Super additive similarity in Dioula tone harmony

This paper presents a case of parasitic tone harmony from Dioula d'Odienné in which super additivity of local and long-distance segmental feature similarities increases the likelihood of tone harmony. The analysis is based on an agreement by surface correspondence framework (e.g., ABC: Hansson 2001; Rose & Walker 2004), which formalizes the widespread observation that more similar objects are more likely to interact (e.g., Kaun 1995; Burzio 2002; Zuraw 2002; Frisch et al. 2004). Dioula exhibits super additivity in that the more similar two segments are—along independent but related planes of similarity (e.g., sonority, vowel quality, nasality), the more likely tone is to spread. Super additivity in the Dioula data is formally captured in the present analysis by integrating weighted constraint conjunction into probabilistic Harmonic Grammar (HG: Legendre et al. 1990; Smolensky & Legendre 2006). Such a novel approach combining ABC, probabilistic HG, and conjunction offers insights into the constraint conjunctions that may occur in natural language data, based along dimensions of similarity attraction.

Dioula d'Odienné (Mande, Côte d’Ivoire; Braconnier 1982; a.o.) exhibits a variable tone pattern that is conditioned by consonants and vowels. In Type 1 lexical items, morphological H(igh) tone denoting definiteness appears on the final vowel of the root, as shown in (1a). In Type 2 stems, the definite H tone triggers regressive H tone harmony on the final and penultimate syllables (1b):

(1) a. Type 1 L.L → L.H  
   fôdâ  fôdá  ‘season’
   brisâ  brisâ  ‘bush’

   b. Type 2 L.L → H.H  
   kûnâ  kûnâ  ‘leprosy’
   tûrû  tûrû  ‘oil’

The current work shows that whether nouns exhibit disharmonic Type 1 or harmonic Type 2 behavior is probabilistically dependent on several factors, some of which have been previously identified (e.g., Braconnier 1982). For analysis, all multisyllabic nouns (n = 1173) were collected from the Dioula lexicon (Braconnier & Diaby 1982). The data demonstrate that, most notably, the sonority of the final intervocalic consonant influences tone harmony: nouns with less sonorous final intervocalic consonants (e.g., voiced and voiceless obstruents) are nearly categorically Type 1, while Type 2 behavior is significantly more common when the intervocalic consonant is a sonorant. Amongst the sonorants, liquids are more likely to facilitate tone harmony, as compared to nasal sonorants. This pattern suggests that segments that are more similar in sonority—e.g., liquids and surrounding vowels—are more likely to interact than segments that are less similar in their degree of sonority—e.g., obstruents and surrounding vowels.

In addition to sonority, similarity in nasality and vowel quality in the VCV# sequence also leads to a greater likelihood to exhibit harmonic Type 2 behavior. Words in which the final vowel is nasalized and the intervocalic final consonant is also nasal are more likely to be Type 2 items: nasality similarity facilitates the regressive propagation of H tone harmony through the consonant to the penultimate vowel (e.g., /sânâ/ → [sânä], ‘tree’). Nasalized vowels without adjacent nasal consonants or nasal consonants without adjacent nasalized vowels do not as readily propagate tone harmony. Additionally, long distance similarity between the two vowels also plays a role in predicting tone harmony. Featural identity between the two vowels facilitates tonal agreement (e.g., /tûrû/ → [tûrû], ‘oil’), whereas featural nonidentity inhibits tonal agreement (e.g., /brisâ/ → [brisâ], ‘bush’).

