

The tone system of the Luanyjang dialect of Dinka¹

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Abstract

This paper presents a descriptive analysis of tone in the Luanyjang variety of Dinka, a Nilotic language spoken in Southern Sudan. We show that Luanyjang Dinka has four tonemes, High (H), Low (L), Rising (LH) and Falling (HL). We also describe how underlying tone sequences are often substantially modified in utterances by a number of context-sensitive phonological processes such as dissimilatory lowering of High tones. Given our standard autosegmental description, the phonological categories and processes we posit are broadly familiar from other African languages. However, our analysis requires a typologically less usual understanding of (1) the surface phonetic categories of tone – in particular, what we call “Low” toneme is realized under some conditions as a fairly steep fall; and (2) the relation between the tonal phonology and the quantity system – in particular, we show that each morpheme is underlyingly associated with one and only one toneme, regardless of vowel length. We

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1. We are very grateful to our colleague and reference speaker Caguor Adong Manyang. The exploratory sessions with him led us to our initial hypotheses, and he assisted with data collection in Khartoum. In addition, he provided some of the background information on Luanyjang summarised in Section 1.2. We thank our speakers, in particular Caguor and the other three main speakers: Acuil Malou Choth, Gum Dak Mabior, and Makol Jongkuc Athian. We are indebted to the Institute of African and Asian Studies (University of Khartoum), and in particular to its director, Prof. Al-Amin Abu-Manga, for hospitality at his institute. We presented a preliminary version at the 36th Conference on African Languages and Linguistics (Leiden, August 2006) and at the 2nd Conference on the Typology of Tone and Intonation (Berlin, September 2006). Torben Andersen, Yiya Chen, Laura Downing, Leoma Gilley, Larry Hyman, Constance Kutsch Lojenga, Mary Pearce, Alice Turk, and two anonymous reviewers provided valuable feedback. We gratefully acknowledge their input. Our research on Dinka is sponsored primarily by the Arts and Humanities Research Council (Research Grant no. MRG-AN11781/APN19394). The involvement of Caguor Adong Manyang is supported by the British Academy (Small Grant no. 39265). We gratefully acknowledge their support.

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therefore present a range of acoustic data in support of the basic phonological description.

1. Introduction

1.1. Motivation

Dinka is known for its complex set of suprasegmental contrasts, which includes phonemic distinctions of tone, voice quality, and quantity, that are fairly freely combinable with each other and with different vowel phonemes (Andersen 1987). As in most tone languages, tone in Dinka serves to distinguish unrelated lexical items, but in many respects its more important role is in signalling morphosyntactic distinctions, especially in verb paradigms (cf. Andersen 1993). A detailed understanding of the tone system is therefore of great importance to the study of Dinka grammar. However, the lexically or morphologically specified tonemes of words often cannot be easily observed, because these patterns are modified as a result of phonological tone sandhi and tonal allophony, some cases of which neutralise tonal distinctions.

The co-existence of tonal morphology with phonologically conditioned tonal alternations and neutralisations makes the analysis of the tone system more difficult than in a language where the primary function of tonal distinctions is lexical. In languages with only lexical tone, if we observe a known lexical item with an unexpected tonal pattern, we can confidently attribute the tonal change to the workings of the phonology. In languages with extensive morphosyntactic use of tone, we must always determine whether an observed tonal difference on a known lexical item is morphosyntactically meaningful or phonologically predictable.

For example, the minimal pairs in (1) provide apparently firm evidence of a four-way tone contrast. As seen from these examples, tonemes are specific for particular inflections of the stem.

- | | | | | |
|-----|---------------|------------------------------|---------------|--------------------|
| (1) | kôoot | ‘acacia tree:s’ ² | kööot | ‘care for:PSTPASS’ |
| | wêëer | ‘cow dung:s’ | wëëer | ‘river:s’ |
| | dëel | ‘kind of stubble:P’ | dëel | ‘skin:P’ |
| | gǰëëer | ‘storm:s’ | gǰëëer | ‘kind of tree:s’ |
| | kòk | ‘arm:P’ | kók | ‘hole in tree:s’ |

2. Dinka forms are given as phonemic transcriptions showing the lexically or grammatically specified toneme on each syllable, unless indicated otherwise. We explicitly mark transcriptions as phonetic (i.e. showing the effects of sandhi rules) by means of square brackets. The transcription follows the IPA conventions. The Low (L), Falling (HL), High (H), and Rising (LH) tonemes are transcribed $\grave{}$, $\hat{}$, $\acute{}$, $\check{}$, respectively. While we will argue that the two con-

dence, and by explicitly addressing some doubts about the basic phonetic categorisation of our Dinka surface tone data that have been raised by specialists on African tone systems. We will show that these doubts arise from the way in which Dinka tone interacts – or, rather, fails to interact – with the quantity system: Dinka has a three-level vowel length distinction (Andersen 1987, Remijsen and Gilley 2008), but tonemes associate with syllables irrespective of vowel length, rather than with moras as in many other African languages. As a result, the phonetic realisations of tonemes can vary considerably, depending on the segmental material with which they are associated.

1.2. Background information on (Luanyjang) Dinka

Dinka is a Nilo-Saharan language,³ reportedly spoken by over 2 million people (Gordon 2005), although the actual number may be considerably higher. The Dinkas are spread over much of Southern Sudan, predominantly along the tributaries of the White Nile. As a result of ongoing civil war, there are also communities elsewhere within Sudan, in particular in the capital Khartoum, and abroad. Cattle play a key role in the Dinka economy, and also in the socio-cultural system.

Four major dialect areas are commonly distinguished: Padang, Rek, Agar, and Bor. The variety of Dinka represented here – Luanyjang or Luac, as it is referred to in Roettger and Roettger (1989) – is part of the Rek dialect group, and immediately borders Agar territory. The term Luanyjang (/lwajɲaŋ/) ‘people of Luac’, refers in the first place to a section within the Dinka ethnic group, and by extension also to their variety of the Dinka language. The main town in Luanyjang territory is Wuncuei, which is located about 170 kilometres east of the city of Wau. Luanyjang has around 15000 speakers according to Ethnologue (Gordon 2005). Here again, it is likely that the actual number is much higher.

Dinka phonology other than tone can be summarized as follows. Parallel sets of voiced and voiceless stops and nasals are found at five places of articulation (/p, t̪, t, c, k/, /b, d̪, d, ɟ, g/, /m, n̪, n, ɲ, ŋ/). The voicing contrast in stops is distinctive in syllable onsets, but not in codas. In addition, there are /l/ and /r/, and the semivowels /w, j, ɥ/. There are no fricative consonant phonemes.

There are seven phonemic vowel categories: /i, e, ε, a, ɔ, o, u/. In addition, like most other dialects of Dinka, the Luanyjang dialect has a voice quality distinction involving breathy vs. modal or creaky. This distinction is almost completely orthogonal to vowel quality except that /u/ only ever occurs with

3. The complete genetic path according to *Ethnologue* (Gordon 2005) is: Nilo-Saharan, Eastern Sudanic, Nilotic, Western Nilotic, Dinka-Nuer.

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breathy voice. Luanyjang Dinka also has a quantity contrast involving three levels of vowel length (/V/ vs. /VV/ vs. /VVV/ – referred to as short, mid, and long, respectively). The same distinction is found in the neighbouring Agar dialect (Andersen 1987). Functionally, the three-way vowel length contrast maps onto four levels of lexical / morphological quantity. That is, stems are either lexically short or lexically long. Most of these occur both in a short and in a long grade, with this morphological grade distinction marking several inflections. The phonologically short vowel length is found in the short grade of short stems, and the phonologically long vowel length is found in the long grade of the long stems. The phonologically mid vowel length corresponds to the long grade of a short stem and to the short grade of a long stem alike. In this way, the Dinka quantity system reminds us of Estonian, where, in the words of Lehiste (1997: 25) “[...] there is a morphologically determined two-way opposition between weak and strong degrees, and a three-way phonological opposition between word-level prosodic patterns”. A detailed analysis of the Dinka quantity system can be found in Remijsen and Gilley (2008).

It is a defining characteristic of the Western Nilotic languages that inflected stems are mostly monosyllabic, like the corresponding lexical roots (Andersen 1990: 6, Tucker 1981: 311). Both typically have the form CV(V)(V)C. Instead of being marked by affixes, nominal and verbal inflections are predominantly marked by segmental changes in the nucleus and the coda, and by changes in vowel length, tone and voice quality (cf. Andersen 1993, 1992–1994, 2002). In particular in the verb system, tone plays a key role in distinguishing a rich set of inflections. A few of these are illustrated in (3).

- (3)
- a. **Acóol à-màaan**
Acol AGRS-hate:1s
'I hate Acol.'
 - b. **Acóol à-măaan**
Acol AGRS-hate:PSTPASS
'Acol has been hated.'
 - c. **Acóol à-máan**
Acol AGRS-hate:2s
'You hate Acol.'
 - d. **Acóol à-mâan**
Acol AGRS-hate:PASS
'Acol is hated.'

These examples show that the stem meaning ‘to hate’ can appear with each of the four tonemes, as a function of verb morphology. In (3a, b) the 1st singular and past passive forms differ solely in terms of tone: the 1st singular form has the L toneme, the past passive the LH toneme. Both have the long grade of the stem. In (3c, d), we see another minimal contrast involving the same verb,

now in the short grade of the stem: the 2nd singular form has the H, while the passive has the HL. The important role of tone in the Dinka transitive verb system has been studied in detail by Andersen (1993:8), who focused on the Agar dialect. His analysis reveals that while certain inflections are marked by a particular toneme for all verbs alike, other inflections are specific to particular classes of verbs. In the Luanyjang dialect, for example, while **něem** ‘to check:PST’ and **máaan** ‘to hate:PST’ have different tonemes in the active past infinitive, they have the same toneme in the passive past inflection – **něem** ‘to check:PSTPASS’ and **măaan** ‘to hate: PSTPASS’, respectively. Tone also plays a role in nominal morphology, especially in the marking of number. But while tone patterns of (transitive) verbs are predictable given their inflection and their verb class, they are generally not predictable in noun paradigms. The only consistent generalisation about the marking of number is that, most often, one level of the number distinction appears in the short grade of the stem, while the other appears in the long grade. The combined modifications of quantity and tone can be seen in (4). Other phonological parameters that are sometimes involved in the marking of number are vowel quality and diphthongisation, voice quality, and the nature of the coda phoneme.

