DISTINGUISHING TOTAL AND PARTIAL IDENTITY: EVIDENCE FROM CHOL*

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1. INTRODUCTION

In the correspondence-based theory of faithfulness (McCarthy and Prince 1995), identity between corresponding segments is evaluated feature by feature. The feature-specific theory of faithfulness has been extended to account for assimilation between non-adjacent consonants in the correspondence based frameworks of Hansson (2001) and Rose and Walker (2004). Under this type of correspondence-based approach, total identity between corresponding segments is the result of multiple single-feature agreement constraints. In this paper, we argue instead for an all-or-nothing approach to total identity: corresponding segments must be evaluated for complete, non-feature-specific identity. Total identity is thus formally distinct from single-feature identity, which we analyze as local spreading.

In our proposal, total identity is required of output consonants that stand in a surface relation with one another. We call this relation *linking*. Establishment of the linking relation, and thus the total identity phenomenon, is sensitive to the similarity of the interacting consonants in much the same way as in correspondence-based frameworks. We argue, however, that the relation that governs long-distance agreement is different from classic correspondence. Consonants that stand in this relation (linking) are subject to a single requirement: *total identity*. They are not subject to the feature-specific faithfulness constraints that apply to correspondence relations. There are two main arguments for an analytic distinction between total assimilation and single-feature assimilation. First, a single-feature analysis of total identity predicts the existence of single-feature harmonies that are unattested outside of total identity, for example major place harmony. Second, examination of total identity systems reveals that total identity behaves differently from partial identity, and thus should be treated differently in the grammar.

We present data from Chol (Mayan), which exhibits both total and single-feature identity requirements. Chol is particularly informative because the total and partial identity requirements interact, highlighting the distinction between the two phenomena. Pairs of plain (non-ejective) stridents and pairs of ejectives must be completely identical in order to co-occur in a root, as shown in (1).

(1) Total identity
   a. *Plain stridents in a root agree in all features*

*ts-s	✓sus	'scrape'
*s-tʃ	✓tʃitʃ	'older sister'

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b. *Ejectives in a root agree in all features*
*k'-p' ✓k'ok' 'healthy'
*t^j'-ts' ✓t^j'ot^j' 'snail'

While plain stridents in Chol must be completely identical to co-occur, as in (1a), an ejective and a non-ejective strident are only required to agree for anteriority, as in (2).[1]

(2) Anteriority harmony: *stridents agree only in anteriority if one is ejective*
*ts'-ʃ ✓ts'is 'sew'
*s-tʃ' ✓ʃu^htʃ' 'thief'

We claim that the differing values for ejectivity between the root consonants in the examples in (2) is important because it affects the similarity of the two stridents. An ejective and a non-ejective strident escape the total identity requirement because they are sufficiently *dissimilar* and are thus not required to be linked.

A formal distinction between total identity, as in (1a), and anteriority harmony, as in (2), is necessary in order to account for the fact that ejectivity overrides the total identity requirement on stridents (*[ts-s] vs. ✓[ts'-s]), but anteriority harmony is required irrespective of whether one strident is ejective or not (*[ts'-ʃ] vs. ✓[ts'-s]). Contra proposals in Hansson (2001) and Rose and Walker (2004), we claim that unlike total identity, anteriority harmony is never mediated by a similarity-sensitive relation (either correspondence or linking). Instead, anteriority harmony is analyzed as local articulatory spreading (Flemming 1995; Gafos 1999). This analysis captures the important point that anteriority harmony is not sensitive to similarity. Instead, it applies to all segments that potentially contrast for anteriority.

The rest of this paper is organized as follows. In section 2 we introduce the Chol data, and in section 3 we outline our proposal for non-local consonant interactions. In section 4 we show how our framework accounts for Chol consonant agreement. Section 5 compares our proposal with the correspondence based proposals of Hansson (2001) and Rose and Walker (2004) and section 6 reviews the empirical support for both proposals. Section 7 concludes.

2. Background and Data

2.1. *Chol background*

Chol is a Mayan language spoken in Chiapas, Mexico by approximately 150,000 people. Chol belongs to the Greater Tzeltalan Group of the Mayan family, along with Chontal, Ch'orti', Tzeltal and Tzotzil.

The phoneme inventory of Chol consists of the twenty consonants in (3) and the six vowels [i, ɨ, u, e, o, a], along with the lengthened aspirated counterparts [i^h, $ɨ^h$, u^h, e^h, o^h, a^h] (Vázquez Álvarez 2002).[2] The five ejectives and six coronal stridents, given in bold in (3), figure in the co-occurrence restrictions discussed in this paper.

[1] See Lombardi (1990) and references cited therein for discussion of a similar pattern in Classical Yucatec Maya.
[2] We do not include consonants found only in Spanish loanwords, such as [d], [g] and [r].

(3) Chol consonants

	labial	coronal	velar	glottal
implosive	ɓ			
plosive	p	t^j	k	ʔ
ejective	**p’**	**ts’ tʃ’ t^j’**	**k’**	
fricative		**s ʃ**		h
affricate		**ts tʃ**		
nasal	m	ɲ		
approximant	w	l j		

The ejective consonants contrast with their non-ejective counterparts in all positions, for example [t^j’aɲ] ‘word’ vs. [t^jaɲ] ‘lime (calcium oxide)’ and [buts’] ‘smoke’ vs. [buts] ‘sprout’. While Chol has palatalized coronal consonants [t^j’, t^j, ɲ], it lacks the non-palatalized counterparts.

We assume that the affricates [ts, ts’, tʃ, tʃ’] are specified as [+strident, −continuant] (Clements 1999). They differ from the fricatives in being [−continuant], and from the coronal stops in being [+strident]. We adopt the feature [ejective] to distinguish ejectives from the other laryngeally specified consonants in Chol, [ʔ] and [ɓ], which do not interact with ejectives in the co-occurrence restrictions discussed below.[3] The feature [ejective] is proposed in Steriade (1997) to distinguish ejectives from glottalized sonorants. We propose that even in languages without glottalized sonorants, ejectives may be distinguished as a class with the feature [ejective]. The feature [constricted glottis] distinguishes the entire class of glottalized consonants, including ejectives, implosives, sonorants and the glottal stop. This more detailed feature system allows an account both of languages like Chol, where ejectives are subject to co-occurrence restrictions to the exclusion of other glottalized consonants, as well as languages where ejectives do interact with other glottalized sounds, for example dialects of Aymara (MacEachern 1999). Our featural assumptions for Chol obstruents are summarized in the table in (4).

(4)

	ɓ	p	p’	t^j	t^j’	ts	ts’	tʃ	tʃ’	s	ʃ	k	k’	ʔ
labial	+	+	+	−	−	−	−	−	−	−	−	−	−	−
coronal	−	−	−	+	+	+	+	+	+	+	+	−	−	−
dorsal	−	−	−	−	−	−	−	−	−	−	−	+	+	−
cont.	−	−	−	−	−	−	−	−	−	+	+	−	−	−
strident	−	−	−	−	−	+	+	+	+	+	+	−	−	−
anterior	−	−	−	−	−	+	+	−	−	+	−	−	−	−
ejective	−	−	+	−	+	−	+	−	+	−	−	−	+	−
const. glottis	+	−	+	−	+	−	+	−	+	−	−	−	+	+

In (4), we assume that all consonants are specified for all features, though this is not crucial. The features [-voice] and [-sonorant] are not included in the chart in (4) as these features serve only

[3] What we transcribe as [ɓ] is typically realized as [ʔ] or [p] word-finally and is pre-glottalized elsewhere (Attinasi 1973; Warkentin and Brend 1974). The voiced bilabial stop is described as implosive in other Mayan languages (England 1983).

to distinguish obstruents from non-obstruents. Lexical roots in Chol (and in Mayan languages generally) are predominately CVC in shape, allowing two consonants to combine in a root. In Chol, all twenty consonants may occur in either initial or final position in a root, but not all pairs of consonants may co-occur in the same root. These restrictions are discussed in detail below.

2.2. *Co-occurrence restrictions*

The co-occurrence of pairs of stridents and ejectives is restricted in Chol roots. Pairs of plain (non-ejective) stridents and pairs of ejectives may not co-occur in a root unless they are completely identical. Roots with two non-identical plain stridents or two non-identical ejectives are ungrammatical (*[ts-s], *[k'-p']), but identical pairs of stridents and identical pairs of ejectives are well attested (✓[ts-ts], ✓[k'-k']).

To document co-occurrence restrictions in Chol, we calculated the Observed/Expected (O/E) (Pierrehumbert 1993; Frisch et al. 2004) ratio for all pairs of consonants.[4] An O/E value below 1 indicates that two consonants co-occur less often than would be expected if they combined at random. A low O/E value could show the effect of some grammatical restriction on the co-occurrence of the consonants in question; the lower the O/E value, the stronger the restriction.[5] An O/E value of 1 or above indicates that two consonants co-occur freely. To calculate O/E values for Chol consonants we used a database of 893 CVC roots compiled—with the assistance of native Chol speakers and the second author's field notes—from the Aulie and Aulie (1978) Chol-Spanish dictionary (henceforth A&A).

Because the A&A dictionary lists stem forms, rather than roots, a few notes about the compilation of the database are in order. While some CVC roots may stand alone as words, the vast majority of Chol words are formed by combining a CVC root with one or more other morphemes. A given root may form a number of different stems with related meanings. The form [mɨk], for example, is found in the transitive verb stems [mɨkɨ] 'to cover', and [mɨkt^{j}aɲ] 'to tackle', an adverb [mɨkɨkña] 'in a closing-in manner', an adjective [mɨkɨl] 'dark, foggy', a noun [mɨkibɨl] 'jail', and an intransitive verb [mɨ^{h}kel] 'to become cloudy' (A&A 1978: 71). Due to the difficulty of determining whether two given stems are derived from the same semantically broad root, rather than from distinct but homophonous roots, we have chosen to include only a single member of any groups of homophonic roots in the database.

Furthermore, as noted in the previous section, Chol contains six plain vowels along with their lengthened aspirated counterparts, represented as [V^{h}]. CVC→CV^{h}C is a productive process for forming intransitive stems in Chol, as seen in the stems [hats'] 'hit' and [ha^{h}ts'] 'be hit'. However, there also exist minimal pairs that are less obviously related, such as [t^{j}am] 'long' and [t^{j}a^{h}m] '*mecapal*' (a long strap used for carrying loads). Again due to the difficulty in determining whether two words should be analyzed as derived from the same root, we have included only a single member of any CVC/CV^{h}C minimal pair in the database. The maximum *observed* value for any combination of consonants is thus limited by the number of plain vowels: six. Finally, while most Chol roots are CVC, there are some stem forms that were not obviously

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[4] The *expected* value for a pair of consonants is calculated by multiplying the observed instances of the two individual consonants and then dividing by the total number of roots. For example, the *expected* value for the combination [s-t^{j}] is the number of times [s] occurs in C_1 of a root (52), multiplied by the number of times [t^{j}] occurs in C_2 of a root (58), divided by the total number of roots in the database (893): 3.38. The *observed* value for [s-t^{j}] is 4. O/E = 1.18.

[5] As pointed out by an anonymous reviewer, low O/Es could also be the result of accidental gaps, diachronic sound change, or over-representation elsewhere in the database.

decomposable into CVC roots. These have also been omitted from the database.

Though the roots discussed below were drawn from the 1978 A&A dictionary, the attested forms important for our analysis (for example, forms in (5), (8), and (11) below), have been checked with at least five native Chol speakers between the ages of 18 and 40.[6] A variety of unattested forms were also checked and confirmed to be non-words in Chol. The analysis of the restrictions reported in the following sections is based on the assumption that generalizations about the shape of words in a language are present in the synchronic phonological grammar of any speaker of that language. We are thus claiming that the restrictions on stridents and ejectives in Chol are cognitively real. (Two speakers remarked independently that they found hypothetical roots with distinct ejectives to be "difficult to say".) While we have not conducted experiments confirming the status of root restrictions in Chol, several studies have been done which support the synchronic status of similar restrictions (Berent and Shimron 1997; Frisch and Zawaydeh 2001; Rose and King 2007; Idrissi et al. 2008).

