A TYPOLOGY OF CONSONANT AGREEMENT AS CORRESPONDENCE

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This article presents a typology of consonant harmony or LONG DISTANCE CONSONANT AGREEMENT that is analyzed as arising through correspondence relations between consonants rather than feature spreading. The model covers a range of agreement patterns (nasal, laryngeal, liquid, coronal, dorsal) and offers several advantages. Similarity of agreeing consonants is central to the typology and is incorporated directly into the constraints driving correspondence. Agreement by correspondence without feature spreading captures the neutrality of intervening segments, which neither block nor undergo. Case studies of laryngeal agreement and nasal agreement are presented, demonstrating the model's capacity to capture varying degrees of similarity crosslinguistically.*

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 constituent, consisting of root and suffixes.

(1) a. m-[bud-idi]$_{stem}$ 'I hit' b. tu-[kun-ini]$_{stem}$ 'we planted'
n-[suk-idi]$_{stem}$ 'I washed' tu-[nik-ini]$_{stem}$ '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 term it, also holds at the root level as a MORPHEME STRUCTURE CONSTRAINT (MSC). In fact, MSCs that require that consonants match for features can also be considered examples of consonant harmony (see also Shaw 1991), but within a more restricted domain, that is, the morpheme. 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. jɨ-kətf 'he hashes (meat)' c. jɨ-t'ək'ɨr 'he hides'
jɨ-kəft 'he opens' jɨ-t'əβk' 'it is tight'
b. jɨ-dəg(ɨ)s 'he gives a feast'
jɨ-dərg 'he hits, fights'

Data such as those in 1 and 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

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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 argue that these accounts are unsatisfactory on the basis of explanatory and theoretical considerations.

The aim of this article is twofold. First, we present a typology of LDCA that includes not only familiar cases of coronal sibilant agreement (e.g. Chumash; see Beeler 1970, Applegate 1972, Poser 1982, Shaw 1991, Gafos 1996), 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 that 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 coindexation.

(3) ABC configuration

$$\begin{array}{cccc} C_x & V & C_x & V \\ | & & | & \\ [\alpha F] & & [\alpha F] & \end{array}$$

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

We present first a crosslinguistic typology of LDCA and discuss the findings that (i) participant consonants share a considerable degree of similarity to each other, and (ii) intervening segments are neutral. We then establish the principles of the ABC approach in connection with the descriptive generalizations that our typology determines. We subsequently demonstrate aspects of the depth and breadth of this model's application through case studies in long-distance laryngeal agreement and nasal agreement. We provide as well a critique of previous research that posits distance featural agreement as the outcome of linkage, and we conclude with a discussion of issues for further study.

2. A TYPOLOGY OF LONG-DISTANCE CONSONANT AGREEMENT.

2.1. CROSSLINGUISTIC OVERVIEW. We begin our survey by defining long distance consonant agreement.

(4) LONG DISTANCE CONSONANT AGREEMENT (LDCA): Agreement for an articulatory or acoustic property that holds between consonants separated by at least one 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 originated via the effect of sound changes on roots, as appears to be the case for many languages in which consonant agreement is synchronically root-bound (i.e. laryngeal agreement discussed in §4). Cases in which alternations co-occur with MSCs either simply show the workings of sound change without any morphological restrictions, or reflect the extension of a once root-based agreement pattern to affixes. An alternate, more traditional, view of MSCs is that they are the remnant of once active sound changes that originally encompassed alternations. This is indeed a possibility, yet many LDCA patterns show no direct evidence of agreement ever having occurred outside the confines of the root, a situation which under that view would necessitate analogical elimination of once-alternating forms. Despite the possibly different historical origins, the parallel between alternations and MSCs strongly points to treating them synchronically with a unified analysis; any distinction between the two is due to their morphological domain of operation. In languages with only MSCs, there are often lexical exceptions, suggesting either an incomplete generalization of the change through the lexicon or the entry of loanwords that have not been phonologically nativized. Nevertheless, this does not mean that MSCs are not synchronically part of the grammar (Frisch & Zawaydeh 2001, Ussishkin & Wedel 2004). LDCA may also involve exceptionless alternations, but with some roots that do not conform to the pattern. For example, Hansson (2001a:127) notes that Bukusu liquid harmony has some disharmonic roots, yet the applicative suffix /-il-/ reliably surfaces as [ir] following a stem ending in [r] (Odden 1994). This is also incompatible with the view that MSCs are leftover sound changes, but consistent with a synchronic interpretation of agreement.

A conflation of MSCs and alternations 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 are 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 (Hoberman 1989, Davis 1995, Shahin 1997, 2002). 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 (see 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-symbolic alternations (Nichols 1971, Cole 1987) and morphological harmonies such as Salish glottalization

(Reichard 1938, Cole 1987) or Chaha labialization (Leslau 1967).[1] Such cases are morphological rather than phonological, in the sense that a series of consonants alternates to convey morphological information, and not necessarily with an overt triggering element. This is true of some cases of diminutive consonant symbolism in Native American languages. Even if triggered by an overt affix, they do not always show a consistent featural match between the consonants of the affix and those of the stem. In Wiyot (Teeter 1959, 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 /ș/ 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 the fact that they have a morphological symbolic function only. In contrast, LDCA is a phonological agreement restriction operating between two or more output consonants. For this reason, we prefer to be conservative 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.

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 2001a.[2]

Nasal. Nasal agreement across intervening vowels and consonants is found in the Bantu languages 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) is that intervening vowels (and other consonants) are not nasalized.

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

(5)	a.	m-[bud-idi]$_{\text{stem}}$	'I hit'	b.	tu-[kun-ini]$_{\text{stem}}$	'we planted'
		n-[suk-idi]$_{\text{stem}}$	'I washed'		tu-[nik-ini]$_{\text{stem}}$	'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.

[1] 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.

[2] Following the original submission of this article, Hansson 2001a 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.

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 over a single 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 (Bantu; Katamba & Hyman 1991, Hansson 2001a), nasal agreement affects homorganic voiceless stops following a nasal within a lexical root. 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 2001a).[3]

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. reeb-era 'ask for'
lim-ila 'cultivate for' kar-ira 'twist'
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 2001a), and in the Chadic language, Hausa, with the retroflex flap and /l/ (Newman 2000, Hansson 2001a). 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.[4]

[3] In Tiene, the prosodic trough refers to the material falling between the initial consonant and final vowel of the stem, a substring in which certain phonological effects are apparent or supressed in the language. As expected, stops and approximant consonants in Tiene become nasal when cooccurring with a nasal; nasals become voiced oral stops when they cooccur with a fricative. Hyman and Inkelas (1997) analyze the denasalization as driven by avoidance of a strident nasal, which prevents nasalization of the fricative.

[4] A separate optional phenomenon changes the glide /j/ to a palatal stop [ɟ] when a palatal consonant [ʃ ɟ ɲ] occurs in the preceding syllable, for example, /ku-miɲ-ija/ → [kumiɲiɟa] '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 and Odden (1996) have argued against the feature [cons].

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 of 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 usually become 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, Hansson 2004).

(9) a. /kV-gə̀r/ → [gə̀gə̀r] 'knee'
b. /dʒàr-ká/ → [dʒàrgá] 'colorful' (fem.)
c. /kV-màanə̀/ → [kəmàanə̀] *[gəmàanə̀] 'woman'
d. /kV-sár-káŋ/ → [kəsárkáŋ] *[gəsárgáŋ] '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'.[5] In Ngbaka, oral stops within a root likewise show a match in voicing (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 restriction between certain pairs of stops in roots under the glottalic theory (Gamkredlidze & Ivanov 1973, Hopper 1973, Salmons 1993). In summary, voicing agreement generally holds between oral stops only.[6] Hansson (2001a, 2004) points out the case of Ngizim, a Chadic language (Schuh 1978, 1997), in which nonimplosive obstruents in a root agree for voicing.[7]

SPREAD GLOTTIS AND CONSTRICTED GLOTTIS. The other laryngeal features, [sg] and [cg], demonstrate MSCs, but we have found no active alternations in affixes.[8] These

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 obligatory contour principle (OCP) effect (Rosenthall 1994). Although generally tolerated in the language, this sequence is worsened by the presence of a preceding palatal consonant that shares place of articulation with the glide. The two compounding OCP effects (which could be modeled using local conjunction; Smolensky 1993, 1997) are alleviated by adjusting the vocoid status of the [j] to [ɟ], which preserves place and voice features and also creates a more respectable sonority contour.