- | | | | | |
|-----|----|--|----|------------------------------------|
| (4) | a. | c̣ok / c̣ok
‘foot:s/P’ | b. | nòoon / nóon
‘grass:s/P’ |
| | c. | apiḳool / apiḳòool
‘story:s/P’ | d. | ḅap / ḅap
‘chief:s/P’ |

As seen from (4), there is no fixed relationship between nominal number on the one hand and the grades of the stem. That is, while in (4a, b) the singular is in the long grade of the stem, in (4c, d) the singular appears in the short grade. As reported by Dimmendaal (2000), it is a general characteristic of the Nilo-Saharan languages that the conceptual nature of a noun determines which level of the number distinction is unmarked. Nouns referring to concepts that are inherently plural or collective such as those in (4a, b) are unmarked in the plural, and nouns referring to concepts that are inherently singular such as those in (4c, d) are unmarked in the singular. In Dinka, the morphologically unmarked form of the stem is in the short grade.

1.3. Data and Methods

We started our investigations with exploratory elicitation sessions with a single speaker referred to here as our reference speaker. These sessions took place in Edinburgh, about twice a week over a period of three months. They were complemented with a weekly session to record audio data, which allowed us to verify auditory impressions. At the end of this three-month period, we had

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hypotheses about the number of tonemes, several tone sandhi phenomena, and we had some knowledge about the role of tone in the verb morphology.

We then proceeded to evaluate our hypotheses through a systematic analysis of tone patterns on the basis of noun data from several speakers. The data were collected in Khartoum. In order to study tone sandhi phenomena, nouns are more suitable than verbs, because they can be relatively freely embedded in a range of sentence contexts. By contrast, inflected verb forms can only appear in particular positions in the sentence. We aimed to record 32 nouns, 8 for each of the 4 tonemes. This set of 8 cases for each toneme includes a range of structural patterns. There are monosyllabic, disyllabic, and trisyllabic words; words with a diphthong vowel; short, mid, and long vowels; some with a voiced coda (nasals, /l/, /r/), others with an unvoiced coda (stop). Several more lexical items ended up in the dataset, as we retained cases in which speakers uttered nouns and noun inflections other than the ones we intended to collect. To gain insight into tonal variation as a function of context, each of the 32 nouns was elicited twice in 11 contexts. The selection of contexts was motivated by our findings in the exploratory investigations with our reference speaker. Together, the exploratory investigations and the recordings make up the empirical basis of the description of Luanyjang Dinka tone that we report in Section 2.

The complete set of materials was elicited from three male speakers, one of whom is the reference speaker of the exploratory sessions. Dinka is their native language, and they use it every day. They speak English as a second language. All three are long-time residents of Khartoum, having left the Luanyjang area as teenagers. Importantly, they use Dinka on a daily basis, often with other speakers of the Luanyjang dialect. The data were recorded over several sessions. In each session, four nouns – one for each of the four tonemes – was elicited in all contexts. The contexts were presented on paper, with the slot of the target noun marked by X, and the first author provided instructions in English when necessary. Because the four nouns were the same within each session, and because the same 11 contexts were used in all sessions, little prompting was needed and the speakers only considered the contexts on paper at the start of the first session. Given these characteristics, the dataset represents elicited – but not read – speech. In addition, one eighth of the dataset was recorded with a fourth Luanyjang speaker, who had recently arrived in Khartoum, and who did not speak English. His data were collected in the same way, but with the assistance of our reference speaker.

Between-speaker variation is very limited, and, crucially, we noted no consistent difference whatsoever between the recently arrived speaker and the others. In total, we recorded 2349 sentences, reflecting 48 lexical items, 11 contexts and 4 speakers. This dataset is available as an electronic resource (Remijssen and Macmartin 2007).

In addition to this large dataset based on the speech of four speakers, we recorded a total of 10 speakers producing the minimal set in (5), in which all four proposed tonemes occur on the same segmental sequence. The members of the minimal set are followed by the contexts in which they were elicited.

- (5) a. **kôoot** > [kôoot] ‘acacia tree:s’ in
 [Acóol à-tìŋ kôoot]
 Acól AGRS-see:ZERO acacia_tree:s
 ‘Acól sees an acacia tree.’
- b. **kǒoot** > [kǒoot] ‘care for:PSTPASS’ in
 [kóoc à-cí kǒoot]
 people AGRS-AUX:PST care_for:PSTPASS
 ‘The people have been cared for.’
- c. **kóoot** > [kóoot] ‘care for:PST’ (following L or HL) in
 [Déeŋ à-cí bàaj kóoot]
 Deng AGRS-AUX:PST house:s care_for:PST
 ‘Deng has cared for the household.’
- d. **kóoot** > [kòoot] ‘care for:PST’ (following H or LH)
 [Déeŋ à-cí kòoc kòoot]⁴
 Deng AGRS-AUX:PST people care_for:PST
 ‘Deng has cared for people.’

The speakers with whom we recorded the minimal set were three women and seven men, including the 4 male speakers of the main dataset. Three of the 10 speakers had recently arrived in Khartoum, while the others had been living there for several years. These minimal-set data are also included in Remijsen and Macmartin (2007). We used the minimal set data as the basis of a statistical analysis of the acoustic detail underlying the proposed four-way tonal contrast. That analysis is reported in Section 3.

2. Qualitative autosegmental analysis of Luanyjang tone

2.1. Initial description of the realisation of the four tonemes

Almost the first thing that becomes apparent in working with Dinka tone is that the same word can have markedly different tonal realisations in different contexts, and that some of the contextually induced changes in phonetic realisation lead to neutralisation or near-neutralisation of tonal contrasts. This contextual

4. The tone on [kòoc] ‘people’ is superficially low, but it has a high tone underlyingly. This underlying high tone triggers the lowering of the following verb **kóoot** ‘care_for:PST’.

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variation in the realisation of the Dinka tonemes is not limited to the Luanyjang dialect. Table 2 in Andersen (1987: 20) documents similar variation in Agar Dinka. However, as already noted in the introduction, with verb forms it is not clear *a priori* whether a given tonal variation is morphologically meaningful or phonologically predictable from the context. We therefore focused on the tonal patterns of nouns, eliciting a large number of nouns in a range of different contexts, and established that the tonal variation can be reduced to a set of four patterns of alternation – differing slightly between monosyllabic and disyllabic nouns – which are summarised in Table 1. This led us to assume that we were dealing with four distinct tonemes, and we then set about trying to establish an appropriate phonological representation for each of the four and to establish the contextual factors that bring about the patterns of alternation.

Although the transcriptions in Table 1 show the surface phonetic detail of the patterns of alternation as we now understand it, we cannot emphasise enough that several of the pairs of surface tonemes that we show as distinct are actually very difficult to distinguish auditorily, and that the patterns of alternation were therefore essential for developing the analysis. This applies particularly to the following cases:

- (a) The distinction between the citation forms of what we transcribe as the Low (L) and Falling (HL) tonemes is difficult to hear on short vowels. Both appear to have falling pitch.
- (b) Following any L tone (e.g., in Context 4 of Table 1), both the High and Rising tonemes sound like rising pitch.
- (c) When the Rising toneme is uttered in the citation forms, its realisation – transcribed as mid tone – sounds very similar to that of the High toneme.
- (d) In Context 2, the tone pattern of disyllabic words that have the Falling (HL) and High (H) tonemes in the citation form is identical to that of words with Low toneme.

In part because of the uncertainty about the phonetic nature of what we were hearing, we took instrumental analyses of the pitch contours into account from the very beginning of our project.

On the basis of the preliminary classification in Table 1, we identified two contexts in which there were four clearly distinct realisations of the four putative tonemes on monosyllables. These contexts are the citation form and what we will refer to as “existential yes/no questions (YNQ)”, e.g.:

- (6) **dě ak̩ʒ̩ʒ̩n**
EXIST elephant:s
'Is there an elephant?'

Except for the Rising toneme, the realisations of the four tonemes are very similar in the two contexts, and we took these realisations as the tonemes' prototypical manifestation. Importantly, YNQs in the Luanyjang dialect do not

Table 1. Context-sensitive tone alternations in mono- and disyllabic words, illustrated in five contexts. In the case of the rightmost context, the tonal realisation of the final word varies as a function of the tone pattern on the target noun. The nouns that are included in this Table are also the words that are used in Figures 1 to 6 below.^a Morpheme glosses appear further on in the paper: existential statement in (19); existential question in (6); between Low tones in (8a); between High tones in (8b).

Toneme	Context				
	1.	2.	3.	4.	5.
Citation form (X)	à-àa-dě X	dě X	Acól à-tij̃ X è-tj̃ne	Acól à-cí X máaan	
	'There is/are X.'	'Is/Are there X?'	'Acol sees X there.'	'A. has hated X.'	
<i>Monosyllabic</i>					
Low (L)	[nòoon]	[nòoon]	[nòoon]	[nòoon]	[nòoon máaan]
Falling (HL)	[t̃iim]	[t̃iim]	[t̃iim]	[t̃iim]	[t̃iim máaan]
High (H)	[léey]	[léey]	[léey]	[léey]	[léey màaan]
Rising (LH)	[láaay]	[láaay]	[láaay]	[láaay]	[láaay màaan]
<i>Disyllabic</i>					
Low (L)	[aɲiic]	[aɲiic]	[aɲiic]	[aɲiic]	[aɲiic máaan]
Falling (HL)	[akɔɔn]	[akɔɔn]	[akɔɔn]	[akɔɔn]	[akɔɔn máaan]
High (H)	[apáaar]	[apáaar]	[apáaar]	[apáaar]	[apáaar màaan]
Rising (LH)	[ag̃oor]	[ag̃oor]	[ag̃oor]	[ag̃oor]	[ag̃oor màaan]

^a The HL toneme on monosyllabic words is represented by **t̃iim** 'tree:p' in Figures 3 and 6, but by **máal** 'meat on hide:s' in other figures.

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appear to be marked by a sentence-final high tone – instead, they are characterised by an increase in f_0 range; as a result, this is a context in which tonemes tend to be realised with maximal salience.

Figure 1 shows f_0 traces of each of the four tonemes in both citation form and existential YNQ contexts. These f_0 traces helped us to determine that the phonetic differences transcribed in Table 1 are genuine even though we found them hard to hear. For example, consider point (a) above, the distinction between the citation forms of the Low and Falling tonemes. The f_0 traces confirm that both are phonetically manifested by a fall in pitch. However, we can also readily see that there is a phonetic difference between them. In the toneme we analyse as Low (L), the fall sets in at the beginning of the syllable nucleus (marked by the vertical line in Figure 1) and continues throughout the syllable (Figure 1, dotted traces). In the toneme we analyse as Falling (HL), the fall invariably occurs later in the syllable, starting well into the vowel (Figure 1, solid traces). It is sometimes preceded within the syllable by a slight rise; if so, the peak involved in the realisation of the HL may be higher than the f_0 value found at the start of the L, other factors being equal. The most consistent difference between the two tonemes in these and other cases appears to lie in the *alignment* of the f_0 contour relative to the segments that make up the syllable. Alignment as a relevant phonetic feature in the description of f_0 patterns is by now well studied in European intonation systems (Bruce 1977; Arvaniti, Ladd and Mennen 1998; Ladd 2006), and in a somewhat different way in Chinese (Xu 1999), but it is still relatively unfamiliar as a phonetic dimension in descriptions of most tone languages. In any case, the acoustic data make it clear that the two tonemes are different. It is not self-evident to infer a Low toneme from the falling f_0 contour of the first toneme – we return to this point below (cf. Section 2.4).

