Long-distance Consonantal Identity Effects

Rachel Walker
University of Southern California

1. Introduction

This paper examines long distance voicing agreement between consonants (Cs). Two related patterns are observed. In the first one [voice] agreement is restricted to pairs of oral stops that match in place of articulation, as seen in Ngbaka. In the second, observed in Kera, [voice] agreement occurs among all pairs of stops. I argue that these agreement patterns come about through a correspondence relation that is established between Cs in the output. The notion of *intersegmental correspondence* will be important in explaining two key properties of the phenomena: (i) the potential for interaction between Cs at a distance, and (ii) the preference for voicing agreement to occur between similar Cs. From a wider perspective, this analysis is supported by work on other consonantal agreement patterns that display similar characterizing properties (Walker 1999, Rose & Walker in prep.). In addition, I propose that the correspondence approach has the potential to extend to cases of voicing dissimilation.

The analysis is couched within Optimality Theory (OT; Prince & Smolensky 1993). The paper is organized as follows. In §2 I present the data illustrating voicing agreement between Cs at a distance. §3 diagnoses the agreement as arising through the mechanism of segmental correspondence rather than feature spreading. In §4 I lay out a theoretical overview of the correspondence approach to long-distance agreement, and then develop the details of analysis of Ngbaka and Kera. §5 discusses an extension to voicing dissimilation phenomena, and §6 gives the conclusion.

2. Voicing agreement data

Some languages display long-distance voicing agreement between Cs. A case is found in the Niger-Congo language, Ngbaka, described by Thomas (1963) (see also Mester 1986; Sagey 1986). Ngbaka exhibits a distributional restriction whereby homorganic oral stops that belong to the

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same morpheme must agree in voicing, as seen in (1a). The data in (1b) show that homorganicity is crucial to trigger the voicing agreement. Hence a voicing mismatch is permissible in tautomorphemic pairs of heterorganic oral stops. In (1c), we see that voicing agreement is not imposed between stops and Cs that differ in manner, such as liquids or fricatives.[1]

(1) a. tita   'grandparent'   *tida, *dita
        pɛpu   'vent'   *pɛbu, *bɛpu
        babã   'companion'   *bapã, *pabã

    b. bata   'three'
        ɡapa   'to divide'
        duka   'shoulder'
        ɡɔtɔ   no gloss

    c. tolo   'strike'
        sakade   'thus'

An intriguing property of this phenomenon is that it presents an instance of action-at-a-distance. Observe that the stops agreeing in [±voice] specification can be separated by a vowel (V). Vs neither trigger voicing agreement nor are they affected by C-to-C agreement across them.

    Another example is found in Kera, a Chadic language. According to Ebert (1979), Kera requires that all oral stops/affricates in a word agree in voicing (see also Odden 1994). This condition produces alternations. In (2a), a root containing a voiced noncontinuant obstruent induces voicing in affix stops. The data in (2b) show that voiceless stops are found in these affixes elsewhere. In contrast to Ngbaka, observe that voicing agreement can occur between either heterorganic or homorganic Cs in Kera. Manner is again important: fricatives and stops can disagree in voicing (2c). Note also that Vs and sonorant Cs can intervene between the agreeing stops/affricates and behave neutral with respect to voicing agreement. In these data, the prefix V is epenthetic, and its quality is determined by a vowel harmony.

(2) a. kV-gə̀r   → [gə̀gə̀r]   'knee'
        kV-dàarə̀   → [gə̀dàarə̀]   'friend'
        kV-ĵàr-káŋ   → [gə̀ĵàrgáŋ]   'colorful' (coll.)
        kV-ĵìr-kí   → [gìĵìrgí]   'colorful' (masc.)
        ĵàr-ká   → [ĵàrgá]   'colorful' (fem.)
        kV-dàygá-w   → [gə̀dàygáw]   'jug' (pl.)

    b. kV-kámná-w→ [kəkámnáw] 'chief' (pl.)
        kV-taatá-w   → [kətaatáw] 'cooking pot' (pl.)

