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Tonal Underspecification and Interpolation in Tommo So

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by

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ABSTRACT OF THE THESIS

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A growing body of evidence (e.g. Pierrehumbert and Beckman 1988, Keating 1988, Myers 1998) supports the idea that, rather than the phonology feeding the phonetics a fully specified representation, underspecification may persist all the way to the surface. This typically results in either a linear interpolation between two flanking specifications or in a so-called "trough" as the articulators slouch between two identically specified values on either side (Pierrehumbert 1980). In this thesis, I show that in Tommo-So, a Dogon language spoken in Mali, a ternary contrast exists between H, L and Ø, with underspecified segments receiving their pitch by linear interpolation. This interpolation may be between surrounding lexical tones, or, if at the end of a phonological phrase, between a lexical tone and a L⁻ boundary tone. Unlike the Ø tone in Chichewa, Tommo-So Ø is grammatically constrained to later level material

like enclitics, suffixes, and epenthetic vowels. However, underspecification may also be created on stems by the repair of non-final contour tones when a toneless suffix is added. I argue that the distribution of Ø tone in Tommo-So is best captured by a level-ordered grammar such as Stratal OT (Kiparsky 2000), with *Ø demoted after the stem level. This distribution is also typologically natural, mirroring the behavior of stress on similar grammatical elements. The discovery of underspecified tone in Tommo-So raises important questions about the many fully specified tonal analyses of African languages and demonstrates the importance of acoustic analysis in fieldwork on tone.

1 Introduction

A growing body of evidence supports the idea that underspecification may persist into the phonological output, leaving a gap in the featural directions for the phonetics. The phonetic output for these underspecified segments shows an interpolation between flanking specifications. Thus, the exact pronunciation of the segment will depend on its immediate context and is often not categorical. Examples of this surface underspecification include Pierrehumbert (1980) on English intonation, Shih (1987) on Mandarin tone, Keating (1988) on place of articulation in English consonants, Pierrehumbert and Beckman (1988) on Japanese pitch accent, Cohn (1993) on English nasality, Huffman (1993) on Yoruba nasality, Choi (1995) on Marshallese vowels, and Myers (1998) on tone in Chichewa. The interpolation between specified features has generally been assumed to be linear, but others have instead found a "sagging" transition (Pierrehumbert 1980, Keating 1990, Myers 1998). In these so-called "trough transitions", the articulators involved hit a phonetic target then slouch towards a more neutral position until again called upon to hit another phonetic target, resulting in a dip or trough in the acoustic signal. See Figure 1, taken from Keating (1988), which shows linear interpolation of F1 and F2 through an intervocalic /h/.

Phonological theory has a history of limiting the role of underspecification. Chomsky and Halle (1968) assumed that the output of the phonology must be fully specified, whereas Goldsmith (1976, as cited in Archangeli 1988) ensured that all segments were specified prior to the application of phonological rules, which followed the Universal Association Conventions; hence, in his theory, underspecification was constrained to the lexicon alone. Until recently, studies of tone in African languages included default fill-in rules for tone, the most famous perhaps being the default L insertion rule proposed for many Bantu languages, including Chichewa (Mtenje

1987, Kanerva 1989). In these theories of phonology, surface underspecification did not exist–the input to the phonetics was always fully specified.

As Myers (1998) demonstrated, such fill-in rules do not correctly characterize the surface representation of Chichewa tone; instead, L must be left unspecified. His work is reviewed below. In this paper, I present evidence of another case of surface tonal underspecification in Tommo So, a Dogon language of Mali. The data are taken from recordings I made in the field of four different speakers, one female (RO) and three males (IT, SO, EO). I demonstrate that Tommo So underspecification differs from the Chichewa (Myers 1998) case, which I will describe in more detail in section 2, in the following ways: First, rather than having a two-way contrast of /H/ vs. /Ø/, Tommo So has a ternary contrast on the surface between /H/, /L/, and /Ø/, with the realization of the null tone dependent upon surrounding tones and phrase boundaries. Second, while the null tone in Chichewa is seemingly unlimited in its distribution, Tommo So null tone is restricted to enclitics (postpositions, definite, and plural), human suffixes, and epenthetic vowels.

The paper is organized as follows: In section 2, I review the underspecification data from Chichewa (Myers 1998) to serve as a foundation for the discussion of Tommo So that follows. Section 3 provides a basic overview of Tommo So tone as a background to section 4, which lays out the arguments for tonal underspecification in Tommo So, focusing on underspecified enclitics. This section includes a discussion of boundary tones, based on typologically natural phrasing as described by the Prosodic Hierarchy (Selkirk 1978, 1986; Nespor and Vogel 1986, among others), as well as sequences of toneless elements and tone shift. In section 5, I show that underspecified surface F0 patterns likewise arise in human suffixes and epenthetic vowels. Section 6 argues that the distribution of null tones is best accounted for in Stratal OT (Kiparsky 2000), where *Ø is undominated in earlier levels, and Dep-T undominated subsequently. I address possible alternative analyses in section 7, before drawing conclusions and discussing the implications in section 8.

2 Chichewa /H/ vs. /Ø/

Treating one surface tone as underlyingly unspecified is not a new idea, particularly in the literature on Bantu (with arguments for privative tone dating back to such works as Stevick 1969). The phonological inertness of the L tone was often taken as a sign that the contrast was not /H/ vs. /L/, but /H/ vs. /Ø/, the absence of tone, and that the L seen on the surface was filled in by a default insertion rule at some point during the phonology. This may be true of some, if not many, languages, but Myers (1998) has shown that in Chichewa, a Bantu language of Malawi, the underspecification of the null tone carries through to the surface.

He set up an experiment in which Chichewa-speaking participants were asked to pronounce a series of sentences in which the distance between two H tones on a verb stem was systematically varied from one to three syllables. Two more H tones remained constant in the frame sentence. In addition to the variation in the stimuli, the participants were also asked to pronounce the sentences in varying speeds and loudness levels. He extracted pitch tracks from these recordings and compared the F0 transition from the second to the third H tones (henceforth H2 and H3).

Myers focused on the following points from those spans: 1) the F0 maxima corresponding to H2 and H3; 2) the F0 minimum between H2 and H3; 3) the time interval between the end of H2 and the begining of H3 (Myers 1998:377). Assuming full specification, L syllables should reach a L target quickly after the offset of the H tone and remain level until the next H tone. Assuming a linear interpolation model, we would predict that the F0 would remain high and level between two fully specified H targets. Neither prediction is borne out. Myers's results were instead consistent with underspecification and the sagging model of interpolation found in Pierrehumbert (1980), among others: the F0 formed a trough between the H tones (see Figure 2). The depth of this trough positively correlated with the time between H2 and H3. On the extreme end, where there was only one syllable between the H tones, there was no trough due to what Myers and others have called "peak merger". For most participants, peak merger was restricted to the one syllable context. In the end, he found that whether there was peak merger or a trough, and the depth of this trough, was predictable by an equation taking into account the F0 of the surrounding peaks and the time between them. In short, there was no evidence for a L target, demonstrating that the privativity of tone can persist through to the phonetic input.

This important result has received attention in the literature on African tone systems (eg. Bickmore 2000, Paster and Kim to appear) as proving that L tone may be underlyingly toneless, and that this underspecification may remain unrepaired by phonology. However, there have been very few further studies examining the phonetic realization of these underspecified tones. In what follows, I will show that pitch tracks clearly support a surface underspecification account in Tommo So as well, but that the underspecified tone contrasts with both surface H and L. The interpolation appears to be linear, but this could be an artifact of the distribution of toneless segments in the language and the absence of laboratory controlled recordings.

3 Background: the phonology and phonetics of Tommo So tone

Tommo So is one of around twenty Dogon languages spoken in east central Mali. The Dogon family is currently seen as its own branch of Niger-Congo (Blench 2005), though its exact position within this family has been disputed over the years. I have undertaken fieldwork on the variety of Tommo So spoken in the commune of Tédié since 2008 in an effort to produce a comprehensive lexicon and reference grammar of the language. Prior work is limited (Plungian 1995) and contains only a brief mention of tone.

Before delving into underspecified elements, I present here the basics of phonological and phonetic tone in Tommo So. This will serve as a foundation when examining the data presented in the body of the paper.

3.1 Lexical tone

There are two tonal primitives L and H, which, in nominal elements, combine to form stem-level tone melodies {LH} and {H} on native lexical items. For example:[1]

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[1]The transcription system used in this paper is not strict IPA, but rather a transcription system common in the description of African languages. The divergences from IPA are: *j* stands for /ʤ/, *y* stands for /j/, and *r* stands for /ɾ/.

(1) {LH}

a. nàá 'cow'

ɛ̀nɛ́ 'goat'

pàgálá 'rheumatism'

{H}

b. náá 'mother'

núyɔ́ 'song'

sɛ́mmɛ́lɛ́ 'rags'

Verb stems also take either {LH} or {H}, but the choice is mainly predictable based on the first segment. Since the underspecified elements identified thus far are all in the NP, I will focus on nouns here.

The {LH} tone melody can have different surface realizations, so that tone mapping cannot be made automatic. For instance, on disyllabic words, {LH} can either surface as LH, ex. *ɲòŋóm* 'camel', or LR, ex. *sàŋǎm* 'sourness'. On trisyllabic words, the choice is between LLH and LHH, as in *kɛ̀bɛ̀lɛ́* 'shard' versus *kògódó* 'shell'. There appear to be no phonological predictors of where the break between the two tones is located. Mapping is not of importance to the topic at hand, which relies solely on the surface outputs of the phonology, at which point tones are already assigned to whatever syllables receive them.

{HL} lexical stems have been introduced via Fulfulde and other loans, ex. *sɔ́bbɔ̀* 'dry-sowing'. Nonetheless, such words make up only a small proportion of the vocabulary (270 of 4405 entries classified with a noun in my database). {LHL} French loans are also present in small numbers. Finally, there is a constraint against lexically {L} stems; in other words, all lexical stems must have at least one H tone, and this

H tone prefers to be on the right. Taken together, this means that nouns (or NPs) ending in a L tone are relatively rare. This will become important in the upcoming discussion of contexts for underspecified tones.

In addition to lexically specified tone patterns, Tommo So makes wide use of grammatically-induced tone overlays. These overlays often make a word surface as all {L} in a process I call "tone lowering". For example, an adjective like *kómmó* 'skinny' induces tone lowering on a preceding noun like *jàndúlú* 'donkey', yielding *jàndùlù kómmó* 'skinny donkey'. A possessor does the same on the possessed noun that follows, as in *sáná jàndùlù* 'Sana's donkey'. Verbs rarely surface with their lexical tone, since most inflectional categories impose their own tonal melodies. For the discussion at hand, it suffices only to know that such processes exist, and that grammatically controlled tone overlays are marked as .L or .HL (for a {L} and {HL} overlay) in interlinear glosses. I refer interested readers to Heath and McPherson (in prep) for a thorough discussion of these tonal facts in Tommo So and other Dogon NPs.

3.2 Phonetic realization of tone

The phonetic realization of phonological tone is subject to many standard processes, discussed, for example, in Gussenhoven (2004). Tommo So displays an unsurprising subset of these, including consonant and vowel effects, declination, and downdrift. In the interest of space, I will not give any specific pitch tracks here, but rather intend to alert the reader to issues that may arise looking at the pitch tracks in later sections. Starting with consonant effects, the F0 does typically appear higher for a few milliseconds after a voiceless sound or a fricative/affricate than it does after a voiced stop. This effect is phonologized in verbs, where verb stems that begin with a voiced stop have {LH} melody and stems that begin with a vowel or a voiceless consonant take {H}; stems that begin with sonorants, which have little phonetic effect on F0 (Gussenhoven 2004), may be lexicalized with either tone melody.[2] Vowel effects are also clear, with high vowels /i/ and /u/ tending to pull the F0 value up relative to other vowels. Thus, in a word like *gìnɛ̀-ý* 'house', the L tone on the /i/ tends to be higher than that on the /ɛ/.

Declination and downdrift are both apparent in Tommo So tone. These effects are typical of West African languages, such as Yoruba (Connell and Ladd 1990) and Bole (Schuh et al. 2010), and, in the case of declination, of languages in general. Following Connell and Ladd (1990), I use the term 'declination' here in reference to a modification of the "phonetic backdrop" on which tones are played out. This modification takes the form of a gentle downward trend in the F0 throughout the course of an utterance and has clear physiological origins (Gussenhoven 2004:97), hence its universal presence in human speech. A more language-specific effect is downdrift, or "automatic downstep" (Stewart 1965), common among West African languages; Tommo So shows no evidence of non-automatic, or phonemic, downstep. In downdrift, the second H in a HLH sequence will be pronounced substantially lower than the first, and this second H tone then sets the bar for subsequent H tones. In essence, the H tone "ceiling" is progressively lowered. In Tommo So, this lowering is extreme, with the second H tone pronounced at the same level as the preceding L or only slightly above; see LH transition in the verb *jàŋgá-dɛ́* 'studies' in Figure 3. Thus, after a H tone, LH is differentiated from LL not by raising the F0, but by keeping the tone level, while in LL, it will continue to fall. Note that the presence of

[2]Gussenhoven (2004) also notes that, unsurprisingly, vowels do not affect F0, so the fact that vowel-initial stems are all {H} in Tommo So does not seem to be phonetically motivated.

the initial H is strictly necessary for downdrift; it will not be triggered by LH alone.

Importantly, these two downtrends are bounded by different domains. Downdrift only occurs within a phonological phrase (henceforth ϕ-phrase). Register is reset at ϕ-phrase boundaries, but declination is not, ensuring that later phrases tend to be lower on average than earlier ones. Declination is instead bounded by intonational phrases (henceforth I-phrases), though it may be disturbed by the intonational effects of emphasis.[3] While ϕ-phrases consist generally of two to three words, and there is no clear pause between the phrases, I-phrases can be composed of numerous ϕ-phrases; a pause tends to mark the boundary of an I-phrase, if the utterance contains more than one. See Figure 3 above for an example of several ϕ-phrases contained within a single I-phrase; the H ceiling is reset at each boundary, but later Hs are still marginally lower than earlier ones. The same can be said of most Ls.

Figure 4 shows a derivation of the pitch track in Figure 3. (4a) shows the phonological tones associated with the sentence. In (b), these are plotted onto the guidelines set by declination. Next, these tone targets are schematically connected in (c), with downdrift applied within ϕ-phrases. The new H tone ceiling is shown by a third horizontal dotted line between the two set for declination, and crucially, this H tone ceiling is erased at the start of the next ϕ-phrase. Finally, consonant and vowel effects are taken into account in (d): voiced consonants pull the F0 down, fricatives raise the F0, and high vowels have higher F0s. This diagram also shows segment boundaries to show how the pitch set at the beginning of a vowel carries through until the following consonant, rather than interpolating directly to the next vowel target. Consistent with the pitch tracks created by Praat, this last diagram shows

[3] Intonational effects on tone are not yet well understood for Tommo So, though it is clear that emphasis, among other things, may cause a word to be higher and louder than expected for its position within a phrase.