The distinction between the High and Rising tonemes (point (b) above) is similarly confirmed by the f_0 traces, and similarly depends on the alignment of the f_0 contour with the segmental string. The toneme we analyse as High (H) is characterised by high f_0 throughout most or all of the syllable (Figure 1, dash-dotted traces). From a preceding Low target, f_0 starts rising steeply right from the onset of the syllable, and remains high once it has reached a certain level. It may continue to rise somewhat, remain level, or drop off somewhat, without altering the impressionistic perception of high pitch. In the existential YNQs with their characteristically wide f_0 range, the rise carries on throughout the syllable, as can be clearly seen in Figure 1. By contrast, the pitch rise of the toneme we analyse as Rising is a low-then-rising f_0 pattern, which can be seen clearly in the existential YNQ context (Figure 1C, D, dashed traces). This realisation is also found in non-phrase-final contexts generally, as we shall see below (cf. Figure 2). The key phonetic property of this variant of the Rising toneme is that f_0 remains low well into the vowel and then starts going up. This contrasts with the very early rise followed by level pitch in the High toneme.

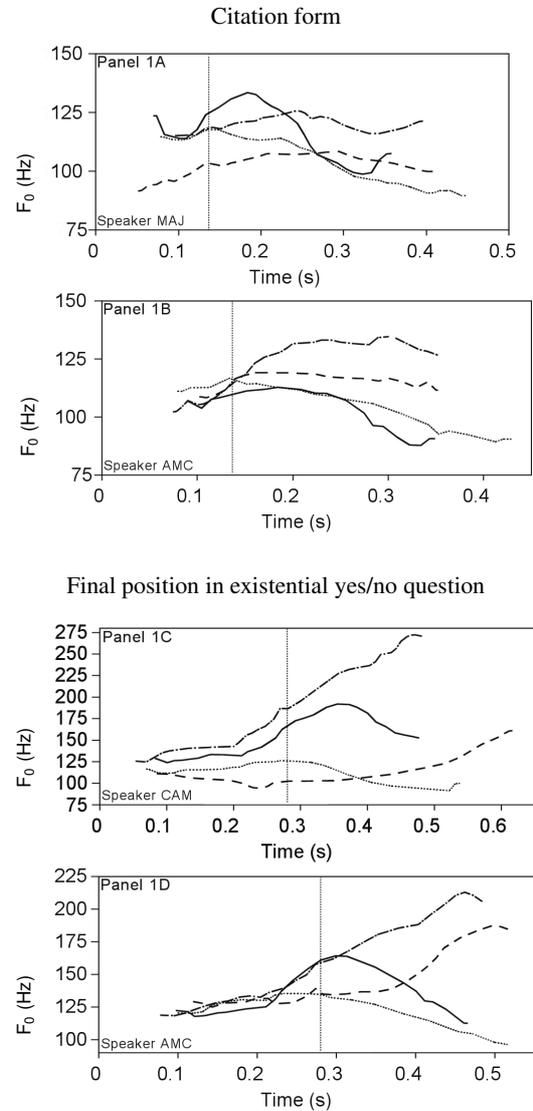


Figure 1. The four tonemes on monosyllabic words with a mid or long vowel and a sonorant coda in two sentence-final contexts. The nouns in question are presented in Table 1. Two speakers (identified by their initials) are represented for each context. High (H): dash-dotted; Rising (LH): dashed; Low (L): dotted; Falling (HL): solid. The f₀ traces are aligned on the start of the vowel of the target word, which is marked by a dotted vertical line. To achieve this alignment, the irrelevant initial sections have been truncated to a variable extent. These conventions hold for all following Figures unless indicated otherwise.

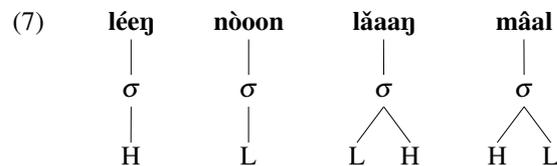
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Just as in the case of the distinction between the Low and Falling tonemes, in other words, the alignment of the f₀ contour with the segments is the crucial characteristic that differentiates High from Rising.

The Rising toneme is of particular interest because it is not found in the neighbouring Agar dialect (Andersen 1987). It is also more variable in its phonetic realisation than the other tonemes are, being the only toneme whose realisation on monosyllabic nouns differs markedly between the citation form and the YNQ context. In citation form (or more generally, in final position in any declarative sentence), it is realised with level f₀ in the middle of the speaker's tone space (Figure 1A, B, dashed traces). Impressionistically, this sounds like moderately high level pitch, and as noted above (point (c)) it can be difficult to distinguish this level realisation from that of the High. That is, because the syllable contour shape is the same as that of the High toneme in this context, and because the f₀ height is not very different, the Rising and High tonemes are easily confused in citation form or declarative sentence-final context (Figure 1A-B, dashed vs. dash-dotted traces). It will thus be important to present further evidence for the existence of the distinction between them; we return to this point repeatedly below.

2.2. *Tonal processes and the motivation for an autosegmental analysis*

Having established a basic phonetic description of the four tonemes, we next proceed to describe three processes of contextual variation. As we shall see, these processes provide the main motivation for the autosegmental analysis of the four tonemes as L, HL, H and LH. The form of the argument is one familiar to anyone with experience in African tonal phonology (e.g., Goldsmith 1990: 39 ff): (a) a process that is triggered by a preceding High toneme is also triggered by a preceding Rising toneme; (b) a process that affects a following High toneme also affects a following Falling toneme; (c) therefore it makes sense to reject a holistic interpretation of the contour tonemes as Rising and Falling, and to interpret them phonologically as being made up of L and H tone components, as in (7).



If we do this, the descriptions of the processes need to refer only to H tones, not to High and Rising or High and Falling tonemes: the H tone component of the contour tonemes is accessible to phonological processes.

2.2.1. *Dissimilatory Lowering.* The most important sandhi process is the dissimilation of sequences of H tones. Specifically, H tone turns into L when preceded by another H. In keeping with the observations just made about the composite nature of the contour tonemes, this dissimilation process also applies to a High toneme preceded by a Rising (LH) toneme, and to a Falling (HL) toneme preceded by either High (H) or Rising (LH) tonemes; more detail is given below.

Figure 2 shows f₀ traces illustrating the tonemes on the same monosyllabic words that are represented in Figure 1. Now they are embedded in three sentence-medial contexts differing crucially in their tonal specification. The sentence structures are illustrated in the examples in (8).

- (8) a. **Acóol à-tíŋ akḥḥḥon è-téne** (L __ L)
 Acol AGRS-see:ZERO elephant:S PRP-there
 ‘Acol sees an elephant there.’
- b. **Acóol à-cí akḥḥḥon máaan** (H __ H)
 Acol AGRS-AUX:PST elephant:S hate:PST
 ‘Acol has hated an elephant.’
- c. **Acóol à-cìi akḥḥḥon tíŋ** (L __ H)
 Acol AGRS-AUX:NEG elephant:S see:NEG
 ‘Acol does not see an elephant.’

Panels A, B of Figure 2 present the target words preceded and followed by Low tonemes. This context can be considered as a baseline for comparison: when embedded in this context, the tonemes are realised in the prototypical way found in existential YNQs described in the preceding section.⁵ The other two contexts – represented in Figure 2C, D and in Figure 2E, F – involve H tones in the immediate context. Panels C, D display f₀ traces of the four tonemes with H tones both before and after the target word. In panels E, F, the target words are preceded by L and followed by H.

We can determine the effect of a preceding H tone by comparing the tonal realisation of the target words in the different contexts. When preceded by a L tone, the traces of both H and HL show high or rising f₀ (Figure 2A, B, E, F, dash-dotted and solid traces). When they follow H tone, however, both are falling right from the beginning of the vowel (Figure 2C, D), with the result that they are indistinguishable in tonal shape from the L. This indicates that H tone targets dissimilate to L when preceded by another H tone.

There are several other instances of this phenomenon elsewhere in Figure 2. In panels 2E, F, we can observe it on the H-toned negative infinitive

5. The only exception is the realisation of the HL-toned noun by speaker CAM – we will return to this issue in section 2.2.2.

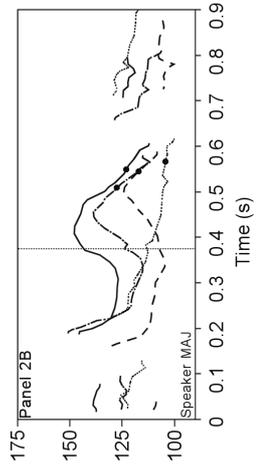
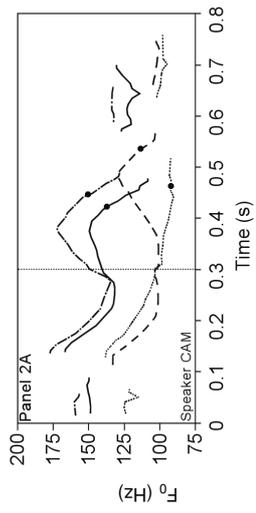
(**tíj** ‘see:NEG’) that follows the target words (i.e., the portion of the f₀ traces to the right of the dot). The underlying H of this infinitive is evident when it is preceded by the L or the HL tonemes (dotted and solid traces). When preceded by the LH or H tonemes, though, the f₀ pattern on the infinitive is a fall (dashed and dash-dotted traces). Something similar happens with the infinitive **máaan** ‘to hate-PSR’, which follows the target word in Figure 2C, D (i.e., after the dot). Here again, the underlying H tone can be observed when it follows the HL and L tonemes. The H on **máaan** dissimilates to L when preceded by either the H or the LH tonemes.

Of particular interest is what happens when the infinitive is preceded by an underlyingly H-toned noun (Figure 2C, D, dash-dotted traces). Here we have a sequence of three H tonemes: **cí léerj máaan**. The H on the target noun, the second H in this sequence, has itself dissimilated to L, due to the H toneme on the preceding auxiliary. Nonetheless, the third H also dissimilates to L, even though the underlying H of the preceding noun is not evident from the surface realisation. The crucial contrast here is between the traces for Low- and High-toned nouns (Figure 2C, D, dotted vs. dash-dotted traces). Both nouns have the Low toneme on the surface, one because it has the Low toneme underlyingly, the other as a result of the dissimilation process. Crucially, the following infinitive **máaan** has high f₀ when it follows the underlying L, but it shows a falling pattern when the preceding L is actually a dissimilated H. We can infer that the H on **máaan** dissimilates to L after another H, even when this H has itself dissimilated to L. This phenomenon presents compelling support for a distinction between underlying and surface representations in the description of tone, and raises a variety of formal issues, which we return to only briefly below.

