Chapter 6

Hybrid falling tones in Limbum

Siri Gjersøe
Leipzig University

Jude Nformi
Leipzig University

Ludger Paschen
Leipzig University

This paper examines the interaction between lexical tone and phrase-level intonation in Limbum. On the basis of an acoustic study of novel data, we claim that Limbum has a phrase-final low boundary tone (L%) that interacts with lexical tones to give rise to *hybrid* falling tones: tones whose specifications are partially lexical and partially phrasal. We argue that hybrid tones and other tonal processes in Limbum are readily captured in an analysis that assumes tonal geometry and empty nodes. We propose to represent L% as a floating low register feature (l) that links to lexical tonal root nodes, giving rise to various surface patterns depending on the tonal specifications of the root nodes. Our account supersedes previous analyses in terms of tone sandhi rules.

1 Introduction

Limbum is a Grassfields Bantu language spoken by about 1,340,000 speakers in the Donga Mantung division of the North West region of Cameroon. Limbum is an understudied language, especially with regards to its suprasegmental phonetics and phonology. In previous work (Fiore 1987; Fransen 1995), Limbum has been described as a tone language with three level tones (H, L, M) and four contour

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tones (HL, LM, ML, LL).[1] It has also been observed that low-falling tones appear as level tones when they occur in a non-sentence-final position, a process which Fransen (1995) argues is the result of a sandhi simplification rule.

In this paper, we present an acoustic analysis of novel data from recordings of three native speakers of Limbum. We show that the data are actually more complex and Fransen's analysis fails to account for the whole range of tonal alternations. Instead, we claim that Limbum has a final low boundary tone (L%) in certain syntactic contexts. Adopting the decompositional approach by Snider (1999), we argue that L% is a floating low register feature that can create phrase-final falling contour tones by associating to lexical tonal root nodes. Crucially, we assume that falling contour tones are not falling underlyingly: they only differ from level tones by having an additional empty tonal root node associated to their TBU. L% interacts with lexical tonal specifications to create *hybrid* surface tones, i.e. tones that combine lexical and phrasal tonal features.

The paper is structured as follows. In §2, we present our acoustic study and offer a qualitative analysis of F0 tracks for all tested items. §3 comprises the formal part of this paper, in which we provide a unified analysis of the tonal processes described in the previous section. In §4, we discuss why our analysis fares better than alternative accounts and probe typological implications.

2 Acoustic Study

2.1 Data and Methods

Data presented in this study were collected from two male (ages 23 and 29) and one female (age 26) speakers of Limbum (Central/Warr dialect). Recordings of one of the male speakers were conducted at the phonetics laboratory at Leipzig University in the winter of 2015 using a T-bone SC 440 supercardioid microphone (sampling rate 44.1 kHz, 16-bit). The recordings of the two other speakers were conducted in Buea, Cameroon using an H5 Zoom recorder with a SM10A Shure microphone (same sampling and bit rates).

The speakers were given a reading task with a set of constructed test sentences. In the examples in (1), *lé* (in boldface) is the target word. We tested five sentence

[1] The sources mentioned also discuss a somewhat dubious fifth contour tone, HM. Fiore (1987) argues that HM is an allotone of HL and proposes segmental length as a factor conditioning allotony, a view that is shared in Fransen (1995). However, Fiore (1987) presents only two examples of HM-toned words, and our informants accept this tone on only a single lexical item, *báā* 'two'. On the basis of its highly limited distribution, we decided not to include HM in our study.

types: Declarative sentences in which the target word appears in a sentence-final position (*Decl.Fin*), declaratives in which the target word appears in a non-sentence-final position (*Decl.Med*), simple wh-questions with the target word as the last item (*Wh.Fin*), wh-questions with the final question particle *a* (*Wh.Prt*), and polar questions which always end in the particle *a* (*Pol*). The semantic difference between *Wh.Fin* and *Wh.Prt* is that the latter signals that the wh-element is a known referent.[2] A complete list of target words (two words per tone)[3] is given in Table 1.[4] In total, our study comprises 7 tones x 2 words x 5 sentence types x 3 speakers. Each sentence was pronounced 1–2 times by each speaker. Values for sentences with more than one repetition were aggregated in R studio (v. 3.2.2).[5]

(1) Tánkó àm yɛ̄ **lé**
T. PST see bat
'Tanko saw a bat.' *(Decl.Fin)*

(2) Tánkó àm yɛ̄ **lé** fī
T. PST see bat new
'Tanko saw a new bat.' *(Decl.Med)*

(3) á ndā àm yɛ̄ **lé**
FOC who PST see bat
'Who saw a bat?' *(Wh.Fin)*

(4) á ndā àm yɛ̄ **lé** a
FOC who PST see bat PRT
'Who saw a bat?' *(Wh.Prt)*

[2]See Driemel & Nformi (forthc.) for further discussion of the functional domains of particles in Limbum.

[3]We found two microprosodic effects of vowel height: (1) With low-vowel items, F0 values overlap for HL and ML; (2) with high-vowel items, LM undergoes flattening when it precedes a L tone. Since these effects appear to be due to phonetic variation and distract away from the actual tone patterns, we present the F0 traces of all items combined rather then separating them into high- and low-vowel items.