F0 interpolation through voiced consonants but not voiceless ones. Together, these diagrams show that applying these basic rules of phonetic implementation to the phonological tone targets results in a highly accurate representation of actual surface forms.

Finally, Figure 5 shows the reset of declination after an I-phrase boundary. The word *mɛ̀* 'but' closes the first I-phrase, then in the next I-phrase, the H of *jɔ̀mɔ́* 'hare' is much higher than it would be if it fell within the guidelines of the previous phrase's declination.

4 Enclitics

With the phonological and phonetic facts of Tommo So tone in mind, let us now return to the issue of underspecification. The first class of underspecified elements I will address is enclitics. In Tommo So, this class includes the following:[4]

(2)

Clitic	*Form*	*Example*	*Gloss*
Oblique	nɛ	dámmá=nɛ	'in a village'
Possessive	mɔ	wó=mɔ	'his/hers'
Associative	le	màlbá=le	'with a gun'
Definite	gɛ	ìsé=gɛ	'the dog'
Plural	mbe	ìsé=mbe	'dogs'

Unlike the lexical stems mentioned above, the surface realization of these elements varies depending on their context. This variation is audible to the non-native ear, but the pitch contours often defy phonological categorization. At times, they sound

[4] It is noteworthy and perhaps not a coincidence that none of these elements meet the lexical bimoraic minimality requirement.

like the result of simple tone spreading from the left: L after a L-final word, H after a H-final word, but this is not the full story.

The pitch tracks in Figure 6 show a preliminary illustration of what will be expanded upon in the subsequent sections. The pitch tracks contain the underspecified definite marker *gɛ* in three different contexts: (a) preceded by a H and followed by a L, (b) flanked by Hs,[5] and (c) flanked by Ls.

(The fourth logical possibility, Ø preceded by a L and followed by a H, is unattested in my data, but the theory put forth here would predict a rising interpolation in this case.) Notice that in 6a, the F0 falls steadily throughout the definite, forming a smooth linear interpolation between the H and the L (with a discontinuity in during the stop closure of /b/). In 6b and 6c, the enclitic is indistinguishable from a lexical H or L, respectively, since the linear interpolation is between two identical tones.[6] I set aside for the time being the issue of phrase boundaries and their effects on underspecified tones. In sum, Figure 6 shows that the exact same enclitic may surface with at least three different F0 contours, and that these contours are entirely predictable based on context. Note that crucially, the enclitic does not receive tone via spreading from the left (a common rule attested in many African languages; Hyman and Schuh 1974, among others); if this were the case, the definite in Figure 6a and 6b should be identical.

For further evidence that the surface realization of underspecified elements depends on interpolation, consider Figure 7 on the next page, where interpolation between a H tone and a L-toned ϕ-phrase boundary (see section 4.2), indicated by a

[5] Note that the second H is the first portion of a falling tone. This, combined with its phrase-final position, accounts for the H looking lower than the preceding H.

[6] The F0 shows halving on the first syllable of /bánú/ in Figure 4a, as the speaker was an old man whose voice would sometimes crack, and the recording itself was quiet.

dotted line, extends linearly through a sequence of three underspecified enclitics.

In the sections that follow, I will present evidence that the surface realizations of these enclitics are decidedly different from those of phonological H or L tones in the same contexts. Phrasing and boundary tones will also play a role. Thus, the first subsection focuses solely on sequences of tones contained within a phonological phrase, while section 4.2 introduces phrase boundaries. In section 4.3, I expand on Figure 7 and show how the rules of interpolation hold over sequences of enclitics. Finally, section 4.4 discusses cases where toneless elements may receive phonological tone via tone shift, which blocks interpolation.

4.1 Enclitics and interpolation

An examination of pitch tracks confirms that clitics often are categorically different from the Hs and Ls seen in lexical stems. Instead of acquiring their tone from a phonological spreading rule, toneless enclitics never acquire phonological tone. Their surface pitch is simply an interpolation between specified tones on either side. If the tones before and after are the same, the tone contour on the enclitic looks indistinguishable from its neighbors: between Hs, it appears H; between Ls, it appears L. (See (4) and (7) for statistics confirming this conjecture.)

Consider the pitch tracks in Figure 8. The underlined portion in the transcription corresponds to the arrows on the pitch track itself.

In 8a, definite *gɛ* is flanked by the final H of /bánú/ 'red' on the right and the initial H of ultimately falling /dúù-ndì̀-ɛ^{n}/ 'put down'. The slight fall during the definite is due simply to normal declination in a declarative sentence. Compare this to the pitch track in 8b, where the preverbal tone is a specified H (/dámmá/ 'village'), and it is flanked by the preceding H tone in the stem and the following H[7] in the falling tone /yáà-dɛ̀/ 'she will go'. This fully specified H tone does not look significantly different from the pitch contour on the underspecified enclitic. Finally, 8c shows an example of a specified L tone flanked by Hs. Notice that this surfaces as completely different from the underspecified tone, showing clear evidence that L cannot be unspecified in Tommo So as it is in many Bantu languages.[8] One should also note the existence of automatic downstep or downdrift of the H after the intervening L tone.

These pitch tracks do not show evidence of a three way tone contrast. But when we change the context surrounding *gɛ*, we find that, unlike its specified comrades in the lexicon, the definite's surface representation likewise changes. Look now at Figure 9a, where the definite is flanked by a H tone and a L tone. Instead of appearing as a H, with a very level F0 slope, the pitch falls rapidly, continuing its trajectory through the consonant to the L tone on the following vowel in /bàláá/. A specified H tone does not show this fall–in Figure 9b, the H tone at the end of /jáŋgú/ remains level. The fall only begins during the consonant closure before the L tone.[9]

The other point to note in both pitch tracks in Figure 9 is the total downdrift of the H tones in /bàláá/ and /jàŋgá-dɛ́/ 'she studies', discussed in the last section.

[7]The lower F0 on this H is explained by the same principles discussed in footnote 5.

[8]This case, however, may not be perfect. Notice that what is marked as a H tone preceding the L actually shows some degree of downward F0 movement. This word, 'boubou (West African garment)', is a Fulfulde loan, and it may be that only the first and last tones are specified. That is, words that appear HHL may in fact be HØL, as Tommo So speakers borrow a downward pitch movement that is familiar from the behavior of clitics and apply it to the strange-sounding dropping prosody of loanwords. This difference would be slight, though, and seeing as {HL} words are very uncommon and do not figure prominently in my recordings, I am unable at this stage to draw a distinction between a specified or unspecified middle tone. Nevertheless, it is clear in this case that we have a specified L tone and that it differs considerably from the null tone in 8a.

[9]There is a perturbation in the pitch at the beginning of the L-toned vowel in /jàŋgá-dɛ́/ 'she studies', which is mostly likely caused by the /j/ consonant.

Due to the tonal effects of phrasing, I have taken care in this section to compare only words in the same syntactic configuration, namely direct objects and their verbs, since theories of phonological phrasing often predict that these will phrase together (Nespor and Vogel 1986, Selkirk 1986). Given these strict context requirements, though, and the low frequency of HL words in the language, no adequate recording of HL L was available in my corpus of recordings to compare with the pitch tracks in Figure 9. Even so, the data in Figure 8 have already shown that L and Ø do not have the same realization, and Figure 9 serves only to extend this differentiation to H and Ø as well.

I have been focusing on the definite in this section for the sake of illustration, but the other enclitics also behave the same way. To show that these differences between H and Ø and L and Ø are not simply impressionistic, I ran statistics on sequences of tones from my corpus of recordings. In Praat (Boersma 1996), I extracted the average F0 value over the duration of the vowel. If the flanking tone in question was a contour, the local minimum or maximum was measured instead of the average F0 value. I normalized the recordings using the following equation:

(3) $(\log(T1)-\log(T2)) / \log(2^{1/12})$

This yielded the number of semitones between two consecutive tones (ex. HØ or HH). I averaged these numbers for each sequence of two tones (HH, HL, and HØ) in the __H context. To supplement the small number of HL sequences within a single word (of which only four good cases were found), I also included sequences of word-final H followed by word-initial L within the same phrase. Running an unpaired T-test on these numbers yielded the following results:

(4) *Distance between the two tones HH, HØ, and HL followed by H*

	Mean Δ semitones	# of tokens
HH(H)	0.43	12
HØ(H)	0.65	21
HL(H)	3.73	25

The difference between HH and HØ was not significantly significant ($p = .27$), but the difference between both of these and HL was highly significant ($p < .001$). This is exactly the result expected given the pitch tracks in Figure 6 and an interpolation analysis of underspecification.

We expect a significant difference in the number of semitones between T1 and T2 of HHL and HØL, if interpolation is indeed at play. Indeed, we expect a three-way difference between HHL, HØL and HLL, but no instances of the latter where HL is within a single word can be found in my corpus of recordings. In its place, I have once again used a word ending in H followed by a word beginning with a L and followed by another L tone, of which I could find only four cases. The table below summarizes the average number of semitones between HH, HØ, and HL when followed by a L tone:

(5) *Distance between the two tones HH, HØ, and HL followed by L*

	Mean Δ semitones	# of tokens
HH(L)	0.71	12
HØ(L)	1.80	11
HL(L)	3.19	4

The difference between each was significant at $p < .01$, showing that indeed a three-way contrast exists between H, L and Ø tones within a ϕ-phrase. For further evidence that Ø and L are different, see the comparison of two Hs flanking each tone in example

(29).

4.2 Phrase boundaries and boundary tones

In section 3, I alluded to the fact that underspecified tones provide independent evidence for the ϕ-phrases identified by downdrift. Consider the pitch track in Figure 10a, where there appear to be two instances of the environment H__H for the underspecified tones. Unlike in Figure 8, interpolation is not seen between the flanking H tones. Rather, the interpolation appears to be in each case between the preceding H tone and some covert L tone following the enclitic. I attribute this lowering to a L⁻ boundary tone, associated with the ϕ-phrase boundary (cf. the intermediate intonational phrase of Pierrehumbert and Beckman 1988 or the phonological phrase of Hayes and Lahiri 1991), which provides an endpoint for interpolation across the toneless enclitic. The existence of phrase boundaries in these locations, shown in the pitch tracks with a dashed line and a L⁻ tone marked beneath them, is bolstered by the fact that the H tone following each one is significantly higher than the L ending point of the toneless enclitics; that is, downdrift is blocked from applying.

What about the fully specified cases? In Figure 10b, the HHH sequence seems unaffected by the presence of a phrase boundary between the subject *bé ní́nɛ́* 'their aunt' and the verb *yɛ́llɛ̀* 'will come'. The boundary is evident in Figure 10c from the lack of downdrift, but it is unclear if the boundary tone has any effect on the lexical L.[10] Especially in the case of HHH, one might expect downstep on the first H across the phrase boundary, since L⁻ has nowhere to dock and cannot be realized. But this

[10]The pitch does seem to drop at the end of the L tone, but this could be due to the following glottal stop. We once again fall victim to the rarity of HL stems and must draw conclusions based on the data available.

is unattested.

The exact fate of this boundary tone is unclear, but the data suggest that, when surrounded by fully specified tones, the boundary tone is unable to be realized and is hence deleted. That is, the strength of lexical tones outweighs the strength of boundary tones, and only the lexical ones are realized. Tommo So has no grammatical floating tones of the sort so common in African languages, so we have no evidence elsewhere in the language of floating tones docking to specified syllables. The lack of realization of the intonational boundary tone could be enforced simply by faithfulness constraints–faithfulness to lexical tones is greater than faithfulness to boundary tones, and this ranking predicts that boundary tones will not be realized. On underspecified elements, there is no lexical tone to be faithful to, so the boundary tone surfaces.

It is crucial to draw a distinction between this L^- intonational boundary tone and the lexical tones of the language. While lexical tones dock to moras and determine the pitch of the whole vowel span (or half, in the case of a contour tone), the L^- tone must remain at the phrase boundary. It must come after the string of lexical tones, or even after the slot where the Ø tone would be. This suggests the need for two different tonal tiers, one lexical, the other intonational, though I leave the exact implementation of such an analysis to future work.

4.2.1 H__]H

Returning to the three pitch tracks in Figure 10, we see that the tone in the environment [H__]H is distinct in each case. In 10a, the underspecified tone begins at the same pitch as the preceding H, then falls sharply into the phrase boundary. In 10b, the H tone remains level between the identical flanking tones, its slight downward slope due only to declination. Finally, in 10c, the change from H to L is carried out during the intervening consonant, leaving the vowel at a relatively level L pitch.

As before, I averaged the normalized number of semitones between the two tones preceding the boundary. Though I pointed out two probable locations of HØ]H in Figure 10a, I only included measurements for the first environment, since the second includes a grammatically-controlled H overlay on *náá* 'mother'. It is not yet clear how grammatically controlled tone differs from lexical tone. The results are summarized below, where] stands for the phrase boundary. Again, cases of H#L] were included here to supplement the small number cases of HL within the same word:

(6) *Distance between the two tones HH, HØ, and HL followed by a ϕ-phrase boundary*

	Mean Δ semitones	# of tokens
HH]	0.78	10
HØ]	2.23	14
HL]	3.66	10

Unsurprisingly, the difference in semitones between HH and HØ is highly significant, with $p < .001$. The difference between HØ and HL was also significant, at $p < .01$. While all three are significantly different (once again confirming our ternary contrast), the HØ cases are closer to HL than to HH in terms of semitone difference, rather than being evenly spaced between them. The explanation of this seems to stem from the fact that Ø tones on average ended at a lower F0 than L tones, which pulled their average F0 down as well. Why the endpoint of downward interpolating Ø tone gets lower than lexical a L remains a mystery, as a Ø with flat interpolation from a preceding L does not show this effect (see below).

4.2.2 L__]H

In Figure 10, we saw the underspecified tone appearing distinct from either lexical H or L. If the first tone in the sequence were L, however, we would expect the surface realizations of L and Ø to merge, since the underspecified tone would be interpolating from one L element to another. This is exactly what we see.

Look at Figure 11 on the next page. Here, the environment is [L__]H. As predicted, the tonal sequences in 11a and 11c look indistinguishable, in contrast with the specified H tone in 11b. Here, the underspecified enclitic shown is the oblique *nɛ* rather than definite *gɛ* due to the fact that most examples with the definite were preceded by falling rather than level L tone.

The numbers confirm the predictions of the theory:

(7) *Distance between the two tones LL and LØ followed by a ϕ-phrase boundary*

	Mean Δ semitones	# of tokens
LL]	0.518	8
LØ]	0.506	24

The two averages are practically identical, with a p-value of 0.96. In short, an underspecified tone interpolating between two L elements is indistinguishable from a lexical L. Due to the variation between downstepped H (in a HLH phrase) and non-downstepped H (in a LH phrase), I have not pooled the numbers of LH before a phrase boundary. Nevertheless, it is clear that the difference in semitones would be a negative number, since the F0 would rise between the L and H to varying degrees.

I have not included any examples of a L tone after the phrase boundary in this section, because these do not look any different. The underspecified enclitics are in effect blind to what lies outside of their own phonological phrase. In the presence of a phrase boundary, only what precedes the underspecified element is able to affect the surface realization, since the boundary that follows always carries a L- tone itself, which bookends the interpolation and renders following tones irrelevant.