2.2.1. *Stridents*

The first restriction on root consonants applies to the four plain (non-ejective) stridents, [ts, tʃ, s, ʃ]. Two plain stridents may not co-occur in a root unless they are completely identical. Non-identical plain stridents may co-occur in a word across a morpheme boundary, as discussed below. Examples of attested roots with identical plain stridents are given in (5a). Roots of the type in (5b), where two stridents disagree for continuancy, anteriority, or both, are nearly or completely unattested.[7]

(5) a.	ses	'salamander'[8]	b.	*sots
	sos	'gizzard'		*tʃiʃ
	sus	'scrape'		*tʃuts
	tsats	'sardine'		*ʃats
	tsɨts	'difficult'		*seʃ
	tsots	type of edible fruit		
	tsuts	'blanket'		
	ʃaʃ	'contaminate, stain'		
	ʃeʃ	'shrimp'		
	ʃiʃ	'grounds' (e.g., of coffee)		
	ʃuʃ	'wasp'		
	tʃitʃ	'older sister'		
	tʃutʃ	'squirrel'		

6 The A&A dictionary was compiled in the 1970's using data from the Tumbalá dialect of Chol. Two of the roots discussed below, [tʃ'atʃ'] 'bush' and [k'ak'], from the compound [ʃujk'ak'], a type of woody vine, were not recognizeable to the Chol speakers consulted in this study. This could be due to the fact that these speakers are from the Tila dialect region, or that these words—both words for plants—have fallen out of regular use. The exclusion of these two roots would not affect the analysis presented here, and as the dictionary is in general quite reliable, we have chosen to retain these roots.

7 As discussed above, while some of these roots may stand alone as words, others must appear in larger stem forms. See A&A (1978) for full forms.

8 The A&A dictionary lists *salamander* as a compound: [ses p'ok]. The root [p'ok] is listed as *lizard*, though [ses] is not independently listed. Consulted speakers identified the root [ses] as a type of small red insect.

There are two counterexamples to the strident restriction: the roots [tʃaʃ] ‘without leaves (tree), without walls (house)’ and [tʃoʃ] ‘open (at the bottom)’ (A&A 1978). Not only are these two apparent counterexamples of the same shape, [tʃVʃ], they also both belong to the class of “positional” roots found in Mayan languages, typically used to describe physical shape, configuration, or surface quality (see England 1983; Haviland 1994). Positional roots in Chol canonically appear in adjectival stem forms CVC-Vl (Vázquez Álvarez 2002), and are listed as such in the A&A dictionary: [tʃoʃol], [tʃaʃal]. Possible explanations for these roots are that the class of positional roots are subject to a special faithfulness constraint, as for example, in Ito & Mester’s (1995) analysis of Japanese word classes, or that the -Vl suffix has a floating [+cont] feature, which shows up only in this environment, though further work is needed here.[9] Interestingly, there are no contrasting roots of the form [tʃatʃ] or [tʃotʃ]. While additional work is needed to confirm the status of these roots in Chol, Lombardi (1990) finds no exceptions to the restriction on non-identical plain stridents in Classical Yucatec.

The O/E ratios of co-occurring plain stridents are given in the table in (6). The individual O and E values are given in (7). (Complete observed, expected and O/E values for all pairs of Chol roots are listed in Appendix A).[10] With the exception of the two apparent counterexamples discussed above, all non-identical pairs of stridents have an O/E of 0, while identical pairs all have O/Es around or above 1. These figures show that the co-occurrence of distinct plain stridents is highly restricted (there are many less than is expected by chance), while the co-occurrence of identical stridents is not (there are as many or more than is expected by chance).[11]

(6) O/E ratio for co-occurring plain stridents

C1 \ C2	ts	tʃ	s	ʃ
ts	**4.40**	0	0	0
tʃ	0	**0.79**	0	0.88
s	0	0	**1.39**	0
ʃ	0	0	0	**1.89**

(7) Strident O/Es compared

	Observed	Expected
Identical plain stridents	13	8
Non-identical plain stridents	2	22

A chi-square “goodness of fit” test confirms that the strident restriction in Chol is significant: $\chi^2 = 15.1$, $p < 2\text{x}10^{-5}$.

2.2.2. *Ejectives*

The second restriction applies to the five ejectives [p’, tʲ’, ts’, tʃ’, k’]. As is the case for plain stridents, two ejectives may not co-occur in a root unless they are completely identical. Attested

[9] We thank an anonymous reviewer for these suggestions.

[10] The O/E tables in the appendix reveal that Chol also shows co-occurrence restrictions on pairs of labials and pairs of ejectives and otherwise identical plain stops (e.g. [ts’-ts]). These restrictions are not analyzed in this paper (though they are compatible with the general linking framework).

[11] If we were to analyze the two [tʃVʃ] roots as containing a final affricate, all non-identical plain stridents would have an O/E of 0, and [tʃ-tʃ] would receive an O/E of 1.59.

roots with two identical ejectives are given in (8a). The hypothetical roots with non-identical ejectives in (8b) are all unattested.

(8) a. p'ip'	'wild'	(A&A 1978)	b.	*p'itʲ'
tʲ'otʲ'	'snail'			*k'ap'
ts'aʰts'	'soak'			*tʲ'uts'
ts'uʰts'	'kiss'			*tʃ'utʲ'
tʃ'atʃ'	'bush'			*p'otʃ'
tʃ'ɨtʃ'	'absorb'			*ts'ek'
tʃ'itʃ'	'blood'			
tʃ'otʃ'	'throat'			
tʃ'utʃ'	type of tree			
k'ak'	'woody vine'			
k'ɨk'	'flame'			
k'ok'	'healthy'			
k'uk'	'plumage'			

The O/E ratios of co-occurring ejectives are given in the table in (9). O and E values are given separately in (10). All non-identical pairs of ejectives have an O/E of 0, showing that there are no roots at all of this type. All pairs of identical ejectives have O/E values greater than 1 — they are all over-represented in the grammar.

(9) O/E ratio for co-occurring ejectives

C1 \ C2	p'	tʲ'	ts'	tʃ'	k'
p'	**1.79**	0	0	0	0
tʲ'	0	**2.35**	0	0	0
ts'	0	0	**1.42**	0	0
tʃ'	0	0	0	**2.88**	0
k'	0	0	0	0	**1.23**

(10) Ejective O/Es compared

	Observed	Expected
Identical ejectives	13	7
Non-identical ejectives	0	25

A chi-square "goodness of fit" test confirms that the ejective restriction in Chol is significant: $\chi^2 = 22.9$, $p < 4x10^{-7}$. The restrictions on plain stridents and ejectives only apply to *non-identical* pairs. The tables in (6) and (9) show that non-identical pairs are nearly absent (there are two exceptions, noted above), while identical pairs of stridents and ejectives are attested.

2.2.3. *The interaction between stridents and ejectives*

Above we saw that plain stridents must be totally identical to co-occur in a root. Total identity between plain stridents results from agreement in both stricture ([ts, tʃ] vs. [s, ʃ]) and minor place ([ts, s] vs. [tʃ, ʃ]). While two plain stridents must be totally identical to co-occur, an ejective and a plain strident need not be. If one strident in a root is ejective, only minor place agreement is required. In the attested roots in (11a), an ejective and a non-ejective strident agree in anteriority but not continuancy. Pairs of stridents that disagree in anteriority may not co-occur in a root, even if one is ejective, as in (11b).

(11)	a.	sɨts'	'stretch'	(A&A 1978)	b.	*tʃ'ɨs
		sits'	'saliva'			*ts'uʃ
		suts'	'bat'			*satʃ'
		ts'is	'sew'			*ʃots'
		ʃu^{h}tʃ'	'thief'			
		tʃ'ɨʃ	'boil'			
		tʃ'iʃ	'thorn'			
		tʃ'oʃ	'worm'			

The O/E values for roots with one plain and one ejective strident which agree in anteriority are as follows: [ts'-s] = 0.64; [s-ts'] = 1.56; [tʃ'-ʃ] = 1.38; [ʃ-tʃ'] = 0.59. All roots with combinations of stridents *not* agreeing in anteriority have an O/E of 0.

There is also some evidence that regressive anteriority harmony applies outside of the root. For example, the feminine noun class proclitic [ʃ-], urfaces as [s-] when attached to a root with a [+anterior] initial consonant. Compare, for example, [ʃ-wetʃ] 'armadillo' and [ʃ-wu^{h}t^j] 'shaman' with [s-ts'i^{h}b] 'scribe' and [s-tsats] 'sardine' (A&A 1978). The causative suffix [-(i)s] also triggers regressive anteriority harmony, as seen in the pair [tʃɨm] 'die' and [tsɨɲ-s] 'kill'. Forms like these highlight the contrast between anteriority harmony and total identity. While anteriority harmony extends beyond the domain of the root, the ban on the co-occurrence of very *similar* but non-identical pairs of consonants such as [ts] and [s] is confined to the root level. That is, while a root like *[sats] is impossible, words like [s-tsats] are grammatical. There are no affixes with ejectives in Chol, but compound words with two different ejectives do exist, for example, [tʃ'ɨm-pɨk'] (type of bird) (A&A 1978).

To summarize the data, stridents in a Chol root are subject to two restrictions. If both stridents are non-ejective and tautomorphemic, then they must agree in both stricture and minor place (resulting in total identity) in order to co-occur. If one strident is ejective or outside of the root, then only agreement in minor place ([anterior]) is required. Pairs of ejectives within a root must be totally identical.

3. LONG DISTANCE AGREEMENT – THE FRAMEWORK

In this section we lay out our analysis of long-distance consonant assimilation. We claim in §3.1 that total assimilation between non-adjacent consonants is the result of a relation between the two consonants, which we call *linking*. The establishment of the linking relation is sensitive to the similarity of pairs of consonants. Unlike total identity, we claim that partial identity between non-adjacent consonants is always the result of local articulatory spreading (Flemming 1995; Gafos 1999). The framework for partial assimilation is laid out in §3.2.

3.1. *Total identity through linking*

We propose that total identity between non-adjacent consonants is mediated through a relation between output consonants: *linking*. There are two types of markedness constraints that refer to the linking relation. One family of constraints requires that two consonants be linked if they are above a certain similarity threshold. A distinct constraint demands that linked consonants be featurally identical.

The LINK-CC family of constraints, defined in (12), requires that similar consonants stand in a linking relation. The formulation of LINK-CC is very similar to Rose and Walker's (2004) Corr-CC, which demands correspondence between output consonants.

(12) LINK-CC[αF, βG…] Given two consonants that co-occur in an output candidate, C_i and C_j, if C_i and C_j have the same values for features [αF], [βG], …, then C_i and C_j are linked. Assign one violation mark for every pair of consonants C_i C_j if first C_i and C_j share features [αF], [βG], … and second C_i and C_j are not linked.

The similarity of pairs of output consonants is crucial to the linking relation. We assume, following Rose and Walker (2004) and Hansson (2001), that similarity is represented in the grammar through the fixed ranking of LINK-CC constraints. Constraints that refer to more similar consonants universally outrank constraints that refer to less similar pairs of consonants. Similarity is defined through shared features.

