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Tone melodies in the age of surface correspondence

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1 Introduction

The behavior of tone systems was a central motivation for Autosegmental Phonology (AP; Goldsmith 1976; Leben 1978), a theory couched in phonological representations and rules operating over representations.* Because tone seems to do everything that segmental features can and more (Hyman 2011), it made sense to design a theory around tone and then to apply its apparatus to the tamer behavior of consonants and vowels. Since the introduction of Optimality Theory (OT; Prince & Smolensky 1993), however, tone has been relegated to an increasingly peripheral role in theoretical development. New, surface correspondence-driven approaches to segmental effects of harmony and dissimilation (such as Agreement by Correspondence, or ABC; e.g., Hansson 2001, Rose & Walker 2004, Bennett 2013) supplant the rules and representations once needed in AP to handle consonant and vowel harmony. So where does this leave tone?

In this paper, we reexamine tone melody inventories in Mende, a landmark case study in the development of AP. We argue that, in an correspondence approach, tone melody inventories emerge naturally from the phonological grammar, rooted in independently-motivated principles of similarity and proximity with proven effects in segmental phenomena. The ABC-driven approach allows more fine-grained predictions in OT for the behavior of tone, and unites the analysis of tone and segmental patterns without the need for the representations and rule-based mechanisms of AP.

2 Tone melodies

One canonical tone behavior that AP was designed to capture is tone melody patterns, i.e. the association of abstract melodic patterns with surface tone bearing units (TBU). Familiar to all students of tone are the Obligatory Contour Principle in (1), and the universal tone association conventions in (2) (Goldsmith 1976):

(1) Obligatory Contour Principle (OCP): no adjacent identical autosegments

(2) Universal Association Conventions (UAC)
   a. Associate tones to tone-bearing units (TBUs) in a 1↔1, L→R manner
   b. Spread the rightmost tone to any remaining toneless TBUs
   c. Dock any leftover tones to the rightmost TBU

*Thanks to Larry Hyman and Will Leben for feedback on an early version of this work. Author order is alphabetical.

The OCP and UAC together produce the famous 5-way tone melody pattern of Mende (Leben 1973, 1978; Williams 1976) (a pattern arguably attested even better in Kukuya; Hyman 1987). The AP analysis posits five OCP-conforming melodies in UR, shown in Table 1 (note the exclusion of HLH). Each noun is lexically associated with one of these five melodies. The association of underlying tones to surface TBUs follows from the UAC:

Melody in UR	σ	$\sigma\sigma$	$\sigma\sigma\sigma$
L	L	L.L	L.L.L
H	H	H.H	H.H.H
L H	L͡H	L.H	L.H.H
H L	H͡L	H.L	H.L.L
L H L	L͡H͡L	L.H͡L	L.H.L

Table 1: Mende tone melodies, following e.g. Leben 1973

When the number of TBUs in the word exceeds the number of tones in the UR melody, Association Convention (2b) is responsible for the spreading of the rightmost tone, producing stretches of level tone word-finally. When the number of tones in the melody exceeds the number of TBUs, Association Convention (2c) takes over, producing contours. Crucially on this view, a contour tone is a complex melody —a string of tones— associated with a single TBU. On this account, all contour tones will be final, and all stretches of level tone will include the final TBU. This latter generalization famously parallels the distribution of root consonants in Arabic verbs, under the name of Greenberg's Asymmetry (Greenberg 1950), whose implementation in Autosegmental Theory by McCarthy (1979, 1981) was pivotal in the emergence of AP as the dominant analytical framework of the 1970's and 1980's.

3 Challenges for the AP melody account

The AP melody account of Mende, as sketched above, suffers from three problems, two of which are well-known. The first problem is that Mende exhibits surface tone melodies beyond the 5 canonical ones posited by Williams and Leben (Table 1), a point emphasized by Dwyer 1978. The second, also noted by Dwyer (1978) (see also Conteh et al. 1983), is that the alignment of melody tones to TBUs frequently violates the UAC. The third problem, which to our knowledge has not previously been discussed, is the observation that melody complexity in Mende is correlated with word length to a degree greater than chance. We will discuss these three challenges in turn, before presenting our own alternative account of the distribution of lexical tone in Mende nouns.

The data that forms the basis for this discussion is a list of ca. 4,000 headwords taken from Innes's (1969) Mende dictionary, of which some 2,700 are nouns. This is the subset of words—nouns in particular—for which the AP melody analysis was said to hold. About 2,500 (92%) of the nouns are 1 to 3 syllables in length. Innes's dictionary does not indicate morpheme breaks. The main source of morphological complexity in listed nouns appears to be total reduplication in 4-syllable words (e.g., *yapiyapi*, 'bragging'); to avoid the tonal effects of reduplication, we restrict ourselves here to the shorter nouns.

