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1 Introduction

Agreement by correspondence (ABC) is a theory of long-distance assimilation processes, particularly consonant harmony (Hansson 2001, Rose & Walker 2004, Walker 2000a, b). The central tenet of ABC is that a relation of correspondence can exist between segments in surface structure, and long-distance assimilation happens via this correspondence relation rather than autosegmental spreading. Because of the focus on consonant harmony, this correspondence relation is often referred to as consonant-consonant or CC correspondence, a practice I will continue in this paper.

As originally proposed, ABC has two types of constraints that reference both segmental identity and CC correspondence. One type is known as CORR. These constraints require CC correspondence between any pair of segments that agree in certain features. For instance, a constraint requiring correspondence between plosives is defined in (1). This constraint is active on words of the form [kak], [tap], or [pad], but not [pas] or [pan]:

(1) *CORR-K⇔D*
Assign one violation mark for every pair of segments that are [−sonorant, −continuant] and not in CC correspondence.

The other type of constraint in ABC is IDENT-CC(F). These constraints work like the familiar IDENT constraints that operate on other dimensions of correspondence: if two segments are in correspondence, they must have identical values for the feature [F]. For instance, IDENT-CC(voice) is violated by [p$_i$ad$_i$], with coindexation indicating that [p] and [d] are in CC correspondence.

Tableau (2) illustrates. It is based on an analysis of Chaha in Rose & Walker (2004). In this language, plosives within a verb root are required to agree in the laryngeal features [voice] and [constricted glottis]: [dɨgɨs], *[tɨgɨs] 'give a feast (imperative)'. CORR-K⇔D and IDENT-CC(voice) dominate the input-output faithfulness constraint IDENT-IO(voice), thereby favoring [d$_i$ɨg$_i$ɨs], whose plosives are in correspondence and agree in [voice], over alternatives where the plosives are not in correspondence (2)b or correspond but fail to agree in [voice] (2)c:

(2) *Chaha plosive laryngeal harmony (after Rose & Walker 2004)*

/tɨgɨs/	CORR-K⇔D	ID-CC (voice)	ID-IO (voice)	CORR-K⇔Z	Description of candidate
a. → d$_i$ɨg$_i$ɨs			1	1	Plosives are in correspondence and agree in [voice].
b. t$_i$ɨg$_j$ɨs	1 W		L	1	Plosives are not in correspondence.
c. t$_i$ɨg$_i$ɨs		1 W	L	1	Plosives are in correspondence but do not agree in [voice].
d. d$_i$ɨg$_i$ɨz$_i$			2 W	L	All obstruents are in correspondence and agree in [voice].

The final candidate, *[d$_i$ɨg$_i$ɨz$_i$] in (2)d, shows what would happen if all obstruents, and not just plosives, were required to be in correspondence with one another. This candidate is ruled out by ranking IDENT-IO(voice) above CORR-K⇔Z, which would otherwise require correspondence among all obstruents rather than just plosives.

CC correspondence is an abstract relation between segments in the surface form. Whether it has any visible effects is determined by the ranking of IDENT-CC(F) relative to IDENT-IO(F). Because IDENT-CC(voice) dominates IDENT-IO(voice) in Chaha, CC correspondence has a visible effect in the /tɨgɨs/ → [d$_i$ɨg$_i$ɨs] mapping. But when the underlying representation happens to contain plosives that already agree in [voice], then there will be correspondence without visible effects: (hypothetical) /tɨkɨs/ → [t$_i$ɨk$_i$ɨs]. The only possible visible effect would be assimilation in some other feature, such as place, but that is ruled out by the ranking IDENT-IO(place) ≫ IDENT-CC(place):

(3) *CC correspondence without visible effects*

/tɨkɨs/	CORR-K↔D	ID-CC (voice)	ID-IO (place)	ID-IO (voice)	ID-CC (place)	CORR-K↔Z
a. → t$_i$ɨk$_i$ɨs					1	1
b. t$_i$ɨk$_j$ɨs	1 W				L	1
c. k$_i$ɨk$_i$ɨs			1 W		L	1

Tableaux (2) and (3) can be generalized to a ranking schema for ABC using CORR constraints:

(4) *Ranking schema for ABC with CORR constraints*

CORR constraint for class of segments that participate in assimilation (CORR-K↔D in Chaha.)

IDENT-CC constraints for features that assimilate. (IDENT-CC(voice) and IDENT-CC(constricted glottis) in Chaha.)

≫

IDENT-IO constraints for features that assimilate. (IDENT-IO(voice) and IDENT-IO(constricted glottis) in Chaha.)

≫

CORR constraints for classes of segments that do not participate in assimilation. (CORR-K↔Z in Chaha.)

and

IDENT-IO constraints for features that do not assimilate. (IDENT-IO(place) in Chaha.)