Co-occurrence restrictions in Chol underscore the fact that certain features matter more to similarity than others. The fixed hierarchy of LINK-CC constraints gives more weight to certain features than to others, and thus the notion of similarity in this family of constraints is crucially different from that in Frisch et al. (2004). That features are necessarily weighted differently in similarity measures is shown in §4.1, in the context of our analysis of Chol (see also Coon and Gallagher to appear). The idea, however, is not new, and is supported by much other work on co-occurrence restrictions. MacEachern (1999) and Rose and Walker (2004), as discussed below, assume differential feature weighting in their discussion of similarity, though neither work highlights this point in particular.[12]

The importance of similarity to long-distance interactions (both assimilatory and dissimilatory) has been frequently discussed in recent literature (Pierrehumbert 1993; MacEachern 1999; Hansson 2001; Frisch et al. 2004; Rose and Walker 2004; Coetzee and Pater to appear). The observation is that the co-occurrence of more similar consonants is more restricted than that of less similar consonants.

In the correspondence-based framework of Rose and Walker (2004), the constraints that require correspondence stand in a stringency relation (Prince 1997; de Lacy 2002) such that correspondence between a particular pair of consonants implies correspondence between all pairs of consonants of equal or greater similarity. In this framework similarity is referenced by looking at the shared features between consonants. The formulation of the constraints, however, assumes that sharing certain features contributes more to similarity than sharing other features. For the purposes of laryngeal harmony, for example, agreeing in place is more important to similarity than agreeing in voicing (e.g. the pair [t'-d] is more similar than the pair [t'-k]). Stops that agree

[12] Feature weighting is more directly proposed in Coetzee and Pater's weighted constraint analysis of place co-occurrence restrictions in Muna (Coetzee and Pater to appear). Markedness constraints on certain features have a higher weight (and thus a greater influence on grammaticality) than markedness constraints on other features. In this model, features themselves are not weighted, but a similar effect is achieved by the variable weighting of constraints referring to different features.

in place may be required to correspond to the exclusion of stops that agree in voicing, but not vice-versa.

MacEachern (1999) presents a similarity hierarchy of pairs of consonants, which also demonstrates that certain features matter more to similarity than others. MacEachern claims that languages differ in the strength of their co-occurrence restrictions, but are sensitive to the same similarity hierarchy. If a language restricts the co-occurrence of a certain pair of consonants, it also restricts all more similar pairs. Not all features are equal on the similarity hierarchy. Ejectivity, for example, is a stronger determiner of similarity than aspiration. While there are languages like Bolivian Aymara that allow pairs of aspirates but not pairs of ejectives, no language in MacEachern's survey has the opposite pattern, restricting pairs of aspirates but not pairs of ejectives.

In our framework, similar pairs of consonants are required to be linked by the violable markedness constraints from the LINK-CC family. These linked consonants are subject to a single requirement, total identity. The only constraint besides LINK-CC (12), which refers to the linking relation, is IDENTITY, defined in (13).

(13) IDENTITY Linked consonants are identical. Given two linked consonants, C_i C_j, assign one violation mark if any feature of C_i is not present in C_j or vice-versa.

The constraint IDENTITY evaluates total featural identity between pairs of linked consonants; it is equally violated by pairs of consonants that disagree in one feature as by pairs that differ in several features. LINK-CC and IDENTITY are the only constraints that refer to the linking relation. Linking is thus quite different from a correspondence relation, to which single-feature identity constraints, among others, refer.

In Chol, as is the case for many other languages showing similar phenomena, the majority of roots have at most two consonants (or at most two stops that may potentially be ejective, e.g. Cuzco Quechua and other languages discussed in MacEachern (1999)). For now, we make several non-crucial claims about the linking relation, which may need to be revised by examination of co-occurrence restrictions in languages with more than two consonants per root. First, we assume that violations of LINK-CC and IDENTITY are computed for *pairs* of consonants. A candidate with three consonants may thus violate either of these constraints multiple times. In a language where all ejectives are above the similarity threshold, a candidate like [k'ap'at'] satisfies LINK-CC if all three ejectives are linked [$k'_x ap'_x at'_x$] (the linking relation is notated with matching subscripts), but violates it twice if only two ejectives are linked, e.g. [$k'_x ap'_x at'_y$]. The candidate [$k'_x ap'_x at'_y$] violates LINK-CC once for the unlinked pair k'_x-t'_y and once for the unlinked pair p'_x-t'_y. Similarly, if all ejectives in a language are linked, a candidate like [$k'_x ap'_x at'_x$] violates IDENTITY three times, once for each of the non-identical linked pairs k'_x-p'_x, k'_x-t'_x and p'_x-t'_x. A candidate like [$k'_x ak'_x at'_x$] violates IDENTITY twice.[13]

Second, we assume that the linking relation is transitive; if A is linked to B and B is linked to C, then A is linked to C. The issue of transitivity of linking is potentially relevant to the issue of locality. Because Chol roots have only two consonants, the question of locality in the linking relation does not come up. Co-occurrence restrictions do, however, show locality effects (Frisch et al. 2004; Buckley 1997; Coetzee and Pater 2008). In languages with place restrictions, for example, consonants that are separated by a single vowel are more tightly restricted than

[13] See Hansson (2007) for more explicit discussion of the computation of violation marks for candidates with more than two interacting consonants.

consonants that are further apart (e.g. $\mathbf{C_1}V\mathbf{C_2}VC_3$ v $\mathbf{C_1}VC_2V\mathbf{C_3}$). In the cases of consonant harmony discussed in Hansson (2004), some total identity effects are restricted to consonants in adjacent syllables. In Yabem, for example, prefix alternations are only triggered by the initial root consonants; the interacting consonants may only be separated by a single vowel. Cases of this sort suggest that there are locality conditions on a relation like linking. To account for locality, Link-CC constraints may specify that interacting consonants must be in adjacent syllables. More research is required to determine what locality conditions are prevalent in cases of long-distance total identity. For now, we leave the possibility open that Link-CC constraints impose locality conditions.

In order for total identity to occur between a pair of consonants, both Link-CC and Identity must outrank input-output faithfulness, as demonstrated by the hypothetical example in (15). Consider a language where ejectives are subject to a total identity requirement. The Link-CC constraint active in this case is defined in (14); it requires the linking relation to hold between pairs of ejectives.

(14) Link-CC[+ejective] Given two output consonants, C_i and C_j, if C_i and C_j are both [+ejective], then C_i and C_j are linked. Assign one violation mark for every pair of consonants C_i C_j if first C_i and C_j share the feature [+ejective] and second C_i and C_j are not linked.

(15)

/k’ap’i/	Link-CC	Identity	IO-Ident[F]
a. → k’$_x$ak’$_x$i			*
b. k’$_x$ap’$_x$i		* !	
c. k’$_x$ak’$_y$i	* !		*
d. k’$_x$ap’$_y$i	* !		
e. → k’$_x$ap$_y$i			*

The tableau in (15) gives two winning candidates. The candidate in (15a) satisfies the high-ranked constraints through linking and assimilation. The alternative winning candidate in (15e) is dissimilatory. This candidate changes the input consonants such that they are no longer above the similarity threshold. Consequently, they are not required to be linked by Link-CC and Identity is vacuously satisfied. The ranking of feature specific IO-Ident constraints decides between dissimilatory and assimilatory outputs. In (15), for example, the output depends on the relative ranking of IO-Ident[ejective] and IO-Ident[place]. This issue is discussed further with respect to the analysis of Chol presented in §4.

If either Link-CC or Identity is ranked below IO-Ident[F], the faithful candidate wins, as shown in the two tableaux in (16).

(16) a.

/k’ap’i/	Link-CC	IO-Ident[F]	Identity
a. k’$_x$ak’$_x$i		* !	
b. → k’$_x$ap’$_x$i			*
c. k’$_x$ak’$_y$i	* !	*	
d. k’$_x$ap’$_y$i	* !		

b.

/k'ap'i/	IDENTITY	IO-IDENT[F]	LINK-CC
a. k'$_x$ak'$_x$i		* !	
b. k'$_x$ap'$_x$i	* !		
c. k'$_x$ak'$_y$i		* !	*
d. → k'$_x$ap'$_y$i			*

As can be seen from the examples above, we assume that linking relations are freely generated in output candidates by GEN. Whether linking has any effect in a language depends on the relative ranking of IDENTITY and LINK-CC with respect to IO-faithfulness constraints, as shown in the two tableaux in (16). Given Richness of the Base (Prince and Smolensky 1993/2004), linking relations may also be present in underlying forms. Both LINK-CC and IDENTITY, however, are *markedness* constraints, which look only at the output. Linking relations in the input are thus not subject to any faithfulness constraints, and will be preserved or deleted based on the relative ranking of LINK-CC and IDENTITY with other constraints.

The formulation of the linking relation given above has two major consequences. The first is that the only truly long-distance interaction between consonants is total assimilation. Long-distance interactions are mediated by the linking relation, but the only constraint on linked consonants is IDENTITY, which requires complete assimilation. There are no constraints that demand partial assimilation between linked consonants. The second consequence is that total identity should be sensitive to similarity. Since LINK-CC references similarity, we expect to see total identity requirements on more similar pairs of consonants to the exclusion of less similar pairs. Furthermore, since only total identity is mediated through the linking relation, we should not see similarity effects for partial assimilation.

The consequences discussed above are the two principal differences between our proposal and the correspondence-based approaches to long-distance agreement in Hansson (2004) and Rose and Walker (2004). In these proposals, both partial identity and total identity are mediated through a similarity-sensitive correspondence relation between output consonants, called CC-correspondence.[14] As in input-output and base-reduplicant correspondence (McCarthy and Prince 1995), in CC-correspondence corresponding consonants are subject to feature-specific IDENT[F] constraints. Thus, partial identity may be a truly long-distance effect, skipping intervening segments entirely.

Under the correspondence analysis, partial identity should show sensitivity to the similarity of the interacting consonants (since correspondence itself is determined based on similarity), applying to more similar pairs to the exclusion of less similar pairs. In §6 we compare linking to correspondence-based proposals and show that the more restrictive typological predictions of the linking proposal are borne out by the majority of consonant harmony patterns.

3.2. *Minor place harmony through articulatory spreading*

While we analyze total identity as the result of similarity-sensitive linking between consonants, partial identity effects are analyzed as articulatory spreading. We thus make a distinction between *total* identity between non-adjacent consonants, which is a truly non-local effect, and *partial* identity between non-adjacent consonants, which we argue is in fact a local phenomenon. Arguments for this distinction are presented in §5.

[14] Neither Hansson nor Rose and Walker claim that *all* partial assimilations involve correspondence. Both allow that some coronal harmonies result from local spreading.

Local analyses of partial identity requirements have been proposed for minor place harmonies, for example, for many coronal harmonies (Flemming 1995; Gafos 1999; Ní Chiosáin and Padgett 1997). In these proposals, the autosegmental or gestural features for minor place contrasts spread through all consonants and vowels intervening between the affected segments. Minor place specifications have no audible effect on non-contrastive segments, creating the appearance of a long-distance effect. The general idea, without adopting the specifics of any one proposal, is illustrated by the example from Chumash in (17) (Hansson 2001: 58, from Applegate 1972).

(17) Local analysis: ʃapi**t**ʃʰolit /**s**-api-**t**ʃʰo-it/ 'I have a stroke of good luck'

Chumash shows minor place harmony between stridents. In a local analysis, the autosegmental or gestural feature for minor place in stridents is present on each of the segments intervening between the two stridents. The scope of spreading is represented by the underlining in *ʃapi**t**ʃʰolit*. In contrast, a non-local analysis based on correspondence or linking would look as in (18). The two affected stridents are connected via a correspondence relation and only these two segments bear the minor place feature, again indicated by underlining.

