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## Abstract

This paper addresses the on-going debate over the distinction between Agreement by Correspondence (Hansson 2001; Rose and Walker 2004; a.o.) and the previously dominant theory of autosegmental feature spreading, focusing on a key conceptual difference between the two theories: the role of similarity as the basis of harmony patterns. It is argued that Agreement by Correspondence’s unique ability to make direct reference to similarity in determining segmental agreement makes it better suited for handling consonant-tone interaction, a phenomenon that has heretofore remained a challenge for autosegmental feature spreading accounts. This paper proposes that a single dimension—sonority, a common trigger of consonant harmony—underlies the relationship between segments and tone. Evidence for this view comes from a pattern of consonant-tone interaction in Dioula d’Odienné nouns, in which less sonorous onset consonants prevent leftwards tone spread (i.e., tone agreement) while more sonorous onsets facilitate the process. Agreement by Correspondence easily captures this similarity basis for tone: segments that are similar in sonority strive to become more similar by agreeing in tone specification. It is also shown that an Agreement by Correspondence system can capture more familiar depressor and elevator consonant-tone effects from high-ranking markedness and segmental opacity. While phenomena like Dioula d’Odienné’s differ from these typical depressor and elevator effects, they are necessary to consider in the development of a framework for consonant-tone interaction, as they provide potential motivation for shifting from autosegmental feature spreading to similarity-based approaches for harmony systems and for tone.

## Keywords

tone, sonority, phonological similarity, consonant-tone interaction, Agreement by Correspondence, Dioula d’Odienné

## 1 Introduction

Since the advent of Agreement by Correspondence (henceforth ABC; Walker 2000a, 2000b; Hansson 2001; Rose and Walker 2004), a debate has continued over the distinction between ABC and the previously predominant theory of autosegmental feature spreading (Rose and Walker 2004; Gallagher 2008; Gallagher and Coon 2009; a.o.). Some claimed differences between ABC and autosegmental approaches limit the use of ABC to the consonant agreement phenomena that were the original motivation behind the development of the theory, stipulating that ABC must only apply to long distance consonant interactions involving transparent intervening segments that typically exhibit preferential directionality from left to right. On such accounts, feature spreading is otherwise reserved for all other cases, including local assimilation, phenom-

ena with blocking effects by opaque intervening segments or no preferential directionality, and vowel harmony (Rose and Walker 2004; Gallagher 2008).

The ABC framework, however, is inherently capable of capturing many of the differences that are claimed for the feature spreading domain, as shown by recent literature and as further argued for in this paper. Nothing in the framework of ABC itself restricts the theory's extension beyond long distance consonant agreement. Subsequent work, for instance, has shown that ABC can apply to vowel harmony (Sasa 2009; Walker 2009; Rhodes 2010) and that it can handle blocking and segmental opacity (Hansson 2007; Rhodes 2010). Nor does anything within the theory itself prevent ABC from enforcing local assimilation; any previous requirements that correspondence be long-distance have been externally-imposed stipulations. In fact, McCarthy (2010) demonstrates that ABC can work without certain specifications on non-locality in the correspondence constraints used in the system.

This paper focuses on the key conceptual and architectural difference that remains between ABC and autosegmental feature spreading approaches: the role of similarity as the basis of harmony patterns and correspondence. In ABC, similarity drives agreement between segments, derived from the observation that segments that are already similar strive to become more so (Padgett 1991, 1994; Hansson 2001; Zuraw 2002; Rose and Walker 2004; a.o.). In Kikongo (Bantu), for example, nasal agreement targets amongst voiced stops within the root and suffix complex (example from Rose and Walker 2004: 503): /tu-kin-idi/ → [tukinini] 'we planted.' Voiceless stops do not undergo nasal agreement because they are insufficiently similar in voicing to the triggering nasal segments: /tu-nik-idi/ → [tunikini], \*[tuniɲini] 'we ground.' Feature spreading, on the other hand, has no such preconditioning requirement for harmony. This difference between the foundational architectures of the two theories is crucial in addressing the question of whether ABC supplements or supplants autosegmental representation in our theoretic arsenal. This paper argues that ABC's unique ability to make direct reference to a similarity basis in determining segmental agreement offers important insight and a distinct advantage over autosegmental theory when dealing with consonant-tone interaction, a phenomenon that has been persistently difficult for feature spreading accounts, despite being a local effect.

In traditional autosegmental treatments, vowels are usually at the forefront in discussions of lexical tone while consonants remain largely ignored, under the widespread assumption that these two classes of sounds operate independently in their tonal behaviors. When tone is present, vowels are almost always tone-bearing while the status of consonants as tone-bearers varies from language to language. Furthermore, consonants that bear tone are typically coda consonants, sonorants, or syllabic sonorants, leading to the view that it is not the segments themselves but the moras which they head that are the tone-bearing units (henceforth TBU; Yip 2002 and references therein). Onset consonants that interact with tone, on the other hand, are not moraic and are usually treated as existing outside the TBU of the mora or syllable rhyme. Forcing the interaction of these consonants with tone typically requires supplemental mechanisms that refer to segmental features beyond the TBUs that normally carry tone, such as [stiff], [slack], [laryngeal], or [voice] (Halle and Stevens 1971; Bradshaw 1999; Downing 2001; Lee 2008; a.o.)

In this paper, I propose that whether a consonant affects tone is an emergent effect of a single dimension—sonority—that underlies the relationship between segments and tone. Sonority facilitates the transmission of pitch information, and because vowels and sonorant consonants are more similar in sonority, they are cross-linguistically more likely to agree in tone and remain transparent to tone spread. In contrast, obstruents interfere with tonal agreement between more sonorous segments, either by disrupting the transmission of pitch or by the articulatory incompat-

ibility of specific tone values and segmental features. The sonority basis for tone is naturally captured through similarity in an ABC framework, in which segments that are similar in sonority strive to become more similar by also agreeing in tone specification. I present evidence from Dioula d’Odienné<sup>1</sup> (henceforth Dioula; also known as Jula, Dyula, and Odyene Dyula; Braconnier 1982, 1983; Braconnier and Diaby 1982; Hyman 1985, 2011b), a Mande language spoken in Côte d’Ivoire, that suggests a direct relationship between sonority and tone, and demonstrates scalar effects of the sonority hierarchy in the tone behavior of onset segments. The relationship between sonority and tone is formalized in Optimality Theory (OT; Prince and Smolensky 1993; et seq.) through the combination and interaction of the sonority hierarchy and ABC constraints.

The paper is organized as follows. Section 2 provides an overview of the relationship between sonority and tone. Section 3 presents data from Dioula d’Odienné that demonstrates a direct sonority-tone interaction. The ABC analysis of the Dioula pattern follows in §4. Section 5 considers the typological implications of the ABC analysis for consonant and tone interactions, and some further issues of an ABC approach and a sonority basis for tone are discussed in §6. Section 7 concludes.

## 2 The sonority-tone relationship

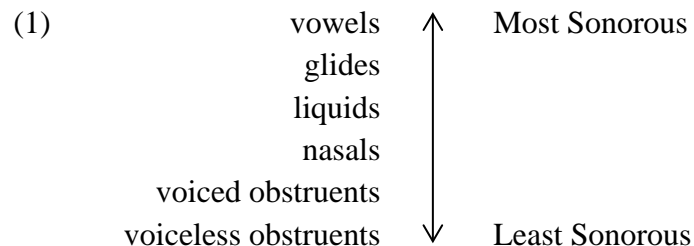
In this paper, I will show that reference to sonority is essential in defining the class of segments that can interact for the purposes of tone. While it is generally acknowledged that sonority has a central role in interactions with syllables, weight, and stress, the nature of the relationship between sonority and tone is more readily contested (e.g., de Lacy 2007: 299). The predominant view is that sonority and tone only share an indirect relationship, which is mediated by prosodic structure: moras are the customary TBUs, and more sonorous segments are more likely to be moraic. Under this view, no evidence presented where the sonorant resides in a syllable rhyme and interacts with tone will be sufficient for demonstrating a direct sonority and tone relationship because segments in the syllable rhyme are coextensive with moras. Therefore, the critical data that bears on this debate is the behavior of segments—obstruents and sonorants alike—in syllable *onset* position with respect to tone. Because onsets are external to syllable rhymes or moras, examining the interaction between onset segments and tone detangles the issue of sonority from intermediary prosodic structure. This section outlines the interactions of sonority with other suprasegmental features and provides background on the debate surrounding the relationship between sonority and tone. I will argue that the case of Dioula (§3) is particularly important to consider in light of this issue because it offers crucial evidence of sonority and tone interaction in syllable onset position.

The idea of sonority has been useful for many aspects of suprasegmental phonology: for instance, in sequencing constraints, in the determination of syllable nuclei and margins, and as measures of syllable weight (Jespersen 1904; Selkirk 1982; Clements 1990; Zec 1995; Gouskova 2004; a.o.). While the exact phonetic correlates of sonority are still debated (e.g., Parker 2002; Miller 2012; Sylak-Glassman 2012), sonority is generally agreed to be an abstract conceptualization of the degree of inherent perceptibility, inherent voicing, and acoustic intensity of a given segment. An example sonority hierarchy is given in (1), ranging from the most sonorous seg-

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<sup>1</sup> Unless otherwise specified, all data from Dioula used herein comes from Braconnier and Diaby’s (1983) Dioula dictionary.

ments—vowels—to the least sonorous—voiceless obstruents. Glides, liquids, nasals, and voiced obstruents fall along the spectrum between vowels and voiceless obstruents.



How fine-grained, variable, and linear or nonlinear the sonority hierarchy must be remains a contentious issue (e.g., Clements 1990; Cho 1991; Parker 2002; Jany et al. 2002; Parker 2012 and references therein); however, for the purposes of this paper, the scale and granularity presented in (1) will suffice.

Evidence for the scalar nature of sonority is found in principles of syllabification and the interaction of sonority with stress, as well as elsewhere. Dips in sonority denote syllable boundaries, and peaks in sonority indicate syllable nuclei, even if the actual threshold of sonority for syllable nuclei varies from language to language (Blevins 1995; Zec 2007; and references therein). Gradient sonority is active even amongst vowels. In Nanti (Kampa, Peru), for example, Crowhurst and Michael (2005: 50) note that syllables with lower vowels “are more stressable” than those containing higher vowels:  $a > e \bullet o > i$ . Similarly, Nganasan (Uralic, Siberia) stress is attracted to more sonorous vowels, following a general low-to-high correlation between height and sonority (de Lacy 2004: 146). Finnish secondary stress assignment also demonstrates such sensitivity to sonority (Anttila 2010). As evidenced by these examples from a wide spread of unrelated languages, the relationship between sonority and suprasegmental processes such as stress and syllable weight is robust and well-recognized.

In contrast, a connection between sonority and tone is not as widely acknowledged. The received view is that sonority does not directly influence tone, and that the relationship between sonority and tone is an indirect one, mediated by prosodic structure (Zec 1995; Yip 2002; de Lacy 2007: 299; a.o.). One arena of evidence for this view is the behavior of coda segments and tone. In contour tone licensing, for example, syllables closed by sonorant codas more commonly allow contour tones than obstruent-final syllables, following the implicational hierarchy:  $CVV > CVR > CVK > CV^2$  (Gordon 2001; Zhang 2001; a.o.). In Chinese languages like Cantonese, for example, obstruent-final syllables only carry level tones whereas sonorant-final syllables allow both level and contour tones (Yip 1995: 488). Less frequent are languages like Hausa (Chadic), in which all closed syllables can license contour tones, regardless of the sonority of the coda consonant (Yip 2002: 27): in Gordon’s (2001) survey of contour tone distributions across 105 languages, only three demonstrated this pattern. While contour tone licensing may appear to be conditioned by sonority, the ability of a consonant to license contour tone parallels the ability of the consonant to head a mora. Thus, contour tone licensing has been traditionally attributed to moraic structure: consonants contribute moras in the coda position of a closed syllable, and the moras—and not the consonants themselves—license the ability to carry contour tones.

Alternatively, Gordon (2001) and Zhang (2001, 2004) argue for a phonetic view of contour tone licensing based on sonority, showing that the amount of sonorous energy or the dura-

<sup>2</sup> R = sonorant consonant; K = obstruent consonant.

tion of the sonorous segments in syllables facilitates the presence of contour tones. This phonetically-based approach predicts that there should be more subtle effects of sonority at work in contour tone licensing beyond what is predicted by a mora-based analysis. Gordon (2001: 442; following Tucker 1967) points to Luganda (Bantu, Uganda) as an example of such: in Luganda, CVC syllables ending with voiced obstruents will pattern like CVR syllables and regularly allow contour tones, whereas CVC syllables closed with voiceless obstruents will not. Because voicing provides more sonorous energy to the syllable, this divide between voiced and voiceless obstruents in permitting contour tones is expected under a phonetic view of contour tone licensing (though cf. Dutcher and Paster 2008 for a dissenting view on the phonetics of Luganda contour tones).

For onset segments, sonority does not usually register in discussions of consonant-tone interaction. Obstruent voicing, along with certain other laryngeal features, is known to be a relevant feature in typical depressor and elevator phenomena (Bradshaw 1999; Lee 2008; Tang 2008; a.o.). Sonorants, though they are often overlooked due to the focus on voice-tone interaction, are typically treated as neutral to tone processes, especially when they occur in onset position (Peng 1992; Tang 2008)—although, there are exceptions in which sonorant consonants have been known to interfere with tone (e.g., in Zina Kotoko (Chadic, Cameroon), sonorants behave like depressors in lowering high tones in certain morphological environments; Odden 2007; a.o.). When sonorants pattern with the transparency of voiced or voiceless obstruents alternately, the underspecification or redundant specification of [voice] is invoked (e.g., Peng 1992). Vowels, the usual tone-bearing segments, are treated separately from consonants in discussions of tone. The resulting picture of consonant-tone interaction from the existing literature is at best a fragmented view, dependent on prosodic structure and the ability to be a legitimate TBU, voicing or the specification of [voice] features, and distinctions between the relevance of consonants and vowels and of codas and onsets for tone processes.

As an alternative, I advocate here for a view that reconciles the behavior of obstruent, sonorant, and vowel-tone interactions under the umbrella of a sonority and tone relationship: more sonorous segments will be more likely to facilitate tone processes like tone spread (i.e., tone agreement or copying), especially when in the environment of equally sonorous segments, whereas less sonorous segments will be more likely to interfere with tone. From a phonetic point of view, sonority and tone have the potential to interact: sonorants, including both sonorant consonants and vowels, are inherently voiced and continuant and thus should transmit pitch more readily than obstruent consonants. Tang (2008: 34) offers an articulatory perspective on this idea, citing “articulatory continuity” in laryngeal gestures as a reason that obstruents and less sonorous segments are more likely to perturb the F0 signal. Whatever the details of the phonetic basis, we know that phonologically, vowels do not usually block tonal effects and obstruents are the segments that most commonly interfere with tone spread or docking, either by their non-participation in transmitting tone or by raising and lowering pitch in local contexts. Given the sonority scale, vowels and obstruents behave as expected in a sonority-tone relationship, with vowels transmitting pitch easily and obstruents disrupting the F0 signal.

Though a large portion of the existing consonant-tone literature focuses on obstruents, the interaction of sonorant consonants with tone is of particular interest to the issue of a sonority-tone relationship because sonorant consonants fall between vowels and obstruents—the typical tone-bearers and disruptors, respectively—along the sonority hierarchy. A similarity-based account built around sonority predicts that sonorants should behave variably in segment-tone interactions, either like vowels or like obstruents. This expectation is borne out in the typological

patterns of contour tone licensing, for instance, where CVV syllables more often allow contour tones than those closed by consonants, and where sonorant consonant-final heavy syllables license contour tones more often than obstruent-final syllables (Gordon 2001).

For onset segments, previous research on sonorant-tone interaction also demonstrates that sonorants can affect tone in the same way that obstruents do. Hyslop (2009) reports that Kurtöp (Tibeto-Burman, Bhutan) has only recently developed tone and that tonogenesis, which is usually triggered by a contrast in voiced and voiceless obstruents, was in this case first triggered following sonorants. Based on comparisons with Written Tibetan, Hyslop posits that /s/-initial sonorant onset clusters developed into voiceless sonorants with the loss of the /s/ over time. The distinction between voiced and voiceless sonorants then led to tone's development, with high tone following voiceless sonorants and low tone following voiced sonorants, much like elevator and depressor consonant phenomena. Once the tonal differences were phonologized, Kurtöp lost the voicing distinction amongst sonorants, which merged back into a single voiced sonorant series (Hyslop 2009: 830–831). Initial tonogenesis in Kurtöp following sonorants offers evidence that sonorant consonants can act like obstruents in their interactions with tone. In fact, it is even more telling that voiced and voiceless sonorants—as opposed to voiced and voiceless obstruents in the same language—first gave rise to a tone distinction. Following the sonority scale, we expect sonorant consonants to be able to transmit pitch better than obstruents; consequently, it is likely that tone effects involving sonorants were more salient to Kurtöp speakers than tonal effects involving obstruent and, as such, sonorants were the first to generate phonological differences in tone. Similar diachronic explanations of tonogenesis following sonorants have been suggested in other Tibeto-Burman languages as well (Hyslop 2009: 843, and references therein).

In the following section, I present a case from Dioula where sonorants in syllable onset position interact with tone. Like Kurtöp, the Dioula case offers critical data that is external to the syllable rhyme and thus cannot be analyzed as mora-based, unless onsets are allowed to be moraic. Dioula exhibits differences in tonal behavior between sounds along the sonority hierarchy, including, crucially, gradient effects within the sonorant consonant series. Vowels in Dioula obligatorily transmit tone, and obstruents almost always block tone. Sonorants show variability for the blocking or transmission of tone depending on their sonority level: liquids are more likely to allow tone spread than nasals. The evidence from Dioula suggests that, counter to standard conceptions of sonority-tone interaction, a direct relationship between sonority and tone in fact exists and is active in language.

### 3 Consonant-tone interaction in Dioula d'Odienné

The phenomenon of primary interest in Dioula is the effect that intervocalic consonants can have on tone patterns in nouns. To understand this pattern, some background information about Dioula nouns is necessary. Noun roots in Dioula fall into two lexical classes, which I call “high-toned” and “low-toned.” High-toned roots must have at least a lexically-specified high tone on the penultimate syllable and may also have a high tone on the final syllable: /fólón/ → [fólón]<sup>3</sup> ‘sheath, indef.’ Low-toned roots do not have a lexically-specified high tone on the penultimate syllable and surface as low in isolation: /folon/ → [fòlòn] ‘ditch, indef.’

<sup>3</sup> Following Braconnier and Diaby's (1982: 5) Dioula dictionary convention, word-final orthographic *n* indicates a nasalized vowel: for example, orthographic *folon* is phonetically [fólõ]. Word-internal orthographic *n*'s are regular nasals: for example, orthographic *sene* is [sene].

An independent difference in tone pattern, which is of primary interest here, cross-cuts the high/low root classification. Within each of the high- and low-toned classes of roots, there is a binary distinction in the type of tonal behavior preceding high tone: these behaviors are referred to here as Type 1 versus Type 2<sup>4</sup>. Type 1 nouns exhibit tonal changes only on the final syllable when preceding a high tone while in Type 2 nouns, tones on two syllables—both the penultimate and final—change. The high tone environment may be either the high tone of an immediately following word or the high tone that marks definiteness. All available examples from Braconnier (1982), Braconnier and Diaby (1982), and cited herein are definiteness markers.