3.1 How many tone melodies?

The 2,700 nouns in the Mende wordlist reveal many surface tone melodies. Considering only distilled melodies that conform to the OCP, i.e. disregarding for now the alignment of tones to syllables and focusing only on the overall shape of the melody, Table 2 provides the attested patterns:

Melody in UR	σ	$\sigma\sigma$	$\sigma\sigma\sigma$
L	25	251	25
H	53	531	101
LH	27	400	112
HL	31	243	127
LHL	9	276	204
HLH	0	6	22
LHLH	0	3	13
HLHL	0	11	12
LHLHL	0	1	10

Table 2: Mende tone melodies for nouns in dictionary

The important point to observe here is the numbers of nouns in the rows below the first five 'official' melodies (in bold). Although there are fewer nouns associated with HLH, LHLH, HLHL and LHLHL melodies, the numbers are not zero, particularly in longer (2+ syllables) nouns.

Certainly the AP account could be modified to include more than 5 underlying melodies, increasing its descriptive adequacy. It is interesting to note, though, the commitment at the time to capturing those melodies which appear *most commonly* anticipates the goal of modern-day Maximum Entropy grammars, namely predicting the relative probabilities of possible structures (Goldwater & Johnson 2003, Hayes & Wilson 2008, Hayes et al. 2009). The binary method used in the AP analysis of listing or not listing a melody in an "inventory" is ultimately too crude a method of predicting distributions to be useful, but the laudable goal of predicting distributions is something we pick up in our own analysis, presented in section 6.

3.2 Tone alignment

A topic of discussion in the early days of the AP account of Mende was the number of exceptional nouns in which the surface alignment of melody tones to TBUs violates the UAC. For example, consider the four nouns in (3). The two disyllabic nouns in (3a,b) both have HL melodies, yet the tones align differently. To account for this discrepancy, Leben (1978) proposed prelinking H to the second syllable of *ngɔ́ngɔ̂*, the noun not conforming to the UAC. The two trisyllabic nouns in (3c,d) both have abstract LH melodies under an autosegmental account, but only (3c) conforms to the UAC. However, the alignment pattern of (3d) was thought to be the more common pattern for longer words with LH melody. To account for this, Leben (1978) proposed to modify Association Convention (2a) so that in a LH melody, the H would associate to the final syllable, rather than obeying left-to-right, 1-to-1 association. This modification rendered (3d) the well-behaved form and (3c) the exceptional form; Leben accounted for forms like (3c) through prelinking of the H to the second syllable.

(3) Examples of exceptional tone alignment in Mende

	UR melody	*surface alignment*		
a.	HL	H.L	ngíla	‘dog’
b.	HL	H.HL	ngɔ́ngɔ̂	‘tooth’
c.	LH	L.H.H	ndàvúlá	‘sling’
d.	LH	L.L.H	lèlèmá	‘praying mantis’

The issue of unpredictable tone alignment extends beyond just these examples, however (e.g., Dwyer 1978, Conteh et al. 1983). Table 3 shows the large number of nouns whose surface patterns do not conform to the predictions of the UAC, even with Leben’s (1978) modification. Forms in bold conform to the modified conventions; plain forms violate them.

σs	Melody	n	σs	Melody	n	σs	Melody	n
1	**H**	53	3	**L.H.L**	142	3, cont.	H.L.LH	1
	HL	31		**H.H.H**	101		HL.H.HL	1
	LH	27		**L.L.H**	63		HL.H.L	1
	L	25		H.H.L	58		**L.H.LH**	1
	LHL	5		L.H.H	40		L.HL.HL	1
	LHHL	4		**H.L.L**	38		LH.LH.L	1
2	**H.H**	531		L.L.HL	31			
	L.H	380		H.H.HL	25			
	L.L	251		**L.L.L**	25			
	H.L	212		**H.L.H**	21			
	L.HL	204		LH.L.L	17			
	LH.L	64		LH.L.H	12			
	H.HL	17		LH.L.HL	8			
	HL.L	14		**H.L.HL**	7			
	LH.H	13		LH.H.H	6			
	HL.HL	11		HL.L.L	5			
	LH.HL	8		L.H.HL	4			
	L.LH	7		LH.H.HL	4			
	H.LH	4		LH.H.L	4			
	HL.LH	2		H.LH.L	3			
	LH.LH	2		L.L.LH	3			
	LH.LHHL	1		L.HL.L	2			
	LHHL.H	1		H.HL.L	1			