(18) Non-local analysis: ʃ$_x$api**t**ʃʰ$_x$olit

Without committing to the specific assumptions of any one author, we adopt an articulatory spreading analysis of partial identity. The gestural specifications for the spreading feature are maintained through all intervening segments. Following Gafos (1999), we propose that spreading is the result of a constraint expressed in the Generalized Alignment theory of McCarthy and Prince (1993), which demands that a particular feature be aligned with a particular edge of the root or word. Chumash has right-to-left anteriority harmony, which is required by the constraint in (19).[15]

(19) ALIGN([α anterior]; RT; L)
An [α anterior] specification is aligned with the left edge of the root.

In (19), we use the feature [α anterior] to stand in for the gestural configuration that corresponds to the contrastive property of stridents.[16] Following Gafos, the two other arguments of the constraint are the domain and direction of spreading. If the constraint in (19) outranks IO-faithfulness, harmony is preferred, as shown in (20).

(20)

/**s**-api-**t**ʃʰo-it/	ALIGN[ant]	IO-IDENT[ant]
a. **s**api**t**ʃʰo-it	* !	
b. → ʃapi**t**ʃʰolit		*

[15] The minor-place contrast in Chumash is described by Gafos (1999) as a laminal-apical contrast. See Gafos (1999) and references cited there for further discussion.

[16] Gafos proposes two gestural features, Tongue Tip Constriction Area [TTCA] and Tongue Tip Constriction Orientation [TTCO] in his analysis of Chumash. In the absence of articulatory data, we cannot be specific as to which gestural parameter is at play in a given language.

4. THE ANALYSIS OF CHOL

In this section we present an analysis of total and partial identity in Chol. The first subsection discusses the role of similarity in the Chol phenomena and presents the analysis of total identity between ejectives and plain stridents. Anteriority harmony is accounted for in §4.2.

4.1. *Total identity*

Recall that in Chol, total identity is required of pairs of ejectives and pairs of *plain* (non-ejective) stridents in a root. We have proposed that total identity is required of all linked consonants, and that the linking relation is established based on similarity. LINK-CC constraints must be able to pick out pairs of ejectives and pairs of plain stridents to the exclusion of all other pairs of consonants. We propose the fixed hierarchy of LINK-CC constraints in (21).

(21) LINK-CC[+ejective] >> LINK-CC[+strident, −ejective] >> LINK-CC[+strident]

LINK-CC constraints referring to other features are ranked below LINK-CC[+strident]. This hierarchy makes two main claims about similarity. First, the features [+ejective] and [+strident] are stronger determinants of similarity than other features. Second, [+ejective] matters more to similarity than [+strident] (Coon and Gallaghr to appear). Both of these claims boil down to the idea that a measure of similarity must involve differential feature weighting.

The total identity requirement in Chol clearly shows that certain features are more important to similarity than others. That is, it is not the number of features two consonants share that makes them similar; rather it is *which* features they share. For example, the two ejectives in *[k’-p’] and two plain stops in ✓[k-p] each differ in one feature, yet only the co-occurrence of the first is restricted. Similarly, the grammatical pair in ✓[ts’-s] differs in only two features while the ungrammatical pair *[k’-tʃ’] differs in three.

The observed interaction of ejectivity and stridency in Chol follows from assuming that ejectivity is even more important to similarity than stridency. While agreeing in ejectivity makes two consonants very similar, disagreeing in ejectivity makes them very dissimilar, hence the grammaticality of an ejective and a plain strident: ✓[ts’-s]. While disagreement in ejectivity outweighs agreement in stridency, the converse is not true: a strident and a non-strident ejective are still ungrammatical: *[ts’-k’]. This asymmetry follows from the proposal that ejectivity is a stronger determinant of similarity than stridency, thus the constraint LINK-CC[+strid, −ej], which picks out non-ejective stridents, outranks LINK-CC[+strid], which requires linking in all pairs of stridents.

If LINK-CC[+strid, −ej] and IDENTITY outrank IO-IDENT[F] constraints, then total identity will be required of plain stridents and ejectives in Chol. Under the principle of Richness of the Base (Prince and Smolensky 1993/2004), a complete analysis must map any input to a grammatical output. To show that the analysis accounts for the data in Chol, we thus consider various ungrammatical and grammatical inputs and show that they map to grammatical Chol outputs. Given an ungrammatical input with two non-identical ejectives, as in (22) and (23), the optimal output has two identical ejectives, regardless of how many IO-IDENT[F] violations are required.

(22)

/k'-p'/	LINK-CC	IDENTITY	IO-IDENT[place]
a. → k'_x-k'_x			*
b. k'_x-p'_x		* !	
c. k'_x-p'_y	* !		

(23)

/ts'-t^j'/	LINK-CC	IDENTITY	IO-IDENT[strid]	IO-IDENT[ant]
a. → ts'_x-ts'_x			*	*
b. ts'_x-$t^{j}{'}_x$		* !		
c. ts'_x-$t^{j}{'}_y$	* !			
d. ts'_x-$tʃ'_x$		* !	*	

Another possible optimal output for ungrammatical inputs like /k'-p'/ or /ts-s/ is dissimilatory, as in [k'-p] or [t^j-s]. Dissimilation makes two consonants less similar, and thus escapes the linking and total identity requirements. The ranking of specific IO-IDENT[F] constraints chooses between the assimilatory and dissimilatory candidate, though because the root co-occurrence restrictions in Chol are static, we do not have data to discover this ranking.

An anonymous reviewer points out that another potential way of satisfying IDENTITY and LINK-CC is deletion. In Chol, roots are always CVC, and thus deletion of a consonant would violate whatever high-ranked prosodic constraints impose this root shape. The vast majority of total identity cases in the literature are static restrictions on roots, and thus it is impossible to diagnose which faithfulness constraints are being violated, though nothing seems to rule out deletion in principle. Whether assimilation, dissimilation or something else occurs, however, does not affect the core of the analysis.

The tableau in (23) above shows that partial assimilation does not satisfy IDENTITY. Two stridents that disagree only in anteriority, as in (23d), violate IDENTITY once, just like two consonants that disagree in both stridency and anteriority, as in (23b). In (24) and (25) we show that the ranking schema of LINK-CC[+strid, −ej], IDENTITY >> IO-IDENT[F] accounts for total identity between stridents.

(24)

/ts-s/	LINK-CC	IDENTITY	IO-IDENT[cont]
a. → ts_x-ts_x			*
b. ts_x-s_x		* !	
c. ts_x-s_y	* !		

(25)

/tʃ-s/	LINK-CC	IDENTITY	IO-IDENT[cont]	IO-IDENT[ant]
a. → $tʃ_x$-$tʃ_x$			*	*
b. $tʃ_x$-s_x		* !		
c. $tʃ_x$-s_y	* !			
d. $tʃ_x$-$ʃ_x$		* !		*

Grammatical inputs with two identical stridents or ejectives surface faithfully, as exemplified in (26). The two consonants are linked, and satisfy high-ranked IDENTITY without violating any IO-IDENT[F] constraints.

(26) /s-s/	LINK-CC	IDENTITY	IO-IDENT[F]
a. → s_x-s_x			
b. s_x-s_y	* !		
c. s_x-t^j_y			** !

LINK-CC[+strid, −ej] only demands that plain stridents and ejectives (due to the fixed ranking of LINK-CC[+ej] at the top of the hierarchy) be linked. Since IDENTITY only requires total identity of linked consonants, many pairs of Chol consonants are free to co-occur. An ejective strident and a plain strident, for example, are not required to be completely identical or linked.

(27) /ts'-s/	LINK-CC	IDENTITY	IO-IDENT[ej]	IO-IDENT[cont]
a. → ts'$_x$-s_y				
b. ts'$_x$-s_x		* !		
c. ts'$_x$-ts'$_x$			* !	*

In (27), LINK-CC is satisfied by the winning candidate. Linking is not required between an ejective strident and a plain strident. While linked and un-linked candidates are freely generated, linked consonants are subject to further requirements that doom the candidates in (27b–c). While an ejective and a plain strident do not have to be totally identical, they must agree in anteriority. We turn to this portion of the analysis next.

4.2. *Anteriority harmony*

In Chol, all pairs of stridents in a root must have the same anteriority value. When the two stridents in a root are both non-ejective or both ejective, anteriority harmony is subsumed under total identity. When a plain strident and an ejective affricate combine, however, anteriority harmony can be seen in isolation. While a plain strident and an ejective affricate do not have to be totally identical, they do have to have the same minor place of articulation. The pattern is summarized in (28).

(28) a. plain stridents in a root – anteriority harmony subsumed under total identity
*ts-tʃ *ʃ-s ✓ts-ts ✓ʃ-ʃ

b. an ejective and a plain strident in a root – anteriority harmony alone
*ts'-ʃ *s-tʃ' ✓ts'-s ✓ʃ-tʃ'

Anteriority harmony applies independently of total identity in Chol, thus highlighting the distinction between these two processes in the language. While we analyze total identity as the effect of long-distance linking between two consonants, anteriority harmony is the result of local, articulatory spreading. The application of anteriority harmony outside of the root shows that Chol, like Chumash, has regressive spreading. As discussed in section 2.2.3 above, a suffix with an anteriority specification triggers changes in root stridents, and root specifications trigger alternations in the noun class morpheme /ʃ-/. We follow Gafos' formulation of spreading inducing markedness constraints, though the specifics of his formulation are not critical to our broader claims. In Gafos' framework, an ALIGN constraint takes three arguments: the articulatory parameter that spreads, the domain of spreading, and the direction of spreading. The more common [α anterior] feature is used in place of Gafos' articulatory features simply for convenience.

(29) ALIGN([α anterior]; WD; L)
An anteriority specification spreads to the left edge of the word.

Anteriority harmony in Chol is the result of the ALIGN constraint in (29) outranking IO-faithfulness to anteriority, as shown in (30).

(30)

/ts'-ʃ/	ALIGN(ant)	IO-IDENT[ant]
a. → tʃ'-ʃ		*
b. ts'-ʃ	* !	

When two plain stridents co-occur in a root, linking and total identity apply. The ALIGN constraint is also satisfied in this case, though its effects on the two stridents duplicate those of the total identity requirement.

(31)

/ts-ʃ/	LINK-CC	IDENTITY	ALIGN(ant)	IO-IDENT[F]
a. → $tʃ_x$-$tʃ_x$				**
b. $tʃ_x$-$ʃ_y$	* !			*
c. ts_x-$ʃ_y$	* !		*	

Total identity applies long-distance, via linking, ignoring the intervening vowel. Alignment of the anteriority gesture spreads through the vowel, though any effects on the vowel are inaudible.

5. A COMPARISON OF LINKING AND CC-CORRESPONDENCE

The proposal that total identity between non-adjacent consonants is established via a relation between these consonants draws on the correspondence based approaches to non-local assimilation in Hansson (2001) and Rose and Walker (2004). Linking, however, is fundamentally different from correspondence-based approaches in assuming that the only requirement on consonants that stand in this relation is total identity. In this section, we present a CC-correspondence based analysis of Chol. While it is possible to analyze the Chol phenomena in this framework, we argue that an analysis based on linking and articulatory spreading is simpler and makes better predictions.

5.1. *The correspondence-based analysis of Chol*

In the correspondence-based theory of long-distance agreement, interacting consonants stand in correspondence with one another. As with the linking relation discussed in §3, correspondence is established between non-adjacent segments based on their similarity. In both frameworks, then, we expect to see effects of similarity on long-distance agreement. Agreement between corresponding consonants is demanded on a feature-by-feature basis, as in other dimensions of correspondence (input-output, output-output, base-reduplicant, etc.), by constraints from the CC-IDENT[F] family.