[5] Because [β] patterns as a sonorant, there is only one voiced fricative [z] in Chaha, and forms like the verb [wɨzf] 'procrastinate!' and noun [zəfər] 'track, trace' suggest that fricatives do not agree for [voice].

[6] 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 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 (e.g. [ss-ukz] 'recognize' *zz-ukz) but not by voiced elements, even obstruents such as [g]: [ʒˤ-gˤrˤuˤʒʒˤmˤ] '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 its 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.

[7] Ngizim voicing is asymmetric in that a voiceless-voiced sequence is disallowed but a voiced-voiceless sequence is permitted (e.g. [bàkú] 'roast'). See discussion of the role of directionality in §5.2.

[8] 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

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) documents several cases of laryngeal constraints requiring agreement among homorganic stops in roots. For example, in 'Bolivian' Aymara,[9] 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 2001a), 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.

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) and are therefore relevant only 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 (e.g. Sapir & Hoijer 1967, Beeler 1970, Hansson 2001a). (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 (Hoijer 1945, Sapir & Hoijer 1967, Kari 1976, McDonough 1990, 1991), Tahltan (Hardwick 1984, Nater 1989, Shaw 1991, Clements 2001), Chilcotin (Cook 1983, 1993), Chiricahua Apache (Hoijer 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 (Ntihirageza 1993), and Omotic languages such as Aari (Hayward 1990) and Maale (Amha 2001). The key characteristic

Quechua (Parker & Weber 1996) and Chaha (Banksira 2000). Under the glottalic theory of Proto-Indo-European stops, the stops traditionally labeled as voiced are treated rather as glottalized and are the most marked members of the series; they also generally do not occur in suffixes (Salmons 1993). McCarthy and 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 $\gg$ 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.

[9] Bolivian aymara is the term MacEachern uses to refer to the dialect of Aymara spoken primarily in Bolivia and described in de Lucca 1987.

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 consonant of the suffix 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.	na̤ʃ-	'like, love'	na̤ʃ-ʃiʃ-	'cause to like'
		tʃ'a̤a̤q-	'curse, swear an oath'	tʃ'a̤a̤q-ʃiʃ-	'cause to curse, etc.'
		ʃaan-	'urinate'	ʃaan-ʃiʃ-	'cause to urinate'
		ʒa̤a̤g-	'sew'	ʒa̤a̤g-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 the 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 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).[10]

(12)	a.	dɔ̄l	dùdò	'to fold something'	b.	d̪īr	d̪ìd̪ò	'to jostle'
		nʊ̄ʊr	núudó	'to press something down'		t̪ōōr	t̪òod̪ò	'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 /-ɛt̪/ and /-ʌt̪/ and the suffix /-it̪/ may optionally be realized with an alveolar [t] when the root contains an alveolar stop, including the implosive stop [ɗ] (13b). The

[10] Dental stops in these languages may be pronounced phonetically with affrication.

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.	bɛɛl-ɛt̪	'cane'	b.	ɗɪɪn-ɛt̪	~	ɗɪɪn-ɛt	'bird'
		ŋaj-it̪	'snail'		kɛt-ɪn-ɛt̪	~	kɛt-ɪn-ɛt	'star'
		ʔīn-ʌt̪	'intestine'		tiɗ-ʌt̪	~	tiɗ-ʌt	'doctor'
					tuɣ-it̪	~	tuɣ-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'.[11] Gimira has a series of plain coronal obstruents [t ts tʃ tʃ' s z ʃ ʒ] and retroflex [ts̢ ts̢' s̢ z̢]. Roots such as the following are attested. The numbers indicate tone levels.

(14)	s̢as̢ 3	'vein'	ʃatʃ 4	'stretcher'
	ts̢'uts̢' 4	'louse'	tʃ'aʃt 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)		Stem		Causative	
	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.	z̢ert 1	'be red'	z̢ers̢ 1	'make red'
		s̢up 3	'slaughter'	s̢us̢ 3	'cause to slaughter'
		ts̢'ud'	'spit'	ts̢'uts̢'	'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 when 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, traditionally the features [distributed], [anterior], [apical], or [laminal]. Gafos (1996) proposes instead the feature [tongue tip constriction area] ([TTCA]) and the feature [tongue tip constriction orientation] ([TTCO]) for coronal harmonies. 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.

[11] Breeze does not mention root cooccurrence restrictions on alveolars and palatoalveolars, as found in other Omotic languages. We could find no examples of this cooccurrence in the data provided in her article.

DORSAL. The final type we consider is dorsal agreement. Our discussion is based on examples identified in Hansson 2001a. 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'atsaː/ ʔuksk'atsaː '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 occurs only in a strictly local environment and does not interfere with dorsal agreement. This underscores the fact that dorsal agreement cannot be analyzed as extension of a feature to all segments in the domain; otherwise nonlocal vowel lowering should result. Hansson (2001a: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-puːtiq'i-ni-j/ → [laqpuːteʔenij] 'X recounted it to them', /i/ lowers to [e] directly preceding the uvular (the [q'] debuccalizes to [ʔ]), but /uː/ located between the agreeing dorsal consonants fails to lower to [oː]. Other cases of dorsal agreement are found in Misantla 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 subtypes.[12] 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 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]. Table 1 summarizes our similarity findings with respect to LDCA, and lists one example language for each type.

[12] Hansson (2001a) 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 (2001a) points out an alternate analysis in Hyman 1993 and 1994, which suggests that the patterns may have another source, from imbrication of the perfective suffix. The only clear-cut case 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-táŋ/ → [té-táŋ] '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. See also Hansson 2004 on Yabem agreement and its interaction with tone. Given the paucity and questionable nature of the stricture cases, we conclude that there is not enough evidence to warrant positing another main class.

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

TABLE 1. Similar segment types interacting in long-distance consonant agreement.

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 de Weijer (1994), Broe (1996), Frisch (1996), Frisch and colleagues (2004), and MacEachern (1997), although most of these works focus primarily on dissimilatory constraints (but Frisch et al. 2004 discusses possible extensions to harmony systems). The metric for computing similarity proposed by Frisch and colleagues (2004) 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 nonshared 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 may not have the exact same similarity rating in different languages, its position as more or less similar with respect to another consonant pair is 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. Homorganic consonants, for example, 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 and colleagues (2004) point out that 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 assume 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, 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. But if specific targets are apparently singled out in harmonies, Gafos (1996) 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 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. In sum, although similarity may be involved in other kinds of assimilation, it is not a systematic property of such interaction. Assimilating segments may in fact be quite dissimilar, such as nasal consonants and low vowels. See also discussion in §3.2 on the difference between local and long-distance agreement.

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'.[13] 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, that is, they are local, and the assimilation does not hold between consonants alone; vowels may trigger the assimilation and be audibly affected themselves. Moreover, the 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], a case of blocking due to incompatibility. In Ijo (Kwa) (Williamson 1965, 1969, 1987, Walker 1998), leftward nasal harmony issues from a nasal consonant or nasal vowel (17a), but obstruents block the assimilation (17b).

(17) a. ãnda 'wrestle' b. izõŋgo 'jug'
ȷ̃ãr̃ĩ 'shake' abãmu 'loft'

Obstruents are the segments least likely to participate in nasal harmony systems. This stands in contrast to nasal consonant agreement, where voiced stops are often targets,

[13] Hansson (2001a) 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, for example, Kikongo nasal agreement in §5. Second, the possible 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 2001a, in which vowels are ignored. See §3 and §6 for further discussion. In addition, a possible role for reference to syllable position in LDCA is discussed in §5.

and other obstruents, which often remain unaffected, do not interfere with the agreement. A comparable incompatibility 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, 2002). Archangeli and 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), 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 (18a). The assimilation is blocked by intervening plain labial consonants (in careful speech) (18b). 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.