4.3 Sequences of enclitics

If interpolation is seen on one underspecified element, we predict that this same interpolation should apply through any sequence thereof. This prediction is borne out by the data. Compare the pitch tracks in Figure 12a-b. In 12a, only the definite *gɛ* is present, and though the recording is of an object-verb sequence, the lack of downdrift on the verb *dɔ̀ɔ̀-gú sɛ́-m* 'I am pounding' suggests that there is a phrase boundary between the two. This could be due to the length and morphological complexity of the verb phrase.

(8) shows an interlinear gloss of this VP:[11]

(8) [tàgá=gɛ] [dɔ̀ɔ̀-gú sɛ̂-m]
shoe=Def pound-Ppl have-1sgS
'I am pounding the shoe'

The verb is made up of not only a stem+participial suffix combination, but also a separate auxiliary verb that carries the pronominal inflection. It is possible that phonological phrases are defined largely based on syntactic configuration but can be affected by the amount of phonological material as well (cf. Nespor and Vogel 1986 and Ghini 1993 for Italian; for a good discussion of the difficulties in determining phrasing, see Shattuck-Hufnagel and Turk 1996). Unfortunately, the behavior of the toneless enclitics do not help in this case, since it is not possible to distinguish

[11] Another curious element of these pitch tracks is the seemingly rising tone on the second syllable of *tàgá* 'shoe'. Lexically, short syllables do not license contour tones in Tommo So.

whether the phrase boundary or the lexical L of the verb is serving as the endpoint of interpolation.

In Figure 12a, the F0 interpolates linearly over the toneless enclitic from the offset of the H-toned vowel through the consonant onset of the verb. In Figure 12b, both the definite and the associative *le* are present after the object, and so consequently the interpolation cuts straight through both clitics. The slope remains linear, rather than sagging or leveling out. Note, however, that the interpolation does not end as low in 12a as it does in 12b. This is probably the result of undershoot; the single clitic is not long enough to fully achieve the L target, so the F0 only falls partway, and the following consonant carries interpolation from the phrase boundary to the vowel of the verb. With a sequence of two clitics in 12b, the full interpolation from H to L can be realized.

Recall Figure 7, which takes the extended interpolation one step further with a sequence of three underspecified enclitics. The behavior is the same, and the interpolation from H to L complete.

So far, all of these sequences of enclitics have preceded phrase boundaries, and hence the interpolation all ends in L. As it turns out, I have no instances of any other sort of interpolation over more than one enclitic in my corpus of recordings. I can see two reasons for this. First, many enclitics regularly mark the ends of phrases, such as the oblique and the associative. When a sequence of enclitics is found, it is more likely to contain one of these phrase-ending elements, and hence we are more likely to find a phrase boundary. Second, even if the sequence were something neutral like the definite followed by the plural, the existence of two (or more) enclitics increases the weight of that phonological phrase, which in turn increases the likelihood of splitting the phrase into two. The theory of interpolation put forth here predicts that if a sequence of underspecified elements were phrase-internal, interpolation would apply the same as it would to a single underspecified element; that is, we could find sequences of enclitics that look like H tones between flanking Hs, L tones between flanking Ls, and linear interpolations between dissimilar tones on either side, assuming linear rather than slouching interpolation. I await further data to confirm this hypothesis.

4.4 Tone shift and specification

One issue remains to be addressed before leaving the topic of enclitics, and that is tone shift. There are a few words in Tommo So that lexically contain a contour tone on a syllable too light to host it. When surrounded by specified tones in the output, several repair strategies are attested for these situations: 1) The syllable may lengthen, allowing the full contour to be expressed. 2) A tone may be deleted and only one of the tones in the contour is expressed. 3) The syllable may be slightly lengthened, and the contour slightly "truncated"; that is, there can be a compromise between the two strategies. The details of such repair strategies are not important here. What concerns the present discussion is the behavior of these "crowded tones" when followed by an underspecified enclitic.

With the empty tone slot of an enclitic next to it, a crowded syllable is allowed to hoist its second tone rightward, as schematized in Figure 13 above. This both alleviates the crowding and results in a surface-specified enclitic–the interpolation seen above no longer occurs. Look at the near minimal pair in Figure 14:[12]

In Figure 14a, the interpolation is linear from the delayed peak of *nàá* 'cow'

[12]Both of these phrases are object+verb combinations, hypothesized to form single phonological phrases in Tommo So. Nevertheless, the H of the auxiliary verb *bé-m* 'I was' (in this case used as 'I had' in 'I had seen') is significantly higher than the preceding L. Downdrift would predict this to be impossible. However, it may be that downdrift is often not operative in phrase-final position, as Hausa is purported to show a similar phenomenon (Russell Schuh, p.c.).

through the enclitic and the /y/ of *yàà* 'seen'. Contrast this with Figure 14b, where a plateau is seen on the enclitic in place of interpolation, since the H portion of the contour on /nɔ̌/ 'this' has shifted onto it. Consequently, the slope of the interpolation during the following /y/ is much steeper, since there is less time to interpolate from H to L. We will encounter this tone shift again in the upcoming discussion of underspecified nominal suffixes.

Tone shift onto underspecified elements has important consequences for the phonological analysis of Tommo So tone. As I will argue in section 6, if surface underspecified elements are not added until a later level, then such tone crowding must also remain unrepaired until such a level. There is some question as to how the phonology deals with tone crowding when tone shift is not possible. One solution would be to suggest that if the phonology can feed the phonetics something underspecified, then it can also feed it something overspecified. At this point, it would be up to the phonetics to implement a repair strategy. This could explain the presence of the third "in-between" strategy described above, which is not structure-preserving (the length is neither short nor long, the tone neither level nor contour). Another possible solution would be to use Harmonic Grammar (Legendre et al. 1990), in which two constraints can be partially satisfied, resulting in a compromise solution: slightly longer vowel, slightly simpler tone. It is up to our theories of phonetics-phonology interface to determine the correct division of labor between the two grammatical components and how to implement such non-categorical repairs (see Flemming 2001 for a proposal to bring constraints into the realm of phonetics).

4.5 Enclitics: a summary

I began this section with Figure 4, which showed an enclitic between two Hs, between two Ls, and between a H and L. This was to illustrate that in the first two cases, where the underspecified element is flanked by identical tones, its surface realization looks identical to those tones around it–it could simply be the result of spreading. Between a H and L, however, we find that the F0 interpolates from the H to the L, resulting in something resembling a falling tone.

Here, I have pooled the numbers from a couple dozen cases of each environment, grouping lexical L and L_ϕ together. Again, I averaged the F0 of the vowels (or took the local minimum or maximum if it was a contour tone) then calculated the number of semitones between the preceding vowel and the enclitic (ignoring, here, the following vowel, since we expect to see its effect on the enclitic itself). The numbers are summarized below:

(9) *Distance between the two tones HØ followed by H and HØand LØ followed by L*

	Mean Δ semitones	# of tokens
HØ(H)	0.65	21
LØ($L^{(-)}$)	.51	24
HØ($L^{(-)}$)	2.18	26

Our theory predicts there to be no difference between the HØH and LØL cases, since the enclitics in each interpolate between two like tones, resulting in a level interpolation. This is confirmed by the calculations. An unpaired T-test reveals that there is no statistical difference between the identical tone environments ($p = .44$). On the other hand, the difference between the HØL case and both of the others were highly significant ($p < .0001$ for each).

Thus, while we do not have very many cases of lexical tones to compare to the enclitics, looking at the enclitics themselves in each available environment gives significant results that are consistent with an analysis of underspecification and interpolation.

5 Other underspecified elements

In the last section, I gave evidence that enclitics should be treated as surface underspecified for tone. When flanked by words within a ϕ-phrase, the enclitic is pronounced with an F0 interpolation between the lexical tones on either side; when at a phrase boundary, the interpolation is between the preceding lexical tone and a floating L^- ϕ-phrase boundary tone. Here, I extend tonal underspecification to two other domains: human suffixes (*-nɛ*, singular, and *-m*, plural) and epenthetic vowels. The data here are preliminary, as neither class is as common as enclitics in my corpus, but an examination of pitch tracks indicates that their behavior is exactly parallel to that seen in the last section.

5.1 Human suffixes

Nominal morphology in Dogon languages is largely isolating, making little use of suffixes, none of prefixes, and extensive use of enclitics of the type described above. The exception in Tommo So to this isolating rule are suffixes that mark certain human nouns, singular *-nɛ* and plural *-m* (which syllabifies as a coda). The singular also has the allomorphs *-nɔ* and *-na*, and which vowel is chosen is either lexicalized or conditioned by vowel harmony. Consider the following pairs:

(10)	*Singular*	*Plural*	*Gloss*
	àn-ná	àná-m	'man'
	púlɔ̀-nɔ	púlɔ̀-m	'Fulani person'
	sɔ́í́-nɛ́	sɔ́í́-ḿ	'speaker'

The chosen allomorph is lexicalized as *-na* in the first case (though presumably as a result of earlier strong vowel harmony), created by vowel harmony in the second case, and is simply the underlying form in the last case. Like the enclitics above, pitch tracks show that these suffixes can behave either as though specified or underspecified, depending on the context. Compare the three phrases in Figure 15. In the first, we see a falling F0 contour on *-nɛ*, which is an interpolation between the preceding H and a L^{-} boundary tone. In 15b, the suffix, as expected, appears L between a preceding lexical L tone and the following L^{-}. The suffix in 15c appears as a H between two Ls within a ϕ-phrase, which is the result of tone shift and specification. I have not labeled the lexical tones after a phrase boundary here, since the last section showed that they have no effect on an underspecified element. In sum, the suffixes in 15a and 15b are receiving their tones by interpolation, while the suffix in 15c is receiving its specification by tone shift.

Consider the different surface forms containing stem for 'chief' or 'Hogon' (traditional Dogon chief):

(11) a. ɔ̀gɔ̀-nɔ́ 'chief'

b. ɔ̀gɔ̀-ḿ 'chiefs'

c. ɔ̀gɔ́ 'chiefdom'

The stem appears all L with a suffix and LH without. These facts are consistent with an analysis in which the stem 'chief' is underlyingling /ɔ̀gɔ̌/, with tone crowding on the final syllable. In the absence of a suffix, the preferred repair strategy is to delete one of the stem Ls, shifting the H leftward. If an underspecified suffix, like *-nɔ*, is present, the crowded tone can shift rightward, specifying this syllable. The stem /dɔ̀gɔ̌/ 'Dogon' behaves identically.

The words for 'man' and 'woman' also appear to participate in this specification. On their own as 'male' and 'female' (often compounded with animals, plants, or even tools), the stems surface as [àná] and [yàá], respectively. With the human singular suffix, we find [àn-ná] 'man' (with syncope of the medial /a/) and with the human plural, [àná-m] 'men'. This is inconsistent with a crowding account, with an underlying form /ànǎ/, since here we would expect the plural to surface as [ànà-ḿ]. Instead, the specification of the suffix in the singular must be due to the deletion of the stem-final vowel, which formerly carried the H tone.

'Woman' is a little more problematic. In the singular, 'woman' surfaces as somewhere between [yàà-ná] and [yàá-ná], that is, with a slight rise before the specified H suffix. The stem has a long vowel, and so conceivably it should not need to push the H portion of the rise onto the suffix (as shown in Figure 16). I hypothesize that in addition to a constraint against contour tones on a single mora, the language also has a constraint against word internal contour tones: [yàá-na] and [yàá-ná] are bad, while [yàà-ná] is fine. However, as I will model in the following section, tones cannot be inserted at this level, so it is preferable to move the second half of the contour to the suffix, leaving the second mora of the stem underspecified. The F0 is filled in by interpolation between the initial L and the H, now on the suffix:

Allowing contour tones at the ends of words but not word-medially is typologically natural (Zhang 2004), and thus it is not surprising to find this pattern in Tommo

So. On a phonetic level, this restriction is grounded in the duration of the syllable carrying the contour tone. A light syllable anywhere is shorter than a heavy syllable, but a heavy syllable word-medially is shorter than a heavy syllable word-finally. The types of syllables that can carry contour tones tend to form an implicational hierarchy, and Tommo So sets the cut-off before heavy final syllables.

The behavior of the tone in this area again clearly distinguishes clitics seen in the last section from the suffixes shown here. The addition of either will force the redistribution of contours on a single mora, but only suffixes cause redistribution of stem-final contours on a heavy syllable, since the stem and suffix form a single phonological word. This is schematized as follows:

(12)

		Suffix	Clitic
	v̌	v̀-x́	v̀=x́
	v̀v́	v̀v-x́	v̀v́=x

Before proceeding, I would also like to briefly address a divergent case of human suffixes, which is their use in deverbal agentive nouns. There is a highly productive pattern of agentive derivation that uses the -*nɛ* and -*m*. Consider the following:[13]

(13)

	Verb stem	*Gloss*	*Agentive N*	*Gloss*
	gìrɛ́	'herd'	gírí-nɛ́	'herder'
	kálá	'lie'	kálí-nɛ́	'liar'
	gòó	'go out'	góí-nɛ́	'one who goes out'

The final vowel of the verb stem is replaced with /i/ and the suffix is added. Regardless of the lexical tone of the verb, agentive nouns always appear all H. No interpolation is seen on these suffixes and the verb stem always surfaces as H, sug-

[13]In each case, the plural form would simply use -*m* instead of -*nɛ*.

gesting that the {H} is a grammatically controlled melody imposed after the suffix has been added, thus fully specifying the form. I leave the question of at which level grammatical tone applies to future research.

5.2 Epenthetic vowels

In addition to regular, run-of-the-mill stem vowels, there is another [u] that displays some curious behavior. First, this [u] can follow non-identical stem vowels, which is generally forbidden by vowel phonotactics. Stems typically have either identical vowels or a high vowel followed by mid vowels agreeing in backness, as in *ɛ̀nɛ́* 'goat', *kádáná* 'oldest person in a village', or *kúló* 'hair'. Word-final [u], on the other hand, can co-occur with any other vowels, as in *pílu* 'white' or *yàmú* 'waste'.[14] Second, after sonorants in the final syllable of a word, this [u] is optional; *pílu* 'white' can also be pronounced *píl*. Third, and most crucial to the discussion at hand, its tone is often underspecified. These three facts suggest that this [u] is not underlyingly part of the stem, but is instead epenthetic.

In many instances, these vowels show the same interpolation seen with enclitics or human suffixes, as shown in the pitch tracks in Figure 17.
In both pitch tracks, we see straight interpolation through both the epenthetic vowel and the following underspecified enclitic. This slope looks identical to that seen in Figures 7 or 12b with sequences of enclitics.

Nevertheless, not all word-final [u] show this interpolation. We also appear to have cases of tone shift, where an obstruent-final, and hence light, underlying syllable pushes one of its tones onto the epenthetic vowel. An example of this can be seen

[14] /u/ here is specified due to tone shift. See below.

in Figure 13c, where underlying /úrûk/ 'prayer' surfaces as [úrúkù], with the L tone shifted to the epenthesized vowel. The fact that this lower F0 on the final [u] is lexical and not interpolated is evident from the downdrift on the following verb *ínnɛ̀* 'doesn't know'.