Type 1 nouns that are low-toned roots are shown in (2a). In definite Type 1 nouns, high tones occur on the final syllables. In Type 2 nouns (2b), high tone occurs on two syllables rather than one. (L = low tone; H = high tone)

(2) Low-toned roots

		indef.	before H (def.)	
a. TYPE 1		sèbè	sèbé	‘paper’
		fòdà	fòdá	‘season’
		brìsà	brìsá	‘bush’
		hàmì	hámí	‘concern’
		tùrù	túró	‘oil’
b. TYPE 2		bègì	bégí	‘white cotton cloth’
		kùnà	kúná	‘leprosy’
		kùmàn	kúmán	‘bird’

High-toned roots surface with different tonal patterns in the relevant following high tone environment. The distinction between the boundedness of tone change remains the same: only the tone of the final syllable changes in Type 1 nouns whereas a change in tone appears on the penultimate syllable in Type 2 nouns. In Type 1 nouns with an underlying penultimate high, the tone on the final syllable becomes a low-high contour tone (3a). For disyllabic Type 2 high-toned roots, the entire tonal melody of the word changes to low-high (3b).

(3) High-toned roots

		indef.	before H (def.)	
a. TYPE 1		bésé	bésě	‘machete’
		dáfé	dáfě	‘horse’
		jámú	jámǔ	‘clan name’
		bákàn	bákǎn	‘belt/wrist protector’
b. TYPE 2		múró	mùró	‘knife’
		jégí	jègí	‘hope’
		télú	tèlú	‘tree’ <sup>5</sup>
		nyúmán	nyùmán	‘bond’

In nouns longer than two syllables, the tone behavior pattern is the same: high-toned, Type 1 nouns trigger tone contouring on the final syllable (4a), while low-toned roots trigger ei-

<sup>4</sup> Type 1 and Type 2 correspond to Braconnier’s (1982) Type SEBE/BESE and Type TURU/MURU classes, respectively.

<sup>5</sup> Braconnier and Diaby (1982: 114) list the definite of this word as variable, either *télú* or *tělǔ*.

ther a single word-final high tone (4b)—Type 1 behavior—or two word-final high tones (4c)—Type 2 behavior.

- (4)
- |    |          |                 |                         |                     |
|----|----------|-----------------|-------------------------|---------------------|
|    | indef.   | before H (def.) |                         |                     |
| a. | káráfè   | káráfě          | ‘bride’                 | TYPE 1 (high-toned) |
| b. | ɲàmàkù   | ɲàmàkú          | ‘ginger’                | TYPE 1 (low-toned)  |
| c. | dàràminà | dàràminá        | ‘interpreter/spokesman’ | TYPE 2 (low-toned)  |

There are no nouns in the Dioula dictionary (Braconnier and Diaby 1982) that are high-toned, longer than two syllables, and belong to Type 2.

Whether a Dioula noun exhibits Type 1 or Type 2 tone behavior is not random and is of particular interest to this paper. As first observed by Braconnier (1982), the distinction between Type 1 and Type 2 nouns is in large part highly correlated with the final intervocalic consonant (henceforth  $C_f$ , as in (5)).

- (5)
- |                      |
|----------------------|
| CVC <sub>f</sub> V # |
| t u r u              |

Dioula’s consonant inventory is provided in (6).

- (6) Dioula consonant inventory (Braconnier and Diaby 1982: 5)

		labial	alveolar	palatal	velar
obstruents	voiceless stops	p	t	c	k
	voiced stops	b	d	j	g
	voiceless fricatives	f	s	ʃ	
	voiced fricatives	v	z		
sonorants	nasals	m	n	ɲ	ŋ
	liquids		l r		
	glides	w	y		(w)

Braconnier originally observed that when fricatives and stops occupy  $C_f$  position, as in *sèbè* ‘paper, indef.’ (2a), the given noun is Type 1, with high tone realized on only the final syllable in the definite form, *sèbé* ‘paper, def.’ (1982: 27). Nouns with nasals and liquids in  $C_f$  position can be either Type 1 (7a) or Type 2 (7b).

- (7)
- |    |          |                 |                    |        |
|----|----------|-----------------|--------------------|--------|
|    | indef.   | before H (def.) |                    |        |
| a. | mòrà     | mòrá            | ‘cold’             | TYPE 1 |
|    | dágbànàn | dágbànán        | ‘stuttering’       |        |
| b. | hèrà     | hérá            | ‘peace, happiness’ | TYPE 2 |
|    | lànkanà  | lànkaná         | ‘scarf, shawl’     |        |

According to Braconnier’s (1982: 32) description, CVV nouns, with no intervening  $C_f$  position, are always Type 2 (8), though some exceptions do occur in the dictionary (see §3.1, (11)):



- (8)
- |                 |        |                 |                                  |
|-----------------|--------|-----------------|----------------------------------|
|                 | indef. | before H (def.) |                                  |
| low-toned root  | fùà    | fúá             | ‘land naturally devoid of trees’ |
| high-toned root | sáo    | sàó             | ‘willingness’                    |

While Braconnier identifies the quality of the final intervocalic consonant as the most robust predictor of Type 1 versus Type 2 tone behavior, he also suggests other possible conditioning environments for the tone type distinction, including nasalized final vowels and the vocalic environment surrounding the  $C_f$  (1982: 29, 38). These additional factors are discussed at greater length in §6.1.

### 3.1 Sonority and the Type 1/Type 2 distinction

To examine the distribution of nouns in the Type 1 versus Type 2 groups based on the final intervocalic consonant, a corpus was constructed for this study using the Dioula dictionary (Braconnier and Diaby 1982) that includes all listed nouns and their definite forms, with 1027 tokens total. The distribution of nouns in Type 1 and Type 2 groups is given in (9) below.

- (9) Distribution of  $C_f$  sonorants and obstruents by tone class

$C_f =$	Type 1	Type 2
obstruent	290	4
sonorant	381	352

Only four nouns with obstruents /b/ or /ʃ/ in  $C_f$  position pattern exceptionally with Type 2 behavior. These are listed in (10).

- (10)
- |    |       |         |                 |                |
|----|-------|---------|-----------------|----------------|
|    | $C_f$ | indef.  | before H (def.) |                |
| a. | /b/   | sànkàbà | sànkábá         | ‘cloudy’       |
|    |       | tèbèn   | tébén           | ‘fish’         |
|    |       | wààjìbì | wààjíbí         | ‘obligation’   |
| b. | /ʃ/   | sìfàn   | sífán           | ‘lung disease’ |

Despite the anomalous behavior of the nouns in (10), which appear to be lexical exceptions, nouns with obstruent  $C_f$ s are significantly more constrained to Type 1 than nouns with sonorants in the same final intervocalic position ( $\chi^2 = 1220.27$ ,  $df = 1$ ,  $p < 0.0001$ ), as Braconnier observed.

Another notable exception is the phoneme /g/: nouns with /g/ in  $C_f$  position pattern like nouns with  $C_f$  nasals and liquids rather than nouns with  $C_f$  stops and fricatives. Braconnier notes that in general, /g/ holds a special status and limited distribution in Dioula (1983). According to Braconnier, the phoneme /g/ behaves phonotactically like a sonorant: it occurs rarely word-initially and more frequently intervocalically (Braconnier 1983: 36–38). Word-initially, /g/ is realized on the surface as [g]. Between vowels, as in the  $C_f$  position, /g/ may surface as [g] but is more commonly realized instead as [w], [j]<sup>6</sup>, [ŋ], or [ɣ] depending on surrounding vowel quality

<sup>6</sup> Braconnier (1983: 99) describes the [j] realization of /g/ as a more relaxed version of the actual palatal glide phoneme /y/, following his transcription orthography.

(Braconnier 1983: 97–105)<sup>7</sup>. For the purposes of this paper, I treat the phoneme /g/ as a sonorant in Dioula (e.g., /g/ is counted as a sonorant  $C_f$  segment in the table in (9)) and leave further investigation of the phoneme’s specific behavior and phonetic realization to future study.

There are also a few exceptions to Braconnier’s description that CVV nouns are always Type 2. These nouns, which are Type 1 but have no  $C_f$ , are given in (11).

(11)	$C_f$	indef.	before H (def.)	
	low-toned	∅	hátèi	‘desire, greed’
		kábìà	kábìá	‘people of the same clan’
		líánsèi	líánsèí	‘Tabaski’
		wáfìà	wáfìá	‘tree, a specific one’
	high-toned	dúáù	dúáũ	‘benediction’ <sup>8</sup>
		lían	liǎn	‘sacrificial animal on the day of Tabaski’
		múán	múǎn	‘twenty’
		wòróntiá	wóróntiá	‘seven’

Like the exceptions in (10), these nouns in (11) that do not have a  $C_f$  also appear to be lexical exceptions. The large majority of CVV nouns are Type 2 ( $n = 33$ ).

In his original work, Braconnier provides no further breakdown amongst nouns with sonorants in  $C_f$  position, and he concludes that their distribution in tonal behavior classes must be encoded lexically (Braconnier 1982: 39). Corpus and quantitative examination of each sonorant individually, however, uncovers marked differences amongst the sonorant series, which are shown in Figure 1<sup>9</sup>.

<sup>7</sup> The environments for each of the surface realizations of /g/ are as follows (from Braconnier 1983: 97–105). [g] occurs between high front vowels [i\_i]. [w] occurs between high rounded vowels [u\_u]. [j] occurs between vowel sequences [e\_i], [i\_ε], and [ɔ\_i]. [ŋ] occurs following nasalized non-low, front or high, back vowels [ĩ, ĕ, ê, ũ] (orthographically *in, en, un*). The [+continuant] counterpart [ɣ] occurs between non-high vowels [o\_o], [ɔ\_ɔ], and [a\_a]. Given the propensity of /g/ to surface as a sonorant, I speculate as to whether [ɣ], as notated by Braconnier, is actually the velar approximant [ɰ]; further phonetic evidence would help elucidate this matter.

<sup>8</sup> *Dúáù*, ‘benediction,’ has a variant *dùà*, which is homophonous with *dùà*, ‘ink,’ and *dùà*, ‘place.’ The definite form is invariably *dúáũ*.

<sup>9</sup> Graphics and statistics herein were prepared using the R statistical computing platform (R Development Core Team 2010) and the *rms* library (Harrell 2012).

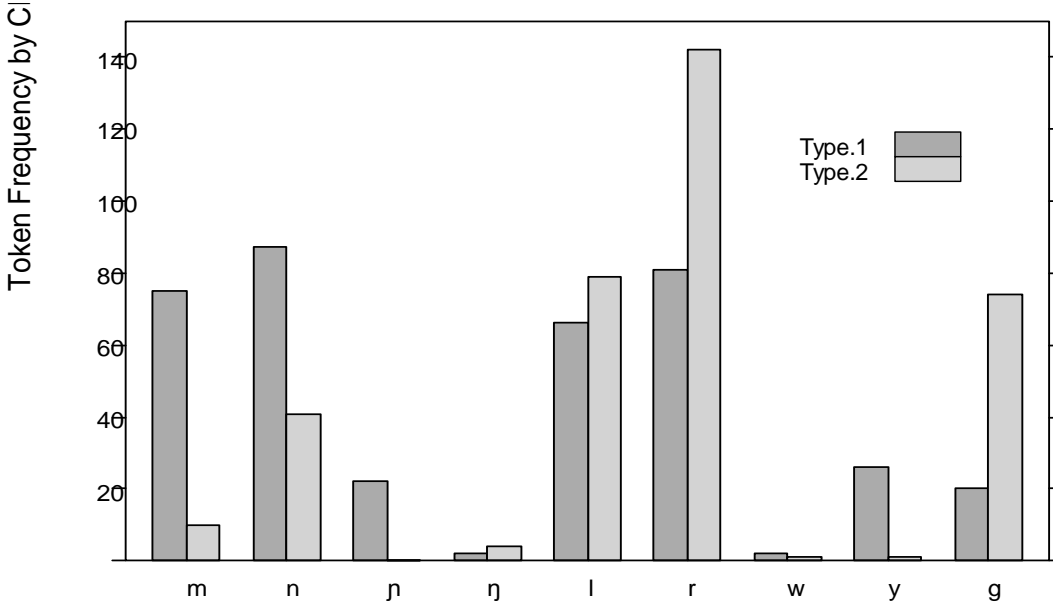
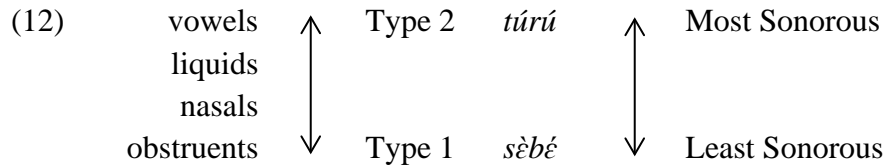


Figure 1. Token frequency of nouns by tone type and  $C_f$  sonorant

The tone type distributions of  $C_f$  nasals /m, n, ɲ, ŋ/ and  $C_f$  liquids /l, r/ exhibit a significant difference ( $\chi^2 = 67.85$ ,  $df = 1$ ,  $p < 0.0001$ ). Nouns with nasals in  $C_f$  position are more likely to behave as Type 1 forms than Type 2 forms. The palatal nasal /ɲ/ has no Type 2 tokens. The velar nasal /ŋ/ appears to have the opposite distribution from the other nasals, but six tokens are an insufficient number by which to distinguish the behavior of /ŋ/.

Conversely, nouns with liquids /l, r/ in  $C_f$  position are more likely to be Type 2 forms than Type 1 forms.  $C_f$  /g/ nouns also pattern with liquids, with more forms occurring as Type 2 than as Type 1. As for glides, the palatal glide /y/ behaves like nasals, with twenty-six Type 1 tokens and only one Type 2 token. While Braconnier (1982: 35) suggests that nouns with /w/ in  $C_f$  position are Type 2, there are too few observations ( $n = 3$ : Type 1 = 2, Type 2 = 1) to make conclusions about their behavior or of the patterning of glides /y/ and /w/ as a natural class.

A clear gradient emerges in the relationship between the Type 1/Type 2 tonal behavior classes and the  $C_f$  segments. Obstruents do not allow tonal changes beyond the final syllable in the following high environment. Vowels almost always do, either with high-high on the penultimate and final syllables in low-toned nouns or with low-high on the final two syllables in high-toned nouns (examples in (8)). Sonorants fall in between, showing variability between liquids and nasals: liquids behave more like vowels while nasals pattern more closely with obstruents. The scale is schematized in (12).



The hierarchy of  $C_f$  segments in (12) mirrors the sonority hierarchy. The distribution of nouns in tone behavior classes in Dioula, then, correlates with sonority. Obstruents—the least sonorous

sounds—prohibit tonal effects from affecting anything but the final syllable: their lack of sonority in essence blocks the transmission of tone from the high tone contributed by the definite marker. Vowels, which are the most sonorous sounds, do not block tonal effects that continue inwards from the right. The most sonorous consonants in the scale in (12)—liquids—are most likely to allow tonal effects on the penultimate syllable, and nasals are more likely to block tone transmission, like obstruents. The scalar variability that Dioula sonorants exhibit provides evidence to unify consonant-tone and vowel-tone interactions as a relationship of sonority and tone. Given the discussion of sonority in §2, the tonal behavior of Dioula  $C_f$  sounds pattern as we would expect: the more sonorous the segment, the more likely it is to transmit tone onto the penultimate syllable, whereas the less sonorous the segment, the more likely it is to prevent the transmission of tone.

## 4 An Agreement by Correspondence approach

The core insight underlying ABC is that segments that are similar are more likely to interact and strive to be maximally similar in harmony and agreement processes. Though the bulk of the previous ABC literature has focused on long distance phenomena, I demonstrate here that the theory can apply to local, similarity-driven agreement as well. For tone and specifically for the analysis of Dioula's tone type behaviors, an ABC approach entails that segments sharing sufficient similarity in sonority interact and become more alike through the sharing of tonal specifications. Autosegmental feature-spreading does not share ABC's basic prerequisite of similarity for harmony (and disharmony), and this similarity basis makes ABC a natural and particularly well-suited framework in which to deal with the type of sonority-based tone processes that are found in Dioula and potentially elsewhere.

A brief introduction to the ABC framework is provided in §4.1. The ABC analysis for the Dioula sonority-tone pattern follows, with some preliminaries in §4.2 and a discussion of low- and high-toned nouns in §§4.3–4, respectively.

### 4.1 Introduction to Agreement by Correspondence

ABC is a framework designed around a well-known empirical generalization that segments that are similar for a given preconditioning feature share a privileged correspondence relationship for interaction (e.g., Frisch et al. 1997; Walker 2000a, 2000b; Hansson 2001; Rose and Walker 2004). For example, in Chaha (Semitic, Ethiopia) consonant harmony (from Rose and Walker 2004; McCarthy 2010; following Leslau 1979; Banksira 2000), coronal and velar segments within a verb root that are [-continuant] must also agree in [ $\pm$ voice] and [constricted glottis] features:

- |      |    |         |         |   |
|------|----|---------|---------|---|
| (13) | a. | k'it'ir | *kit'ir | 'kill, imperative'                        |
|      | b. | digis   | *tigis  | 'give a feast, imperative'                |
|      | c. | kətkit  | *gətkit | 'hit with a stick repeatedly, imperative' |
|      | d. | gərdif  | *kərdif | 'grind coarsely, imperative'              |

Consonants that are not specified for [-continuant] and [-sonorant], as [r] in (13a, d) or [s] in (13b), do not participate in laryngeal feature agreement (e.g., \*[digiz]).

ABC achieves this similarity-driven agreement through the interaction of two types of constraints. One type, MAX-CC (following McCarthy 2010; CORR in Walker 2000a, 2000b; Hansson 2001; Rose and Walker 2004), requires that segments (consonants, as specified by “CC” here) be in a correspondence relationship: [d<sub>i</sub>g<sub>j</sub>] therefore satisfies this requirement, and [d<sub>i</sub>g<sub>j</sub>] does not, given the non-correspondence between the pair [d<sub>i</sub>] and [g<sub>j</sub>]. The other type is a family of identity constraints, IDENT-CC [F] (Walker 2000a, 2000b; Hansson 2001; Rose and Walker 2004), which require that corresponding segments be faithful to one another in a particular output feature. For voicing agreement, IDENT-CC [voice] penalizes corresponding segments that do not have matching [voice] features (e.g., [t<sub>i</sub>g<sub>i</sub>]); [d<sub>i</sub>g<sub>i</sub>] satisfies CC voicing agreement.

In this paper, I follow a revised version of ABC theory introduced by McCarthy (2010), which I call “MAX-ABC.” The original instantiation of ABC (e.g., Rose and Walker 2004) makes reference to specific features in two families of constraints: CORR and IDENT-CC [F]. For Chaha, CORR K ↔ D specifies that plosives ([-sonorant, -continuant]) must be in a corresponding relationship, and IDENT-CC [voice] requires that corresponding segments match in voice. The aim of McCarthy’s revision in MAX-ABC is to remove feature specifications (except [consonantal]) from the set of ABC-specific constraints requiring correspondence (formerly, CORR). MAX-ABC instead places the responsibility of identifying all features that participate in the correspondence and agreement system solely on the IDENT-CC [F] constraints, and replaces the CORR family with a single, general MAX-CC, which requires correspondence over all consonants regardless of feature specifications. In MAX-ABC, harmony is achieved through the ranking of constraints rather than through constraint proliferation in the CORR family. Interacting sets of faithfulness constraints (IDENT-CC [F])—instead of identity-specific correspondence constraints—determine the triggering and targeting features of agreement.

The basic constraint inventory and definitions for MAX-ABC are given in (14) below.

- (14) ABC without CORR constraint inventory
- a. MAX-CC: Consonants must be in a corresponding relationship with other consonants.
  - b. IDENT-CC [F]: If consonants correspond, they must be identical in feature [F].
  - c. FAITH-IO/OI [F]: Output and input forms must correspond and remain faithful in feature [F].