≫

IDENT-CC constraints for features that do not assimilate. (IDENT-CC(place) in Chaha.)

2 Eliminating CORR constraints

CORR constraints require correspondence if certain identity conditions are met, while IDENT-CC constraints require identity when there is correspondence. It would be preferable to limit reference to featural identity to constraints of one type only. Since IDENT constraints are needed independently in other dimensions of correspondence but CORR constraints do not seem to be, we might well ask whether CORR constraints can be dispensed with.

In fact, there is no need for identity-referring CORR constraints. The work of CORR constraints can be done by IDENT-CC constraints, which are needed anyway, and by a single constraint that requires CC correspondence without regard to featural identity.[1] This constraint, which I call MAX-CC, is analogous to the MAX constraints operative on other dimensions of correspondence, since they too require correspondence without mentioning featural identity (McCarthy & Prince 1995, 1999). MAX-CC is defined in (5):

(5) *MAX-CC*

Assign a violation mark for every consonant that is not in the domain of the CC correspondence relation.

Other, roughly equivalent definitions are possible, but this is closest to the familiar MAX constraints. It presupposes an irreflexive, endomorphic correspondence relation from and to the set of consonants in an output candidate. It assigns three violation marks to [tɨgɨs], where no consonant is in correspondence with any others, one to [t$_i$ɨg$_i$ɨs], where [s] is outside the domain of correspondence, and none to [t$_i$ɨg$_i$ɨs$_i$], where all consonants are in the domain of correspondence. The important point is that, unlike the CORR constraints, MAX-CC is not sensitive to whether two consonants are similar or not. It therefore avoids the redundancy of having two different constraint types that refer to featural identity between segments.

Tableau (6) shows how it is possible to obtain the Chaha consonant harmony pattern without CORR constraints, using only MAX-CC to require CC correspondence. Because MAX-CC wants every consonant to correspond, the key to the analysis is limiting MAX-CC'S effect, and that can be done by judiciously deploying IDENT-CC and IDENT-IO constraints — which are needed anyway, of course. In Chaha, CC correspondence has to be limited to consonants that agree in [continuant], which is why /s/ does not take on /g/'s voicing, as in (6)b *[d$_i$ɨg$_i$ɨz$_i$]. This candidate loses because IDENT-CC(continuant) dominates MAX-CC: consonants that disagree in [continuant] cannot be in CC correspondence. This restriction could be circumvented by changing /s/ to a plosive, as in (6)c *[d$_i$ɨg$_i$ɨd$_i$]. Since this does not happen either, IDENT-IO(continuant) must also dominate MAX-CC, preventing /s/ from hardening to a stop as a way of bringing it into correspondence with /t/ and /g/. Correspondence entails voicing agreement because IDENT-CC(voice) and MAX-CC dominate IDENT-IO(voice), thereby ruling out (6)d *[t$_i$ɨg$_j$ɨs] and (6)e *[t$_i$ɨg$_i$ɨs]. Finally, a candidate where the corresponding consonants have assimilated in place as well as voice (6)e is included to complete the parallel with the CORR analysis in (3). It is ruled out by ranking IDENT-IO(place) over IDENT-CC(place):

(6) *Chaha without CORR*

/tɨgɨs/	ID-CC (cont)	ID-IO (cont)	ID-CC (voice)	ID-IO (place)	MAX-CC	ID-CC (place)	ID-IO (voice)
a. → d$_i$ɨg$_i$ɨs					1	1	1
b. d$_i$ɨg$_i$ɨz$_i$	1 W				L	1	2 W
c. d$_i$ɨg$_i$ɨd$_i$		1 W			L	1	2 W
d. t$_i$ɨg$_i$ɨs			1 W		1	1	L
e. t$_i$ɨg$_j$ɨs					3 W	L	L
f. g$_i$ɨg$_i$ɨs				1 W	1	L	1

The analysis of Chaha in (6) can be generalized to the ranking schema in (7):

[1] Cf. Gallagher (2008), in which CORR constraints are kept but feature-specific IDENT-CC constraints are eliminated.

(7) *Ranking for ABC with MAX-CC*

IDENT-CC and IDENT-IO constraints for features that define the class of consonants that participate in assimilation. (IDENT-CC(continuant), IDENT-IO(continuant), IDENT-CC(sonorant), and IDENT-IO(sonorant) in Chaha.)

≫

MAX-CC

≫

IDENT-IO constraints for features that assimilate. (IDENT-IO(voice) and IDENT-IO(constricted glottis) in Chaha.)

and

IDENT-CC constraints for features that assimilate. (IDENT-CC(voice) and IDENT-CC(constricted glottis) in Chaha.)

