A Foot-Based Reanalysis of Edge-in Tonal Phenomena in Bambara

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1.   Optimal Tone Mapping and 'edge-in' tonal forms in Bambara

Bambara is a Manding language spoken in Mali. Rialland & Badjimé (1989) report that it has five tone patterns for quadrisyllabic nouns, as shown in (1). Data are Bamako Bambara (Mamadou (Sangaré) Badjimé's dialect), and are shown in the indefinite form with the presentative verb *dôn*.

(1) a.   LLLL   bùgùnìnkà dôn   'It is a whip'   d.   LLHH   gàrìjégé dôn   'It is a chance'
     b.   HHHH   jánkárábú dôn   'It is a rogue'   e.   LLHL   kòròkárà dôn   'It is a tortoise'
     c.   HHLL   kúlúkùtù dôn   'It is a ball'

Bambara cannot employ strictly left-to-right or right-to-left tone association and spreading, or else tone patterns such as *HHHL or *HLLL would be expected. Instead, Rialland and Badjimé (1989) argue that it requires "edge-in" association and edge-in spreading of lexical tone melodies as shown in (2):

(2) a.   kúlúkùtù   'a ball'   b.   gàrìjégé   'a chance'

            \\/ ˙ ˙\\/   \\/ ˙ ˙\\/
            H   L   L   H

Edge-in association and edge-in directional spreading present a problem for *Optimal Tone Mapping (OTM)* (Zoll 2003), a theory which dispenses with 'directionality' in tone mapping (i.e. left-to-right, right-to-left), but advocates interaction of constraints on tone sequencing to account for tonal patterns. Sequences of identical tone are ruled out by the constraints in (3):

(3) a.   CLASH: No high tone sequence on adjacent TBUs
     b.   LAPSE: No non-high tone sequence on adjacent TBUs

Zoll cites the case of Kukuya, with trisyllabic patterns of LLL, HHH, HLL, LLH and LHL. The absence of *HHL and *LHH motivates the ranking of CLASH > LAPSE, as these patterns violate CLASH. Hausa non-derived trisyllabic forms require the opposite ranking. The tone patterns are LHL, HLH, LHH and HHL, but there are no *LLH or *HLL patterns, which violate LAPSE. Nevertheless, edge-in forms as in (1c,d) are hard to reconcile with OTM as they violate CLASH and LAPSE equally:

(4)

kulukutu H L *'a ball'*	LAPSE	CLASH
a. HHLL kúlúkùtù	*!	*
b. ☹ HHHL kúlúkútù		**
c. HLLL kúlùkùtù	**!	

(5)

kulukutu *'a ball'* 　　H　L	CLASH	LAPSE
a.　　　　HHLL　　kúlúkùtù	*!	*
b.　☹　HLLL　　kúlùkùtù		**
c.　　　　HHHL　　kúlúkútù	**!	

No ranking of these constraints will favor the edge-in form. We argue that Bambara tone does not require edge-in association if tones are associated within optimally bisyllabic "tonal feet" (Bamba 1991; Bickmore 2005, 2003; Leben 1997, 2002, 2003; Zec 1999; deLacy 2002), as shown in (6).

(6)　　　　(kú.lú)(kù.tù)

　　　　　　H　　L
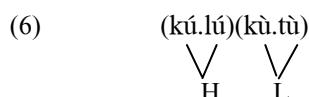
By adopting tonal feet, all three directional association patterns are replaced with constraints on tonal configurations. Edge-in is no longer problematic for Optimal Tone Mapping. Moreover, tonal feet offer a better characterization than edge-in directional tone mapping for three puzzling properties of Bambara nominal tonal melodies: i) alternate tonal patterns of trisyllabic nouns (ex. mángòrò/mángórò 'mango'), ii) association of the LHL tonal pattern, and iii) tone shift caused by the 'liaison high tone' in definite phrasal contexts. The paper is organized as follows. In §2, we outline the edge-in analysis proposed by Rialland & Badjimé (1989). In §3, we introduce the tonal foot approach and show how the analysis handles basic tonal patterns. In §4, we discuss alternate tonal patterns and in §5, we provide an analysis of the LHL tone pattern. In §6, we show how the analysis accounts for tone shift due to the 'liaison high tone' and in §7, we compare our approach to another tonal foot account of Bambara (Leben 2002, 2003), which addresses alternate data and differs in application.

