TONAL NONITERATIVITY

4.1 Tone Spreading and Shifting

There are many claims for many languages to the effect that a tone spreads or moves by one syllable, typically to the right (Hyman & Schuh 1974). To pick just one example, Myers (1987) uses both iterative and noniterative rules to account for various tone spread phenomena in Shona. As Kisseberth (2007:663) states in his recent review of Yip (2002), "the proper way to get at [noniterative tone shift] is a significant issue in OT." A completely satisfactory account of such phenomena within OT has so far eluded phonologists. This chapter adds to research in this area by building on the reasoning that motivates this dissertation as a whole.[1]

If, as I have argued in previous chapters, the appearance of noniterativity elsewhere in phonology is the result of factors that do not explicitly call for noniterativity, we might ask whether or not similar conclusions can be drawn for tonal phenomena. This chapter investigates noniterative tonal phenomena with this question in mind. I present two very different analyses that aim to reduce tonal noniterativity to a confluence of factors that do not explicitly require noniterativity.

The first analysis, which is based on what I will call Peak Delay Theory (PDT),

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[1] I am grateful to Larry Hyman and Michael Marlo for their thoughtful comments on an earlier draft of this chapter.

builds on work suggesting that noniterative tonal phenomena reflect facts about phonetic implementation and not the languages' phonological grammars. The evidence for this view from two languages, Chichewa (Myers 1999) and Kinyarwanda (Myers 2003), is compelling. I argue below that it is worth viewing all noniterative tonal phenomena in this light, although whether all relevant cases are actually inherently phonetic remains an open question that can only be answered by future phonetic and experimental work.

The other approach is couched within Optimal Domains Theory (ODT), a framework developed by Cole & Kisseberth (1994, 1997, 1995) as a way of understanding opacity and transparency in harmonic systems and extended to tonal phenomena by researchers such as Cassimjee (1998), Cassimjee & Kisseberth (1998), and Downing (2008).[2] This theory rejects Autosegmental Phonology's formalism of features and tones as autosegments that are associated with individual timing units. Instead, abstract domains corresponding to specific features are posited, much like feet, and features can be realized or not in their corresponding domains. Spreading results when a domain extends beyond the input featural "sponsor" and each host within the domain expresses the feature. Shifting is similar except that only one host within the domain expresses the feature. Transparency and opacity result when a host is barred from expressing a feature. For noniterative tone spread and shift, Cassimjee & Kisseberth (1998) posit a constraint requiring non-unary domains. To satisfy this constraint, bimoraic domains are built, and tones are either expressed on both units in the domain (spreading) or just one of them (shifting).

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[2]I thank Laura Downing for reminding me of the relevance of ODT to this chapter.

Both the peak delay analysis and ODT are appealing in various ways, but each has shortcomings. With this in mind, a lack of conclusive evidence for one over the other prevents a choice between these alternatives from being made here. It should be stressed, however, that either theory supports the Emergent Noniterativity Hypothesis in that neither stipulates noniterativity. Movement or spreading of a tone by one syllable or mora is produced by independent principles. The choice between these theories is immaterial for the purposes of this dissertation, although I argue for PDT elsewhere (Kaplan 2008b).

If these proposals prove unsatisfactory and no suitable alternative can be found, we have the option of concluding that tone is simply different from other phonological entities in that it manifests true noniterativity after all. This would be a disappointing result: As Autosegmental Phonology has developed, tones have been increasingly viewed as rather closely related to segmental features in that, as autosegments, both tones and features can behave as autonomous units that are independent of the timing units that host them. It might be a step backward to conclude now that tones and features really are formally different entities after all. But this might be the conclusion we are led to. In this case, the ENH should be revised as in (1):

(1)   **Emergent Noniterativity Hypothesis (possible revision):** *No **non-tonal** formal entity in phonological grammars may require noniterativity.*

We can then posit markedness constraints for tone that access the input and can therefore require noniterativity. The next question we should ask is why tone should be exempt from the ban on formal noniterativity. What makes tone

so special that it can do what featural assimilation, foot assignment, syllable construction, etc., cannot? No obvious answer presents itself, so we are left no more enlightened (and actually significantly less enlightened, I would argue) than we are if we assume that tone is not in fact exempt from the ENH and seek alternative explanations for the apparent counterexamples.

