root with stops that disagree only for [cg] and Place (i.e. [t k'] or [k't]), whereas various examples of stops show disagreement for [voice] and Place (i.e. [g t] or [d k]). If the [cg] and [voice] scales are combined, this seems to point to a ranking of  $\text{CORR-}K \leftrightarrow T' \gg \text{CORR-}K \leftrightarrow D$ . Furthermore, on a similarity scale (Frisch *et al.* in press), voiceless-ejective combinations are rated much higher in similarity than voiceless-voiced or ejective-voiced pairs within their respective homorganic or heterorganic classes.

IDENT-CC requires that for the relation  $C_i RC_j$ , if  $C_i$  bears a particular laryngeal feature, then  $C_j$

bears the same. IDENT-CC constraints are defined with respect to [voice] (see (24), §3.2) and [cg]:

- (35) **IDENT-CC(cg)**: Let  $C_i$  be a segment in the output and  $C_j$  be any correspondent of  $C_i$  in the output. If  $C_i$  is [cg] then  $C_j$  is [cg].

As outlined in §3.2, monovalent features entail the use of both IDENT-IO and IDENT-OI for [cg] and for [voice]. Since the Chaha pattern is consistent with conversion of voiced stops to ejectives and ejectives to voiced stops, we assume that both types of constraints will be low-ranked.

A correspondence relation is established between oral stops in a root, and the identity constraints require that they match for the features [voice] and [cg]. We illustrate the ranking for the stem [wit'ək'] 'fall!', for which we consider a possible input /widək'/ with a mix of a voiced stop and ejective. For reasons of space, we allow the capital letters T and K to stand for both ejectives and plain voiceless stops in the following tableau. Because laryngeal agreement includes all stops, including heterorganic pairs, the IDENT-IO/OI constraints are ranked below the CORR-K↔D constraint. Candidates (36b) and (36c) lose out to candidate (36a) because there is no correspondence relation established between the two stops in the root. Candidate (36d) loses to candidate (36a) because the corresponding stops do not match for [cg]. It is not enough that the consonants match only for [voice]. Finally, candidate (36e) shows that the IDENT-CC constraints must outrank the IDENT-IO/OI constraints in order to compel agreement.

(36) CORR-K↔D >> IDENT-IO/OI(cg), IDENT-IO/OI(voice),

/widək'/	ID-CC (cg)	ID-CC (voi)	CORR- T↔T	CORR- T↔D	CORR- K↔T	CORR- K↔D	ID-IO/OI (voi)	ID-IO/OI (cg)
a. $\text{wit}'_x\text{ək}'_x$							*(IO)	*(OI)
b. $\text{wit}'_x\text{ək}'_y$					*!	*	*(IO)	*(OI)
c. $\text{wid}_x\text{ək}'_y$						*!		
d. $\text{wit}_x\text{ək}'_x$	*!						*(IO)	
e. $\text{wid}_x\text{ək}'_x$	*(!)	*(!)						

The tableau in (36) illustrates an output with ejective agreement. However, it is also possible to derive a form with two voiced stops from a mixed ejective-voiced stop input. The choice of one versus the other would depend on directionality, which we set aside here in the synchronic grammar of Chaha.<sup>23</sup> The important point is that agreement for laryngeal features is enforced via CORR-C↔C at the expense of faithfulness.

In conclusion, Chaha shows evidence of a laryngeal agreement pattern operating between a

three-way series of oral stops. Under an ABC analysis, the restriction to stops alone is a function of their similarity. This contrasts with the pattern of local laryngeal assimilation, which operates between obstruents, both stops and fricatives.

4.3 BOLIVIAN AYMARA. ‘Bolivian’ Aymara (Davidson 1977, De Lucca 1987, Hardman *et al.* 1974, MacEachern 1996, 1997[1999]) has cooccurrence restrictions on both [cg] and [sg] in morphemes. Unlike Chaha, Bolivian Aymara imposes a homorganicity restriction on its agreement effect. Homorganic stops agree for laryngeal features, as shown in the following combinations in (37). There are no voiced oral stops in the language. If heterorganic, stops may combine freely, except for ejectives, which must be identical to cooccur. The Bolivian Aymara consonant inventory consists of /p t tʃ k q p’ t’ tʃ’ k’ q’ p<sup>h</sup> t<sup>h</sup> tʃ<sup>h</sup> k<sup>h</sup> q<sup>h</sup> s x h r m n ɲ l ʎ w j/.

(37)	<b>Homorganic</b>		<b>Heterorganic</b>	
	tunti	‘arid, dry’	qotu	‘group, pile’
	k’ask’a	‘acid to the taste’	*t’ank’a	
	k <sup>h</sup> usk <sup>h</sup> u	‘common’	p <sup>h</sup> ut <sup>h</sup> u	‘hole, hollow’
	*k’aka	(rare)	t’aqa	‘flock, herd’
	*k <sup>h</sup> aka	(rare)	t <sup>h</sup> ampa	‘dense’
	*k’ak <sup>h</sup> a		t’alp <sup>h</sup> a	‘wide’

We focus on the [sg] agreement effects. Stops agree for [sg] if homorganic. No agreement is enforced if they are heterorganic. We assume the same basic hierarchy of CORR-C↔C constraints for [sg] as we did for [cg] in our analysis of Chaha. The faithfulness constraints IDENT-OI(sg) and IDENT-IO(sg) are ranked over the correspondence constraint applicable to heterorganic, laryngeally nonidentical stops, CORR-K<sup>h</sup>↔T. This ranking effectively prevents altering the [sg] feature specification of the second consonant, as shown in (38).

(38) IDENT-IO(sg), IDENT-OI(sg) >> CORR-K<sup>h</sup>↔T

/t <sup>h</sup> ampa/	ID-CC(sg)	CORR-T <sup>h</sup> ↔T <sup>h</sup>	CORR-T <sup>h</sup> ↔T	ID-IO(sg)	ID-OI(sg)	CORR-K <sup>h</sup> ↔T
a. t <sup>h</sup> <sub>x</sub> amp <sup>h</sup> <sub>x</sub> a					*!	
b. ↗ t <sup>h</sup> <sub>x</sub> amp <sub>y</sub> a						*
c. t <sup>h</sup> <sub>x</sub> amp <sub>x</sub> a	*!					
d. t <sub>x</sub> amp <sub>x</sub> a				*!		

If the input contained two aspirated stops, as in [p<sup>h</sup>ut<sup>h</sup>u], then the constraint ranking would engender

no alteration, because no high-ranking constraints compel violations of input-output faithfulness.

In (39), we illustrate an example with homorganic stops and consider an input with only one aspirated stop. The constraint  $T^h \leftrightarrow T$  requires correspondence between any homorganic oral stops. By ranking this constraint above one of the input-output [sg] faithfulness constraints, agreement for [sg] is enforced. In the tableau given here, IDENT-IO(sg) is located above IDENT-OI(sg), which selects a winning candidate with double aspiration. However, the reverse ranking is equally possible and will favor a candidate with no aspiration. Both candidates (39a) and (39d) are well-formed roots; given that the agreement effect holds of roots and therefore shows no alternations, we cannot determine the exact ranking of the IDENT-IO/OI constraints. However, the point of this tableau is to illustrate that *single* aspiration candidates cannot emerge as winners even if faithful to the input.

(39) CORR- $T^h \leftrightarrow T$  >> either IDENT-OI(sg) or IDENT-IO(sg)

/k <sup>h</sup> usku/	ID-CC(sg)	CORR- $T^h \leftrightarrow T^h$	CORR- $T^h \leftrightarrow T$	ID-IO(sg)	ID-OI(sg)	CORR- $K^h \leftrightarrow T$
a. $k^h_x usk^h_x u$					*	
b. $k^h_x usk_y u$			*!			*
c. $k^h_x usk_x u$	*!					
d. $k_x usk_x u$				*!		

Homorganic ejectives show the same pattern, so the crucial ranking would be CORR- $T' \leftrightarrow T$  >> either IDENT-OI(cg) or IDENT-IO(cg). By positioning the input-output faithfulness constraint between the CORR- $C \leftrightarrow C$  constraint that refers to homorganic ( $T^h \leftrightarrow T$ ) and the one that encompasses heterorganic ( $K^h \leftrightarrow T$ ), we model the restriction of laryngeal agreement to apply only between homorganic stops.<sup>24</sup>

In conclusion, Bolivian Aymara resembles Chaha in imposing an MSC on roots such that stops must agree for laryngeal features, either [sg] or [cg]. It differs from Chaha in that heterorganic stops do not respect this condition. This is expressed by ranking faithfulness constraints in different places in the hierarchy with respect to CORR- $T'/T^h \leftrightarrow T$ , as shown in (40) for [cg] and [sg].

(40) **Chaha:** CORR- $T' \leftrightarrow T$  >> CORR- $K' \leftrightarrow T$  >> IDENT-IO(cg), IDENT-OI(cg)

**Bolivian Aymara:** CORR- $T^h \leftrightarrow T$  >> IDENT-IO(sg), IDENT-OI(sg) >> CORR- $K^h \leftrightarrow T$

Bolivian Aymara laryngeal agreement presents no proximity restriction, and agreement may apply across other segments, including fricatives ([k'ask'a] 'acid to the taste', [k<sup>h</sup>usk<sup>h</sup>u] 'common') and sonorants ([t'irt'ana] 'button up one's dress, shawl', [k<sup>h</sup>ank<sup>h</sup>a] 'rough to the touch'). There is

no indication that these segments are also glottalized or that sonorants are aspirated/devoiced. Under an ABC analysis, intervening segments are ignored, as they are dissimilar from oral stops and accordingly do not enter into correspondence relations with them.

## 5. CASE STUDIES II: NASAL AGREEMENT

Ngbaka and Kikongo each present patterns of long-distance nasal agreement. Like the preceding laryngeal cases, they demonstrate a difference in the strictness of similarity: Ngbaka nasal agreement is restricted to homorganic consonants, while Kikongo agreement extends to certain heterorganic consonants as well. The juxtaposition of these two languages also shows how differences in the phoneme inventory can impact the set of consonants that interact in LDCA. In addition, Kikongo presents a case in which unidirectionality is witnessed in the agreement pattern.