(18)	a.	gᵻ-sᵻbᵻta	'sandal'	b.	gɨ-mu	'heat'
		gɨ-keːliː	'kapok tree'		gɨ-fufuli	'white'
		gʊ-sʊ	'ear'		gɨ-pula	'burial'
		gu-ɟo	'yam'		gɨ-boːtoː	'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 ([labial], [coronal], etc.) occupy the same tier in both 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 that 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 due either to featural incompatibility or to specification with the agreeing feature. The approach we take to LDCA treats it separately from spreading-based phenomena. We turn now 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). 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*.[14]

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 1996–97, 2002, Pouplier et al. 1999). This parallels the pattern of LDCA. Moreover, work by Pouplier and colleagues (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 that 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 and 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

[14] Such analogical changes are also attested across words, for example, *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.

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 interpret these production-based pressures as supplying the functional origins and motivation for the formal phonological constraints that drive LDCA. We assume a model of phonology that includes constraints informed by factors in the domains of psycholinguistics and phonetics but that nevertheless stands apart from these as an autonomous grammatical component. This model finds an antecedent in work by Howe and Pulleyblank (2001), and it is implicit in a range of research in grounded phonology, building on Archangeli & Pulleyblank 1994. On integrating functional grounding in the constraint-based framework of optimality theory, see Hayes 1999 and Smith 2002.

Our particular claim is that LDCA is a phonologized means of accomplishing matching for individual features in consonants with a source in production-based factors. We speculate that such patterns 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: for example, Amharic [wɨdək']/Chaha [wɨt'ək'] 'fall! (2M.SG)' (Banksira 2000). In this case, there is no direct evidence that the agreement ever occurred outside the root. In circumstances where affixation forms words containing consonant combinations excluded within morphemes, the condition could be extended by analogy within a language to operate over the entire word. This produces alternations in affix consonants, such that they change to agree with some featural property of a root segment. Alternatively, agreement could occur concomittantly with root-bound 'MSC' agreement, and result in cases in which affixes influence the root and vice versa depending on the location of the trigger, for instance, Navajo leftward sibilant harmony (Sapir & Hoijer 1967, McDonough 1990, 1991). The grammatical reflexes of MSCs versus alternations in a synchronic grammar would be the domains over which the relevant phonological constraints operate, that is, morpheme or word.

Our hypothesized grounding of LDCA in speech production provokes the question of 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 and colleagues (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 (2001a,b) 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 discussed in §5. The occurrence of anticipatory errors in speech rather than perseveratory ones likewise stands as a tendency.[15]

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 using 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). We identify further connected research 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 and 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

[15] A possible 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 might not (see n. 13). This suggests that the operative 'similarity' in LDCA might be computed myopically over sound segments and not reference higher levels of organization. Work by Suzuki (1999) and Zuraw (2000), however, 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). Also, in §5 we discuss a kind of neutrality in nasal agreement which might be explained by appeal to a segment's position in the syllable. We leave further exploration of this issue for future research.

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.

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 19.

(19) CORR-C↔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.

The schema in 19 provides 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↔C label. Nevertheless, we allow that a more general CORR-Seg↔Seg label would have utility in agreement phenomena not limited exclusively to consonants. In cases of consonant agreement, the restriction of CORR-Seg↔Seg constraints to consonants follows from their similarity. This is illustrated in the definition of the constraint that we label CORR-T↔D in 20. This constraint requires that a correspondence relation be established between stops in the output that agree in place, that is, pairs that are AT LEAST as similar as [t] and [d] (e.g. [. . .p. . .b. . .], [. . .d. . .t. . .], [. . .k. . .k. . .]).

(20) CORR-T↔D: Let S be an output string of segments and let X and Y be segments specified [−sonorant, −continuant, αPlace]. If X, Y ∈ 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↔C constraints in a fixed hierarchy—a familiar implementation of scalar phenomena in the theory (see e.g. Prince & Smolensky 1993, Kenstowicz 1996, Walker 1998, Crosswhite 1999). 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 21 (drawing on Walker 2000a and determined by similarity calculations used in Frisch et al. 2004). We note that in large part the ranking of these constraints need not be stipulated, but is an expositional convenience. The implications largely follow from superset relations between constraints encompassing increasingly less similar segments.

(21) 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 21 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 use the similarity scales resulting from the method of computation proposed in Frisch et al. 2004—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 22. 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.

(22) Consonantal correspondence model

Input /b e p o/

⇕ IO FAITHFULNESS

Output [b e p o]

⇖ ⇗ CC FAITHFULNESS

A FAITH-CC constraint applicable to voicing is given in 23, again with expositional focus on consonants. It requires that if a segment in the output is specified for [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.

(23) 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 23 is formulated without reference to segment order. But the existence in some languages of unidirectional rightward or leftward ABC that is not derivative from morphological structure necessitates 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 and Prince (1995, 1999) for binary features). Examples are given in 24. IDENT-IO(voice) penalizes the loss of input [voice] specifications, and IDENT-OI(voice) punishes segments that acquire [voice] in the output.

(24) a. IDENT-IO(voice): Let α be a segment in the input and β be any correspondent segment of α in the output. If α is [voice], then β is [voice].

b. IDENT-OI(voice): Let α be a segment in the input and β be any correspondent segment of α in the output. If β is [voice], then α is [voice].

We illustrate the above constraints' evaluation with respect to various candidates in 25. 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.

(25) Correspondence relations 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_xep_yo				*		*
b. b_xep_xo	*					
c. b_xeb_xo		*(OI)				

Candidates 25a,b do not display voicing agreement. In 25a the homorganic consonants are not in correspondence, violating CORR-T↔D, and by implication, CORR-K↔D as well. In 25b, the consonants are in correspondence, but they do not agree for voicing, incurring a violation of IDENT-CC(voice). Candidate 25c exemplifies the ABC outcome. The consonants are in correspondence with each other and they agree in their voicing specification.

This approach utilizes two kinds of constraints in accomplishing LDCA, IDENT-CC and CORR-C↔C. A reason that these are separately necessary is because the features that induce correspondence in cases of LDCA are not the same features that undergo changes to increase the similarity. IDENT-CC constraints are formulated in accordance with the general IDENT(F) schema given in McCarthy & Prince 1995. But CORR-C↔C constraints are not part of classic correspondence theory. They enforce the existence of a correspondence relation between similar segments in a word in the form of rankable constraints. This is because LDCA shows similarity-sensitive scalar effects—agreement is restricted in some languages to only highly similar consonant pairs, while other agreement patterns are more inclusive. In contrast, the familiar relation between an input and output does not appear to show scalar effects.

The notion of rankable constraints compelling correspondence between phonological or morphological elements is not without precedent. On the basis of pseudo-reduplication phenomena, Zuraw (2002) has argued for a constraint, REDUP, which requires that a general relation which she calls ‘coupling’ hold between substrings in a word (cf. Zuraw 2000). Coupled substrings are subject to faithfulness constraints such as MAX and IDENT(F). A way in which REDUP differs from CORR-C↔C constraints is that it is not sensitive to similarity between the potentially related elements. In contrast, similarity is directly encoded in faithfulness constraints by both Suzuki (1999) and Burzio (1999, 2000). Suzuki elaborates faithfulness constraints to operate between adjacent onsets, thereby coercing the existence of a correspondence relation between these elements. Burzio’s proposal invokes a correspondence relation between words that is coerced by output-output faithfulness constraints which are ranked as a function of the words’ gradient similarity. Our approach segregates the similarity attraction apart from faithfulness constraints, locating the former in CORR-C↔C constraints and leaving the general faith schema unaltered.

Quite generally, our proposal 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. This work includes Goad 1996, MacEachern 1997, Rose 1997, Yip 1997, Kitto & de Lacy 1999, Ussishkin 1999, Clements 2001, Krämer 2001, Feng 2002, Pater 2003, and Karabay 2004; note also Baković 2000.

Returning to our illustration, as 25 shows, CORR-C↔C constraints automatically favor 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 is 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.

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.

(26) a. Kikongo
m-[bud-idi]$_{stem}$ 'I hit'
tu-[kun-ini]$_{stem}$ 'we planted'
tu-[nik-ini]$_{stem}$ 'we ground'

b. Ndonga
[pep-el-a]$_{stem}$ 'blow towards'
[kun-in-a]$_{stem}$ 'sow for'
[nik-il-a]$_{stem}$ '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.[16]

(27) PROXIMITY: Correspondent segments are located in adjacent syllables.