Recall that total identity in Chol is required between pairs of plain stridents and pairs of ejectives. In the feature-by-feature correspondence-based theory, total identity must be the result of multiple, single feature identities. Ejectives in Chol contrast for major place ([p’] vs. [k’] vs. [t^j’, ts’, tʃ’]), minor place ([ts’] vs. [tʃ’]), and stridency ([t^j’] vs. [ts’, tʃ’]). Plain stridents contrast for minor place ([ts, s] vs. [tʃ, ʃ]) and continuancy ([s, ʃ] vs. [ts, tʃ]). To account for total identity in Chol with feature-specific identity constraints, then, the four constraints in (32) are needed.

(32) a. CC-Ident[place]
b. CC-Ident[α anterior]
c. CC-Ident[α continuant]
d. CC-Ident[α strident]

For the constraints in (32) to affect the output, pairs of ejectives and pairs of plain stridents must correspond. In the correspondence-based framework, Corr-CC demands correspondence between certain similar sets of consonants, just like Link-CC. The exact formulations of Corr-CC proposed in Hansson (2001) and Rose and Walker (2004) do not bear on the current discussion and these constraints are omitted from the following tableaux for reasons of space. The feature-by-feature analysis of total identity in Chol is given in (33) and (34).

(33) Total identity between ejectives

/ts’-k’/	CC-Id[ant]	CC-Id[strid]	CC-Id[place]	IO-Id[ant]	IO-Id[strid]	IO-Id[place]
a. → ts’$_x$-ts’$_x$				*	*	*
b. ts’$_x$-t^j’$_x$	* !	*				*
c. ts’$_x$-tʃ’$_x$	* !				*	*
d. ts’$_x$-k’$_x$		*	* !			

(34) Total identity between plain stridents

/ts-ʃ/	CC-Id[ant]	CC-Id[cont]	IO-Id[ant]	IO-Id[cont]
a. → ts$_x$-ts$_x$			*	*
b. ts$_x$-tʃ$_x$	* !			*
c. ts$_x$-s$_x$		* !	*	
d. ts$_x$-ʃ$_x$	* !	*		

The tableaux in (33) and (34) illustrate that in the correspondence-based analysis, total identity results from multiple CC-Ident[F] constraints outranking their IO-counterparts.

Independent of the total identity requirement, Chol exhibits anteriority harmony. An ejective and a non-ejective strident escape the total identity requirement (✓[ts’-s]), but are still required to have a single value for [α anterior] (*[ts’-ʃ]). In a feature-by-feature correspondence-based analysis, anteriority harmony is the effect of CC-Ident[α anterior]. For CC-Ident[α anterior] to have the desired effect, Corr-CC must demand that all pairs of stridents stand in correspondence. The correspondence-based analysis of anteriority harmony in Chol is shown in (35).

(35)

/ts'-ʃ/	CORR-CC	CC-ID[ant]	IO-ID[ant]
a. → ts'_x-s_x			*
b. ts'_x-$ʃ_x$		* !	
c. ts'_x-$ʃ_y$	* !		

Integrating the correspondence-based analyses of anteriority harmony and total identity between stridents is somewhat challenging. Our proposal claims that an ejective and a plain strident in Chol are not required to be totally identical because they are not *linked* (since they are below the relevant similarity threshold). If this line of thinking is translated into the correspondence approach, then an analysis of Chol is impossible. If an ejective and a plain strident don't correspond, then CC-IDENT[α anterior] cannot require anteriority harmony.

An alternative for a correspondence-based approach would be to assume that similarity is not relevant to the behavior of stridents in Chol and that all stridents stand in correspondence. If all stridents stand in correspondence, then the consistent application of anteriority harmony to all pairs of stridents can result from ranking CC-IDENT[α anterior] over IO-IDENT[α anterior]. Continuancy harmony, however, applies to some pairs of stridents, but not all. This inconsistency is the challenge for a partial identity analysis. It can be handled by ranking IO-faithfulness constraints to [+continuant] and [−continuant], defined in (36), separately (cf. Hall 2006).[17] If the ranking in (37) holds, then an affricate may be mapped to a fricative in order to achieve identity, but a fricative will not change to an affricate.

(36) IO-IDENT[+continuant] Given an input segment S_i and a corresponding output segment S_o, if S_i is [+continuant] then S_o is [+continuant].

IO-IDENT[−continuant] Given an input segment S_i and a corresponding output segment S_o, if S_i is [−continuant] then S_o is [−continuant].

(37) IO-IDENT[+continuant] >> CC-IDENT[continuant] >> IO-IDENT[−continuant]

Given the ranking in (37), continuancy harmony will hold for pairs of plain stridents. An ejective affricate and a plain strident, however, will not agree in continuancy, as the following tableaux illustrate.

(38)

/tsas/	IO-ID[+cont]	CC-ID[cont]	IO-ID[−cont]
a. → $s_x a s_x$			*
b. $ts_x a ts_x$	* !		
c. $ts_x a s_x$		* !	

(39)

/ts'as/	*s'	IO-ID[ej]	IO-ID[+cont]	CC-ID[cont]	IO-ID[−cont]
a. → $ts'_x a s_x$				*	
b. $s'_x a s_x$	* !				*
c. $s_x a s_x$		* !			*
d. $ts'_x a ts_x$			* !		

[17] Thanks to an anonymous reviewer for bringing this analysis to our attention.

In (38), the winning candidate has two identical stridents. Crucially, the input affricate surfaces as a fricative, violating IO-IDENT[−continuant] but not higher ranked IO-IDENT[+continuant]. The candidate with two affricates in (38b), which satisfies IDENTITY equally well, loses on high ranked IO-IDENT[+continuant], because an input fricative surfaces as an affricate. In (39), there is no way to satisfy CC-IDENT[continuant] without violating some higher ranked constraint. As seen in (39), a fricative cannot become an affricate, ruling out candidate (39d). The markedness constraint against ejective fricatives, *s', and the faithfulness constraint to ejectivity eliminate candidates (39b–c) which satisfy CC-IDENT[continuant] by changing the input affricate to a fricative. The stridents in the winning candidate thus do not agree in continuancy.

This section has shown that a correspondence-based feature-by-feature identity analysis of Chol is possible. In the following section, we argue that our IDENTITY based analysis is preferable for the total identity phenomena in Chol and other languages.

5.2. *Total identity is special*

In a correspondence-based approach to total identity, complete identity between interacting consonants is an accidental side effect of multiple single-feature agreements. Total identity is not given any privileged or independent status in the theory. If this analysis is correct, there should be independent motivation for each of the feature specific CC-IDENT[F] constraints needed to account for total identity in a particular language. The co-occurrence of these harmonies should be only one of several typological possibilities.

Given the analysis of Chol outlined in the previous section, there should be independent evidence for long-distance agreement in major place, stridency and continuancy, since all of these are required to account for total identity between plain stridents. There should be possible languages where each of these CC-IDENT[F] constraints is active in the absence of the others. Besides the pattern in Chol, we would expect to find languages with *only* major place harmony between ejectives, or *only* continuancy harmony between stridents, to name just a few of the predicted patterns. Given correspondence between pairs of ejectives and plain stridents, as in Chol, the languages in (40) and (41) are predicted.

(40) Major place harmony between ejectives: *tʲ'-k', *ts'-p' ✓tʲ'-ts', ✓tʲ'-tʃ'

Predicted by: CC-IDENT[place] >> IO-IDENT[place]
IO-IDENT[α strid] >> CC-IDENT[α strid]
IO-IDENT[α ant] >> CC-IDENT[α ant]

(41) Continuancy harmony between stridents: *ts-s, *tʃ-ʃ ✓ts-tʃ, ✓s-ʃ

Predicted by: CC-IDENT[α cont] >> IO-IDENT[α cont]
IO-IDENT[α ant] >> CC-IDENT[ant]

In (40), the ranking of CC-IDENT[place] over IO-IDENT[place] requires major place harmony between ejectives. The rankings IO-IDENT[ant] >> CC-IDENT[ant] and IO-IDENT[strid] >> CC-IDENT[strid] will allow pairs of ejectives to disagree in anteriority and stridency. In (41), CC-IDENT[cont] >> IO-IDENT[cont] requires agreement in continuancy between stridents, but IO-IDENT[ant] >> CC-IDENT[ant] allows stridents to disagree in anteriority.

The languages in (40) and (41) are not attested in the available literature. Major place harmony and stridency harmony do not appear in Hansson's (2001) survey of consonant harmony systems. Hansson finds only one case of continuancy harmony, Yabem, (Oceanic: Bradshaw 1979; Ross 1995), which results in total identity. The third person plural prefix /se-/ is [te-] or [de-] if the root begins with an alveolar stop (data from Hansson: 138, citing Ross 1995), as shown in (42).

(42) Yabem

a. sé-líʔ 'see (3pl realis/irrealis)'
sé-kátóŋ 'make a heap (3pl realis/irrealis)

b. té-táŋ 'weep (3pl realis/irrealis)'
dè-dèŋ 'move towards (3pl realis)'

This pattern can be accounted for straightforwardly as the effect of linking and IDENTITY. Alveolar obstruents are linked in Yabem and are required to be completely identical. As discussed briefly in section 3.1 above, Yabem exhibits a locality effect on total identity. A non-initial alveolar obstruent in the root does not trigger total identity (**s**é-ká**t**óŋ, ***t**é-ká**t**óŋ) (see Hansson (2001) for further discussion). While Yabem shows continuancy harmony, it does not provide support for a feature-specific correspondence constraint like CC-IDENT[continuant]. Three out of the four constraints needed to analyze total identity are thus unmotivated: agreement in major place, stridency and continuancy are not active outside of total identity requirements.

It would be possible to account for the dependency relations between certain single-feature harmonies through a fixed ranking of CC-IDENT[F] constraints. For example, since continuancy harmony is never found in the absence of anteriority harmony, it may be that the ranking CC-IDENT[ant] >> CC-IDENT[cont] holds universally.[18] While a fixed ranking can account for the facts, it is not clear what motivates the particular dependency relations we see in long-distance assimilation. Moreover, there is additional evidence, beyond the absence of certain isolated feature specific harmonies, that total identity is explicitly required by the grammar.

Total identity stands out as unique in typological surveys of both laryngeal and place co-occurrence restrictions. While restrictions on ejectives (and other laryngeal features) are common, no language requires ejectives to agree in only *some* features. In MacEachern's (1999) survey of laryngeal co-occurrence restrictions, languages come in two varieties: either *all* pairs of ejectives (or aspirates or implosives) are prohibited from co-occuring, including identical ones (*[k'-p'], *[k'-k']), or *only non-identical* pairs are disallowed and identical ones are grammatical (*[k'-p'], ✓[k'-k']). The only type of assimilation that applies to non-adjacent ejectives is *total* assimilation.

A similar phenomenon is found in place co-occurrence restrictions. Many languages restrict the co-occurrence of homorganic consonants in a root. As in laryngeal restrictions, identical pairs of consonants may be exempt from this restriction. Moreover, the gradient patterns of ungrammaticality show that only total identity, and never partial identity, may be preferred in place co-occurrence restrictions. In Muna (Austronesian) (van den Berg 1989; Coetzee and Pater 2008), for example, two homorganic consonants are less likely to co-occur the more subsidiary features (voicing, stricture, sonorancy) they share. While more similar homorganic pairs of

[18] We thank an anonymous reviewer for pointing this out.

consonants like [b-p] and [t-d] are less common than less similar homorganic pairs like [b-f] and [d-s], identical pairs of consonants are extremely common. Similar patterns are found in Javanese (Uhlenbeck 1949, 1950; Mester 1986) and Ngbaka (Thomas 1963; Mester 1986).

To summarize, in the correspondence based analysis, *total* identity is an accident. Under the CC-IDENT[F] formulation, there is nothing special about being totally identical as opposed to being partially identical. Looking at languages with a total identity requirement, however, we find that there *is* something special about being totally identical. In languages with place co-occurrence restrictions, for example, identical pairs of consonants may be allowed, while increasingly similar pairs of consonants are increasingly disfavored. Being very similar and being totally identical are thus quite different. Total identity is special, and we argue that it should be represented as such in the grammar by way of a total identity constraint like IDENTITY.