1. The long-distance agreement effects in Ngbaka exemplified here are a subset of those found in the language (for a fuller treatment, see Thomas 1963; Mester 1986; Sagey 1986). The focus of the present work is on [voice] agreement among stops, but the other cases could fall under the general approach developed here.

kV-màanə̀ → [kəmàanə̀] 'woman'
kV-sár-káŋ → [kəsárkáŋ] 'black' (coll.)
kV-sír-kí → [kisírkí] 'black' (masc.)
sár-ká → [sárká] 'black' (fem.)

 c. [fèrgé] No gloss
    [dèfé] No gloss

Cases of this general type involving other laryngeal features are found in Aymara dialects (MacEachern 1997). For example, Peruvian Aymara prohibits tautomorphemic homorganic Cs with acoustically similar but different laryngeal properties, such as glottalization and aspiration, i.e. *[pʰ...p'...], *[t'...tʰ...]. However, homorganic segments that are identical in laryngeal specification are permitted, e.g. [pʰuspʰu] 'boiled beans', [t'ult'u] 'stubble field of barley or quinoa', [k'ink'u] 'clay'. Though the Aymara data will not be the focus of this paper, they indicate that long-distance agreement for laryngeal properties is not limited to [voice].

To summarize, the voicing agreement data above depict two patterns. In Ngbaka, [voice] agreement holds between homorganic stops, and in Kera, it holds between homorganic and heterorganic stops. The agreement presents two main characteristics that must be addressed by the analysis. First, it displays a potential for action-at-a-distance: the segmental interactions are non-local in the sense that the Cs agreeing for [voice] need not be root-adjacent. Also, intervening Vs and Cs can occur without triggering or blocking voicing agreement. Second, the agreement presents a similarity effect, that is, agreement for [voice] between less similar stops implies that agreement will occur between more similar stops.

3. Diagnosing the phenomenon

As a first step towards analysis, I start by diagnosing the phonological mechanism that underlies the long-distance voicing agreement. Two chief theoretical approaches to producing featural agreement are spreading and segmental correspondence. In a feature spreading approach, [voice] is linked between the agreeing Cs across intervening neutral segments, as depicted in (3a). Under a correspondence account, in (3b), a correspondence relation is established between similar segments. Agreement arises here via a requirement of identity for [voice] specification in corresponding segments. Observe that in contrast to the spreading representation, no links that gap over intervening segments are posited in (3b). In what follows, I will argue that it is the correspondence mechanism that gives rise to voicing agreement at a distance.

(3) a. Feature spreading   b. Segmental correspondence
    t i t a t_α i t_α a
     \   / | |
    [-voice]   [-voi] [-voi]

Support for correspondence as the basis for long-distance voicing agreement comes on three fronts. First of all, correspondence relations are typically not limited to root-adjacent segments. For example, in reduplication, corresponding segments are often separated by one or more intervening segments, as in [RED-kɔlat] -> [$k_1ɔ_2l_3a_4$-$k_1ɔ_2l_3a_4$t] 'spoon' (West Tarangan; Spaelti 1997). In addition, although reduplication most often copies segments starting at the edge of the base where RED is located, producing a kind of locality effect, studies have shown that such edge-anchoring is violable in reduplicative correspondence (e.g. Gafos 1996; Spaelti 1997; Walker 1998). Hence the action-at-a-distance in [voice] agreement is consistent with correspondence. A second point is that correspondence explains the lack of participation or blocking by intervening segments. As seen in (3b), since agreement is achieved by checking identity for [voice] specification in related stops rather than through cross-segment feature linking, the neutrality of intervening segments is straightforward. Third, correspondence offers the potential for explanation of the similarity effect in voicing agreement. I suggest below that a correspondence relation arises between Cs in a word, because the segments are similar. Finally, it may be noted that this approach has found fruitful application with another case of consonantal agreement. Walker (to appear) argues that correspondence underlies a pattern of nasality agreement between voiced Cs at a distance in Yaka. Like the voicing agreement examined here, the nasality agreement exhibits a similarity effect; in particular, it targets segments that are similar to the nasal trigger.