2.　An 'edge-in' analysis of Bambara tone

Rialland & Badjimé (1989) propose that Bambara nouns have five possible tonal melodies: H, L, HL, LH, and LHL. For monosyllabic and bisyllabic nouns, association is unproblematic: only H and L melodies are attested.

(7)　a.　L　bà dôn　　*'It is a goat'*　　　c.　L　bàlà dôn　*'It is a porcupine'*
　　　b.　H　bá dôn　　*'It is a river'*　　　d.　H　bálá dôn　*'It is a balafon'*

For trisyllabic nouns, all five attested melodies are found.

(8)　a.　L　gàlàmà dôn　*'It is a ladle'*　　　c.　LH　bànfúlá dôn　*'It is a hat'*
　　　b.　H　súngúrún dôn　*'It is a young girl'*　d.　HL　mángòrò dôn　*'It is a mango'*
　　　　　　　　　　　　　　　　　　　　　　e.　LHL　sàkénè dôn　*'It is a lizard'*

Melodies can be derived by edge-in association, supplemented by directional spreading. Tones associate to the edge syllables, then spread right-to-left to fill the remaining syllable(s). The key data are those in (9c,d). These trisyllabic forms could also be derived via left-to-right association, but edge-in is required for the corresponding bitonal quadrisyllabic forms.

(9)　a.　gàlàmà　b.　súngúrún　c.　bànfúlá　d.　mángòrò　e.　sàkénè

　　　　　　L　　　　　　H　　　　　L　H　　　　　H　L　　　　L　H　L

Edge-in association *and* edge-in spreading must be assumed for HHLL and LLHH quadrisyllables (as illustrated in (2)). To account for tri-tonal LLHL quadrisyllables (*kòròkárà*) an edge-in analysis must make two stipulations. First, tones left over after the edge syllables are filled associate preferentially at the *right* edge of the word and second, tones spread left-to-right to fill remaining unassociated syllables (10a) (or tones spread from the edge syllable inwards), thus preventing *LHHL (10b) and *LHLL (10c).

(10)   a. kòròkárà   b. * kòrókárà   c. *kòrókàrà

             |⁄ | | | ⟍⁄ | | | ⟍|
             L   H L   L   H L   L H   L

Thus, Rialland & Badjimé's edge-in account requires a series of steps:

(11) i)   edge-in association
     ii) leftward spreading for bi-tonal trisyllables (9c,d)
     iii) edge-in spreading for bi-tonal quadrisyllables (not full leftward spreading *HLLL) (2a,b)
     iv) edge-in spreading or rightward spreading for tri-tonal quadrisyllables (10a)

We argue in the next section that these patterns emerge naturally from a tonal foot account.

3.   A tonal foot approach

In this section, we sketch the basics of a tonal foot analysis. Tonal feet or association of tone within metrical structure have been proposed by a number of researchers (Sietsema 1989, Bamba 1991, Bickmore 2003, 2005, de Lacy 2002, Leben 1997, 2002, 2003, Zec 1999). Tonal feet constitute binary groupings of tone bearing units into metrical constituents. There is no necessary correlation with stress patterns. Indeed, Bambara is not reported to have a stress system.

We make two basic assumptions concerning foot construction. First, tones associate within binary feet in bisyllabic and quadrisyllabic nouns, but full binary footing is not possible for monosyllabic or trisyllabic forms.[1] Second, exhaustive parsing of syllables into feet is assumed, and a degenerate foot is located at the left edge of trisyllabic nouns: (σ)(σσ) (see also Leben 2002, 2003). In addition, we propose a set of high-ranked constraints governing foot construction (based on Yip 2002):

(12)   a. MAX-T: Every input tone has an output correspondent
        b. DEP-T: Every output tone has an input correspondent
        c. PARSE-σ: All TBUs (syllables) must be parsed into a tonal foot
        d. RH-TYPE: TROCHAIC: Feet are left-headed
        e. FTBIN: Tonal feet must contain only two TBUs (syllables) *(violable)*

To ensure that the degenerate monosyllabic foot appears at the left edge in trisyllabic nouns, we employ NON-FINALITY (HD):

(13)   NON-FINALITY(HD): No heads of feet word-finally

Assuming that degenerate syllables are heads, this penalizes the configuration (σσ)(σ). The desired parsing (σ)(σσ) would violate a lower-ranked constraint CLASH(HD) (after Zoll 2003):

(14)   CLASH(HD): There are no adjacent heads of tonal feet

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[1] Anne-Michelle Tessier suggested that input tone melodies run afoul of Richness of the Base. Output constraints can rule out unattested sequences (i.e. *HLH or OCP on singly-linked sequences of identical tones), but whether a lexical item has a LH or H tone melody cannot be derived via general constraints, so we represent this in the input.