[4]We adopt the convention of writing two vowels for syllables with contour tones in order to accommodate the tonal diacritics. However, this also reflects the extra length observed especially (but not exclusively) on sentence-final contour tones. Note that the use of two vowel symbols does *not* represent a phonemic length contrast because such a contrast is absent in the dialect of Limbum under discussion.

[5]It was only possible to record *tāà* 'father' and *sòō* 'basket' for one speaker. We used two repetitions per item from that speaker, aggregated in R.

(5) Tánkó àm yē **lé** a
T. PST see bat PRT
'Did Tanko se a bat?' *(Pol)*

The aim of our acoustic study was to test prior observations that contour tones alternate with level tones phrase-medially (Fransen 1995), and also to examine whether lexical tones interact with boundary tones. In the following, we abbreviate alternating low-falling/level tones as *L(L)*, *M(L)*, and *H(L)*, and we use *T(L)* to refer to the whole group of alternating tones. Level tones are abbreviated as *L*, *M*, *H*, and *T*, respectively. Annotations were done in Praat (Boersma & Weenink 2016) and automatically extracted from TextGrid and PitchTier files. Starting from the M-toned verb *yē* 'see' (see (1)), the onset (O) and nucleus (N) of the target words and any syllables following them (*fī* in *Decl.Med* and the particle *a* in *Pol* and *Wh.Prt*) were annotated. A Praat script by Remijsen (2013b) was run to generate Pitch objects that are automatically trimmed for spikes using the algorithm in Xu (1999). The items were manually corrected for microprosodic effects on F0. Interpolation for words with voiceless consonantal onsets (for two out of our 14 test words) was done using the smoothing algorithm in Praat. F0 values at equidistant time points within intervals were then extracted using the Praat script by Remijsen (2013a). The F0 values were converted into semitones (st) in R, with the midpoint value of *yē* 'see' serving as base line for the semitone scale for each individual item.

Table 1: List of target words and attested tone types in Limbum

Tone	Word 1	Gloss 1	Word 2	Gloss 2
		LEVEL TONES		
L	*bà*	'bag'	*bì*	'people'
M	*bā*	'fufu'	*bō*	'children'
H	*bá*	'hill'	*lé*	'bat'
		LOW-FALLING CONTOUR TONES		
L(L)	*ràà*	'bridge'	*rdòò*	'going'
M(L)	*tāà*	'father'	*bīì*	'co-wife'
H(L)	*dáà*	'cutlass'	*kúù*	'funnel'
		RISING CONTOUR TONES		
LM	*yàā*	'princess'	*sòō*	'basket'

2.2 Results

The graphs below show the descriptive statistics of the tones in each tested context with F0 traces normalized for all three speakers.

2.2.1 Falling contour tones

The nuclei of L(L), M(L), and H(L) toned words are all falling sentence-finally (*Decl.Fin* and *Wh.Fin*, left graph in Figure 1). Sentence-medially, no pronounced falling movement can be observed in the nuclei, confirming the claim in Fransen (1995) that contour tones alternate with level tones sentence-medially (*Decl.Med*, right graph in Figure 1). LM is rising in all sentence-types and the F0 traces show that LM is not lowered sentence-finally. Low-falling L(L) is accompanied by breathy voice in *Decl.Fin* and *Wh.Fin* (see Gjersøe et al. 2016 for discussion). Pitch contours in *Decl.Fin* largely overlap with those in *Wh.Fin*.

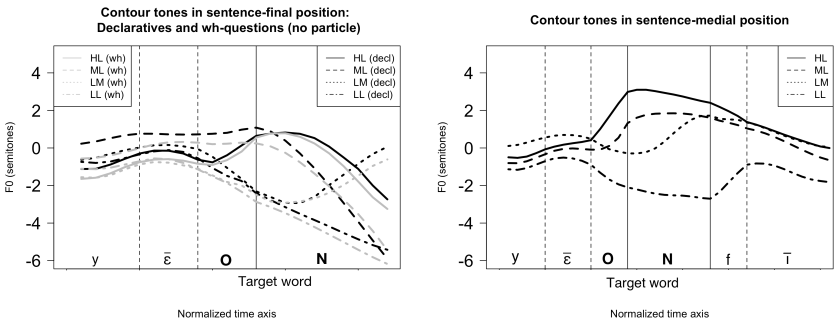


Figure 1: T(L) contour tones realized as falling tones sentence-finally (*Decl.Fin* and *Wh.Fin*, left graph); the same tones showing a flat pitch trace in non-final position (*Decl.Med*, right graph).

2.2.2 Level tones

Figure 2 shows F0 traces for the level tones L, M, and H in *Decl.Fin*, *Wh.Fin*, and *Decl.Med*. In sentence-medial position (right graph), the three level tones are realized with a stable flat contour. Sentence-finally (left graph), H and M are also flat. The L tone, however, shows a conspicuous falling contour extending to almost six semitones below the mid level of *yɛ̄*. That the L tone is realized as low-falling sentence-finally is a new observation that has not been noted in Fiore

(1987) or Fransen (1995). As with contour tones, F0 movements in *Decl.Fin* were not different from those in *Wh.Fin*.