≫

IDENT-IO constraints for features that assimilate. (IDENT-IO(voice) and IDENT-IO(constricted glottis) in Chaha.)

and

IDENT-IO constraints for features that do not assimilate. (IDENT-IO(place) in Chaha.)

≫

IDENT-CC constraints for features that do not assimilate. (IDENT-CC(place) in Chaha.)

The high-ranking IDENT-CC constraints specify which features must match for two consonants to be in CC correspondence. Unlike the CORR constraints, they do not distinguish between those feature matches that are a precondition for CC correspondence and those that are a consequence of it. Instead, this distinction is derived from constraint interaction: if a feature match is a *precondition* for CC correspondence, then both its IDENT-CC and its IDENT-IO constraints are high ranking; if a feature match is a *consequence* of CC correspondence, then its CC IDENT constraint is ranked high, but its IO IDENT constraint is ranked low. Finally, there are features that neither affect nor are affected by CC correspondence — [place] is an example in Chaha. For these features, IDENT-IO dominates IDENT-CC, so faithfulness to the input is preferred to the CC match.

Except for MAX-CC, the constraints in (7) are already assumed to exist in the theory of ABC. In other words, the whole apparatus of CORR constraints can be eliminated by positing a single general-purpose correspondence constraint, MAX-CC, and making better use of the theory's other, independently motivated resources. This is a desirable result for two reasons. First, it is a fundamental tenet of the OT research program that it is preferable to derive results from constraint interaction rather than constraint proliferation (Prince & Smolensky 1993/2004). Second, this move eliminates the redundancy noted at the beginning of this section: both CORR and IDENT-CC constraints require identity between consonants in CC correspondence. Under the system in (7), the identity-requiring function is left up to IDENT-CC constraints, and MAX-CC is insensitive to the featural composition of the consonants involved.

3 Points of difference

Although this revision of ABC appears to be adequate, there are some respects in which it does not quite reproduce the effects of CORR constraints. I discuss those differences in this section and find that they are at least neutral and even support the revision.

3.1. Conditional blocking effects with CORR constraints

Hansson (2007) identifies a prediction of ABC with CORR constraints that he calls "conditional blocking". This prediction, which is not realized in any known language, does not emerge from the CORR-less version of ABC proposed here.

Assume a language with anteriority harmony affecting sibilants. Assume too that the system of sibilants is asymmetric: [+anterior] [s, z, ʦ, ʥ] are opposed by [–anterior] [ʃ, ʧ, ʤ] — that is, there is no [ʒ] because of an undominated constraint *ʒ. Under the ranking in (8), *ʒ blocks [anterior] harmony between [ʧ] and [s]:

(8) *Conditional blocking in ABC with CORR I (after Hansson 2007: 401)*[2]

/ʧ…z…s/	*ʒ	ID-C_LC_R (–ant)	CORR-Š↔Z	CORR-Č↔S	CORR-Č↔Z	ID-IO (+ant)
a. $ʧ_i$…$ʒ_i$…$ʃ_i$	1 W			L	L	2 W
b. $ʧ_i$…z_i…$ʃ_i$		1 W		L	L	1 W
c. $ʧ_i$…z_i…s_i		2 W		L	L	
d. $ʧ_i$…z…$ʃ_i$			1 W (z…ʃ)	L	2 (ʧ…z), (z…ʃ)	1 W
e. → ʧ…z_i…s_i				1 (ʧ…s)	2 (ʧ…z), (ʧ…s)	

The constraint ID[–ant]-C_LC_R says that if the first member of any pair of CC-corresponding segments is [–anterior], then the second must be as well. It therefore enforces left-to-right propagation of the harmonizing feature. The various CORR constraints require correspondence between consonants of varying degrees of similarity:

(9) *CORR constraints in (8) and (10)*

a. CORR-Š↔Z
Assigns a violation mark for every pair of coronal sibilants that agree in (af)fricativeness but are not in correspondence.

b. CORR-Č↔S
Assigns a violation mark for every pair of coronal sibilants that agree in voicing but are not in correspondence.

c. CORR-Č↔Z
Assigns a violation mark for every pair of coronal sibilants that are not in correspondence.

(As an aid in understanding how the CORR constraints work, I've shown the violating consonant pairs below the number of violations in the tableaux.) Candidates (8)a, (8)b, and (8)c show that across-the-board CC correspondence is ruled out by the two undominated constraints: it requires violation of *ʒ or the IDENT-CC constraint. The best that can be done, then, is for two of the three consonants to be in correspondence with one another. The crucial choice is between (8)d and (8)e, and this is where the CORR constraints come in. The general effect of these constraints is that greater similarity means a stronger impetus to correspond. Because the two fricatives are more similar to each other than either is to the affricate, correspondence between the two fricatives is favored and the affricate is left out. In effect, [z] has acted as a

[2] Tableau (8) omits a harmonically bounded candidate in Hansson's original tableau.

blocker to [anterior] harmony because [z] is unpaired in the harmony system.