5.1 NGBAKA AND KIKONGO. The first case of nasal agreement that we consider is found in Ngbaka, a Niger-Congo language spoken in the Democratic Republic of the Congo (Thomas 1963, 1970, Wescott 1965). The inventory of Ngbaka includes four series of stops on the nasality-voicing continuum: nasal, prenasal, voiced, and voiceless. The language displays restrictions on possible combinations of homorganic consonants in noncompound words (Mester 1986, Sagey 1986, van de Weijer 1994, Broe 1996). We focus here on the restriction involving nasals, wherein nasal stops are excluded from cooccurring with homorganic prenasal stops. A sketch of the prohibited stop pairs is given in (41). [ɲ] represents a dorso-palatal stop.<sup>25</sup>

(41) Prohibited combinations (either order): \*m<sup>-nasal</sup>b    \*n<sup>-nasal</sup>d    \*ɲ<sup>-nasal</sup>g    \*m<sup>-nasal</sup>gb

By contrast, pairs of homorganic nasals or homorganic prenasals (i.e. identical) are permissible:

(42) a. nanè                    ‘today’                    \*na<sup>n</sup>dè  
       b. <sup>m</sup>bɛè<sup>m</sup>bɛ                ‘snail’                    \*<sup>m</sup>bɛè<sup>m</sup>ɛ

The generalization is that nasal and prenasal stops which match in place must also agree in nasality, i.e. both must be fully nasal or both (partially) oral. In this regard, a remark on the status of prenasal stops in Ngbaka is warranted. Prenasals are uncontroversially monosegmental in this language (Thomas 1963, 1970, Mester 1986, Sagey 1986). Drawing on proposals by Piggott (1992) and Rice (1993), we posit that they belong to the class of sonorants. They are phonetically realized as prenasal as an implementation of a type of voicing that occurs in sonorants (e.g. ‘spontaneous voicing’), but they lack a phonological specification for [nasal]. The motivation is

two-fold. First, the occurrence of single segments that contain featural contours for nasality in their phonological representation is questionable (Padgett 1995b). Moreover, we have found no indication of phonologically active nasality in the prenasals of Ngbaka. Second, the existence of stops in which prenasalization is purely phonetic has been confirmed in other languages, including Barasano (Piggott 1992, Rice 1993) and Mixtec (Iverson & Salmons 1996). The nature of voicing in such segments differs from voicing in purely oral voiced stops in that it is partly accomplished by a phase of velic lowering. The sonorant status of prenasals in Ngbaka distinguishes them from the obstruent oral voiced series, and it renders them most similar among the stop series to nasals.<sup>26</sup>

In Ngbaka, the nasal agreement is limited to (near)-identical stops. Accordingly, consonant pairs that are less similar can disagree in nasality, for instance, in homorganic pairs, a nasal can occur with a (fully) oral stop (43a), and in heterorganic pairs, a nasal can occur with a prenasal stop (43b). In addition, two heterorganic nasals or prenasals are acceptable (43c-d).<sup>27</sup>

- (43) a. boma ‘how’                      c. mini ‘tongue’  
       b. mà<sup>h</sup>gà ‘net’                      d. <sup>h</sup>gá<sup>m</sup>ba ‘navvy’

A critical aspect of the agreement is that it operates between stops at a distance. Ngbaka permits only CV syllables (Sagey 1986:261), and vowels that intervene between agreeing consonants are unaffected. In addition, phonemic nasal vowels in Ngbaka do not trigger nasal agreement; they are found in combination with onset stops of any nasality-voicing quality: [ɲẽ] ‘dew’, [m̃bẽ] ‘brown, dark’, [gõ] ‘tender’, [tõ] ‘to spit’. Nasal agreement is thus limited to a subset of the consonants.

Our second case of nasal agreement occurs in Kikongo, a Bantu language spoken in the Democratic Republic of the Congo (Bentley 1887, Meinhof 1932, Dereau 1955, Webb 1965, Ao 1991, Odden 1994, Piggott 1996). The Kikongo inventory differs from Ngbaka’s in distinguishing just three stop series: nasal, voiced and voiceless. As previewed in §2.1.1.1, a nasal stop in Kikongo induces nasalization of certain voiced consonants occurring at any distance to its right in the stem (root and suffixes). The Kikongo nasals are [m n]. The data in (44) show three suffixes containing /l/ which is realized as [l] or [d] when the stem contains no nasal; it is realized as [d] before [i] and as [l] before other vowels. When preceded by a nasal in the stem, /l/ becomes [n]. Vowel quality in suffixes obeys a height harmony. The alternating suffixes are the perfective active (with variants *-idi*, *-ele*, *-ini*, *-ene*), perfective passive (*-ulu*, *-olo*, *-unu*, *-ono*) and applicative (*-il-*, -

*el-, -in-, -en-).28*

(44)	a.	m-bud-idi	‘I hit’	tu-kun-ini	‘we planted’
		n-suk-idi	‘I washed’	tu-nik-ini	‘we ground’
		sos-ele	‘searched for’	sim-ini	‘prohibited’
				leem-ene	‘shone’
				futumuk-ini	‘resuscitated (intr.)’
	b.	m-bul-ulu	‘I was hit’	ma-nik-unu	‘it was ground’
	c.	ku-toot-ila	‘to harvest for’	ku-kin-ina	‘to dance for’
		sakid-ila	‘congratulate for’	non-ena	‘to pick up for’
				ku-dumuk-ina	‘to jump for’
				ku-kin-is-ina	‘to cause to dance for’
				ku-dumuk-is-ina	‘to cause to jump for’

As in Ngbaka, Kikongo nasal agreement operates between segments at a distance. The agreeing consonants in Kikongo can be separated by multiple syllables, and intervening vowels and voiceless consonants are neutral. Observe that Kikongo nasal agreement operates only rightward in the stem – [l] and [d] appearing to the left of a nasal stop remain oral. This is also confirmed by the lack of LDCA in an example such as [bilumuka] ‘assemble in crowd’.<sup>29</sup>

The nasal agreement of Kikongo targets not only /l/, but also voiced stops at all places of articulation (/d/ exists as a separate phoneme in the language). Alternations involving /b d g/ could not be found, because these phonemes do not occur or are rare in Kikongo suffixes outside of NC sequences. Nevertheless, on the basis of a dictionary search, Piggott (1996) determines that the consonants in question do not appear after nasals in a stem, in other words, the following distributional generalization holds: \*[…{m n}…{b d g l}…] (see also Ao 1991:195-6, fn. 3).<sup>30</sup>

Let us consolidate the chief properties of Ngbaka and Kikongo nasal agreement. The patterns present two primary characteristics of LDCA identified in §2.1: the potential for nonlocal interactions, and a similarity effect. Evidence for the first property is abundant: the agreeing consonants need not be root-adjacent, and intervening segments, such as vowels, voiceless stops and fricatives, neither participate in nor block the nasal agreement.

The consequence of the similarity effect in these languages is moderated by the richness of their

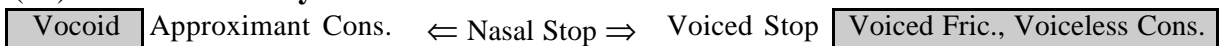
phonemic stop inventory. On the nasality-voicing continuum, Ngbaka maintains four distinctive series of stops and Kikongo three, as depicted in (45) for bilabials. The preferential targeting of similar segments is evident from nasal agreement in both languages affecting the series of stops that is closest to the nasals, that is, the prenasal series in Ngbaka and the voiced series in Kikongo.

- (45) **Ngbaka:** Four stop series                      **Kikongo:** Three stop series  
           p – b – <sup>m</sup>b – m                                      p – b – m

Ngbaka levies a stricter similarity requirement, limiting agreement to stops of the adjacent series that are homorganic with the nasal. Kikongo targets all stops in the adjacent series, whether homorganic or heterorganic, as well as approximant consonants that also share some properties with nasals.

We have calculated similarity among singleton consonants of the inventories using the methodology of Frisch *et al.* (in press). For Ngbaka, the highest similarity ratings are among adjacent stops on the scale in (45), and the least similar are those that are furthest apart. Similarity rankings averaged for homorganic pairs are as follows, with a rating of 1 as complete identity (illustrated with labials): *adjacent pairs*: b–<sup>m</sup>b (.70) > p–b (.60) > m–<sup>m</sup>b (.46) > *non-adjacent pairs*: p–<sup>m</sup>b (.44) > b–m (.35) > p–m (.25). For Kikongo, the results also match the scale in (45), with averages for homorganic and heterorganic pairs combined: voiced stop-nasal (.30) > voiceless stop-voiced stop (.27) > voiceless stop-nasal (.17). In addition, the nasal class is closer overall to voiced stops (.30) and approximant [l] (.28) than to voiced fricatives (.15) and voiceless stops (.17). The resulting overall similarity scaling for Kikongo is shown in (46) (shaded classes of sounds are least similar to nasals) and is consistent with the trends outlined in §2.

(46) **Nasal similarity scale**



The sounds that emerge as most similar to nasals are voiced (prenasal) stops and approximant consonants. In agreement with our inventory-driven calculation, previous work has pointed out phonetic commonalities between these consonants (Walker 2000b). Voiced stops are similar to nasals in their articulatory configuration – both are characterized by full closure in the oral tract. They also share the acoustic correlates of voicing and produce similar transitions in the formant structures of neighboring vowels. In the case of nasals and approximant consonants, their acoustic properties are similar in their intensity and in displaying well-defined formants. The closeness between nasals and voiced stops/approximant consonants has been observed to trigger phonological

effects in other languages. For example, [n] substitutes for /l/ in fortition environments in Korean and Cuna, a pattern which Flemming (1995a) suggests is due to their auditory resemblance. Voiced stops alternate with nasals in Irish Eclipsis environments, part of a chain shift phenomenon that Ní Chiosáin (1991) analyzes as involving a minimal change in sonority (cf. Gnanadesikan 1997).

Relative similarity is informative not only about which segments might participate in long-distance nasal agreement but also about which ones might not. The shaded classes of sounds in (46) are sufficiently different from nasal stops to render them neutral in the Kikongo system. Fricatives and voiceless stops remain unaffected in this language, as do vowels. The vowel/consonant separation in terms of similarity also prevents nasal vowels from triggering LDCA for [nasal] in consonants. In Ngbaka, the stricter similarity effect together with the inclusion of a series of prenasal stops in the inventory limits nasal agreement to targets that are homorganic and prenasal. Conversely, in the few languages where nasal agreement affects a larger set of consonants, such as Ganda or Tiene, the participation of voiceless consonants in nasal agreement is observed to imply the inclusion of voiced consonants, which are more similar to nasals.