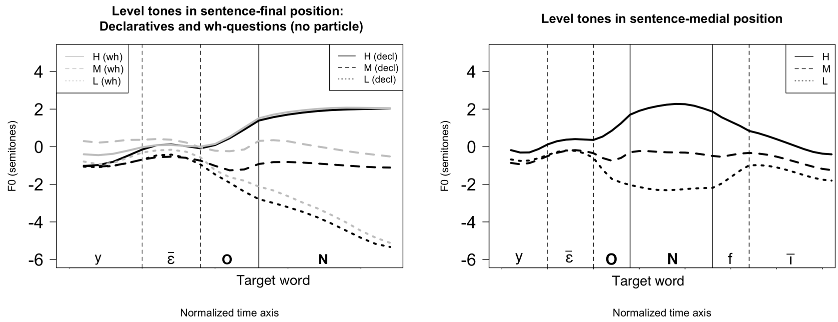


Figure 2: T level tones in final (*Decl.Fin* and *Wh.Fin*, left graph) and sentence-medial (*Decl.Med*, right graph) position.

2.2.3 Questions with the final particle *a*

There are a number of striking differences between the two sentence types with the final question particle *a*, i.e. between *Wh.Prt* and *Pol*. The main difference is that F0 trends on the particle are generally low-falling in *Wh.Prt* while F0 remains on the same level as that of a previous T tone in *Pol*. Following a T(L) tone, particles have a mid tone in *Pol*. In other words, *Wh.Prt* is very similar to *Wh.Fin* and *Decl.Fin* whereas *Pol* more closely resembles *Decl.Med*.

T(L) tones in *Wh.Prt* (left graph of Figure 3) reach a low target on the particle. Level tones in *Wh.Prt* (gray F0 traces in Figure 4) also reach a low target on the particle. Note that both the T(L) and level tones show a small anticipatory fall from the nucleus midpoint before the low target in the particle. The rising tone LM has only a small-scale rise from its nucleus to the particle. The flattened LM trace appears to be an effect of the L target of the following particle, conditioned by a tonal coarticulation effect which lowers the mid peak in the sequence LM.L. This effect was weaker for the low-vowel item (see footnote 3).

In polar questions, the particle has a mid tone when it follows a T(L) toned word (right graph in Figure 3). However, F0 on the particle remains stable after a level tone, continuing its low, mid, or high pitch level (black F0 traces in 4). F0 on the particle shows a small but insignificant rise after L, and the mid target of LM seems a little higher than that of T(L) tones. We will briefly consider explanations for these rises in §2.3. The divergent tonal behavior of polar and wh-questions is another new observation missing in previous descriptions of Limbum. A final point to note is that F0 values for HL and ML appear to converge in pre-particle position. However, this convergence only seems to occur on low-vowel items (see footnote 3).[6]

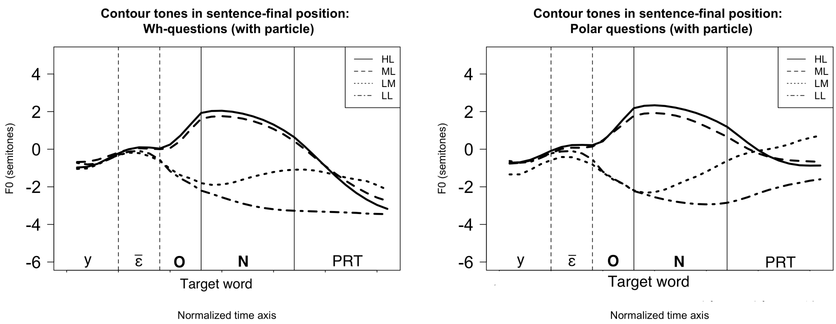


Figure 3: Words with a T(L) contour tone preceding a final particle in *Wh.Prt* (left graph) and *Pol* (right graph).

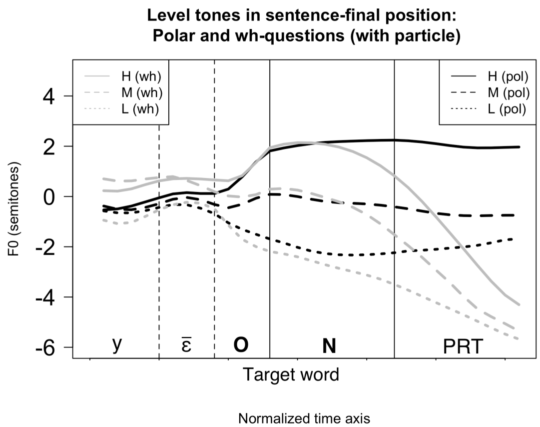


Figure 4: Words with a level tones preceding a final particle in *Wh.Prt* (gray F0 traces) and *Pol* (black F0 traces).