For LH and HL melodies, tones spreads within the binary foot rather than crossing foot boundaries (see Bickmore 2003, Pearce 2006), the result of a constraint ALIGN(T,HD), which requires association of lexical tones with foot heads (after Zec 1993).

(15)   ALIGN(T, HD): Align the left edge of a tonal span with the head of a tonal foot

To illustrate how these constraints combine to produced the desired outcome, consider first a quadrisyllabic form. ALIGN(T,HD) penalizes forms in which the left edge of the tonal span is not aligned with a tonal foot head, thus preventing tonal spans from crossing foot boundaries and associating with non-heads as in (16a). Although not shown, high-ranked FT-BIN rules out alternate parsings of syllables into non-binary feet. The winning candidate has a tone associated within each foot.

(16)

kulukutu 'a ball' H L	ALIGN(T,HD)	NON-FINALITY (HD)	CLASH(HD)
a. (kúlù)(kùtù) 　　　　|　　＼／ 　　　　H　　　L	*!		
b. ☞ (kúlú)(kùtù) 　　　　＼／　　＼／ 　　　　H　　　L			

With a trisyllabic form, FT-BIN is always violated, and the ranking of NON-FINALITY(HD) above CLASH(HD) determines the winning candidate. This ranking places the degenerate syllable at the left edge with the first tone, and the second tone spreads within the remaining binary foot. ALIGN(T, HD) prevents the initial tone from spreading across a foot boundary to the next foot head (17b) and NON-FINALITY(HD) eliminates the candidate with the opposite footing (17c).

(17)

mangoro 'a mango' H L	ALIGN(T, HD)	NON-FINALITY(HD)	CLASH(HD)
a. ☞ (mán)(gòrò) 　　　　|　　＼／ 　　　　H　　　L			*
b. (mán)(górò) 　　　　＼／　　| 　　　　H　　L	*!		*
c. (mángó)(rò) 　　　　＼／　　| 　　　　H　　L		*!	

Under an edge-in analysis, trisyllabic tonal patterns require edge-in association and an additional leftward spreading rule. By using tonal feet, the constraints ALIGN(T,HD) and NON-FINALITY(HD) produce the effects of edge-in association and directional spreading. This analysis will now be extended to examine alternate tonal melodies.

4.   Alternate tonal melodies of trisyllabic nouns

Only bi-tonal trisyllabic nouns have an alternate tonal melody, as shown in (18b) and (18d).

(18)   a.   HL   mángòrò   *'mango'*   c.   LH   bànfúlá   *'hat'*
         b.   mángórò   d.   bànfùlá

While the standard "dictionary" forms (18a) and (18c) satisfy NON-FINALITY (HD), the alternate forms (18b) and (18d) are those which satisfy CLASH (HD). The alternate forms can be derived by switching the ranking of NON-FINALITY(HD) and CLASH(HD).

(19)

mangoro 'a mango' H L	CLASH(HD)	NON-FINALITY(HD)
a. (mán) (gò.rò) H L	*!	
b. ☞ (mán.gó)(rò) H L		*
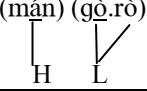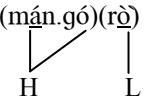
If alternate forms correspond to alternate footing, only these forms are expected to have alternate tone patterns. [2] Quadrisyllabic forms have binary footing, and alternate tone patterns for mono-tonal and tri-tonal trisyllables would produce no surface effect: (sà)(kénè) and (sàkɛ́)(nè). Under an edge-in account, two opposite spreading rules are needed. The HHL pattern is derived via left-to-right spreading and the HLL pattern is derived via right-to-left spreading. Although the analyses appear comparable, the use of directional spreading to explain alternate patterns has negative consequences for the quadrisyllables, as will be seen in the next section.

5.   The distribution of tri-tonal LHL melody for quadrisyllablic nouns

The LHL melody maps to a quadrisyllabic noun as LLHL (kòròkárà). We argue that this is due to tonal heads. Heads of feet prefer H tones, as is documented for other languages (de Lacy 2002).