Crucially for MAX-ABC, there are two sets of IDENT-CC and FAITH-IO/OI constraints. One set identifies the triggering features for agreement and correspondence in the output (IDENT-CC [αF] and FAITH-IO/OI [αF]; for Chaha, IDENT-CC [cont] and FAITH-IO/OI [cont]). Another set of IDENT-CC and faithfulness constraints identifies the features that undergo agreement (IDENT-CC [βF] and FAITH-IO/OI [βF]; for Chaha, IDENT-CC [voice] and FAITH-IO/OI [voice]). The FAITH-IO/OI constraints represent bundles of possible faithfulness constraints, including IDENT, MAX, and DEP, which can be ranked separately if needed. One aspect in which I depart from McCarthy’s MAX-ABC is the evaluation and penalization of correspondence constraints (MAX-CC and IDENT-CC): in this respect, I follow Hansson (2007: 402–404) and others (Walker 2009; Rhodes 2010: 27–29) in assessing correspondence on local pairwise segments to prevent the pathological predictions found with global evaluation. Comparative tableaux (Prince 2000) are used.

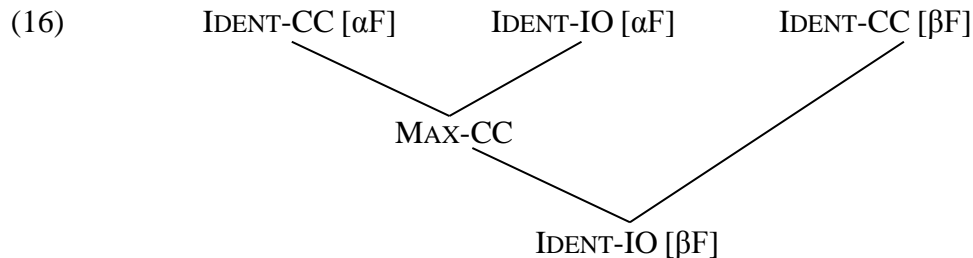
Correspondence and agreement in MAX-ABC are derived from the interaction of sets of IDENT-CC and input-output faithfulness constraints for [αF] and [βF]. To specify the candidates in which only segments with the triggering features for agreement enter corresponding relationships, IDENT-CC [αF], where [αF] is [cont] for Chaha, must outrank MAX-CC. The ranking of

IDENT-CC [cont] » MAX-CC in (15) rules out candidates like (15b), in which non-plosive segments would participate in voicing harmony. Input-output faithfulness to the triggering features (IDENT-IO [cont]) must also outrank MAX-CC, in order to prevent any repairs in consonant continuancy (e.g., candidate (15c)).

(15) MAX-ABC: Chaha consonant harmony (from McCarthy 2010: 3)

	/tigis/	IDENT-CC [cont]	IDENT-IO [cont]	MAX-CC	IDENT-CC [voice]	IDENT-IO [voice]
☞ a.	d <sub>i</sub> ig <sub>i</sub> is <sub>j</sub>			1		1
b.	d <sub>i</sub> ig <sub>i</sub> iz <sub>i</sub>	W1		L		W2
c.	d <sub>i</sub> ig <sub>j</sub> id <sub>i</sub>		W1	L		W2
d.	t <sub>i</sub> ig <sub>j</sub> is <sub>k</sub>			W2		L
e.	t <sub>i</sub> ig <sub>i</sub> is <sub>j</sub>			1	W1	L

MAX-CC and IDENT-CC [βF], where [βF] is [voice] or [constricted glottis] for Chaha, need not be ranked with respect to each other in a MAX-ABC system; however, they must crucially outrank input-output faithfulness to the target feature in order for agreement to occur between corresponding segments. MAX-CC rules out candidates that lack corresponding segments (e.g., candidate (15d)), and Ident-CC [voice] bans candidates in which corresponding segments do not agree in voicing (e.g., [t<sub>i</sub>ig<sub>i</sub>...] in candidate (15e)). The winning candidate in the MAX-ABC system will be one that optimally satisfies the IDENT-CC constraints and MAX-CC without violating highly-ranked input-output faithfulness. The structure for how MAX-ABC constraints must be ranked in order to achieve correspondence and agreement between similar segments in a harmony system is given in (16).



One advantage that MAX-ABC affords the analysis presented here is the simplification of the overall ABC system. As McCarthy (2010) demonstrates, the use of feature-specific CORR constraints is for the most part unnecessary because the same work can be done with constraints already in place in the Optimality-theoretic system—IDENT and MAX. Moreover, the removal of assumptions on featural identity in the CORR constraints is particularly useful here for the application of ABC to tonal phenomena. In dealing with segment-tone interactions, as in Dioula, it is necessary that all segments—regardless of consonant or vowel-hood—be able to enter correspondence relationships. Therefore, I will propose the use of MAX-XX and IDENT-XX [F] constraints that apply over all segments. Because McCarthy’s move from the CORR constraint family to MAX-CC served the purpose of stripping reference to featural identity from the correspond-

ence constraints, the move from MAX-CC to MAX-XX here is in the same spirit insofar as it strips reference to consonant-vowel feature identity from the correspondence constraint. In any case, to utilize ABC for phenomena outside of consonant harmony, a family of MAX correspondence constraints is inevitable: in vowel harmony, for example, MAX-CC would be ineffectual, and MAX-VV would be necessary. Crucially though and in line with McCarthy's MAX-ABC, most of the feature specification in targeting the features that participate in the agreement system is still accomplished by the IDENT-XX [F] constraints.

## 4.2 An ABC analysis for tone: some preliminaries

The ABC analysis presented here makes a few basic assumptions with regards to segments and tones. Some preliminary assumptions are discussed in turn in this section.

### 4.2.1 *On segments and tones*

Regardless of whether it is a vowel or consonant, I assume here that each segment has a specification for an abstract feature [tone], akin to other features such as [ $\pm$ voice]. To what degree this pitch is realized is left up to the phonetics. Each segment's tone specification may be one of the following: L for specified low tone, H for specified high tone, or T, to mean the absence of a particular specification for the tone value. Contour tones, as will be discussed at further length in §4.4, are represented as two tone specifications realized linearly on one segment. Output tone features of value [T] realize as low tone phonetically (Pulleyblank 1986; Hyman 2011c: 1084–1085, and references therein; a.o.). Because tone is treated here as a featural property of each individual segment, tone features do not have the ability to spread or delink and re-associate on other segments. Instead, ABC handles vowel and consonant harmony and assimilation processes as agreement of tone features from segment to segment. Thus, in this treatment, tone, as a property of the segment, does not have quite the same amount of independence that it does in traditional autosegmental approaches.

I also assume here that there are no free-standing specified L tones on the surface in Dioula, and that specified L tones only occur within contours (e.g., rising LH). Phonetic low tones, as in *tùrù* 'oil, indef.', are underspecified for a tone value in the output (i.e., T). This assumption appears to be in line with the facts of Dioula tone as described by Braconnier (1982): for instance, Dioula does not exhibit neutral, mid tones.

Low tone licensing in contours as such is also found in other African tone languages. In Arusa (Maa, Tanzania), for example, low tones are taken to be specified only in contour tones because contours block the application of rules that depend on high tone adjacency whereas surface low tones do not (Levergood 1989; Odden 1995). In Arusa, a rule lowers prepausal high tones when they are preceded by a high tone anywhere in the phrase. Surface low tones that are underlyingly underspecified do not block the application of this rule (17a); examples from Odden 1995: 466–467):

- (17) a. /ol-óríka sídáy/ → òlóríkà sìdày                      'good chair'  
       b. /ol-kilânjékúk/ → òlkilânjékúk, \*[òlkilânjékúk]                      'new garment'

Falling contour tones, on the other hand, block the application of the adjacent high tone lowering rule, as in (17b); therefore, low tones are taken to be necessarily specified as part of a contour when they are underspecified as free-standing lows.

Traditional autosegmental analyses typically capture the asymmetry in L and H tone specification by positing that there are no free-standing L tones underlyingly, and that only H tones and contours are lexically programmed. Hyman (2011b) proposes a few possible analyses dependent on the underspecification of L tones to explain the facts of Dioula, though his approaches differ from the one used here in that they still utilize free-standing L tones in addition to underspecified surface lows (represented by “Ø” for Hyman, as opposed to “T” here). Furthermore, the underspecification of L tones in input forms is a standard approach in autosegmental tone literature at large (e.g., Hyman 2000 and references therein).

Under an Optimality-theoretic treatment, however, Richness of the Base disallows restrictions on input forms. To rule out free-standing L tones, then, I use here a constraint licensing L tones only in contours, as defined in (18).

(18) L/CONTOUR: L tones are only licensed in contours.

If L/CONTOUR outranks faithfulness to input tones, specified L tones present underlyingly will never surface (19b).

(19) L/CONTOUR violations

	/ V V / L LH	L/CONTOUR	FAITH-IO (tone)
☞ a.	V V T LH		1
b.	V V L LH	W1	L

No matter what the input, a high-ranking L/CONTOUR will eliminate all candidates with free-standing surface L specifications that are not part of a contour. As a consequence of the failure of free-standing L specifications to surface, free-standing L specifications in underlying forms will be ruled out by Lexicon Optimization (Prince and Smolensky 1993).

#### 4.2.2 *RealizeMorph*

Because there is a lack of tone independence (e.g., floating features) under this ABC approach, the high tone exposing the definite suffix is realized on the final vowel not by autosegmental docking but via a special faithfulness constraint, REALIZE-MORPHEME (henceforth REALIZEMORPH; Samek-Lodovici 1996; Rose 1997; Walker 1998; van Oostendorp 2005; Trommer 2008; cf. Kurisu 2001 for a different interpretation of REALIZEMORPH based on anti-homophony between paradigmatically related forms). The constraint is defined in (20), following van Oostendorp (2005: 118).

(20) REALIZEMORPH: For every morpheme in the input, some phonological element must be present in the output.



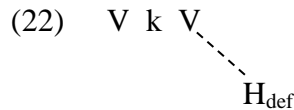
I assume that the definite suffix is a H feature value<sup>10</sup> and must be realized on a segment in the root in accordance with REALIZEMORPH: failure to do so incurs a violation (21b).

(21) REALIZEMORPH violations<sup>11</sup>

	/V k V, -H/ T T T	REALIZE MORPH	ALIGN-R (suffix, word)	DEP-IO <sup>12</sup> (H tone)
☞ a.	V k V T T H <sub>def</sub>			1
b.	V k V T T T	W1		L
c.	V k V T H <sub>def</sub> T		W1	1

An alignment constraint, ALIGN (Suffix, R, Word, R), requires that the high tone of the definite marker in Dioula nouns appear word-finally (cf. (21c)). The definite suffix in Dioula is an example of a dominant suffix, rewriting the melodic material of the stem to which it attaches; thus, to capture the dominance effect, faithfulness to the suffix tone—in this case, REALIZEMORPH—must outrank general faithfulness (Inkelas 1998: 139–140). For Dioula definite nouns, these two constraints dominate the ranking, because the definite high tone must always be expressed. Similar overwriting effects of dominant affixes are found in other tone languages as well, including Hausa (Inkelas 1998, and references therein) and Chichewa (Bantu) (Hyman and Mtenje 1999; Inkelas, to appear), for example. Together, REALIZEMORPH and ALIGN-R will rule out all candidates without a H tone contributed by the definite marker at the right edge of the word.

REALIZEMORPH differs from tone association in feature-spreading because it does not necessarily assume that the high tone expressed in the output is the same high tone present in the input. Under feature-spreading, the H tone of the suffix would dock on the root, illustrated in (22).



Under the REALIZEMORPH approach, the presence of a H tone representing and indexed to the definite form is sufficient (see also van Oostendorp 2005: 120). For instance, if the final segment

<sup>10</sup> It is possible to push the ABC analysis further away from autosegmental approaches by disallowing such free-standing, “floating” feature values: in this case, the definite suffix could be a tone feature H belonging to a null segment that has no other feature specifications. REALIZEMORPH would require some phonological exponence of the definite suffix in the output, and the only candidate for this phonological material would be the high tone feature specification.

<sup>11</sup> Subscript *def* denotes the definite marker.

<sup>12</sup> DEP-IO (H tone) penalizes for every insertion of a tone specification not present in the input. Even though there is a H tone feature for the suffix underlyingly, the realization of the H tone marking the definite on another segment still incurs a violation of DEP-IO because that particular segment, as in (21a, c), did not underlyingly have a H tone specification. The division of FAITH-IO (tone) into DEP and MAX for H tone and L tone will be motivated in subsequent sections.

of the root already has a high tone underlyingly, this H can be appropriated to satisfy REALIZE MORPH (23a).

(23) REALIZE MORPH violations<sup>13</sup>

/V k V, -H/ T T H	REALIZE MORPH
☞ a. V k V T T H <sub>def</sub>	
b. V k V T T H <sub>rt</sub>	W1

The constraints presented in this section (§4.2: REALIZE MORPH; ALIGN (suffix, R, word, R); L/CONTOUR) reduce the candidate set that the primary ABC system, as presented in the following sections (§§4.3–4), need to handle; namely, candidates without a H tone exponing the definite marker at the right edge and candidates with free-standing L tone specifications will not be considered as they are ruled out by these three dominating constraints.

#### 4.3 ABC for tone: Dioula low-toned roots

I begin first with the ABC analysis for low-toned roots in Dioula. Because high-toned roots involve contour tones, they are reserved for discussion in §4.4.

An example input and optimal output candidate for low-toned, Type 1 nouns is shown in (24). In the following examples, subscript letters denote correspondence relationships.

(24) /hàkɛ, -H/ → [hàkɛ́] ‘sin, def.’

$$\begin{array}{ccc} / \dots V & k & V, -H / \rightarrow [ \dots V_i k_j V_k ] \\ T & T & T \qquad \qquad \qquad T & T & H \end{array}$$

The optimal output candidate for a low-toned, Type 1 noun will be one where the definite high-tone marker surfaces on the final vowel and does not copy inwards. In contrast, an example input and optimal output candidate for low-toned, Type 2 nouns is given in (25).

(25) /turu, -H/ → [túru] ‘oil, def.’

$$\begin{array}{ccc} / \dots V & r & V, -H / \rightarrow [ \dots V_i r_i V_i ] \\ T & T & T \qquad \qquad \qquad H & H & H \end{array}$$

In low-toned, Type 2 nouns, the optimal output candidate will be one where the final two vowels bear high tone—and, crucially to this analysis, the  $C_f$  also bears high tone in satisfying correspondence and agreement with the surrounding vowels.

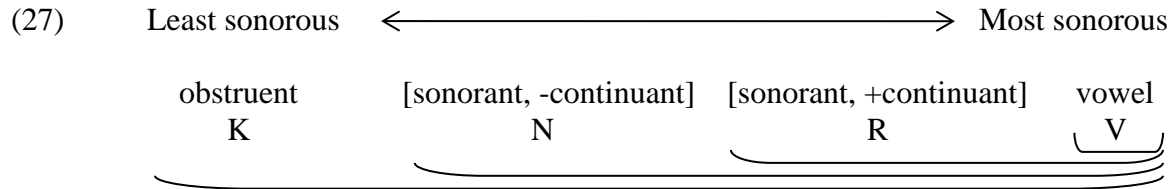
For an ABC analysis of tonal agreement in Dioula, sonority is the relevant triggering feature [αF] that identifies segments in a corresponding relationship<sup>14</sup>. Segments that are sufficient-

<sup>13</sup> Subscript *rt* denotes a root tone.

ly similar in sonority are the ones that correspond and match in tone: vowels in Dioula always share the same tonal specifications when there are no intervening consonants (26a), while more sonorant consonants in  $C_f$  position facilitate tone copying between vowels (Type 2; 26b) and less sonorant consonants and obstruents prevent tone copying (Type 1; 26c).

- (26) a.  $V_i \quad V_i$       b.  $V_i \quad r_i \quad V_i$       c.  $V_i \quad k_j \quad V_k$   
           H    H                    H    H    H                                    H

The sonority effect is scalar; therefore, IDENT-XX [ $\alpha$ F] must be scalar. Following stringent hierarchies for sonority (Kiparsky 1994; de Lacy 2002, 2004; cf. Smith and Moreton 2012 for discussion on stringent versus scale partition sonority constraints), I propose a set of IDENT-XX { $x$  sonority} constraints that target contiguous segments of the sonority hierarchy starting with the most sonorous, as shown in (27).



The constraints and the sections of the sonority hierarchy that they represent are given in (28).

- (28) a. IDENT-XX {V}                                    vowels  
       b. IDENT-XX {V, R}                            vowels, [sonorant, +continuant]  
       c. IDENT-XX {V, R, N}                        sonorants  
       d. IDENT-XX {V, R, N, K}                    all segments, including obstruents

IDENT-XX { $x$  sonority} is violated when corresponding segments do not both fall within the targeted contiguous range of the sonority hierarchy. For example, a pair of corresponding vowel and obstruent segments (e.g.,  $a_i \quad k_i$ ) would violate IDENT-XX {V, R, N, K}, but the same pair of segments would not violate the constraint that refers only to the most sonorous end of the hierarchy, IDENT-XX {V}. Note that this use of IDENT over a stringent sonority hierarchy differs from de Lacy's (2002: 11) stringent faithfulness constraints (e.g., IDENT {dor, lab, cor, gl}) in that two segments falling within the targeted range of the sonority scale can satisfy IDENT-XX { $x$  sonority} without being themselves identical in the exact specification of sonority. That is, the IDENT-XX constraint is defined over the entire range of the stringent hierarchy, rather than on specific values within the targeted range. Example candidates with corresponding segment pairs and the IDENT-XX { $x$  sonority} constraint they violate are given in (29).

<sup>14</sup> Walker (1998) observes a similar sonority-based implication for nasalization on more sonorous segments in nasal agreement.

(29) IDENT-XX { $x$  sonority} violation table

		IDENT-XX {V}	IDENT-XX {V, R}	IDENT-XX {V, R, N}	IDENT-XX {V, R, N, K}
a.	$a_i a_i$				
b.	$a_i r_i$	1			
c.	$a_i n_i$	1	1		
d.	$a_i k_i$	1	1	1	

The basic ABC constraint inventory for Dioula is provided in (30). These constraints are supplemented by those presented in §4.2.

(30) Basic constraint inventory<sup>15</sup>

- a. MAX-XX: Segments must be in correspondence with other segments. (Penalize every pair of segments that does not correspond.)
- b. IDENT-XX { $x$  sonority}: Corresponding segments must agree in  $x$  sonority. (Penalize every pair of corresponding segments that do not fall within the targeted range of the sonority scale.)
- c. IDENT-IO (sonority): Sonority identity must remain faithful to the input.
- d. IDENT-XX (tone): Corresponding segments must agree in tone. (Penalize every pair of corresponding segments that do not agree in tone.)
- e. DEP-IO (H tone): Output high tone specifications must have input correspondents.
- f. DEP-IO (L tone): Output low tone specifications must have input correspondents.
- g. MAX-IO (H/L tone): Input high and low tone specifications must have identical output correspondents.

The ranking of the IDENT-XX { $x$  sonority} constraints relative to the other constraints in the ABC system determine the range of the sonority hierarchy that triggers high tone agreement across the final vowels and the intervocalic consonant. For tone agreement, the relevant IDENT-XX { $x$  sonority} constraint targeting the appropriate range of the sonority hierarchy must rank high in the system, crucially above MAX-XX, shown in (31). Because vowels and liquids in Dioula allow high tone copying leftwards from the suffix, the active constraint here is IDENT-XX {V, R}, which requires that corresponding segments be either vowels or liquids. Following the ranking schema for correspondence and agreement in (16; §4.1), the ranking of IDENT-XX {V, R} » MAX-XX will prevent segments that do not fall within the more sonorous section of the sonority scale from corresponding (e.g., candidate (31b)). Additionally, ranking input-output faithfulness to sonority (IDENT-IO (sonority)) above MAX-XX prevents changes in segmental quality: for example, obstruents will not become sonorants in order to satisfy correspondence (e.g., candidate (31c)). DEP-IO (H tone) must be ranked low, for agreement to occur (cf. (32)). The low ranking of input-output faithfulness to tone, DEP-IO (H tone), prevents candidates that skip over the intervening consonant in correspondence from surfacing (e.g., harmonically bounded candidate (31d)).