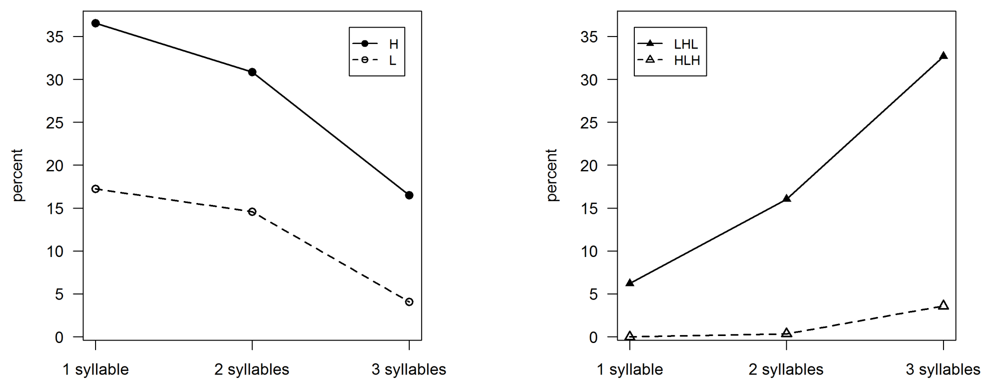
Table 3: Mende tone melodies for 1-3 syllable nouns in dictionary

While successful at handling forms just like those in (3), the modified AP account is weakened by the number of unpredictable forms (11%) that require lexical prelinking of tone. For two-syllable words, the success rate of Leben's modified UAC is 92%, but for three-syllable words where there is more work for the UAC to do, it is only 60%.

3.3 Tone Melody Complexity

A key insight of the AP account, and a hallmark of the predictions of the UAC, is the independence of the tone melody from other characteristics of the noun with which it is lexically associated. Leben (1978:186) writes that "By regarding the tone pattern as phonologically separate from the segments in these words, we capture the fact that a given pattern can occur regardless of how many syllables a word has."

Inspection of the Mende wordlist, however, suggests that this AP prediction is not borne out for Mende. Rather, more complex melodies correlate with increasing word length, as illustrated in Figures 1a and 1b, for 1- and 3-tone melodies, respectively.



(a) 1-tone melody tokens (b) 3-tone melody tokens

Figure 1: Tone melody complexity by word length

The inevitable conclusion from this finding is that the distribution of tone on surface syllables in Mende is driven by principles that either supplement or, ideally, fully supplant the original principles of AP.

4 A fresh look at tone

The goal of this study is to take a fresh look at tone, to transcend the familiar analytical space of AP, with its floating tones and association conventions, and develop a new set of principles to govern the distribution of tone in Mende nouns. Specifically, we strive in this study to characterize the distribution of tone using the same kinds of tools that have proven so successful in the analysis of long-distance (and local) segmental phenomena and phonotactics, namely correspondence constraints based on proximity and similarity. We conclude that the resulting model is better suited than AP to predicting the observed surface tone patterns in the Mende wordlist.

The framework that we use for this analysis is twofold, a combination of Agreement by Correspondence Theory (ABC) (Hansson 2001, Rose & Walker 2004, Bennett 2013) and Q-theory, a theory of subsegmental structure developed in Shih & Inkelas (2013).

Originally developed for long distance consonant agreement but since extended to vowel harmony and other local harmonies, ABC is a theory of syntagmatic interactions. The key claim of ABC is that syntagmatic units which are both sufficiently similar and sufficiently close to one another will correspond, and thus interact. Interaction occurs when correspondence between elements which are similar yet not identical is unstable; interaction either improves identity (assimilation) or undoes correspondence (via dissimilation, deletion, or other repairs) (see e.g., Bennett 2013). Assimilation and dissimilation are thus repairs for unstable correspondence.