In Kikongo there is a particular configuration in which nasals and voiced stops do not participate in nasal agreement. The phonotactics of the language admit NC clusters composed of a nasal stop-oral stop sequence. Such clusters behave neutral in nasal agreement in two respects: they do not induce nasalization of voiced stops or sonorant consonants (47a), and they are transparent to agreement between simple nasals and voiced stops/sonorant consonants (47b).<sup>31</sup>

(47)	a.	bantik-idi	‘begun’	b.	tu-mant-ini	‘we climbed’
		tu-biŋg-idi	‘we hunted’		tu-meŋg-ini	‘we hated’
		kemb-ele	‘swept’			
		n-tond-ele	‘I loved’			
		dimb-ulu	‘had listened’		wu-mant-unu	‘it was climbed’
		tu-konŋ-olo	‘we were tied’		tu-meŋg-ono	‘we were hated’
		tu-biŋg-ulu	‘we were hunted’			

We attribute the neutrality of nasals in NC clusters to their dissimilarity from the targeted oral consonants. We hypothesize that the dissimilarity stems from the unreleased status of a pre-stop nasal versus the released nature of a singleton onset oral consonant. Release refers to the offset of

the consonantal constriction, which under some conditions occurs with a salient burst. An unreleased stop, be it oral or nasal, lacks this audible offset of the oral constriction. It is widely recognized that the distinction between released and unreleased stops plays an important role in phonology. It connects with the relative informativeness of the transitions contained within a CV sequence versus a VC one. The highly perceptible oral release portion of a stop carries cues about its contrastive properties, such as place of articulation, and hence can serve as a pivotal identifying phase. Furthermore, the information carried by release applies not only to oral stops, but also to nasals, as discussed by Padgett (1995c).

Several studies have addressed the special role of release by incorporating it into segmental/featural representations (including Selkirk 1982, Steriade 1993, 1994) or referencing it or its context in grammatical constraints (e.g. Padgett 1995c, Steriade 1997, Lombardi 1999, Bauer 2001). For example, Padgett (1995c) proposes a constraint that preserves segments' place features specifically in released environments. We view the quality of being released as separate from the acoustic correlates of distinctive features that may be perceived during release, such as [labial], [coronal], [sg], [cg], in the respect that release is a property of a consonant – generally determined by position – that may be referenced in phonological processes, but it is not a distinctive feature. However it is represented, the presence or absence of a release phase stands as an independent characterizing quality of segments. We interpret the failure of nasals that lack release from entering into LDCA with released consonants as evidence that the property of release factors into the calculation of similarity and suggest that the similarity metric be augmented to reflect that stops with a mismatch in release are less similar than those that match.<sup>32</sup> This is a further instance of release playing a role in determining the character of a segment.<sup>33</sup>

We do not preclude the possibility that release will also play a role in laryngeal agreement or other LDCA patterns. In the laryngeal case studies that we discussed in §4, release is not decisive in determining the set of interacting consonants. In Bolivian Aymara, obstruent stops occur only in onset, i.e. in released position (Davidson 1977). In the case of Chaha, its nonconcatenative morphology means that within the verbal paradigm, the same root consonant will occur in both released positions and potentially unreleased position (i.e. codas). It could be surmised that paradigm uniformity effects prevent release/unrelease from interfering with agreement. However,

Chaha stops are released even in coda position. There is gradient reduction of the release in one special case: when a velar ejective precedes an alveolar ejective, which Coulston (2001) attributes to aerodynamic difficulties in timing.

Finally, the second type of neutrality presented by NC clusters is that the oral consonant fails to become nasal. We suppose that this neutrality is not similarity-based but rather follows straightforwardly from avoidance of the structure that would result: geminate nasals are prohibited in Kikongo (Laman 1936).

5.2 ANALYSIS. The preceding discussion supports the following hierarchy for correspondence between nasals and other consonants. In these constraints, ‘L’ represents an approximant consonant; ‘<sup>M</sup>B’ and ‘<sup>N</sup>D’ represent singleton prenasal stops, such as those in Ngbaka; they do not refer to NC clusters found in Kikongo.

$$(48) \quad \text{Nasal correspondence hierarchy: } \text{CORR-N} \leftrightarrow \text{N} \gg \text{CORR-N} \leftrightarrow \text{<sup>N</sup>D}, \text{CORR-M} \leftrightarrow \text{N} \gg \\ \text{CORR-N} \leftrightarrow \text{<sup>M</sup>B}, \text{CORR-N} \leftrightarrow \text{D} \gg \text{CORR-N} \leftrightarrow \text{B}, \text{CORR-N} \leftrightarrow \text{L}$$

This hierarchy encodes that a pair of identical nasals is more similar than a homorganic nasal/prenasal pair, which is in turn more similar than a pair comprised of a heterorganic nasal/prenasal or a homorganic nasal and voiced oral stop, and so on. Although the similarity metric we are using is tied to particular language inventories, it still results in general rankings for classes of consonants which are valid cross-linguistically. The nasal correspondence hierarchy in (48) is applicable across languages. Certain languages may have more refined similarity rankings. For example, similarity ratings for Ngbaka situate the prenasal-nasal series above the two nasals and hence warrant a ranking of  $\text{CORR-N} \leftrightarrow \text{<sup>N</sup>D} \gg \text{CORR-M} \leftrightarrow \text{N}$ . Given our observation above that unreleased nasals are not sufficiently similar to released stops to enter into long-distance agreement with them in our case studies, we let the constraints in (48) hold specifically of released consonants (building on a proposal by Bauer 2001) – this will be the set relevant for the patterns under scrutiny. We will argue that what distinguishes nasal agreement in Ngbaka and Kikongo is the ranking of faithfulness with respect to this hierarchy. The differences that we have identified in the inventory structure of the two languages will also have ramifications.

In our analysis, we will assume that [nasal] is a privative feature (Trigo 1993, Steriade 1993, 1995), although this is not crucial. As discussed in §3.2 with respect to [voice], we will require

IDENT-IO(nasal), which is violated by the loss of an input [nasal] specification, and IDENT-OI(nasal), which penalizes segments that gain [nasal] in the output. Since alternations in Kikongo produce structures in which an output segment acquires nasalization, but denasalization of a nasal trigger does not occur, we posit the ranking IDENT-IO(nas) >> IDENT-OI(nas). Although alternations are not observed in Ngbaka, we will assume that the same ranking holds for this language, and in what follows we omit candidates involving denasalization from consideration.

5.2.1 HOMORGANIC NASAL AGREEMENT. We focus first on the rankings for Ngbaka. In this language, prenasal stops display nasal agreement with a homorganic nasal. Since prenasal stops in Ngbaka do not have a phonological [nasal] specification, the constraint demanding identity between corresponding stops must override IDENT-OI(nas). The ranking is illustrated in (49) with a hypothetical input. We interpret IDENT-CC(nas) as requiring that if a segment  $C_i$  in the output is [nasal], then any correspondent  $C_j$  of  $C_i$  in the output must also be [nasal]. (An elaboration of IDENT-CC that discriminates left/right directionality is discussed in the Kikongo analysis.)

(49) IDENT-CC(nas) >> IDENT-OI(nas)

/na <sup>n</sup> dε/	ID-CC(nas)	ID-OI(nas)
a. $n_x a n_x \epsilon$		*
b. $n_x a^n d_x \epsilon$	*!	

In order to compel correspondence between homorganic nasal and prenasal stops in the output, CORR-N $\leftrightarrow$ <sup>N</sup>D must dominate IDENT-OI(nas), as shown in (50). The winning candidate is (50a), in which the stops are in correspondence and agree in nasality, incurring a violation of IDENT-OI(nas). The competitor in (50b) fails because the homorganic stops do not correspond. Candidate (50c) establishes correspondence between the stops, but incurs a fatal IDENT-CC(nas) violation. IDENT-CC(nas) only crucially outranks IDENT-OI(nas) here, but since it is consistently obeyed in the language, we situate it at the top of the hierarchy.

(50) CORR-N $\leftrightarrow$ <sup>N</sup>D >> IDENT-OI(nas)

/na <sup>n</sup> dε/	ID-CC(nas)	CORR-N $\leftrightarrow$ N	CORR-N $\leftrightarrow$ <sup>N</sup> D	ID-OI(nas)
a. $n_x a n_x \epsilon$				*
b. $n_x a^n d_y \epsilon$			*!	
c. $n_x a^n d_x \epsilon$	*!			

Since nasal agreement is not enforced in heterorganic pairs, IDENT-OI(nas) must outrank CORR-

$N \leftrightarrow^M B$ . The ranking is supported in (51). The winning output in (51a) does not establish correspondence between the heterorganic nasal and prenasal consonants, violating  $CORR-N \leftrightarrow^M B$  but obeying  $IDENT-OI(nas)$ . The alternative in (51b), in which the consonants agree, loses because nasalization of the second stop violates  $IDENT-OI(nas)$ .

(51)  $IDENT-OI(nas) \gg CORR-N \leftrightarrow^M B$

/ma <sup>n</sup> ga/	IDENT-CC(nas)	$CORR-N \leftrightarrow N$	$CORR-N \leftrightarrow^N D$	$CORR-M \leftrightarrow N$	IDENT-OI(nas)	$CORR-N \leftrightarrow^M B$
a. $m_x a^n g_y a$						*
b. $m_x a^n n_x a$					*!	

The lack of nasal agreement between nasal and voiced oral stop pairs is similarly captured via the ranking:  $IDENT-OI(nas) \gg CORR-N \leftrightarrow D$ .

What is important to notice about the constraint ranking for Ngbaka is that  $IDENT-OI(nas)$  is situated between the  $CORR-C \leftrightarrow C$  constraints requiring correspondence between homorganic nasal/prenasal stops and the ones that enforce correspondence between heterorganic nasal/prenasal stops and nasal/voiced oral stop pairs.  $IDENT-CC(nas)$ , which promotes nasal identity between corresponding segments, stands undominated.

5.2.2 HOMORGANIC AND HETERORGANIC NASAL AGREEMENT. We turn our attention now to Kikongo, where nasal agreement holds between nasals and voiced oral stops, both homorganic and heterorganic pairs. Approximant consonants also are targeted. First, some preliminaries are in order. As the Kikongo inventory does not include prenasal stops, the  $CORR-C \leftrightarrow C$  constraints involving prenasals will not be of relevance here, and so we omit these constraints from Kikongo tableaux. We also omit  $CORR-N \leftrightarrow N$  and  $CORR-M \leftrightarrow N$ , as these constraints only produce redundant nasal agreement and will not play a critical role in the alternations we examine.