<sup>15</sup> Motivation for DEP-IO (L tone) and MAX-IO (H/L tone) is given in §4.4.

(31) Type 1, low-toned root: e.g., /hakɛ, -H/ → [hàkɛ́] ‘sin, def.’						
/V k V, -H/ T T T	...	IDENT-IO (sonority)	IDENT-XX {V, R}	MAX-XX	IDENT-XX (tone)	DEP-IO (H tone)
☞ a. V <sub>i</sub> k <sub>j</sub> V <sub>k</sub> T T H				2		1
b. V <sub>i</sub> k <sub>i</sub> V <sub>i</sub> H H H			W2	L		W3
c. V <sub>i</sub> r <sub>i</sub> V <sub>i</sub> H H H		W1		L		W3
d. V <sub>i</sub> k <sub>j</sub> V <sub>i</sub> H T H				2		W2
(32) Type 2, low-toned root: e.g., /turu, -H/ → [túrú] ‘oil, def.’						
/V r V, -H/ T T T	...	IDENT-IO (sonority)	IDENT-XX {V, R}	MAX-XX	IDENT-XX (tone)	DEP-IO (H tone)
☞ a. V <sub>i</sub> r <sub>i</sub> V <sub>i</sub> H H H						3
b. V <sub>i</sub> r <sub>i</sub> V <sub>i</sub> T T H					W1	L1
c. V <sub>i</sub> r <sub>j</sub> V <sub>k</sub> T T H				W2		L1
d. V <sub>i</sub> r <sub>j</sub> V <sub>i</sub> H T H				W2		L2

For segments that fall within the targeted range of the sonority hierarchy, tone agreement is obtained by the ranking of MAX-XX and IDENT-XX (tone) above input-output faithfulness constraints to tone. For Type 2 nouns, the agreement of triggering features for correspondence, as specified by IDENT-XX {V, R}, is satisfied by the sonorant  $C_f$ . Because the segments correspond, they must also agree in tone specification, as required by the agreement constraint targeting the [βF], IDENT-XX (tone). The tableau in (32) demonstrates Type 2 behavior across a liquid  $C_f$ . Candidates with corresponding segments that do not agree in tone incur violations of IDENT-XX (tone) (e.g., (32b)). Candidates that have sufficiently similar sonorant segments that do not correspond are ruled out by MAX-XX (e.g., (32c)). Due to pairwise evaluation of correspondence relationships, MAX-XX prohibits candidates in which only the vowels correspond and match in tone and in which the intervening  $C_f$  is skipped over for correspondence (32d). Because both IDENT-XX (tone) and MAX-XX outrank DEP-IO (H tone), H tone insertion is allowed so as to have a maximally corresponding and agreement winner (32a).

Under the analysis presented here, sonority determines the surface tonal pattern, and tone specification on an onset consonant is only licensed when it is required for agreement with its surrounding vowels. The ranking of IDENT-XX { $x$  sonority} constraints determine the segments that pre-condition correspondence. If, for example, only IDENT-XX {V, R, N, K} were highly ranked above MAX-XX and the other IDENT-XX { $x$  sonority} constraints that target more limited

ranges of the sonority scale were low-ranked, unattested Type 2 tone agreement through an obstruent  $C_f$  would be generated (33b):

(33) low-toned root with obstruent  $C_f$

/V k V, -H/ T T T	...	IDENT-XX {V, R, N, K}	MAX-XX	IDENT-XX (tone)	IDENT-XX {V, R}
(☞) a. $V_i k_j V_k$ T T H			W2		L
☛ b. $V_i k_i V_i$ H H H					2

Because Dioula is more restrictive in which segments may allow tone agreement, IDENT-XX { $x$  sonority} constraints that target a more restricted range of the sonority scale must rank above the correspondence constraint, MAX-XX, to prevent tone agreement across less sonorant  $C_f$ s. In (34) (cf. (33)), the high ranking of IDENT-XX {V, R}, which targets a limited range of the sonority hierarchy with only the most sonorous segments, prohibits the correspondence of an obstruent with the surrounding vowels because the obstruent is not sufficiently sonorant.

(34) low-toned root with obstruent  $C_f$

/V k V, -H/ T T T	...	IDENT-XX {V, R}	MAX-XX	IDENT-XX (tone)
☞ a. $V_i k_j V_k$ T T H			2	
b. $V_i k_i V_i$ H H H		W2	L	

As long as a more restrictive IDENT-XX { $x$  sonority} constraint ranks highly, the ranking of less restrictive IDENT-XX { $x$  sonority} constraints in relation to MAX-XX is of no import.

While the tone type distinction for obstruent  $C_f$ s is nearly categorical, nouns with sonorant consonants in the same position may be either Type 1 or Type 2. As discussed in §3, nasal  $C_f$  roots are more likely to be Type 1, and liquid  $C_f$  roots are more likely to be Type 2. Optimality Theory can capture this gradient behavior through the partial ranking of stringent sonority constraints in relation to the correspondence constraint, MAX-XX (Anttila 1997, 2002, 2007, 2008; a.o.)<sup>16</sup>, which will dictate the segments that must correspond and agree in tone. The ranking of a more restrictive sonority correspondence constraint—in this case, IDENT-XX {V, R}—above MAX-XX will preclude nasals from the set of agreeing segments and force them to behave like obstruents in blocking tone copy, as in *diná* ‘religion, def.’ (35).

<sup>16</sup> Partial ranking is only one of the numerous proposals that have been put forward to formalize variation in Optimality Theory. Stochastic, weight-based ranking (Boersma 1997; Boersma and Hayes 2001; a.o.) would be another option here, for example.

(35) Type 1: /dina, -H/ → [díná] ‘religion, def.’

/V n V, -H/ T T T	...	IDENT-XX {V, R}	MAX-XX	IDENT-XX (tone)
☞ a. V <sub>i</sub> n <sub>j</sub> V <sub>k</sub> T T H			2	
b. V <sub>i</sub> n <sub>i</sub> V <sub>i</sub> H H H		W2	L	

On the other hand, if a less restrictive IDENT-XX {*x* sonority} constraint remains highly ranked above MAX-XX while the more restrictive sonority agreement constraints are ranked below, less sonorous segments will allow Type 2 behavior. For Type 2 nasal *C<sub>f</sub>* nouns (e.g., *jíná* ‘devil, def.’ (36)), the ranking of IDENT-XX {V, R, N} » MAX-XX » IDENT-XX {V, R} produces Type 2 tone agreement across the nasal. Because the more restrictive sonority constraint, IDENT-XX {V, R}, is dominated by MAX-XX in (36), the system will not prevent nasal and vowel correspondence, which satisfies the higher-ranked IDENT-XX {V, R, N}.

(36) Type 2: /jina, -H/ → [jíná] ‘devil, def.’

/V n V, -H/ T T T	...	IDENT-XX {V, R, N}	MAX-XX	IDENT-XX (tone)	IDENT-XX {V, R}
a. V <sub>i</sub> n <sub>j</sub> V <sub>k</sub> T T H			W2		L
☞ b. V <sub>i</sub> n <sub>i</sub> V <sub>i</sub> H H H					2

In this system with stringent hierarchy constraints for sonority agreement, it is impossible to target less sonorous segments for correspondence and tone agreement without also including more sonorous segments. Moreover, to include less sonorous segments in correspondence, the grammar requires more ranking information, specifying not only which IDENT-XX {*x* sonority} constraints outrank MAX-XX but also which IDENT-XX {*x* sonority} constraints are outranked by MAX-XX. The less sonorous the segment to allow tone agreement, the more IDENT-XX {*x* sonority} constraints must be specified as outranked by MAX-XX. For liquid *C<sub>f</sub>* segments to allow tone agreement, IDENT-XX {V} must rank low; for nasals, both IDENT-XX {V} and IDENT-XX {V, R} must also rank low; and if obstruents were to allow tone agreement, IDENT-XX {V, R, N}, in addition to any more restrictive IDENT-XX {*x* sonority} constraints, must rank low.

With the partial ranking of stringent hierarchy sonority constraints and the increasing grammatical complexity of involving less sonorous segments in tone agreement, an implicational universal arises: a given segment of *x* sonority should only transmit tone and allow tonal agreement when more sonorous segments in the same system do. The factorial typology in (37), generated using OTSoft (Hayes et al. 2003), demonstrates this prediction.

(37)

Input $C_f$ =	Output 1	Output 2	Output 3	Output 4
obstruent	tone spread	no spread	no spread	no spread
[nasal]	tone spread	tone spread	no spread	no spread
[liquid]	tone spread	tone spread	tone spread	no spread

The distribution of Dioula nouns into Type 1 and Type 2 distinctions conforms to the typology given in (37): sounds on the lower end of the sonority hierarchy will block tone more often than those on the more sonorous end. Furthermore, under a partial ranking analysis, the participation of less sonorous segments in tone agreement necessitates more grammatical complexity in ranking information, while fewer ranking specifics are required for more sonorous segments to participate in tone transmission. It has been demonstrated previously in gradient phonotactic patterns that such increasing grammatical complexity is inversely correlated with the well-formedness and likelihood of a given form (Anttila 2008, and references therein). Thus, the avoidance of increasing grammatical complexity may drive the participation of sonorous segments and the non-participation of less sonorous segments in tone agreement, with the trend towards grammatical simplicity.

The Dioula lexicon, it appears, is organized in a way that reflects the typological likelihood of tone agreement as predicted by the sonority- and similarity-based ABC system laid out here. While most of the nouns themselves have a fixed pronunciation<sup>17</sup>, there is variation across the lexicon that is phonologically patterned according to the sonority of the  $C_f$ . Zuraw (2010) provides a two-part model for capturing such lexical variation. Words with fixed pronunciations are listed in the lexicon (following previous work with lexical indexation; e.g., Inkelas et al. 1997; Becker 2009; a.o.), with high-ranking faithfulness constraints protecting these listed forms. Words that do not yet have a fixed pronunciation are subject to the phonological grammar that includes partially ranked or weighted constraints, which, as Zuraw demonstrates using learning simulations, can be learned from the phonologically-conditioned frequencies in the lexicon. In this way, the patterning in the lexicon continually reinforces itself according to the predictions of the phonological system.

I have assumed here that the lexical variation of Dioula tone types should arise from and therefore be represented in the phonological grammar; but, it is left up to further investigation to see if this grammar is productively extended to novel forms by Dioula speakers, and if the typological prediction made here of the connection between sonority and tone transmission holds at large cross-linguistically.

#### 4.4 ABC for tone: Dioula high-toned roots

Like low-toned roots, high-toned roots in Dioula exhibit Type 1 and Type 2 tone behaviors, albeit with different surface realizations of tone melodies, as discussed in §3. Type 1, high-toned nouns demonstrate a change in tone on the final syllable only in the definite form (38a); Type 2 nouns change tone on both the penultimate and final syllables (38b).

<sup>17</sup> There are a couple of listed variations in the Dioula dictionary (Braconnier and Diaby 1982): for example, *télú* ‘tree, indef.’ can be variably *tèlú* or *télŭ* ‘tree, def.’.



(38)			indef.	before H (def.)	
a.	high-toned	TYPE 1	kúkù	kúkǔ	‘dancing woman’
b.		TYPE 2	kúró	kùró	‘mountain’ <sup>18</sup>
c.	low-toned	TYPE 1	fùfù	fùfú	‘type of basket’
d.		TYPE 2	fùnùn	fúnún	‘bladder’

In low-toned roots, a high tone is realized either on the final syllable in Type 1 nouns (38c) or on the final two syllables in Type 2 nouns (38d). The high-toned roots differ from the low-toned roots in that a low-high sequence surfaces instead on the syllables in question. In Type 1 nouns, a rising contour tone (LH) appears on the final syllable in the definite form (38a). In Type 2 nouns, the tone melody of the final two syllables is replaced by a low-high sequence, with low tone on the penultimate syllable followed by high tone on the final syllable (38b).

Despite these differences between low- and high-toned roots, the core of the ABC analysis remains the same for high-toned roots: the interaction between MAX-XX and the IDENT constraints for the trigger and target features of correspondence and agreement drives the behavior of Type 1 versus Type 2 nouns. Additional constraints that do not affect the core ranking of correspondence and agreement constraints in the ABC system are necessary here to address the complexity of high-toned roots (e.g., for contour tones). Each additional constraint is motivated in turn in §4.4.1, followed by illustrations of the ABC system for high-toned roots in §4.4.2.

Nouns are classified as high-toned if there is an underlying high tone in the penultimate syllable. Example inputs and optimal output candidates for high-toned, Type 1 nouns are given in (39). In some high-toned, Type 1 roots, there may also be a high tone present on the final syllable underlyingly (39b); however, both underlying representations—with or without H on the final syllable—will produce the same definite output, with a LH rise on the final syllable.

(39) a. /kúku, -H/ → [kúkǔ] ‘dancing woman, def.’

$$\begin{array}{ccc} / \dots V & k & V, -H / \rightarrow [ \dots V_i & k_j & V_k ] \\ & H & T & T & & H & T & LH \end{array}$$

b. /mákó, -H/ → [mákǒ] ‘need, def.’

$$\begin{array}{ccc} / \dots V & k & V, -H / \rightarrow [ \dots V_i & k_j & V_k ] \\ & H & T & H & & H & T & LH \end{array}$$

All high-toned, Type 2 nouns in the Dioula dictionary have penultimate and final high tones in isolation. The optimal candidate in the definite form preceding a H tone suffix is one in which only the final syllable bears high tone.

<sup>18</sup> *kùró* also means ‘button, def.’, ‘ball, def.’, or ‘spoon, def.’ (Braconnier and Diaby 1982: 61).

(40) /mùrú, -H/ → [mùrú] ‘knife, def.’

$$\begin{array}{ccc} / \dots V & r & V, -H / \rightarrow [ \dots V_i & r_i & V_i ] \\ & H & T & H & & T & T & H \end{array}$$

An output candidate with the surface pattern [L L H] for high-tone, Type 2 nouns is ruled out by the high-ranking L/CONTOUR constraint, introduced in §4.2, which only licenses low tones within contours and disallows free-standing Ls.

#### 4.4.1 Additional constraints

There are several possible analyses of the difference between low- and high-toned roots in their realization of the definite form. The problem here is one of opacity: in Type 2 roots, the conditioning environment for the low-high sequence—a penultimate high tone in the root—is overridden and does not appear in the output (e.g., /mùrú, -H/ → [mùrú]; §4.4, (40)). One approach to this problem is to assume phonologically-conditioned allomorphy in the definite marker. Under this approach, the allomorph [-H] occurs following low-toned roots that are underlyingly unspecified for tone, and the allomorph [-LH] occurs following high-toned roots with a specified penultimate high tone.

The crucial insight for high-toned roots that an allomorphy analysis seems to miss, however, is that low tone insertion in Type 1 roots and dissimilation in Type 2 roots both conspire to prevent adjacent heteromorphemic high tones in a derived environment between the root and suffix morpheme. Furthermore, low tone insertion and dissimilation help to maintain phonological distinctiveness and recoverability between the isolation, indefinite and the suffixed, definite forms. As an alternative to an allomorphy approach, I use here an Obligatory Contour Principle-type anti-homophony constraint, as defined in (41), which militates against sequences of heteromorphemic high tones that do not have an intervening specified L tone (OCP: Leben 1973; et seq.; hetero-morphemic anti-homophony: Golston 1995; Yip 1998; a.o.; OCP in OT: Myers 1997; a.o.).

(41) ANTI-HOMOPHONY: No sequence of heteromorphemic high tones without an intervening specified low tone.

The ANTI-HOMOPHONY constraint is violated if two high tones contributed by separate morphemes are not separated by a specified low tone. Underspecified tone slots (T, ((42a)) and derived high tones (H, (42b)) do not count as intervening tones, and the intervener must be a specified low tone in the output, either as a free-standing L (42c) or as a specified L within a contour (42d). Though they satisfy ANTI-HOMOPHONY, candidates with free-standing Ls (42c) will be ruled out by the undominated constraint, L/CONTOUR (shown in (43)).

## (42) ANTI-HOMOPHONY violations

	ANTI-HOMOPHONY
a. H <sub>rt</sub> T H <sub>def</sub>	1
b. H <sub>rt</sub> H H <sub>def</sub>	1
☞ c. H <sub>rt</sub> L H <sub>def</sub>	
☞ d. H <sub>rt</sub> T L H <sub>def</sub>	
☞ e. T T H <sub>def</sub>	

If no specified L can be inserted to satisfy the anti-homophony condition due to other constraints in the system, then other repairs, including the deletion of high tone specification, must occur to satisfy ANTI-HOMOPHONY (42e). Such is the case with high-toned, Type 2 nouns. Low-toned roots are unaffected by ANTI-HOMOPHONY because there are no underlying root high tones<sup>19</sup>.

For high-toned Dioula nouns, ANTI-HOMOPHONY works together with the high-ranking constraints introduced in §§4.2.2–3, REALIZEMORPH, ALIGN (suffix, R, word, R), and L/CONTOUR. Because REALIZEMORPH and ALIGN-R require that a H tone specification expounding the definite suffix must surface word-finally, ANTI-HOMOPHONY must prevent the adjacency of H specifications from both the definite suffix and the root: that is, H tones from the suffix and the root must be separated by a specified low tone. L/CONTOUR will prohibit this specified low from surfacing anywhere except within a contour tone. An example tableau demonstrating the high-ranking of these constraints is given below in (43): these constraints must crucially outrank input-output faithfulness to tone specifications so that the insertion of a L tone specification in a contour can repair ANTI-HOMOPHONY violations.

## (43) Type 1, high-toned root: e.g., /kúku, -H/ → [kúkũ] ‘dancing woman, def.’

/V k V, -H/ H T T	REALIZE MORPH	ANTI- HOM	L/ CONTOUR	...	DEP-IO (L tone)
☞ a. V <sub>i</sub> k <sub>j</sub> V <sub>k</sub> H <sub>rt</sub> T L H <sub>def</sub>					1
b. V <sub>i</sub> k <sub>j</sub> V <sub>k</sub> H <sub>rt</sub> T H	W1				L
c. V <sub>i</sub> k <sub>j</sub> V <sub>k</sub> H <sub>rt</sub> T H <sub>def</sub>		W1			L

<sup>19</sup> ANTI-HOMOPHONY also explains the gap in the lexicon of high-toned nouns that are longer than two syllables and belong to Type 2. All high-toned nouns that are longer than two syllables have antepenultimate high tones underlyingly, in addition to penultimate high tones: e.g., /cékóróba/ → [cékóróbà] ‘old man, indef.’. Given the underlying antepenultimate high tones, the possible output candidates may have the following tone melodies on the final three syllables, excluding tone specifications on consonants for simplicity: [... H<sub>rt</sub> L H<sub>def</sub>], [... H<sub>rt</sub> T H<sub>def</sub>], [... H<sub>rt</sub> H<sub>rt</sub> L H<sub>def</sub>]. Candidates with the tone melody [...H<sub>rt</sub> L H<sub>def</sub>] are ruled out because L cannot occur outside a contour tone, as specified by L/CONTOUR. ANTI-HOMOPHONY prohibits candidates with the tone melody [...H<sub>rt</sub> T H<sub>def</sub>], which would be analogous to a Type 2 output, because there is no overtly specified L tone between the two heteromorphemic high tones. The only possible remaining outcome for high-toned nouns that are longer than two syllables is [... H<sub>rt</sub> H<sub>rt</sub> L H<sub>def</sub>], in which a L occurs in a word-final contour. Due to ANTI-HOMOPHONY and antepenultimate high tone, therefore, there are no nouns in the Dioula lexicon that belong to the high-toned class, are longer than two syllables, and feature Type 2 tone behavior.

d.	V <sub>i</sub> k <sub>j</sub> V <sub>k</sub> H <sub>rt</sub> L H <sub>def</sub>			W1		1
----	--	--	--	----	--	---

ANTI-HOMOPHONY rules out any candidates that do not have an overtly specified L tone intervening between heteromorphemic H tone specifications (e.g., candidate (43c)). In order to satisfy the anti-homophony requirement, several repairs are possible. Deleting the morpheme indexation (e.g., (43b)) satisfies ANTI-HOMOPHONY but violates the equally high-ranked REALIZEMORPH. Likewise, insertion of a L tone specification on the sonorant consonant, as in (43d), satisfies ANTI-HOMOPHONY but violates L/CONTOUR, which disallows free-standing surface L tone values outside contours. Therefore, the winning candidate, (43a), is one in which the L tone intervening between the heteromorphemic high tones is located inside a rising contour on the final segment, thus satisfying all of the highly-ranked constraints, even if input-output tone faithfulness is violated.