Q theory addresses the question of what units the correspondence constraints of ABC can refer to. The standard in the ABC literature is for correspondence constraints to refer to segments. The theory has also been applied to strings of segments, inasmuch as it has been invoked to handle reduplication (Yu 2005, Inkelas 2008; see also Zuraw 2002 for a conceptually similar approach under a different name). ABC has its formal roots in Correspondence theory; see e.g. McCarthy & Prince 1994. But assimilation and dissimilation effects involving complex segments frequently demand a finer-grained level of representation for constraints to operate on. This is where Q-theory steps in. Building off the earlier Aperture Theory of Steriade (1993), Q theory proposes that every segment *Q* (every vowel, every consonant) is decomposed into a small number of sequenced, featurally uniform subsegments (*q*). This is illustrated in (4) for vowels and consonants:

(4) Q-theory: representations

$Q(q^1\ q^2\ q^3)$
$V(v^1\ v^2\ v^3)$ (a vowel)
$C(c^1\ c^2\ c^3)$ (a consonant)

In Q theory, each *q* subsegment is featurally uniform. Complex segments are *Q*'s whose *q*'s do not all agree featurally, as illustrated in (5a, b). A contour 'tone' is a case in which q's are not tonally uniform within a *Q* (5c, d):

(5) Q-theory: contour segments

a. V(e̯ a i̯) = the Romanian triphthong *e̯ai̯* (Dindelegan 2013)
b. C(n d z) = the prenasalized affricate ^{n}dz
c. V(à á à) = a LHL contour, as in Mende *mbâ* 'companion'
d. V(à á á) = a LH contour
e. V(á á á) = an all-H vowel

As example (5) indicates, the minimal TBU in ABC+Q theory is the subsegment. In practice, the functional 'TBU' is whatever string of *q*'s a given correspondence constraint refers to. Below, we will motivate several constraints that constrain tonal correspondence at the *Q* level, as well as constraints that constrain tone correspondence at the *q* level of representation.

5 The ABC+Q analysis of Mende noun tone

In this section we develop ABC+Q constraints that, embedded in a Maximum Entropy grammar (Goldwater & Johnson 2003, Hayes & Wilson 2008, Hayes et al. 2009; see §6), predict the inventory and relative frequency ranking of attested tone melodies of Mende nouns. The constraints take the form of similarity- and proximity-based correspondence and identity requirements. Each is motivated by an empirical aspect of the data. The analysis makes no reference to autosegmental representations, to tone association rules, to the OCP, or to tone contours or melodies as units of grammar.

5.1 Level vs. contour: syllable-internal *q* correspondence

Our first observation over the 2,700 Mende nouns (containing 5,467 syllables) in the wordlist is that syllables with contour tones are relatively infrequent (*n*=587, 10.75%). Of the syllables with contours, 76% (*n*=446) are in final position.

To model this asymmetry in the distribution of contours, we introduce the concept of correspondence and tonal identity between *q* subsegments within the same syllable. The correspondence constraints in (6) follow the general schema of any correspondence constraint in ABC. The first, most general constraint compels correspondence between any consecutive pair of *q* subsegments. The second constraint requires correspondence only between strictly adjacent subsegments—non-adjacent subsegments are not compelled to correspond. The third constraint compels correspondence between any consecutive pair of tautosyllabic *q* subsegments. The fourth constraint, which plays a major role in Mende, compels correspondence between any consecutive pair of tautosyllabic *q* subsegments in a weak, or nonfinal, syllable. These CORR constraints are accompanied by IDENT-qq[tone] constraints (not shown), compelling tonal identity among corresponding *q*'s. We assume here that candidates that satisfy *qq* Correspondence constraints automatically satisfy IDENT-qq[T]. (See Hansson 2014 for an implementation of ABC that formally combines CORR and IDENT-qq constraints.)

(6) *qq* Correspondence

CORR-qq	*q* subsegments correspond
CORR-q::q	strictly adjacent *q* subsegments correspond
CORR-$[q::q]_\sigma$	tautosyllabic adjacent subsegments correspond
CORR-$[q_w::q_w]_\sigma$	adjacent *q*'s in a nonfinal syllable correspond

The tableau in (7) compares two possible alignments of a LHL tone sequence on a disyllabic word. As seen, the CORR-$[q_w::q_w]_\sigma$ constraint favors the alignment in which the first syllable has level tone and the contour occurs on the final syllable (7a). CORR constraints penalize any change of tone across consecutive *q*'s. The penalty is higher if the tone change takes place within a (nonfinal) syllable (7b).

(7)

		CORR-$[q_w::q_w]_\sigma$	CORR-$[q::q]_\sigma$	CORR-qq
☞ a.	L.HL (= $l_x l_x.h_y l_z$)		1	2
b.	LH.L (= $l_x h_y.l_z l_z$)	W	1	2

5.2 A preference for tones to change at syllable boundaries

In polysyllabic nouns, we observe that across syllable boundaries, it is more common for tone to change than to remain constant. This is shown numerically in example (8):

(8)

tone changes at syllable boundaries	1,532	79.0%
tone agreements across syllable boundaries	408	21.0%

In ABC, a type of constraint that limits correspondence relationships (the LIMITER constraint family of Bennett 2013) can account for this observed tendency by penalizing correspondence across specified boundaries:

(9) Limiter constraint on trans-boundary correspondence:

qq-EDGE-σ Assess a violation for each pair of corresponding *q* subsegments separated by a syllable boundary.