Other cases are less clear. Consider the word *jáŋgú* 'studies' in Figure 3. Here, the [u] looks as though it is specified for H, despite otherwise looking like an epenthetic vowel. It is possible that deverbal nouns are assigned grammatical tone overlays, but the fact that both {H} and {LH} deverbal nouns exist suggests that this is not a postlexical process. A more likely explanation is that the final [u] on these nouns is a derivational suffix, used to derive nouns from verbs, and it is added at an earlier stage in the grammar where full specification is obligatory. I leave this question to future research.

6 Deriving underspecification: an analysis in Stratal OT

Thus far, I have argued that the surface realization of tone on some elements in Tommo So is the result of underspecification and interpolation. Yet as I mentioned in section 4, no lexical stems show this tonal behavior; all stems are fully specified. This pattern is easily captured in a level-ordered framework like Stratal OT (Kiparsky 2000), where different morphological levels are subject to different grammars.

The crucial facts we want to capture are the following: 1) All stems are specified for tone. 2) Enclitics, human suffixes, and epenthetic vowels can be tonally underspecified. 3) On the surface, contour tones on light syllables are disallowed, but these tonal clusters must persist until a level where epenthesis, suffixation or cliticization takes place to account for tone shift. 4) Similarly, obstruent codas are not allowed on the surface, but they must persist until a level where epenthesis takes place.

6.1 Level 1: stems

The first fact is easy to account for, simply by ranking *Ø at the top of the grammar at the first level, where only stems are evaluated. Richness of the Base (ROTB) (Prince and Smolensky 1993) states that anything is a possible input to the grammar and it is the job of the constraint ranking to arrive at the attested surface forms. Under this principle, the grammar may receive as input underspecified stems, all of which will be repaired due to undominated *Ø. We have no evidence for which stems could be underlyingly unspecified, and hence no evidence as to whether H or L is the tone inserted to repair this underspecification. Since L is seen as the unmarked tone in many African languages, I will posit that Dep(H) outranks Dep(L), so L is inserted where the tone is underspecified.

Section 3 noted that native words and loanwords can have very different tonal patterns. Assuming this a productive difference, we can assign different cophonologies (Orgun 1996, 1998; Inkelas 1998) to native words and loanwords, with the native cophonology being much more restrictive as to what is a licit surface tone pattern. The synchronic divide between native words and loanwords (especially from Fulfulde and French) appears to be a salient one for speakers. Not only are the tone patterns different in loanwords, namely allowing the natively unattested {HL}, but other areas of native phonotactics are violated as well. Voiceless consonants can occur word-medially, different vowels freely co-occur, and non-native segments like /f/ and /h/ appear more readily. Though some speakers repair certain violations and make the loanwords more Dogon-like, others preserve more of the foreign phonology, or fluctuate between multiple pronunciations.

Thus, it would be unsurprising for different speakers to draw the line between native and non-native in different locations, but in this paper, I will assume a strict division between native Dogon stems and those I know to be borrowed from other languages. In the interest of space, I focus only on native stems here. Two markedness constraints that are necessary for Tommo So tonology are *L#, which assigns a violation whenever a word ends in a L tone, and *HLH, which assigns a violation whenever a word contains two H tones with one or more intervening Ls. While the first constraint may be language-specifc, the latter is common cross-linguistically (Hyman 2010).

What of a change from underlying L to surface H? This would be necessary if the input ended in L. Here, I view a tonal replacement as a combination of deletion (violating MAX(T)) and insertion (violating DEP(T)), rather than a one-step ID(T) violation. This is simply a matter of notation and is not a crucial claim of the theory put forth here. Also in terms of notation, I include in my tableaux only tones marked on the surface by accents, remaining neutral to the question of whether a string of H tones is a multiply-linked H tone underlyingly or several singly-linked Hs. Nowhere in the tonology of Tommo So does such an analysis become necessary.

Nevertheless, in the analysis given here, each orthographic accent mark is treated as the equivalent of an autosegment. Thus, in a nonce word like /kàkàkà/, a surface form [kàkàká] would incur a violation of MAX(T), not MAX(ASSOCIATION), assuming that the final L that was deleted was separate from the other L tones in the word. This method assumes one tone per syllable, but an analysis with multiply-linked tones would work as well. One final note regarding association lines: if a nonce word like /kàkǎk/ becomes surface [kàkàkú] after epenthesis, I claim here that this violates *MOVE, which can be understood as a local conjunction of MAX-ASSOCIATION and

DEP-ASSOCIATION. That is, the underlying form has three tonal gestures, LLH, as does the surface form–the H has simply been relocated, as opposed to being deleted and replaced by an identical tone on the epenthetic vowel. This is simply a notational convenience and has no direct bearing on the analysis.

The other fact relevant to Level 1 is that there is no vowel epenthesis, but illicit coda consonants are kept. Therefore, both DEP-V and MAX-C must outrank *CODA. The tonal clusters on light syllables are also retained, so MAX-T must outrank *CONTOUR-μ, which penalizes a single mora with more than one tone. However, no stems have medial contour tones, so *CONTOUR...$]_w$, which assigns a violation to candidates with contours not aligned at the right edge of a phonological word, must be undominated.

(14) summarizes the constraints needed in Level 1:

(14) *Ø, *L#, *HLH, DEP-V, MAX-C, *CONTOUR...$]_w$ >> DEP-H, *CODA, MAX-T >> DEP-L, *CONTOUR-μ, *MOVE

In the first two tableaux, I address only forms with no coda consonants and no contours, and hence leave out the constraints specific to these issues: DEP-V, MAX-C, *CONTOUR-μ, *CONTOUR...$]_w$ and *MOVE. The first tableau shows the output of a totally underspecified nonce input /kakaka/. MAX-T plays no role here, as there are no tones to delete.

(15)

/kakaka/		*Ø	*HLH	*L#	Dep-H	Dep-L
a.	kakaka	*!**				
b.	kákàká		*!		**	*
c.	kákàkà			*!	*	**
d.	kàkàkà			*!		***
e.	kákáká				**!*	
f. ☞	kàkàká				*	**

Fully faithful candidate (a) is ruled out by three violations of undominated *Ø. Candidate (b) violates undominated *HLH and is ruled out. The next two candidates, (c) and (d), are likewise eliminated, as they violate undominated *L#. Candidate (e) avoids violating any undominated constraints, but candidate (f) is optimal in that it incurs only one violation of Dep-H as opposed to the three violations of candidate (e).

The tableau in (16) is similar, but here only the last syllable is underspecified:

(16)

/kákàka/		*Ø	*HLH	*L#	Dep-H	Max-T	Dep-L
a.	kákàka	*!					
b.	kákàká		*!		*		
c.	kákàkà			*!			*
d.	kákáká				**!	*	
e. ☞	kàkàká				*	*	*

Candidate (a), which is fully faithful, is ruled out by *Ø. Any repair of the underspecified syllable alone violates an undominated constraint: *HLH in the case of candidate (b) and *L# in the case of candidate (c). Candidate (d) attempts to fix this by replacing the middle tone with H and inserting a H tone on the final syllable, but this incurs more violations of Dep-H than candidate (e), which instead replaces a H tone with L. Thus, the output of the two tableaux seen here are the same, despite very different inputs.

Running all 27 possible combinations of H, Ø, and L on trisyllabic words yielded only attested tone patterns in Tommo So: 6 HHH, 6 LHH, and 15 LLH. Interestingly, the preponderance of LLH compared with LHH is mirrored almost exactly in my lexicon, with 134 of 444 {LH} trisyllabic nouns having the distribution LHH. The low level of HHH words is not mirrored in the lexicon, however, and since the number 444 reflects token rather than type frequencies, we should approach this result with slight hesitation awaiting analysis of a larger corpus.

What about a real stem that undergoes epenthesis later? The following tableau shows the Level 1 output for underlying /àdǎd/ 'slight bitterness', leaving out constraints that do not play a role:

(17)

/àdǎd/		*Ø	*Contour…]$_w$	Dep-V	*L#	Max-C	*Coda	Max-T	*Contour-μ	*Move
a.	àdǎdu	*!	*	*					*	
b.	àdàdú			*!						*
c.	àdàd				*!			*		
d.	àdǎ					*!			*	
e.	àdád							*!		
f. ☞	àdǎd								*	

Candidate (a) fatally incurs violations of three undominated constraints. Candidate (b) resolves the contour, but it inserts a vowel, and is ruled out. Deleting a tone in either (c) or (e) is not optimal, since Max-T outranks *Contour-μ, and it results in a word-final L for candidate (c). Candidate (d) is ruled out, since Max-C is undominated. Thus, at this level, faithful candidate (f) wins.

A rich base input with a word-medial contour tone would also be repaired due to undominated *Contour…]$_w$. For example:

(18)

/kàáka/		*Ø	*Contour…]$_w$	Dep-H	Max-T	Dep-L	*Move
a.	kàáka	*!	*				
b.	kàaká	*!					*
c.	kàáká		*!	*			
d.	kààká			*!	*	*	
e. ☞	kààká					*	*

The faithful candidate (a) cannot surface, because it violates both *Ø and *CONTOUR...]$_w$. Candidate (b) moves the H tone from the second mora to the third, satisfying the constraint against contours, but it continues to violate *Ø. Candidate (c) inserts a H tone to resolve the underspecification, but it does nothing to resolve the contour. Candidates (d) and (e) are surface-identical, but they were arrived at by different means. For candidate (d), the H tone in the contour was deleted (MAX-T violation) and replaced by L (DEP-L violation), and a H was inserted on the final syllable (DEP-H violation). In winning candidate (e), on the other hand, no H was inserted. Instead, the tone was delinked from its position in the contour and relinked to the final syllable, in violation of lowly ranked *MOVE, then a L was inserted on the then empty second mora. Our grammar predicts this method of determining the tones, but functionally, the two candidates are equivalent.

6.2 Level 2: epenthesis and human suffixes

While the outputs from Level 1 are fully specified, underspecification is not repaired at Level 2. This means that *Ø must move down in the ranking, crucially below DEP-H and DEP-L, which we may collapse under the heading DEP-T, since no new tones are added at this stage in the derivation. In fact, *Ø seems to have no effect at all at this stage, so I leave it out of the tableaux here, assuming it to be in the bottom tier of constraints.[15] Similarly, no tones may be deleted either, which is ensured by undominated MAX-T. Essentially, the number of tones provided by the output of Level 1 remains fixed through all subsequent levels.

At this stage, epenthesis may occur. This is mandatory after an obstruent coda,

[15]In a weighted constraint theory, it would have a weight of 0.

but optional after a sonorant coda, which indicates the need to split up the original *CODA constraint into *CODA-OBS, abbreviated *CODAO, and more general *CODA. Consistent with cross-linguistic patterns, the former is ranked higher than the latter. The optionality of epenthesis with sonorant codas can be broadly captured here by placing DEP-V on the same tier as *CODA. If we can determine the exact proportion of epenthesis to sonorant-codas in a spoken corpus, we could model this variation in a weight-based framework, such as Harmonic Grammar (Legendre et al. 1990), though any such weight-based probabilistic grammar would work (Noisy Harmonic Grammar, Boersma and Pater 2008; Maximum Entropy Grammar, Goldwater and Johnson 2003; Stochastic Optimality Theory, Boersma 1997, Boersma and Hayes 2001). In the interest of space, I leave this modeling to future work.

As with Level 1, Level 2 must continue to preserve tone crowding in words like /nɔ̌/ 'this' so that they may be repaired by tone shift at the post-lexical level when clitics are added.[16] Therefore, MAX-T must continue to be ranked above *CONTOUR-μ at this level. I assume in all tableaux presented here that DEP-μ, or any other constraint against lengthening the vowel to relieve crowding, is undominated until the post-lexical grammar.

The ranking for Level 2 is thus as follows:[17]

(19) *CONTOUR...$]_w$, *CODAO, DEP-T, MAX-T >> *CODA, DEP-V, *CONTOUR-μ >> *MOVE

[16] I assume vowel epenthesis is not a valid repair here, due to a constraint against vowel hiatus. CV epenthesis is similarly ruled out by undominated DEP-C.

[17] Since the output of Level 1 will never contain a final L nor a HLH sequence, and since Level 2 cannot add or delete tones, it is unnecessary to include the constraint *L# and *HLH at this level, though in principle they continue to be undominated for native words.

Let us look at a few tableaux for this level. First, let us pass the output of Level 1 [àdǎd] 'bitter' through Level 2. MAX-C continues to be undominated, and I leave out here candidates violating this constraint:

(20)

	/àdǎd/	*CONTOUR...$]_w$	*CODAO	DEP-T	MAX-T	*CODA	DEP-V	*CONTOUR-μ	*MOVE
a.	àdǎdú	*!		*			*	*	
b.	àdǎdu	*!					*	*	
c.	àdád		*!		*	*			
d.	àdǎd		*!			*		*	
e. ☞	àdàdú						*		*

Candidates (a) and (b) are ruled out due to their violations of *CONTOUR...$]_w$. Candidate (c) violates undominated *CODAO, in addition to MAX-T, and is eliminated. Faithful candidate (d) is also ruled out by *CODAO, but incurs a violation of *CONTOUR-μ rather than MAX-T. These candidates also violate more general *CODA, but this has no effect. Finally, candidate (e), with epenthesis and contour tone redistribution, is the optimal output.

The tableau in (21) shows how sonorant codas may optionally be repaired by epenthesis. It also shows how underspecification may result from epenthesis, but one should keep in mind that if the input contains a contour tone rather than a level one, the tones will be redistributed to relieve crowding when the consonant no longer serves as a coda, and the epenthesized vowel will be specified (as in /yǐm/ 'death' → [yǐm] ∼ [yìmú]). I have left out *CODAO, Max-T, and *CONTOUR-μ, since they play no role.

(21)

/bán/	Dep-T	*Coda	Dep-V	*Move
a. bánú	*!		*	
b. banú			*	*!
c. ☞ bán		*		
d. ☞ bánu			*	

Both candidate (c) and (d) are selected as optimal, since Dep-V and *Coda are unranked with respect to one another. The fully specified option (a) is ruled out, since Dep-T is undominated, and candidate (b) is ruled out due to a spurious tone shift.

Tone shift and specification is predicted for crowded stems when a toneless suffix is added. In fact, it is doubly predicted, in that even stems with a non-crowded contour that becomes word-medial with the addition of a suffix will be forced to redistribute (see the next tableau). This tableau gives the derivation for /ɔ̀gɔ̌+nɔ/ 'chief'. As before, unused constraints are not included.

(22)

/ɔ̀gɔ̌+nɔ/	*Contour...]$_w$	Dep-T	Max-T	*Contour-μ	*Move
a. ɔ̀gɔ̌nɔ́	*!	*		*	
b. ɔ̀gɔ̌nɔ	*!			*	
c. ɔ̀gɔ́nɔ			*!		
d. ☞ ɔ̀gɔ̀nɔ́					*

A stem with a final contour will be forced to redistribute the tones at this level when a suffix is added, due to *Contour...]$_w$. Because Dep-T and Max-T are undominated, this results in underspecification on the stem itself:

(23)

/yàá+na/		*CONTOUR...]$_w$	DEP-T	MAX-T	*MOVE
a.	yàáná	*!	*		
b.	yàána	*!			
c.	yààná		*!		*
d.	yàana			*!	
e. ☞	yàaná				*

A tonally underspecified suffix added to a stem with no contour tones on the stem will remain underspecified, since there is nothing to motivate tone spread onto the suffix and DEP-T is undominated. This ensures that words like /bàlíɛ́+nɛ/ will surface faithfully as [bàlíɛ́nɛ] (see Figure 15a).