(20)   *HD-L: No low tones on the heads of tonal feet

Binary footing combined with *HD-L favors (LL)(HL) over *(LH)(LL). *(LH)(HL) as in (21b) is ruled out due to H crossing a foot boundary which results in an additional ALIGN(T, HD) violation.

(21)

korokara 'a tortoise' L H L	ALIGN(T, HD)	*HD-L

a.   (kòró)(kàrà)
            | | ∨
            L H   L
	*	**!

b.   (kòró)(kárà)
            | ∨ |
            L   H   L
	**!	*

c.   ☞   (kòrò)(kárà)
            ∨ ||
            L   H L
	*	*

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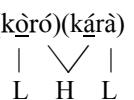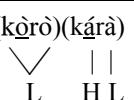
[2] Rialland & Badjimé report an additional pattern: *mángóró* and *bànfùlà*, which they relate to compounds – *mángóró-sún* 'mango tree' or *bànfùlàbá* 'big hat'. The tone of the initial syllable spreads throughout the first word and the second formative is always H tone. The same pattern is found with other forms: /sàkénè - mùsò / → [sàkènèmúsó] 'female lizard'.

The use of *HD-L avoids the stipulation employed by the edge-in analysis to derive the LLHL form and rule out unattested *LHLL, as explained in (10). Furthermore, it also has the advantage of ruling out alternate tone melodies. Since these derive from the placement of degenerate feet, no alternate tone melodies are expected with tonal feet. Under an edge-in analysis, since alternate melodies result from different directional spreading, one might expect the LHL melody to result in an alternate pattern if the opposite spreading direction is used. The attested pattern LLHL is derived via leftward spreading, as found with the *alternate* trisyllabic forms, such as *bànfùlá*, as shown in (22).

(22)   a.   kòròkárà   b.   bànfùlá

                     |⁄ | | |⸌ |
                     L H L   L   H

Since the standard trisyllabic form uses leftward spreading (23b), the same analysis could be applied to produce a LHHL pattern, with rightward association of the H tone, and leftward spreading (23a).

(23)   a.   *   kòrókárà   b.   bànfúlá

                     | ⸌∨ | | ∨ |
                     L H L   L   H

To prevent (23a), a stipulation that spreading can only originate from edge syllables would have to be invoked. Under the tonal foot analysis, no alternate forms are predicted for quadrisyllables, so no additional restrictions on spreading are required.

6.   High liaison tone and alternation in final tones on nouns

The final piece of evidence in favor of the tonal foot explanation for edge-in patterns comes from the behavior of the high liason tone. So far, we have been investigating indefinite forms. In definite phrasal contexts, a 'liaison' H tone associates to the final syllable of the noun. It changes the final L tone to H (or creates a contour in the case of monosyllables – (24a)). No alternation is found when the noun ends in a H tone.

(24) *Indefinite*   *Definite*

a.	L	bà dôn	*'It is a goat'*	L̂H	bǎ dòn	*'It is the goat'*
b.	LL	bàlà dôn	*'It is a porcupine'*	LH	bàlá dòn	*'It is the porcupine'*
c.	LLL	gàlàmà dôn	*'It is a ladle'*	LL*H*	gàlàmá dòn	*'It is the ladle'*
d.	LLLL	bùgùnìnkà dôn	*'It is a whip'*	LLL*H*	bùgùnìnká dòn	*'It is the whip'*
e.	HLL	mángòrò dôn	*'It is a mango'*	HL*H*	mángòró dòn	*'It is the mango'*
f.	HHLL	kúlúkùtù dôn	*'It is a ball'*	HHL*H*	kúlúkùtú dòn	*'It is the ball'*
g.	LHL	sàkénè dôn	*'It is a lizard'*	L̂HL*H*	sǎkèné dòn	*'It is the lizard'*
h.	LLHL	kòròkárà dôn	*'It is a tortoise'*	LHL*H*	kòrókàrá dòn	*'It is the tortoise'*

For the LHL tone pattern, the H tone shifts leftwards (24g,h) to accommodate the extra H liaison tone. For the quadrisyllabic form (24h), the extra H tone creates a one-to-one match between tones and tone-bearing units, resulting in a LHLH pattern. For definite *sǎkèné* (24g) there are four tones and three syllables. Therefore it is necessary to create a contour tone (contours only emerge when there are more tones than TBUs – MAX-T > *CONTOUR), as shown in (25b):