Dissimilation can satisfy a limiter condition by undoing the similarity that qualifies two units for correspondence. Together with the CORR constraints in (6), qq-EDGE-σ (9) derives a generalization we have already observed, namely the correlation between the number of tonal transitions in a word (the complexity of its 'tone melody') and the number of TBUs. As shown in (10), where two tableaux compare different tone alignments on candidates of equal length, the grammar prefers those candidates with level tones within nonfinal syllables (e.g. (10a-f) vs. (10g)) and tonal transitions at syllable boundaries (e.g., (10a) versus (10b); (10c) versus (10d)). This preference is reflected in the observed frequencies with which the various alignments occur in the Mende wordlist.

(10)

	$\sigma\ \sigma$	*freq*	qq-ED-σ	CORR-$[q_w::q_w]_\sigma$	CORR-qq
☞ a.	L.H (= $l_xl_x.h_yh_y$)	**380**			1
b.	L.L.(= $l_xl_{x,y}.l_{y,z}l_z$)	251	W1		L
	$\sigma\ \sigma\ \sigma$	*freq*	qq-ED-σ	CORR-$[q_w::q_w]_\sigma$	CORR-qq
☞ c.	L.H.L (= $l_xl_x.h_yh_y.l_zl_z$)	**142**			2
d.	L.L.L (= $l_xl_{x,y}.l_{y,z}l_z.h_ah_a$)	63	W1		L1
e.	L.H.H (= $l_xl_x.h_yh_{y,z}.h_{z,a}h_a$)	40	W1		L1
f.	L.L.L (= $l_xl_{x,y}.l_{y,z}l_{z,a}.l_{a,b}h_b$)	25	W2		L
g.	L͡H.L.H (= $l_xh_y.l_zl_z.h_ah_a$)	12		W1	3

5.3 A bias toward H

For nouns in the Mende wordlist, syllables with H tone (including contours, *n*=3219, 59%) slightly outnumber those with L (including contours, *n*=2836, 52%). Among words with level tone, all-H predominates (*n*=685, 69%) over all-L (*n*=301, 31%). This 'H bias' can be modeled by a markedness constraint favoring H tone:

(11) HAVE-H: A word must have at least one H-toned subsegment.

5.4 A bias against HLH

The Mende data exhibit a bias against HLH troughs, which is common in tonal languages (e.g., Cahill 2007). This bias was reflected in the classic AP analysis of Mende tone melodies by the decision to leave HLH out of the inventory of five melodies allocated to nouns. HLH does in fact occur in nouns, but it is not as common a melody as LHL. LHL sequences outnumber HLH sequences overall; the disparity decreases with word length:

(12)

	σ	$\sigma\ \sigma$	$\sigma\ \sigma\ \sigma$
LHL	11	382 (93%)	156 (76%)
HLH	0	27 (7%)	49 (24%)

Figure 12 shows that the bias against HLH is stronger the closer together the two H's are; HLH melodies in two-syllable words are less frequent than HLH in three-syllable words. This pattern lends itself very naturally to modeling in the ABC framework, where proximity catalyzes correspondence. In comparison, the distance disparity is not predicted by a melody markedness analysis using e.g., *TROUGH (Yip 2002) or *HLH, which are by nature insensitive to surface distance. In our ABC analysis, two constraints interact to penalize troughs. The first (13) requires a pair of consecutive H-toned subsegments to correspond (regardless of distance); the second (14), following the format of Bennett 2013, requires corresponding H subsegments to be adjacent.

(13) CORR-q[H]q[H]: H-toned *q* subsegments must correspond.

(14) q[H]q[H]-qADJ: Corresponding H-toned *q* subsegments must be adjacent.

q[H]q[H]-qADJ is the constraint that in some languages derives tone plateauing, the phenomenon whereby a stretch of L tone between two H's raises to H, creating a 'plateau' of level-H tone (on plateauing, see e.g., Hyman 2011; on q[H]q[H]-qADJ, see Shih & Inkelas 2015). In Mende, the constraint causes the grammar to favor LHL sequences over HLH sequences, as illustrated in example (15). (The relatively low-ranked HAVE-H is suppressed in (15) for reasons of space.)