We also require a constraint that bans low tone insertion into a contour on the penultimate syllable, forming a [HL T H] candidate (45) that satisfies both ANTI-HOMOPHONY and L/CONTOUR. In Dioula, contour tones are restricted to the final syllable at the right edge of a word. This restriction is a common pattern for contour tones cross-linguistically (Gordon 2001; Zhang 2001, 2004), and Zoll (2003) provides a general constraint licensing contour tones word-finally to account for this distribution, which I adopt here:

(44) COINCIDE(Contour=final): Contour tones are only licensed word-finally.

The example tableau in (45) demonstrates how COINCIDE(Contour=final) selects the winning candidate that limits contour tones to the word-final position.

(45) Type 1, high-toned root: e.g., /kúku, -H/ → [kúkǔ] ‘dancing woman, def.’

	/V k V, -H/ H T T	COINCIDE (Cont=final)
☞ a.	V <sub>i</sub> k <sub>j</sub> V <sub>k</sub> H <sub>rt</sub> T LH <sub>def</sub>	
b.	V <sub>i</sub> k <sub>j</sub> V <sub>k</sub> H <sub>rt</sub> L T H <sub>def</sub>	W1

With contour tones restricted to the right edge of a word, a candidate that inserts low tone on the penultimate syllable (45b) loses to a candidate that creates a contour word-finally (45a).

High-toned nouns further necessitate the division of input-output faithfulness constraints to tone specifications. While the insertion of a low tone specification between two heteromorphemic high tones satisfies ANTI-HOMOPHONY, another possible repair is to delete the underlying root high tone specification (46b). The ranking of MAX-IO (H/L tone) » DEP-IO (L tone) privileges the maintenance of underlying Hs<sup>20</sup>:

<sup>20</sup> The deletion of the suffix high tone, even if a H specification marking the definite surfaces on another segment, incurs one violation of MAX-IO.

- (46) Type 1, high-toned root: e.g., /kúku, -H/ → [kúkũ] ‘dancing woman, def.’

/V k V, -H/ H T T	ANTI-HOM	...	MAX-IO (H/L tone)	DEP-IO (L tone)
☞ a. $V_i k_j V_k$ $H_{rt} T LH_{def}$			1	1
b. $V_i k_j V_k$ $T T H_{def}$			W2	L

Some low-toned, Type 1 roots have underlying high tones on both the penultimate and final syllables, as in /mákó, -H/ ‘need, def.’ (39b). In these cases, DEP-IO (H tone) prevents the formation of complex contours—made up of a faithful root H, a H tone for the definite, and an inserted L to satisfy the anti-homophony constraint—on the final syllable:

- (47) Type 1, high-toned root: e.g., /mákó, -H/ → [mákõ] ‘need, def.’

/V k V, -H/ H T H	ANTI-HOM	...	DEP-IO (H tone)
☞ a. $V_i k_j V_k$ $H_{rt} T LH_{def}$			
b. $V_i k_j V_k$ $H_{rt} T H_{rt} LH_{def}$			W1

#### 4.4.2 ABC analysis for high-toned roots

With the addition of the constraints discussed in §4.4.1, the remainder of the ABC approach for Dioula high-toned roots remains the same as laid out in §4.3 for low-toned roots.

The tableau in (48) illustrates the ABC analysis for high-toned, Type 1 roots. Constraints not critical to illustrating the correspondence and agreement relationships have been omitted.

- (48) Type 1, high-toned root: e.g., /kúku, -H/ → [kúkũ] ‘dancing woman, def.’

/V k V, -H/ H T T	...	IDENT-IO (sonority)	IDENT-XX {V, R}	MAX-XX	...
☞ a. $V_i k_j V_k$ $H_{rt} T LH_{def}$				2	
b. $V_i k_i V_i$ $T T H_{def}$			W2	L	
c. $V_i r_i V_i$ $T T H_{def}$		W1		L	

Like the low-toned, Type 1 roots, no agreement occurs when the  $C_f$  is an obstruent because the relevant IDENT-XX { $x$  sonority} constraint at work targets only the select range of the sonority hierarchy that includes more sonorous consonants and vowels. Specifically, IDENT-XX {V, R} prevents obstruents from corresponding their surrounding vowels (e.g., (48b)), and because this triggering feature for correspondence is not satisfied, no tone agreement can occur. Faithfulness

to input sonority also prevents changes in consonant quality that would otherwise satisfy correspondence (48c). The winning candidate for low-toned, Type 1 roots is one in which ANTI-HOMOPHONY is not violated, and no correspondence or tone agreement occurs.

The tableau in (49) provides the basic ABC analysis for high-toned, Type 1 roots with underlying penultimate and final high tones in the root. The analysis is the same as in (48), with no correspondence and tone agreement between vowels and the  $C_f$  because the sonority requirement imposed by IDENT-XX {V, R} is not met by obstruent  $C_f$ s. As discussed in §4.4.1, a faithful candidate that maintains the word-initial high tone and does not have a contour is ruled out by the high-ranking ANTI-HOMOPHONY constraint and therefore is not considered here.

(49) Type 1, high-toned root: e.g., /mákó, -H/ → [mákõ] ‘need, def.’

/V k V, -H/ H T T	...	IDENT-IO (sonority)	IDENT-XX {V, R}	MAX-XX	...
a. $V_i$ $k_j$ $V_k$ $H_{rt}$ T $LH_{def}$				2	
b. $V_i$ $k_i$ $V_i$ T T $H_{def}$			W2	L	
c. $V_i$ $r_i$ $V_i$ T T $H_{def}$		W1		L	

For Type 2 roots that are high-toned, the  $C_f$ s fall within the range of the sonority hierarchy targeted by IDENT-XX { $x$  sonority} that pre-conditions correspondence and thus tone agreement. Consequently, the segments—vowels and consonants alike—will correspond and strive to become more similar by agreeing in tone, as Type 2, low-toned roots do (§4.3). However, due to the high-ranking, undominated constraints introduced in §§4.2 and 4.4.1—notably, ANTI-HOMOPHONY, amongst others—candidates that correspond and agree fully in tone specifications will not win. A fully agreeing candidate with high tones (50b) violates ANTI-HOMOPHONY; a candidate with all underspecified tone features (50d) violates REALIZE MORPH; and a candidate with all contour tones (50c), assuming segment-by-segment correspondence (see §5 for more discussion regarding contours), violates COINCIDE(Contour=final) with non-final contour tones. Instead, the optimal candidate is one in which as many segments as possible will agree in tone specification—or the lack thereof, in the case of high-toned roots—and is still sufficiently faithful to the definite marker to fulfill REALIZE MORPH (50a).

(50) Type 2, high-toned root: e.g., /múru, -H/ → [mùru] ‘knife, def.’

/V r V, -H/ H T H	REALIZE MORPH	L/ CONTOUR	ANTI- HOM	COINCIDE (Cont=final)	...	IDENT- XX (tone)
a. $V_i$ $r_i$ $V_i$ T T $H_{def}$						1
b. $V_i$ $r_i$ $V_i$ $H_{rt}$ H $H_{def}$			W1			L
c. $V_i$ $r_i$ $V_i$ LH LH $LH_{def}$				W2		L

d.	V <sub>i</sub> r <sub>i</sub> V <sub>i</sub> T T T	W1					L
e.	V <sub>i</sub> r <sub>j</sub> V <sub>i</sub> H <sub>rt</sub> T H <sub>def</sub>			W1			L
f.	V <sub>i</sub> r <sub>i</sub> V <sub>i</sub> L L H <sub>def</sub>		W2				1

The high-ranking, undominated constraints also exclude other candidates that, like the winner, are in correspondence and feature partial tone agreement. ANTI-HOMOPHONY prevents candidates that have heteromorphemic H tones that are not separated by an overtly specified L tone, as in the faithful candidate (50e). Likewise, a candidate that has specified L tones that are not part of a contour will also be ruled out by the high-ranking L/CONTOUR constraint (e.g., (50f)).

Given these undominated constraints and the narrowed field of candidates, the tableau in (51) illustrates the basic ABC system for Type 2, high-toned roots. Because MAX-XX and IDENT-XX (tone) are unranked in relation to each other, there are two possible optimal candidates for Type 2, high-toned roots that both satisfy the triggering sonority feature for correspondence, IDENT-XX {V, R}. There is no need to distinguish between these two winners, however, because both are phonetically identical and produce the [T T H] surface tone pattern that we see in Dioula. The difference between these two candidates lies only in the degree of correspondence between the segments. With MAX-XX » IDENT-XX (tone), the winner (51a) will have maximal correspondence between all of the segments involved. With the opposite ranking, the alternate winner (51b) features only partial correspondence between the C<sub>f</sub> and its surrounding vowels, but this correspondence is sufficient for producing the partial tone agreement that occurs in the Type 2, high-toned roots. A candidate of the same surface tone pattern and any less correspondence (e.g., V<sub>i</sub> r<sub>j</sub> V<sub>k</sub>) will always be harmonically bound by (51b) and cannot win. Because input-output faithfulness to tone specifications is ranked below both MAX-XX and IDENT-XX (tone), a candidate that repairs ANTI-HOMOPHONY through the insertion of a L tone specification in a final contour (51c), as in Type 1, high-toned roots (e.g., (49a)), will always lose to candidates that correspond and agree as much as possible in tone.

(51) Type 2, high-toned root: e.g., /mùrú, -H/ → [mùrú] ‘knife, def.’

/V r V, -H/ H T H	...	IDENT-XX {V, R}	MAX-XX	IDENT-XX (tone)	DEP-IO (H tone)	MAX-IO (H/L tone)	DEP-IO (L tone)
☞ a. V <sub>i</sub> r <sub>i</sub> V <sub>i</sub> T T H <sub>def</sub>				1		2	
(☞) b. V <sub>i</sub> r <sub>i</sub> V <sub>j</sub> T T H <sub>def</sub>			W1	L		2	
c. V <sub>i</sub> r <sub>j</sub> V <sub>k</sub> H <sub>rt</sub> T L H <sub>def</sub>			W2	L		L1	W1

The partial ranking of MAX-XX and IDENT-XX (tone) will produce multiple acceptable optimal candidates whenever the desired output has partial agreement and correspondence, as Type 2,

high-toned roots do. Partial agreement and correspondence in these forms indicates that there will always be violations of one of the correspondence or [βF] (tone) agreement constraints. This situation does not occur when the optimal output is one in which there is complete agreement and correspondence, as in Type 2, low-toned roots, because the output will never have violations of either MAX-XX or IDENT-XX (tone). Nevertheless, the multiple optimal outputs pose no problems for the analysis here because both produce equivalent surface phonetic results.

The high-toned nouns in Dioula present complexities that require additional constraints that regulate the behavior of contour tones and adjacent heteromorphemic high tones, as discussed in §4.4.1. Crucially, however, the basic ABC system holds. Segments that are similar in sonority will correspond, agreeing in sonority and further agreeing in tone: this causes the tone copying that we see with sonorant  $C_f$  segments like liquids in Dioula Type 2 nouns. Segments that are insufficiently similar in sonority—that is, vowels and some sonorants versus obstruent consonants and, variably, nasals—will not correspond and seek to agree in tone. This lack of correspondence and sonority similarity gives rise to the bounded effect in the tone copying of Type 1 nouns, where the high tone contributed by the following morpheme and any associated changes of the tone melodies is restricted to the final syllable only. The ABC approach outlined here allows us to capture the Dioula pattern without the heavily representation-dependent machinery of autosegmental theories. Instead, the ABC approach uses the interaction of pre-existing Optimality-theoretic constraints that have been shown to be at work in harmony systems: that is, IDENT-XX [F] constraints targeting the triggering and agreeing features and MAX-XX, which, to the extent possible, requires correspondence between all segments.

## 5 Consonant-tone interaction beyond Dioula

As alluded to in §2, there are two ways in which segments can interfere with tonal agreement: [1] by their non-participation in the correspondence system because they are insufficiently sonorous, and [2] by the articulatory or otherwise phonetic incompatibility of specific tone values and segmental features. The Type 1 versus Type 2 tone pattern in Dioula described above is an example of [1], in which less sonorous consonants fail to meet the triggering requirement to participate in correspondence and tone agreement. This type of pattern, however, is fairly atypical in the consonant-tone interaction literature. More commonly discussed consonant-tone phenomena involve depressor and elevator consonants, and these phenomena are examples of [2], in which segments disrupt and perturb F0 locally.

The ABC framework presented here can generate both effects of consonant-tone interaction. While a complete study of consonant-tone phenomena is beyond the scope of this paper, I offer the following sketches as possible ABC analyses of common consonant-tone behavior and argue that typical depressor consonant effects such as the blocking of high tone spread can be captured by ABC via segmental opacity (§5.1). Moreover, the ABC approach makes the correct typological prediction that tones can affect consonant quality, a noted phenomenon in consonant-tone interactions (§5.2). Beyond the examples here, it remains an open challenge for the ABC analysis proposed herein as to whether it can capture the breadth of consonant-tone interactions found more widely, and I leave this more extensive typological investigation for future work.

### 5.1 Segmental opacity to tone in ABC



Depressor consonants are usually voiced obstruents or aspirated, fricated, or breathy voiceless obstruents, and elevator, anti-depressor consonants are usually plain, voiceless obstruents (Bradshaw 1999; Lee 2008; Tang 2008; a.o.). These depressor and elevator consonants interfere with and affect tone in a variety of ways, including low tone insertion, low tone spread, the blocking of low tone docking, downstep insertion, the blocking of high tone docking, the blocking of high tone shift, and voicing changes.

The example in (52) from Ikalanga (Bantu, Botswana) demonstrates a typical depressor consonant effect (data from Mathangwane 1999).

(52) Ikalanga: depressors block H tone spread/realization

	Underlying	Surface	
a.	/né-tʃi-wilo/	nétʃíwílo	‘by chance’
	/né-tʃi-lopa/	nétʃílópa	‘and a liver’
b.	/né-báni/	nébani	*nébáni ‘and a forest’
	/né-záni/	nézani	*nézáni ‘and a leaf’

In Ikalanga, the prefix *né-* usually causes high tone spread rightwards onto the root TBUs, as in (52a). When a voiced obstruent depressor is present, as in (52b), this rightward high tone spread is blocked, with no realization of high tones following a depressor consonant. The realization of underlying high tones is also blocked following a depressor consonant.

Under an ABC approach, the blocking of high tone spread by depressor consonants, as demonstrated by Ikalanga in (52), is an instance of opaque segments interfering with tone correspondence and agreement. In the original formulation of ABC, segmental opacity was argued to be undesirable for the theory because long distance consonant agreement phenomena do not typically exhibit blocking effects (Rose and Walker 2004: 486–487). Later treatments of ABC, however, have shown that, because the constraints in an ABC system are violable, a high-ranking markedness constraint can force the opacity of an intervening segment (Hansson 2007). Such blocking has been noted to occur in vowel harmony (Walker 2009; Rhodes 2010). Specifically, a markedness constraint must outrank IDENT-XX [βF], which requires the agreement of the harmonic feature on corresponding segments. If a higher-ranked markedness constraint prevents the application of IDENT-XX [βF], the segment targeted by the markedness constraint will be opaque to agreement and correspondence.

Markedness constraints targeting depressor and elevator consonants are given in (53) (following Yip 2002; Lee 2008).

- (53) a. \*H/[+voice]: No H tone may co-occur with a [+voice] segment.  
b. \*L/[-voice]: No L tone may co-occur with a [-voice] segment.

These markedness constraints, which prohibit the co-occurrence of tone values (H, L) with [+voice] or [-voice], are part of a family of phonetically-grounded constraints based on the articulatory incompatibility or affinity of certain feature values (Tang 2008; following Peng 1992; Archangeli and Pulleyblank 1994). These constraints give rise to consonant-tone interaction without reference to feature geometry (Hansson 2004; Lee 2008; Tang 2008; cf. Peng 1992; Bradshaw 1999).

In Ikalanga words with non-depressor consonants, the regular high tone agreement pattern works similarly to Dioula<sup>21</sup>. Because voiceless obstruents allow tone spread, the preconditioning feature for Ikalanga is IDENT-XX {V, R, N, K}, encompassing the entire range of the sonority hierarchy. More restrictive IDENT-XX {*x* sonority} constraints, such as IDENT-XX {V, R, N}, must rank below MAX-XX; otherwise, voiceless obstruents would not allow tone spread (e.g., candidate (54e)). The ranking of MAX-XX and IDENT-XX (tone) above input-output faithfulness to tone<sup>22</sup> produces the harmony of H tones that occurs in Ikalanga words without depressor consonants:

(54) Non-depressor: e.g., /né-tʃi-lopá/ → [néʃilópa] ‘and a liver’

/V tʃ V/ H T T	FAITH-IO (tone <sub>1</sub> )	IDENT-XX {V, R, N, K}	MAX-XX	IDENT-XX (tone)	IDENT-XX {V, R, N}	IDENT-IO (tone)
a. V <sub>i</sub> tʃ <sub>i</sub> V <sub>i</sub> H H H					1	2
b. V <sub>i</sub> tʃ <sub>i</sub> V <sub>i</sub> H T T				W1	1	L
c. V <sub>i</sub> tʃ <sub>j</sub> V <sub>j</sub> H H H			W1		1	2
d. V <sub>i</sub> tʃ <sub>i</sub> V <sub>i</sub> T T T	W1				1	L1
e. V <sub>i</sub> tʃ <sub>j</sub> V <sub>k</sub> H T T			W2		L	L

Though the winning candidate (54a) violates input-output faithfulness to tone, the higher-ranking correspondence and agreement constraints rule out candidates without matching tones (54b) or with insufficient correspondence between segments (54c). A high-ranking faithfulness constraint protecting the leftmost tone specification (FAITH-IO (tone<sub>1</sub>)) induces rightwards agreement (54d).

Blocking occurs when the relevant markedness constraint in (53) outranks IDENT-XX (tone). In these cases, the consonant will be opaque to an agreement and correspondence relationship because the markedness constraint disallows voiced segments from having a H tone specification. Instead, the result is an output that has maximal correspondence and tone agreement while taking into account the limitations imposed by the high-ranking markedness constraint, which prevents complete correspondence and H tone agreement as in forms with no depressor consonants present (e.g. (54)). When the outcome has only partial agreement, as with Type 2, high-toned definite nouns in Dioula (§4.4.2), there are multiple acceptable output candi-

<sup>21</sup> In the discussion of Ikalanga here, I follow previous work (Hyman and Mathangwane 1998; Mathangwane 1999) in assuming that Ikalanga only has specified H tones on the surface. Underspecified tone specifications ([T]) are realized as low phonetically, and free-standing, specified L tones on the surface are ruled out by a high-ranking constraint such as \*L or L/CONTOUR, as with Dioula. Therefore, candidates with free-standing specified L tones are not considered here.