5.3. *Anteriority harmony and similarity*

In a correspondence-based framework, languages may differ from one another on two dimensions: the set of consonants that must correspond (e.g. stridents, homorganic stops, voiceless stops, etc.) and the features in which corresponding segments must agree (e.g. laryngeal features, minor place, etc.). The CORR-C⇔C constraints that determine correspondence, and the feature specific CC-IDENT[F] constraints which determine the harmonizing feature, are independent from one another. This means that under a correspondence-based analysis the set of consonants that is required to agree, and the feature in which they are required to agree, are not correlated. We have shown in the previous sub-section that certain features like major place do not undergo long-distance assimilation. Here we show that many of the similarity effects in anteriority harmony that are predicted in the CC-correspondence approach are unattested, and argue that articulatory spreading is a preferred analysis. Potential counterexamples to the claim that minor place harmonies are not similarity sensitive are discussed in section 6.

While anteriority harmony is well attested (compared to many other consonant harmonies), it does not show similarity effects. In Chol, for example, while total identity is sensitive to the similarity of the interacting consonants—it only applies to two plain stridents, not to an ejective and a plain strident—anteriority harmony is not. Anteriority harmony applies to all stridents regardless of continuancy and ejectivity. This observation is not unique to Chol. In Hansson's survey, no case of anteriority harmony demands assimilation in only the most similar pairs of stridents. To be concrete, we know of no languages that restrict anteriority harmony to non-ejective stridents, as in (43a), or to stridents that agree in stricture, as in (43b), among other possibilities.

(43) Unattested cases of anteriority harmony:
 a. *anteriority harmony only between non-ejective stridents*
  i. non-ejective stridents must agree in anteriority
  *ts-ʃ *tʃ-s ✓ts-s ✓tʃ-ʃ
  ii. an ejective and a non-ejective strident need not agree
  ✓ts'-ʃ ✓tʃ'-s
 b. *anteriority harmony only between stridents that agree in stricture*
  i. stridents that agree in stricture must agree in anteriority
  *ts-tʃ *ʃ-s ✓ts-ts ✓ʃ-ʃ
  ii. stridents that disagree in stricture need not agree in anteriority
  ✓ts-ʃ ✓tʃ-s

The odd, and as yet unattested, patterns of anteriority harmony in (43) are predicted to be possible under the correspondence-based approach to long-distance agreement, since partial identities are analyzed as the effect of a similarity-sensitive correspondence relation. In our proposed linking analysis, however, only total identity involves a similarity sensitive relation between non-adjacent consonants. Partial identities, like anteriority harmony, are analyzed instead as local spreading. We thus do not predict languages with the patterns in (43).

Under our proposal, there is an explanation for why anteriority harmony, and not continuancy harmony, is active outside of the total identity requirement in Chol. Anteriority can spread unnoticed through intervening segments. The tongue tip can remain in a particular configuration through the articulation of vowels and non-alveolar stops, and thus this type of minor-place agreement can feasibly result from articulatory spreading of the tongue tip gesture. Continuancy, however, cannot spread through intervening segments. A [−continuant] specification results in a complete closure in the oral cavity. In order to articulate intervening vowels and consonants, air must be allowed to travel through the vocal tract. This difference between features like anteriority, which does figure in consonant harmonies, and continuancy, which does not, serves as the basis for local analyses of consonant harmonies (Flemming 1995; Ní Chiosáin and Padgett 1997; Gafos 1999).

Long-distance agreement in continuancy is then necessarily non-local; it *must* be mediated through a long-distance relation (like linking or correspondence). If partial identities are always the result of local spreading, and only total identity involves a similarity sensitive relation, then we predict languages like Chol. Languages with the opposite pattern, where continuancy harmony is active outside of total identity, as illustrated by the hypothetical language Chol′ in (44), are impossible.

(44) Impossible Chol′

total identity between plain stridents:	*ts-s, *ts-ʃ	✓ts-ts, ✓ʃ-ʃ
continuancy harmony elsewhere:	*ts’-s	✓ts’-tʃ

While anteriority harmony cross-linguistically targets all stridents, total identity may pick out a sub-set of the stridents for total assimilation, as in Chol. The fact that single-feature harmonies, like anteriority harmony, fail to show similarity effects, which are a central aspect of the correspondence or linking relation, supports our claim that only total identity is a long-distance effect. Partial identities are the result of articulatory gestures aligning with the edges of prosodic or morphological domains, and hence are blind to the similarity of the segments they affect.

To summarize, in our proposal assimilation between non-adjacent consonants comes about in two ways. Total identity is mediated by the similarity sensitive linking relation, and demanded by the total identity constraint, IDENTITY. Partial assimilation is local spreading. Crucially, there are no constraints that demand assimilation in only a single feature between linked consonants.

6. THE TYPOLOGY OF CONSONANT HARMONY

We have argued thus far that total identity must be explicitly required by the grammar, and should not be analyzed as the cumulative effect of multiple single-feature harmonies. The minimal revision that this finding requires for the grammar is the addition of a new constraint, IDENTITY. This new constraint could coexist with single-feature constraints, though this scenario would result in a duplicate analysis of all cases of total identity, as the effect of IDENTITY or multiple CC-IDENT[F] constraints. A stronger hypothesis, and the one that we have been advocating, is that the need for a total identity constraint undermines the existence of CC-IDENT[F] constraints entirely. We have pointed out, as is mentioned in Hansson (2001) and Rose and Walker (2004), that certain features like major place do not undergo long-distance assimilation. If major place harmony is unattested, the logical conclusion is that CC-IDENT[place] does not exist, as is briefly suggested by Rose and Walker (2004). In this section, we examine to what extent it is feasible to eliminate feature specific CC-IDENT[F] constraints from the grammar altogether. In our proposal, the only mechanisms of long-distance assimilation are total identity via the linking relation and articulatory spreading. The predictions of this theory are more restrictive than those of a theory with CC-IDENT[F] constraints. To evaluate these two theories, we look at the typology of consonant harmony and show that the vast majority of attested cases involve either total identity or agreement in minor-place. We suggest alternative lines of analysis for some seemingly problematic cases.

Before diving in to the data, it is worth being very explicit about the different predictions of the two proposals. In a correspondence-based framework, languages may differ from one another on two dimensions: the set of consonants that must correspond (e.g. stridents, homorganic stops, voiceless stops, etc.) and the features in which corresponding segments must agree (e.g. laryngeal features, minor place, etc.). The CORR-C⇔C constraints, which determine correspondence, and the feature specific CC-IDENT[F] constraints which determine the harmonizing feature, are independent from one another.

The predictions of this theory and our proposal differ in two important ways. First, we predict that partial identities should not show similarity effects, since they are not mediated through the similarity sensitive linking relation. In correspondence based theories, both partial and total identities involve a similarity sensitive relation, and both are thus predicted to show similarity effects. Second, we predict that all consonant harmonies that result in partial identity are in fact local phenomena that result from articulatory spreading. Partial identity harmonies are predicted to be restricted to only those features that can spread unnoticed through intervening segments. In a correspondence-based theory, partial identity harmony may target any feature; since harmony obtains long distance, intervening segments are irrelevant. The problematic cases that are discussed below are thus one or both of the following: partial identity harmonies that appear to show similarity effects, and partial identity harmonies in features that cannot spread unnoticed through intervening segments.

6.1. *Problematic cases of consonant harmony*

Hansson (2001) includes a survey of 109 cases of consonant harmony.[19] In this survey, the majority of cases show either minor-place harmony[20] or total identity, phenomena that can be accounted for with the more restricted constraint set we proposed above. Of the 109 cases of consonant harmony, 64 are minor-place harmonies and 23 show total identity. The outstanding 22 cases are composed of one case of liquid harmony (attested in alternations in two suffixes in the Bantu language Mwiini), six instances of laryngeal harmony (discussed in 6.1.1 below) and 15 cases of nasal consonant harmony in Bantu languages (discussed in 6.1.2 below).

[19] We are excluding the sixteen cases in Hansson's database that he marks as "marginal".
[20] In the category "minor place harmony" we include coronal harmonies as well as harmony in secondary place specifications like pharyngealization and velarization.

While a large majority (80%) of cases of assimilation between non-adjacent consonants in Hansson's survey either show total identity or minor-place harmony, which are clearly analyzable within our linking and local-spreading proposal, there are a few cases which seem to show truly non-local, partial assimilation. These cases provide possible support for the argument that feature-specific CC-IDENT[F] constraints are necessary in the grammar, and we review them here.

6.1.1. *Laryngeal harmony*
A class of potentially problematic cases is laryngeal harmony between stops. In Chaha (Leslau 1979; Banksira 2000; Rose and Walker 2004), stops in a root must have the same laryngeal features: ejective, voiced or voiceless. The examples in (45) are from Rose and Walker (2004: 475).

(45)	a.	jɨ-kətf	'he hashes (meat)'	b.	jɨ-dəg(ɨ)s	'he gives a feast'
		jɨ-kəft	'he opens'		jɨ-dərg	'he hits, fights'
	c.	jɨ-k'ət'ɨr	'he hides'			
		jɨ-t'əβk'	'it is tight'			

In (45), two stops in a root are either both voiceless as in (45a), both voiced as in (45b), or both ejective as in (45c). Intervening vowels and consonants are not affected by the laryngeal agreement; they do not de-voice or glottalize. A similar case is the Kalabari dialect of Ijo (Hansson 2001; Jenewari 1989). In this language, pulmonic and implosive voiced stops may not co-occur with one another.

(46)	a.	ébébé	'talk while sleeping'	ɓɪɓɪ	'mouth'
		badara	'be(come) very wide'	ɗáɓá	'lake'
	b.	*d-ɓ *ɓ-d *b-ɗ *ɗ-b			

Two pulmonic or two implosive stops may combine in a Kalabari Ijo root, as shown in (46a). Combinations of a pulmonic and an implosive stop, as in (46b), are unattested. Like Chaha, Kalabari Ijo is a case of laryngeal harmony between stops across an unaffected vowel. Laryngeal harmony may result in partial identity between the harmonizing segments, as seen in the examples above. Unlike minor place harmony, laryngeal harmony does not have a possible analysis as articulatory spreading. If laryngeal harmony were the result of extending an articulatory gesture throughout a domain, intervening segments would be audibly affected, counter to what is reported in the description of languages exhibiting this phenomenon.

6.1.2. *Nasal harmony*
Another potentially problematic case is long-distance nasal assimilation in Bantu languages. An example from Hansson (2001) is Tiene (data taken from Hyman 1996), where the stative suffix has a nasal velar [ŋ] when following a stem with a nasal, and a voiceless velar stop [k] elsewhere. Intervening vowels are reported not to be nasalized.

(47)	jaat-a	'split'	[jat-a**k**]-a	'be split'
	vwuɲ-a	'mix'	[vwu**ɲ**-e**ŋ**]-ɛ	'be mixed'
	sɔn-ɔ	'write'	[sɔ**n**-ɔ**ŋ**]-ɔ	'be written'

The nasal agreement in Bantu is problematic for the same reason as laryngeal harmony: it clearly shows a long-distance, partial identity effect. The place of the suffix consonant is fixed across contexts, only the nasality or orality is affected by the root consonants. Nasal consonant harmony is also attested in alternations of the perfective suffix [-ili]/[-ele] in many Bantu languages. The suffix surfaces as [-ini]/[-ene] following roots with a nasal consonant.