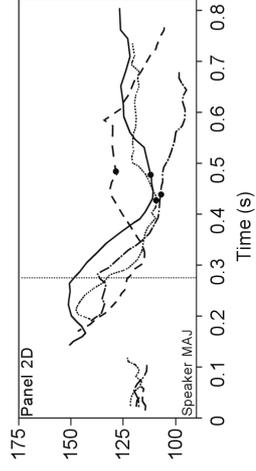
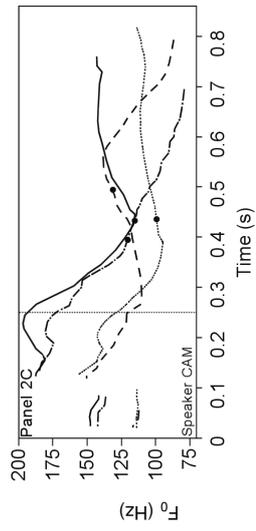
The traces in Figure 2 also provide confirmation of our analysis of the Rising toneme. As we saw in the previous section, in citation form and in sentence-final position in declarative utterances, this toneme is difficult to distinguish from the High toneme. However, in existential YNQs it is realised as a low-then-rising contour, which provides a phonetic basis for analysing it as involving an initial L component, and this phonetic form appears again in all the non-final contexts shown in Figure 2. Moreover, the initial phonological interpretation on the basis of phonetic form is corroborated by its behaviour when preceded by H tone (Figure 2C, D, dashed traces). Unlike the High toneme, the Rising toneme does not dissimilate to L, which supports the suggestions that it contains an initial L component that protects the following H component from the dissimilation process. The low-then-rising contour is also present when the word is followed by a L (Figure 2A, B, dashed traces), indicating that the high target must be accounted for in terms of the underlying phonological representation.

The dissimilation process itself can be represented autosegmentally using the formula in (9), where the square bracket symbolises a morpheme boundary.

Medial context: L__L



Medial context: H__H



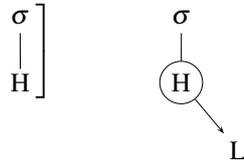
Medial context: L __ H



Figure 2. The four tonemes on monosyllabic words with a mid or long vowel and a sonorant coda, embedded in three sentence-medial contexts. H: dash-dotted; LH: dashed; L: dotted; HL: solid. The f0 traces are aligned on the start of the vowel of the target word, which is marked by a dotted vertical line. The end of the target syllable is marked by a dot.

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(9) Dissimilatory Lowering (preliminary version)

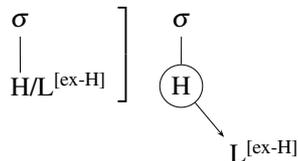


As seen from Figure 2C, D, Dissimilatory Lowering can apply twice in a row. This is illustrated in (10), where **cí** triggers dissimilation on **léey**, and **léey** itself triggers dissimilation of **máaan**.

- (10) **Acóol à-cí** **léey** **máaan** **è-téne**
 [Acóol à-cí] **lèey** **màaan** **è-téne**
 Acól AGRS-AUX:PST drum-S hate:PST PRP-there
 ‘Acól has hated a drum there.’

Because a L tone resulting from dissimilation of H can trigger Dissimilatory Lowering, we need to ensure that its underlying H is somehow accessible to the second application of Dissimilatory Lowering in a sequence. This motivates the reformulation of Dissimilatory Lowering in (11), where we specify that a L tone that results from dissimilation can itself trigger the application of Dissimilatory Lowering, on a par with a non-dissimilated H.

(11) Dissimilatory Lowering



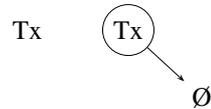
We do not of course regard the notation $L^{[\text{ex-H}]}$ as anything other than an ad hoc descriptive device, and we note that the phenomenon it expresses actually poses an interesting problem for any formalisation of phonological theory. In a rule-based derivational description, the application of Dissimilatory Lowering (as stated in its preliminary version in (9) above) should bleed its application to a following H tone, yet it does not. Here we report the facts as we have observed them, and do not attempt to resolve this theoretical issue.

In our dataset, we find a small number of exceptions to the iterated application of Dissimilatory Lowering to strings of underlying High tonemes. Specifically, we find cases structurally identical to (10) in which Dissimilatory Lowering applies between the auxiliary and the noun, but not between the noun and the infinitive. These exceptions appear more often in slower speech, and in

initial sessions with particular speakers. Although such realisations are atypical in the dataset they suggest that Dissimilatory Lowering scans the string in left-to-right fashion, and that the process requires some degree of cohesion in terms prosodic constituent structure. As we will see below, Dissimilatory Lowering is not the only tone sandhi process that requires the constituents to be closely connected. Presumably, any influence between adjacent tones can be disrupted if the words at issue are uttered with insufficient prosodic cohesion. Similar phenomena are of course known in other languages, perhaps the best known case being that of Tone 3 sandhi in Mandarin Chinese (e.g., Chen 2000: Chapter 9).

Finally, we note that when Dissimilatory Lowering affects the initial tone component of a HL contour toneme, the resulting surface pattern is indistinguishable from a L toneme. There is no support, then, for postulating a LL toneme, for which there is no evidence in terms of minimal distinctions anyway. Given this, we invoke the Obligatory Contour Principle (OCP), which says that a sequence of two adjacent, identical tones within a morpheme is reduced to one (cf. Goldsmith 1990: 23). The rule in (12) deletes the second of any identical tones within the same morpheme.

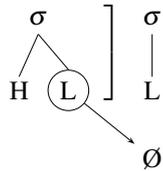
(12) Obligatory Contour Principle



2.2.2. Low Absorption. Figure 2 presents evidence of a second tone sandhi process. If we consider the realisation of the HL toneme between two L tones (Figure 2A, B, solid traces), we find that speaker CAM, in panel 2A, produces the word with high level f₀. We can describe this phenomenon as Low Absorption: the Low component of the HL contour toneme is lost or absorbed by a following L tone. The latter term – Low Absorption – is adopted from Andersen (1987), who postulates such a process for the Agar dialect. An autosegmental representation of Low Absorption is presented in (13), which can be paraphrased as follows: the Low component of the HL is deleted when it is followed by another Low, associated with a following morpheme.

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(13) Low Absorption



Going back to Figure 2, we find that the same HL-toned noun in the same context uttered by speaker MAJ is unaffected by Low Absorption. That is, there is a late fall in the target word, albeit associated somewhat later in the rhyme than in the utterance-final contexts. In order to understand the source of this variability we need to consider additional data.

Figure 3 shows the realisation of the HL-toned noun **túim** in two different contexts, identical in terms of tonal specification (L __ L). In one context, the HL is followed by a L-toned adjective (solid trace); in the other, it is followed by a L-toned adverb (dash-dotted trace) – the same tonal context as in Figure 2A, B. The syntactic structures are illustrated in (14). Separate panels represent different speakers. As in Figure 2, the dot marks the end of the syllable. When the underlyingly HL-toned noun is followed by the adjective, all three speakers realise it as high f₀, indicating that Low Absorption has taken place. But when it is followed by the adverb, the speakers differ in their behaviour. Speakers MAJ and CAM realize HL prototypically, with a fall setting in well after the onset of the vowel. In panel 3C (speaker GDM), by contrast, f₀ remains high up to the end of the syllable, indicating that Low Absorption has taken place.

- (14) a. **Acóol à-tùḡ** **túim è-téne** (L __ L [adverb])
 Acól AGRS-see:ZERO tree:P PRP-there
 ‘Acól sees a tree there.’
- b. **Acóol à-tùḡ** **túim tít** (L __ L [adjective])
 Acól AGRS-see:ZERO tree:P red:P⁶
 ‘Acól sees red trees.’

How can this state of affairs be explained? The noun phrase made up of noun plus adjective is a cohesive syntactic domain, much more so than the sequence of a noun phrase followed by an adverb. It appears that Low Absorption only takes place when the morphemes at issue are within the same phrase-level prosodic domain. The units of the syntactic noun phrase tend to be part of the same prosodic phrase. The sequence of noun phrase plus adverb, on the

6. The adjective agrees with the head noun in quantity. That is, it appears in the long grade when it modifies a singular noun and in the short grade when it modifies a non-singular noun – as in (14b). Attributive adjectives invariably have the Low toneme.

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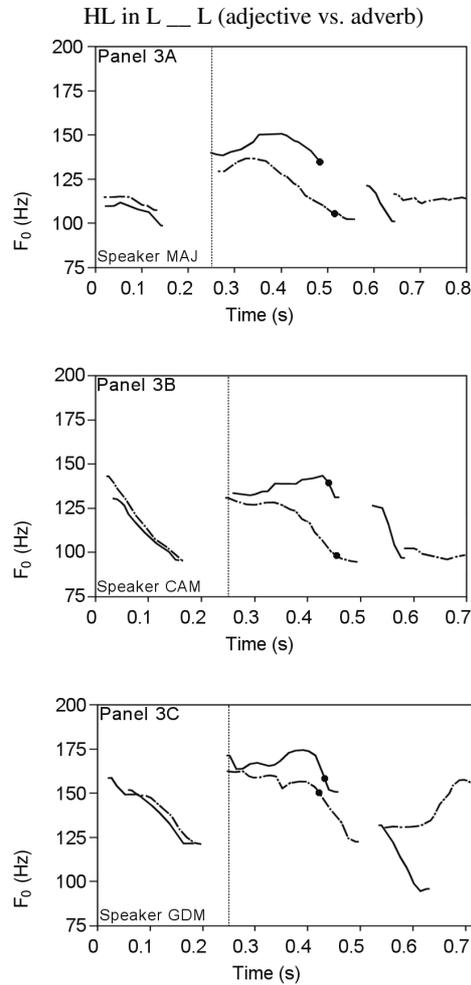
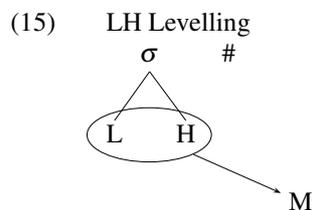


Figure 3. F0 traces illustrating variation in the realisation of HL-toned *t̥im*, in two different contexts, namely with the target noun followed by an adjective (solid) or by an adverb (dash-dotted). Different speakers are represented in separate panels. The f0 traces are aligned on the start of the vowel of the target word, which is marked by a dotted vertical line. The end of the target syllable is marked by a dot.

other hand, may or may not be broken up by a prosodic phrase boundary, and Low Absorption only takes place if no such prosodic boundary is present.