6.3 Level 3: clitics and postlexical phonology

Levels 1 and 2 so far account for everything except enclitics and stems with tone crowding but no affixes or epenthesis with which to repair it. Both issues are resolved at Level 3, which I assume to be the postlexical level, since clitics are added here.

The ranking is similar to that of Level 2, with a couple of exceptions. First, since lexical tone crowding is never seen on the surface level, it must be ruled out at Level 3.[18] This means that *CONTOUR-μ must be undominated. Since contours on heavy syllables are not repaired with the addition of a clitic, we can posit either that

[18]Examination of pitch tracks shows that grammatically controlled overlays, such as the {HL} overlay associated with certain possessive constructions, may in fact impose a falling tone on a short syllable. This indicates the need for another level, but since grammatical tone is outside of the scope of this paper, I will not present such a level here.

there is a phonological word boundary between the stem+suffixes and a clitic, or that *CONTOUR...$]_w$ has been demoted. I will assume the former–that clitics are not as closely connected to the stem as suffixes, and hence contour tones before a clitic are not considered word-medial. Thus, *CONTOUR...$]_w$ can also remain undominated at this level.

Level 2 will have already ruled out all candidates with obstruent codas, so even if *CODAO is still undominated, it will not be active and hence I omit it at this level. DEP-T continues to be undominated, but here MAX-T must be crucially dominated by *CONTOUR-μ, since tone deletion is attested as a repair for crowding. For sub-minimal roots like /nɔ̌/ 'this', lengthening may be used as a repair for crowding, but this is unattested for roots that meet the bimoraic minimality requirement. I will discuss this case below. To keep most roots from lengthening, DEP-μ must be ranked above MAX-T.

The ranking for Level 3 is as follows:

(24) *CONTOUR...$]_w$, *CONTOUR-μ, DEP-T >> DEP-μ >> *CODA, DEP-V, MAX-T >> *MOVE

I have included *CODA and DEP-V in the ranking again, since presumably outputs of Level 2 that allowed sonorant codas could once again either be repaired by epenthesis or allowed to stand. I will not demonstrate any such cases here.

Consider first the surface form of underlying /ɔ̀gɔ̌/ 'chiefdom' if it takes no suffix in Level 2:

(25)

/ɔ̀gɔ̌/	*Contour-μ	Dep-T	Dep-μ	Max-T	*Move
a. ɔ̀gɔ̌	*!				
b. ɔ̀gɔ̀ɔ́			*!		
c. ☞ ɔ̀gɔ́				*	

Here at Level 3, the tone crowding on the final syllable is repaired by deleting the L tone (note that deleting the H would violate *L#), rather than by lengthening the final vowel, as in candidate (b).

The crowded subminimal demonstrative is more problematic. I mentioned in section 4.4 that the crowding on /nɔ̌/ 'this' can either be repaired by lengthening the vowel, deleting the L tone, or some combination of each. I leave the question of halfway violations for a later time, as these require new representations for phonetically gradient outputs. Even the variation between categorical repairs (deletion or lengthening) is difficult to capture in a theory of strict ranking. The problem is easy to solve, however, in a weight-driven theory of constraints like Harmonic Grammar, where the combined weight of Minimality and Max-T would equal the weight of Dep-μ. In the case of 'chiefdom', Minimality would not be violated, so the balance tips towards Dep-μ and candidates violating this constraint are ruled out. For the demonstrative, however, a tone-deleting, subminimal candidate [nɔ́] would incur the same amount of violation as a non-deleting, lengthening candidate [nɔ̀ɔ́], and so the two could be in free variation.

If a clitic is added and there is no tone crowding, as in /íí=gɛ/ 'the child', underspecification will result:

(26)

/ı́ı́=gɛ/	*Contour-μ	Dep-T	Dep-μ	Max-T	*Move
a. ı́ı́=gɛ́		*!			
b. ı́ı́=gɛ̀		*!			
c. ☞ ı́ı́=gɛ					

No matter what tone is inserted, it violates Dep-T. The faithful candidate (c) would violate only the extremely low-ranked *Ø constraint, and underspecification of the enclitic is optimal.

As in Level 2, if a clitic is added to a crowded stem, we will see tone shift and specification of the clitic, as in:

(27)

/nɔ̌=mbe/	*Contour...]$_w$	*Contour-μ	Dep-μ	Max-T	*Move
a. nɔ̌=mbe		*!			
b. nɔ̀ɔ́=mbe			*!		
c. nɔ́=mbe				*!	
d. ☞ nɔ̀=mbé					*

Faithful candidate (a) is ruled out due to a violation of *Contour-μ. Candidate (b) repairs this, but in doing so violates Dep-μ. Candidate (c)'s repair, L-deletion, violates Max-T, which is more highly ranked than *Move, so candidate (d) is optimal.

Note that when the stem contour is not on a single mora, the contour is not redistributed:

(28)

/nàá=mbe/		*CONTOUR...]$_w$	*CONTOUR-μ	DEP-μ	MAX-T	*MOVE
a.	nàa=mbé					*!
b. ☞	nàá=mbe					

The faithful candidate (b) would incur only violations of very low-ranked constraints like *Ø.

6.4 Stratal OT summary

The level-ordered grammar presented here is split into three levels. Level 1 deals only with stems and ensures that all outputs are fully specified for tone. However, this level does not repair underlying ungrammatical elements like tone crowding on a light syllable or codas, unless the crowded tones can be more evenly distributed over the TBUs. In Level 2, the toneless human suffixes are added, but these are allowed to remain underspecified, since *Ø has been demoted to the bottom of the grammar. Also at this level, obstruent codas are obligatorily repaired by epenthesis, and sonorant codas optionally so. Here too tone crowding will be repaired if there are enough TBUs, but if not, it is allowed to persist into Level 3. At this level, clitics are added, and these may also be underspecified for tone due to DEP-T ranked at the top of the grammar and *Ø at the bottom. Tone shift will occur if there is crowding on the stem and an underspecified enclitic, but not if the output of Level 2 (stem+suffixes) ends in a contour tone. In the absence of an enclitic, crowding is repaired by tone deletion for words that meet the bimoraic minimality requirement, and by either tone deletion or vowel lengthening for subminimal words. The latter can be achieved in a weight-based grammar by having the sum of the weights of

MAX-T and MINIMALITY equal that of DEP-μ.

One might try and argue for a single level grammar, with underspecification constrained to suffixes and enclitics by constraints indexed to morphological category like "stem". However, the existence of underspecification on stems caused by tone shift (as in [yàaná] 'woman') makes it impossible to argue for such a strategy. Furthermore, the lack of harmony on epenthetic vowels argues for different levels subject to different phonotactic constraints. Elsewhere in the language, derivational suffixes and inflectional suffixes behave differently with regards to vowel harmony, confirming the need for levels; this topic will be explored further in future research.

7 Weak target analysis

In the analysis I have presented, enclitics, human suffixes and epenthetic vowels are underlyingly, and often surface, underspecified for tone. As the pitch tracks and semitone measurements have shown, these Ø tones are not the same as either L or H, and their surface realizations are entirely predictable based on context. If underspecification is not repaired by tone shift, then these syllables surface with an F0 contour that results from linear interpolation between specified lexical or boundary tones on either side.

This is not, however, the only possibility. We could propose that rather than having no tonal specification of their own, these so-called "toneless" elements actually have a weak tone target. This is the analysis pursued by Chen and Xu (2006) for the Mandarin neutral tone, which has been argued by others to be toneless (Shih 1987) or even L (Lin 2006). Chen and Xu note that rather than showing pure interpolation between the offset of the preceding tone and the onset of the following one, neutral tones tend to turn away from the path of interpolation towards a latent mid target (see Figure 18). This becomes more and more apparent with longer strings of neutral tones. The authors argue that this indicates the presence of a weak mid tone specification that is slower to take effect than full tone targets and more susceptible to variation based on context.

They implement this weak target in a target approximation model (Xu 2005, Xu and Wang 2001), wherein to produce any tone, a speaker has an articulatory goal that must be achieved within a specifiable window of time. The strength of this goal is also specifiable, and thus the model can differentiate between strong goals (the "specified" tones of Chinese) and weak goals (the neutral tone).

The question to consider is whether this sort of latent target analysis could work for Tommo So. That is, does what we have been calling the Ø tone actually have an articulatory target, and if so, what is it? In the interpolations we have seen, the F0 during a Ø tone either stays level (disregarding declination) or falls. This suggests that if a weak target were to exist, we would want to call it L rather than H. But a number of factors point to true underspecification for these elements rather than a weak target analysis.

First, the target approximation model predicts that if an element is shorter, it will have less time to attain its target. This hypothesis is upheld in Mandarin, with neutral tones usually half as long as full-toned syllables (Lin and Yan 1980, as cited by Chen and Xu 2006), and much less likely to reach their tonal targets. In Tommo So, on the other hand, underspecified syllables are no shorter than specified short vowels, and yet speakers have no problem hitting tonal targets on these specified short vowels. Furthermore, interpolation causes far greater F0 movement on underspecified syllables than is normally allowed on such light syllables, where contours are disallowed. Thus, if speakers are able to modulate their pitch so drastically in a short period of time, they ought to have no problem reaching a target if the vowel is specified for one.

One could argue that the issue at hand is one of target realization, not simply the ability to change pitch during a short period of time. If a target were specified as strong, the articulators would carry out the command to reach it quickly, whereas if it were weak, it would take more time for the articulation to be activated. If this were the case, then we might expect a longer series of toneless elements to flatten out towards L as the target is given a wider window in which to be articulated. Yet even in strings of three consecutive underspecified elements, the interpolation remains linear, as shown in Figure 7. No L target for the underspecified elements becomes apparent.

Next there is the issue of tone shift. Here, underspecified elements may become specified as a tone is reassigned from a preceding crowded syllable. If the allegedly toneless elements do in fact carry a tonal specification, what becomes of it when a "stronger" tone shifts? Presumably it deletes, since the grammar would impose a hierarchy wherein the deletion of a strong tone incurs more penalty than the deletion of a weak tone. Nonetheless, with the Ø tone weakly specified, tone shift loses some degree of naturalness as a fix for tone crowding, since the Ø tone is no longer an empty landing spot.

If there were a latent L target for underspecified elements, we might expect the sequence HØH to also show automatic downstep on the second H. To test this, I calculated the number of semitones between the initial and final H tones in the sequences HHH, HØH, and HLH. The results are as follows:

(29) *Distance between the initial and final H tones in HHH, HØH, and HLH*

	Mean Δ semitones	# of tokens
HHH	1.51	12
HØH	1.34	22
HLH	2.98	21

There is no statistical difference between the H tones in HHH and HØH, in contrast with the Hs in HLH, which is significantly different from both others at $p < .0001$. This strongly suggests that there is no covert L.

Finally, there is the question of learnability. Nothing in the data we have thus far indicates the existence of a weak L target. It would be easier for a learner to simply posit that there is no tone inherent to Ø syllables, rather than a very weak one that plays only a small role. Without this weak target, the tone system would also not need to both with specifying the strength of tonal targets. Tone would either exist or not exist. In Mandarin, learners need some explanation as to why interpolation is not linear, and so they are driven to other explanatory means, such as varying strengths of articulation.

Of course, if we were able to see recordings where the expected interpolation is a rise from L to H and instead we find a flat interpolation as if from L to L, then we may need to reconsider this weak target proposal. Remember that the difference between a rising and a flat interpolation would be subtle, since the words involved must be contained within a single ϕ-phrase; the fact that there are no entirely L words means that there must also be a H preceding the L within the phrase, resulting in automatic downstep of the final H. Say we had a phrase *sɔ́lɔ́gɔ̀-nɛ yɛ́-dɛ̀-m* 'I will see a Bozo'. The H on *yɛ́* will be barely higher than the L on *gɔ̀*, leaving not much pitch distance for the underspecified human suffix *-nɛ* to rise. Nevertheless, careful measurement of a large number of tokens could distinguish between the two possibilities, allowing us to either accept or reject the weak target proposal with confidence.

8 Conclusion

In this thesis, I have demonstrated that Tommo So has a three-way tonal contrast of H, L and Ø, and this contrast persists all the way to the surface. The surface form of Ø is entirely predictable based on context, as it is assigned an F0 contour by interpolation between the preceding and following specified tones. Both lexical and boundary tones are able to serve as endpoints of interpolation.[19]

Unlike in Chichewa, underspecification in Tommo So is grammatically restricted to suffixes, clitics, and epenthesized vowels–namely, elements that are added after Level 1 in a stratified grammar. This tonal distribution falls in line with the typology of stress on grammatical elements. Consider first clitics. Almost definitionally, clitics do not bear stress, and if they do, it is often secondary (Aikhenvald 2002). In some languages, stress assignment shows cyclicity with regards to clitics, with stress first being assigned to the stem, then to the clitic group (Brame 1974 on Palestinian Arabic, Hayes 1995 on Central Alaskan Yupik). At the end of the derivation, the stem ends up with the highest prosodic prominence. It is thus unsurprising that if some element would fail to bear tone in a language like Tommo So, it would be a clitic.

Similarly, the unstressed nature of epenthetic vowels is well-attested in many languages. A case that has received a great deal of attention is that found in various Ara-

[19] Left-edges of phrases have no phonological effect in Tommo So, and we have no underspecified proclitics or prefixes, so we have no evidence of a boundary serving as the beginning point of interpolation.

bic dialects. For example, in Palestinian Arabic (Brame 1974, Kager 1999, Kiparsky 2000), there is an opaque interaction of stress and epenthesis, wherein a heavy syllable that would normally receive stress does not when the vowel is epenthetic. The epenthetic vowel /i/ otherwise looks like a normal, lexical /i/. Likewise, epenthesis in Tommo So does not partake in tone unless it has to due to tone crowding in the stem, but it differs from the Arabic case in that Tommo So epenthetic /u/ is further differentiated from non-epenthetic vowels due its lack of harmony with the stem.

Finally, the typological similarities with suffixes and stress are just as clear. In many languages, at least some affixes fall outside of the domain of stress assignment (Hayes 1995). For example, Level 2 suffixes in English are added after primary stress assignment and thus they behave as extrametrical (Kiparsky 1982). In Persian, derivational suffixes often are stressed, while inflectional ones do not (Kahnemuyipour 2003). Thus, the fact that nominal suffixes in Tommo So do not receive prosodic prominence (in the form of tone) is unsurprising, nor is the fact that other suffixes in the language (specifically verbal) do have tone; suffixes may pattern either way.