PROXIMITY is invariably obeyed in Ndonga, but it is violated in words of Kikongo in which nasal agreement holds between consonants that belong to nonadjacent syllables, as shown in 28. By ranking PROXIMITY over the relevant CORR-C↔C constraints in Ndonga, nasal agreement obtains only among consonants separated by no more than a single vowel, but consonants standing at a greater distance fail to agree or correspond. When PROXIMITY is ranked lower, agreement obtains regardless of distance between the relevant consonants, as in Kikongo.

(28)

Ndonga	PROXIMITY	Kikongo	PROXIMITY
kun$_x$in$_x$a	✓	tukun$_x$in$_x$i	✓
n$_x$ikil$_y$a	✓	tun$_x$ikin$_x$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↔C places on correspondence is the similarity of the interacting segments. Nevertheless, just as CORR-C↔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 would 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, for example, /hudi-s-tʃa/ → [hudiʃtʃa] 'I love them', and distance contexts, for example, /ya-s-tɬ'ɛtʃ/ → [yaʃtɬ'ɛtʃ] 'I splashed it'. PROXIMITY is a separate constraint that regulates maximal distance between corresponding segments. If PROXIMITY is ranked higher than CORR-C↔C, as in Ndonga, then the upper bound of correspon-

[16] 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 subconstraints 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 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 they regularly target all stops, rather than a subset. They may be analyzed as following from a phonotactic constraint on sonority sequencing rather than as nasal agreement. Nevertheless, interaction between vowels and consonants as in Harari (Rose 2004) may warrant more complex proximity relations.

dence 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 that 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, for consonants, entails root adjacency. For example, postnasal 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: for example, *mismo* [mizmo] 'same'.[17] 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.[18] 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: 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) 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. Since 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 are 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 are separated by an intervening vowel in the verbal paradigm. We provide additional evidence that the agreement also holds at a distance across intervening consonants.

Stops are ejectives (29a), voiced (29b), or voiceless (29c). In general, the interacting stops are heterorganic, either coronal or velar. Due to Semitic MSCs that prevent conso-

[17] We consider /s/ to be the underlying phoneme for distributional reasons; [z] occurs only preceding nasals.

[18] 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.

nants 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 3M.SG imperfective and 2M.SG imperative to illustrate that different vowels may appear between the consonants.[19] 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^j k^j' k^w k^w' g^j g^w ʃ tʃ tʃ' ʒ]. /x/ is included as separate from /k/, since, although they alternate in verb paradigms, their distribution is not entirely complementary.[20]

(29)		Imperfective	Imperative	
	a.	jɨ-t'ək'ɨr	t'ɨk'ɨr	'hide'
		jɨ-rət'ɨk'	nɨt'ɨk'	'snatch'
		jɨ-k'ət'ɨr	k'ɨt'ɨr	'kill'
		jɨ-rək'ɨt'	nɨk'ɨt'	'kick'
	b.	jɨ-dəg(ɨ)s	dɨg(ɨ)s	'give a feast'
		j-ad(ɨ)g	əd(ɨ)g	'make fall'
		jɨ-gədɨr	gɨdɨr	'put to sleep'
		j-ag(ɨ)d	əg(ɨ)d	'tie'
	c.	jɨ-kətf	kɨtf	'hash (meat)'
		jɨ-təks	tɨks	'set on fire'
		jɨ-ktəkɨt	kətkɨt	'hit with a stick repeatedly'

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

(30)		Imperfective	Imperative	
	a.	jɨ-k'mət'ɨr	k'əmt'ɨr	'amputate'
		jɨ-t'əβk'	t'ɨβək'	'be tight'
	b.	jɨ-dərg	dɨrg	'hit, fight'
		jɨ-grədf	gərdɨf	'grind coarsely'
	c.	jɨ-kəft	kɨft	'open'

The labial stops do not participate in the agreement, as either 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] appears only 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 appears only to meet morphological requirements, which outrank laryngeal agreement. As for voiced

[19] 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: for example, [gɨdɨr] corresponds to perfective [gətərəm]. The devoicing effect does not extend to the initial consonant, suggesting that voice agreement is not controlled by voiceless segments (which can be achieved through ranking IDENT-IO(voice) over IDENT-OI(voice)). A paradigm uniformity constraint, ranked below the morphological devoicing constraint and above IDENT-CC(voice), would require the perfective to match the imperative base form for voicing (see Petros 1993 on imperative as the base), thereby ensuring initial voiced stops in the perfective match those of the base, despite the morphologically induced devoicing of the penultimate consonant.

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

[b], this segment is also restricted; it is the sonorant [β] that appears in the paradigm in most instances (eg. [zəbək'əm] 'he daubed' vs. [jɨzəβk'] '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.[21]

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 twenty 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] 'he laughed', although many analysts would treat this verb as having a root with three segments /dak'/.[22] 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 nonadjacent 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 2004). As discussed previously, the former view is not compatible with cases displaying active alternations but having a few disharmonic roots, or with our position that languages may develop consonant agreement only within roots, and thereby exhibit a stage at which the sound change is only partially complete. Synchronic analyses of lexical exceptions include lexically specific rankings or stratified lexicons (Itô & Mester 1995, Pater 2000), or lexically specified co-phonologies (Inkelas et al. 1997). 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 (31a). Nor do fricatives and sonorants trigger agreement (31b).

(31) a. sɨgd 'worship!' sɨdɨβ 'curse!'
b. kɨzəβ 'become inferior!' t'ɨma 'be thirsty!'

The restriction of [cg] agreement to stops is not surprising given that all ejectives in the language are stops. Nevertheless, the restriction of [voice] agreement to stops cannot be due to the absence of voiced fricatives. Chaha has a contrast between /s/ and /z/ (the fricative inventory is [f s z x]). Yet, as seen in 31, [s] freely combines with voiced stops and [z] with voiceless stops. This appears to be a property typical of

[21] 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.

[22] See Banksira 2000, Chamora 1997, Lowenstamm 1996, Prunet 1996a,b, and Rose 1997 on root 'a' in Gurage languages.

LDCA in which participant segments are those with a high degree of similarity; in this case, the subclass of stops among the larger class of obstruents. Contrast plays no role in favoring stops for agreement over the coronal fricatives.

The LDCA pattern in verb roots contrasts with local voicing assimilation in Chaha, which includes all obstruents (Banksira 2000). Patterns of local voicing assimilation crosslinguistically show two predominant patterns: assimilation between all consonants including sonorants, or voicing assimilation between obstruents (Lombardi 1991, Fallon 1998). We know of no cases in which local voicing assimilation is restricted to the subclass of stops or the subclass of fricatives. The passive-reflexive prefix /t-/ in imperfective verb forms in Chaha is optionally voiced before voiced obstruents,[23] but not before sonorants. It is also optionally glottalized before ejectives.

(32)	jɨ-t-gəməs	*or*	jɨ-d-gəməs	'he cuts off into chunks'
	jɨ-t-zəməd		jɨ-d-zəməd	'he stretches (intr.)'
	jɨ-t-k'anəm		jɨ-t'-k'anəm	'he insults'
	jɨ-t-rək'ər		*jɨ-d-rək'ər	'it is uprooted'
	jɨ-t-manəx		*jɨ-d-manəx	'it is captured'

Crucially, the voicing assimilation is also triggered by fricatives. In addition, if a vowel intervenes, no voicing assimilation is attested. The /t-/ prefix of the verbs in 32 has an extra vowel, /tə-/, when attached to a perfective stem. Yet it is not realized with a voiced segment in this case: [tə-gəməsəm] 'he cut off into chunks' not *[də-gəməsəm]. As with [voice], local [cg] assimilation does not operate across a vowel: [tə-k'anəməm] 'he insulted' not *[t'ə-k'anəməm]. These data suggest that LDCA and local spreading of [voice] and [cg] are differentiated by the fact that local spreading may affect the whole class of obstruents, whereas LDCA is commonly restricted to stops. 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 at the point where agreement arose, compared with their participation in local voicing assimilation between obstruents. Combinations of laryngeally mismatched stop-fricative combinations are frequent in roots. Furthermore, as 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↔T), homorganic segments (T↔D), and heterorganic stops (K↔T, K↔D), as repeated from 21 in 33a for voicing only. With [cg] adding another dimension, there are further correspondences between homorganic voiceless stops (T↔T'), heterorganic voiceless (K↔T'), homorganic (D↔T'), and heterorganic (D↔K'), as shown in 33b.