Let us now consider the spreading alternative. Previous accounts of long-distance voicing agreement by Mester (1986) and Odden (1994) have proposed that spreading or linkage of [voice] (or a dominating node) occurs between the agreeing Cs at some site in the segment structure. Although this work represented an important development in research in this area, the status of this kind of approach to long-distance interactions has since grown to be questionable. I consider here some general issues; for discussion of specifics of the analyses by Mester and Odden, see Walker (1999).

A chief issue is locality. A growing body of work supports a theory in which features spread only between root-adjacent segments. A theory that admits representations in which feature linkage may gap across segments is argued to be too permissive—it predicts a range of spreading phenomena that are not borne out (Padgett 1995; Ní Chiosáin & Padgett to appear; Walker 1998; see Gafos 1996 for a related proposal). In connection with this notion of locality, spreading is viewed as the result of extending a feature span, where features represent unitary and continuous entities. As the above researchers note, this understanding has foundation in concepts of Articulatory Phonology (Browman & Goldstein 1986). Extending a continuous feature cannot produce an outcome where the span of the spreading property contains interruptions; hence it must obey root-level locality.

A second issue concerns the similarity effect. A spreading account

offers no direct insight into the preferential targeting of similar segments seen in long-distance voicing and nasality agreement. Cases of agreement restricted to adjacent segments that are uncontroversially due to spreading often do not display a similarity condition. For example, Walker (1998) discusses a kind of nasal harmony that propagates only among root-adjacent segments and always includes Vs in its set of targets. This harmony does not present a similarity effect, since the target V is quite different from the trigger nasal stop, and segments more similar to the nasal, such as sonorant Cs or voiced stops, may be excluded as targets. Walker argues that the mechanism underlying this local harmony is feature spreading and the basis for preferred targets is their compatibility with superimposed nasalization. If spreading were viewed as the source of agreement in long-distance inter-actions as well, the important correlation between similarity and action-at-a-distance would accordingly be missed. Long-distance nasal (or voicing) agreement would then be expected to exhibit the same sets of targets as local spreading. However, this is not the case—in nasalization at a distance, Vs are regularly excluded as targets, while Cs similar to nasals are favored.

The general issue of determining which segments will participate in a given featural agreement also raises the matter of the underspecification or other inertness that must be assumed for neutral segments under a spreading approach. See Walker (1999, to appear) for discussion of problematic aspects of this assumption in relation to voicing and nasality agreement.

To sum up, at this stage we have seen that the long-distance interaction and the similarity effect in voicing agreement are compatible with segment correspondence, but they are problematic or unexplained under feature spreading. Accordingly, I pursue a correspondence analysis below.

4. Analysis: Intersegmental correspondence

4.1 Agreement at a distance as a correspondence effect

I formalize the analysis in OT, along with the Correspondence model of faithfulness, as elaborated by McCarthy & Prince (1995). I assume a basic familiarity with the formalisms and underpinnings of this theory.

At the core of the present proposal is the claim that correspondence can hold between segments in the output of a word; I will call this *intersegmental correspondence* (Walker 1999, to appear; for related proposals see Suzuki 1999; Zuraw 2000; other research on linguistic requirements that phonological elements be repeated or copied outside of morphological reduplication includes Yip 1995; MacEachern 1997; Rose 1997; Ussishkin 1999; Kitto & de Lacy to appear). In general, correspondence is established between structures that are recognized as related. Familiar examples of corresponding structures include input-output, base-reduplicant, and morphologically-related outputs. In the case at hand, the correspondence relation is suggested to stem from similarity, in other words, segments that are recognized as alike in many ways are prone to be

identified as related, and thus correspondence is established between them.