(25)   *Indefinite*   *Definite*
            a.   sàkénè   b.   sǎkèné

                     | | | ∧ | |
                     L H L   LH L H

Rialland & Badjimé (1989) do not explain why the contour tone in *săkèné* appears in initial position rather than elsewhere. The tonal foot account predicts an initial contour due to two constraints already motivated: ALIGN(T, HD) and *HD-L. Only one footing and tone pattern emerges as optimal; there is no alternate tonal pattern for this word (CLASH(HD) and NONFINALITY(HD) are ranked lower). ALIGN(T, HD) is violated for every tone (contours count as two) that are not aligned with a head, and the candidate that best satisfies this constraint and manages to avoid low tones on heads is (26f).

(26)	sakene *'the lizard'* L H L H̄	ALIGN(T, HD)	*HD-L	NON-FINALITY(HD)	CLASH(HD)
	a. (sà)(kɛ́nɛ̌)	**!	*		*
	b. (sàkɛ́)(nɛ̌)	*	**!	*	
	c. (sàkɛ̂)(nɛ́)	**!	*	*	
	d. (sà)(kɛ̂né)	*	**!		*
	e. (sǎ)(kɛ̀né)	*	**!		*
	f. ☞ (sàkɛ̀)(nɛ́)	*	*	*	

In summary, tonal feet employ basic constraints on foot construction and association of tones to foot heads which capture the binary tonal distribution, which was the impetus behind edge-in association. Tonal feet allow for alternate forms only with bi-tonal trisyllables and explain the LHL tonal distribution and position of the initial contour in *săkèné*. In contrast, edge-in association must employ a series of stipulatory constraints on association and spreading to account for basic trisyllables and quadrisyllables and requires additional stipulations to explain the LHL tonal pattern association

7. An alternate tonal foot analysis: Leben (2002, 2003)

Leben (2002, 2003) also proposes tonal feet for Bambara, but not to address the 'edge-in' problem, only to account for trisyllabic nouns. The data he addresses represent a different dialect, but the fact that both analyses converge on the use of tonal feet is strong confirmation that they are an ideal analytical tool to explain tone distribution. In this section we attempt to compare the two analyses, and sketch an approach in which our analysis can be extended to account for the data differences.

Two ingredients of Leben's analysis are similar. He assumes that tonal feet are maximally binary, and that tonal feet parse a form exhaustively. His analysis diverges from ours in three respects. First, for trisyllabic forms, the position of the degenerate foot is lexically determined. Second, he assumes two tone melodies, LH and H, which are assigned directly to feet rather than words. Third, the high 'liaison' tone in definite contexts is analyzed as part of the tonal melody of the noun, a position adopted by other Bambara researchers (Creissels 1978, Dumestre 1994). All nouns are analyzed as ending in a high tone (which is lost in some forms in the indefinite context). Shading indicates tone patterns not found among the standard forms of Rialland & Badjimé (1989). The alternate patterns are the same as (27d) and (27g).

(27)

	Indefinite context		*Definite context*		
a.	HHH	kámélén	HHH	káméleń	'young man'
b.	LHH	jàkúmá	LHH	jàkúmá	'cat'
c.	HLL	mángòrò	HLH	mángòró	'mango'
d.	LLH	tùbàbú	LLH	tùbàbú	'European'
e.	LHL	nyə̀nínsà	LHL͡H	nyə̀nínsǎ	'fever'
f.	L͡HLL	jǎnkàmù	L͡HLH	jǎnkàmú	'black scorpion'
g.	HHL	kábásù	HHL͡H	kábásǔ	'chalk'

Each word is parsed into two feet, one binary and one degenerate. Tones are assigned to each foot. The combination of two tonal melodies with two possible footings gives eight parses. The all H form shows no surface difference, and seven different surface patterns are generated.