(33) a. [voice]: CORR-T↔T ≫ CORR-T↔D ≫ CORR-K↔T ≫ CORR-K↔D
b. [cg]: CORR-T'↔T' ≫ CORR-T↔T' ≫ CORR-K↔T', CORR-D↔T' ≫ CORR-D↔K'

The [voice] agreement hierarchy is familiar from §3.2. The [cg] constraints are interpreted as follows. CORR-T↔T' requires correspondence between homorganic voiceless stops, including ejective and plain voiceless. CORR-K↔T' holds over the superset of homorganic and heterorganic voiceless stops. CORR-D↔T' expands to include homor-

[23] Obligatory total assimilation occurs before coronal stops and affricates: /jɨ-t-dəməd/ → [jɨddəməd] 'he joins (intr.)'.

ganic pairs that disagree in [voice] and [cg], and finally CORR-D↔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 CORR-K↔T’ ≫ CORR-K↔D. Furthermore, on a similarity scale (Frisch et al. 2004), 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 $C_i\mathscr{R}C_j$, if C_i bears a particular laryngeal feature, then C_j bears the same. IDENT-CC constraints are defined with respect to [voice] (see 23, §3.2) and [cg].

(34) 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 are 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 [wɨt’ək’] ‘fall!’, for which we consider a possible input /wɨdək’/ 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 35b and 35c lose out to candidate 35a because there is no correspondence relation established between the two stops in the root. Candidate 35d loses to candidate 35a because the corresponding stops do not match for [cg]. It is not enough that the consonants match only for [voice]. Finally, candidate 35e shows that the IDENT-CC constraints must outrank the IDENT-IO/OI constraints in order to compel agreement.

(35) CORR-K↔D ≫ IDENT-IO/OI(cg), IDENT-IO/OI(voice)

/wɨdək’/	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. ☞ wɨt’$_x$ək’$_x$							*(IO)	*(OI)
b. wɨt’$_x$ək’$_y$					*!	*	*(IO)	*(OI)
c. wɨd$_x$ ək’$_y$						*!		
d. wɨt$_x$ək’$_x$	*!						*(IO)	
e. wɨd$_x$ək’$_x$	*(!)	*(!)						

The tableau in 35 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 over the other would depend on directionality, which we set aside here in the synchronic grammar of Chaha.[24] The important point is that agreement for laryngeal features is enforced via Corr-C↔C and Ident-CC 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) 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 combinations in 36. 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^h t^h $tʃ^h$ k^h q^h s x h ɾ m n ɲ l ʎ w j/.

(36)

Homorganic		Heterorganic	
tunti	'arid, dry'	qotu	'group, pile'
k'ask'a	'acid to the taste'	*t'ank'a	
k^husk^{h}u	'common'	p^hut^{h}u	'hole, hollow'
*k'aka	(rare)	t'aqa	'flock, herd'
*k^haka	(rare)	t^hampa	'dense'
*k'ak^{h}a		t'alp^{h}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^h↔T. This ranking effectively prevents altering the [sg] feature specification of the second consonant, as shown in 37.

(37) Ident-IO(sg), Ident-OI(sg) ≫ Corr-K^h↔T

/t^hampa/	Id-CC(sg)	Corr-T^h↔T^h	Corr-T^h↔T	Id-IO(sg)	Id-OI(sg)	Corr-K^h↔T
a. t^h_xamp^h_xa					*!	
b. ☞ t^h_xamp$_y$a						*
c. t^h_xamp$_x$a	*!					
d. $t_x$amp$_x$a				*!		

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

If the input contained two aspirated stops, as in [p^hut^hu], then the constraint ranking would engender no alteration, because no high-ranking constraints compel violations of input-output faithfulness.

In 38, we illustrate an example with homorganic stops and consider an input with only one aspirated stop. The constraint T^h↔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. The reverse ranking is equally possible, however, and favors a candidate with no aspiration. Both candidates 38a and 38d 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. But the point of this tableau is to illustrate that SINGLE aspiration candidates cannot emerge as winners even if faithful to the input.

(38) CORR-T^h↔T ≫ either IDENT-OI(sg) or IDENT-IO(sg)

/k^husku/	ID-CC(sg)	CORR-T^h↔T^h	CORR-T^h↔T	ID-IO(sg)	ID-OI(sg)	CORR-K^h↔T
a. ☞ k^h_xusk^h_xu					*	
b. k^h_xusk$_y$u			*!			*
c. k^h_xusk$_x$u	*!					
d. $k_x$usk$_x$u				*!		

Homorganic ejectives show the same pattern, so the crucial ranking would be CORR-T'↔T ≫ either IDENT-OI(cg) or IDENT-IO(cg). By positioning the input-output faithfulness constraint between the CORR-C↔C constraint that refers to homorganic (T^h↔T) and the one that encompasses heterorganic (K^h↔T), we model the restriction of laryngeal agreement to apply only between homorganic stops.[25]

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↔T, as shown in 39 for [cg] and [sg].

(39) Chaha

CORR-T'↔ T >> CORR-K'↔ T >> IDENT-IO(cg), IDENT-OI(cg)

Bolivian Aymara

CORR-T^h↔ T >> IDENT-IO(sg), IDENT-OI(sg) >> CORR-K^h↔ T

[25] There are some additional complications in Aymara that we do not delve into here for lack of space. Aspirated stops pattern slightly differently than ejectives in that heterorganic ejectives may not cooccur: *[t'ank'a]. 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) 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 for an analysis of these additional facts.

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^husk^{h}u] 'common') and sonorants ([t'irt'aɲa] 'button up one's dress, shawl', [k^hank^{h}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: 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 and neutrality of nasals in NC sequences 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 40. [ɲ] represents a dorso-palatal stop.[26]

(40) Prohibited combinations (either order)
*m–^{m}b *n–^{n}d *ɲ–^{ŋ}g *m–^{ŋ}gb

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

(41) a. nanɛ̀ 'today' *na^{n}dɛ̀
b. ^{m}bɛɛ̀^{m}bɛ 'snail' *^{m}bɛɛ̀mɛ

The generalization is that nasal and prenasal stops that match in place must also agree in nasality, that is, 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 &

[26] 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.

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.[27]

In Ngbaka, the nasal agreement is limited to (near-)identical stops. Accordingly, consonant pairs that are less similar can disagree in nasality; in homorganic pairs, for instance, a nasal can occur with a (fully) oral stop (42a), and in heterorganic pairs, a nasal can occur with a prenasal stop (42b). In addition, two heterorganic nasals or prenasals are acceptable (42c–d).[28]

(42)	a.	boma	‘how’	c.	mini	‘tongue’
	b.	mà^{ŋ}gà	‘net’	d.	^{ŋ}gá^{m}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’, [^{m}bẽ] ‘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, 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 43 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-*).[29]

(43)	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’

[27] We remain neutral regarding particulars of the phonological representation of the sonorant nature of prenasal stops. See Piggott 1992 and Rice 1993 for discussion.

[28] 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 representations that he assumes, van de Weijer posits [p] and [m] as less dissimilar than [b] and [m]. Our crosslinguistic observations about similarity in LDCA suggest otherwise. Furthermore, similarity calculations using the method in Frisch et al. 2004 show that voiced stops are more similar to nasals than voiceless stops, for example, the pair [p]–[m] has a similarity rating of .29, whereas [b]–[m] has a similarity rating of .40.