As I have demonstrated in this paper, a ternary tone distinction of H vs. L vs. Ø is not only possible but attested with a typologically sensible distribution in Tommo So. This is a language that obeys the usual rules of phonetic tone realization, so the fact that tonal underspecification can exist here suggests that its existence may be lurking in many other African languages as well, as Myers (1998) has also demonstrated. The scope of tonal documentation needs to expand from simple phonological analysis to including a close phonetic analysis as well to determine how widespread surface underspecification is and what patterns emerge of its distribution within a given language's grammar.

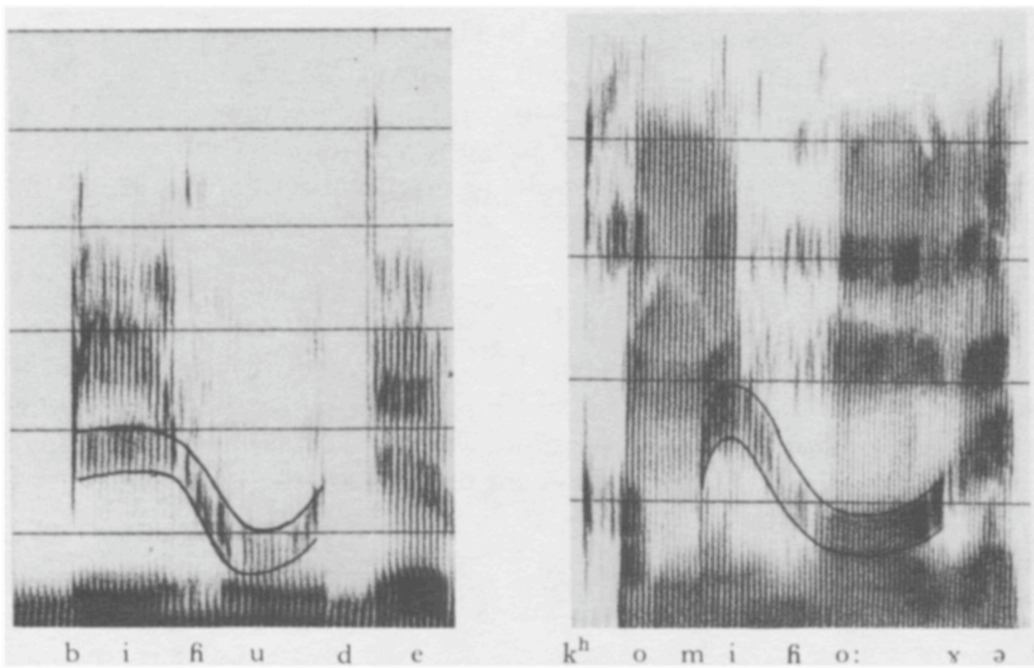


Figure 1: Examples of the interpolation of intervocalic /h/ in Farsi *bihude* 'useless' and Swedish *komihåg att* 'remember to do something', taken from Keating (1988:283), copyright © 1988 Cambridge University Press. Reprinted with the permission of Cambridge University Press.

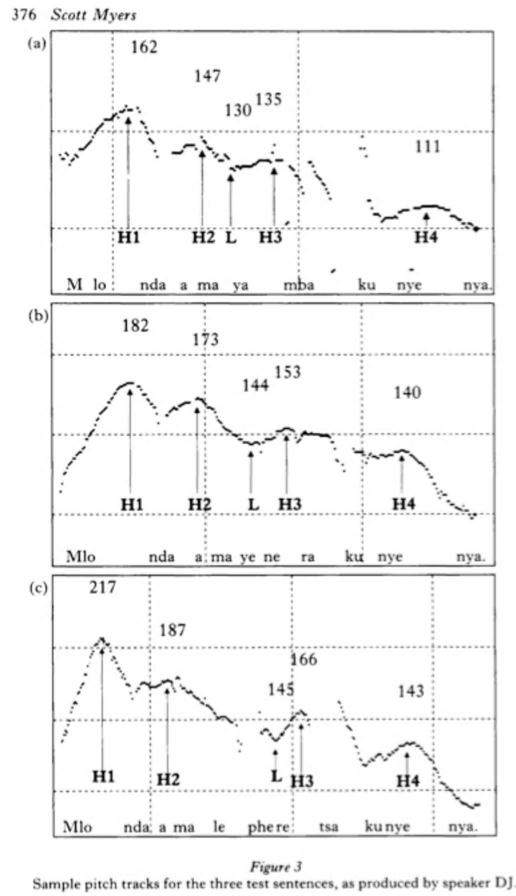
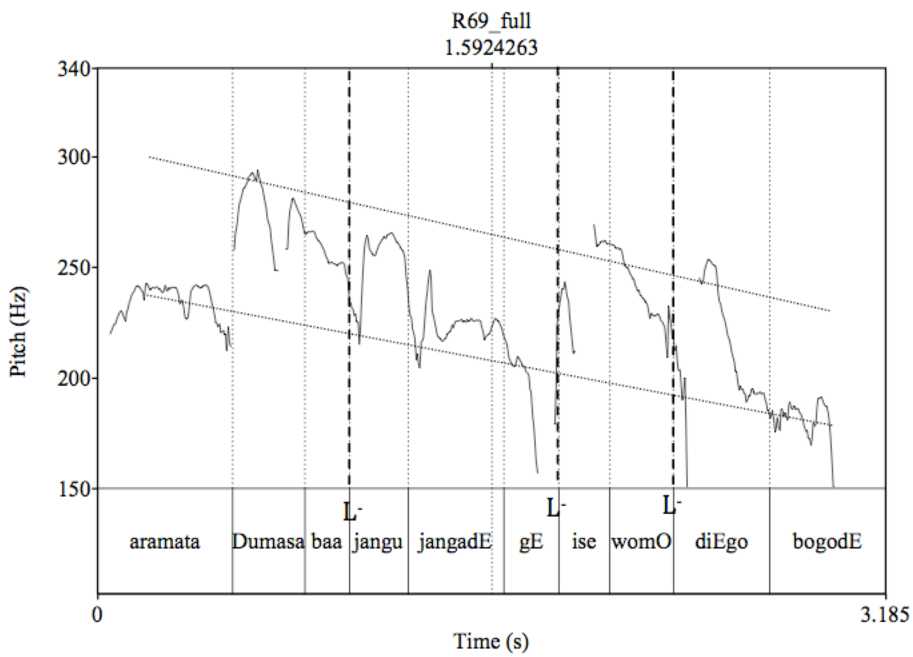


Figure 2: Sample pitch tracks of (a) one syllable between H2 and H3, (b) two syllables between H2 and H3, and (c) three syllables between H2 and H3 (Myers 1998:376), copyright © 1998 Cambridge University Press. Reprinted with the permission of Cambridge University Press.



[àràmàtà Dúmásá = baa][jáŋgú jàŋgá-dɛ́ = gɛ][ìsé wó = mɔ][dîɛ̀-gò bógò-dɛ̀]

'Ramata who studies in Douentza, her dog barks a lot.'

Figure 3: A single I-phrase consisting of four ϕ-phrases, separated by dotted lines.

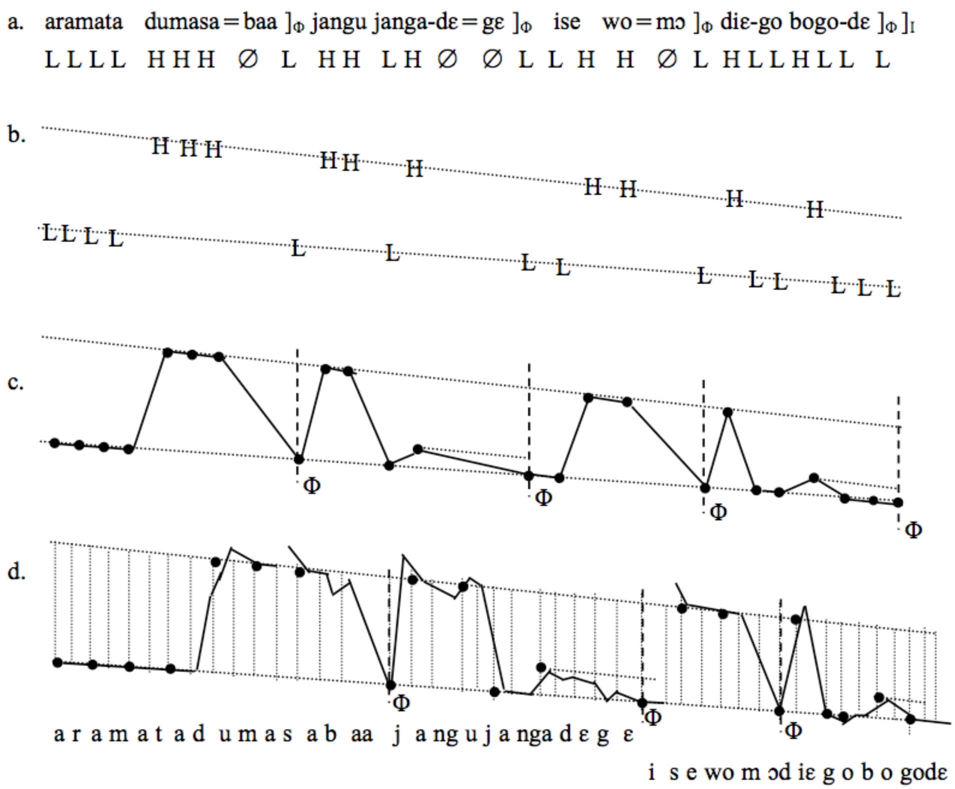
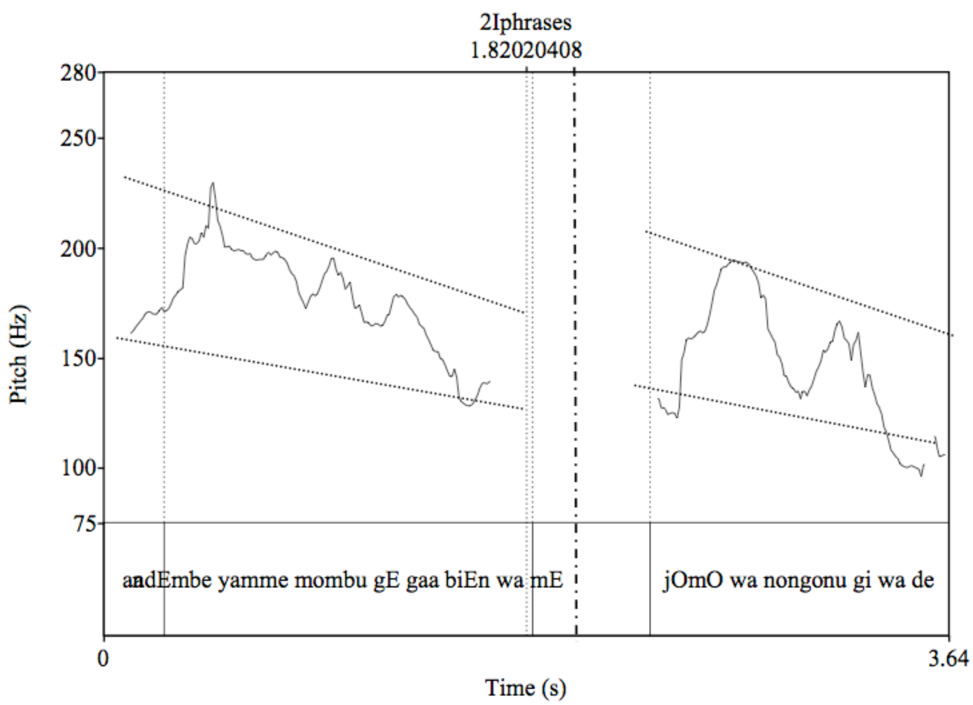


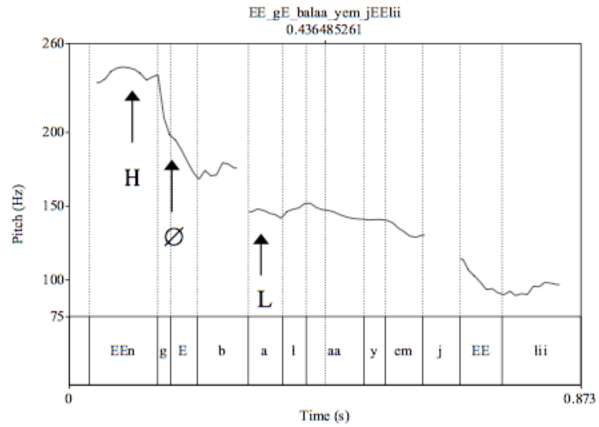
Figure 4: (a) The phonological specifications of the sentence in Figure 3, (b) phonological targets mapped onto declination guidelines, (c) targets connect with downdrift imposed, (d) F0 realization with segmental effects.



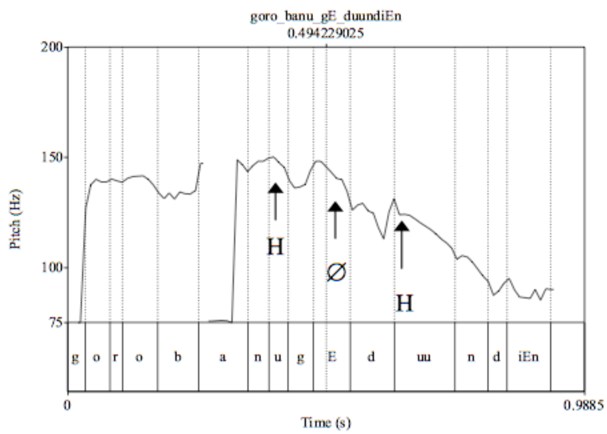
[Àà, ǹdɛ́mbé yàmmé mómbú = gɛ gàà bí-ɛ̀^{n} wa mɛ̀,]$_{I}$ [jɔ̀mɔ́ wa nɔ̀ŋ-gó-nṵ́ gì wà dè.]$_{I}$

'[They said], ah, they had met the other day, but Hare had said like that (that it wasn't good).'