(15)

	$\sigma\ \sigma\ \sigma$	*freq*	qq-ED-σ	q[H]q[H]-qADJ	CORR-q[H]q[H]
☞ a.	L.H.L (= $l_x l_x.h_y h_y.l_z l_z$)	**142**			
b.	H.H.H (= $h_x h_{x,y}.h_{y,z} h_{z,a}.h_{a,b} h_b$)	101	W2		
c.	H.L.H (= $h_x h_x.l_y l_y.h_z h_z$)	21			W1
d.	H.L.H (= $h_x h_x.l_y l_y.h_x h_x$)	(21)	W2	W1	

6 ABC+Q and AP-style analyses compared

Having discussed the insights behind the original AP analysis of Mende, the generalizations emerging from a closer inspection of the Mende data, and the corresponding constraints that comprise an ABC+Q analysis of the data, we are now ready to compare the two approaches side by side by means of a maximum entropy model that examines which type of model is better able to predict the existence and relative frequency of attested surface tone patterns in Mende nouns.

Table 4 compares the constraints developed for the ABC+Q analysis of Mende to the constraints of an OT version of an AP analysis. ALIGN-R(H.H, L.L) corresponds to UAC (2b). ALIGN-R($\widehat{\text{HL}}$, $\widehat{\text{LH}}$) corresponds to UAC (2c). (It is equivalent to Zoll's (2003) COINCIDE-CONTOUR constraint, accomplishing the same goal of limiting contour tones to the final syllable.) The OCP and *HLH (or *TROUGH, accounting for the absence of HLH troughs in lexical tone melodies) complete the original AP analysis. Because the original AP analysis was about tone alignment, not about predicting melody frequency, we have augmented it here with two additional constraints: *CONTOUR and HAVE-H, which have counterparts in the ABC+Q constraint set. They capture the bias toward level tones and toward H.

ABC+Q	AP	*Notes on AP constraints*
CORR-qq	ALIGN-R(H.H, L.L)	"spreading", (2b)
CORR-$[q_w{::}q_w]_\sigma$	ALIGN-R($\widehat{\text{HL}}$, $\widehat{\text{LH}}$)	"docking", (2c); see Zoll 2003
	*CONTOUR	update added in this paper
qq-EDGE σ	OCP	limits underlying melodies
CORR-q[H]q[H]	*HLH (or *TROUGH)	no HLH sequences within melodies
q[H]q[H]-qADJ		
HAVE-H	HAVE-H	update added in this paper

Table 4: ABC+Q and AP analyses, side by side

The analyses have comparable numbers of constraints, and even overlap in one constraint (HAVE-H). But they differ in their key insights, as reflected in the constraints that they do not share. The AP account places the burden of explanation on a fixed set of melodies that are aligned in predictable ways. The ABC+Q account places the burden of explanation on correspondence. Under ABC, H-subsegments should correspond (and be adjacent); subsegments should not correspond across syllable boundaries; subsegments should correspond within nonfinal syllables.

6.1 Results

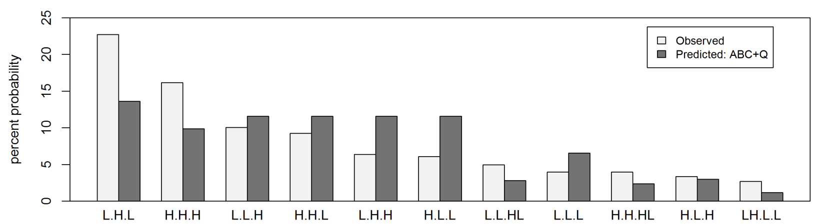
In comparing these two models, with their different foundational insights, we use a Maximum Entropy Harmonic Grammar (MaxEnt) model (Goldwater & Johnson 2003; Wilson 2006, Hayes & Wilson 2008), in which constraint weights are fitted using maximum likelihood estimation in the MaxEnt Grammar Tool (Hayes et al. 2009). Instead of outputting a single winning output for a given lexical input, MaxEnt assesses the relative harmony of different tone patterns, and ranks the probabilities (i.e., comparative grammaticality) of outcome candidates in variable data, based on the formula in (16):

(16)