[6]At present, we cannot offer a convincing explanation why the M and H targets converge for some items in this context. We suspect that it is due to an independent process that does not interfere with the tonal alternations that we consider in this paper. Further studies are needed to scrutinize the conditioning factors and the productivity of this process.

2.2.4 Duration

Vowels on our target words are generally longer sentence-finally (*Decl.Fin* and *Wh.Fin*) than in other contexts. Duration differences are most prominent for alternating falling/non-falling tones, which are realized as TL sentence-finally and as T sentence-medially. For instance, in ‘bridge’, ‘father’ and ‘cutlass’, vowels are long sentence-finally (*ràà*, *tāà*, and *dáà*) but short sentence-medially (*rà*, *tā*, and *dá*). Level tones, in particular H, may also occasionally be longer sentence-finally. Thus, ‘hill’ and ‘bat’ are sometimes pronounced as long *báá* and *léé* in *Decl.Fin* and *Wh.Fin* but as short *bá* and *lé* in *Decl.Med* and *Wh.Prt*. The rising contour tone LM shows no durational differences across the different sentence types. Even though differences in vowel duration are attested in the recordings of all of our three speakers, there is a great deal of inter- and intra-speaker variation as to how big these length differences are, and failure to lengthen a final vowel in *Decl.Fin* and *Wh.Fin* is not considered ungrammatical. We therefore attribute the observed durational differences to an optional pre-boundary lengthening effect.

2.3 Interim summary

Table 2 summarizes the tonal alternations described in this section. Low-falling contour tones (LL, ML, HL) only occur in phrase-final position (*Decl.Fin* and *Wh.Fin*). Elsewhere, the fall to L is missing, and the first part of the contour is realized as a level tone. Non-low level tones are invariant in all contexts, while L is lowered phrase-finally. The question particle *a* receives a L tone in *Wh.Prt*, while in *Pol*, it copies the tone of a preceding level tone but receives a M tone when it follows a contour tone. L can thus be distinguished from L(L) only in *Pol*. LM is always realized as LM in all tested environments.

Table 2: Surface tones across all tested sentence types

	L	M	H	L(L)	M(L)	H(L)	LM
Decl.Fin	LL	M	H	LL	ML	HL	LM
Decl.Med	L	M	H	L	M	H	LM
Wh.Fin	LL	M	H	LL	ML	HL	LM
Wh.Prt	L.L	M.L	H.L	L.L	M.L	H.L	LM
Pol	L.L	M.M	H.H	L.M	M.M	H.M	LM

Our data also reveal a small number of minor phonetic effects. First, the mid target in the sequence LM.L is not reached in *Wh.Prt*. We assume that this is a coarticulatory effect conditioned by the two L targets, one from the lexical tone and other from the particle. As mentioned earlier, this effect is stronger for the high-vowel item than the low-vowel item. We do not have a straightforward explanation for the small rise on the particle in *Pol* following L and LM. For now, we do not consider this a relevant phonological process because the extra rise on L does not reach a M target and the extra rise on LM does not reach a H target.

3 A formal account of tone-intonation interaction

In this section, we present our formal analysis of tonal alternations in Limbum. We assume that each of our test sentences constitutes an Intonational Phrase (IP). The core idea of our analysis is that Limbum has a low boundary tone L% at the right edge of an IP in *Decl.Fin*, *Decl.Med*, *Wh.Prt*, and *Wh.Fin*, but not in *Pol*. We represent L% as a floating register feature *l*. Lowering of L, the falling/non-falling alternations, and the divergent tonal patterns on the particle *a* in *Wh.Prt* and *Pol* all result from the presence (or absence) of *l* and constraints governing if and how *l* associates to tonal root nodes.

3.1 Theoretical background

3.1.1 Tonal root nodes and floating tonal features

The central idea of our analysis is that boundary tones and lexical tones are crucially represented by the same tonal features. Adopting the idea of tonal decomposition and geometry (Clements 1983; Hyman 1986; Snider 1999; Yip 1999), we assume that tones – much like segments – can be decomposed into distinctive features. Following Snider (1999)'s Register Tier Theory (RTT), we distinguish four different tiers: a register tier (with register features h and l), a tonal tier (with tonal features H and L), a tonal root node (or o) tier, and a TBU tier. A register feature specifies whether it is higher or lower compared to an adjacent register feature, while a tonal feature specifies whether a tone is high or low within a given register. As shown in Figure 5, RTT thus allows to distinguish four pitch levels: High (H/h), Mid1 (H/l), Mid2 (L/h), and Low (L/l) (Snider 1999: 62). Since there is only one mid pitch level in Limbum, we represent M as L/h and assume that the combination H/l (Mid1) is not part of the tonal lexicon.

We represent contour tones as two o's linked to a single TBU (following Fiore 1987 and Fransen 1995, we assume that the syllable is the TBU in Limbum). While

LM, the only rising tone in Limbum, is fully specified for both o's, low-falling contour tones have one fully specified and one empty tonal root node underlyingly (see Figure 6). Basing our analysis within the broader framework of featural affixation (Akinlabi 1996), we represent the boundary tone L% as a floating low register feature l. This floating feature interacts with lexically underspecified (and in some cases also with fully specified) o's, most notably by creating low-falling contour tones. Table 3 gives a summary of the tonal features of underlying tones in Limbum.