If the [z] stands between two affricates, however, their greater similarity to one another prevails, and the [z] acts as transparent:

(10) *Conditional blocking in ABC with CORR II (after Hansson 2007: 401)*[3]

	/tʃ…z…ʣ/	*ʒ	ID-C_LC_R (–ant)	CORR-Š↔Z	CORR-Č↔S	CORR-Č↔Z	ID-IO (+ant)
a.	tʃ$_i$…ʒ$_i$…ʤ$_i$	1 W			L	L	2 W
b.	tʃ$_i$…z$_i$…ʤ$_i$		1 W		L	L	1
c.	tʃ$_i$…z$_i$…ʣ$_i$		2 W		L	L	L
d. →	tʃ$_i$…z…ʤ$_i$				1 (z…ʤ)	2 (tʃ…z), (z…ʤ)	1
e.	tʃ…z$_i$…ʣ$_i$			1 W (tʃ…ʣ)	L	2 (tʃ…z), (tʃ…ʣ)	L

This pattern of blocking is "conditional" because it depends on which is more similar to the target segment, the potential trigger or the potential blocker. In (11), the potential trigger is more similar, and thus it is the actual trigger. In (8), on the other hand, the potential blocker is more similar to the target, and so it blocks.

Because this behavior is unattested, it would be preferable if the theory did not predict it. And indeed it does not if the CORR constraints are replaced by MAX-CC. The difference is that MAX-CC favors correspondence among all segments, not only those that are similar to one another. As we know from the ranking schema in (7), the similarity requirements are enforced by ranking above MAX-CC all of the IDENT-CC and IDENT-IO constraints for features that define the class of consonants that participate in assimilation. In this case, those features are [coronal] and [strident], the features that define the class of coronal sibilants.

Tableaux (11) and (12) show that there is no conditional blocking effect in ABC with MAX-CC. Blocking is categorical, in the sense that the presence of disharmonic [z] prevents the target consonant from harmonizing regardless of whether it is more similar to [z] or to [tʃ].[4]

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[3] Tableau (10) omits Hansson's candidate (f), which appears to be an error (it is identical to (e), but has different violation marks).

[4] The IDENT-CC constraints on [coronal] and [strident] are included in (11) for completeness. They are inactive on this input because it consists exclusively of coronal stridents.

(11) *No conditional blocking in ABC with MAX-CC I (cf. (8))*

/ʧ…z…s/	*ʒ	ID-CC (cor)	ID-IO (cor)	ID-CC (strid)	ID-IO (strid)	ID-C_LC_R (–ant)	MAX-CC	ID-IO (ant)
a. ʧ$_i$…ʒ$_i$…ʃ$_i$	1 W						L	2 W
b. ʧ$_i$…z$_i$…ʃ$_i$						1 W	L	1 W
c. ʧ$_i$…z$_i$…s$_i$						2 W	L	
d. ʧ$_i$…z…ʃ$_i$							1	1 W
e. → ʧ…z$_i$…s$_i$							1	

(12) *No conditional blocking in ABC with MAX-CC II (cf. (10))*

/ʧ…z…ʣ/	*ʒ	ID-CC (cor)	ID-IO (cor)	ID-CC (strid)	ID-IO (strid)	ID-C_LC_R (–ant)	MAX-CC	ID-IO (ant)
a. ʧ$_i$…ʒ$_i$…ʤ$_i$	1 W							2 W
b. ʧ$_i$…z$_i$…ʤ$_i$						1 W		1 W
c. ʧ$_i$…z$_i$…ʣ$_i$						2 W		
d. ʧ$_i$…z…ʤ$_i$							1	1 W
e. → ʧ…z$_i$…ʣ$_i$							1	

The reason for this difference between the versions of ABC with and without CORR is that the CORR constraints allow fine control over the degree of similarity between segments in correspondence. If there is a choice between putting two fricatives in correspondence or an affricate and a fricative, CORR-Š↔Z favors the first option. Even greater specificity is possible — for example, the ranking of CORR-Š↔Z and CORR-Č↔S determines which is favored, putting a voiceless fricative in correspondence with a voiced fricative, or putting a voiceless fricative in correspondence with a voiceless affricate.

Such exquisite control over the role of similarity in correspondence relations does not seem to be warranted by the facts, as Hansson (2007: 402) observes. It is therefore of some interest that ABC without CORR lacks this capacity entirely. Rather, similarity is determined in a categorical fashion by the ranking of constraints relative to MAX-CC. For any feature [F], if IDENT-CC(F) and IDENT-IO(F) dominate MAX-CC, then agreement in [F] is an absolute precondition to correspondence. There is no calculus of similarity beyond this, and hence there is no possibility of conditional blocking.