6.2. *Sibilant harmony*

Minor place harmony in sibilants is the most common of all consonant harmonies (forty-four, or 40%, of the 109 cases of consonant harmony in Hansson's survey are of this type). This type of harmony has been argued to be the result of local articulatory or autosegmental spreading, as it is precisely the minor place features of coronals that may spread unnoticed through intervening segments (Flemming 1995; Ní Chiosáin and Padgett 1997; Gafos 1999). Here we address three cases of sibilant harmony that could be used to argue against the local analysis of minor place harmony: Baztan Basque, Berber and Chumash. All three cases involve segments that are either transparent or opaque to harmony.

Berber shows minor place harmony in sibilants that appears to be similarity sensitive.[21] In this language, harmony applies to only some of the sibilants that should be affected by the spreading feature. In Moroccan Arabic, both plain /s, z/ and pharyngealized /sˤ, zˤ/ do not co-occur with /ʃ, ʒ/. In Berber, however, the single pharyngealized sibilant /sˤ/ may freely co-occur with both /s, z/ and /ʃ, ʒ/, though these two series of sibilants may not co-occur with one another. In a CC-correspondence analysis of Berber, only non-pharyngealized sibilants would stand in correspondence, and thus only those pairs of sibilants would be required to harmonize. The distribution of /sˤ/ with the other sibilants is unrestricted because the pharyngealized sibilant is sufficiently dissimilar from the other sibilants. In Moroccan Arabic, the similarity threshold is different, and all pairs of sibilants stand in correspondence and undergo harmony.

There is an alternative analysis, however, which does not require CC-correspondence. The similarity effect apparent in the comparison of Moroccan Arabic and Berber can be achieved in an articulatory spreading analysis through the ranking of IO-IDENT constraints and standard markedness constraints. Both languages lack the pharyngealized alveopalatals /ʃˤ, ʒˤ/, showing the effect of a high-ranked markedness constraint against these segments. Minor place harmony between pharyngealized and non-pharyngealized sibilants is then only possible if faithfulness to pharyngealization is low-ranked. This is the case in Moroccan Arabic, minor place harmony is achieved at the expense of faithfulness to both input anteriority and pharyngealization, as shown in (48).

[21] Thanks to an anonymous reviewer for pointing out this case.

(48) Anteriority harmony in Moroccan Arabic

/sˤ-ʃ/	*ʃˤ	ALIGN	IDENT[ant]	IDENT[phar]
a. → /ʃ-ʃ/			*	*
b. /sˤ-ʃ/		* !		
c. /ʃˤ-ʃ/	* !		*	

In Berber, unlike in Moroccan Arabic, the pharyngealized sibilant does not participate in minor place harmony because IDENT[phar] outranks ALIGN, as in (49).

(49) Anteriority harmony blocked in Berber

/sˤ-ʃ/	*ʃˤ	IDENT[phar]	IDENT[–ant]	ALIGN	IDENT[+ant]
a. /ʃ-ʃ/		* !			*
b. → /sˤ-ʃ/				*	
c. /ʃˤ-ʃ/	* !				*
d. /sˤ-s/			* !		

The analysis of Berber also requires that IDENT[–anterior] and Ident[+anterior] be ranked differently with respect to ALIGN, as can be seen by comparing the desired winner, (49b) ,with the harmonizing candidate in (49d). When pharyngealization is not involved, as with two plain sibilants, the ranking of ALIGN over IDENT[+ant] induces harmony, as shown in (50).

(50) Anteriority harmony in Berber

/s-ʃ/	*ʃˤ	IDENT[phar]	Ident[–ant]	ALIGN	IDENT[+ant]
a. → /ʃ-ʃ/					*
b. /s-ʃ/				* !	

While minor place harmony in Berber shows what could be considered a similarity effect, we have shown that this case can also be analyzed as local spreading.

A second potential argument against the local analysis of sibilant harmonies is the transparency of non-sibilant coronals to these harmonies. If minor-place harmony is articulatory spreading, then all segments that intervene between the harmonizing consonants are affected by the harmony. While vowels and non-coronal consonants have been convincingly argued to undergo harmony, though they are not audibly affected, coronal consonants that appear to be transparent to harmony are more problematic. Hansson (2001) brings up just such a case in Baztan Basque. In this dialect of Basque (also discussed in Clements 2001), there is a three-way contrast between apico-alveolar [s̺ ts̺], lamino-alveolar [s, ts] and lamino-postalveolar [ʃ, tʃ] stridents. Stridents that co-occur in a root are always drawn from the same series (Hualde 1991). The non-strident coronals (dental [t, d, n, l] and palatal or pre-dorsal [c, ɲ, ʎ]), however, may intervene between the two harmonizing stridents.

Harmony systems like that in Baztan Basque are only problematic if the transparent non-strident coronals are incompatible with the spreading feature that is contrastive for stridents. It is possible, as is extensively argued for in Gafos (1999), that fricative and affricate coronals may contrast along a different articulatory parameter than stop and sonorant coronals. Coronal stops and sonorants may thus undergo harmony in exactly the same fashion as vowels and non-coronal consonants. An articulatory spreading account of coronal harmony is dependent on the possibility of categorizing coronal stridents and non-stridents along different articulatory parameters. It should be noted that the categorization of the apico-alveolar series in Baztan Basque as retroflex is problematic for such an account, as retroflex stridents should interact with the palatal stops. With this caveat, without articulatory data it is impossible to conclusively state that whether an articulatory distinction between stop and non-stop contrasts is possible.

Gafos (1999) argues for just such a distinction in articulatory parameters to account for coronal transparency in Tahltan (Northern Athabaskan).[22] Harmony in Tahltan obtains between the three series of fricatives and affricates: dental [θ, ð, tθ, tθ', dð], alveolar [s, z, ts, ts', dz] and postalveolar [ʃ, ʒ, tʃ, tʃ', dʒ]. Tahltan also has a series of plain [d, n, n'] and lateral [dl, tɬ, tɬ', ɬ, l] coronals that may intervene between two harmonizing segments, e.g. *εθduuθ* 'I whipped him' (Nater 1989). Gafos, advocating an articulatory spreading account of minor place harmony, hypothesizes that the articulatory parameters by which the harmonizing and non-harmonizing coronals contrast are not the same. The three-way contrast in the harmonizing segments is due to articulatory differences in the cross-sectional channel of the tongue tip. By contrast, the transparent coronals contrast in what Gafos calls 'Tongue Tip Constriction Orientation', an articulatory parameter that leaves the cross-sectional channel free. Plain and lateral coronals are thus not actually transparent to harmony, they undergo it in exactly the same way as vowels and non-coronal consonants.

The apparent transparency of certain coronals to sibilant harmony is not necessarily a problem for articulatory locality. Articulatory data (e.g. from palatography) are necessary to determine the exact articulatory parameter along which harmonizing/transparent segments are specified. Without articulatory data showing that the gesture for strident contrasts cannot spread unnoticed through non-strident coronals, languages like Baztan Basque cannot be conclusively said to falsify the articulatory spreading account of minor place harmony.

Finally, a further challenge to the articulatory based account of coronal harmony is brought up in McCarthy's analysis of Chumash (McCarthy 2007). As discussed in §3.2 above, Chumash shows regressive harmony between alveolar and post-alveolar stridents. Long-distance harmony is active both root-internally and across morpheme boundaries. In addition to non-local assimilation, Chumash shows local dissimilation in minor-place features between coronals. Coronal stridents preceding a heteromorphemic non-strident coronal [t, n, l] dissimilate (51a); dissimilation is not required in tautomorphemic sequences (51b). The examples in (51) are taken from McCarthy (2007), who cites Applegate (1972) and Poser (1993).

(51) a. Dissimilation in heteromorphemic sequences

/s-nanʔ/	[ʃnanʔ]	'he goes'	/s-tepuʔ/	[ʃtepuʔ]	'he gambles'

b. No dissimilation in tautomorphemic sequences

/slowʔ/	[slowʔ]	'eagle'	/wastuʔ/	[wastuʔ]	'pleat'

McCarthy argues convincingly that the derived environment effect shown in (51) reflects a representational distinction between heteromorphemic and tautomorphemic coronal sequences. In Chumash, he argues, heteromorphemic sequences may be doubly linked to a single minor-place specification. Multiple association to a single autosegment, however, is blocked across morpheme boundaries. The result of this representational distinction is that heteromorphemic,

[22] The analysis of Tahltan sibilant harmony is also discussed in Clements (2001).

but not tautomorphemic, sequences of a strident and non-strident violate the OCP, resulting in the dissimilation seen in (51a).

While accounting for the data in (51), McCarthy's analysis conflicts with a local account of long-distance harmony between stridents. In a local analysis, whether based on autosegmental or articulatory representations, minor-place specifications crucially spread across morpheme boundaries to result in harmony between heteromorphemic stridents. It is exactly this type of spreading that McCarthy argues is disallowed in Chumash, based on the local dissimilation data.

The problem for the local spreading account of anteriority harmony in Chumash arises from a particular analysis of the derived environment effect in this language. Given an alternative analysis of the dissimilation data in (51), Chumash may no longer be a problem for a local account of minor-place harmony. A spreading analysis of Chumash strident harmony is tenable if the dissimilatory facts are accounted for in the framework of Comparative Markedness (CM) (McCarthy 2003). In CM, standard markedness constraints are split into a "new" and an "old" version. "New" markedness constraints are violated if the output contains a violation that is not present in the input, while "old" markedness constraints are violated if the output contains a violation that is present in the input. The ranking schema M_{new} >> FAITH >> M_{old} results in derived environment effects like that seen in Chumash.

(52)

/s-nanʔ/	OCP_{new}	IDENT[ant]	OCP_{old}
a. → ʃnanʔ		*	
b. snanʔ	* !		

(53)

/slowʔ/	OCP_{new}	IDENT[ant]	OCP_{old}
a. →slowʔ			*
b. ʃlowʔ		* !	

The tableaux in (52) and (53) show how splitting the OCP into a "new" and an "old" version accounts for Chumash dissimilation without imposing restrictions on spreading across morpheme boundaries. Only OCP_{new} outranks faithfulness to anteriority, and thus only OCP violations that are not present in the input, i.e. those resulting from morpheme concatenation, are repaired via dissimilation. The candidate in (53a) does not violate OCP_{new} since the sequence [sl] is present in the input; it is not created by morpheme concatenation and thus does not count as a "new" violation of the OCP. Given this analysis of dissimilation, anteriority harmony in Chumash is not a problem for a local analysis of minor-place harmony.

6.3. *Summary of consonant harmony typology*

Surveys of consonant harmonies like the one in Hansson (2001) show that the vast majority of consonant harmonies described for the world's languages can be handled by the proposal put forth in this paper. Namely, total identity is the result of a similarity sensitive long-distance relationship called *linking*, while partial identity is the result of local spreading. Total identity and partial identity are thus distinct and are treated as such in the grammar.

In the preceding sections, we have reviewed the few cases that appear to pose a problem for this analysis. We have suggested alternative accounts for some of these cases, while others remain troublesome. One possibility, mentioned above, is that linking and correspondence coexist. If we admit correspondence and single-feature identity constraints into the grammar, we run the risk of overgenerating but are able to account for the few problematic cases above. On the other hand, if we maintain that only total identity is controlled by long-distance agreement and all partial identities are spreading, we risk undergenerating, but are able to account for the vast majority of consonant harmony cases described, and make better overall typological predictions. We leave the final word on this issue as a topic for future work.

7. Conclusion

This paper has argued for a formal distinction between total and partial identity phenomena between non-adjacent consonants. The interaction of total identity and anteriority harmony in Chol highlights the distinction between the two phenomena. With Chol stridents and ejectives as a starting point, we claim that total identity between non-adjacent consonants is always the result of a similarity sensitive relation, which we call *linking*. Anteriority harmony and other single-feature identities are the result of local, articulatory spreading.