Recall that in Figure 2, we found similar between-speaker variability in the application of Low Absorption in the case of a sequence of noun followed by infinitive. Moreover, we noted in Section 2.2.1 that Dissimilatory Lowering may fail to apply recursively, in particular in sentences that are not uttered fluently. All of these cases of variability in the application of sandhi processes indicate that the domain in which they apply is not strictly of a syntactic nature, and suggest that it is more appropriate to characterise it as a prosodic one. The question of prosodic domain structure in Luanyjang Dinka is beyond the scope of the current paper.

2.2.3. *LH levelling.* Our autosegmental account has now almost caught up with the data considered so far, but we have yet to comment explicitly on the allophonic variation in the LH. As we saw in Figure 1, in a prepausal declarative context this toneme is realised with level f0 in the middle of speakers' tonal space. This f0 pattern is distinct in form from the prototypical low-then-rising contour which characterises the realisation of the LH when it is not in phrase-final position. Because of the salient difference in realisation, it may be considered appropriate to incorporate this allotonic variation into the phonological representation. An autosegmental rule that does this is presented in (15), where # stands for a declarative phrase boundary. This allophonic implementation rule is ordered after rules that could make reference to the tone components of the LH toneme.



Rule (15) treats the level realisation of the Rising toneme as a surface mid tone. Importantly, there is no evidence for mid tone as a distinctive pattern at the underlying level. It may be instead that this allophony should be treated in terms of language specific phonetic realisation rules that somehow merge or overlap the pitch-lowering and pitch-raising gestures in the sentence-final context. Note that, although the H and LH tonemes are difficult to distinguish impressionistically in citation form or sentence-final context, they do not appear to be truly neutralised (see further Section 3). We leave this matter unresolved for the present, and note only that the two impressionistically distinct realisations of the LH toneme must be accounted for somewhere in a complete description of Luanyjang Dinka tone.

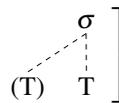
2.3. *Polysyllabic words and the sensitivity of tone processes to morphosyntax*

The great majority of Dinka morphemes are monosyllabic (Andersen 1987, Storch 2005). The same goes for inflected word forms, because, as we have seen, inflections modify the prosodic and segmental features of the stem rather than adding affixes. To the best of our knowledge, verbs are strictly monosyllabic in Dinka. Nouns, by contrast, can consist of more than one syllable. In an overview of Dinka noun morphology, Storch (2005:168) states that, excluding loanwords and compound nouns, the word pattern /aCV(V)(V)C/ is the only polysyllabic noun template. In some cases, this initial /a-/ can be analysed as a prefix that derives nouns from verbs, or that marks feminine gender on cattle colour terms. But, as Storch (2005: 171) writes, “there is also a large group of primary [i.e., underived] nouns that exhibits [the initial /a-/]”. The discussion of polysyllabic words in this section is limited to the /aCV(V)(V)C/ class of words, since other disyllabic word forms are marginal, either because they are morphologically complex or because they are loanwords.

The most striking thing about the tone patterns of these disyllabic morphemes is that they are mostly the same as those of monosyllabic forms. That is, there are four tonemes (H, L, HL, LH), and a morpheme carries one and only one of these patterns, irrespective of its number of syllables. Figure 4 presents f₀ traces of the four tonemes on disyllabic words with a first syllable /a/ – the words in question are listed in Table 1.

The four tonemes are well distinguished on the final syllable, the f₀ pattern of which is entirely as expected on the basis of the lexical specification. This suggests that within each segmental morpheme, the lexical/morphological tone pattern – H, L, HL or LH – associates with the rightmost syllable. This Association Rule is illustrated in (16), where the square bracket stands for a morpheme boundary.

(16) Association Rule



This pattern of association is somewhat at odds with what one might expect from tone languages elsewhere in Africa. That is, given Dinka’s rich quantity system, we might expect tones to associate with moras, thereby affording richer tonal specifications in heavier syllables. However, we find no evidence for this in the Luanyjang dialect, and our findings are consistent with Andersen’s analysis of the Agar Dinka tone system.

The Association Rule means that any non-final syllables are initially unspecified for tone, as seen from (17):

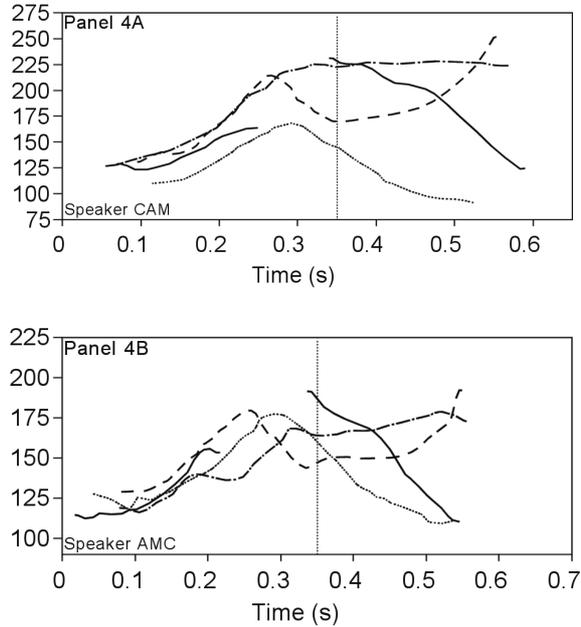


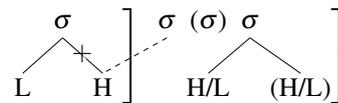
Figure 4. The four tonemes on disyllabic words with a mid or long vowel in the final syllable, in final position in an existential yes/no-question – cf. (6). Data from two speakers. H: dash-dotted; LH: dashed; L: dotted; HL: solid. The start of the vowel of the final syllable is marked by a dotted vertical line.

- (17) **apáaar** ‘buffalo:s’
 σ σ
 H

However, the graphs in Figure 4 show a phenomenon we have not accounted for so far. While the f0 trace on the final syllable follows from the Association Rule, that of the penultimate syllable does not. In each trace of each speaker, we find high f0 on the penultimate syllable (before the vertical line). The phenomenon is clearest in the case of the LH (dashed traces), where there is a well-defined peak on the penultimate syllable. These f0 data compel us to postulate a H tone on the penultimate syllable. But where does it come from, and why does it not trigger dissimilation on the nouns that have patterns H or HL? With regard to the former question, we note that this H tone is not present invariably. It is absent in the citation form, and in contexts where the noun is preceded by

a Low-toned verb. This suggests that it needs to be attributed to this particular context. We argue that its source is the existential marker **dě**, which we hypothesize to have the LH toneme, and that the H tone of this toneme shifts to the toneless following syllable, as in (18).

(18) High Shift



This process has as one of its effects that the surface phonetics of Dinka approximate a little more closely the presumably ideal one-to-one correspondence between tones and syllables. However, since most words are monosyllabic and since only disyllabic words with a toneless initial syllable provide the appropriate input for High Shift to apply, surface phonetic tonal sequences of this sort in Dinka remain relatively unusual.

High Shift is not, of course, limited to existential YNQs, nor to contexts involving **dě**. We also find it in existential declaratives, and in the basic inflected form of a class of long transitive verbs. We will consider each of these in turn, because they each reveal sensitivity of the Dinka tone system to morphosyntax.

In existential declaratives (“There is/are X”), the noun is preceded by the existential marker **dě**, just as in the existential questions. This sentence type is illustrated in (19), and f0 traces are presented in Figure 5. As in the corresponding questions (Figure 4), there is evidence of High Shift, clearest in the case of the LH (Figure 5, dashed traces), where there is a well-defined peak before the onset of final syllable. The main difference between the existential questions and the existential declaratives relates to the application of Dissimilatory Lowering. The nouns that have HL or H tonemes underlyingly are realised with an f0 fall, which sets in at the start of the vowel (Figure 5, solid and dash-dotted traces). That is, Dissimilatory Lowering has applied. The application of this process confirms that there is a preceding H tone, which we have accounted for by postulating a LH toneme on **dě** in combination with High Shift.

(19) **à-dě** **ak̚ɔ̃ɔɔn**
 AGRS-EXIST elephant:s
 ‘There is an elephant.’

The fact that Dissimilatory Lowering does not apply in yes/no-questions, even though it does when the same sequence of morphemes is uttered as a declarative, means that the application of this sandhi process is to some extent conditioned by sentence type. The ultimate scope of this exception can only be determined on the basis of an in-depth study of tonal morphophonology; for example, it is conceivable that other question types are also implicated in

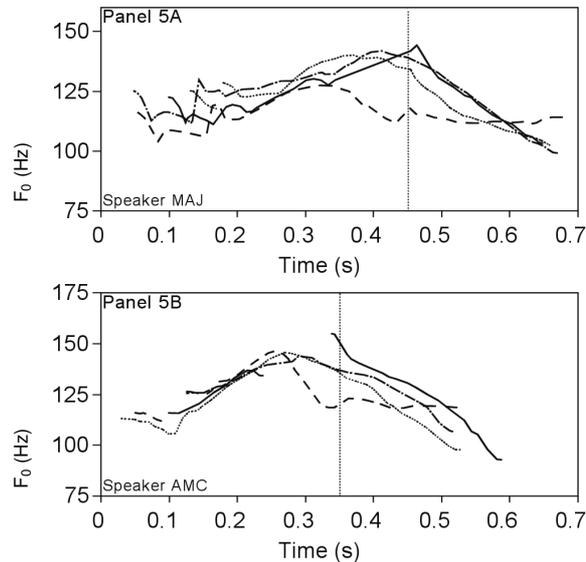


Figure 5. The four tonemes on disyllabic words with a mid or long vowel in the final syllable, in final position in an existential declarative – cf. (19). Data from two speakers. H: dash-dotted; LH: dashed; L: dotted; HL: solid. The start of the vowel of the final syllable is marked by a dotted vertical line.

this exception. However, it is well known that in many languages certain tone-lowering processes (such as downstep or downdrift) are suspended in questions (e.g., Lindau 1986 on Hausa).

Another construction in which High Shift applies involves the basic inflected form of certain transitive long verbs, e.g., *mǎan* ‘to hate:ZERO’ and *lǎel* ‘to provoke:ZERO’. We postulate that these verbs have the LH toneme in this inflection. An example is presented in (20b). Panels A, B in Figure 6 illustrate the baseline condition. Here the target nouns are preceded by the Low-toned verb form *tǎj* ‘to see:ZERO’; cf. the example in (20a). In this baseline condition, the patterns under evaluation – monosyllabic (A) and disyllabic (B) nouns with either H (dash-dotted) or HL (solid) tonemes – are realised as expected. That is, we find high level pitch in the case of H and a delayed fall in the case of HL, just as in Figures 1 and 4, for mono- and disyllabic nouns respectively. Panels 6 C, D display the same nouns preceded by the verb *mǎan* ‘to hate:ZERO’. As stated above, this verb has the LH contour toneme in this inflection. Comparing the realisations of the monosyllabic H- and HL-toned nouns preceded by the LH-toned verb with their realisations when preceded by the L-toned verb, we find no difference. By contrast, there is a clear difference in the realisation of

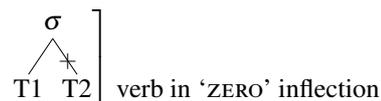
the disyllabic words as a function of the preceding context. The disyllabic H and HL-toned nouns both show f0 falling from the beginning of the vowel in panel 6D.