[29] The data in 43 and 44 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).

c. ku-toot-ila	'to harvest for'	ku-kin-ina	'to dance for'
sakid-ila	'congratulate for'	non-ena	'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'.[30]

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 (discussed below). 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 1991:195–96, n. 3).[31]

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 as neutral in nasal agreement in two respects: they do not induce nasalization of voiced stops or sonorant consonants as in 44a, and they are transparent to agreement between simple nasals and voiced stops/sonorant consonants as in 44b.[32]

[30] Though the canonical Bantu radical is of the structure CVC- (Guthrie 1962:202), the lexical entry for this form appears to comprise the sequence [CV1VN. . .], as it is listed in the dictionary (Bentley 1887) without a corresponding [CV1-] verb entry (i.e. without [bil-a]). Hence, it is suggestive that the rightward direction of nasal agreement is not reducible to 'cyclic application' together with privileged root-initial faithfulness (cf. Hansson 2001a:380). The same is true of Yaka, which shows nasal agreement matching Kikongo's in the essentials (e.g. /nútúk-idi/ → [nútúk-ini] 'to slant', Hyman 1995). The rightward directionality in Yaka is apparent in cases like [fólámá] 'be delighted', [fwɛ́ɛ́bámá] 'be curved (back)' (Comparative Bantu On-Line Dictionary, http://linguistics.berkeley.edu/CBOLD), wherein stem-medial [1 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.

[31] 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 ɣ] to the list. But 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 [ɣ], 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 [ɣ] 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 /ʋ/.

[32] 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).

(44)

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-koŋg-olo	'we were tied'		tu-meŋg-ono	'we were hated'
	tu-biŋg-ulu	'we were hunted'			
	somp-ela	'borrow from/for'			

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–^{m}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 in Frisch et al. 2004. 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–^{m}b (.70) > p–b (.60) > m–^{m}b (.46) > NONADJACENT PAIRS: p–^{m}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 those least similar to nasals) and is consistent with the trends outlined in §2.

(46) Nasal similarity scale

Vocoid	Approximant Consonant	⇐ Nasal Stop ⇒	Voiced Stop	Voiced Fricative, Voiceless Consonant

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 that 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 implicate the inclusion of voiced consonants, which are more similar to nasals. Moreover, we argue below that the neutrality of NC clusters in Kikongo nasal agreement is attributable to a (dis)similarity effect, together with an avoidance of nasal geminates in the language.

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

(47) Nasal correspondence hierarchy: CORR-N↔N ≫ CORR-N↔^{N}D, CORR-M↔N ≫ CORR-N↔^{M}B, CORR-N↔D ≫ CORR-N↔B, CORR-N↔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 that are valid crosslinguistically. The nasal correspondence hierarchy in 47 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 CORR-N↔^{N}D ≫ CORR-M↔N. We 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 also have ramifications.

In our analysis, we 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 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 assume that the same ranking holds for this language, and in what follows we omit candidates involving denasalization from consideration.

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 48 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.)

(48) IDENT-CC(nas) ≫ IDENT-OI(nas)

/na^{n}dɛ/	ID-CC(nas)	ID-OI(nas)
a. ☞ $n_x a n_x$ɛ		*
b. $n_x a^n d_x$ɛ	*!	

In order to compel correspondence between homorganic nasal and prenasal stops in the output, CORR-N↔^{N}D must dominate IDENT-OI(nas), as shown in 49. The winning candidate is 49a, in which the stops are in correspondence and agree in nasality, incurring a violation of IDENT-OI(nas). The competitor in 49b fails because the homorganic stops do not correspond. Candidate 49c establishes correspondence between the stops, but it incurs a fatal IDENT-CC(nas) violation. IDENT-CC(nas) crucially outranks only IDENT-OI(nas) here, but since it is consistently obeyed in the language, we situate it at the top of the hierarchy.

(49) CORR-N↔^{N}D ≫ IDENT-OI(nas)

/na^{n}dɛ/	ID-CC(nas)	CORR-N↔N	CORR-N↔^{N}D	ID-OI(nas)
a. ☞ $n_x a n_x$ɛ				*
b. $n_x a^n d_y$ɛ			*!	
c. $n_x a^n d_x$ɛ	*!			

Since nasal agreement is not enforced in heterorganic pairs, IDENT-OI(nas) must outrank CORR-N↔^{M}B. The ranking is supported in 50. The winning output in 50a does not establish correspondence between the heterorganic nasal and prenasal consonants, violating CORR-N↔^{M}B but obeying IDENT-OI(nas). The alternative in 50b, in which the consonants agree, loses because nasalization of the second stop violates IDENT-OI(nas).

(50) IDENT-OI(nas) ≫ CORR-N↔^{M}B

/ma^{ŋ}ga/	ID-CC(nas)	CORR-N↔N	CORR-N↔^{N}D	CORR-M↔N	ID-OI(nas)	CORR-N↔^{M}B
a. ☞ $m_x a^ŋ g_y a$						*
b. $m_x a$ɲ$_x a$					*!	

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

What is important to notice about the constraint ranking for Ngbaka is that IDENT-OI(nas) is situated between the CORR-C↔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.

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↔C constraints involving prenasals are not of relevance here, so we omit these constraints from Kikongo tableaux. We also omit CORR-N↔N and CORR-M↔N, since these constraints produce only redundant nasal agreement and do not play a critical role in the alternations we examine.

Kikongo nasal agreement shows rightward directionality, as exemplified in /ku-dumuk-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 51. IDENT-C_LC_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_RC_L(nas) is responsible for agreement in the leftward direction. Unidirectional agreement arises under asymmetrical rankings of these constraints. Prioritization of IDENT-C_LC_R(F) produces progressive feature agreement, as in Kikongo, and dominance of IDENT-C_RC_L(F) results in regressive agreement, as in Kinyarwanda sibilant agreement (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.

(51) a. IDENT-C_LC_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_RC_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 $\alpha\mathcal{R}\beta$, faithfulness constraints may target either α or β. In the case of input-output correspondence, examples of constraints that target α include the MAX-IO family (McCarthy & Prince 1995) and the IDENT-IO formalism of Pater 1999, while those focusing on β are DEP-IO constraints and IDENT-OI. The directional constraints in 51 similarly distinguish the target of faithfulness, with characterization of α and β in terms of the precedence dimension.

By incorporating directionality into the expression of the constraint that drives agreement, we employ a tactic similar 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, Ní Chiosáin & Padgett 1997, cf. Walker 1998). 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.[33]

In Kikongo, the rightward direction of nasal agreement indicates that IDENT-C_LC_R(nas) is prioritized above IDENT-C_RC_L(nas). Since IDENT-C_LC_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_RC_L 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_LC_R(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_LC_R(nas) together outrank IDENT-OI(nas), as shown in 52. The winning candidate in 52a establishes correspondence between the nasal and suffix consonant, and they agree for nasality.[34] In 52b, the stops do not correspond, incurring a fatal violation of CORR-N↔B, and in 52c the stops correspond but do not agree in nasality, an outcome ruled out by IDENT-C_LC_R(nas).

(52) IDENT-C_LC_R(nas), CORR-N↔B ≫ IDENT-OI(nas)

/sim-idi/	ID-C_LC_R(nas)	CORR-N↔D	CORR-N↔B	ID-OI(nas)
a. ☞ sim_xin_xi				*
b. sim_xid_yi			*!	
c. sim_xid_xi	*!			

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 53. Candidates 53b and 53c, which do not nasalize /l/ in the output, are eliminated on the basis of CORR-N↔L and IDENT-CC(nas), respectively.[35]

[33] Compare 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).

[34] 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].

[35] 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. When, for instance, [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 twofold. 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.

(53) Corr-N↔L ≫ Ident-OI(nas)

/nik-ulu/	Id-C_LC_R(nas)	Corr-N↔D	Corr-N↔B	Corr-N↔L	Id-OI(nas)
a. ☞ $n_x$ikun$_x$u					*
b. $n_x$ikul$_y$u				*!	
c. $n_x$ikul$_x$u	*!				

Observe that the voiceless stop in 53 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_xiŋ$_x$un$_x$u] incurs a gratuitous violation of Ident-OI(nas), and likewise [$n_x$ik$_x$un$_x$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 tableau in 54 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_LC_R(nas), which requires that corresponding consonants following a nasal be specified [nasal], but it violates Ident-C_RC_L(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_LC_R(nas) over Ident-OI(nas) compels rightward nasal agreement in the /l/, as evident in comparison of 54a and 54e. The one-way directionality is seen in 54a versus 54b,c. In 54a, as opposed to 54b, both candidates establish correspondence between all three voiced consonants and both obey Ident-C_LC_R(nas). But the leftward agreement affecting the first voiced consonant in 54b incurs a fatal violation of Ident-OI(nas). Even though this candidate fares better with respect to Ident-C_RC_L(nas), this constraint is dominated by Ident-OI(nas), and hence a faithful mapping of the leftward /d/ is favored. Candidates 54a and 54c incur equal violations with respect to Ident-OI(nas), but 54c violates Corr-N↔L while 54a obeys it. Nasalization of the first voiced consonant is thus again suboptimal. Corr-C↔C constraints also rule out candidates 54d and 54f.