Our proposal crucially differs from the CC-correspondence framework of Hansson (2001) and Rose and Walker (2004) in eliminating long-distance feature-specific harmony constraints. In our framework, the only long-distance assimilation between two consonants is total assimilation. We showed that with feature-specific CC-IDENT[F] constraints, total identity can only be analyzed as an accidental side effect of multiple single feature harmonies. An analysis along these lines is problematic for two reasons. First, it hypothesizes single feature harmonies that are unattested outside of total identity, and second, it gives total identity no special status. Examination of total identity systems suggests that total identity is very different from partial identity, and should be treated as such in the grammar.

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APPENDIX A: O/E VALUES FOR CHOL ROOTS

C1 \ C2	ɓ	p	p’	ts	ts’	tʃ	tʃ’	t^{j}	t^{j}’	k	k’	ʔ	s	ʃ	h	m	ɲ	w	l	j
ɓ	2	0	0	3	5	3	1	3	1	4	5	2	1	5	4	1	2	0	5	2
p	0	2	0	2	5	4	3	5	0	6	5	1	4	3	3	5	4	0	4	5
p’	0	0	1	2	0	2	0	4	0	4	0	2	3	1	1	0	1	1	3	0
ts	1	1	0	4	0	0	0	1	0	4	3	1	0	0	2	2	2	0	4	3
ts’	4	3	0	0	2	0	0	2	0	4	0	4	1	0	4	3	2	1	5	3
tʃ	3	6	0	0	0	2	0	2	0	6	3	5	0	2	2	4	3	1	4	2
tʃ’	5	2	0	0	0	0	5	2	0	4	0	2	0	3	5	3	5	0	4	3
t^{j}	2	2	3	1	3	2	2	4	0	5	6	4	4	0	3	3	4	3	4	1
t^{j}’	0	0	0	1	0	4	0	0	1	0	0	0	3	1	2	1	2	0	5	0
k	1	1	0	0	2	5	4	1	0	4	0	0	3	2	4	3	4	1	5	2
k’	3	1	0	1	0	6	0	4	0	3	4	2	2	5	3	4	4	0	4	4
ʔ	3	0	0	1	1	4	2	2	0	3	5	0	2	4	4	2	1	1	4	1
s	3	4	5	0	3	0	0	4	3	4	3	1	3	0	3	4	2	2	6	2
ʃ	2	3	1	0	0	0	1	5	4	3	4	2	0	4	3	1	5	1	2	1
h	3	3	3	1	2	4	5	4	3	3	6	4	2	5	3	5	5	1	6	3
m	0	1	2	2	1	4	4	4	0	3	3	2	3	1	1	1	2	0	6	3
ɲ	1	3	4	1	0	4	1	3	2	6	3	2	1	3	4	2	1	1	4	0
w	0	0	0	4	4	1	4	5	1	4	1	5	4	3	3	2	2	1	6	2
l	3	1	1	5	2	5	2	2	2	4	6	4	1	1	4	6	2	4	0	0
j	2	2	0	1	3	0	2	1	2	4	1	4	0	2	2	3	2	1	3	0

TABLE 1: Observed values for all pairs of Chol roots

C1 \ C2	ɓ	p	p’	ts	ts’	tʃ	tʃ’	t^{j}	t^{j}’	k	k’	ʔ	s	ʃ	h	m	ɲ	w	l	j
ɓ	2.09	1.92	1.10	1.59	1.81	2.74	1.98	3.18	1.04	4.28	3.18	2.58	2.03	2.47	3.29	3.02	3.02	1.04	4.61	2.03
p	2.60	2.39	1.37	1.98	2.25	3.42	2.46	3.96	1.30	5.33	3.96	3.21	2.53	3.07	4.10	3.76	3.76	1.30	5.74	2.53
p’	1.06	0.98	0.56	0.81	0.92	1.40	1.01	1.62	0.53	2.18	1.62	1.32	1.04	1.26	1.68	1.54	1.54	0.53	2.35	1.04
ts	1.19	1.10	0.63	0.91	1.03	1.57	1.13	1.82	0.60	2.45	1.82	1.47	1.16	1.41	1.88	1.72	1.72	0.60	2.63	1.16
ts’	1.62	1.49	0.85	1.23	1.40	2.13	1.53	2.47	0.81	3.32	2.47	2.00	1.57	1.91	2.55	2.34	2.34	0.81	3.57	1.57
tʃ	1.91	1.76	1.01	1.46	1.66	2.52	1.81	2.92	0.96	3.93	2.92	2.37	1.86	2.27	3.02	2.77	2.77	0.96	4.23	1.86
tʃ’	1.83	1.69	0.96	1.40	1.59	2.41	1.73	2.79	0.91	3.76	2.79	2.26	1.78	2.17	2.89	2.65	2.65	0.91	4.04	1.78
t^{j}	2.38	2.19	1.25	1.82	2.07	3.14	2.26	3.64	1.19	4.89	3.64	2.95	2.32	2.82	3.76	3.45	3.45	1.19	5.27	2.32
t^{j}’	0.85	0.78	0.45	0.65	0.74	1.12	0.81	1.30	0.43	1.75	1.30	1.05	0.83	1.01	1.34	1.23	1.23	0.43	1.88	0.83
k	1.79	1.65	0.94	1.36	1.55	2.35	1.69	2.73	0.89	3.67	2.73	2.21	1.74	2.12	2.82	2.59	2.59	0.89	3.95	1.74
k’	2.13	1.96	1.12	1.62	1.85	2.80	2.02	3.25	1.06	4.37	3.25	2.63	2.07	2.52	3.36	3.08	3.08	1.06	4.70	2.07
ʔ	1.70	1.57	0.90	1.30	1.48	2.24	1.61	2.60	0.85	3.49	2.60	2.11	1.66	2.02	2.69	2.46	2.46	0.85	3.76	1.66
s	2.21	2.04	1.16	1.69	1.92	2.91	2.10	3.38	1.11	4.54	3.38	2.74	2.15	2.62	3.49	3.20	3.20	1.11	4.89	2.15
ʃ	1.79	1.65	0.94	1.36	1.55	2.35	1.69	2.73	0.89	3.67	2.73	2.21	1.74	2.12	2.82	2.59	2.59	0.89	3.95	1.74
h	3.02	2.78	1.59	2.31	2.62	3.98	2.86	4.61	1.51	6.20	4.61	3.74	2.94	3.58	4.77	4.37	4.37	1.51	6.68	2.94
m	1.83	1.69	0.96	1.40	1.59	2.41	1.73	2.79	0.91	3.76	2.79	2.26	1.78	2.17	2.89	2.65	2.65	0.91	4.04	1.78
ɲ	1.96	1.80	1.03	1.49	1.70	2.58	1.85	2.99	0.98	4.02	2.99	2.42	1.91	2.32	3.09	2.83	2.83	0.98	4.33	1.91
w	2.21	2.04	1.16	1.69	1.92	2.91	2.10	3.38	1.11	4.54	3.38	2.74	2.15	2.62	3.49	3.20	3.20	1.11	4.89	2.15
l	2.34	2.16	1.23	1.79	2.03	3.08	2.22	3.57	1.17	4.80	3.57	2.89	2.28	2.77	3.70	3.39	3.39	1.17	5.17	2.28
j	1.49	1.37	0.78	1.14	1.29	1.96	1.41	2.27	0.74	3.06	2.27	1.84	1.45	1.76	2.35	2.16	2.16	0.74	3.29	1.45

TABLE 2: Expected values for all pairs of Chol roots

C1 \ C2	ɓ	p	p’	ts	ts’	tʃ	tʃ’	tʲ	tʲ’	k	k’	ʔ	s	ʃ	h	m	ɲ	w	l	j
ɓ	0.96	0.00	0.00	1.89	2.76	1.09	0.51	0.94	0.96	0.93	1.57	0.78	0.49	2.02	1.21	0.33	0.66	0.00	1.08	0.99
p	0.00	0.84	0.00	1.01	2.22	1.17	1.22	1.26	0.00	1.13	1.26	0.31	1.58	0.98	0.73	1.33	1.06	0.00	0.70	1.98
p’	0.00	0.00	1.79	2.46	0.00	1.43	0.00	2.46	0.00	1.83	0.00	1.52	2.90	0.79	0.60	0.00	0.65	1.88	1.28	0.00
ts	0.84	0.91	0.00	4.40	0.00	0.00	0.00	0.55	0.00	1.64	1.65	0.68	0.00	0.00	1.06	1.16	1.16	0.00	1.52	2.59
ts’	2.47	2.01	0.00	0.00	1.42	0.00	0.00	0.81	0.00	1.21	0.00	2.00	0.64	0.00	1.57	1.28	0.85	1.24	1.40	1.91
tʃ	1.57	3.40	0.00	0.00	0.00	0.79	0.00	0.68	0.00	1.53	1.03	2.11	0.00	0.88	0.66	1.44	1.08	1.04	0.94	1.07
tʃ’	2.73	1.19	0.00	0.00	0.00	0.00	2.88	0.72	0.00	1.06	0.00	0.88	0.00	1.38	1.73	1.13	1.89	0.00	0.99	1.68
tʲ	0.84	0.91	2.39	0.55	1.45	0.64	0.89	1.10	0.00	1.02	1.65	1.36	1.72	0.00	0.80	0.87	1.16	2.52	0.76	0.43
tʲ’	0.00	0.00	0.00	1.54	0.00	3.57	0.00	0.00	2.35	0.00	0.00	0.00	3.62	0.99	1.49	0.81	1.62	0.00	2.66	0.00
k	0.56	0.61	0.00	0.00	1.29	2.13	2.36	0.37	0.00	1.09	0.00	0.00	1.72	0.94	1.42	1.16	1.55	1.12	1.27	1.15
k’	1.41	0.51	0.00	0.62	0.00	2.14	0.00	1.23	0.00	0.69	1.23	0.76	0.97	1.98	0.89	1.30	1.30	0.00	0.85	1.93
ʔ	1.76	0.00	0.00	0.77	0.68	1.79	1.24	0.77	0.00	0.86	1.92	0.00	1.21	1.98	1.49	0.81	0.41	1.18	1.06	0.60
s	1.36	1.96	4.29	0.00	1.56	0.00	0.00	1.18	2.71	0.88	0.89	0.37	1.39	0.00	0.86	1.25	0.62	1.81	1.23	0.93
ʃ	1.12	1.82	1.06	0.00	0.00	0.00	0.59	1.83	4.48	0.82	1.47	0.90	0.00	1.89	1.06	0.39	1.93	1.12	0.51	0.57
h	0.99	1.08	1.89	0.43	0.76	1.01	1.75	0.87	1.99	0.48	1.30	1.07	0.68	1.40	0.63	1.14	1.14	0.66	0.90	1.02
m	0.00	0.59	2.08	1.43	0.63	1.66	2.31	1.43	0.00	0.80	1.07	0.88	1.68	0.46	0.35	0.38	0.76	0.00	1.48	1.68
ɲ	0.51	1.66	3.88	0.67	0.00	1.55	0.54	1.00	2.04	1.49	1.00	0.83	0.52	1.29	1.29	0.71	0.35	1.02	0.92	0.00
w	0.00	0.00	0.00	2.37	2.08	0.34	1.91	1.48	0.90	0.88	0.30	1.83	1.86	1.14	0.86	0.62	0.62	0.90	1.23	0.93
l	1.28	0.46	0.81	2.80	0.98	1.62	0.90	0.56	1.71	0.83	1.68	1.38	0.44	0.36	1.08	1.77	0.59	3.42	0.00	0.00
j	1.34	1.46	0.00	0.88	2.32	0.00	1.42	0.44	2.69	1.31	0.44	2.17	0.00	1.13	0.85	1.39	0.93	1.34	0.91	0.00

TABLE 3: O/E values for all pairs of Chol roots