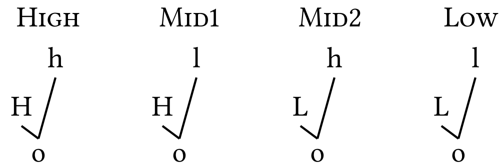


Figure 5: Tonal geometry in RTT

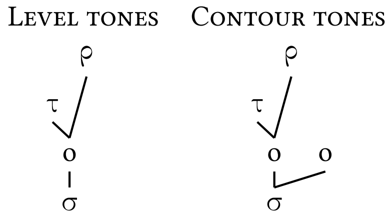


Figure 6: Level and partially specified contour tones

Table 3: Underlying tone inventory

	L	M	H	L(L)	M(L)	H(L)	LM	L%
TONE (τ)	L	L	H	L o	L o	H o	L L	
REGISTER (ρ)	l	h	h	l o	h o	h o	l h	l

While equating phrasal tones with register features might seem ad-hoc and unwarranted at first sight, there is a crucial parallel between the two: both can be understood as abstract phonetic targets relative to a previous target. Boundary tones following a pitch accent of the same type have the effect of intensifying an already initiated downward or upward movement (Pierrehumbert 1980), while a sequence of two low register features is phonetically realized as further lowering in RTT. Lexical tone features show a strikingly different behavior from both register features and boundary tones in this respect, as a sequence of three H-toned TBU's is not expected to show a rising contour under standard assumptions. Instead, it would be more likely for pitch to steadily decrease due to downdrift, or for some of the H tones to undergo downstep. For that reason, we believe that there is a natural ontological link between register features and boundary tones, and we capture this connection by the simplest formal means, viz. an identical representation of the low register feature l and the low boundary tone L%.

3.1.2 Constraining tonal processes

Having established the representations of lexical and phrasal tones, we now detail how the tonal alternations described in the previous sections are derived, using the general framework of Optimality Theory (Prince & Smolensky 2004/1993). While our analysis is in principle compatible with most versions of OT, we couch our analysis in *Coloured Containment* (Trommer 2015; Zimmermann 2017), which provides the means to accurately constrain association lines within and across phonological (sub-)structures. *Containment Theory* (van Oostendorp 2004) restricts the generative power of Gen to manipulating association lines between phonological nodes and inserting epenthetic nodes. This means while Gen can add new lines and mark existing lines as invisible, it cannot delete any phonological material that is present in the input. This vastly reduces the number of possible candidates that need to be evaluated compared to analyses of tone in Correspondence Theory (Zoll 2003; Zhang 2007).

In our analysis, we do not invoke the powerful machinery of multi-level markedness in Containment. We employ Containment solely for its precise way to evaluate association relations between phonological nodes, as illustrated in very general terms in (6) and (7). For our analysis, the relevant nodes are the tonal root node (o), register features (l, h; ρ), and tonal features (L, M, H; τ). The constraint ρ→o, for instance, should be read as "Count one violation for each register feature not associated to a tonal root node".

(6) $\begin{array}{c}\alpha\\ \downarrow\\ \beta\end{array}$ Count one ⋆ for each α not associated to a β.

(7) $\begin{array}{c}\alpha\\ \uparrow\\ \beta\end{array}$ Count one ⋆ for each β not associated to a α.

Two constraints corresponding to classical OT faithfulness constraints Max and Dep are given in (8) and (9), respectively. Note that Ident does not apply in Containment because nodes present in the input cannot be altered in any way.

(8) Max $\overset{\alpha}{\underset{\beta}{|}}$ Count one ⋆ for each deleted association line between a node α and a node β.

(9) Dep $\overset{\alpha}{\underset{\beta}{|}}$ Count one ⋆ for each inserted association line between a node α and a node β.

Another crucial set of constraints is given in (10) and (11). The first constraint militates against not fully specified tonal root nodes while the second constraint demands a TBU (the syllable) to be minimally specified for a tone and a register feature. Note that these constraints are different from a conjunction of $\rho \leftarrow o$ and $\tau \leftarrow o$: while such a local constraint conjunction would penalize only those root nodes (syllables) that are linked to exactly zero tonal and zero register features, the constraints here demand full specification. The last constraint that needs to be introduced here is *loh (12), which penalizes tonal root nodes associated to two non-identical register features.

(10) $\underset{o}{\overset{\tau\quad\rho}{\nwarrow\nearrow}}$ Count one ⋆ for each tonal root *R* such that *R* is not associated to both a register feature and a tonal feature.

(11) $\underset{\sigma}{\overset{\tau\quad\rho}{\nwarrow\nearrow}}$ Count one ⋆ for each syllable node *S* such that *S* is not linked to both a register feature and a tonal feature by a path of association lines.

(12) *loh Count one ⋆ for each tonal root linked to both l and h.

We adopt the theory of morphological colors (van Oostendorp 2006) to restrain access to morphological information by the phonological component. The theory of morphological colors forbids morphological look-up but enables the phonology to distinguish between elements of different morphological provenience. This will become relevant in the analysis of particle tones below.