Kikongo nasal agreement shows rightward directionality, as exemplified in /kudumuk-ila/ → [kudumukina] \*[kunumukina]. We propose that directional agreement arises from an evaluation of faithfulness sensitive to the left/right dimension (i.e. precedence).  $IDENT-CC$  constraints that distinguish progressive versus regressive agreement are given in (52).  $IDENT-C_L C_R(nas)$  requires that if a segment is [nasal], any correspondent that appears to its *right* in the sequence of segments must also be [nasal].  $IDENT-C_R C_L(nas)$  is responsible for agreement in the leftward direction. Unidirectional agreement arises under asymmetrical rankings of these constraints. Prioritization of

IDENT- $C_L C_R$ (F) will produce progressive feature agreement, as in Kikongo, and dominance of IDENT- $C_R C_L$ (F) will result in regressive agreement, as in Kinyarwanda sibilant harmony (see (11)). We posit that the left/right sensitive constraints together replace nondirectional IDENT-CC(F) in *Con* (the set of universal constraints). In Ngbaka, where there is no evidence of unidirectional nasal agreement, both constraints are situated at the same place in the hierarchy, and likewise for the relevant laryngeal IDENT-CC(F) constraints in Chaha and Bolivian Aymara.

- (52) a. **IDENT- $C_L C_R$ (nas)**: Let  $C_L$  be a segment in the output and  $C_R$  be any correspondent of  $C_L$  such that  $C_R$  follows  $C_L$  in the sequence of segments in the output (R>L). If  $C_L$  is [nasal], then  $C_R$  is [nasal].
- b. **IDENT- $C_R C_L$ (nas)**: Let  $C_L$  be a segment in the output and  $C_R$  be any correspondent of  $C_L$  such that  $C_R$  follows  $C_L$  in the sequence of segments in the output (R>L). If  $C_R$  is [nasal], then  $C_L$  is [nasal].

Our account of unidirectional agreement calls on a distinction already available in the formalism of Correspondence Theory: for  $\alpha R \beta$ , faithfulness constraints may target either  $\alpha$  or  $\beta$ . In the case of input-output correspondence, examples of constraints that target  $\alpha$  include the MAX-IO family (McCarthy & Prince 1995) and the IDENT-IO formalism of Pater (1999), while those focusing on  $\beta$  are DEP-IO constraints and IDENT-OI. The directional constraints in (52) similarly distinguish the target of faithfulness, with characterization of  $\alpha$  and  $\beta$  in terms of the precedence dimension.

By incorporating directionality into the expression of the constraint that drives agreement, we employ a similar tactic to that taken in other work dealing with directionality in assimilation. In work on feature spreading, the constraint driving harmony has been formalized in terms of alignment (Kirchner 1993). Such constraints accomplish directionality by including the left/right target edge in their statement (examples for harmonies involving consonants include Cole & Kisseberth 1995, Padgett 1995a, Gafos 1996[1999], Ní Chiosáin & Padgett 1997, cf. Walker 1998 [2000]). Likewise, in rule-based approaches, the direction is incorporated into the rule's description (e.g. Poser 1982, Shaw 1991, Odden 1994). In the ABC approach, IDENT-CC constraints compel agreement between consonants, and it is here that we locate the directionality statement.<sup>34</sup>

In Kikongo, the rightward direction of nasal agreement indicates that IDENT- $C_L C_R$ (nas) is prioritized above IDENT- $C_R C_L$ (nas). Since IDENT- $C_L C_R$  is always obeyed by the consonants that

participate in Kikongo nasal agreement, we locate this constraint at the top of the hierarchy. The dominated status of IDENT-C<sub>R</sub>C<sub>L</sub> will become apparent when we examine forms in which an oral voiced stop or approximant consonant precedes a nasal in a stem.

First, we determine the ranking of IDENT-OI(nas) with respect to IDENT-C<sub>L</sub>C<sub>R</sub>(nas) and the nasal correspondence hierarchy. In Kikongo, any voiced stop becomes nasal if preceded by a nasal in the stem. This signals that CORR-N↔B and IDENT-C<sub>L</sub>C<sub>R</sub>(nas) together outrank IDENT-OI(nas), as shown in (53). The winning candidate in (53a) establishes correspondence between the nasal and suffix consonant, and they agree for nasality.<sup>35</sup> In (53b), the stops do not correspond, incurring a fatal violation of CORR-N↔B, and in (53c) the stops correspond but do not agree in nasality, an outcome ruled out by IDENT-C<sub>L</sub>C<sub>R</sub>(nas).

(53) IDENT-C<sub>L</sub>C<sub>R</sub>(nas), CORR-N↔B >> IDENT-OI(nas)

/sim-idi/	ID-C <sub>L</sub> C <sub>R</sub> (nas)	CORR-N↔D	CORR-N↔B	ID-OI(nas)
a. $\Rightarrow$ sim <sub>x</sub> in <sub>x</sub> i				*
b. sim <sub>x</sub> id <sub>y</sub> i			*!	
c. sim <sub>x</sub> id <sub>x</sub> i	*!			

In addition to voiced stops, approximant consonants participate in Kikongo nasal agreement. This is captured by situating IDENT-OI(nas) below CORR-N↔L as well. We locate CORR-N↔L and CORR-N↔B together in the nasal correspondence hierarchy, as their similarity rankings are very close. The outcome is illustrated in (54). Candidates (54b) and (54c), which do not nasalize /l/ in the output, are eliminated on the basis of CORR-N↔L and IDENT-CC(nas), respectively.<sup>36</sup>

(54) CORR-N↔L >> IDENT-OI(nas)

/nik-ulu/	ID-C <sub>L</sub> C <sub>R</sub> (nas)	CORR-N↔D	CORR-N↔B	CORR-N↔L	ID-OI(nas)
a. $\Rightarrow$ n <sub>x</sub> ikun <sub>x</sub> u					*
b. n <sub>x</sub> ikul <sub>y</sub> u				*!	
c. n <sub>x</sub> ikul <sub>x</sub> u	*!				

Observe that the voiceless stop in (54) does not participate in nasal agreement. This follows from its lack of similarity to the nasal: the nasal and voiceless stop are not sufficiently similar to provoke correspondence in Kikongo, and hence agreement is not enforced between them. Candidates in which these consonants are in correspondence are screened out by faithfulness constraints: [n<sub>x</sub>in<sub>x</sub>in<sub>x</sub>u] incurs a gratuitous violation of IDENT-OI(nas), and likewise [n<sub>x</sub>ik<sub>x</sub>un<sub>x</sub>u] with respect to IDENT-CC(nas). Correspondence between consonants in the output thus occurs only when

compelled by similarity-driven constraints, and the neutrality of voiceless consonants (and vowels and voiced fricatives) follows straightforwardly. The neutrality of the nasal in an NC cluster (e.g. in [kunt-ila] ‘shake for’) receives a parallel explanation. As an unreleased stop it is not sufficiently similar to released oral consonants to stand in similarity-driven correspondence with them, and accordingly, it does not trigger nasal agreement. On the other hand, a voiced oral stop in an NC cluster will not agree with a preceding released nasal because geminate nasals are disallowed in Kikongo, hence /tu-mɛŋg-idi/ → [tumeŋgini] ‘we hated’ \*[tumeŋŋini].

The tableau in (55) addresses directionality. Nasal agreement in this word produces nasalization in the /l/ to the right of the nasal but leaves the oral quality of the /d/ to its left intact. The resulting output sequence obeys IDENT-C<sub>L</sub>C<sub>R</sub>(nas), which requires that corresponding consonants following a nasal be specified [nasal], but it violates IDENT-C<sub>R</sub>C<sub>L</sub>(nas), which requires a [nasal] specification in corresponding consonants preceding a nasal. It is the interleaving of IDENT-OI(nas) between these constraints that achieves unidirectional agreement. The ranking of IDENT-C<sub>L</sub>C<sub>R</sub>(nas) over IDENT-OI(nas) compels rightward nasal agreement in the /l/, as evident in comparison of (55a) and (e). The one-way directionality is seen in (55a) versus (b-c). In (55a) versus (b), both candidates establish correspondence between all three voiced consonants and both obey IDENT-C<sub>L</sub>C<sub>R</sub>(nas). However, the leftward agreement affecting the first voiced consonant in (55b) incurs a fatal violation of IDENT-OI(nas). Even though this candidate fares better with respect to IDENT-C<sub>R</sub>C<sub>L</sub>(nas), this constraint is dominated by IDENT-OI(nas), and hence a faithful mapping of the leftward /d/ is favored. Candidates (55a) and (c) incur equal violations with respect to IDENT-OI(nas), but (55c) violates CORR-N↔L while (a) obeys it. Nasalization of the first voiced consonant is thus again disharmonic. CORR-C↔C constraints also rule out candidates (55d) and (f).

(55) IDENT-C<sub>L</sub>C<sub>R</sub>(nas) >> IDENT-OI(nas) >> IDENT-C<sub>R</sub>C<sub>L</sub>(nas)

/ku-dumuk-ila/	ID-C <sub>L</sub> C <sub>R</sub> (nas)	CORR- N↔D	CORR- N↔B	CORR- N↔L	ID-OI (nas)	ID-C <sub>R</sub> C <sub>L</sub> (nas)
a. $\text{kud}_x\text{um}_x\text{ukin}_x\text{a}$					*	**
b. $\text{kun}_x\text{um}_x\text{ukin}_x\text{a}$					**!	
c. $\text{kun}_x\text{um}_x\text{ukil}_y\text{a}$				*!*	*	
d. $\text{kud}_x\text{um}_y\text{ukin}_y\text{a}$		*!	**		*	
e. $\text{kud}_x\text{um}_x\text{ukil}_x\text{a}$	*!					*
f. $\text{kud}_x\text{um}_y\text{ukil}_z\text{a}$			*(!)	*(!)		

A summary of the constraint rankings determined for Kikongo and Ngbaka is given in (56). We see in (56a) that IDENT-OI(nas) is located below the constraints enforcing correspondence between nasals/voiced stops and nasals/approximant consonants. The simple demotion of IDENT-OI(nas) in Kikongo in comparison to the Ngbaka ranking expands the set of segments participating in nasal agreement to include heterorganic stops and sonorant consonants.