The notion that similar segments in an output may be identified as related, and hence interact, has basis in research on the processing of phonological structure. Psycholinguistic studies of the phonological encoding and production of words reveal that the production of a given C activates or primes other Cs that share a large number of features. The effects are evidenced in speech errors and tongue twisters, whereby Cs that are identical in all but one feature are found to be more likely to induce slips of the tongue (Fromkin 1971; Shattuck-Hufnagel & Klatt 1979; Kupin 1982; among others). It is observed that similar but different sounds frequently shift to identical ones; for example, the tongue twister that begins *she sells sea shells* is often pronounced as *she shells shea shells.* (Note also that a recent study by Pouplier et al. 1999 finds evidence that speech errors can occur at the subsegmental level, i.e. at the gestural or featural level.) Other work has identified gradient perceived similarity as a factor that contributes to the potential for interaction between segments (see Frisch 1996; Frisch et al. 1997 and citations therein). Taken together, this research suggests that the occurrence of segments that are only slightly different in an utterance presents production and perception difficulties, a point reflected in spreading activation models of speech processing (e.g. Stemberger 1985; Dell 1986), and it provides support for the claim that speakers construct a relation between similar segments.

I propose that the formal actualization of such relations arises through a set of violable constraints in the grammar. First, the general formulation for a constraint requiring that correspondence be established between Cs in an output is given in (4). The constraint is generalized here over all Cs.

(4) Consonantal correspondence constraint: Corr-$C_1 \leftrightarrow C_2$
     Given an output string of segments S, and consonants $C_1 \in$ S and C_2 $\in$ S, then C_1 is in a relation with C_2, that is, C_1 and C_2 are correspondents of one another.

The speech error studies and voicing agreement data indicate that the degree of similarity between two Cs is a key factor in triggering a relation between them. I propose to implement this in the grammar by arraying Corr-C$\leftrightarrow$C constraints in a hierarchy such that the more similar the Cs, the higher ranked the constraint requiring that they be in correspondence. The portion of the hierarchy relevant for voicing agreement is given in (5).

(5) Similarity-based correspondence hierarchy for stops:
     Corr-$T_1 \leftrightarrow T_2 \gg$ Corr-$T_1 \leftrightarrow D_2 \gg$ Corr-$K_1 \leftrightarrow D_2$

The constraints are interpreted as follows. Corr-$T_1 \leftrightarrow T_2$ requires correspondence between any pair of oral stops matching in place and voice ([t…t…], [b…b…], etc.). Corr-$T_1 \leftrightarrow D_2$ holds over the superset of stops that

match in place, i.e. ones that are at least as similar as [t] and [d] ([t…d…], [g…k…], [p…p…], etc.). Corr-$K_1 \leftrightarrow D_2$ expands to any pair of oral stops.

Another set of constraints that will be important in C-to-C correspondence is faithfulness. The model in (6) presents a schema of the faithfulness relations at play, using a hypothetical demonstration form [tadu] for illustration. The standard Faith-IO correspondence constraints will hold between the input and output forms of a word. Within the output, Corr-C$\leftrightarrow$C constraints can cause a relation to be established between a pair of Cs. Faith-CC constraints will enforce identity of structure and content between these segments. The relevant Faith-CC constraint is given in (7). It requires that correspondent Cs match in [voice] specification.

(6)   Intersegmental Correspondence model:
      Input   /tadu/
                       ↕   *Faith-IO*
      Output   [ta̠d̠u]
                       ↔   *Faith-CC*
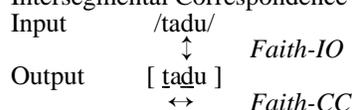
(7)   Ident-CC(voice)
      Let C_1 be a consonant in the output and C_2 be any correspondent of C_1 in the output. If C_1 is [αvoice], then C_2 is [αvoice].