3.2. CORR constraints on specific feature values

CORR constraints formalize the idea "that correspondence between consonants in the output arises from their phonological similarity" (Rose & Walker 2004: 491), and I have shown that IDENT-CC constraints can fulfill that role through interaction with MAX-CC. But CORR constraints have another role as well: they can also require the corresponding consonants to have particular *values* of the features that define similarity. For example, CORR-K↔D requires correspondence between consonants that are similar in [continuant] and [sonorant], but it also imposes the further condition that the consonants be specifically [−continuant] and [−sonorant]. CORR constraints are not required to specify a particular feature value — for instance, CORR-T⇔D looks for homorganicity without requiring a particular place feature (Rose & Walker 2004: 491). But CORR constraints do have the option of being feature-value-specific.

The feature-value specificity of CORR constraints has no counterpart in the alternative I've proposed here. The grammar in (6) (with the addition of the IDENT(sonorant) constraints noted in (7)) requires correspondence between consonants that are similar in [continuant] and [sonorant], but it does not limit correspondence to the [−continuant, −sonorant] oral plosives. Rather, it will also favor correspondence between pairs of consonants that agree in other values of these features, listed in (13)b–d:

(13) *CC correspondence relations predicted for Chaha*

a. Oral plosives
[−sonorant, −continuant] t_iVk_i

b. Nasal stops
[+sonorant, −continuant] m_iVn_i

c. Fricatives
[−sonorant, +continuant] f_iVs_i

d. Liquids
[+sonorant, +continuant] l_iVr_i

Since CC correspondence relations are abstract, their existence can only be inferred from their assimilatory consequences. The correspondence relations in (13)b and (13)d can have no visible effects: all liquids in a word agree in [voice] and [constricted glottis], as do all nasals, because all of Chaha's liquids and nasals are [+voice] and [−constricted glottis] anyway. What about case (13)c, roots containing two fricatives? Voicing but not glottalization in distinctive in Chaha's fricatives, so correspondence between fricatives could in principle lead to voicing assimilation. In fact, it does not: although roots that combine [s] and [z] are ruled out for other reasons, roots that combine [f] with [z] evidently do occur without assimilation (Rose & King 2007). This is presumably why Rose & Walker use CORR-K⇔D in their analysis of Chaha: limiting CC correspondence to plosives accounts for why [f] and [z] can cooccur without undergoing voicing assimilation.

There are other possible explanations for why [f] and [z] can cooccur that do not require CORR's ability to stipulate that CC correspondence is limited to plosives. One explanation is based on the fact that Chaha's segment inventory lacks [v]. There is reason to think that voicing assimilation is achieved by changing voiceless to voiced and not the other way around (Rose & Walker 2004: 496fn.). Assimilation of /f…z/ would therefore be expected to yield [v…z], but with no [v] in the inventory, this outcome is blocked.

As Mackenzie (2009) notes, however, non-participation of fricatives in voicing ABC is also found in languages where it cannot be an inventory effect. (She cites Zulu and Ndebele as examples.) The theory of faithfulness supplies an alternative explanation. Jun (2004) has proposed that faithfulness to place is relativized to manner. More to the point, Beckman et al. (2009), Grijzenhout & Krämer (2000), Krämer (2005), and Morris (2002) have argued that faithfulness to [voice] must be relativized to the stop/fricative contrast. If IDENT-IO(voice)/fricative is ranked above MAX-CC and IDENT-IO(voice)/stop is ranked below it, then stops will be required to agree in [voice] but fricatives will not. This is illustrated in (14), using hypothetical examples and assuming no relevant inventory restrictions.

(14) *Voicing ABC limited to plosives*

	ID-IO (voice)/fric	ID-CC (voice)	MAX-CC	ID-IO (voice)/stop
/tɨg/				
a. → d_iɨg_i				1
b. t_iɨg_j			2 W	L
c. t_iɨg_i		1 W		L
/fɨz/				
d. → f_iɨz_j			2	
e. f_iɨz_i		1 W	L	
f. v_iɨz_i	1 W		L	

There is a larger issue here. Suppose that all and only consonants with the feature value [+F] are observed to assimilate in the feature [A]. In the system with feature-value-specific CORR, the limitation to [+F] can be stipulated in the definition of the constraint. In the system with MAX-CC, it cannot (though see footnote 5). Is the ability of CORR constraints to stipulate the limitation to [+F] consonants actually needed to deal with the full range of attested long-distance consonant assimilation processes?