- (20) a. **Acóol à-tíŋ akḥḥḥon** (L __)
 Acol AGRS-see:ZERO elephant:s
 ‘Acol sees an elephant.’
- b. **Acóol à-mǎan akḥḥḥon** (LH __)
 Acol AGRS-hate:ZERO elephant:s
 ‘Acol hates an elephant.’

The observed variation in the realisation of H and HL disyllabic nouns can be accounted for in terms of the mechanisms already introduced in relation to the existential sentences involving **dě**. That is, the H second component of the LH on **mǎan** reassociates to any toneless syllable to the right – cf. High Shift (18) – thus creating the context where we can invoke Dissimilatory Lowering to account for the fact that HL and H turn into L on the following disyllabic noun.

Interestingly, LH-toned predicate heads such as **mǎan** and **dě** trigger Dissimilatory Lowering only on a following disyllabic noun, but not on a following monosyllabic noun. To account for this limitation, we invoke the process in (21). Contour Simplification reduces the number of tones associated to the verb in the unmarked ‘ZERO’ inflection, retaining only the first component tone. This rule bleeds Dissimilatory Lowering, but only between the head of the predicate and any following constituent. As a result, any second tone component in the ZERO inflection will be deleted, unless it has been shifted to a following toneless syllable as a result of High Shift (18).

- (21) Contour Simplification



The application of Contour Simplification rule is postulated to be sensitive to the morphosyntactic context, applying only on verbs marked for the ‘ZERO’ inflection. This qualification is necessary because Contour Simplification does not apply in contexts like the ones in (3b, d). If Contour Simplification had applied, then the LH-toned past passive in (3b) would become simplified to the form found for the 1st singular form in (3a), and the underlyingly HL-toned passive in (3d) would have become indistinguishable from the H-toned 2nd singular in (3c). But this does not happen.

At this point, we have defined the conditioning domain edge as the verb in the ‘ZERO’ inflection. It may well be necessary to widen its scope as more

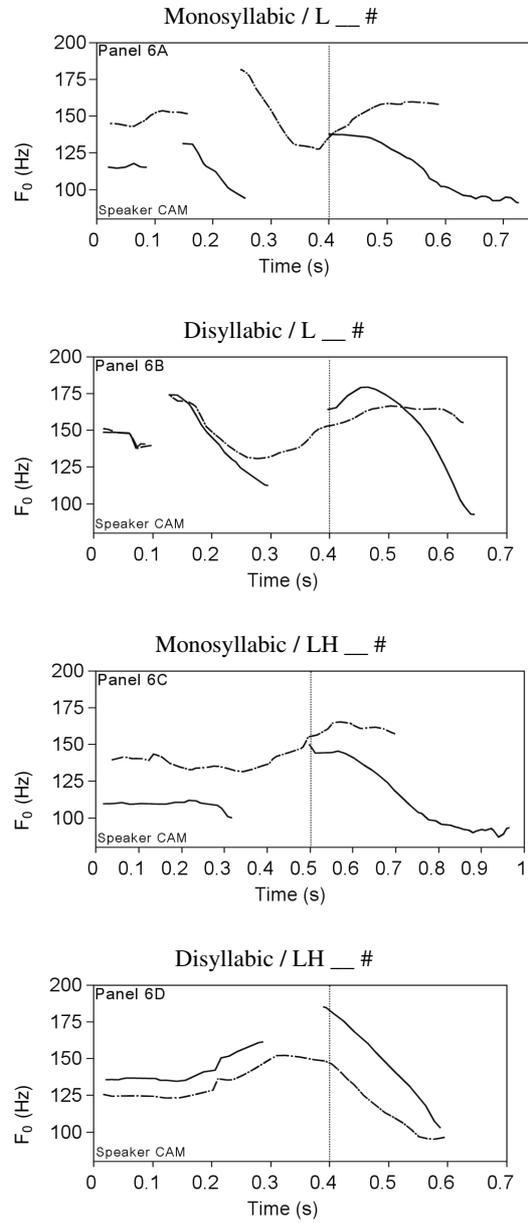


Figure 6. F0 traces showing the realisation of monosyllabic and disyllabic words with underlying toneme H (dash-dotted) or HL (solid), in two sentence-final contexts. A, B: preceded by L tone pattern (*à-tùŋ*); C, D: preceded by H tone (*à-mään*).

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information on the morphophonology of tone becomes available. That is, given that the Contour Simplification is conditioned by morphosyntactic context, the ultimate scope of the process requires a comprehensive survey of tone in verb morphology, which is outside the scope of the current paper. It is worthwhile to note that, in inflecting tone languages, it is not uncommon for tone rules to be sensitive to particular morphosyntactic conditioning (see, e.g., Goldsmith 1990: 33).

2.4. *Tone, quantity and f0 alignment*

In Section 1.2, we briefly introduced the Dinka quantity system, with its unusual three-level vowel length distinction. In African tone languages that have a two-level vowel length distinction, more complex tone patterns tend to be found on long vowels than on short ones.⁷ It would be easily conceivable, then, for the Dinka tones to associate differently depending on the quantity of the vowel, with contour tonemes being restricted to the longer level(s) of vowel length. This does not appear to be the case, though. With respect to the Agar dialect, Andersen (1987:18) writes that “[a]ny tone can combine with any vowel length and with either voice quality”. In the Luanyjang dialect, the contour tonemes (HL, LH) are very rare but attested on nouns with short vowels: **b̂j̄n** ‘cup:s’, **ma-kwăc** ‘BCT-spotted:s’. By contrast, contour tonemes appear commonly in short verb forms, as a result of regular inflection. A minimal-set example involving a verb with a short vowel is presented in (22).

- (22) a. **Acóol à-t̂j̄j̄**
 Acol AGRS-see:2s
 ‘You are looking at Acol.’
 b. **Acóol à-t̂j̄j̄**
 Acol AGRS-see:PASS
 ‘Acol has been seen.’

In summary, it appears that in the Agar and Luanyjang dialects of Dinka alike, the tone-bearing unit (TBU) is the syllable. The association of tones to the segmental string makes no reference to the distinction between short, mid, and long vowels, which in terms of moraic theory (see e.g. Hyman 1985, Hayes 1989) might be regarded as mono-, bi, and trimoraic nuclei respectively. This

7. For example, the Bantu languages Rangi (Stegen 2002) and Matumbi; the Nilo-Saharan language Nara (Dawd and Hayward 2002) the Afro-Asiatic language Somali, and Saramaccan, an English-based creole with a West-African substrate. Languages not followed by a reference were found in the XTone Cross-Linguistic Tonal Database (Allison, Hyman and Mortensen 2006).

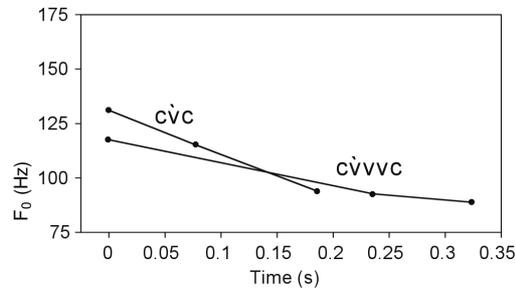


Figure 7. Mean f₀ values for three points in the rhyme (beginning and end of vowel, and end of coda – the values are marked by dots). Separate lines for two L-toned nouns - **gɛ̀m** ‘cheek:P’ and **nòoon** ‘grass:S’. The words are uttered once or twice in citation form, by each of three speakers (AMC, CAM, MAJ). Ten tokens in total.

is noteworthy, because the vowel length distinction greatly affects the duration of the domain on which the tones are realised, and, as already described in Section 2.1, has a considerable effect on the realisation of a given toneme on a given syllable.

In a comprehensive study of the quantity system of Luanyjang Dinka, Remijsen and Gilley (2008) find average durations of 70, 100, and 145 milliseconds in utterance-medial position, for short, mid, and long vowels, respectively. Coda durations are negatively correlated with phonological vowel length. That is, all else being equal, monosyllabic words with a short nucleus have the longest coda, followed by those with a mid nucleus, and items with a long nucleus have the shortest coda. This tendency is illustrated in Figure 7, which shows mean values for the f₀ and duration of nucleus and coda of two Low-toned words – one with a short (/V/) vowel (**gɛ̀m** ‘cheek:P’), the other with a long (/VVV/) vowel (**nòoon** ‘grass:s’). The boundary between nucleus and coda is marked by the middle dot.

As seen from Figure 7, the rhymes of **gɛ̀m** and **nòoon** both show falling f₀ over nucleus and coda. The fall on **gɛ̀m**, though, is considerably steeper than that on **nòoon**. There are three causes for this. First, the duration of the rhyme of **gɛ̀m** is considerably shorter than that of **nòoon** – 185 ms. vs. 324 ms., on average. An equal-sized f₀ fall realised over these two domains will yield a much steeper slope over the shorter domain. Second, the f₀ fall sets in about 8 Hz *higher* at the start of **gɛ̀m** than at the start of **nòoon**, resulting in slope sizes of 37 vs. 29 Hz, respectively. This is remarkable: given that the onset of **gɛ̀m** is a voiced stop, we expect consonantal perturbation to lower f₀ at the start of the vowel that follows it (see Hombert 1978 and other sources cited there). But

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that is not what we find. We speculate that the f_0 at vowel onset may be raised on syllables with a short vowel to ensure that the fall that encodes the Low is saliently marked.

Finally, a third factor in the way the Low toneme is impressionistically perceived is the proportional make-up of the rhyme in terms of nucleus and coda. As seen from Figure 7, the coda makes up most of the rhyme of **gẹ̀m**, while it constitutes less than a third of the rhyme of **nòoon**. In general, the nucleus is the more salient part of the rhyme in perceptual terms. In the case of **gẹ̀m**, but not in the case of **nòoon**, only the higher part of the f_0 fall is realised on the nucleus. In other words, the cue that is prone to give rise to a perception of low pitch is on the less salient constituent in the case of **gẹ̀m**. As a result, researchers who are familiar with other African tonal systems may be prone to analyse the tone pattern of short L-toned words as involving an initial high tone component.⁸ Such interpretations hinge on the assumption that phonetic pitch translates into phonological tone in an unambiguous manner across languages. This assumption may be valid for many African tone languages in which the TBU is the mora, but it does not hold in Dinka, because the realisation of a particular toneme varies as a function of the quantity of the relevant vowel, and it is the alignment of tones with the segmental string that tends to remain constant. Thus, irrespective of the quantity of the syllable with which it is associated, the Low toneme is realised as a fall, the starting point of which is aligned no later than the start of the vowel (cf. Figures 1, 2, 4), i.e., much earlier than in the case of the HL. If the patterns of alignment are taken as a criterion, the typologically unusual phonetic realisations of specific tonemes in specific contexts are almost to be expected, rather than constituting a weak point in the analysis.