To illustrate the application of the above constraints, the tableau in (8) tabulates the violations incurred by various candidates (constraints are unranked here). Subscripted numerals mark IO correspondence and subscripted Greek letters annotate CC correspondence.

(8) Evaluation of various output candidates

/$t_1$ad$_2$u/	Ident-CC (voi)	Ident-IO (voi)	Corr- $T_1 \leftrightarrow T_2$	Corr- $T_1 \leftrightarrow D_2$	Corr- $K_1 \leftrightarrow D_2$
a. $t_{1,\alpha}$ad$_{2,\beta}$u				*	*
b. $t_{1,\alpha}$ad$_{2,\alpha}$u	*				
c. $t_{1,\alpha}$at$_{2,\alpha}$u		*			
d. $t_{1,\alpha}$at$_{2,\beta}$u		*	*	*	*

Candidates (8a-b) display no [voice] agreement. In (a), the output Cs are not in correspondence with each other, violating Corr-$T_1 \leftrightarrow D_2$, and by implication Corr-$K_1 \leftrightarrow D_2$ as well. In (b), the output stops are in correspondence, but they do not agree for voicing; hence this form violates Ident-CC(voi). Candidate (8c) displays the long-distance voicing agreement in which we are interested. Here correspondence is established between the two stops, and the Cs obey Ident-CC(voi). This form violates Ident-IO(voi), which requires that corresponding segments in the input and output have the same specification for [voice]. Finally, (8d) presents an instance where the second C has become voiceless, but without being in correspondence

with the first C. This unmotivated change in [voice] specification is sub-optimal under any ranking of these constraints.

To simplify subsequent tableaux, subscripts marking IO correspondence will henceforth be omitted except where needed for purposes of clarification. When unmarked, I will assume that IO relations in the candidates given are such that segments with matching positions in the input and output strings are in correspondence.

4.2 The Ngbaka pattern

I turn now to the details of the rankings for the Ngbaka pattern. In Ngbaka, stops that match in place must agree in voicing. Since the requirement of voice identity between corresponding stops in the output has the capacity to override IO voicing identity, Ident-CC(voi) must outrank Ident-IO(voi). This is shown in (9) with a hypothetical input /tida/ for [tita]. (I assume that Max-IO outranks Ident-IO(voi) to prevent deletion of Cs.)

(9) Ident-CC(voi) >> Ident-IO(voi)

/tida/	Ident-CC(voi)	Ident-IO(voi)
a. ☞ $t_\alpha it_\alpha a$		*
b. $t_\alpha id_\alpha a$	*!	

The next point to address is that voicing agreement is restricted to stops that match in place. In order to compel correspondence between these stops, the Corr-C↔C constraints for homorganic Cs must also dominate Ident-IO(voi). The ranking of Corr-T_1↔D_2 over Ident-IO(voi) is shown in (10).

(10) Corr-T_1↔D_2 >> Ident-IO(voi)

/tida/	Ident-CC (voi)	Corr-T_1↔T_2	Corr-T_1↔D_2	Ident-IO (voi)
a. $t_\alpha id_\beta a$			*!	
b. ☞ $t_\alpha it_\alpha a$				*
c. $t_\alpha id_\alpha a$	*!			

The winner is (10b), in which the homorganic stops correspond and obey Ident-CC(voi). The alternatives lose either because the Cs do not correspond (10a) or because they correspond but violate Ident-CC(voi) (10c).

Because voicing agreement does not hold between Cs that differ in place, Ident-IO(voi) must dominate Corr-K_1↔D_2, preventing correspondence between heterorganic stops that differ in voicing, as in (11). The winner in (a) does not establish correspondence between the two output stops in order to obey both Ident-IO(voi) and Ident-CC(voi). The failed alternatives in (11b-c) lose on a violation of one of these faith constraints.