The final point that we address in our analysis of Kikongo nasal agreement is the neutrality of NC clusters. We attribute the neutrality of nasals in NC sequences to their dissimilarity from the potentially affected oral consonants. We consider two approaches for distinguishing the behavior of singleton nasals from nasals in NCs: one involves reference to their different syllable positions, and the other involves reference to their different release status. We develop the former approach here, but also sketch the latter possibility, leaving the choice between them to further research.

Turning to the syllable position approach, we speculate that nasals in medial NCs belong in a syllable coda. In contrast, singleton nasals belong to an onset, as do singleton oral stops. If syllable position is a factor contributing to segments' relative similarity, then the coda nasals' difference in this regard from the onset stops could give rise to their neutrality. In the area of language performance, studies have found that segments occupying the same syllable position are more likely to participate in speech errors (Shattuck-Hufnagel 1983, 1987). This lends support to the notion that matching syllable roles contribute to segments' similarity. In support of the heterosyllabic status of medial

(54) IDENT-C$_L$C$_R$(nas) ≫ IDENT-OI(nas) ≫ IDENT-C$_R$C$_L$(nas)

/ku-dumuk-ila/	ID-C$_L$C$_R$ (nas)	CORR-N↔D	CORR-N↔B	CORR-N↔L	ID-OI (nas)	ID-C$_R$C$_L$ (nas)
a. ☞ kud$_x$um$_x$ukin$_x$a					*	**
b. kun$_x$um$_x$ukin$_x$a					**!	
c. kun$_x$um$_x$ukil$_y$a				*!*	*	
d. kud$_x$um$_y$ukin$_y$a		*!	**		*	
e. kud$_x$um$_x$ukil$_x$a	*!					*
f. kud$_x$um$_y$ukil$_z$a			*(!)	*(!)		

NCs in Kikongo, Ao (1991:195, n. 2) points out that nasals devoice before a voiceless C word-initially (e.g. *n̥kosi* 'lion'), but not word-medially in normal rate speech (e.g. *zinkosi* 'lions'). He attributes this difference to the different syllabic roles of the nasals. Word-initial NCs are analyzed as tautosyllabic sequences. Note that with respect to neutrality, our attention is limited to medial NCs only, because in initial NCs the nasal derives from a prefix, which stands outside the stem domain in which nasal agreement operates.

The preference for relations to exist between segments with matching roles in syllable structure is accomplished by the constraint in 55 (after Gafos 1996, 1998; see also McCarthy & Prince 1993, 1994, Suzuki 1999).

(55) SROLE-CC: Corresponding consonants must have identical syllable roles.

The scenario is laid out in 56. SROLE-CC dominates CORR-C↔C constraints so as to inhibit correspondence between similar consonants that have different syllable roles. This ranking is responsible for eliminating candidates 56b and 56c, where the nasal in the NC cluster is in correspondence with a singleton onset consonant. Candidate 56c also fails to show nasal agreement between corresponding consonants, violating IDENT-C$_L$C$_R$(nas). Candidate 56a is optimal: it obeys SROLE at the cost of CORR-N↔L. (It is assumed here that the input contains a high vowel in the suffix, which is lowered through the operation of vowel harmony.)

(56) SROLE-CC ≫ CORR-C↔C constraints

/-somp-ila/	IDENT-C$_L$C$_R$ (nas)	SROLE-CC	CORR-N↔D	CORR-N↔B	CORR-N↔L	IDENT-OI (nas)
a. ☞ σ σ σ /|\ /\ /\ som$_x$p el$_y$a					*	
b. σ σ σ /|\ /\ /\ som$_x$p en$_x$a		*!				*
c. σ σ σ /|\ /\ /\ som$_x$p el$_x$a	*(!)	*(!)				

Nasal agreement across an NC cluster in a form like /tu-mant-idi/ → [tu-mant-ini] 'we climbed' is straightforward. Correspondence is established between /m/ and /d/, both syllabified into onsets, resulting in agreement between these consonants. The coda /n/ does not stand in correspondence with the onset stops, neither instigating nor blocking nasal agreement.

A further type of neutrality presented by NC clusters is that an oral voiced stop in the sequence fails to become nasal. This follows from avoidance of the structure that would result: geminate nasals are prohibited in Kikongo (Laman 1936), hence /tu-meŋg-idi/ → [tumeŋgini] 'we hated' *[tumeŋŋini].

The syllable role approach to the neutrality of nasals in NCs takes the view that prosodic structure contributes to determining segments' similarity, and accordingly, it influences their potential to interact at a distance. This departs from Hansson's claim (2001a) that LDCA patterns do not show sensitivity to prosodic structure. This point warrants further research.

A second possible approach to the neutrality of nasals in NC clusters appeals to dissimilarity with a source in 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. In NC clusters, release occurs not with the nasal but with the oral stop portion of the sequence. The distinction between released and unreleased stops has been argued to play a role in phonological processes. 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 incorporated the notion of release into segmental/featural representations (including Selkirk 1982, Steriade 1993, 1994) or have referenced 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 regard 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 might be referenced in phonological processes, but it is not a distinctive feature. However it is represented, we speculate that the presence or absence of a release phase could function as an independent characterizing property of segments that enters into the calculation of similarity. Under this view, agreement between released stops and nasals that lack release would be prevented by their lack of similarity in the dimension of release.

A possible benefit of the release-based analysis is that it is neutral on 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. 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.[36]

[36] Both the syllable-based and release-based approaches are potentially applicable to an NC dissimilation operative in certain Australian languages, such as Gurindji (McConvell 1993, Odden 1994). In this phenome-

Returning now to the core rankings responsible for producing nasal agreement, a summary of the hierarchies determined for Kikongo and Ngbaka is given in 57. We see in 57a 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.

(57) a. Kikongo: IDENT-C_LC_R(nas) >> CORR-N↔D >> CORR-N↔B, CORR-N↔L >> IDENT-OI(nas) >> IDENT-C_RC_L(nas)

b. Ngbaka: IDENT-C_LC_R(nas), IDENT-C_RC_L(nas) >> CORR-N↔^{N}D >> IDENT-OI(nas) >> CORR-N↔^{M}B, CORR-N↔D >> CORR-N↔B, CORR-N↔L

Another point of contrast between Kikongo and Nbgaka 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 57a, 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_LC_R(nas) and IDENT-C_RC_L(nas). Ngbaka does not restrict agreement to one direction, which results from locating both constraints in the top stratum. Furthermore, Kikongo shows neutrality of nasals in NC clusters, which can be handled by recognizing differences between preconsonantal versus prevocalic consonants, either along lines of syllable position or release status. Ngbaka, by contrast, permits only CV syllables, so the issue of segments' behavior in clusters does not arise.

To conclude, our nasal and laryngeal case studies have demonstrated the application of the ABC approach for different features and in diverse languages. This approach presents two central benefits. First, it restricts the interaction to consonants that are similar, such that participation of a given pair of consonants has the implication that any more similar pair also interacts. Second, implementing LDCA by correspondence accomplishes agreement across intervening segments without their producing blocking or being affected. Moreover, the CORR-C↔C constraints have the capacity to capture the varying degrees of strength of similarity requirements crosslinguistically, such as the restriction of LDCA to homorganic segments in some languages but not others.