- (56) a. **Kikongo:** ID-C<sub>L</sub>C<sub>R</sub>(nas) >> CORR-N↔D >> CORR-N↔B, CORR-N↔L >>  
IDENT-OI(nas) >> ID-C<sub>R</sub>C<sub>L</sub>(nas)
- b. **Ngbaka:** ID-C<sub>L</sub>C<sub>R</sub>(nas), ID-C<sub>R</sub>C<sub>L</sub>(nas) >> CORR-N↔<sup>N</sup>D >> IDENT-OI(nas) >> CORR-N↔<sup>M</sup>B, CORR-N↔D >> CORR-N↔B, CORR-N↔L

Another point of contrast between Kikongo and Ngbaka is their inventory: Ngbaka includes a series of prenasal stops not found in Kikongo. Although the nasal-prenasal correspondence constraints are omitted for simplicity in (56a), the implications for a language with Ngbaka's inventory structure and Kikongo's ranking of IDENT-OI(nas) should be clear. If there were a language that had nasal, prenasal and voiced oral stop series, and nasal agreement included voiced oral stops, then prenasal stops would participate in nasal agreement too. The languages are also distinguished by directionality. In Kikongo, nasal agreement operates only rightward, as produced by the asymmetrical ranking of IDENT-C<sub>L</sub>C<sub>R</sub>(nas) and IDENT-C<sub>R</sub>C<sub>L</sub>(nas). Ngbaka does not restrict agreement to one direction, which results from locating both constraints in the top stratum.

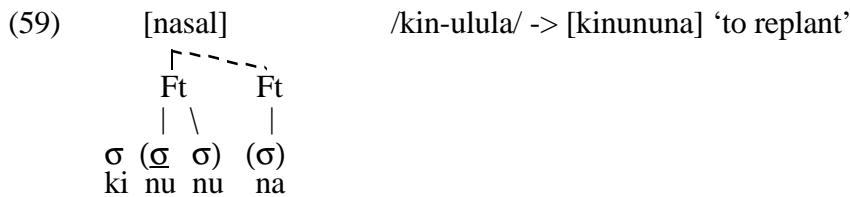
## 6. ALTERNATIVE SPREADING ANALYSES

6.1 SPREADING-BASED APPROACHES. In nonlinear phonology, featural assimilations have been analyzed as the product of spreading, that is, through cross-segmental linkage of the feature in question. This approach has customarily been adopted both for assimilations between root-adjacent segments and for agreement between segments at a distance, such as the LDCA cases under consideration. While assimilations between root-adjacent segments are not problematic for spreading-based approaches, the neutrality of intervening segments in LDCA presents a challenge. Spreading-based analyses generally rely on the assumption of *tier-based locality*. Research in this direction obtains different distances of interactions through geometric organization of feature classes and underspecification of structure (for overviews see Clements & Hume 1995, Steriade 1995). Tier-based locality determines adjacency at a mother-node for the linking feature.



because of their lack of insight and theoretical restrictiveness. Even if it were supposed that the segments in NCs are underspecified because their nasal quality is predictable (i.e. in sonorant-obstruent stop clusters), an underspecification-based account of neutrality in LDCA would fail to capture a key explanatory generalization emerging from our typology in §2: across languages *similarity* is the criterion that determines segments’ potential to interact in LDCA – not predictability of distribution.

Another kind of spreading-based proposal bears further on this issue. Piggott (1996) posits that nasal agreement in Kikongo results from [nasal] spreading at the level of a syllable-organizing node that he calls the harmony foot. The structure is illustrated in (59).



Under this approach, the oral quality of vowels in nasal harmony feet is attributed to Structure Preservation (Piggott 1996:155-6): because nasal vowels do not occur in underlying representations, they are prevented from occurring in outputs. However, our typology reveals that LDCA across languages preferentially targets sounds that are similar. Attributing the neutrality of vowels in nasal agreement to Structure Preservation misses this generalization. Ngbaka is a case in point. This language has phonemic nasal vowels, but oral vowels are nevertheless acceptable in the context of flanking homorganic nasal consonants, i.e. they appear to be unaffected by nasal agreement. Our similarity-based approach correctly predicts both the preference for voiced consonant targets and neutral intervening vowels in LDCA involving nasal stops. We acknowledge that the nasal agreement pattern in Ngbaka is an MSC, and hence it might not be treated by Piggott under a spreading account. However, if it were analyzed differently, that would miss an important connection between MSC agreement and alternations. The Bantu language, Ganda, has a nasal LDCA that stands as an MSC, but related languages, such as Kikongo, also have alternations. We deem a unified analysis preferable, as discussed in §2.

A second problem for tier-based locality concerns the questionable status of gapped configurations in the theory. A group of studies have argued that certain feature assimilation

phenomena which were formerly believed to involve action at a distance do not actually overlook intervening segments. Ní Chiosáin & Padgett (2001) make this claim for transparent consonants in vowel harmony. They argue that the spreading vocalic feature carries through intervening consonants, but they are perceived as transparent, because the relevant vocalic gesture does not have a significant contrast potential in these segments. Other work supporting the occurrence of perceptual transparency includes Walker & Pullum (1999) on transparent glottal stops in nasal harmony, Flemming (1995b), Ní Chiosáin & Padgett (1997) and Gafos (1996[1999]) on certain coronal harmonies, and studies by McCarthy (1994a) and Gafos & Lombardi (1999) on transparent consonants in vowel echo, focusing especially on the transparency of sonorants and consonants with unmarked place (coronal, pharyngeal). Taken together, this research points towards a finding that gapped structures are unnecessary and predict a broader range of so-called long-distance assimilations than are attested. It supports *strict segmental locality*, where feature linkage must obey adjacency at the level of the root node (Ní Chiosáin & Padgett 2001).

Nevertheless, many of the agreement cases outlined in §2 are not amenable to a strictly local spreading approach. For example, laryngeal agreement between consonants across vowels would be problematic. If [-voice] were simultaneously associated to two consonants, it should follow that the intervening vowel is also [-voice]. This is not, however, reported in the description of Ngbaka (Thomas 1963). Although [-voice] could conceivably be rendered absent in representations via a monovalent view of features, the problem persists in agreement for [cg] and [sg] across unaffected vowels. Consider the case of Chaha, where [cg] would be spread from one consonant to another in a continuous span, and the intervening vowel would be phonetically affected by the [cg] feature. It is conceivable that glottalization of vowels may not be indicated in transcription if it is not contrastive. However, we examined spectrograms of Chaha vowels between ejectives and found no evidence of continuous glottalization. A local spreading analysis is even more problematic for the Chaha configurations where sonorants intervene, but are not glottalized (see (31)). The status of intervening consonants also undermines any proposal in which agreement occurs between root consonants projected onto separate morphological tiers (e.g. McCarthy 1986). Furthermore, such an analysis fails to explain the fact that Chaha LDCA for [voice] patterns differently from voice assimilation between adjacent consonants in being restricted to stops.

Other kinds of LDCA also resist a perceptual transparency explanation. Nasal agreement in Kikongo is an example. If [nasal] were associated to the string of segments intervening between the nasal stop and the alternating suffix consonant, all vowels and consonants would be expected to be nasalized – many, if not all, perceptibly so – but they are not. Strictly local spreading cannot distinguish nasal harmony and nasal agreement. The same problem holds for Dorsal agreement. As Hansson (2001) points out, strictly local spreading of [RTR] predicts that intervening high vowels should be affected or act as blockers in Dorsal agreement, and yet they are neutral.

To summarize, a spreading-based treatment of certain kinds of long-distance agreement between consonants is problematic. Under one scenario it entails the assumption of gapped representations, which yields too permissive a theory. On the other hand, if a more constrained view of representations is adopted and spreading is strictly local, the theory wrongly fails to predict LDCA for features such as [voice], [cg], [nasal] and [RTR]. Both alternatives miss the generalization that true action-at-a-distance occurs between similar consonants.

6.2 SPREADING AND CORONAL LDCA. Although other types of LDCA cannot be analyzed via feature spreading, whether coronal agreement should be treated in terms of an ABC analysis or strictly local spreading is more controversial. Gafos (1996[1999]) argues that sibilant agreement of the type found in Tahltan is best analyzed as alignment of [TTCA], a scalar feature which specifies the shape of the tip-blade on the cross-sectional dimension, relevant only for coronal fricatives and affricates. Only segments contrasting for these features are perceived to be involved in the agreement. It is claimed that the spread feature affects all segments in the harmonic span;<sup>37</sup> yet the phonetic effect of [TTCA] on other segments is imperceptible or so slight as to be unreported by researchers (see Flemming 1995b and Ní Chiosáin & Padgett 1997 for similar proposals). Specifically, manipulation of the tip-blade has no significant effect on the acoustic quality of intervening vowels or noncoronal consonants, which are produced with the tongue dorsum or separate articulators. As for coronal stops, Gafos hypothesizes that the tongue blade may still be shaped as flat or grooved behind the tongue tip closure of stops. If the feature spread is [TTCO], which contrasts apical and laminal articulations, as he proposes for Chumash sibilant agreement, coronal stops are assumed to be pronounced as either apical or laminal depending on the harmony span ([+/-TTCO]) in which they are found.

Despite the potential appeal of this proposal, there are reasons to reject a strictly local spreading analysis for such cases of coronal agreement and to treat them in the same manner as other types of LDCA. The strictly local spreading analysis was developed for a limited data set of coronal sibilant and retroflex agreement and was based on the erroneous assumption that these are the only attested types of consonant agreement (see Gafos 1996[1999]). Yet as discussed above, the same kind of analysis cannot reasonably extend to other types of LDCA. For cases of coronal agreement which show the same general characteristics as other kinds of LDCA, i.e. the similarity of interacting segments and the neutrality of intervening segments, we consider it preferable to adopt a unified analysis (cf. our discussion of Sanskrit in §6.3 below). Moreover, the local spreading theory applied to coronal agreement relies on hypothesized pronunciations for intervening segments, which to the best of our knowledge have not been experimentally verified. Indeed, as Hansson (2001:272) argues, the lack of reported phonetic alternation in descriptions of coronal agreement seems to bolster an analysis relying on correspondence constraints over one adopting local spreading.