(11) Ident-IO(voi) >> Corr-$K_1 \leftrightarrow D_2$

/gɔtɔ/	Ident-CC (voi)	Corr-$T_1 \leftrightarrow T_2$	Corr-$T_1 \leftrightarrow D_2$	Ident-IO (voi)	Corr-$K_1 \leftrightarrow D_2$
a. ☞ g$_\alpha$ɔt$_\beta$ɔ					*
b. g$_\alpha$ɔd$_\alpha$ɔ				*!	
c. g$_\alpha$ɔt$_\alpha$ɔ	*!				

This concludes the core rankings for Ngbaka. It should be noted that although Ident-IO(voi) is violated in the optimal output in cases like (10), alternatives that change the sonority or place of one of the Cs are assumed to be non-optimal, e.g. [tiɾa], [tiga]. In Ngbaka, there are no alternations to test this, since C correspondence is limited to tautomorphemic segments. However, the non-optimality of these forms is supported by Kera, which exhibits alternations that change voicing but regularly obey Ident-IO(son) and Ident-IO(Place). I assume that the two languages have in common a ranking that places these faith constraints at the top of the hierarchy shown here (and also over Ident-CC(Place)). More generally, Rose & Walker (in prep.) find that input specifications for major place are unaltered in C correspondence agreement phenomena, a point that I return to in §6. Rose & Walker also observe that sonority is typically unaffected (but see Walker to appear). This matter too is raised again below.

4.3 The Kera pattern

The Kera pattern is minimally different from Ngbaka: voicing agreement expands to include heterorganic Cs. In most respects, the ranking for Kera will be the same as that for Ngbaka. What distinguishes them is the ranking of Ident-IO(voi) in relation to the Corr-C↔C hierarchy. In particular, Ident-IO(voi) moves below Corr-$K_1 \leftrightarrow D_2$ to add heterorganic stops to the set for which correspondence is established. The ranking is illustrated in (12). (I assume that [ĵ] is subject to the Corr-C↔C constraints here by virtue of its noncontinuant element, see also Odden 1994; Walker 1999.) The winning candidate in (12b) establishes correspondence between the noncontinuant obstruents, and it violates Ident-IO(voi) to obtain agreement. The competitor in (12a) is faithful to input voicing, but it loses on a violation of Corr-$K_1 \leftrightarrow D_2$. (12c) is ruled out by high-ranked Ident-CC(voi).

(12) Corr-$K_1 \leftrightarrow D_2$ >> Ident-IO(voi)

/ĵar-ka/	Ident-CC (voi)	Corr-$T_1 \leftrightarrow T_2$	Corr-$T_1 \leftrightarrow D_2$	Corr-$K_1 \leftrightarrow D_2$	Ident-IO (voi)
a. ĵ$_\alpha$ark$_\beta$a				*!	
b. ☞ ĵ$_\alpha$arg$_\alpha$a					*
c. ĵ$_\alpha$ark$_\alpha$a	*!				

In (13) we see the application of the ranking to a word containing only one stop. This form contains a voiced sonorant [r], but it is not sufficiently similar to [k] to be subject to Corr-C↔C constraints. As a result, there is no C-to-C correspondence and no voice agreement occurs.

(13) Sonorant Cs do not trigger agreement

/sar-ka/	Ident-CC (voi)	Corr- $T_1{\leftrightarrow}T_2$	Corr- $T_1{\leftrightarrow}D_2$	Corr- $K_1{\leftrightarrow}D_2$	Ident-IO (voi)
a.☞ $sar_\alpha k_\beta a$					
b. $sar_\alpha g_\alpha a$					*!