A final assumption underlying our analysis is a stratal organization of grammar as it is modeled in Stratal OT (Kiparsky 2000; Bermúdez-Otero 2012). All evaluations relevant for the tonal processes in Limbum that we are concerned with at this point take place at a postlexical level corresponding to the IP domain. The input to this stratum is a sentence, with all words bearing their lexical (and, if applicable, morphological) tones, plus either L% or no boundary tone depending on sentence type. We do not engage in further discussion on tonal processes at lower levels and only concern ourselves with the level of the IP, i.e. the level where L% is introduced.

3.2 Tonal hybridity and tone-intonation interaction

Recall from the previous section that there are three classes of tones in Limbum: level tones which remain level tones in all positions (L, M, H), level tones that alternate with falling contour tones at the end of declarative sentences and wh-questions (L(L), M(L), H(L)), and a rising contour tone (LM).

We begin with our analysis of T(L) (= falling/non-falling alternating) tones. These tones are equipped with a fully specified tonal root node and an additional empty tonal root node. In the presence of L%, i.e. a floating low register feature, a line is inserted between the empty root node and the low register feature and an epenthetic L tone is inserted to make the o fully specified. These processes are driven by three constraints: τ←o→ρ militating against empty o's, Alt(ernation) penalizing insertion of lines between material of the same color, and Dep(H) prohibiting insertion of a H tone. The whole picture is given in the tableau in Table 4.[7] The faithful candidate in a. (which is also the input) violates ρ→o and crucially also τ←o→ρ. Candidate b. incurs violations of Dep(L) and Dep(Line) but is optimal compared to candidates c. (violation of Dep(H)) and d. (violation of Alt). The winning candidate b. is a tonal hybrid: it combines lexical tonal features on its first o and both phrasal and epenthetic tonal features on its second o. Note that in the case of LL, the optimal candidate has two identical tonal root nodes associated to the same TBU. The fact that LL is realized as falling follows directly from RTT: the second l must be realized low relative to the first l.

In phrase-medial position, empty tonal root nodes remain empty. The reason for this is the absence of a boundary tone locally adjacent to the o phrase-medially. The tableau in Table 5 shows how Alt and Dep(ρ) conspire to render the fully faithful candidate a., which violates the markedness constraint against empty o's, optimal. For the same reason, low-falling do not occur in polar questions *Pol* and wh-questions with the particle *a Wh.Prt*: in *Pol*, no L% is present, and in *Wh.Prt*, the low register feature associates to the particle and is not available to fill the empty root node of the lexical word (see below).[8]

[7] Our analysis makes the prediction that if other boundary tones such as H% exist in Limbum, they should also interact with empty tonal root nodes. At present, we have not found any evidence of such boundary tones. Our impressionistic judgment of list intonation in Limbum is that non-final items are marked by a toneless prosodic boundary much like in polar questions, and T(L) tones are realized non-falling accordingly.

[8] It was mentioned in footnote 1 that there is (at least) one lexical item with a HM tone in Limbum. Our informants confirm that for this word, HM patterns like H(L) in that it alternates with a level H tone when not adjacent to L%. While this does not seem to a be productive alternation, it is compatible with our account if we choose to represent the second o of HM as being specified for a H tone and underspecified for a register feature.

Table 4: Combining L% and underspecified tonal root nodes creates hybrid tones

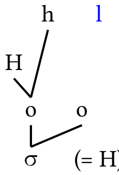
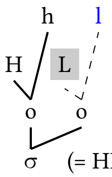
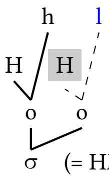
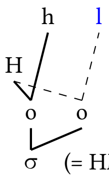
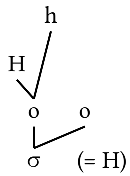
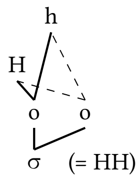
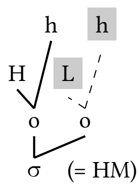
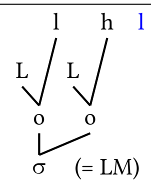
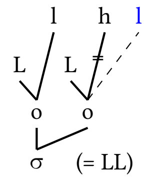
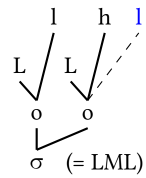
Input = a.	Alt	Dep H	*loh	$\underset{\text{o}}{\overset{\tau\ \ \rho}{\nwarrow\nearrow}}$	Dep L	$\underset{\text{o}}{\overset{\rho}{\downarrow}}$	Dep $\underset{\text{o}}{\overset{\rho}{\downarrow}}$
a.  (= H)				*!		*	
☞ b.  (= HL)					*		*
c.  (= HM)		*!					*
d.  (= HM)	*!						*

Table 5: No falling contour tones in the absence of L%

Input = a.	ALT	DEP l	DEP h	$\tau \leftarrow o \rightarrow \rho$	DEP L	$\rho \rightarrow o$
☞ a. 				*		
b. 	*!					
c. 			*!		*	

The only rising contour tone in Limbum, LM, is unaffected by boundary tones.[9] The interplay of three constraints is responsible for the immunity of fully specified contour tones against overwriting by floating register features: a high-ranked Max constraint against overwriting of register features, a Dep(o) constraint penalizing insertion of tonal root nodes, and the markedness constraint *loh. The tableau in Table 6 shows how the fully faithful candidate a. is chosen as optimal.