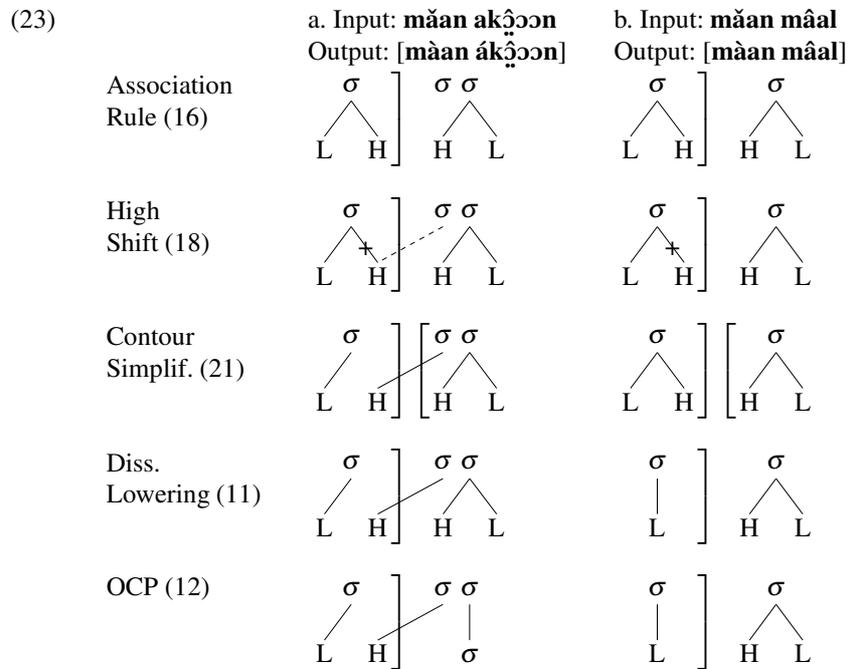
We also note that, once our analysis of the basic tonal contrasts is accepted, the resulting system is governed by processes that are well known from other tone languages. For example, Dissimilatory Lowering parallels Meeussen's Rule (Goldsmith 1984), which is part of many Bantu tone systems. In short, we believe that Dinka's inventory of tonal phonological processes is rather unremarkable, but its tonal phonetics, and the relation between tone and quantity, are of typological interest.

2.5. *The ordering of tone processes*

The ordering of High Shift and Contour Simplification before Dissimilatory Lowering produces the output forms observed for mono- and disyllabic forms

8. Constance Kutsch Lojenga (p.c.) noted that the Low sounds like a downstepped High in some cases. Larry Hyman (p.c.) hypothesised that there could be a High tone, associated with a preceding syllable which gives rise to the steep falling contours.

after a LH toneme in the head of predicate slot. The scheme in (23) specifies the ordering and illustrates the effect of all the rules introduced in the autosegmental analysis. The uncontroversial associations between syllable nodes and the segmental string have been left out to save space. This schema presents the ordering of all but two rules sketched in the foregoing sections of the paper. The LH Levelling rule (15), which is a matter of context-sensitive variation, comes at the very end, after the application of the OCP. We have been unable to establish the relative ordering between Low Absorption and Dissimilatory Lowering.



As stated above, Dinka morphemes are predominantly monosyllabic, and every morpheme is specified for tone. As a result, all monosyllabic morphemes are specified for tone once the Association Rule has applied. Also specified for tone are the originally toneless initial syllables of disyllabic morphemes that are preceded by the LH, as a result of High Shift. In other contexts, the f0 pattern of the toneless non-final syllables of polysyllabic morphemes seems to follow from interpolation between specified tone targets.

3. Quantitative analyses of acoustic data

Given the complexity of the foregoing description, we feel it is worthwhile to offer a different sort of empirical evidence for our analysis. While it is now easy to obtain f_0 data and to run straightforward statistical analyses, quantitative statistical corroboration of such descriptions is still not very common. In Section 2.1, we have already noted the usefulness of supplementing impressionistic description of tonal phonetics with instrumental analysis of f_0 . In this section, we present statistical evidence supporting the most basic feature of our analysis, namely the hypothesis that Luanyjang Dinka has a four-way tonal contrast.

We investigated the f_0 patterns of the members of a minimal set for tone. The members of this set and the contexts in which they were collected are presented in (5). Approximately two realisations of each member of this minimal set were recorded in sentence-final position. They were elicited from 9 speakers by our reference speaker, and he also produced them himself. To characterise the f_0 trajectory across the vowel, we took four measures: the mean f_0 over the middle 50% of the vowel's duration, the standard deviation of the f_0 tracker points over the same domain, and also the values at the boundaries of this domain (i.e., at the 25th and 75th percentile points). In addition, we measured the duration of the vowel, as tone affects vowel duration in some languages – e.g., Mandarin Chinese (Ho 1976, Xu 2004). In Mandarin Chinese, the phenomenon is limited to sentence-final contexts (Ho 1976) – the same context under consideration here.

Because measurements for the same words were collected from each of 10 speakers, we applied within-subjects or repeated-measures ANOVA, calculating the effect of tone on a given measure by dividing its Mean Square by the Mean Square of the interaction between this factor and the factor speaker. Our approach is multivariate, with five dependent measures (cf. above), and a single factor: toneme, which has four levels (H, L, HL, LH). The ANOVA results are presented in Table 2, and the descriptive statistics are included in the Appendix.

As seen from Table 2, all four of the f_0 -related measures are highly significant, but duration is not. The greatest effect is found for the f_0 measurement $\frac{3}{4}$ into the vowel. For the f_0 measures, we carried out post-hoc Bonferroni tests to verify whether each of the four tonemes is significantly different from the others. As it turns out, every toneme is significantly different from every other by at least one of the four f_0 measures. The tonemes most similar to one another are H and LH. This is to be expected, as the LH is realised with level pitch in final context (cf. Figure 1A, B).

To further evaluate the measurements, we carried out a Linear Discriminant Analysis (LDA). LDA is a statistical technique that can reveal to what extent tokens can be classified for a categorical distinction – in this case toneme –

Table 2. The effect of toneme on 5 dependent variables in a within-subjects multivariate ANOVA (86 tokens)

Factor	Degrees of freedom and F value	Probability
Duration	$F(3,9) = 3.06$	$p = 0.084$, n.s.
F0 mean	$F(3,9) = 41.98$	$p < 0.001$
F0 standard deviation	$F(3,9) = 61.25$	$p < 0.001$
F0 at $\frac{1}{4}$ of vowel's duration	$F(3,9) = 29.19$	$p < 0.001$
F0 at $\frac{3}{4}$ of vowel's duration	$F(3,9) = 76.08$	$p < 0.001$

on the basis of one or more continuous measurements – in this case all five of the acoustic measurements described above. All measures were z-transformed to correct for between-speaker variation in speaking tempo and in f0 register and range. Measurements were added to the LDA automatically in stepwise fashion, that is, the measurement with the greatest F value as a function of the criterion toneme was included first, and additional measurements were added in order of decreasing F , as long as their F were above the threshold for significance (corresponding to $p < 0.05$). Crucially, the automatic procedure never added vowel duration to the equation, as its independent contribution did not reach the threshold for inclusion. The resulting model, based on the four f0-related measures, yields a correct classification score of 90.7 percent. This result is to be interpreted relative to a chance-level baseline of 25 percent – the probability of guessing the correct toneme out of four candidates. The lowest correct classification result – 85.7 percent – was obtained for the H, which was mistaken for the LH in the remaining 14.3 percent of the cases. Again, because LH is phonetically similar to H in prepausal position in a declarative sentence, we speculate that correct classification would be considerably higher if we compare the materials in a context in which the LH Levelling rule does not apply. At the same time, the fact that the statistical differentiation was largely successful suggests that LH Levelling, even where it does apply, does not result in complete neutralisation.

These results allow us to conclude that the distinction between the four tonemes argued for on the basis of data from a small number of speakers in Section 2 is valid, thereby corroborating the hypothesis that this four-way tonal distinction is characteristic of Luanyjang Dinka speech community as a whole.

4. Discussion and conclusion

4.1. Main findings

The main characteristics of Luanyjang Dinka tone system can be summarised as follows. Luanyjang Dinka has four tonemes (L, H, LH, HL), and each morpheme carries one, irrespective of its number of syllables. This toneme associates with the rightmost syllable, which is usually the only syllable. The internal composition or “weight” of the syllable is irrelevant to the association of tones. In utterances, the string of underlyingly specified tonemes is distorted due to the effect of tone sandhi processes. The most important of these is Dissimilatory Lowering, which turns H tone into L when it is preceded by H. This applies whether the H tones involved manifest the High toneme or are component tones of the Rising (LH) or Falling (HL) tonemes. The participation of the contour tonemes in this dissimilation rule indicates that the contour tonemes constitute sequences of L and H tones. Both Dissimilatory Lowering and Low Absorption apply only if the constituents are realised with a certain level of phrase-level prosodic cohesion, and they may fail to apply if the relevant constituents are not connected in this way. Finally, we found some evidence of sensitivity of tone processes to morphosyntax: Dissimilatory Lowering does not apply in existential yes/no-questions. Moreover, tone contours are simplified in the basic finite verb form, but not elsewhere.

4.2. Tonal variability and the function of tone

As we have seen throughout the paper, the function of tone in Luanyjang Dinka is to a large extent morphological. The same conclusion can be drawn for the Agar dialect on the basis of Andersen (1993). How can the fact that so many morphologically related words are distinguished by tone be reconciled with the variability in tonal realisation? That is, if tone is so important to Dinka morphosyntax, then how can it be that communication is successful overall in the face of processes that disrupt the faithful rendering of the underlying tonemes? This point is illustrated in example (24). While **tîim** has a HL underlyingly, it can also surface with a Low – due to Dissimilatory Lowering – or with a H – due to Low Absorption, depending on the tonal context.

- (24) a. **Acóol à-tîŋ tîim** /tîim/ > [tîim]
 Acól AGRS-see:ZERO tree:P
 ‘Acól sees trees.’
- b. **Acóol à-cí tîim máaan** /tîim/ > [tîim]
 Acól AGRS-AUX:PST tree:P hate:PST
 ‘Acól hated trees.’