It is noteworthy that voicing agreement involves a configuration of multiple correspondence. When a C in the output is in a relation with an input segment and also in a relation with another C in the output, it violates the Bijectivity constraint, which requires that correspondence be one-to-one. Familiar examples of multiple correspondence either coalesce or break segments mapping from the same domain, such as an input. In voicing agreement, the multiple mapping is from separate domains: in effect, it is an instance of coalescence that merges properties of an input C and an output C. The Bijectivity constraint incorporating the notion of different source domains is given in (14), adapted from Itô et al. (1996) and Suzuki (1996) (building on McCarthy & Prince 1995). The specific application here is outlined in (15): if an output C is in a correspondence mapping from an input C, then it must not also stand in a mapping from a C in the output.

(14) Bijectivity:
     Mapping between correspondents across domains must be one-to-one.

(15) Let $x\mathcal{R}z$ denote that x and z stand in a correspondence relation. For x
     ∈ Input, and y, z ∈ Output, if $x\mathcal{R}z$, then $\neg y\mathcal{R}z$.

Since Bijectivity is violated in voicing agreement, it must be ranked below the relevant Corr-C↔C constraints, as shown in (16) for Kera. The winner in (b) violates Bijectivity by establishing IO correspondence between /k/ and [g] and CC correspondence between [ǰ] and [g] (as noted in the tableau). Candidate (a) fails, because the output Cs do not correspond.

(16) Corr-$K_1{\leftrightarrow}D_2$ >> Bijectivity

/$ǰ_1ar\text{-}k_2a$/	Ident- CC(voi)	Corr- $T_1{\leftrightarrow}T_2$	Corr- $T_1{\leftrightarrow}D_2$	Corr- $K_1{\leftrightarrow}D_2$	Ident- IO(voi)	Bijectivity
a. $ǰ_{1,\alpha}ark_{2,\beta}a$				*!		
b.☞ $ǰ_{1,\alpha}arg_{2,\alpha}a$					*	* IO $k_2\ \mathcal{R}\,g_2$ CC $ǰ_\alpha\ \mathcal{R}\,g_\alpha$

Observe that Bijectivity is clearly violated in the optimal output in (16), because the suffix C agrees with the voicing of an output C while remaining faithful to its input place specification.

(17) gives a ranking summary for Ngbaka and Kera. The distinction between the patterns comes simply from the position of Ident-IO(voi).

(17) Ngbaka:
 Id-CC(voi), Corr-T$\leftrightarrow$T >> Corr-T$\leftrightarrow$D >> <u>Id-IO(voi)</u> >> Corr-K$\leftrightarrow$D, Bijec

 Kera:
 Id-CC(voi), Corr-T$\leftrightarrow$T >> Corr-T$\leftrightarrow$D >> Corr-K$\leftrightarrow$D >> <u>Id-IO(voi)</u>, Bijec

5. Consonantal disagreement at a distance

In this section I explore an extension of the segmental correspondence approach to a kind of voicing dissimilation. The data in (18) illustrate the pattern in Gothic. As discussed by Chomsky & Halle (1968), after an unstressed V, voicing in a continuant obstruent dissimilates with that of a preceding obstruent (see also Mossé 1956). Affixal alternations result:

(18) a. hat-iza   'hatred' (dat.)
   rik^w-iza   'darkness' (dat.)
   ag-isa   'fright' (dat.)

  b. ɸast-uβni 'position'
   ɸraist-uβni 'temptation'
   wald-uɸni 'authority'

Other examples of voicing dissimilation occur in Kikuria and a number of other Bantu languages (Odden 1994) and in Japanese (Mester & Itô 1989).

I suggest that this dissimilation comes about through the ascendance of Bijectivity. In languages that prioritize Bijectivity, multiple correspondence will be avoided, blocking a relation between output Cs. As a result, rather than agreeing through C-to-C correspondence, similar Cs may dissimilate in order to become more harmonic with respect to the Corr-C$\leftrightarrow$C constraints. To exemplify this outcome for Gothic, we will need to call on the portion of the Corr-C$\leftrightarrow$C hierarchy that applies to fricatives. The relevant hierarchy includes fricative-to-fricative and fricative-to-stop correspondence, as in (19). Drawing on Rose & Walker (in prep.), obstruents that match in continuancy are scaled as more similar than ones that differ in this respect.