Clements (2001) makes a related argument regarding sibilant agreement in Baztan Basque. He points out that in the word [ʃiɲetʃi] ‘to believe’, apico-alveolar [ʃ] and [tʃ] show agreement across palatal [j], which is incompatible with the apico-alveolars with respect to apicality and posteriority. Clements observes that if the assimilation in question involved a spreading that encompassed all intervening segments, the intervening [j] should merge with the language’s apico-anterior [ɲ]. However, this does not occur. Accordingly, Clements proposes that the agreement arises through a constraint mandating identical content for coronal nodes of strident segments in a morphological root, a constraint enforced through node copy rather than cross-segmental feature linkage. Clements supposes that a similar operation is active in enforcing the coronal agreement of Tahltan.

A further consideration is that under the local spreading theory articulated in Gafos (1996[1999]), segments perceived as participating in the harmony are those that contrast for the spreading feature. This accounts for the nonparticipation of other segments and the blocking effects of specified segments. Yet it is not always the case that contrast is involved in determining participation in LDCA. Consider the case of dental agreement in the Nilotic language, Anywa (Reh 1996), as discussed in (12). In this language, there is no cooccurrence of dental and alveolar stops in a root. This also pertains to the nasals, even though [ɲ] is almost entirely derivable from /n/. Reh

(1996:24) states that ‘there is no single word in the language with a simple dental nasal which does not comprise a dental stop as well’. Examples of stems are given in (60).<sup>38</sup> Word-final voiced stops are devoiced, which is not indicated here.

(60) <b>Dental</b>		<b>Alveolar</b>	
ṅùḍḍò	‘to lick (sugar)’	núudó	‘to press something down’
ōḍḍòṅṅ	‘mud’	ḍīn	‘to thresh something’
ṅṅṅ	‘to be small’	tḍon	‘to leak (a bit)’
ṅṅḍ	‘ropes’	tūud	‘pus’

The dental nasal arises through LDCA, and it may also emerge as a nasal mutation alternant of oral dental stops, e.g. /póḍḍ/ ‘be smooth’ → [pòṅṅḍò] ‘become smooth’. Anywa presents a counterexample to the claim that contrasts in the inventory determine which segments will participate in harmony. Yet, it is clear that the participating segments are highly similar – all coronal stops. This argument holds despite the status of dental agreement as an MSC in Anywa.

Given the above considerations, we take the position that at least some cases of coronal LDCA, and possibly all those showing the hallmarks of similar interacting segments and no blocking, should be analyzed as agreement by correspondence rather than spreading.

6.3 SANSKRIT. Although we posit the occurrence of coronal agreement via correspondence, this does not exclude the possibility that tongue tip-blade features of consonants may be involved in spreading that carries through vowels. Sanskrit retroflex harmony presents an example. In Sanskrit retroflex harmony, the continuant retroflex segments /ʂ/ and /r/ (and /ɽ/)<sup>39</sup> cause a following /n/ to become retroflex [ɳ] across intervening noncoronals and vowels (61a) if the nasal is followed by a sonorant (vowels, nasals, [y] and [v]). Dental, retroflex and palatal segments (with the exception of the palatal glide [y]) block retroflexion from being spread (61b) (Whitney 1889, Allen 1951, Schein & Steriade 1986, Flemming 1995b, Humbert 1995, Gafos 1996[1999], Ní Chiosáin & Padgett 1997). Alternations are illustrated with the primary derivative forming suffix *-ana* (Whitney 1889:426-7). [dh] is a dental stop; [c] and [j] are palatal stops. We were unable to locate an example showing blocking by retroflex stops, sounds which are relatively rare in the language; however, descriptions are explicit on the question of their blocking.

(61)	a.	rākṣaṇa	‘protection’	b.	vārdhana	‘increase’
		kṛpaṇá	‘miserable’		rocaná	‘shining’
		ākramaṇa	‘striding’		vṛjána	‘enclosure’
		kṣayaṇá	‘habitable’			

Sanskrit presents a case of assimilation that audibly affects only coronal consonants, but it is not an instance of ABC. Sanskrit retroflex assimilation fails to show the two main properties of agreement via correspondence. First, the participant segments /ṣ r (ṛ)/ and /n/ are not the most similar, and second, it exhibits blocking effects. Retroflex oral stops do not trigger retroflexion of the nasal. In contrast, other cases of retroflex assimilation discussed in §2 operate primarily between fricatives/affricates or between stops. Furthermore, among the coronal agreement cases which we analyze as ABC, intervening segments of the same class as the agreeing segments fail to block. For example, in Mayak dental agreement (see (13)), an alveolar oral stop in the stem causes agreement with a dental oral stop in the suffix, across an intervening alveolar nasal.

Unlike the other cases of coronal LDCA that we have discussed, Sanskrit retroflexion assimilation shows unambiguous evidence of a spreading-based harmony. Gafos (1996[1999]), analyzes Sanskrit in terms of local spreading of [TTCO]. The assumption is that this feature has no perceptible impact on other segments in the string, but dental and retroflex oral stops, which contrast for [TTCO], block further spreading (see Flemming 1995b and Ní Chiosáin & Padgett 1997 for similar analyses; Allen 1951, assumed a prosodic characterization of retroflex harmony as affecting the whole span of segments). We concur that Sanskrit retroflexion harmony is indeed spreading (see Hansson 2001 for a similar conclusion). Hence, patterns of assimilation operating between coronal consonants have the potential to arise through both spreading and ABC, although the resulting patterns may show differences with respect to similarity of participants and blocking.

## 7. FURTHER ISSUES AND CONCLUSION

LDCA patterns fall into five main groups: nasal, laryngeal, liquid, coronal and dorsal. One group of features that do not display LDCA consists of the features [sonorant] and [consonantal]. Ní Chiosáin & Padgett (1997) point out that the inactivity of these features is not specific to long-distance phenomena; they also fail to enter into local assimilations.

A second set of features that fails to show distance agreement is major C-Place. Although local spreading of Place features is attested, we know of no cases of long-distance major place agreement between consonants over intervening vowels.<sup>40</sup> The absence of this type of interaction has been a puzzle in phonological theory.<sup>41</sup> Ní Chiosáin & Padgett (1997) speculate that if spreading is local, spreading of major C-Place features across a vowel also entails spreading of stricture features, which are incompatible with intervening vowels. This is explicitly represented in the articulator group model of feature geometry advocated in Padgett (1995b). Yet there is another compelling observation about the nature of place assimilations. They typically involve coda-onset sequences in which the coda assimilates to the onset. This is expressed through markedness conditions on codas (Steriade 1982, Itô 1986[1988]) or as faithfulness to onsets or released positions (Padgett 1995c, Beckman 1998, Lombardi 1999). Jun (1996) claims that casual speech place assimilations involve gestural reduction (but not elimination) of the coda segment, giving the perception of assimilation.

To bring this back to LDCA, long-distance interactions involve consonants that are in different, unconnected prosodic positions. There is no coarticulation impetus for place gestures to be reduced, and accordingly, it appears that retention of place features is favored. This is supported by a recent kinematic study of speech errors by Pouplier *et al.* (1999), which investigated interaction of nonlocal stops of different place of articulation. They found that errors involving place gestures in initial stops in the phrase ‘cop top’ actually involved the *intrusive* production of a dorsal place in the /t/ in addition to its coronal place gesture. However, errorful productions of this kind were often perceived as ‘cop cop’, i.e. as though the coronal place was lost (see also Pouplier & Goldstein 2002). Our interpretation is that place feature errors can produce the perception of one feature replacing another, although the segments are actually produced as complex stops. 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. Place features stand apart from other features such as [nasal] and laryngeal features, because place specifications involve separate articulators. In terms of our present proposal, a possible implementation would be to suppose that IDENT-IO(Place) regularly supercedes IDENT-CC(Place), or the constraint IDENT-CC(Place) does not exist; however, the final word on this issue remains for further research.

Our goal in this paper is to argue that LDCA should be analyzed as featural agreement mediated through an output-based correspondence relation rather than as spreading or multiple linking of features. The correspondence analysis enjoys several advantages over spreading-based accounts. First, it accounts for the behavior of intervening segments either specified or unspecified for the agreeing feature. In LDCA, intervening segments that do not participate in the agreement are transparent to it. Second, agreement is based on similarity of the interacting segments. Output-based correspondence constraints form the core of our analysis, with constraints arrayed according to a scale of descending similarity. This allows us to account straightforwardly for variation between languages with respect to the typology of interacting segments in agreement, a typology informed by close to 50 cases of LDCA identified in §2, as well as further ones discussed in Hansson (2001) which are consistent with the trends we have identified here. Faithfulness constraints are positioned at different locations in the hierarchy, delimiting the extent to which segments interact through agreement.

Intrinsic to our proposal is a claim that there are two kinds of mechanisms at work in segmental assimilations in general: ABC and feature spreading. Correspondence-based agreement is involved in cases where non-local agreement is witnessed, as in LDCA. Such patterns are also marked by the comparative similarity of participant segments and the absence of blocking by intervening segments. On the other hand, feature spreading is at work in cases of local assimilation, i.e. where the participant segments are root adjacent. These cases also might show blocking effects, either by segments that are incompatible with the spreading feature or by ones that are already specified for it. Furthermore, the participant segments are not regularly determined by their relative similarity.

Vowel harmony presents a promising area in which to explore further applications of the ABC approach. As mentioned in §3.1, certain cases of rounding harmony limit the participant segments to ones that are similar, specifically, they match in height. In addition, many patterns of vowel harmony show nonlocal interactions across intervening transparent vowels, suggesting that ABC might be at work. Yet some vowel harmonies show apparent blocking by certain vowels. Under an ABC account, this might arise if a proximity restriction were in effect, which would require that correspondent segments belong within a two syllable window. The suitability of an ABC approach for such patterns would need to be assessed in the context of individual case studies.<sup>42</sup>

Finally, it has been established that similarity also plays a role in distance dissimilation and future research may illuminate how dissimilation differs from long-distance agreement. One striking divergence is the propensity for place dissimilations and OCP effects on place, which are notably absent from LDCA. We envision that sound similarity, its calculation and its sensitivity to inventory structure, is an area that deserves continued study in the exploration of these patterns.

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\* Acknowledgements omitted.

<sup>1</sup> Chaha labialization (Leslau 1967) is not actually harmony, but involves the morphological feature of labialization appearing on reduplicated consonants. In Inor (Prunet 1991), a related dialect, the labialization can extend to other velars and labials in the stem.

<sup>2</sup> Following the original submission of this paper, Hansson (2001) was completed and made available to us. That work provides a survey of consonant agreement patterns that is wider in scope and offers more detailed descriptions than we have space for here. Although the research was conducted independently, there is considerable convergence in the findings and analytical results, which we take as a positive sign that the general model is correct.