A multivariate analysis of the data reveals that the sonority of the final intervocalic consonant is the strongest single predictor of Type 1 versus Type 2 behavior, followed second by nasality and then by vowel identity. Moreover, these independent effects of similarity are additive: the more similarity that is exhibited between members of the VCV# sequence, the more likely it is that the penultimate vowel will assimilate the H tone of the final vowel in the definite form (i.e., Type 2 behavior). For example, 71% (202/284) of nouns with liquid sonorants, nasality agreement, and vowel quality agreement (e.g., /tûrû/ → [tûrû], ‘oil’) are Type 2 items, with tone harmony; in contrast, only 38% (37/97) of nouns with liquid sonorants but no nasality nor vowel quality agreement (e.g., /tûlça/ → [tûlça], ‘raven’) are Type 2.
The basic system of tone harmony in Dioula can be modeled in ABC as the propensity for similar segments to correspond and become more similar via tonal harmony. Local and long-distance correspondences between featurally similar segments are mandated by the CORR constraints in (2):

(2)  
\[
\begin{align*}
\text{CORR-X::X [sonority]} & \quad \text{Adjacent [sonorant] segments correspond.} \\
\text{CORR-X::X [±nasal]} & \quad \text{Adjacent [±nasal] segments correspond.} \\
\text{CORR-VV} & \quad \text{Adjacent identical vowels correspond.}
\end{align*}
\]

The CORR constraints are paired with IDENT-XX [H] (shown below), which requires agreement in H tone over corresponding segments, and input-output faithfulness (e.g., IDENT-IO V [tone]). Segments that do not meet the similarity prerequisites for correspondence will not be units relevant to correspondence-triggered tone harmony, as demonstrated in (4, TYPE 1) versus (5, TYPE 2) with a sonority-prerequisite correspondence:

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</tr>
</thead>
<tbody>
<tr>
<td>/brisà, -H/</td>
<td>brisá ~ bríʃ,ʒ,ʒ</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>/kùnà, -H/</td>
<td>kùná,ː ~ kùná,ː</td>
<td>W</td>
<td>W</td>
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The additive similarity preconditions to tone agreement in Dioula amount to a ganging effect, with more similarity in sonority, nasality, and vowel quality leading to a greater likelihood of tone harmony. Constraint conjunction has been one method proposed in Optimality Theory for managing such additive effects (e.g., Smolensky 2006). With weighted constraints in Harmonic Grammar approaches that can also model variation, however, it has been argued that constraint conjunction is unnecessary and that weighted constraints are by themselves sufficient to capture additive ganging (in harmony systems, see e.g., Potts et al. 2010). Although an additive similarity precondition effect for Dioula can be obtained via the additive calculation of Harmony scores, the quantitative data from Dioula shows that the simple addition of constraint weights in HG is insufficient to adequately model the probabilistic super-stacking effects of similarity. Two analyses of the lexical data were fit and compared using a logistic regression implementation to simulate Maximum Entropy OT (a log-linear form of probabilistic HG; e.g., Goldwater & Johnson 2003): one without constraint conjunction and one with an array of binarily-conjoined CORR constraints. The conjoined CORR constraints (i.e., interaction terms in the regression implementation) provide an independent weighting for the conjunction of two constraints: for example, when an item occurs with both a sonorant consonant and identical vowels, the cost of tone disharmony is a super-additive penalization above and beyond the additive Harmony score of the individual, non-conjoined CORR-X::X [son] and CORR-VV constraints. Information-theoretic model comparison (based on Burnham & Anderson 2002; a.o.) demonstrates that the analysis with conjoined constraints significantly better captures the lexical patterns in Dioula than an analysis with no constraint conjunction, without overfitting (ΔAIC = 18). These results indicate the data-driven validity of the super-additive effects.

The variable lexical tone pattern in Dioula d’Odienné offers evidence that, to capture observed phonological patterns, super additivity using both constraint conjunction and constraint weights is necessary. Although the tone phenomenon of Dioula is unusual in comparison to more familiar consonant-tone depressor/elevator phenomena, a probabilistic ABC treatment of tone harmony predicts the existence of such a system, in which increasing similarity along multiple dimensions results in the increasing likelihood of harmony. Couching the analysis in ABC furthermore provides a potential explanation for which constraints are most likely to be conjoined, based on principles of similarity attraction rooted in phonetics and feature theory (e.g., Wayment 2009).