Philippson (1998) explicitly argues for a conceptual dichotomy between iterative ("unbounded") tone spread/shift and noniterative but otherwise identical phenomena. For an example of the latter, in Kikuyu, tones appear one syllable to the right of their underlying hosts (Clements 1984, Clements & Ford 1979; data from Clements 1984). The data in (2) show this for verbs.

(2) to rɔr aɣ a   'we look at'

     to mo rɔr aɣ a   'we look at him/her'

     to ma rɔ́r aɣ a   'we look at them'

     má rɔ́r aɣ a   'they look at'

     má mó rɔr aɣ a   'they look at him/her'

     má má rɔ́r aɣ a   'they look at them'

The first two forms establish that the root -rɔr- 'look at' and the object prefix mo- 'him/her' are low-toned morphemes. In the third form, the introduction of the object prefix ma- 'them' causes a high tone to appear on the root. The conclusion we're led to is that this H is part of the object prefix and shifts to the following morpheme. Similarly, when the subject prefix ma- 'they' appears instead of to- 'we' in the last three forms, the following morpheme surfaces with a high tone. Again, since we've already seen that -rɔr- and mo- are low-toned, the

obvious conclusion is that the subject prefix supplies the H, which links not to the subject prefix but to the following morpheme (and then, in Clements & Ford's (1979) and Clements's (1984) analyses, spreads leftward back to the subject prefix so that this morpheme isn't left toneless). In the last form, both high-toned *ma*-prefixes are present (one the subject, the other the object), and H appears on the morpheme following each prefix.

Similarly, a high-toned root such as *-tom-* 'send' causes the following morpheme to surface with H. The data in (3) show this. Whereas the habitual suffix *-aɣ-* was low-toned throughout (2), here it is high-toned because the preceding morpheme now contributes a high tone.

(3)   to tom áɣ a   'we send'

       to mo tom áɣ a   'we send him/her'

       to ma tóm áɣ a   'we send them'

       má tóm áɣ a   'they send'

       má mó tom áɣ a   'they send him/her'

       má má tóm áɣ a   'they send them'

Both Clements & Ford (1979) and Clements (1984) produce this pattern with an early rule that associates the first tone, whether H or L, to the second tone-bearing unit (TBU). The normal tone association conventions subsequently apply, with the second tone associating to the third TBU, etc. Then, since the first TBU was skipped, a repair rule spreads the first tone leftward back to this TBU.

The same thing occurs in nouns. For example, the root in *mo-ɣatě* 'bread' (where the root is preceded by a noun-class prefix) belongs to the tone class

LH. But instead of associating with the first root syllable, L associates with the second syllable along with H. Clements's account for this form works as follows: The prefix (like all noun-class prefixes) contributes a low tone of its own. As with verbs, the first tone—here the prefix's L—associates with the second TBU. This means that the first root syllable bears the L of the prefix, and the root's final syllable bears the root's LH. The first L then spreads leftward to the prefix.

Similarly, in Chichewa (Hyman & Mtenje 1999, Kanerva 1990, Moto 1983, Mtenje 1987, Myers 1999, Myers & Carleton 1996, Peterson 1987), it is claimed that "a high tone spreads rightward onto the following syllable *only if the high tone is not in the last three syllables of a phrase*" (Myers 1999:215; emphasis original). Mtenje (1987:174) specifically identifies this as the product of a noniterative rule. Compare the pairs of examples in (4). In each pair, the first item has a high tone in the antepenultimate syllable of the phrase, and the tone does not spread. But when the phrase or word is lengthened, as in the second items, the high tone is no longer in the phrase's last three syllables, so it spreads to the following syllable:

(4) a. mtsíkaana   'girl'
         mtsíkána uuyu   'this girl'

     b. zidzábeera   'they will steal x for/with you'
         zidzábéraana   'they will steal x for each other'

It is reasonably common to encounter diachronic explanations for this kind of phenomenon (e.g. Schuh 2005, 2007, Silverman 1997) grounded in "peak delay" (e.g. Myers 1999). Spreading and shifting begin, as the claim goes, with tones

spilling over into adjacent syllables. For shifting, eventually this leads to the pitch target being reached only in the adjacent syllable. A generation of learners encounters this situation and mistakenly assumes that these tones are actually moving or spreading, when they are actually simply not being articulated strictly within the boundaries of their hosts. This is a straightforward and appealing explanation, but it leaves an important question unanswered: When these learners assume that they've encountered spreading or shifting, what exactly do they add to their grammars? There may be clear diachronic reasons for these phenomena, but they don't explain how speakers produce them in their synchronic grammars.

The most obvious solution is to posit a noniterative rule or other mechanism that produces the shifted tone.[3] But if noniterative mechanisms are unavailable to phonological grammars, this cannot be the correct solution. In the first part of this chapter I argue that phenomena like Kikuyu's tone shift are phonetic at root. There is no active phonological process in Kikuyu that docks tones one syllable to the right of their expected hosts. Rather, the phonetic pitch correlate of a tone is delayed, resulting in the pitch peak being realized on the following syllable.[4] This is the conclusion that Myers (1999) draws, based on phonetic data, for Chichewa: The spreading illustrated in (4) is not phonological spreading, but rather phonetic

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[3]However, if tone shift involves the lexical tone pattern in monomorphemic contexts (or solely within morphemes) in a language being shifted one syllable (or other unit) to the right compared to related languages, analysis is trivial. This is part of the situation in Kikuyu (Schuh 2007). For example, the tonal pattern in the Kikuyu form *mòtĕ* 'tree' appears to be shifted to the right compared to the cognate from Mwimbi, *mòté* 'tree.' In languages where this is the entire story, the solution is rather simple: lexical representations are simply different, and the surface forms reflect this. Unfortunately, this is not the entire story in Kikuyu, as the discussion above makes clear. Schuh (2007), in contrast, argues that a tone-shift pattern in Ngamo that is very similar to Kikuyu's pattern is purely a diachronic effect, in which case it is subject to this simple analysis.

[4]I use the term "peak" for both the f_0 maximum for high tones and the f_0 minimum for low tones. The analysis is easily extendable to other tone levels.

encroachment of one syllable's H onto the next syllable.

However, while it might be tempting to chalk up tone shift to peak delay entirely and absolve phonologists of any analytical responsibility, there is evidence that peak delay is at least somewhat phonologically controlled. For example, while a historically final H in Kikuyu docks onto the word-final syllable to create a rising contour tone with the preceding shifted (and historically penultimate) L as in (5a), a historically final L does not appear on the final syllable. Instead, as (5b) shows, this displaced L remains afloat, as evidenced by the downstep it induces on the following word. The forms in (5c) verify that the initial words in in (5b) are responsible for the downsteps.

(5)   a.   moɣatĕ   'bread'
           némátéŋeraɣă   'they run'
           némátómírĕ   'they sent'

      b.   moaɣáhiɲá ˈné moɛɣá   'the weakling is good'
           karioki̋ ˈné moɛɣá   'Kariũki is good'
           keaɣárarɔ ˈné keɛɣá   'the stile is good'
           βiriβiri ˈné ɲjɛɣá   'chillies are good'

      c.   moβake né moɛɣá   'the tobacco-plant is good'
           βaŋgírí né ɲjɛɣá   'bangles are good'

The downstep indicates that there is a phonological floating L, and in fact this L is quite mobile under certain conditions (Clements & Ford 1981, Clements

1984, Clements & Ford 1979). For example, as Clements & Ford (1981) describe it, the downstep operator (which they do not explicitly identify as L, although other research cited in this paragraph makes this connection) may move from the right edge of a [+assertive] verb to the right edge of the verb's complement. This is illustrated in (6) with examples drawn from Clements & Ford (1981). In (6a), the matrix verb lacks a complement, so it induces downstep on the immediately following word. The verb in (6b) has a complement (*móɣɛraniá* 'examiner'), and its downstep operator moves to the right side of this complement and triggers downstep on the word after the complement. The same verb appears in (6c), but here it is not [+assertive]. Its downstep operator cannot move across the NP complement and therefore stays on the verb.