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- c. **Acóol à-tìŋ** **tíim tít** /tíim/ > [tíim]
 Acól AGRS-see:ZERO tree:P red:P
 ‘Acól sees red trees.’

Several factors play a role here. First, morphologically related forms tend to differ from one another in terms of several dimensions of phonological contrast. In nouns, for example, while the singular and plural forms of nouns may differ solely in terms of tone, as in **píic- píic** ‘stirringstick:s/P’, several common patterns of number marking involve some combination of tone, quantity, and vowel height/breaking – e.g., **tíl-tjèl** ‘thistle:s/P’, and also example (4). Less commonly, changes in voice quality and in the coda consonant can also be involved – e.g., **wáal-wál** ‘plant:s/P’; **ròow-ròot** ‘hippo:s/P’. This redundancy makes the communication of inflected word forms more robust – when the lexical / morphological tonal marking of a particular word is not evident from the context, other cues are often available.

A second factor is the role of certain function morphemes. Given its recursive nature, it is conceivable for Dissimilatory Lowering to change each non-initial H in a sequence of 8 or 10 H-toned words. This is unlikely to happen, though, because certain high-level grammatical domains are marked off by Low-toned function morphemes. This is illustrated in (10), repeated for convenience in (25).

- (25) **Acóol à-cí** **léey máaan è-téne**
 [Acóol à-cí] **lèey màaan è-téne]**
 Acól AGRS-AUX:PST drum-S hate:PST PRP-there
 ‘Acól has hated a drum there.’

Both finite verbs and auxiliaries take a prefix that marks number agreement with the preceding topic: **à-/àa-** ‘AGRS/AGRP’ (cf. Andersen 1993). This L tone preserves the tone pattern of the morphemes in the verb phrase from the influence from any H tone at the end of the preceding topic. The prepositional marker **è-** similarly limits the potential for utterances to contain long sequences of dissimilated H’s. Its distribution is very wide – this prefix is found before most common adverbs, before external arguments of the verb, and between possessed and possessor, among others. Just like **à-/àa-**, **è-** plays a crucial role in preserving the stability of tone patterns within particular grammatical constituents. It appears, then, that the application of Dissimilatory Lowering is limited to well-defined syntactic domains, bounded by Low-toned function morphemes. In this context, it is worthwhile to note the difference between /aCV(V)(V)C/ sequences like **à-léel** ‘AGRS-provoke:2s’, and those like **apáaar** ‘buffalo:s’. In the former, the initial /a/ is a separate morpheme with its own L tone, buffering the following H tone from sandhi. In the latter, the initial /a/ is toneless – it is not the rightmost syllable within a morpheme – and therefore

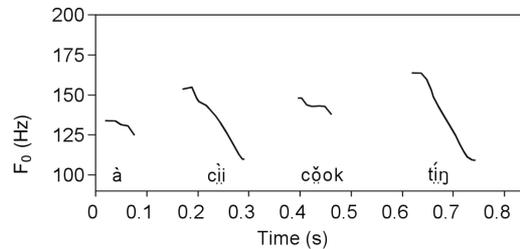
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Figure 8. Segmented F0 track of the predicate of the sentence in (26), uttered by speaker MAJ

the H tone on the final syllable is exposed to Dissimilatory Lowering under the influence of a preceding H tone.

More generally, the fact that a greater proportion of the f0 fall is realised on the coda after a short vowel means that, when the coda of a /*(a)CVC/* or /*(a)CVVC/* word is voiceless, there is considerably less time to fully realise the fall, and it is underarticulated as a result (cf. Sundberg 1979, Xu 2004). In such situations, Dissimilatory Lowering may constitute a crucial indication of the toneme of a given noun. That is, when the surface phonological tone pattern of a given word may not be reflected clearly in its own f0 pattern, the (lack of) application of Dissimilatory Lowering on the following word may provide a crucial cue. This is illustrated in Figure 8, which shows the f0 trace of the sentence in (26). In the absence of a voiced coda, the LH on **c̣ɔ̣ok** ‘foot:s’ is realised suboptimally, without its characteristic late-aligned rise.⁹ Nonetheless, its H tone component can easily be inferred from the application of Dissimilatory Lowering on the following word **ṭịŋ** ‘to see:NEG’.

- (26) **Acóol à-c̣j̣i c̣ɔ̣ok ṭịŋ** /ṭịŋ/ > [ṭịŋ]
 Acól AGRS-AUX:NEG foot:s see:NEG
 ‘Acól does not see a foot.’

Finally, while Dissimilatory Lowering distorts the string of underlying tones, it does so in a predictable way, shifting to the right the tonal cues that are relevant to lexical decision and morphosyntactic processing. We speculate that, paradoxically, this distorting process may actually be beneficial to communication, in particular when it is conditioned by short vowels (cf. Figure 8). In those situations, the underlying toneme of the short-vowel word is cued more

9. As noted in Section 1.2, most Dinka stems are closed by a coda. Exceptions to this are very rare, in particular in content words (Andersen 1987: 2, Malou 1988: 11). Importantly, the nature of the coda does not restrict the distribution of tonemes – i.e., both level and contour tonemes combine with any coda type.

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saliently by its effect or lack of effect on a following toneme, than by the f₀ pattern of the word itself.

4.3. *Comparison with the Agar dialect*

The Agar dialect is spoken in a territory that is geographically adjacent to Luanyjang Dinka. Andersen (1987) distinguishes three tonemes: H, L, and HL. The crucial difference between Agar and Luanyjang in terms of the inventory of tonemes is the LH of Luanyjang Dinka. On this issue, our own explorations with 2 speakers of Agar Dinka are in agreement with Andersen: we found no evidence to postulate this toneme for the Agar dialect. Nouns that have the LH in Luanyjang were found to have the H in Agar. As for the other three tonemes, their realisations in the two dialects broadly correspond. One minor difference has to do with HL. Andersen writes that, in the Agar dialect, this toneme is realised as high level pitch anywhere but in prepausal context. In Luanyjang, however, HL is faithfully realised as a fall in pitch when followed by a H tone, and turns into H only when followed by L, as a result of Low Absorption. This process, Low Absorption, has also been hypothesised for the Agar dialect (Andersen 1987). By contrast, Dissimilatory Lowering, which in Luanyjang Dinka has a greater functional load than Low Absorption, does not appear to occur in the Agar dialect in the same way.¹⁰ When we elicited past-tense constructions like (25) from speakers of Agar Dinka, we found that the past-tense auxiliary *cí* – which has a High toneme in Agar Dinka just as in the Luanyjang dialect – does not trigger dissimilation on a following H- or HL-toned noun. Interestingly, we also found that, whereas Luanyjang Dinka marks existential yes/no-questions purely using f₀ register and range, Agar Dinka has a high question-marking boundary tone.

In summary, while there are important parallels between the tone systems of Luanyjang and Agar dialects, we also find non-trivial differences at every level – with respect to the inventory and realisation of tonemes, with respect to tone-in-context processes, and with respect to the morphophonological use of tone.

4.4. *Directions for further research*

We found evidence that the tone sandhi processes are to some extent conditioned by morphosyntax. That is, Contour Simplification is limited to verb

10. Andersen (2002: 21 f) does report regressive tone dissimilation in some nouns, triggered by a High tone on a following demonstrative – e.g., *niir* ‘girl:P’ becomes *niir-ká* ‘girl:DEM’. Thanks to an anonymous reviewer for pointing this out to us.

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forms marked for the ‘ZERO’ inflection. Also, Dissimilatory Lowering does not apply in yes/no questions. This conditioning reveals that the importance of morphosyntax to the Dinka tone system is not limited to the specification of underlying tonal inflections, but that it extends to the system of phonological tone processes. Given these findings, a comprehensive analysis of the Dinka tone system necessarily encompasses a detailed study of Dinka tonal morphology, and such a study may lead to additions and/or reformulations of the overall analysis postulated here. A detailed study of Dinka tonal morphology is a major challenge, given the rich system of nominal and verbal inflections that involve a tonal component. At the same time, the current study is of value to such a project, allowing to distinguish between the effects of tone sandhi and those of morphological tone.

The relevance of tone sandhi to the study of morphosyntax can be illustrated by the issue of case-marking on postverbal noun subjects. Andersen (2002) reports that, in the Agar dialect, the underlying tonemes H, L, and HL on nouns are replaced by L, L, and HL, respectively, as a tonal form of case marking. This is illustrated in (27) – from Andersen (2002: 7).

- (27) a. **bàŋ** à-tòoc d̩̀òk
 chief:S AGRS-send:ZERO boy:S
 ‘The chief is sending the boy.’
 b. d̩̀òk à-tóoc **bàŋ**
 boy:S AGRS-send:NTS chief:S:OBL
 ‘The chief is sending the boy.’

Whereas **bàŋ** ‘chief:s’ is specified for the High toneme, as in (27a), it has the Low toneme in the pragmatically marked sentence in (27b), where the object appears in topic position. This syntactic pattern is marked on the verb by means of quantity (long grade), and by the High toneme. As noted above, we found no evidence that Dissimilatory Lowering exists in Agar. As a result, Andersen’s morphosyntactic interpretation of the tonal alternation on the noun is not controversial. However, if the same tonal alternation exists in the Luanyjang dialect, then the replacement of a High by a Low following a High on the verb could be interpreted in terms of Dissimilatory Lowering instead. This, in turn, could explain the historical origin of this tonal inflection in dialects like Agar that do not show Dissimilatory Lowering.

The current study reveals both similarities and differences between the tone systems of the Luanyjang dialect at issue here, and the Agar dialect studied in Andersen (1987). Further study on prosody in particular dialects of Dinka is required to determine the range of variation in terms of tone, other prosodic systems such as quantity, vowel quality, and voice quality and the relation between them. Given the typologically unusual nature of the Dinka prosodic system, this line of research is likely to yield new insights into possible prosodic

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configurations. In addition, given the central role of suprasegmental features in Dinka morphosyntax, such studies will be of great value to the study of Dinka, and to certain aspects of Dinka applied linguistics such as orthography development and language learning resources.

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Appendix

Table A. Means and (in parentheses) standard deviations for each of the five measurements by tone (86 tokens)

Measurement	H	HL	L	LH	Overall
Duration (in ms)	186 (32)	202 (44)	191 (39)	208 (48)	197 (42)
F0 mean (Hz)	172 (56)	179 (53)	135 (48)	175 (51)	166 (54)
F0 st.dev. (Hz)	1.9 (1.1)	8.0 (4.6)	6.5 (3.7)	1.1 (0.7)	4.4 (4.2)
F0 at 1/4 of V (Hz)	170 (56)	189 (58)	146 (51)	176 (52)	171 (56)
F0 at 3/4 of V (Hz)	174 (56)	162 (49)	124 (44)	175 (50)	160 (53)

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