As we have seen, there are at least three possible alternative explanations for why only [+F] segments assimilate in [A]:

(i) Because of restrictions on the inventory, all [−F] consonants have the same value of [A] anyway. Assimilation in [A] is therefore vacuous in the [−F] class. This is the explanation for why there is no assimilation among nasals or liquids in Chaha: they are all [+voice] and [−constricted glottis].

(ii) Because of restrictions on the inventory, the [−F] consonants are blocked from assimilating in [A]. This was the explanation offered for why there is no assimilation in [f…z] in Chaha.

(iii) As in (14), IDENT-IO(A)/[−F] ≫ MAX-CC ≫ IDENT-IO(A)/[+F].

The alternatives in (i)–(iii) define the burden of proof that must be overcome in any defense of the feature-value-specificity of CORR constaints. In any particular case, it will be a relatively straightforward matter to determine whether (i) or (ii) is applicable, but dealing with (iii) is not as easy. To foreclose this option, it would be necessary to show on independent grounds that IDENT-IO(A)/[+F] has to dominate IDENT-IO(A)/[−F] in the language in question, or show by typological argument that IDENT-IO(A)/[+F] must dominate IDENT-IO(A)/[−F] universally, or show that [±F]-differentiated IDENT-IO(A) is typologically problematic. Until this has been done — and that has not yet happened in the literature I am familiar with — the case for feature-value-specificity in CORR constraints will remain unproven.[5]

[5] There is an obvious point of retreat: relativize MAX-CC to feature values. MAX-CC(+F) would then be violated by any [+F] segment that is not in CC correspondence. There is precedent for this move in the more familiar dimensions of correspondence: the MAX(C)/MAX(V) distinction is as old as correspondence theory, and Gouskova (2003: 151) introduces a constraint MAX(V:) that protects long vowels from deletion.

4 Case study: Ngbaka

I will conclude with a case study of Ngbaka to show the CORR-less version of ABC at work. Ngbaka is attractive for this purpose because the facts are rather complex and there are CORR-based analyses readily available for comparison (Hansson 2001: 291ff., Rose & Walker 2004: 502ff.), as well as analyses in other frameworks (Mackenzie 2009: 71ff., Mester 1986, Sagey 1986)

Ngbaka enforces a restriction on root consonant cooccurrence that is summarized in the following tables (from Mackenzie 2009: 72-73):

(15) *Consonant cooccurrence restrictions in Ngbaka*

Labials					Coronals					Dorsals					Sibilants				
	p	b	^{m}b	m		t	d	^{n}d	n		k	g	^{ŋ}g	ɲ		s	z	^{n}z	n
p		x			t		x			k		x			s		x		
b	x		x		d	x		x		g	x		x		z	x		x	
^{m}b		x		x	^{n}d		x		x	^{ŋ}g		x		x	^{n}z		x		x
m			x		n			x		ɲ			x		n			x	

Within each of the four classes labial, coronal, dorsal, and sibilant, pairs of consonants marked with an *x* cannot cooccur. Thus, there can be no roots like *[paba] or *[bapa], but [pa^{m}ba] is allowed. Combinations of consonants from different classes, such as [taba], can cooccur freely.[6]

We know from the ranking schema in (7) that the IDENT-CC and IDENT-IO constraints for the features that define these classes have to be stationed at the top of hierarchy. Those features are [place] and [continuant].[7] We also know from (7) that MAX-CC and the IDENT-CC for features that assimilate have to dominate the IDENT-IO constraints for those features. In Ngbaka, the assimilating features include [voice], [nasal], and [sonorant], under the assumption that the prenasalized consonants are [+nasal, −sonorant].[8] These rankings are illustrated using schematic examples in (16). I have omitted the high-ranking IDENT(continuant) constraints to save space.

(16) *Ranking for Ngbaka*

a.

	ID-CC (plc)	ID-IO (plc)	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
/p-b/									
i. → b_i-b_i							1		
ii. p_i-b_j						2 W	L		
iii. p_i-b_i			1 W				L		

[6] The labial class also includes the labiovelars [k͡p], [g͡b], and [^{ŋm}g͡b]. Like Rose & Walker (2004: 502fn.), I take them to be primary labials, following Sagey (1986).

[7] The presence of [n] in both the coronal and sibilant classes is puzzling. Perhaps the non-occurrence of words like [^{n}zana] and [na^{n}za] is an accidental gap, if the highly marked prensalized fricative is a rare segment, as one suspects.

[8] The proposal that prenasalized consonants are [+nasal, −sonorant] is attributed by Chomsky & Halle (1968: 317fn.) to a suggestion from Jim McCawley. (Thanks to Sam Rosenthall for tracking down this reference.)

b.