(28)

a.	(Hσσ)(Hσ) / (Hσ)(Hσσ)	(kámé)(leń) / (ká)(mélén)	'young man'
b.	(LHσ)(Hσσ)	(jǎ)(kúmá)* → (jà)(kúmá)	'cat'
c.	(Hσ)(LHσσ)	(mán)(gòró)	'mango'
d.	(LHσσ)(Hσ)	(tùbá)(bú)* → (tùbà)(bú)	'European'
e.	(Hσσ)(LHσ)	(kábá)(sǔ)	'fever'
f.	(LHσσ)(LHσ)	(nyə̀nín)(sǎ)	'black scorpion'
g.	(LHσ)(LHσσ)	(jǎn)(kàmú)	'chalk'

Patterns (28b) and (28d) undergo a rule of H tone deletion, which applies at foot boundaries. In the configuration L H)(H , the first H is deleted. The form (jǎ)(kúmá), which has $\widehat{LH})(H$ loses the H of the contour tone, resulting in a (L)(HH) output. The form (tùbá)(bú) loses the first H resulting in a (LL)(H) output (the remaining L tone spreads within the foot). This same rule is used to delete the 'H liaison tone' when it occurs in indefinite contexts before H-toned [té] 'it is not'[3], as shown in (29). This rule applies to all forms with a LH final foot (27c, e-g).

(29)   H L H   H   H   L   H
            (mán)(gòró) (té)   →   (mán)(gòrò) (té)

Leben's anlysis cannot account for two main aspects of the Rialland & Badjimé data. The first concerns the tone shift with the LHL pattern. An initial contour in the indefinite form is not present in the definite form (indef. *sǎkèné* / def. *sàkénè* 'lizard', as discussed in (25). Leben's data does not exhibit tone shift: indefinite *jǎnkàmù* 'chalk' corresponds to definite *jǎnkàmú*, and therefore his analysis has no provision for this. Leben's analysis also cannot extend to the quadrisyllabic noun patterns. The combination of two tonal melodies LH and H and two bisyllabic feet generates only four tone patterns. The LLLL/LLLH pattern (indef. *bùgùnìnkà* /def. *bùgùnìnká* 'rogue') cannot be generated. In addition, the tone shift found with (24h) LHL (indef. *kòròkórà* / def. *kòrókòrá* 'tortoise') is not predicted.

Our analysis can be adapted to handle the dialect described by Leben's analysis. Only four tonal melodies (H, LH, HL, LHL) are required, as there are no all L trisyllabic forms in this dialect. As in his analysis, in order to generate seven trisyllabic forms, lexical specification of the position of the degenerate foot would be required. Second, contour tones must be allowed to surface with the LHL tone pattern: (jǎn)(kàmù). If contours are allowed, ranking of ALIGN(T, HD) over *HD-L will favor the form with an initial contour tone, as it avoids ALIGN (T,HD) violations. Nevertheless, contours must only be permitted in degenerate feet to avoid them appearing in quadrisyllabic forms for the same reason. Such an analysis would also favor *(nyə̀nìn)(sâ) over attested (nyə̀nín)(sà), so HL contours

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[3] Leben states that this tonal change does not occur before low-toned [dòn]. This is not in accordance with Rialland & Badjimé's data (which reports [dôn]) or other sources. Courtenay (1974) proposes a similar rule but triggered by a following H or #, which would account for the tone change before either a H or L toned following word. Leben further states that only words that end in a (LH) tonal foot lose the final H tone in indefinite contexts (e.g. (mán)(gòró) → (mán)(gòrò) but not (tùbà)(bú)). This is not reported in other sources. In Dumestre (1994), words like *jàkúmá* are realized as all low-tone before [té], whereas they are not in Rialland & Badjimé or other sources, so some dialectal differences must be at work.

must be banned (a high-ranking *$\widehat{\text{HL}}$). Finally, in order to restrict tone shift, definite and indefinite forms must match in tone association (output-output faithfulness).

In summary, our analysis can be adapted to handle this different dialect data with a few minor additions. Leben's analysis could be similarly adapted to our data except for the all low-tone patterns, which would presumably be derived via an additional H-tone deletion rule. Despite the differences, both analyses demonstrate the utility of tonal feet in analyzing the distribution of lexical tone in Bambara. Our analysis has the additional benefit of well-motivated constraints on tone distribution instead of specific rules of tone deletion.

8.   Conclusion

Constraints on tonal feet, incorporating the notion of a foot head, offer a superior account of Bambara nominal tonal patterns than an edge-in directional analysis. Our analysis utilizes general constraints on foot construction and tonal association, and adds to the growing body of research connecting tone distribution to metrical structure. As a result of this proposal, Zoll (2003)'s theory of Optimal Tone Mapping is no longer undermined by the case of Bambara.

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