<sup>22</sup> IDENT-IO (tone) penalizes for every change of value of the input tone specification. A /H/ → [L] change, therefore, results in two violations: once for the removal of the high tone specification and once more for the specification of low tone. A /H/ → [T] change only incurs one violation, for the deletion of the H tone value.

dates due to the partial ranking of MAX-XX and IDENT-XX (tone). For Ikalanga forms with depressor consonants, both optimal candidates (55a, b) exhibit as much tone agreement as the \*H/[+voice] constraint will allow: because the obstruent [b] cannot have a H tone specification (cf. (55c)), it remains underspecified for tone, and the corresponding vowel on the right deletes its input H in order to agree in tone specification, producing the surface tone melody [H T T]. The difference in correspondence relationships has no effect on the pronounced outcome. Fully faithful candidates (e.g., (55d, e)) are ruled out by the ranking of MAX-XX and IDENT-XX (tone) over input-output faithfulness to tone.

(55) Depressor effect: e.g., /né-báni/ → [nébani] ‘and a forest’

	/V b V/ H T H	...	*H/ [+voice]	IDENT-XX {V, R, N, K}	MAX-XX	IDENT-XX (tone)	IDENT-IO (tone)
☞ a.	V <sub>i</sub> b <sub>i</sub> V <sub>i</sub> H T T					1	1
(☞) b.	V <sub>i</sub> b <sub>j</sub> V <sub>j</sub> H T T				W1	L	1
c.	V <sub>i</sub> b <sub>i</sub> V <sub>i</sub> H H H		W1			L	1
d.	V <sub>i</sub> b <sub>j</sub> V <sub>k</sub> H T H				W2	L	L
e.	V <sub>i</sub> b <sub>i</sub> V <sub>i</sub> H T H					W2	L

## 5.2 Tones affecting consonant quality

Though less common, another way in which consonants and tones may interact is the influence of tones on consonant quality. In Wuyi (Wu, China), for example, high tone spread causes devoicing: the underlying voiced obstruent /v/ in /sa24-vuo31/ ‘raw meal’ devoices to [f] in [sa24 fuo53] when high tone spreads rightwards (Yip 2002: 34). Similarly in Yabem (alternatively, Jabem; Austronesian, Papua New Guinea), leftwards low tone spread causes voicing of underlying voiceless obstruents: /ká--wiŋ/ → [gàwiŋ] ‘accompany, 1 sg. realis’ (Yip 2002: 34; Hansson 2004). Additional examples of changes in consonant quality triggered by tone cross-linguistically are collected in Lee (2008: 56–58).

The typology of consonant-tone interactions generated by the basic ABC constraints predicts that it is possible for tones to affect consonant identity. Recall that in the typical ABC harmony system such as Dioula’s, input-output faithfulness to the triggering feature [αF]—for example, sonority—is usually ranked high, above the IDENT-IO constraint that targets the agreeing feature [βF] (see Hasse diagram in §4.1, (16)). If, however, IDENT-IO (sonority) is ranked below input-output faithfulness to tone, IDENT-IO (tone), consonant identity will be sacrificed for tone agreement. The toy example in (56) demonstrates voicing alternation in a system in which

segments and tones must correspond and agree, satisfying the IDENT-XX and MAX-XX constraints of the ABC system.

(56) Devoicing triggered by tone

/V b V/ H T H	*H/ [+voice]	IDENT-XX {V, R, N, K}	MAX-XX	IDENT-XX (tone)	IDENT-IO (tone)	IDENT-IO (sonority)
☞ a. V <sub>i</sub> p <sub>i</sub> V <sub>i</sub> H H H						1
b. V <sub>i</sub> b <sub>i</sub> V <sub>i</sub> H H H	W1					L
c. V <sub>i</sub> b <sub>i</sub> V <sub>i</sub> T T T					W2	L

In (56), a high-ranking markedness constraint banning the co-occurrence of H and [+voice] on a segment prevents a fully harmonic candidate that is faithful to voicing and sonority (56b) from surfacing because the voiced obstruent [b] would be associated with a high tone in the output. The ranking of IDENT-XX (tone) » IDENT-IO (sonority) produces devoicing of the obstruent (56a) to satisfy \*H/[+voice] and the correspondence and agreement constraints, IDENT-XX and MAX-XX. Because IDENT-IO (tone) outranks IDENT-IO (sonority), changes in sonority between input and output forms will be preferred to changes in tone (cf. (56c)).

## 6 Discussion



The ABC approach to consonant-tone phenomena put forth here has theoretical and typological implications for issues of ABC versus autosegmental feature spreading theories as well as for the treatment of the segment-tone relationship. In this section, I take up these issues in turn: the similarity basis as the primary difference between ABC and feature spreading (§6.1); boundedness and foot structure as an alternative approach to the Dioula pattern (§6.2); and consequences of the treatment of tone as a property of the segment (§6.3).

### 6.1 ABC versus feature spreading: the similarity basis

The crucial difference that distinguishes ABC from previous autosegmental feature spreading theories is the similarity basis that underlies harmony patterns in ABC. Under ABC, the determination of participants in a harmonic system depends on similarity: the more similar segments are—for instance, if they share specific feature values or even if they reside in similar syllabic or prosodic positions (e.g., Inkelas 2008; Adams 2010)—the more likely they are to interact and become more similar through agreement. Feature spreading approaches, on the other hand, do not regularly depend on relative similarity to determine the participants of a harmony system. Under autosegmental feature spreading, the burden of determining the participant segments in tone and harmony processes falls largely on the representational architecture (for an overview,

see Rose and Walker 2011: 257–260, and references therein). For tone in autosegmental approaches, theoretical stipulations governing what can be a legitimate TBU define the set of segments that can interact with tone. Segmental considerations, including the featural make-up of the segments themselves or the degree of similarity between segments, should play no roles.

With its segmental limitations, phenomena that require reference to properties of segments—for example, laryngeal features in depressor consonants—have remained a challenge for traditional feature spreading treatments. Likewise for Dioula tone type behavior, the sonority of the intervocalic final consonant finds no place in previous feature spreading analyses of the phenomenon, despite the fact that the relevance of the  $C_f$  has been recognized since the original description by Braconnier (1982; see also Hyman 1985: 476). Instead, previous autosegmental feature spreading analyses have focused on a representational puzzle of Type 1 versus Type 2 forms in describing the Dioula facts, positing that the tonal associations of the two tone types must differ underlyingly (Hyman 1985, 2011b). Because Type 2 nouns spread high tone twice from right to left, they should have the autosegmental representation given in (57a), in which the underlying low tone in *turu* links to both tone-bearing vowels. Before a high tone, the low tone deletes and is replaced by the high tone, which maintains the original tonal associations of the deleted low.

- (57) a. *turu*                      b. *sɛbe*  



Type 1 nouns cannot have the same autosegmental representation because high tone only replaces low tone on the final syllable of these forms. To explain the difference in tone spread between Type 1 and Type 2 nouns, Hyman’s (1985, 2011b) solution is to represent the tones of Type 1 nouns as two separate low tones (57b), where only the final low is deleted in the environment preceding a high tone. The representational solution presented in (57b), however, is noted by Hyman to be problematic because it violates the Obligatory Contour Principle in allowing two adjacent, tautomorphic low tones (Leben 1973). While this linking problem has been what has attracted the most attention to the Dioula pattern in the tone literature, it is a problem only for traditional feature spreading analyses that limit tone-bearing to vowels or moras, thus overlooking the crucial role that the intervocalic consonant plays in determining tone spread, as discussed in §§3–4.

It is possible, with modification to traditional autosegmental approaches, to escape the Dioula linking problem and include consonants in tone interactions. Lee’s (2008) xTBU theory is an example of a relaxation of the restriction in traditional autosegmental approaches on the strict association between TBUs and tones: in an xTBU approach, tones are allowed to associate with root nodes as well, although mora and tone associations remain the preferred mapping. By allowing onset consonants and tones to associate in this way, xTBU theory manages to achieve depressor and elevator effects in much the same way as the ABC approach proposed in §5 does, by using functionally-motivated markedness constraints restricting the co-occurrence of certain tone specifications and laryngeal features such as [voice]. A pattern like Dioula tone types, however, requires further amendments to xTBU theory to achieve, including the addition of a family of markedness constraints governing sonority and tone associations. While an analysis as such—though complex—is possible, it would still, like more traditional autosegmental feature spread-

ing approaches, miss the crucial insight that ABC provides: that the *similarity* of the segments involved facilitates tone agreement.

Strictly local feature spreading (Gafos 1996, 1998; Ní Chiosáin and Padgett 1997, 2001; a.o.) is another alternative approach building on autosegmental feature spreading that might deal well with consonant-tone interactions. The underlying assumption in strictly local spreading is that no intervening segments are wholly transparent to harmony—that is, all segments, including consonants and vowels, are undergoers. As such, consonant and tone interactions like depressor and elevator effects are allowed because consonants are part of the spreading domain (e.g., McCarthy 2004). The ABC analysis proposed here resembles strictly local spreading approaches in that MAX-XX requires the correspondence of all segments. Yet, ABC’s similarity precondition as the basis of harmony patterns remains the crucial difference between these two approaches, as with ABC and any feature spreading-based theory discussed thus far.

Because of its similarity precondition, an ABC approach to tone processes predicts that not only will the similarity in featural make-up of a segment determine agreement but also the degree of similarity between segments should have an effect: the more similar segments are, the greater the likelihood of agreement should be. Feature spreading and TBU-based approaches make no such similarity-based prediction. Here, Dioula Type 1 and Type 2 nouns provide further evidence in favor of a similarity-based approach.

In his original description of Dioula tone patterns, Braconnier (1982) mentions two other possible conditioning factors for the tone type distinction, though he provides no further investigation beyond impressionistic observation: the similarity of the vocalic environment surrounding the  $C_f$  and the presence of nasalization on the word-final vowel. An analysis of the Dioula noun corpus confirms Braconnier’s observations. If the vowels surrounding the  $C_f$  are identical, as in [félé] ‘collective hunting, def.’, the noun is more likely to exhibit Type 2 behavior than Type 1 behavior ( $\chi^2 = 15.322$ ,  $p < 0.0001$ ). If the final vowel has nasalization and the vowel preceding the  $C_f$  does not, as in [gèré] <sup>23</sup> ‘flank, def.’, the noun is more likely to be a Type 1 noun than a Type 2 noun ( $\chi^2 = 15.87$ ,  $p < 0.0001$ ). These corpus results suggest that tone agreement between the final two syllables is not only conditioned by the similarity in sonority of the  $C_f$  and the two surrounding vowels but also by the similarity of the vowels themselves.

Using regression modeling, we can further examine the effects of consonant and vowel similarity on determining tone agreement in Dioula nouns. The results of a logistic regression model with tone type class (Type 1 versus Type 2) as the dependent variable are given in the table in (58).  $C_f$  sonority, whether the surrounding vowels are identical, and nasalization on the final vowel were included as independent variables in the model.  $C_f$  sonority was coded on a numerical scale: obstruents = 1, nasals = 2, liquids = 3, and absence of  $C_f$ s = 4. Glides [y, w] and [g] were excluded. All predictors were centered by subtracting their means, and the numerical predictor of sonority was also divided by twice its standard deviation (following Gelman 2008).

(58) Logistic regression estimates: conditioning factors for Dioula Type 1 vs. Type 2 nouns

Factor	Odds Ratio	Estimate	Std. Error	z value	Pr (> t )	
Intercept	0.448	-0.804	0.089	-9.03	<0.0001	***
$C_f$ sonority	21.082	3.048	0.215	14.21	<0.0001	***
Nasalized final vowel	0.54	-0.617	0.198	-3.12	0.0018	*
Identical V...V	1.437	0.363	0.173	2.09	0.0364	.

<sup>23</sup> Orthographically, *gèrén*.

model $\chi^2$ (likelihood)	328.89 (df = 3)***	$R^2$	0.409
$D_{xy}$	0.678	%correct (%baseline)	83.9 (48.4)
. significant at $p < 0.05$ , * significant at $p < 0.01$ , ** significant at $p < 0.001$ , *** significant at $p < 0.0001$			

The model results demonstrate that whether a noun is Type 1 or Type 2 is dependent on the similarity in sonority between the  $C_f$  and its surrounding vowels as well as on the similarity of the surrounding vowels with each other. All else being equal, when the two vowels are identical, the likelihood that the noun is Type 2 and allows tone agreement on the two syllables increases by 43.7%. When the surrounding vowels are different and especially when the final vowel exhibits nasalization, the likelihood that the noun is Type 2 significantly decreases; the presence of nasalization on the final vowel alone lowers the likelihood of tone agreement by 54%. These results control for the effect of the sonority of the  $C_f$ , which the model results show to be the most robust predictor of tone agreement. This finding indicates that though similarity between the vowels affects tone agreement, the intervening consonant, as part of segment-to-segment correspondence, matters more<sup>24</sup>.

Taken together, these results suggest that the similarity of the string of segments involved crucially determines whether there is tone agreement in Dioula. Nouns in which the  $C_f$  is most similar in sonority with the surrounding vowels and in which the surrounding vowels are identical are the most likely to facilitate tone agreement between the penultimate and final syllables: for example, [fɛ́lɛ́] ‘collective hunting, def.’. Nouns in which the  $C_f$  is insufficiently similar in sonority with the surrounding vowels and in which the surrounding vowels differ in quality and nasalization will be less likely to facilitate tone agreement between the two syllables, resulting in Type 1 tone behavior limited to the final syllable: [fɔ́kǎ́]<sup>25</sup> ‘promise, def.’. An ABC approach, which takes similarity to be a determining factor of tone agreement, predicts that we should see such stacking effects of similarity that are found in Dioula. Feature spreading and TBU-based approaches, on the other hand, do not make this prediction. Therefore, insofar as similarity underlies the harmony process in question—for example, as in Dioula and in long distance consonant agreement—ABC offers a choice framework that allows the incorporation of said similarity basis.

## 6.2 Boundedness and a foot-based alternative

One issue that has not yet been addressed in the analysis of the Dioula pattern is the boundedness of tone agreement in words longer than two syllables. In Type 2 nouns of this length, the definite high tone spread is limited to the penultimate and final syllables: /dàrà̀mìnà -H/ → [dàrà̀míná] ‘interpreter/spokesman, def.’. There are no instances of Dioula nouns where the tone agreement triggered by the definite continues past the penultimate syllable: \*dàrá́míná.

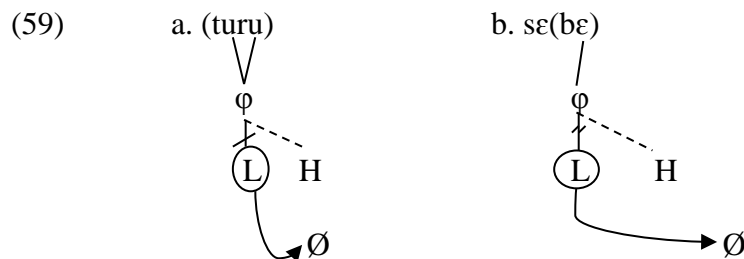
<sup>24</sup> The importance of the  $C_f$  can be better illustrated through a drop-one, -2 log likelihood test in which each predictor is removed in turn from the full model and the decrease in model goodness-of-fit (increase in -2 log likelihood) is recorded. The results of this test reveal that  $C_f$  sonority makes the greatest contribution to determining Type 1 versus Type 2 classification: removing sonority as a predictor from the model resulted in a larger significant decrease in model goodness-of-fit from the full model (increase in -2 log likelihood = 593.44,  $p < 0.0001$ ) when compared to removing any one of the other vowel similarity predictors. (Significant increases in -2 log likelihood, indicating decreases in model goodness-of-fit, by removing each of the following predictors: nasalized vowel = 20.08,  $p < 0.0001$ ; identical V...V = 8.84,  $p = 0.0029$ )

<sup>25</sup> Orthographically, fɔ́kǎ́n.

An analysis of the Dioula data must provide an explanation for the boundedness of tone agreement. Under an ABC approach, there are at least two ways to achieve agreement domains when necessary: the boundaries of correspondence and agreement could be dictated by morphological domains such as the word or root, or the domain of agreement could be demarcated by a segment that blocks further directional correspondence. To be able to attribute the boundedness of Dioula tone agreement to a morphological domain would be convenient and consistent with the behavior of consonant harmony systems, which are most commonly constrained by morphological constituents (Hansson 2001), but this is obviously not the case in Dioula as there is, to the best of my knowledge, no consistent internal morphological structure to the longer nouns. I argue, therefore, that the boundedness of Dioula tone spread arises from the latter cause: blocking segments that are not sufficiently sonorant to transmit tone. A corpus count reveals that the onset consonants of the penultimate syllables of Type 2 nouns are more often obstruents (e.g., [bòròkúru] ‘fist, def.’) than they are sonorants (e.g., [dàràmíná] ‘interpreter/spokesman, def.’). This distribution significantly differs from the expected, null hypothesis distribution, given the number of obstruents and sonorants in the Dioula inventory ( $\chi^2 = 12.233$ ,  $p = 0.0005$ ). Amongst sonorants in Type 2 nouns longer than 2 syllables, there is only one instance where the penultimate onset consonant is a liquid: [lògòlógó] ‘corner, def.’. All other sonorant penultimate onset consonants are mostly nasals or less commonly, [w]. This finding suggests that while the  $C_s$  in Dioula Type 2 nouns facilitate tone agreement by being sonorous, the penultimate onset consonants of these same nouns are more likely to halt tone spread because they are not sonorous enough to correspond with the surrounding vowels and transmit pitch: this is the same correspondence preconditioning mechanism that derives tone behavior in Type 1 nouns.

The shortcoming of the sonority and similarity-based analysis is that it does not adequately limit spread to the final two syllables for nouns where the penultimate onset consonant is a sonorant, as in [dàràmíná] or [lògòlógó]: what prevents further leftwards tone agreement in these cases if sonority does not? Moreover, to achieve the boundedness effect using an ABC approach, there must also be some phonotactic mechanism that constrains the co-occurrence of two sonorous consonants in the onsets of adjacent syllables, if it is the sonority of these segments that defines the boundaries of the tone agreement domain.

An alternative analysis is suggested by Larry Hyman (*p.c.*) and proposes to introduce intermediary prosodic structure to the Dioula analysis via an appeal to tonal feet to address the boundedness of tone in Type 1 versus Type 2 behavior. In this foot-based approach, tone in Dioula is a property of a bimoraic foot. For Type 2 nouns, the final two moras form a foot, as shown in (59a), and the definite high tone marker replaces tone on the entire foot:



Type 1 nouns are posited to have a different underlying foot structure than Type 2 nouns, as illustrated in (59b), with a word-final degenerate foot with a single mora. Because high tone only spreads to the final foot of the word, Type 1 nouns surface with a different tonal pattern limited



in scope to the final, monomoraic foot. The difference in the boundedness of tone spread, under this autosegmental, foot-based analysis, stems from the differences in footing between Type 1 and Type 2 nouns. Having a bimoraic word-final foot, furthermore, limits the domain of tone spread to the final two syllables in Type 2 words that are longer than a bimoraic foot.

There are advantages to this alternative, foot-based approach: most notably, that boundedness is easily explained using prosodic structure. In his grammar of Dioula tone, Braconnier also notes that in careful speech, final vowel lengthening occurs in definite, Type 1 nouns (e.g., /sɛbɛ -H/ → [sɛ́bɛ:] ‘paper, def.’) and does not occur in definite, Type 2 nouns (e.g., /turu -H/ → [tú́rú], \*tú́rú: ‘oil, def.’) (Braconnier 1982: 23). Under a foot-based analysis, this alternation can be taken as compensatory lengthening in Type 1 nouns to provide an additional mora to a degenerate foot when the definite high tone is compelled to link to two moras. There is also some precedence for tonal and segmental foot-based proposals for related languages in the Mande family, though these have been motivated for other reasons (e.g., for various dialects of Bambara: Leben 2002, 2003; Weidman and Rose 2006; Green et al. 2012).