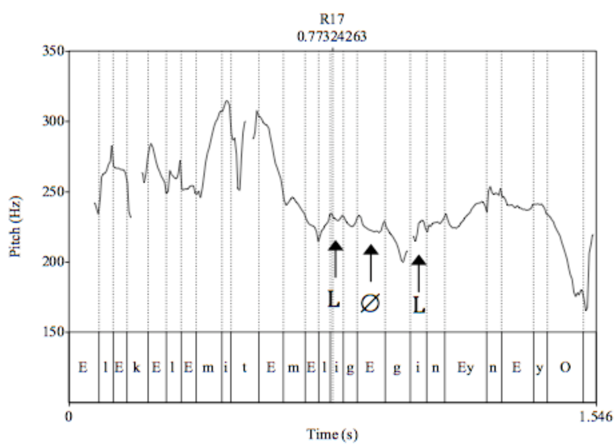
Figure 5: An example of declination reset after an I-phrase boundary.



a. SO: [ɛ́ɛ́^{n}=gɛ bàláá][yém jɛ̂ɛ̀lìì] ‘she swept up the ashes and brought them like that’

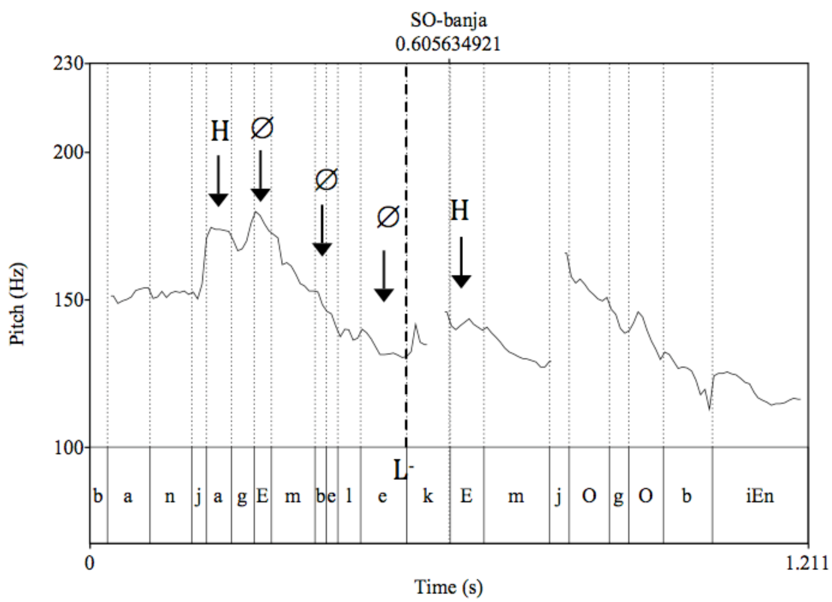


b. EO: gòrò bánú=gɛ dúùndìɛ̀^{n} ‘they put down the red hat’



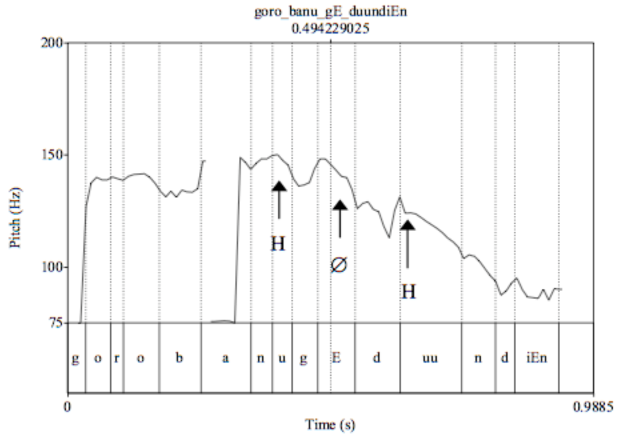
c. RO: [ɛ̀lɛ̀kɛ̀lɛ̀][mí tɛ́mɛ̀-lì=gɛ][gìnɛ̀-ý=nɛ yɔ̂] ‘the peanuts I didn’t eat are in the house’

Figure 6: Sample pitch tracks of the definite *gɛ* in the contexts (a) H__L, (b) H__H, and (c) L__L.

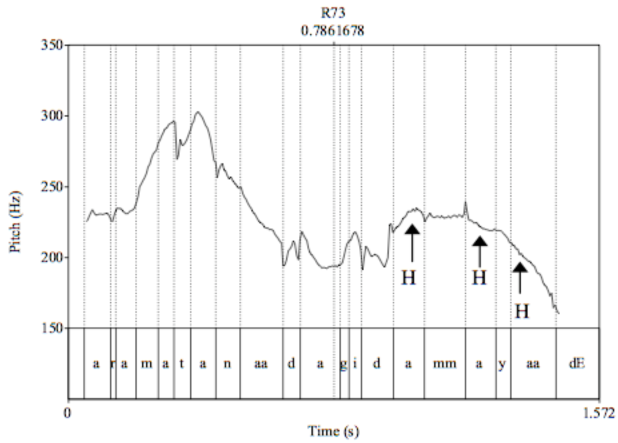


MM: [bànjá = gɛ = mbe = le][kɛ́m][jɔ́gɔ̀ bì-ɛ̀^{n}] ‘and they used to break all of the bowls’

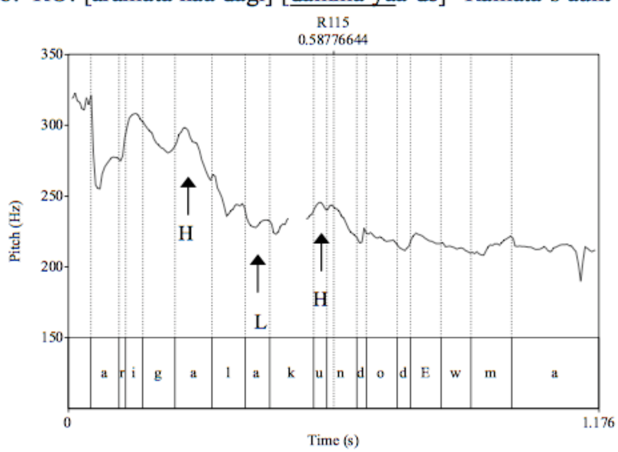
Figure 7: Sample pitch track of HØØØ]H.



a. EO: gòrò bánú = gɛ dúùndìè^{n} ‘they put down the red hat’

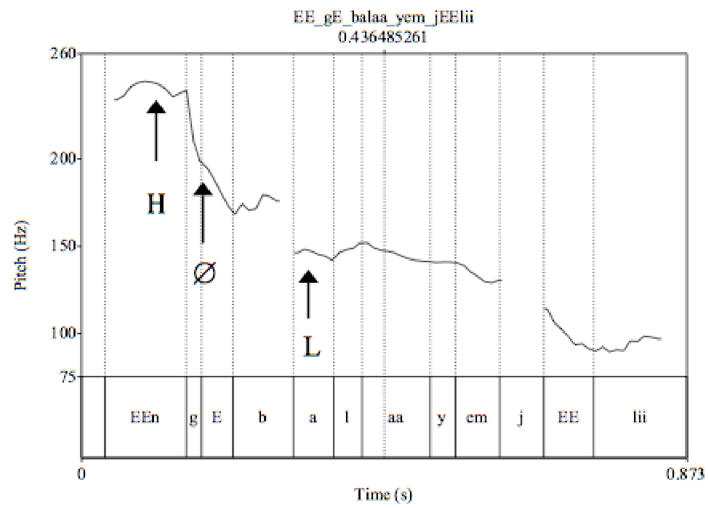


b. RO: [àràmátâ náà dàgì] [dámmá yáà-dè] ‘Ramata’s aunt will go to her village’

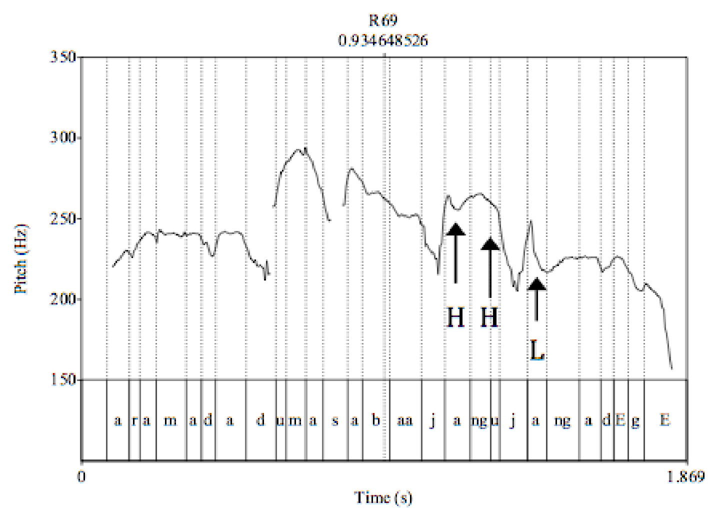


c. RO: [árígálà kúndò-dè-w mà] ‘Will you wear a boubou?’

Figure 8: Sample pitch tracks of (a) HØH (b) HHH (c) HLH

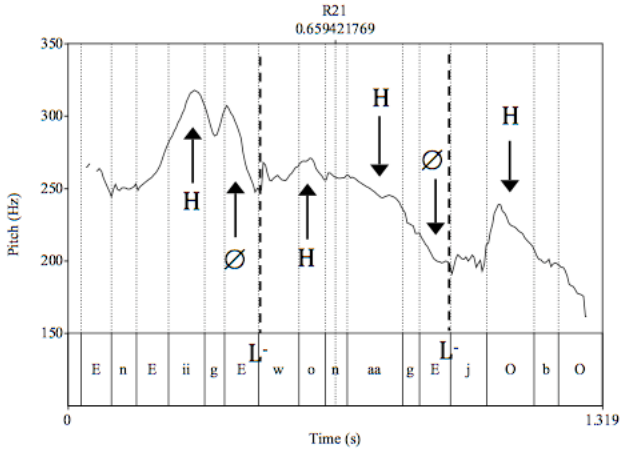


a. SO: [ɛ́ɛ́ⁿ = gɛ bàláá][yém jɛ́ɛ̀lìì] 'she swept up the ashes and brought them like that'

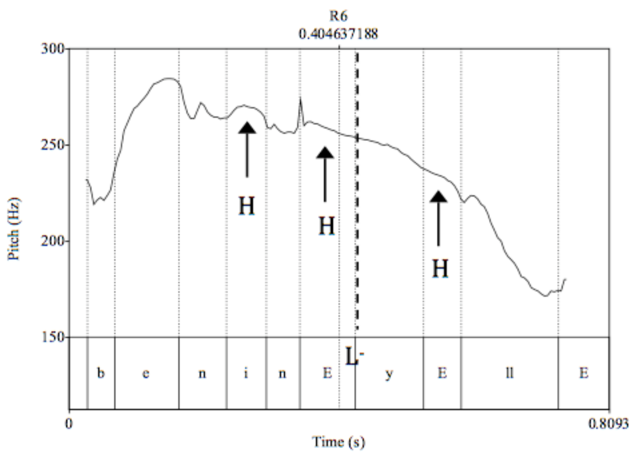


b. RO: [àràmàdà dúmásá = baa][jáŋgú jàŋgá-dɛ́ = gɛ] 'Ramata, who studies in Douentza…'

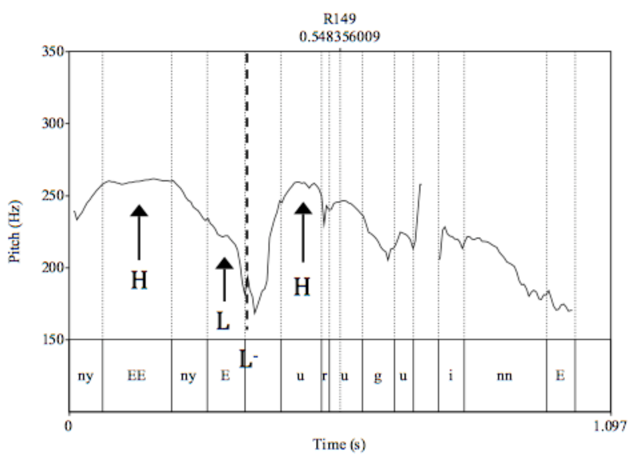
Figure 9: Sample pitch tracks of (a) HØL and (b) HH L.



a. RO: [ɛ̀nɛ̀ íí=gɛ][wó náá=gɛ][jɔ́bɔ̀-dɛ̀] 'the little goat's mother will run'

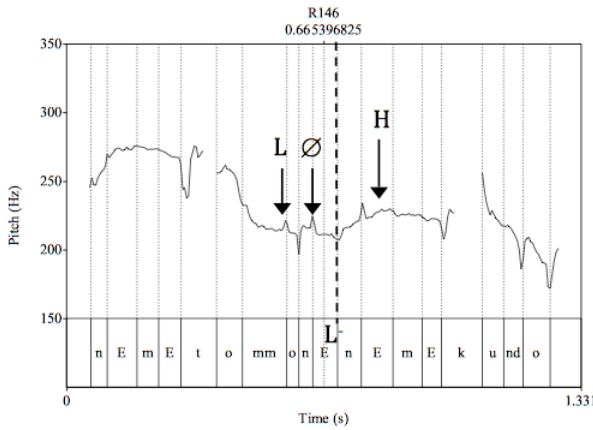


b. RO: [bé nínɛ́][yɛ́llɛ̀] 'their aunt will come'

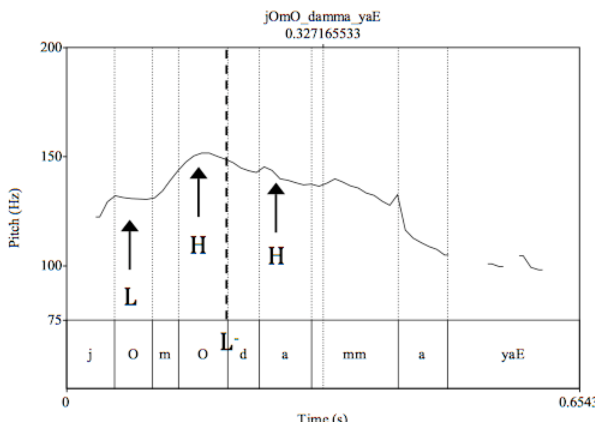


c. RO: [ɲɛ́ɛ́ɲɛ̀][úrúgù ínnɛ̀] 'the beggar doesn't know how to pray'

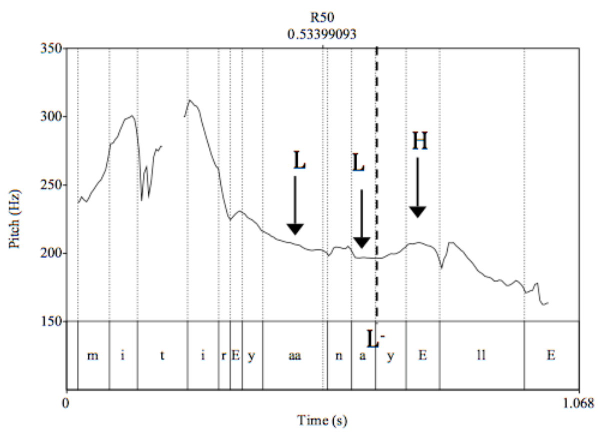
Figure 10: Sample pitch tracks of (a) [H∅]H, (b) [HH]H, and (c) [HL]H.



a. RO: [némé tómmò = nɛ][némé kúndó] ‘put trash in the trash basket’



b. SO: [jɔ̀mɔ́][dámmá yàè] ‘Hare had gone to his village’



c. RO: [mí tírè yàà-nà][yɛ́llɛ̀] ‘my grandmother will come’

Figure 11: Sample pitch tracks of (a) [LØ]H, (b) [LH]H, and (c) [LL]H.