(19) Fricative correspondence hierarchy:
 Corr-$S_1 \leftrightarrow S_2$ >> Corr-$S_1 \leftrightarrow Z_2$ >> Corr-$Z_1 \leftrightarrow X_2$ >> Corr-$Z_1 \leftrightarrow G_2$ >>
 Corr-$S_1 \leftrightarrow G_2$

(20) gives the tableau for Gothic with a possible input /ag-iza/. Ident-IO(voi) is low-ranked and Bijectivity dominates the Corr-C$\leftrightarrow$C hierarchy.

(20) Voicing dissimilation

$/ag_1\text{-}iz_2a/$	Bijectivity	Corr-$S_1{\leftrightarrow}S_2$	Corr-$S_1{\leftrightarrow}Z_2$	Corr-$Z_1{\leftrightarrow}X_2$	Corr-$Z_1{\leftrightarrow}G_2$	Corr-$S_1{\leftrightarrow}G_2$	Id-IO (voi)
a.☞ $ag_{1,\alpha}is_{2,\beta}a$						*	*
b. $ag_{1,\alpha}iz_{2,\alpha}a$	*!IO $z_2 R z_2$ CC $g_\alpha R z_\alpha$						
c. $ag_{1,\alpha}iz_{2,\beta}a$					*!	*	

Candidate (20b) establishes correspondence between [g] and [z], but it loses on Bijectivity. (20a) and (20c) both obey Bijectivity by failing to set up a relation between the output Cs. As a consequence, they violate Corr-C↔C constraints. The voicing dissimilation candidate in (a) is more harmonic, because the output Cs are less similar; hence the constraint requiring they correspond is lower ranked than one violated by (c). In this way Bijectivity together with the Corr-C↔C hierarchy can bring about dissimilation.

6. Conclusion and further research

I have argued here that long-distance voicing agreement is the product of correspondence between Cs in the output. This approach brings explanation to two key properties: action-at-a-distance and the similarity effect. In languages displaying [voice] agreement, correspondence between output Cs comes at the price of Bijectivity, i.e. one-to-one correspondence. I have suggested that when avoidance of multiple correspondence is prioritized instead, voicing dissimilation effects can be obtained.

The findings of the present work invite re-examination of other long-distance interactions. Research under way by Rose & Walker (in prep.) is directed towards exploring a fuller typology of agreement-at-a-distance, and thus far the findings of this work are consistent with intersegmental correspondence. There are several connected issues that still require further study. One area concerns which properties can agree (or dissimilate) at a distance. Rose & Walker observe that while many features display long-distance agreement, the traditional root features, [son] and [cons], seem to be exceptions. A possible explanation is that these properties should not be characterized by features, but rather are emergent from other aspects of segment structure. More perplexing is the absence of long-distance major C-place agreement. Understanding why C-to-C correspondence does not induce C-place agreement is an area that demands further research. It is conceivable that this distinction is connected to asymmetries for C-place vs. certain other features that have been identified elsewhere (e.g. Lombardi 1995). A connected area of inquiry has to do with the extent to which dissimilation and agreement phenomena are alike. Both share the potential for long-distance interaction and they display similarity effects. However, it is not clear that they regularly involve the same groups of segments or types of properties. For instance, C-place dissimilation is attested, but not C-place

agreement. Continued investigation into the psycholinguistic factors involved may shed light on these matters. A final question concerns limits on the distance at which corresponding Cs may occur. For example, some cases of agreement require that the Cs occur in adjacent syllables (Lamba [nasal] agreement; Odden 1994) or that they be tautomorphemic (Ngbaka). Incorporating a hierarchy of phonological and morphological proximity into the Corr-C↔C constraints could prove fruitful in this direction.

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