Under a foot-based analysis, the distribution of sonorant and obstruent consonants in Dioula becomes a consequence of foot structure and is epiphenomenal to the tone agreement patterns. The particular distribution of consonant types arises from restrictions placed on feature contrasts or on consonant inventories in foot-internal positions. Such effects involving foot-based constraints have been noted in other languages. Gahl (1996: 339–340) reports that Mathimathi (Kulin, Australia) tends to have coronal consonants intervocally, restricting the occurrence of non-coronals in these positions. In Ibibio (Cross-River, Nigeria), the voiceless velar stop contributed by the negative suffix *-ké* weakens when it forms a trochaic foot with the root, either by spirantization (/dí-ké/ → [díyɛ], ‘come.NEG’), assimilation (/díp-ké/ → [dippé], ‘buy.NEG’), or deletion (/wèèm-ké/ → [wèémé], ‘flow.NEG’). When *-ké* does not form a trochaic foot with the root, no weakening occurs: /dápá-ké/ → [dápáké], ‘dream.NEG’ (Hyman 2011a: 69–70, and references therein). Other languages, like Tieni (Bantu, Democratic Republic of Congo), have been observed to restrict not only consonants but also vowels in certain prosodic domains (Hyman and Inkelas 1997). For Dioula, then, we would have to posit a set of segmental restrictions relating to feet: foot-internal consonants must be sonorous, foot-initial consonants must be obstruent, and vowels belonging to the same foot should be maximally similar.

As reasonable as a foot-based analysis may be, there are also arguments and advantages against such an approach and for the ABC analysis used herein. First, it is unclear from Braconnier’s description of Dioula whether the vowel lengthening process on Type 1 nouns is contrastive or merely phonetic. Braconnier himself comments that the effect is only robust in slow, careful speech situations (1982: 71), and the lengthening remains unnoted in the majority of the phonological description of Dioula and in the Braconnier and Diaby (1982) dictionary. It is possible that this lengthening is merely a phonetic consequence of longer durations to host the contours and tone contrasts that occur on Type 1 and not on Type 2 nouns—lengthening to support contour tones, for example, is a well-known phonetic effect (e.g., Zhang 2001). Future phonetic investigation and more data are necessary to elucidate the vowel lengthening effect in Dioula. Second, a foot-based analysis posits prosodic structure that has not been shown to be necessary in or referenced by other parts of Dioula phonology; for example, there is no minimal, bimoraic word constraint, and a monomoraic syllable with no vowel lengthening is a perfectly acceptable word (e.g., *cé* ‘man, husband, indef.’). Lastly, insofar as phonological grammars should strive to be rooted by functional motivations, ABC allows us to capture a phonetically-grounded basis to the Dioula tone type phenomena—that the ability of specific segments to carry and transmit pitch

determines tone spread—without having to assume extra prosodic structure where there is limited language-internal evidence at this point to do so.

### 6.3 The tone-bearing unit in ABC

The major contribution of autosegmental theory for tone is the independence—or “semi-autonomy” (Hyman 2011b: 206)—of tones from the segments with which they are associated (Leben 1973; Goldsmith 1976; et seq.). Autosegmental theory liberated tones from their representations as feature values of segments in the earlier segmental approach (e.g., Chomsky and Halle 1968). The independence of tones and the mechanisms to deal with them provided by autosegmental theory reflect a number of properties observed for tone behavior: non-isomorphism between tones and segments, the mobility of tones, the stability and perseverance of tones following the deletion of segments, and the presence of tone-only morphemes with no segmental material (Yip 2002; Hyman 2011b; and references therein). Many of these insights and devices of autosegmental theory have found their way into feature geometry extensions beyond the tonal domain—to vowel and consonant harmony systems, for example (Rose and Walker 2011, and references therein).

Whereas autosegmental theory treats tones as independent entities, the proposed ABC-based analysis given in this paper maintains that there exists a closer relationship between tones and the properties of the segments with which they are associated—returning, in some respects, to a segment-based view of tone. Positing this type of more intimate connection between tones and segments and removing reference to intermediary structure such as TBUs and moras allows tones to be more grounded—either phonetically or phonologically—to the segments on which they are realized, a concept which is particularly useful for handling consonant-tone interactions. An advantage of this arrangement, for example, is that the functionally-motivated markedness constraints posited for depressor and elevator effects (e.g., \*H/[+voice]) fit naturally into a framework in which tone processes depend in part on segment quality: if we allow the properties of segments to determine the extent to which the segments themselves can host tones and transmit pitch information to begin with, then the idea that certain articulatory incompatibilities can interfere with segment-tone co-occurrences is not surprising and is in fact expected. Under autosegmental feature spreading analyses, however, the introduction of the depressor and elevator markedness constraints seems like a more ad hoc patch on a representational system otherwise based on moras and legitimate TBUs<sup>26</sup>.

Although consonant-tone interactions have been the primary focus here, it is also expected under the current proposal that vowels and tones could exhibit similar interactions given the direct relationship permitted between tones and segments. Phonetically, there is a link between vowel height and F0 (Whalen and Levitt 1995; a.o.), usually noted in the direction of

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<sup>26</sup> Lee’s (2008) xTBU theory is perhaps the closest autosegmental-based analogue to the current ABC proposal. xTBU theory forces all root nodes and tones to interact through the presence of a ROOTNODE→T constraint, akin in some respects to MAX-XX in the ABC system. With the direct association of consonants and tones, depressor and elevator effects are achieved through the use of markedness constraints such as \*H/[+voice]. xTBU theory makes many of the same predictions as ABC, but crucially, ABC constrains the typological space of segment-tone behavior by building in the similarity prerequisite for agreement and harmony that xTBU theory does not have. The insight from ABC that is missing in xTBU theory is that the relationship between tones and segmental properties is essential in determining segment-tone interactions. This difference allows ABC to capture both the more familiar depressor and elevator effects as well as phenomena like the Dioula tone type pattern.

higher vowels correlating with heightened pitch (though cf. Hombert et al. 1979: 52–53 for a phonetic explanation of the opposite effect). Phonologically, whether there is a correlation between vowel quality and tones remains an unresolved question, often mired in the same issues of syllable structure and mora licensing as the coda consonant and tone interactions discussed in §2 (e.g., Jiang-King 1996). Becker and Jurgec (to appear) report on at least one possible unambiguous case in Slovenian, in which tense and lax vowels correlate with high and mid tones, respectively. To account for this pattern, the authors propose a markedness constraint governing the co-occurrence of high tones and [-ATR, -low] vowels (\*H/[-ATR, -low]), achieving an effect similar to the treatment of depressor and elevator consonants using markedness constraints as outlined in §5 (see also Lee 2008).

While allowing tones to behave as properties of segments facilitates the treatment of consonant and tone interaction, whether this segmental approach is the correct one to take, given a complete and thorough examination of the tone facts, is a question saved for future work. I will, however, mention briefly one potential ramification here, where the proposed, segment-based ABC theory will necessarily require some expansion. ABC, as used here, assesses the correspondence and agreement of tones on a segment-by-segment basis. As a consequence of this analysis, contour tones (§4.4) are treated as a unit in agreement, whereas in traditional autosegmental feature spreading approaches, contour tones are series of independent tones associated with a single node. The segmental, ABC treatment predicts, then, that there should be patterns where contour tones behave as a unit. Though rare, such cases of contour tone copying have been reported (Yip 1989; Chan 1991; Duanmu 1994; a.o.). In Changzhi (a dialect of Mandarin Chinese), the suffixes /-təʔ/ and /-ti/ feature duplication of the entire contour tone of the preceding root, as shown in (60) (data from Duanmu 1994: 562):

- |      |    |                                       |                      |
|------|----|---------------------------------------|----------------------|
| (60) | a. | kuə <sup>213</sup> təʔ <sup>213</sup> | ‘pan, diminutive’    |
|      | b. | səŋ <sup>24</sup> təʔ <sup>24</sup>   | ‘rope, diminutive’   |
|      | c. | ti <sup>535</sup> təʔ <sup>535</sup>  | ‘bottom, diminutive’ |
|      | d. | təu <sup>53</sup> təʔ <sup>53</sup>   | ‘bean, diminutive’   |

In autosegmental feature spreading, the spreading of an entire contour tone requires the use of tonal nodes in feature geometry in order to avoid the representational crossing of association lines. In an ABC approach, however, no such problem arises since the contour tones, as a whole property of the segment, are copied to the next segment in an agreement and correspondence relationship. Duanmu (1994: 586) arrives at a similar conclusion for the Changzhi pattern, arguing that Changzhi is an example of tone copying rather than of the spreading of contours.

The Optimality-theoretic treatment of contour tones given here moreover predicts that patterns exhibiting the copying of contour tones should be vanishingly rare—as they cross-linguistically are. Recall that the Dioula analysis restricted the copying of contour tones using a COINCIDE(Contour=final) constraint that licensed contours in word-final position only (§4.4.1). This constraint comes from a family of contour tone licensing constraints, as proposed by Zoll (2003; following Zhang 2001), which limit the appearance of contour tones to “positions of canonically longer duration or greater sonority” (Zoll 2003: 236), such as long vowels, word-final positions, and sonorous rhymes. Given that there are more constraints of this type that restrict contour tones than there are constraints that require them—for instance, there are no constraints of the type HAVECONTOUR—there will always be more grammars that prohibit contour tones and

thus contour tone copying than there will be possible grammars that allow the proliferation of contour tones.

The problem for the segment-based, ABC approach, then, comes from the cases where the individual components of contour tones can act independently, which are easily captured using autosegmental theories based on the mobility and autonomy of tones. One example of the independence of parts of contours is Hakha-Lai (Tibeto-Burman, Burma) tone sandhi in compounds (Hyman and VanBik 2002). In certain Hakha-Lai compound constructions, halves of contours must agree with the neighboring tone on adjacent syllables following the prefix *ka-* ‘my’ (data from Hyman and VanBik 2002: 17)<sup>27</sup>:

(61)		Underlying	Surface	
a.	LH HL	thlaán + zuù	thlaán zuù	‘grave beer’
	HL LH	tlaàŋ + tsaán	tlaàŋ tsaán	‘mountain time’
	L LH	koom + tsaán	koom tsaán	‘corn time’
	HL L	tlaàŋ + saa	tlaàŋ saa	‘mountain animal’
	L L	koom + saa	koom saa	‘corn animal’
b.	HL HL → HL L	tlaàŋ + zuù	tlaàŋ zuu	‘mountain beer’
	L HL → L L	koom + zuù	koom zuu	‘corn beer’
	LH LH → LH HL	thlaán + tsaán	thlaán tsaàn	‘grave time’
	LH L → L L	thlaán + saa	thlaan saa	‘grave animal’

If the immediately adjacent tones in the underlying forms are identical (61a), then no tone changes will occur: for example, a rising contour LH next to a falling contour HL share identical adjacent H tone specifications, and no input to surface changes occur. In contrast, when the neighboring tones do not agree, as in a sequence of two rising LH contours (61b), then tones of the second syllable will change so as to have identical adjacent tone specifications across the nouns of the compound. In the case of two adjacent rising contours—/LH + LH/—the second rise will become a fall, to produce a sequence of two high tones—[LH HL].

Because the ABC analysis for contour tones used here treats contours as units as a consequence of correspondence and agreement on a segmental level, a pattern like Hakha-Lai tone sandhi is a challenge. The current formulation of ABC for tone lacks a method of targeting parts of segments, and given the prevalence of the independence of contour tone components (for an overview, see Yip 2002: 47–50, and references therein), some means to refer to the subparts of a segment are needed, if we are to pursue the use of ABC for tonal phenomena. Moreover, how to deal with contour features is not a problem unique to the use of ABC for tone. Vowel and consonant harmony phenomena also present a similar issue with contour segments: prenasalized consonants, affricates, diphthongs. Prenasalized consonants can, for example, require agreement as a unit (as in Ngbaka; Rose and Walker 2004: 502–507), be transparent to nasal harmony (as in Kiyaka; Hyman 1995), and be triggers to (regressive) nasal harmony (as in Guaraní; Walker 1998: 211; or as in Terena; Piggott 2003: 417). The treatment of these contour segments within previous ABC analyses has relied on a variety of representational solutions—for instance, the lack of

<sup>27</sup> Departing from Hyman and VanBik’s (2002) tonal representations but in keeping with their orthographic tones for Hakha-Lai, fall = HL, à; rise = LH, á; low = L, Ø.

[nasal] specification or assumptions on syllable structure (e.g., Rose and Walker 2004: §5)—and a systematic treatment, if one exists, has yet to be reached<sup>28</sup>.

Finally, there remains the possibility that phenomena involving parts of contour tones and contour segments mark the limits of ABC. The use of ABC here allowed the theory to operate locally from segment to segment, demonstrating that the theory need not be limited to long distance interactions, as it was originally intended. Crucially, however, the local correspondence and agreement is still dependent on the prerequisite of similarity, and if segments are insufficiently similar, they will not interact. An obvious case based on syllable similarity might be made for instances of whole contour tone copying such as the Changzhi pattern in (60), but it may be that cases like Hakha-Lai in (61) exemplify truly autosegmental behaviors. Likewise, analogous distinctions have been made between strictly local spreading phenomena and long distance consonant and vowel harmonies (e.g., Gafos 1996; Piggott 2003; Rose and Walker 2004). An open question for future investigation, then, is to what extent there is a similarity basis underlying the local phenomena of contour tone behavior: the answer to this question will dictate the suitability of extending ABC to tonal phenomena as well as to other phenomena traditionally reserved for autosegmental feature spreading.

## 7 Conclusion

This paper offers evidence that sonority and tone have a direct relationship. Under the hypothesis that more sonorous sounds are better at transmitting pitch than less sonorous sounds, we expect to see gradient differences between how sounds along the sonority scale interact with tone. More sonorous segments, including vowels or liquids, should allow for the transmission of tone more freely, while less sonorous segments, including obstruents and nasals to some extent, should disrupt the transmission of tone and more often exhibit blocking effects. The case of Dioula d'Odienné's definite nouns offers critical evidence from onset consonants in the sonorant range of the sonority hierarchy, showing that, even amongst sonorant consonants, sonority affects how well tone will carry through a segment. Moreover, cases like Dioula, which are distinct from more widely discussed depressor and elevator consonant-tone phenomena, are necessary to consider in the development of a framework for consonant-tone interaction, as they provide possible motivation for shifting from traditional autosegmental feature spreading approaches to similarity-based approaches like Agreement by Correspondence for tone.

ABC's similarity-based approach offers a distinct advantage in describing certain vowel-tone and consonant-tone interactions that depend on sonority and similarity whereas feature spreading makes no reference to such a similarity basis. In the particular case of Dioula, the autosegmental analyses that have been proposed treat the sonority-tone effect as epiphenomenal rather than an actual driving force behind the tonal patterns that the language exhibits. Furthermore, ABC dispenses with the reliance on representational and process-based machinery that autosegmental theories bring to a decidedly non-representational, output-oriented theory like OT.

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<sup>28</sup> Many of the previous discussions of contour segments suggest a potential unifying solution in Aperture Theory (Steriade 1993) in allowing release and closure phases of contour segments to play into correspondence, similarity assessment, and agreement. While this may be a promising solution for contour segments like prenasalized consonants and affricates, it remains to be seen how an approach like Aperture Theory, which was originally based on the phonetics of consonantal segments, could extend to vowel and tonal phenomena (e.g., see Inkelas and Shih (2013) for a unified approach to contour segments and tones based on Aperture-theoretic, subsegmental correspondence).

ABC removes the need to include nodes or make reference to feature geometric representations, and it places no *a priori* restrictions on which segments may enter into correspondence relationships. Instead, the determination of correspondence and agreement between segments is left to functionally motivated constraints that are general to the phonological system—such as those based on the sonority as a prerequisite for correspondence—rather than singular to the tone system alone.

It has been demonstrated, in previous work and in this paper, that ABC has the ability to operate beyond its originally established parameters of long distance consonant harmony phenomena, including dealing with vowel harmony (Sasa 2009; Walker 2009; Rhodes 2010), dissimilation (Bennett 2013), and consonant-tone patterns (this paper). In the push to distinguish ABC and autosegmental feature spreading, the arena of tone makes for a particularly fertile testing ground for probing the limitations and differences between the two theories. Tone phenomena once provided the strongest impetus for the development of autosegmental theory, the insights of which were also adopted for segmental phonology. As Hyman (2011b) asserts, “*Tone can do everything that segmental or metrical phonology can do, but the reverse is not true*” (236, his emphasis). The challenge for ABC, then, is whether the insights gained from similarity-driven consonant and vowel harmonies can extend back into tone phenomena, and to what extent ABC can account for everything that tone can do.

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## References

- Adams, Matthew E. 2010. Poetic correspondence and the Welsh *cynghanedd* meter. Paper presented at the Metrics and Poetic Forms Workshop. Stanford University. 10 April 2010.
- Anttila, Arto. 1997. Deriving variation from grammar. In *Variation, Change, and Phonological Theory*. Frans Hinskens; Roeland van Hout; and Leo Wetzels (eds). 35–68. Amsterdam: John Benjamins.
- Anttila, Arto. 2002. Morphologically conditioned phonological alternations. *Natural Language and Linguistic Theory*. 20: 1–42.
- Anttila, Arto. 2007. Variation and optionality. In *The Cambridge Handbook of Phonology*. Paul de Lacy (ed). 161–194. Cambridge, UK: Cambridge University Press.
- Anttila, Arto. 2008. Gradient phonotactics and the Complexity Hypothesis. *Natural Language and Linguistic theory*. 26: 695–729.
- Anttila, Arto. 2010. Word stress in Finnish. Paper presented at Yale University. 1 February 2010. <http://www.stanford.edu/~anttila/research/yale-ho-2010-final.pdf>
- Archangeli, Diana and Douglas Pulleyblank. 1994. *Grounded Phonology*. Cambridge, MA: MIT Press.
- Banksira, Degif Petros. 2000. *Sound mutations: The morphophonology of Chaha*. Amsterdam: John Benjamins.