/p-d/	ID-CC (plc)	ID-IO (plc)	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
i. → p_i-d_j						2			
ii. b_i-d_i	1 W					L	1 W		
iii. d_i-d_i		1 W				L	1 W		

c.

/b-^{m}b/	ID-CC (plc)	ID-IO (plc)	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
i. → $^{m}b_i$-$^{m}b_i$								1	
ii. b_i-$^{m}b_j$						2 W		L	
iii. b_i-$^{m}b_i$				1 W				L	

d.

/^{m}b-m/	ID-CC (plc)	ID-IO (plc)	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
i. → m_i-m_i									1
ii. $^{m}b_i$-m_j						2 W			L
iii. $^{m}b_i$-m_i					1 W				L

Although this much is a straightforward application of the ranking schema in (7), the analysis is not yet complete. As table (15) shows, consonants differing in two or three of the features [voice], [nasal], and [sonorant] cooccur freely. The grammar in (16) wrongly predicts that assimilation will also affect all of the combinations that differ in two or three of these features, such as [p-^{m}b], [b-m], or [p-m], all of which are in fact allowed. Tableau (17) shows this for underlying /b-m/: the predicted winner given this ranking is assimilated and corresponding [m_i-m_i], but the desired winner is unassimilated and non-corresponding [b_i-m_j].

(17) *Wrong result from /b-m/*

/b-m/	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
a. → m_i-m_i						1	1
b. b_i-m_j				2 W		L	L
c. b_i-m_i		1 W	1 W			L	L
d. $^{m}b_i$-m_i			1 W			1	L

It seems that assimilation is blocked unless perfect satisfaction of the high-ranking IDENT-CC constraints can be achieved by changing the value of a single feature.[9]

[9] Compare van de Weijer's (1994: 262) "sufficient dissimilarity" hypothesis: "Root consonants … must differ by more than one feature to be acceptable in Ngbaka, or they must be completely identical."

This behavior is exactly what Harmonic Serialism (HS) predicts, given the grammar in (16). HS is a derivational version of OT in which GEN is limited to making a single change at a time (see McCarthy 2010 and references cited there). Under the assumption that feature values can only change one at a time, the problematic winner [m_i-m_i] is not a possible candidate from input /b-m/, since /b/ and [m] differ in two features. Rather, the candidates at the first step of the /b-m/ derivation are limited to those in (18). Faithful but non-corresponding [b_i-m_j] wins in because there is no way of eliminating all of the IDENT-CC violations in a single step of the derivation:

(18) *Correct result from /b-m/ in HS*[10]

/b-m/	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
a.→ b_i-m_j				2			
b. b_i-m_i		1 W	1 W	L			
c. ^mb_i-m_i			1 W	L		1 W	

But when the consonants differ in only a single feature, the lone IDENT-CC violation can be removed in a single step, so the harmonizing candidate wins:

(19) *Correct result from /p-b/ in HS*

/p-b/	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
a.→ b_i-b_i					1		
b. p_i-b_j				2 W	L		
c. p_i-b_i	1 W				L		

This proposal readily generalizes to all of the data in (15), accounting for the observation that harmony occurs only when a single feature change is sufficient to satisfy all of the IDENT-CC constraints that dominate MAX-CC.

There are other ways of accounting for the observation that only single-feature assimilations occur in Ngbaka. One obvious possibility is local conjunction of faithfulness constraints (Kirchner 1996, Smolensky 1995, 2006). The unintended winner in (17) is doubly unfaithful, violating both IDENT-IO(nasal) and IDENT-IO(sonorant). If the conjunction of these two constraints is ranked above MAX-CC, then the correct result is obtained:

[10] Tableau (18) is presented under the assumption that the HS GEN can create a CC correspondence relation at the same time that it changes a feature value. This assumption is a necessary one. If establishing the relation and assimilating the feature took place in separate steps, the cases where assimilation actually occurs, such as /^{m}b-m/ → [m_i-m_i], could not be obtained under the ranking in (18). That's because the first step of the presumed derivation, /^{m}b-m/ → [^mb_i-m_i], introduces a violation of top-ranked IDENT-CC(sonorant) while removing a violation of lower-ranked MAX-CC.

(20) *Correct result from /b-m/ with local conjunction (cf. (17))*

/b-m/	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	ID-IO(nas) & ID-IO(son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)
a. m_i-m_i				1 **W**	**L**		1 **W**	1 **W**
b. → b_i-m_j					2			
c. b_i-m_i		1 **W**	1 **W**		**L**			
d. $^{m}b_i$-m_i			1 **W**		**L**		1 **W**	

Similarly, to prevent assimilation with input /p-^{m}b/, the conjoined constraint IDENT-IO(voice) & IDENT-IO(nasal) will also have to dominate MAX-CC. It will then favor faithful and non-corresponding [p_i-$^{m}b_j$] over doubly unfaithful but corresponding [$^{m}b_i$-$^{m}b_i$].