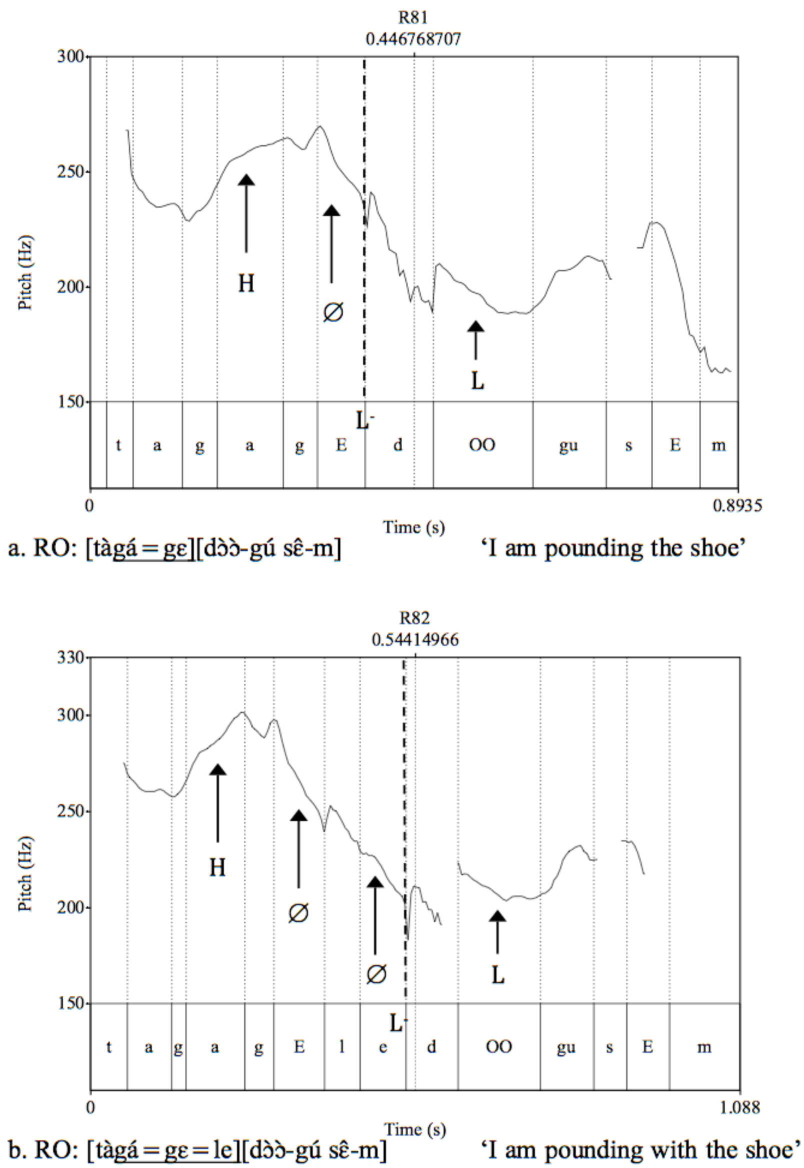


Figure 12: Sample pitch tracks of (a) [HØ]L and (b) [HØØ]L.

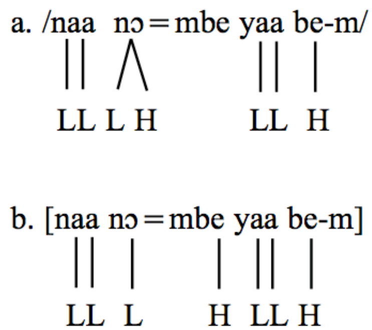
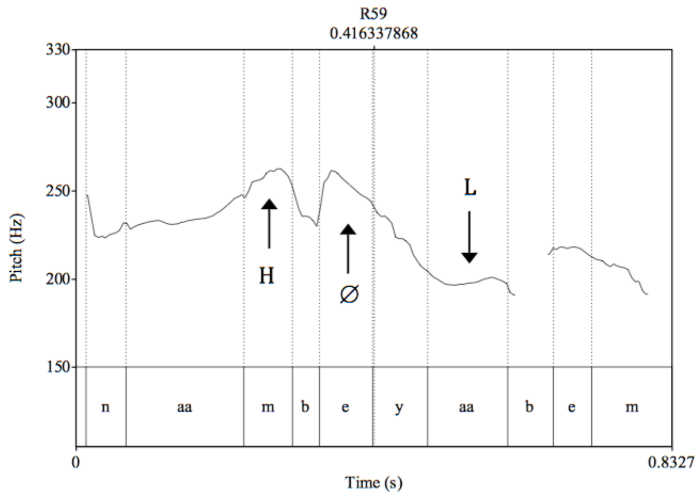
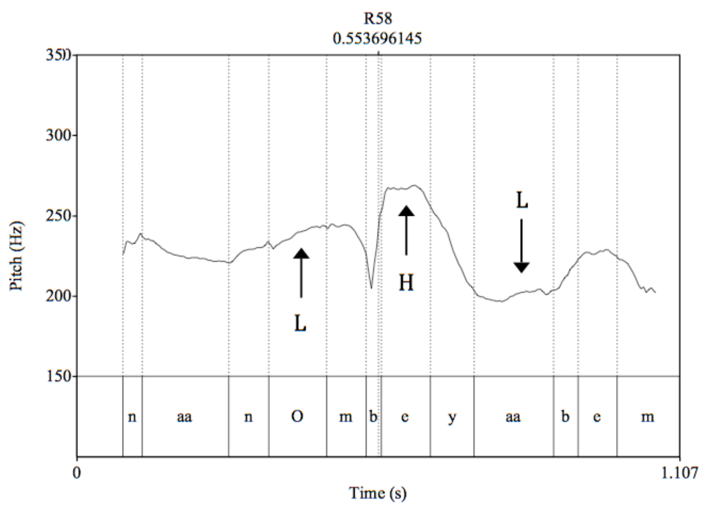


Figure 13: Reassigning a tone from a crowded syllable to a toneless one.

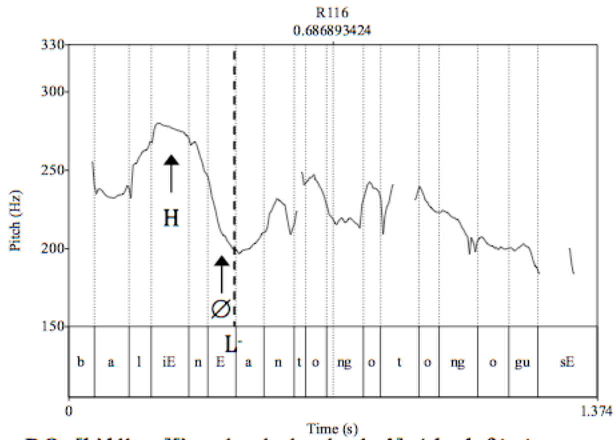


a. RO: [nàá=m̩be yàà bé-m] ‘I saw cows’

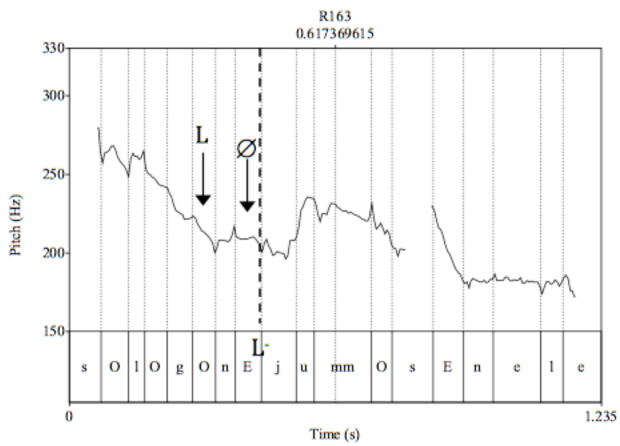


b. RO: [nàà nɔ̀=mbé yàà bé-m] ‘I saw those cows’

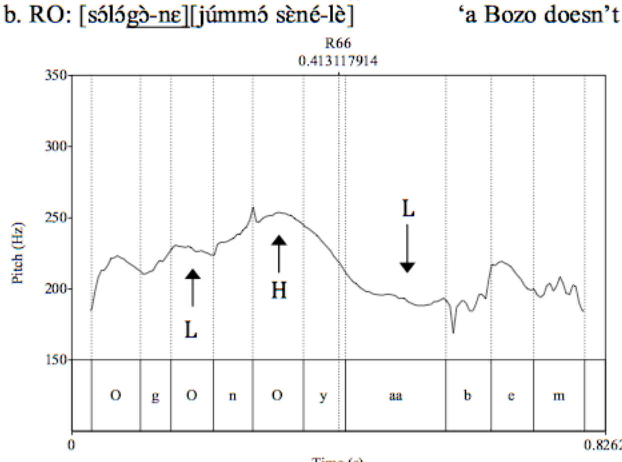
Figure 14: Sample pitch track of RØL and LHL as the result of tone shift.



a. RO: [bàlíɛ́-nɛ][àn-tóŋgó tóŋgó-gú sɛ̂] ‘the leftie is not pounding broken millet stalks’



b. RO: [sɔ́lɔ́gɔ̀-nɛ][júmmɔ́ sɛ̀né-lè] ‘a Bozo doesn’t do the Friday prayer’



c. RO: [ɔ̀gɔ̀-nɔ́ yàà bé-m] ‘I saw a chief’

Figure 15: Human suffixes in the contexts (a) H_], (b) L_], and (c) specified to H by tone shift.

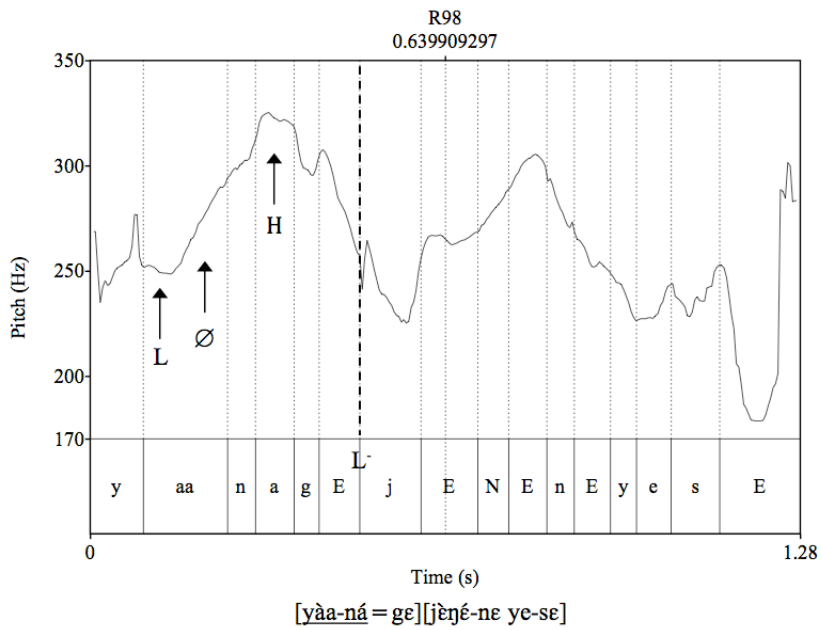
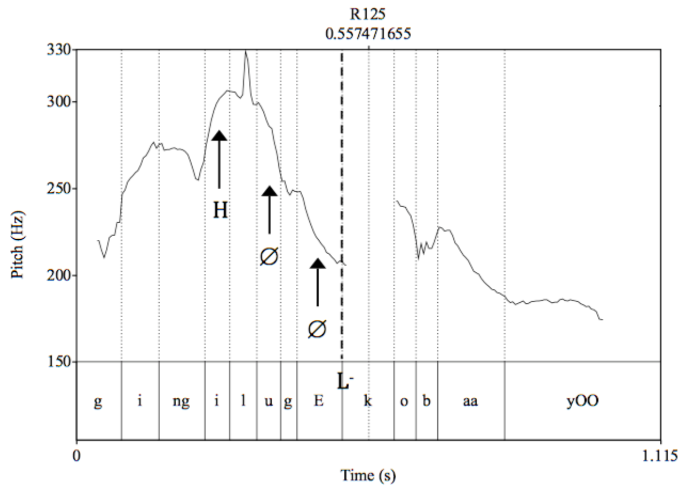
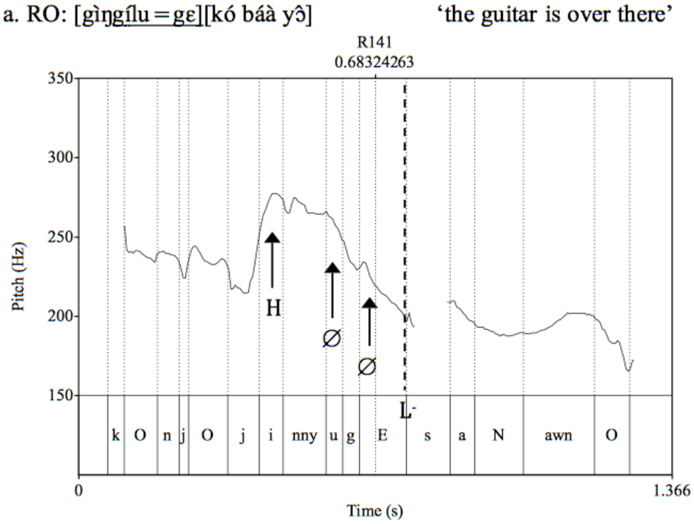


Figure 16: An underspecified stem vowel caused by the resolution of a word-medial contour tone by tone shift.



a. RO: [gìŋgílu = gɛ][kó báà yɔ̂] ‘the guitar is over there’



b. RO: [kɔ̀ɲjɔ̀ jíɲɲu = gɛ][sàŋǎm wɔ̂] ‘the smell of beer is sour’

Figure 17: Epenthetic vowels followed by the definite enclitic between H and a ϕ-phrase boundary.

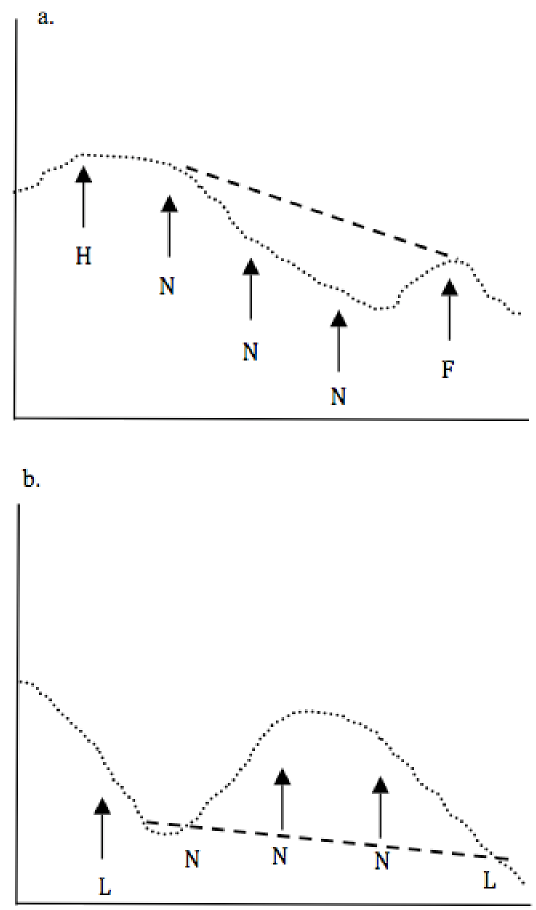


Figure 18: Schematic example of three neutral tones in Mandarin flanked by (a) H and F and (b) two Ls. The dotted line represents the actual F0 found by Chen and Xu (2006), the dashed line what interpolation would look like.

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