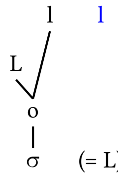
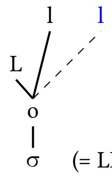
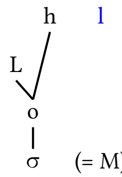
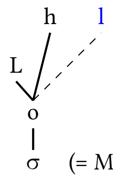
Table 6: Full specification as a protective shield: LM in the presence of L%

	Input = a.	Dep o	Max ρ↓o	*loh	ρ↓o
☞	a. 				*
	b. 		*!		
	c. 			*!	

We now turn to the discussion of level tones. One of the striking arguments in favor of an analysis with L% as opposed to a phrase-medial contour simplification rule (Fransen 1995) is the observation that L is realized as LL in *Decl* and *Wh*. These are the exact same environments for which we independently assume a L% based on the behavior of T(L) tones. The fact that L tones are further lowered in these environments is strong evidence for the presence of L%, and the fact that M and H tones are not affected by it follows directly from the constraint *loh. The tableau in Table 7 illustrates this process. Candidate b. is a hybrid that hosts two l features of different affiliation under the same o, satisfying *loh. In RTT, this configuration is equivalent to that of a low-falling LL tone spread over two tonal

[9] See §2.3 for a discussion of incomplete plateauing of LM before L% in *Wh.Prt*.

Table 7: L% affects L but not M

	Input = a./a’.	Dep o	Max $\overset{\varrho}{\underset{o}{\downarrow}}$	*loh	$\overset{\varrho}{\underset{o}{\downarrow}}$	Dep $\overset{\varrho}{\underset{o}{\downarrow}}$
	a.  (= L)				*!	
☞	b.  (= LL)					*
☞	a’.  (= M)				*	
	b’.  (= ML)			*!		*

root nodes. M and H level tones, however, have a h register feature that blocks association of a floating l feature. The immunity of M and H thus follows from the same set of constraints as the immunity of LM discussed above.

We now turn to polar and wh-questions with the final particle *a*. Polar questions are marked with a toneless particle *a* but lack the L% boundary tone. Recall from §2.2.3 that the flat contour of level tones extends to the particle *a* while the particle receives a M tone following T(L) toned words. As shown in the tableaux in Table 8 and Table 9, the tonal features of an underlying level tone with a single, fully specified o can spread to the tonally unspecified particle because this does not violate NoSkip or Alt. When there is a o intervening between the fully specified root node and the tonal root node on the particle, spreading with skipping is ruled out by NoSkip and across-the-board spreading is ruled out by Alt. Therefore, the optimal repair for the toneless TBU is insertion of a default M tone. Empty o's remain empty in T(L) tones in *Decl.Med* because the Dep constraints penalizing M tone insertion outrank τ←o→ρ. Leaving the particle o empty, however, would fatally violate higher-ranked τ←σ→ρ.

Table 8: Spreading of a level tone in the absence of L%

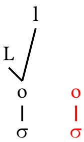
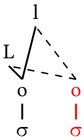
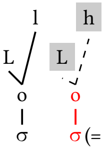
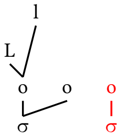
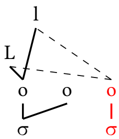
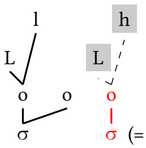
	Input = a.	NoSkip	Alt	τ←σ→ρ	Dep H	Dep l	Dep h	τ←o→ρ	Dep L	Dep ρ↓o
	a.  (= L)			*!				*		
☞	b.  (= L.L)									*
	c.  (= L.M)						*!		*	

Table 9: Default M insertion in the absence of L%

	Input = a.	NoSkip	Alt	τ←σ→ρ	Dep H	Dep l	Dep h	τ←o→ρ	Dep L	Dep ρ↓o
	a.  (= L)			*!				**		
	b.  (= L.L)	*!						*		*
☞	c.  (= L.M)						*	*	*	

In *Wh.Prt*, the particle receives a low tone and the preceding T(L) tones are realized as level tones. This pattern follows assuming there is an additional markedness constraint $*\rho^{2o}$: "Count one ⋆ for each register feature associated to more than one o", ranked below Dep(h) but outranking $\tau \leftarrow o \rightarrow \rho$. The floating l links to the particle o (because of $\sigma \rightarrow \rho$) but not to the other empty tonal root node due to $*\rho^{2o}$. In other words, it is better to use the floating l to fill one unspecified syllable but leave a o on a specified syllable empty than to violate $*\rho^{2o}$ and fill every o. Spreading of level tones to the particle in polar questions (tableau in Table 8) is not affected by $*\rho^{2o}$ because it is ranked below Dep(h), leaving the potential repair of $\tau \leftarrow \sigma \rightarrow \rho$ by epenthesis suboptimal.