Constraints are conjoined in a domain. Although the domain *segment* would suffice to rule out the mapping /b-m/ → [m_i-m_i] in (20)a, the domain *root* is needed to rule out the mapping /b-m/ → [$^{m}b_i$-$^{m}b_i$], where the two feature changes are executed in different segments. This is not a particularly attractive option, however, because conjunctions like IDENT-IO(voice) $\&_{root}$ IDENT-IO(nasal) make notoriously problematic typological predictions. For example, this conjoined constraint predicts the existence of a language where nasal harmony in one part of a root blocks coda devoicing in another part of the root. This is an example of the *co-relevance* problem in local conjunction (Bakovic 1999, 2000, Fukazawa & Miglio 1998, Łubowicz 2005, McCarthy 1999, 2003, Padgett 2002, Pater 2009a): conjunction can create dependencies between non-interacting constraint violations. An adequate theory of local conjunction would rule out IDENT-IO(voice) $\&_{root}$ IDENT-IO(nasal) universally and not embrace it expediently in Ngbaka.

Harmonic Grammar (HG) (Legendre et al. 1990a, b, Legendre et al. 2006, Pater 2009b, Potts et al. to appear) offers another possible approach to the problem of limiting assimilation to a single feature change. There is a weighting of the constraints in (17) that produces the right result. Tableau (21) shows (17) with weighting and harmony scores rather than ranking:

(21) *Correct result from /b-m/ in HG*

weights	3.0	3.0	3.0	1.5	2.0	2.0	2.0	Harmony
/b-m/	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)	
a. m_i-m_i						−1	−1	−4.0
b. → b_i-m_j				−2				−3.0
c. b_i-m_i		−1	−1					−6.0
d. $^{m}b_i$-m_i			−1			−1		−5.0
e. $^{m}b_i$- $^{m}b_i$		−1	−1					−6.0

Candidate (21)e has been added to show that distributing the two faithfulness violations across different segments does not improve the prospects for assimilation. In this case as in others (Pater 2009a), HG produces some of the same effects as constraint conjunction, but without the co-relevance problem.

The weighting in (21) is also valid for all other combinations of homorganic consonants in Ngbaka, as determined by OT-Help 2.0 (Becker et al. 2009). For example, tableau (22) applies this weighting to underlying /p-b/, correctly mapping it to /b-b/.

(22) *Correct result from /p-b/ in HG*

weights	3.0	3.0	3.0	1.5	2.0	2.0	2.0	Harmony
/p-b/	ID-CC (voi)	ID-CC (nas)	ID-CC (son)	MAX-CC	ID-IO (voi)	ID-IO (nas)	ID-IO (son)	
a.→ b_i-b_i					−1			−2.0
b. p_i-b_j				−2				−3.0
c. p_i-b_i	−1							−3.0

In summary, the complex pattern of consonant cooccurrence in Ngbaka has shown itself to be amenable to analysis without CORR constraints. This analysis highlights the fact that assimilation must be achieved in a single unfaithful mapping — or not at all. In HS or HG, this restriction can be derived from basic properties of the grammar.[11]

5 Conclusion

Agreement by correspondence is an appealing idea about how consonant harmony should be analyzed, but it has an unappealing feature in current implementations: it posits two distinct types of identity-referring constraints. CORR-CC constraints require correspondence when an identity condition is met. IDENT-CC constraints require identity when there is correspondence.

In this paper, I have argued that the work of CORR-CC constraints can be done by the IDENT-CC constraints and MAX-CC, which requires correspondence generally. If IDENT-CC(F) and IDENT-IO(F) dominate MAX-CC, then consonants that agree in [F] will be in correspondence. If, on the other hand, IDENT-CC(F) and MAX-CC dominate IDENT-IO(F), then consonants in correspondence will assimilate in [F]. What the previous approach achieved by having two types of identity-referring constraints, CORR and IDENT, this new approach achieves by maximally exploiting the possibilities afforded by constraint interaction.

One interesting result of this refinement of ABC is that it strengthens the link between CC correspondence and other types of correspondence (IO, BR, OO). In the other dimensions of correspondence, there is an important role for MAX constraints, but there is nothing akin to CORR. Dispensing with CORR and adding MAX to CC correspondence eliminates this difference and thereby improves the case for ABC.

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[11] Joe Pater points out the following typological difference between the HS and HG accounts. In HS, the distinction is necessarily between changing one feature to achieve identity and changing more than one. In HG, the distinction is between changing *n* features and changing more than *n*, with the value of *n* depending on the weights assigned to the constraints.

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