<sup>3</sup> As expected, stops and approximant consonants in Tiene become nasal when cooccurring with a nasal. However, nasals become voiced oral stops when they cooccur with a fricative. Hyman & Inkelas (1997) analyze the denasalization as driven by avoidance of a strident nasal, which prevents nasalization of the fricative.

<sup>4</sup> A separate optional phenomenon changes the glide /j/ to a palatal stop [tʃ] when a palatal consonant [ʃ ʝ ɲ] occurs in the preceding syllable, e.g. /ku-miŋ-ij/ --> [kumiŋtʃja] ‘to press for’. At first blush, this appears to be an agreement for [consonantal] between palatal segments, as this is the only feature shared by the three palatal consonants. Yet, Hume & Odden (1996) have argued against the feature [cons]. Instead, we suggest that the fortition effect is conditioned by the intervening high vocoid. An [i.j] sequence of two high front vocoids is dispreferred, an OCP effect (Rosenthal 1994[1997]). Although generally tolerated in the language, this sequence is worsened by the presence of a preceding palatal consonant which shares place of articulation with the glide. The two compounding OCP effects (which could be modeled using local conjunction) are alleviated by adjusting the vocoid status of the [j] to [ɨ], which preserves place and voice features and also creates a more respectable sonority contour.

<sup>5</sup> There is only one voiced fricative [z] in Chaha, and forms like the verb [wizf] ‘procrastinate!’ and noun [zəfər] ‘track, trace’ suggest that fricatives do not agree for [voice]. ([β] is a sonorant.)

<sup>6</sup> Imdlawn Tashlhiyt Berber (Elmedlaoui 1992) has a voicing alternation that is unusual in two respects. First, it is concomitant with sibilant agreement. The causative prefix /s-/ is realized as [ʃ], [z] or [ʒ] depending on the coronal

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sibilants in the stem. Second, the voicing agreement appears to be blocked by voiceless obstruents intervening between a voiced sibilant in the stem and the prefix: ex. *ss-ukz* ‘recognize’ \**zz-ukz*, but not by voiced elements, even obstruents such as [g]: [<sub>3</sub><sup>̣</sup>-g<sup>̣</sup>r<sup>̣</sup>u<sup>̣</sup>ʒ<sub>3</sub><sup>̣</sup>m<sup>̣</sup>] ‘extinguished (cooking)’. Elmedlaoui (1992) analyzes this pattern as the feature [+voice] spreading but fusing with other [+voice] features in the word. Segments with [-voice] block spreading. If correct, the coronal sibilant alternation would be analyzed as a case of LDCA, but the voicing pattern would be an example of long-distance iterative spreading of [+voice] rather than a case of consonant agreement. The restriction of the voicing alternation to coronal sibilants points to it being triggered by a general constraint on homorganic obstruents also active in the root. Elmedlaoui notes (p. 52) that such segments distinguished solely by voicing do not cooccur within a root.

<sup>7</sup> Ngizim voicing is asymmetric in that a voiceless-voiced sequence is disallowed but a voiced-voiceless sequence is permitted (e.g. [bàkú] ‘roast’).

<sup>8</sup> We hypothesize that the scarcity or possible absence of [sg] and [cg] alternations in affixes is due to the propensity of glottalized and aspirated segments to occur in roots. Languages of this type include Cuzco Quechua (Parker & Weber 1996) and Chaha (Banksira 2000). Under the Glottalic Theory of Proto-Indo-European stops, voiced stops are reanalyzed as glottalized and the most marked members of the series; they also do not occur in suffixes (Salmon 1993). McCarthy & Prince (1994, 1995, 1999) observe that marked segments, such as pharyngeals, tend not to occur in affixes. They attribute this to a meta-constraint, Root-Faith >> Affix-Faith, wherein faithfulness to root content is prioritized over that of affixes. We make the uncontroversial assumption that glottalized and aspirated stops are marked in relation to their plain counterparts. So the rarity or absence of alternations is due to these independent factors.

<sup>9</sup> ‘Bolivian Aymara’ is the term MacEachern uses to refer to the dialect of Aymara spoken primarily in Bolivia and described in De Lucca (1987).

<sup>10</sup> Dental stops in these languages may be pronounced phonetically with affrication.

<sup>11</sup> Breeze does not mention root cooccurrence restrictions on alveolars and palatoalveolars, as found in other Omotic languages. However, we could find no examples of this cooccurrence in the data provided in her article.

<sup>12</sup> Hansson (2001) also lists ‘stricture’ as a possible agreement type. This includes any agreement holding between stops and fricatives or fricatives and approximants. The cases cited all involve alternations among coronals. Two cases (Shambaa and Mwiini) are suspect. Hansson (2001) points out an alternate analysis in Hyman (1993, 1994) which suggests that the patterns may have another source, from imbrication of the perfective suffix. The only clear-cut case

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appears to be Yabem (Ross 1995) in which a prefix /sé-/ is realized with a [t] instead of [s] when preceding an alveolar stop across a single vowel: /sé-táj/ → [té-táj] ‘weep (3pl. realis/irrealis)’. In roots, there are no s...t or s...d sequences. As the agreement pattern is restricted to coronal obstruents, it seems to represent another class of coronal agreement in which a larger set of coronals is implicated. Given the paucity and questionable nature of the ‘stricture’ cases, we conclude that there is not enough evidence to warrant positing another main class.

<sup>13</sup> Hansson (2001) recognizes the lack of blocking property and also adds prosodic structure and directionality to the list of characteristics. He argues that consonant agreement effects are typically regressive and show no sensitivity to prosodic structure. We do not discuss these characteristics here as they are less clear-cut. First regressive directionality appears to be only a tendency. See, e.g., Kikongo nasal agreement in §5. Second, the lack of reference to prosodic structure could follow from the fact that vowels play no role in consonant agreement. However, since some analyses of consonant harmony or agreement propose spreading to vowels, this lends support to the typology and analysis advocated here and in Hansson (2001), in which vowels are ignored. See §3 and §6 for further discussion.

<sup>14</sup> Such analogical changes are also attested across words, e.g. *Abu Dhabi* → *Abu D(h)abu* (Zuraw 2000). In addition, Bybee (1985:118) argues that phonological similarity is one of the factors that can contribute to connections between lexical items within her ‘dynamic lexicon’ model.

<sup>15</sup> An apparent departure in the patterning of speech error phenomena and LDCA is that the former may show sensitivity to prosodic structure (see, e.g., Shattuck-Hufnagel 1983, 1987), while the latter appears not to (see fn. 13). This suggests that the operative ‘similarity’ in LDCA is computed myopically over sound segments and might not reference higher levels of organization. However, work by Suzuki (1999) and Zuraw (2000) has proposed that syllable structure can indeed figure in certain kinds of correspondence relations that produce agreement between segments in the output of a word (see §3.2). We leave further exploration of this issue for future research.

<sup>16</sup> Other researchers have proposed more complex proximity relations. In particular, Suzuki (1998) incorporates a full Proximity Hierarchy into his dissimilatory constraints through constraint encapsulation, which has the effect of exploding each dissimilatory constraint into a hierarchy of sub-constraints depending on the amount of intervening material. We advocate instead a single independent PROXIMITY constraint that refers to corresponding segments. Only proximity as we have formulated it appears warranted by available data. It subsumes S. Rose’s (2000) ‘consonant adjacency’, wherein consonants may interact across at least an intervening vowel, either in the same or adjacent syllables, Suzuki’s (1998) ‘single consonant adjacency’, which allows two vowels to interact across only a single consonant, and Odden’s (1994) parameter of ‘syllable adjacency’, which applies to interaction among consonants in adjacent syllables. While both Odden (1994) and Suzuki (1998) recognize a root-adjacent parameter in determining

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proximity of interacting segments, the majority of the cases discussed involve dissimilations. Local consonant assimilations, such as Chukchi or Korean nasal assimilation, in which a stop-nasal sequence becomes nasal-nasal, behave differently from nasal agreement in that all stops, rather than a subset, are targets. They may be analyzed as following from a phonotactic constraint on sonority sequencing rather than as nasal agreement.

<sup>17</sup> This leaves open the question of how to handle root-adjacent dissimilation. These cases could conceivably be reanalyzed through coarticulation or phonotactic pressures, such as constraints against gemination or poor sonority sequencing (see Rice & Avery 1991 and Davis & Shin 1999 for an analysis of Korean nasal assimilation that stems from syllable contact). This would lead us beyond the scope of this paper, so we do not explore this possibility further here.

<sup>18</sup> There is a morphologically-conditioned process that devoices penultimate obstruents in the perfective (normal citation form) if the following consonant is sonorant, [x] or [t], giving the surface appearance of a mix of voicing: e.g. [gidir] corresponds to perfective [gətərəm]. The devoicing effect does not extend to the initial consonant, suggesting that either voice agreement is not triggered by voiceless segments or the morphological devoicing requirement overrides agreement.

<sup>19</sup> Banksira (2000) argues that there is no underlying /k/, but /x/, which strengthens to [k] in certain circumstances, such as preceding fricatives.

<sup>20</sup> Although /k/ alternates with /x/ in penultimate root position ([səkərə] ‘he was drunk’ vs. [jəsxər] ‘let him be drunk’), none of these verbs involves laryngeal mismatches. There is possibly a connection between contrasts in the inventory of sounds and their participation in agreement; a more thorough exploration of this pattern awaits further research.

<sup>21</sup> See Banksira (2000), Chamora (1997), Lowenstamm (1996), Prunet (1996a,b) and Rose (1997) on root ‘a’ in Gurage languages.

<sup>22</sup> Obligatory total assimilation occurs before coronal stops and affricates: /ji-t-dəməd/ → [jiddəməd] ‘he joins (intr.)’.

<sup>23</sup> Banksira (2000) points out that cognate examples from Amharic reveal that the laryngeal specification of the rightmost consonant determined the direction of agreement in Chaha. While directionality may have been involved in producing the pattern diachronically, there is no evidence in the synchronic language for directionality, as the agreement pattern is restricted to roots. Accordingly, in our discussion of Chaha, we do not posit an asymmetrical ranking for directional IDENT-CC constraints, but note that dominance of the leftward constraint, IDENT-C<sub>R</sub>C<sub>L</sub>(F),

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discussed in §5, could be invoked. See Hansson (2001) for further discussion of directionality in agreement systems and the relationship between historical and synchronic forms.