4 Discussion

In this section, we briefly consider three potential alternative analyses and discuss some typological implications of our own account.

4.1 Alternative: Contour simplification

Our analysis differs substantially from the rule-based account in Fransen (1995). Fransen proposes an analysis in which T(L) tones are fully specified as LL, ML, and HL underlyingly. They are then subject to a tone sandhi rule, TL → T, which applies in all environments except before a pause. This means that contour tones always surface faithfully phrase-finally in all sentence types. The tone sandhi rule seems rather arbitrary, and it seems like a mere stipulation that the rising tone LM is not subject to simplification. An even more severe drawback of Fransen's sandhi analysis is that it fails to predict the lowering of L. On our account, the fact that L becomes LL in exactly the same environments in which T(L) are realized as TL follows from the presence of L%. Also, our account does not need to stipulate an exception to contour simplification for LM because its immunity follows directly from its full specification and higher-ranked Max(Line) constraints.

4.2 Alternative: Moras

Another possible approach would be an account on which the mora is the TBU. Throughout the paper, we have followed Fiore (1987) and Fransen (1995) in assuming the syllable to be the TBU in Limbum. Since in §2.2.4 we reported that T(L) tones are longer phrase-finally than phrase-medially, it seems appropriate that we defend our decision to ignore the mora in our analysis. First, our informants rejected all minimal pairs that were put forward to support a phonemic opposition of long vs. short vowels in Fiore (1987) and Fransen (1995). We therefore conclude that there is no independent reason to assume a moraic level of representation in the variety of Limbum discussed here. Second, in order to account for the shortness of medial T(L) tones, a moraic analysis would have to argue that a prosodically fully integrated mora is only realized when it is also tonally specified. This would require a rather unusual definition of structure integration and is at odds with standard assumptions about moras and prosodic structure (Hyman 1985; Hayes 1989; Davis 2011b,a; Zimmermann 2017). Third, phrase-final lengthening also applies to level tones, especially to H. This shows that there is no 1:1 relationship between contour tones and vowel length. Fourth, there seems to be a great deal of inter-speaker variation in how prominent the length differences are. It is therefore safe to assume that the emergence of vowel length is best ascribed to boundary effects and accommodation to contour tones and does not need to be reflected on an abstract phonological level.

4.3 Alternative: Cophonologies

Another possible approach to the data discussed here would be to adopt cophonologies (Orgun 1996; Inkelas & Zoll 2007; Sande 2017). A cophonology approach to Limbum tone would assume that certain sentence types have their own grammar, each giving rise to a specific tone pattern. A cophonology analysis does not need resort to tonal decomposition, floating features, or assumptions about morphological colors. Rather, it would have to stipulate specific (sub-)rankings for declarative sentences, wh-questions, and polar questions. While such an approach might be technically feasible, we believe it would have a number of disadvantages over our unified item-based account as it would miss crucial generalizations about the data. For instance, the asymmetry between alternating T(L) tones and non-alternating LM persists through all sentence types. Also, under a cophonology account it would be entirely accidental that M and LM are both unaffected by L%-induced lowering regardless of the sentential context.

4.4 Typological considerations

The interaction between lexical tones and intonation is a topic that has recently attracted growing attention by scholars (Hyman & Monaka 2011; Gussenhoven 2014; Downing & Rialland 2016). In Limbum, ρ→o is ranked relatively low which has the effect that the boundary tone L% fails to be realized in some cases (in particular following non-low level tones and LM). Limbum can therefore be characterized as an instance of *incomplete avoidance* according to Hyman's (2011) typology: *avoidance* because lexical M and H block L% from surfacing, *incomplete* because L and toneless root nodes do allow it to surface. It is also interesting to note that in Limbum, boundary tones affect only final syllables, as opposed to other languages where sequences of more than one syllable are affected (see Kula & Hamann 2017).

From a functional point of view, it is not surprising that Limbum makes use of intonational means to distinguish declarative sentences from polar questions, and neither is it unusual that wh-questions pattern differently from polar questions (see e.g. the surveys in Chisholm et al. 1984 and Jun 2005). Curiously, the two wh-question constructions in Limbum differ in the presence of the final particle *a* but not in their tonal make-up. A promising road for future research would be to investigate whether lexical optionality is more generally associated with prosodic uniformity, and if the opposite relation holds as well.

5 Conclusion

In this paper, we have argued that Limbum has a low boundary tone L% in declaratives and wh-questions but not in polar questions based on an acoustic study with three native speakers. We have shown how tonal alternations, both across lexical items and across sentence types, follow from basic assumptions about tonal geometry and from the distinction between fully specified and empty tonal root nodes. By representing L% as a low register feature, we have proposed a uniform way to model tonal alternations at phrasal edge positions. On our account, tonal hybridity follows straightforwardly from autosegmental linking of phrasal tonal features to lexical tonal root nodes. Limbum thus illustrates the benefits of register features and empty phonological representations, and provides justification for the use of geometry-oriented constraints for analyzing tone-intonation interactions.

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