6. ALTERNATIVE SPREADING ANALYSES.

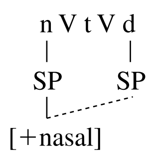
6.1. SPREADING-BASED APPROACHES. In nonlinear phonology, featural assimilations have been analyzed as the product of spreading, that is, through cross-segmental linkage of the feature in question. This approach has customarily been adopted both for assimila-

non, the nasal in an NC cluster deletes when preceded by an NC cluster at any distance in the word, for example, /kankula-mpa/ becomes [kankula-pa] 'on the high ground'. But NC clusters are compatible with a singleton nasal: [kani-mpa] 'downstream', signaling that the prevocalic and preconsonantal 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 consonants is deleted (Meinhof 1932). In Ganda, the plosive of the first syllable is lost, as in [enuŋgi] 'good (cl. 9)' for *enduŋgi; in Kuanyama, it is the second nasal, as in [ondoda] 'step (9)' for *ondonda.

tions 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.

Consider the case of nasal agreement. Hyman (1995) sketches a possible spreading-based account for Yaka, which shows an agreement pattern closely resembling that of Kikongo. A treatment of the transparency of vowels and voiceless consonants under tier-based locality is shown in 58. Under this approach, the Soft Palate node (SP), under which [+nasal] is contained, is specified on nasal segments and voiced consonants but is absent on vowels and voiceless consonants. Here /n/ and /d/ are adjacent at the SP tier, thereby accomplishing neutrality of the intervening segments.

(58)

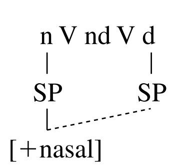


nVtVd → nVtVn

The representation in 58 contains a GAPPED CONFIGURATION. We follow Ní Chiosáin and Padgett (2001) in taking this to refer to structures where feature linkage gaps across an intervening segment of which it is not an associated property. In work assuming tier-based locality, gapped configurations are admitted provided that association lines do not cross (Goldsmith 1976) and locality at the relevant tier is respected. Such structures have not been limited to harmonies that produce alternations. MSCs have also been analyzed with tier-based linkage of features (Mester 1986, Yip 1989) and have given rise to gapped configurations.

Despite the early promise of the tier-based view of locality, this approach has drawbacks. First, it fails to capture the role of similarity. To illustrate, we return to nasal agreement. In spreading accounts, the neutrality of intervening segments is usually obtained through their lack of target node or structure. But the underspecification or other structural inertness that must be assumed for neutral NC complexes in nasal agreement is problematic. Consider the representation in 59, taken from Hyman 1995, where NC is underspecified for [nasal] and its immediately dominating node.

(59)



nVndVd → nVndVn

We must question why [nasal] and SP would be underspecified in NC but not in singleton nasals and voiced stops. In his discussion of Yaka, Hyman (1995) points out that several ad hoc representational solutions could accomplish NC's neutrality. These options are troubling because of both their lack of insight and their 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 60.

```
(60)    [nasal]        /kin-ulula/ → [kinununa] 'to replant'
          |`-.-.-.
         Ft    Ft
         /\     |
     σ (σ̲  σ) (σ)

     ki nu  nu  na
```

Under this approach, the oral quality of vowels in nasal harmony feet is attributed to STRUCTURE PRESERVATION (Piggott 1996:155–56): because nasal vowels do not occur in underlying representations, they are prevented from occurring in outputs. Our typology, however, 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, that is, 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. But 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 and 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 on certain coronal harmonies, and studies by McCarthy (1994) and Gafos and 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, but 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 30). 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 (2001a) 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. But 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) argues that sibilant agreement of the type found in Tahltan is best analyzed as alignment of [TTCA], a scalar feature that 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. Gafos claims that the spread feature affects all segments in the harmonic span;[37] 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

[37] Gafos (1996) 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.

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). Yet as discussed above, the same kind of analysis cannot reasonably extend to other types of LDCA. For cases of coronal agreement that show the same general characteristics as other kinds of LDCA, that is, the similarity of interacting segments and the neutrality of intervening segments, we consider it preferable to adopt a unified analysis (see 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 (2001a: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 about sibilant agreement in Baztan Basque. He points out that in the word [s̺iɲet̺s̺i] 'to believe', apico-alveolar [s̺] and [t̺s̺] show agreement across palatal [ɲ], 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 [ɲ] should merge with the language's apico-anterior [n]. But 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, 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 Anywa, there is no cooccurrence of dental and alveolar stops in a root. This also pertains to the nasals, even though [n̪] 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 61.[38] Word-final voiced stops are devoiced, which is not indicated here.

(61)

Dental		Alveolar	
n̪ùd̪ò	'to lick (sugar)'	núudó	'to press something down'
ōd̪óòn̪	'mud'	dīn	'to thresh something'
t̪ìín̪	'to be small'	tɔ̀ɔn	'to leak (a bit)'
t̪ùd̪	'ropes'	tūud	'pus'

[38] There is one word in which the nasal does not agree for dentality: [d̪àanɔ́] 'person', which Reh assumes was historically a compound.

The dental nasal arises through LDCA, and it may also emerge as a nasal mutation alternant of oral dental stops: for example, /pɔ́ɔd̪/ 'be smooth' → [pòon̪n̪ò] 'become smooth'. Anywa presents a counterexample to the claim that contrasts in the inventory determine which segments 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 by 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 /ṣ/ and /r/ (and /r̩/)[39] cause a following /n/ to become retroflex [ṇ] across intervening noncoronals and vowels (62a) 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 (62b) (Whitney 1889, Allen 1951, Schein & Steriade 1986, Flemming 1995b, Humbert 1995, Gafos 1996, Ní Chiosáin & Padgett 1997). Alternations are illustrated with the nominal and adjectival suffix *-ana* (Whitney 1889:426–27). [dh] is a dental stop; [c] and [j] are palatal stops.

(62) a.	rakṣaṇa	'protection'	b.	vardhana	'increase'
	kr̩paṇa	'miserable'		rocana	'shining'
	ākramaṇa	'striding'		vr̩jana	'enclosure'
	kṣayaṇa	'habitable'		ceṣṭana	'stirring'

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 by correspondence. First, the participant segments /ṣ r (r̩)/ and /n/ do not form a set of similar sounds to the exclusion of others. Although /r/ and /n/ are both sonorant, /ṣ/ is a voiceless continuant fricative whereas /n/ is a voiced nasal stop. Second, the assimilation 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 that we analyze as ABC, intervening segments of the same class as the agreeing segments fail to block. In Mayak dental agreement (see 13), for example, 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) 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 2001a

[39] The syllabic [r̩] is classified as a vowel by the Sanskrit grammarians and in all treatments of Sanskrit (e.g. Whitney 1889) but is clearly connected with consonantal [r], alternating with it under various conditions.

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 and 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.[40] The absence of this type of interaction has been a puzzle in phonological theory.[41] Ní Chiosáin and 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) 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 and colleagues (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. Errorful productions of this kind, however, were often perceived as ‘cop cop’, that is, 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

[40] In the development of certain languages such as Latin and Celtic from Proto-Indo-European, a word-initial *p became a labiovelar [k^w] if the second syllable began with [k^w], for example, Latin: **penk*^{w}*e* > **k*^{w}*enk*^{w}*e* > *k*^{w}*iːnk*^{w}*e* ‘five’ (Palmer 1961), Irish: **penk*^{w}*e* > **k*^{w}*enk*^{w}*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. First, the assimilation is quite restricted. It occurs only between labials and labiovelars and only when the affected consonant is in initial position. Second, the assimilation produces only full identity between consonants, and is not a partial assimilation. We are aware of no cases (in adult language) producing major place changes such as /tʌk/ → [kʌk]. This is suggestive that what underlies the Latin and Celtic phenomenon is a syllable-based reduplication (which yields complete copying), along the lines proposed by Zuraw (2000).

[41] Such a phenomenon is attested in child language. See Smith 1973, Cruttenden 1978, Vihman 1978, Dinnsen et al. 1997, Pater 1997, Goad 1997, 2001, Y. Rose 2000, Pater & Werle 2001, among others. The cause appears to be developmental. Gafos (1996) 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.

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 here 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 fifty cases of LDCA identified in §2, as well as further ones discussed in Hansson 2001a that 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 nonlocal 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. In contrast, feature spreading is at work in cases of local assimilation, that is, 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.[42]

[42] Previous work by Baković (2000) and 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. These analyses depart from the ABC proposal in two important ways, however. First, similarity does not drive the existence of a relation between elements, and second, the related entities are required to be adjacent, that is, local. See also Pulleyblank 2004 on an approach to vowel harmony driven by constraints prohibiting disagreement.

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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