<sup>24</sup> There are some additional complications in Aymara which we do not delve into here for lack of space. Aspirated stops pattern slightly differently than ejectives in that heterorganic ejectives may not cooccur: \*[tʰankʰa]. This follows from separate restrictions on the distribution of ejective stops in Bolivian Aymara. First, only one ejective is allowed per morpheme *unless* they are identical. Second, this single ejective must be positioned as far to the left edge as possible. Ejectives and aspirated stops also obey ordering restrictions, with ejectives preceding aspirated stops. The order is reversed, however, if the initial consonant is labial or uvular. MacEachern (1997[1999]) argues that this is due to markedness restrictions against labial and uvular ejectives, ranked over those pertaining to other ejectives, which are more common crosslinguistically. We direct the reader to MacEachern (1997[1999]) for an analysis of these additional facts.

<sup>25</sup> Sagey (1986) suggests that labiovelars in Ngbaka have a major Labial place specification and a minor Dorsal one. She posits that the homorganicity restriction is sensitive only to major place, thereby obtaining the interaction between labial–labiovelar pairs but not dorsal–labiovelar pairs.

<sup>26</sup> We remain neutral regarding particulars of the phonological representation of the sonorant nature of prenasal stops. See Piggott (1992) and Rice (1993) for discussion.

<sup>27</sup> In a study of cooccurrences among labial stops in Ngbaka, van de Weijer (1994) observes that roots containing [p] and [m] seem to be rare. He reaches the tentative conclusion that roots with this combination of consonants are ill-formed. That hypothesis remains to be verified. Nevertheless, if [p] and [m] were avoided in the language, we would attribute that to some source other than similarity between the two segments, since [b] - [m] combinations are permitted. On this point we depart from van de Weijer – on the basis of feature count in the representation that he assumes, van de Weijer posits [p] and [m] as less dissimilar than [b] and [m]. Our crosslinguistic observations regarding similarity in LDCA suggest otherwise. Furthermore, similarity calculations based on Frisch et al (in press) show that voiced stops are more similar to nasals than voiceless stops, e.g. the pair [p]–[m] has a similarity rating of .29, whereas [b]–[m] has a similarity rating of .40.

<sup>28</sup> The data in (44) and (47) are presented with prefixes (or lack thereof) as they appear in the primary sources (Bentley 1887, Meinhof 1932, Dereau 1955, Ao 1991 and Odden 1994).

<sup>29</sup> Though the canonical Bantu radical is of the structure CVC- (Guthrie 1962:202), the lexical entry for this form appears to comprise the sequence [CVIVN...], as it is listed in the dictionary (Bentley 1887) without a corresponding [CVI-] verb entry (i.e. without [bil-a]). Hence, it is suggestive that the rightward direction of nasal agreement is not

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reducible to “cyclic application” together with privileged root-initial faithfulness (cf. Hansson 2001:380). The same is true of Yaka, which shows nasal agreement matching Kikongo’s in the essentials (e.g. /núúk-idi/ -> [núúk-ini] ‘to slant’, Hyman 1995). The rightward directionality in Yaka is apparent in cases like [fólámá] ‘be delighted’, [fwéébámá] ‘be curved (back)’ (Comparative Bantu On-Line Dictionary, <http://linguistics.berkeley.edu/CBOLD>), wherein stem-medial [l b] do not participate in LDCA (although they undergo nasal agreement when to the right of a nasal). Although [-am-] could be viewed from a historical perspective as a “frozen” derivational extension (see Hyman 1998), the absence of corresponding CVC- forms suggests the stored forms are /folam-/ , /fweebam-/ , thereby warranting statement of rightward agreement. We are grateful to Larry Hyman for discussion on this matter.

<sup>30</sup> On the basis of a search of dictionary entries in Bentley (1887) and Laman (1936), Piggott suggests that nasal agreement in Kikongo actually targets all voiced consonants, adding [v z ʏ] to the list. However, Meinhof’s (1932) description of Kikongo, written in collaboration with Laman, indicates otherwise. Nasal agreement occurs across a neutral [z] in [van-uzuna] ‘give again and again’ and [son-uzuna] ‘write again and again’. Compare [kamb-uzula] ‘tell over and over again,’ where the target consonant is realized as [l] when conditions for nasal agreement are not present (we will see presently that NC clusters do not trigger nasal agreement). In the case of [ʏ], it seems that the status of this phoneme is tenuous. In the central dialects dealt with by Meinhof, the velar fricative appears to have often developed into the glide [j], and it is elided between vowels. Webb (1965) also reports finding no [ʏ] in the Kindibu dialect. We were unable to find data that confirm or deny targeting of [v]. Given the patterning of other sounds, we hypothesize that if this sound is neutral, it has the phonological status of a fricative in the language, and if it is targeted, it is grouped with the approximants as /v/.

<sup>31</sup> That NCs have the status of segmental clusters in Kikongo is in accordance with Ao (1991) and Piggott (1996), who posit that they are nasal-oral stop sequences. A similar claim is made for Yaka, another Bantu language with long-distance nasal agreement, by van den Eynde (1968:6) and Walker (2000b) (note also Kidima 1991:4).

<sup>32</sup> Our analysis is neutral regarding whether an NC cluster is syllabified across two syllables or belongs entirely to a syllable onset. In at least some cases it appears that the latter will be appropriate. A benefit of the release-based analysis is that it is compatible with either analysis. Hubbard (1995) argues that NC sequences in Ganda are (ultimately) syllabified into an onset, and Hyman (1995), finds evidence that nasals in NC sequences of Yaka are nonmoraic, a property consistent with onset syllabification. Yaka and Ganda both belong to the Bantu family and display long-distance nasal agreement.

<sup>33</sup> This interpretation of the facts is independently supported by an NC dissimilation operative in certain Australian languages, such as Gurindji (McConvell 1993, Odden 1994). In this phenomenon, the nasal in an NC cluster deletes

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when preceded by an NC cluster at any distance in the word, e.g. /kankula-mpa / becomes [kankula-pa] ‘on the high ground’. However, NC clusters are compatible with a single nasal: [kani-mpa] ‘downstream’, signalling that the released and unreleased nasal are not judged as sufficiently similar to trigger the dissimilatory deletion. NC dissimilation also occurs in several Bantu languages. If adjacent syllables begin with a nasal-voiced stop sequence, one of the nasals is deleted (Meinhof 1932). In Ganda, the nasal of the first syllable is lost, e.g. [enuŋgi] ‘good (cl. 9)’ for \*enduŋgi; in Kuanyama, it is the second nasal, e.g. [ondoda] ‘step (9)’ for \*ondonda.

<sup>34</sup> Cf. another kind of approach in which apparent directionality effects seen in certain kinds of assimilation are accomplished via positional faithfulness constraints without statement of direction (e.g. Padgett 1995c, Beckman 1997, 1998, Lombardi 1999, Walker 2001b).

<sup>35</sup> Whether we posit /l/ or /d/ as the input suffix consonant does not figure here. Either way, it will be realized as [d] before [i] if oral, which we attribute to a contextual markedness constraint that we refer to descriptively as \*[li].

<sup>36</sup> We regard it as unsurprising that under nasal agreement the affected consonant becomes a plain nasal stop at the cost of manner features that might be active in the segment. For instance, when [l] becomes a nasal segment it does not retain its approximant nature (attributable to the feature [lateral]). In addition, there are no reports of nasal continuants in languages where continuant approximants are affected by nasal agreement in MSCs. The explanation here is two-fold. First, the dispreference for nasalized continuants/approximants is well documented (Padgett 1995b). Constraints on such configurations will trigger the hardening of approximants to stops under nasalization. Second, the formation of nasal stops rather than nasalized segments better satisfies IDENT-CC requirements. These constraints will promote the closest match in stricture and other properties between agreeing segments.

<sup>37</sup> Gafos (1996[1999]) defines locality in terms of Articulatory Locality; however, he observes that defining locality as root adjacency (i.e. strict segmental locality) is essentially consistent with his proposal.

<sup>38</sup> There is one word in which the nasal does not agree for dentality: [ḍàanó] ‘person’, which Reh assumes was historically a compound.

<sup>39</sup> The syllabic [ɾ] is classified as a vowel in Sanskrit grammars (e.g. Whitney 1889), but arises from r-vowel or vowel-r sequences.

<sup>40</sup> In the development of certain languages such as Latin and Celtic from Proto-Indo-European, a word-initial \*p became a labiovelar [k<sup>w</sup>] if the second syllable began with [k<sup>w</sup>], ex. Latin: \*penk<sup>w</sup>e > \*k<sup>w</sup>enk<sup>w</sup>e > k<sup>w</sup>i:nk<sup>w</sup>e ‘five’ (Palmer 1961), Irish: \*penk<sup>w</sup>e > \*k<sup>w</sup>enk<sup>w</sup>e > cóic ‘five’ (Thurneysen 1946). Although this pattern shows some properties suggestive of a case of historical LDCA for C-place, it has others that set it apart, as follows. First, the

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assimilation is quite restricted. It occurs only between labials and labiovelars and only when the affected consonant is in initial position. Second, the assimilation appears to be facilitated by identity of the following vowel for the matching consonants, causing Lindsay (1894) to classify the change as an “assimilation of syllables”. Third, the assimilation produces only full identity between consonants, that is, we are aware of no cases (in adult language) producing changes such as /dʌk/ -> [gʌk]. The latter two points are suggestive that a syllable-based “aggressive reduplication,” along the lines proposed by Zuraw (2000), may be what underlies the Latin and Celtic phenomenon.

<sup>41</sup> Such a phenomenon is attested in child language. See Smith (1973), Cruttenden (1978), Vihman (1978), Dinnsen *et al.* (1997), Pater (1997), Goad (1997, 2000), Y. Rose (2000), Pater & Werle (2001), among others. The cause appears to be developmental. Gafos (1996[1998]) suggests such productions are a kind of articulator miscoordination that results from an underdeveloped motor system in which the contributions or ‘weights’ of individual articulators are not yet properly established.

<sup>42</sup> Previous work by Baković (2000), Krämer (2001) has proposed that vowel harmony comes about through a kind of relation between adjacent elements within an output. Krämer formalizes this in terms of correspondence. However, these analyses depart from the ABC proposal in two important ways. First, similarity does not drive the existence of a relation between elements, and second, the related entities are required to be adjacent, i.e. local. See also Pulleyblank (in press) on an approach to vowel harmony driven by dissimilatory constraints.

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