- Becker, Michael. 2009. Phonological trends in the lexicon: the role of constraints. PhD dissertation. University of Massachusetts, Amherst.
- Becker, Michael and Peter Jurgec. to appear. Interactions of tone and ATR in Slovenian. In *Tone and segmental structure*. Wolfgang Kehrein and Björn Köhnlein (eds). Tübingen: Niemeyer.
- Bennett, William G. 2013. Dissimilation, consonant harmony, and surface correspondence. PhD dissertation. Rutgers, the State University of New Jersey.
- Blevins, Juliette. 1995. The syllable in phonological theory. In *The Handbook of Phonological Theory*. John A. Goldsmith (ed). 206–244. Cambridge, MA: Blackwell Publishers.
- Boersma, Paul. 1997. How we learn variation, optionality, and probability. *Proceedings of the Institute of phonetic sciences of the University of Amsterdam*. 21: 43–58.
- Boersma, Paul and Bruce Hayes. 2001. Empirical tests of the Gradual Learning Algorithm. *Linguistic Inquiry*. 32: 45–86.
- Braconnier, Cassian. 1982. *Le système tonal du dioula d’Odienné*, tome 1. Abidjan, Ivory Coast: Université d’Abidjan.
- Braconnier, Cassian and S. Diaby. 1982. *Dioula d’Odienné: Material Lexical*. Institut de Linguistique Appliquée, No 96. Agence de coopération culturelle et technique.
- Braconnier, Cassian. 1983. *Phonologie du dioula d’Odienné*. Agence de coopération culturelle et technique.
- Bradshaw, Mary. 1999. *A Crosslinguistic Study of Consonant-Tone Interaction*. PhD dissertation. Ohio State University.
- Chan, Marjorie K. M. 1991. Contour-tone spreading and tone sandhi in Danyang Chinese. *Phonology*. 8: 237–259.
- Cho, Young-mee Yu. 1991. Voicing is not Relevant for Sonority. *Proceedings of the 17<sup>th</sup> Annual Meeting of the Berkeley Linguistic Society*.
- Chomsky, Noam and Morris Halle. 1968. *The Sound Pattern of English*. New York: Harper and Row.
- Clements, G. N. 1990. The role of the sonority cycle in core syllabification. In *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*. Mary E. Beckman and John Kingston (eds). 283–333. Cambridge, UK: Cambridge University Press.
- Crowhurst, Megan and Lev Michael. 2005. Iterative footing and prominence-driven stress in Nanti (Kam-pa). *Language*. 81(1): 47–95.
- de Lacy, Paul. 2002. *The Formal Expression of Markedness*. PhD dissertation. University of Massachusetts, Amherst.
- de Lacy, Paul. 2004. Markedness Conflation in Optimality Theory. *Phonology*. 21(2): 145–199.
- de Lacy, Paul. 2007. The interaction of tone, sonority, and prosodic structure. In *The Cambridge Handbook of Phonology*. Paul de Lacy (ed). 281–307. Cambridge, UK: Cambridge University Press.
- Downing, Laura. 2001. Voiceless Tone Depressors in Nambya and Botswana Kalang’a. *Proceedings of the 27<sup>th</sup> Annual Meeting of the Berkeley Linguistic Society*.
- Duanmu, San. 1994. Against Contour Tone Units. *Linguistic Inquiry*. 25(4): 555–608.
- Dutcher, Katharine and Mary Paster. 2008. Contour tone distribution in Luganda. In *Proceedings of the 27<sup>th</sup> West Coast Conference on Formal Linguistics*. Natasha Abner and Jason Bishop (eds). 123–131. Somerville, MA: Cascadilla Proceedings Project.
- Frisch, Stefan; Janet Pierrehumbert; and Michael Broe. 2004. Similarity avoidance and the OCP. *Natural Language and Linguistic Theory*. 22: 179–228.
- Gafos, Diamandis. 1996. *The articulatory basis of locality in phonology*. PhD dissertation. Johns Hopkins University. [Published, New York: Garland. 1999.]
- Gafos, Diamandis. 1998. Eliminating long-distance consonantal spreading. *Natural Language and Linguistic Theory*. 16: 223–278.
- Gahl, Susanne. 1996. Syllable onsets as a factor in stress rules: the case of Mathimathi revisited. *Phonology*. 13: 329–344.
- Gallagher, Gillian. 2008. Total identity in co-occurrence restrictions. *Proceedings of the 34<sup>th</sup> Annual Meeting of the Berkeley Linguistic Society*.

- Gallagher, Gillian and Jessica Coon. 2009. Distinguishing total and partial identity: Evidence from Chol. *Natural Language and Linguistic Theory*. 27: 545–582.
- Gelman, Andrew. 2008. Scaling regression inputs by dividing by two standard deviations. *Statistics in Medicine*. 27: 2865–2873.
- Goldsmith, John A. 1976. *Autosegmental Phonology*. PhD dissertation. Massachusetts Institute of Technology.
- Golston, Chris. 1995. Syntax Outranks Phonology: Evidence from Ancient Greek. *Phonology*. 12(3): 343–368.
- Gordon, Matthew. 2001. A typology of contour tone restrictions. *Studies in Language*. 25: 405–444.
- Gouskova, Maria. 2004. Relational hierarchies in Optimality Theory: the case of syllable contact. *Phonology*. 21(2): 201–250.
- Green, Christopher R.; Stuart Davis; Boubacar Diakite; and Karen Baertsch. 2012. Domain-restricted reduction: A proposal for segmental feet in Bamana. In *Selected Proceedings of the 41<sup>st</sup> Annual Conference on African Linguistics*. Bruce Connell and Nicholas Rolle (eds). Somerville, MA: Cascadilla Proceedings Project.
- Halle, Morris and Kenneth Stevens. 1971. A note on laryngeal features. *Quarterly Progress Report of the Research Laboratory of Electronics*. 101: 198–213.
- Hansson, Gunnar. 2001. *Theoretical and Typological Issues in Consonant Harmony*. PhD dissertation. University of California, Berkeley.
- Hansson, Gunnar. 2004. Tone and voicing agreement in Yabem. In *Proceedings of the 23<sup>rd</sup> West Coast Conference on Formal Linguistics*. B. Schmeiser; V. Chand; A. Kelleher; and A. Rodriguez (eds). 318–331. Somerville, MA: Cascadilla Press.
- Hansson, Gunnar. 2007. Blocking Effects in Agreement by Correspondence. *Linguistic Inquiry*. 38(2): 395–409.
- Harrell, Frank E., Jr. 2012. rms: rms package. R package version 3.6. [cran.r-project.org/web/packages/rms](http://cran.r-project.org/web/packages/rms)
- Hayes, Bruce; Bruce Tesar; and Kie Zuraw. 2003. OTSoft 2.1. software package. <http://www.linguistics.ucla.edu/people/hayes/otsoft/>
- Hombert, Jean-Marie; John J. Ohala; and William G. Ewan. 1979. Phonetic Explanations for the Development of Tones. *Language*. 55(1): 37–58.
- Hyman, Larry. 1985. Review: Le système tonal du dioula d’Odienné. *Language*. 61(2): 474–476.
- Hyman, Larry M. 1995. Nasal consonant harmony at a distance: the case of Yaka. *Studies in African Linguistics*. 24(1): 5–30.
- Hyman, Larry. 2000. Privative tone in Bantu. Paper presented at Symposium on Tone. ILCAA. Tokyo. 12–16 December 2000. [http://www.linguistics.berkeley.edu/~hyman/Privative\\_Tone\\_Tokyo\\_A4.pdf](http://www.linguistics.berkeley.edu/~hyman/Privative_Tone_Tokyo_A4.pdf)
- Hyman, Larry. 2011a. Does Gokana really have no syllables? Or: what’s so great about being universal? *Phonology*. 28: 55–85.
- Hyman, Larry. 2011b. Tone: Is it different? In *The Handbook of Phonological Theory*, Second Edition. John Goldsmith; Jason Riggle; and Alan C. L. Yu (eds). 197–239. Oxford, UK: Blackwell Publishing.
- Hyman, Larry. 2011c. The Representation of Tone. In *The Blackwell Companion to Phonology*. Volume II: Suprasegmental and Prosodic Phonology. Marc van Oostendorp; Colin J. Ewen; Elizabeth Hume; and Keren Rice (eds). 1078–1102. Malden, MA: Wiley-Blackwell.
- Hyman, Larry M. and Sharon Inkelas. 1997. Emergent Templates: The unusual case of Tiene. In *University of Maryland Working Papers in Linguistics 5*. Viola Miglio and Bruce Morén (eds). 92–116. College Park: University of Maryland.
- Hyman, Larry and Joyce T. M. Mathangwane. 1998. Tonal domains and depressor consonants in Ikalanga. *The theoretical aspects of Bantu tone*. 195–230.
- Hyman, Larry and Al Mtenje. 1999. Prosodic morphology and tone: the case of Chichewa. In *The Prosody-Morphology Interface*. René Kager; Harry van der Hulst; and Wim Zonneveld (eds). 90–133. Cambridge, UK: Cambridge University Press.



- Hyman, Larry and Kenneth VanBik. 2002. Tone and syllable structure in Hakha-Lai. *Proceedings of the 28<sup>th</sup> Annual Meeting of the Berkeley Linguistic Society*. 15–28.
- Hyslop, Gwendolyn. 2009. Kurtöp Tone: A tonogenetic case study. *Lingua* 119: 827–845.
- Inkelas, Sharon. 1998. The theoretical status of morphologically conditioned phonology: a case study of dominance effects. In *Yearbook of Morphology 1997*. Geert Booij and Jaap van Marle (eds). 121–156. Dordrecht, The Netherlands: Kluwer Academic Publishers.
- Inkelas, Sharon. 2008. The dual theory of reduplication. *Linguistics*. 46(2): 351–401.
- Inkelas, Sharon. to appear. Over- and underexponence in morphology. In *Revealing structure: Finding patterns in grammars and using grammatical patterns to elucidate language*, A festschrift to honor Larry M. Hyman. Gene Buckley; Thera Crane; and Jeff Good (eds). Stanford, CA: CSLI Publications.
- Inkelas, Sharon; Orhan Orgun; and Cheryl Zoll. 1997. The implications of lexical exceptions for the nature of grammar. In *Derivations and Constraints in Phonology*. Iggy Roca (ed). 393–418. New York: Oxford University Press.
- Inkelas, Sharon and Stephanie S Shih. 2013. Contour segments and tones in (sub)segmental Agreement by Correspondence. Paper presented at the 21<sup>st</sup> Manchester Phonology Meeting. University of Manchester, UK. 25 May 2013. <http://stanford.edu/~stephsus/InkelasShih-mfm2013.pdf>
- Jany, Carmen; Matthew Gordon; Carlos M Nash; and Nobutaka Takara. 2007. How universal is the sonority hierarchy?: A cross-linguistic acoustic study. *Proceedings of the 16<sup>th</sup> International Congress of Phonetic Sciences*. 1401–1404.
- Jespersen, Otto. 1904. *Fonetik*. Copenhagen: Det Schuboeske Forlag.
- Jiang-King, Ping. 1996. An Optimality account of tone-vowel interaction in Northern Min. PhD dissertation. University of British Columbia.
- Kiparsky, Paul. 1994. Remarks on Markedness. Paper presented at Trilateral Phonology Weekend 2. University of California, Santa Cruz. 22 January 1994. [www.stanford.edu/~kiparsky/Papers/trend.pdf](http://www.stanford.edu/~kiparsky/Papers/trend.pdf)
- Kurisu, Kazutaka. 2001. The phonology of morpheme realization. PhD dissertation. University of California, Santa Cruz. ROA-490.
- Leben, William. 1973. *Suprasegmental Phonology*. PhD dissertation. Massachusetts Institute of Technology.
- Leben, William R. 2002. Tonal feet. In *Proceedings, Typology of African Prosodic Systems, Volume 1*. Ulrike Gut and Dayfdd Gibbon (eds). 27–40. Bielefeld, Germany: Bielefeld Occasional Papers in Typology.
- Leben, William R. 2003. Tonal feet as tonal domains. In *Trends in African Linguistics 5: Linguistic typology and representation of African languages*. John Mugane (ed). 129–138. Trenton: Africa World Press.
- Lee, Seunghun Julio. 2008. *Consonant-Tone Interaction in Optimality Theory*. PhD dissertation. Rutgers, the State University of New Jersey.
- Leslau, Wolf. 1979. *Etymological dictionary of Gurage (Ethiopic)*. Wiesbaden: Otto Harrassowitz.
- Levergood, Barbara. 1989. Arusa (Maa) Phrasal Tonology. In *Current Approaches to African Linguistics*, volume 5. Paul Newman and Robert D. Botne (eds). 221–236. Dordrecht, Holland: Foris Publications.
- Mathangwane, Joyce Thambole Mogatse. 1999. *Phonetics and Phonology of Ikalanga: a diachronic and synchronic study*. PhD dissertation. University of California, Berkeley.
- McCarthy, John J. 2004. “Headed spans and autosegmental spreading.” *The Selected Works of John J. McCarthy*. [http://works.bepress.com/john\\_j\\_mccarthy/60](http://works.bepress.com/john_j_mccarthy/60)
- McCarthy, John J. 2010. “Agreement by Correspondence Without Corr Constraints.” *The Selected Works of John J. McCarthy*. [http://works.bepress.com/john\\_j\\_mccarthy/106](http://works.bepress.com/john_j_mccarthy/106)
- Miller, Brett. 2012. Sonority and the larynx. In *The Sonority Controversy*. Steve Parker (ed). 266–288. Berlin, Germany: De Gruyter Mouton.
- Myers, Scott. 1997. OCP Effects in Optimality Theory. *Natural Language and Linguistic Theory*. 15(4): 847–892.

- Ní Chiosáin, Máire and Jaye Padgett. 1997. Markedness, segment realization, and locality in spreading. Report no. LRC-97-01. Linguistics Research Center, University of California, Santa Cruz.
- Ní Chiosáin, Máire and Jaye Padgett. 2001. Markedness, segment realization, and locality in spreading. In *Segmental phonology in Optimality Theory*. Linda Lombardi (ed). 118–156. Cambridge, UK: Cambridge University Press.
- Odden, David. 1995. Tone: African Languages. In *The Handbook of Phonological Theory*. John A. Goldsmith (ed). 476–494. Cambridge, MA: Blackwell Publishers.
- Odden, David. 2007. The Unnatural Tonology of Zina Kotoko. In *Tones and Tunes. Volume 1: Typological Studies in Word and Sentence Prosody*. Tomas Riad and Carlos Gussenhoven (eds). 63–90. Berlin, Germany: De Gruyter Mouton.
- van Oostendorp, Marc. 2005. Expressing inflection tonally. In *Catalan Journal of Linguistics*. 4(1): 107–127.
- Padgett, Jaye. 1991. *Stricture in feature geometry*. PhD dissertation. University of Massachusetts, Amherst.
- Padgett, Jaye. 1994. Stricture and Nasal Place Assimilation. *Natural Language and Linguistic Theory*. 12: 465–513.
- Parker, Stephen G. 2002. *Quantifying the Sonority Hierarchy*. PhD dissertation. University of Massachusetts, Amherst.
- Parker, Steve. 2012. *The Sonority Controversy*. Berlin, Germany: De Gruyter Mouton.
- Peng, Long. 1992. *A unified theory of tone-voice*. PhD dissertation. The University of Arizona.
- Piggott, G. L. 2003. Theoretical implications of segment neutrality in nasal harmony. *Phonology*. 20(3): 375–424.
- Prince, Alan. 2000. *Comparative Tableaux*. ROA-376.
- Prince, Alan and Paul Smolensky. 1993. *Optimality Theory: Constraint Interaction in Generative Grammar*. Report no. RuCCS-TR-2. New Brunswick, NJ: Rutgers University Center for Cognitive Science.
- Pulleyblank, Douglas. 1986. *Tone in Lexical Phonology*. Dordrecht: Reidel.
- R Development Core Team. 2010. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. Vienna, Austria. [www.R-project.org](http://www.R-project.org)
- Rhodes, Russell. 2010/2012. *Vowel Harmony as Agreement by Correspondence*. UC Berkeley Phonology Lab Annual Report. 138–168.  
[http://linguistics.berkeley.edu/phonlab/annual\\_report/annual\\_report\\_2012.html](http://linguistics.berkeley.edu/phonlab/annual_report/annual_report_2012.html)
- Rose, Sharon. 1997. *Theoretical Issues in Comparative Ethio-Semitic Phonology and Morphology*. PhD dissertation. McGill University.
- Rose, Sharon and Rachel Walker. 2004. A Typology of Consonant Agreement as Correspondence. *Language*. 80(3): 475–531.
- Rose, Sharon and Rachel Walker. 2011. *Harmony Systems*. In *The Handbook of Phonological Theory, Second Edition*. John Goldsmith; Jason Riggle; and Alan C. L. Yu (eds). 240–290. Oxford, UK: Blackwell Publishing.
- Samek-Lodovici, Vieri. 1992. *A Unified Analysis of Crosslinguistic Morphological Gemination*. In *Proceedings of CONSOLE-1*. Utrecht, Netherlands: Console. ROA-149.
- Sasa, Tomomasa. 2009. *Treatment of vowel harmony in Optimality Theory*. PhD dissertation. University of Iowa.
- Selkirk, Elisabeth O. 1982. The syllable. In *The Structure of Phonological Representations, Part II*. Harry van der Hulst and Noval Smith (eds). 337–383. Dordrecht: Foris.
- Smith, Jennifer L. and Elliott Moreton. 2012. Sonority variation in Stochastic Optimality Theory: Implications for markedness hierarchies. In *The Sonority Controversy*. Steve Parker (ed). 167–194. Berlin, Germany: De Gruyter Mouton.
- Steriade, Donca. 1993. Closure, release, and nasal contours. In *Phonetics and Phonology 5: Nasals, nasalization, and the velum*. Marie K. Huffman and Rena Krakow (eds). 401–470. San Diego, CA: Academic Press.
- Sylak-Glassman, John. 2012. *Audibility and Syllabic Nuclei*. Ms. University of California, Berkeley.

- Tang, Katrina. 2008. The Phonology and Phonetics of Consonant-Tone Interaction. PhD dissertation. University of California, Los Angeles.
- Trommer, Jochen. 2008. Multiple-Feature Mutation and ‘Realize Moreheme.’ In *Linguistische Arbeitsberichte* 87, ‘Varieties of Competition.’ 163–182.
- Tucker, A.N. 1967. Introduction. In *Luganda-English dictionary*. R.A. Snoxall. xiii–xxxv. London: Oxford University Press.
- Walker, Rachel. 1998. Nasalization, neutral segments, and opacity effects. PhD dissertation. University of California, Santa Cruz. [Published, New York: Garland. 2000.]
- Walker, Rachel. 2000a. Long-distance consonantal identity effects. In *Proceedings of the 19<sup>th</sup> West Coast Conference on Formal Linguistics*. Roger Billerey and Brook Danielle Lillehaugen (eds). 532–545. Somerville, MA: Cascadilla Press.
- Walker, Rachel. 2000b. Yaka nasal harmony: Spreading or segmental correspondence? In *Proceedings of the 26<sup>th</sup> Annual Meeting of the Berkeley Linguistics Society: General Session and Parasession on Aspect*. 321–332.
- Walker, Rachel. 2009. Similarity-sensitive blocking and transparency in Menominee. Paper presented at 83<sup>rd</sup> Annual Meeting of the Linguistic Society of America. San Francisco, CA. 9 January 2009. <http://www-bcf.usc.edu/~rwalker/MenomineeLSAHdt.pdf>
- Whalen, D.H. and Andrea G. Levitt. 1995. The universality of intrinsic F0 of vowels. *Journal of Phonetics*. 23: 349–366.
- Weidman, Scott and Sharon Rose. 2006. A Foot-Based Reanalysis of Edge-in Tonal Phenomena in Bambara. In *Proceedings of the 25<sup>th</sup> West Coast Conference on Formal Linguistics*. Donald Baumer; David Montero; and Michael Scanlon (eds). Somerville, MA: Cascadilla Proceedings Project.
- Yip, Moira. 1989. Contour Tones. *Phonology*. 6(1): 149–174.
- Yip, Moira. 1995. Tone in East Asian Languages. In *The Handbook of Phonological Theory*. John A. Goldsmith (ed). 476–494. Cambridge, MA: Blackwell Publishers.
- Yip, Moira. 1998. Identity avoidance in phonology and morphology. In *Morphology and its Relations to Phonology and Syntax*. Steve LaPointe; Diane Brentari; and Patrick Farrell (eds). 216–246. Stanford, CA: CSLI.
- Yip, Moira. 2002. *Tone*. Cambridge, UK: Cambridge University Press.
- Zec, Draga. 1995. Sonority Constraints on Syllable Structure. *Phonology*. 12(1): 85–129.
- Zec, Draga. 2007. The syllable. In *The Cambridge Handbook of Phonology*. Paul de Lacy (ed). 161–194. Cambridge, UK: Cambridge University Press.
- Zhang, Jie. 2001. The Effects of Duration and Sonority on Contour Tone Distribution—Typological Survey and Formal Analysis. PhD dissertation. University of California, Los Angeles. [Published, New York: Routledge. 2002.]
- Zhang, Jie. 2004. Contour Tone Licensing and Contour Tone Representation. *Language and Linguistics* 5(4): 925–968.
- Zoll, Cheryl. 2003. Optimal Tone Mapping. *Linguistic Inquiry*. 34(2): 225–268.
- Zuraw, Kie. 2002. Aggressive reduplication. *Phonology*. 19: 395–439.
- Zuraw, Kie. 2010. A model of lexical variation and the grammar with application to Tagalog nasal substitution. *Natural Language and Linguistic Theory*. 28: 417–472.