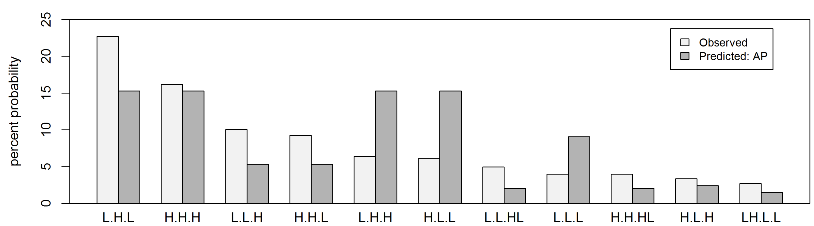
$$Pr(x) = \frac{exp(-\mathcal{H}(x))}{\sum_{y \in \Omega} exp(-\mathcal{H}(y))}$$

where x is the candidate surface form in question, $\mathcal{H}$ is the harmony score of a candidate ($w \cdot C$), and y ranges over all of the candidate surface forms in the candidate set Ω.

For our purposes, since we are interested in predicting the frequency of tone patterns for words of a given length, the input is a fixed number of syllables and the outputs are all possible tone patterns that can be produced for the number of input syllables from the combination of H, L, LH, and HL syllables. The expectation is that the top ranking pattern in terms of predicted output probability will correspond to the most frequent observed melody in the corpus. In Figure 2 we see the predicted frequencies assigned to surface melodies for trisyllabic words by the ABC+Q and AP models, compared to the observed frequencies of these melodies on Mende nouns.



(a) ABC+Q predictions



(b) AP predictions

Figure 2: Predicted versus observed data: trisyllabic words

ABC+Q correctly predicts the top six observed surface tone patterns for trisyllabic words in the wordlist (Figure 2a), whereas AP only correctly predicts the top four observed surface tone patterns (Figure 2b). Of the top patterns, the most frequent by far in trisyllabic words is L.H.L, a predominance that ABC+Q correctly predicts (see Figure 2a and Figure 3). The L.H.L tone pattern changes tone at every syllable boundary, has no contours, has an H, and avoids HLH, thus satisfying the ABC+Q constraints in Table 4. By contrast, the AP analysis predicts incorrectly that L.H.L will have probability equal to that of H.H.H, L.H.H and H.L.L. This is because the AP account, by hypothesis, treats all (licensed) melodies as equally likely and focuses its attention on aligning level tone stretches and contour tones

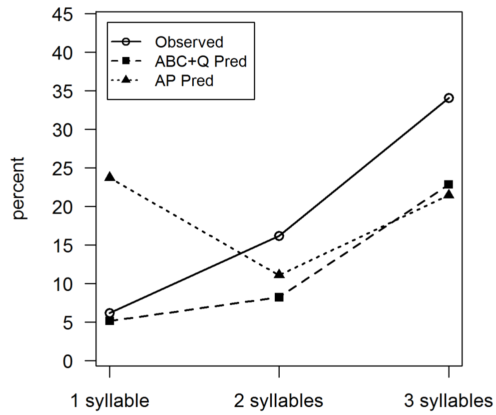


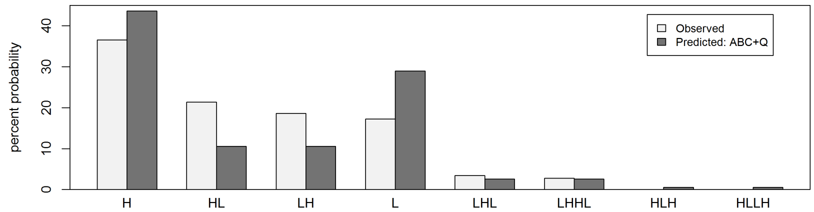
Figure 3: LHL melody percentages by word length

with the right edge, rather than on what is happening at internal syllable junctures.

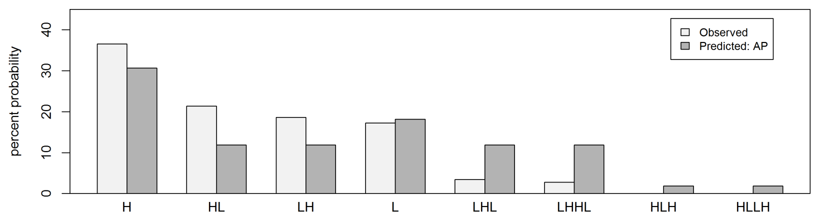
6.2 Where both models could stand to improve

While the ABC+Q model does better than the AP model at predicting the frequency distribution of tone patterns in trisyllabic words (as well as shorter words, shown below), both models show subpar performance in two areas, pointing in the direction of future refinement and research. The first is alignment. As was seen in Figure 2, the observed frequency of L.L.H (10.06%) and H.H.L (9.27%) patterns exceeds that of L.H.H (6.39%), H.L.L (6.07%). The ABC+Q account assigns all four patterns the same probability, failing to capture the differential, while the AP account predicts the *opposite* differential. The empirical observation is that two-tone patterns with a late transition from one tone type to the next seem to be favored (Cahill 2007). By contrast, the UAC of AP (2) predict early, not late, transitions. It was to address this fault in the AP vision that Leben (1978) proposed Mende-specific revisions to tone mapping, though only for the LH melody, and that Zoll (2003) proposed to replace 1-to-1, L-to-R mapping with *CLASH (for H.H), *LAPSE (for L.L), and COINCIDE-CONTOUR. To fully capture the asymmetry between L.L.H, H.H.L and L.H.H, H.L.L, however, the ideal model of Mende tone would need to add a constraint, perhaps perceptually motivated, favoring tonal transitions which are later rather than earlier in the word. This would require a mechanism beyond what has been proposed so far in this paper, as currently 'transition' is not a representational entity that constraints can reference.

A second area in which both models fall short is the overattestion of the level H pattern. In Figure 2, the ABC+Q account incorrectly predicts level H to be less frequent than the tone-tone patterns (L.L.H, H.H.L, L.H.H, H.L.L), when in fact it is more frequent. The AP account incorrectly predicts that level-H will be as frequent as L.H.L, L.H.H, and H.L.L. The effect is even more noticeable in monosyllabic words, depicted in Figure 4. While both ABC+Q and AP accounts correctly assign the highest predicted frequency to level-H, both models overpredict the frequency of level-L, i.e. insufficiently account for H bias.



(a) ABC+Q predictions



(b) AP predictions

Figure 4: Predicted versus observed data: monosyllabic words

It is interesting to note that the H bias weakens as words get longer. This decline is captured better in ABC+Q than in AP, which in its original incarnation posited complete independence between melody and word length. ABC+Q predicts a decline of level-H words because of qq-EDGE-σ, which favors tone transitions at syllable boundaries. In classic AP, level-H should be just as likely as any other of the five existing melodies, regardless of word length, though for our comparisons we did enhance the AP account with HAVE-H and *CONTOUR, which (like their counterparts in ABC+Q) contribute to the predicted predominance of level-H on monosyllabic words specifically.

In sum, while both models give words with level H a boost over words which are level-L, neither is boosting all-H words sufficiently across words of all lengths. Several solutions are possible. One is to model a multiplicative effect of HAVE-H at each domain (segment, syllable, word). Another is to invoke a constraint favoring H on every TBU, not just on every word, to supplement or supplant the existing HAVE-H constraint. A third avenue of investigation lies in the functional load that tone melodies are performing. We have not paid attention in this paper to morphophonological effects, e.g. the indexation of certain tone melodies to morphological derivations or word classes, and save this potential avenue of explanation for future work.

7 Conclusion

The goal of this paper was to examine surface tone melody patterns in a purported classic “tone melody” language, namely Mende, in order to see whether this apparent exotic and tone-specific phenomenon might be capturable without recourse to the representational machinery of AP. The alternative proposal we considered is the surface-oriented, correspondence-driven optimization of ABC, enhanced with the phonetically grounded subsegmental representations of Q theory. Our findings are that the ingredients of an ABC+Q analysis, namely correspondence constraints based on similarity and proximity, produce surprisingly accurate predictions about the lexical distribution of surface tone sequences. Unlike in AP, ABC+Q achieves this surface tonal distribution without the need to *a priori* limit the melodies available to words. On the ABC+Q analysis, the melody inventory is emergent from the grammar. ABC+Q does not need to make overt reference to melodic 'units' (like H, LH, LHL).

This analysis has several theoretical advantages. First is that it solves a problem that lurked behind the scenes in the AP era, namely the need to refer to contour tones as units even though they are not constituents in AP representation. Constraints which license contour tones in final (or other position) are at odds with the position that contour tones in AP are sequences of elements, not units on their own. This is a known problem for the analysis of languages in which contour tones mutually assimilate or dissimilate; see e.g. Yip 1989, Duanmu 1994, Shih & Inkelas 2013.

Second, the ABC+Q analysis of tone carries the distinct advantage of analyzing tone using the same types of representations and constraints that are used for segmental phonology. Just like vowel and consonant harmony, tone patterning is driven by pressures of correspondence at thresholds of similarity and proximity. Porting the analysis of tone into surface correspondence theory and discarding representations that are unique to tone allows tone to take its place as a central phenomenon in guiding the development of phonological theory (Hyman 2011).

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