(6) a. nderáːkamíɾɛ ˈkiɲa ákéˈrúɣá mbɔːcɔ́
         I-milked   until he-cooked beans

     b. ndɔːniɾɛ́ móɣɛraniá ˈðeíne oá ɲómba
         I-saw   examiner inside   house

     c. ndiɔníˈɾɛ   móɣɛraniá ðeíne oá ɲómba
         I-didn't-see examiner   inside   house

Were the downstep-inducing L associated with the verb-final syllable in (6b), it would be expected to be bound to this word and unable to travel across the NP complement. It is therefore not tenable to claim that this L is phonologically associated with the word-final syllable while its associated pitch trough is simply unrealized by the phonetic component since there's no following syllable in the word. We must derive a phonological representation that includes a floating L.

Consequently, the PDT analysis developed in this chapter attributes what has

been called tone shift to peak delay, but this peak delay is itself controlled by the grammar. This approach is very similar to the one taken by Gafos (1999), who uses formal constraints on articulatory gestures to produce phonological phenomena. An even closer predecessor is Xu & Wang (2001). The analysis below also builds on Morén & Zsiga (2006) and Zsiga & Nitisaroj (2007), who seek to transparently connect the seemingly complex pitch patterns in Thai to simple phonological representations, and especially Li (2003), who adopts constraints on phonetic implementation (as distinct from formal tone association) in an OT analysis of Mandarin tones. The upshot, with respect to (5b), is that the grammar blocks an L whose associated pitch contour will not be realized from being associated with any TBU. On the other hand, a high-ranking constraint banning floating high tones requires the creation of a contour in (5a).

Of course, the claim that Kikuyu's tone shift is inherently phonetic is subject to experimental verification. One interesting consequence of placing peak delay in the grammar is that a simple reranking of constraints can produce phonological tone shift under pressure from the constraints responsible for peak delay. This means that whether or not tone shift is purely phonetic, an analysis that treats it as driven by phonetic considerations can account for it.

A treatment of all examples of tonal noniterativity and its interaction with the larger tonal systems in which they are found would be a worthwhile endeavor, but it deserves an entire dissertation of its own. My goals here are much more modest—a demonstration that analyses compatible with the ENH are possible— so I will only discuss Chichewa and Kikuyu in any detail. See Myers (2003) for another application of (what amounts to) PDT in another language, and Cassim-

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jee & Kisseberth (1998) for detailed analyses of languages in ODT.

It is worth emphasizing that I do not claim that all cases of tone spread/shift—bounded or not—fall under the purview of the PDT or ODT analyses developed below. Many phenomena submit to wholly different analyses, and I discuss some salient examples in §4.8 below. For example, tones are often attracted to specific position in a word such as the stem-initial or -penultimate syllable. Rather than coopting the analyses developed here for such phenomena, and it seems better to account for them with constraints requiring edge-alignment or coincidence with specific positions. PDT and ODT may eventually prove applicable to (some of) these cases, but here I wish to pursue the more modest hypothesis that they're relevant to phenomena for which one might be tempted to write a truly noniterative rule.

The chapter is organized as follows: In §4.2, I discuss the existing research that establishes the reality of peak delay. In §4.3, I develop an analysis of Chichewa tone spread based on this research, and §4.4 presents a similar analysis of Kikuyu's tone spread. In §4.5, ODT analyses of Chichewa (§4.5.1) and Kikuyu (§4.5.2) are developed.

4.2   Peak Delay

Peak delay is a phenomenon whereby the f_0 target for a tone is reached some time after the beginning of the syllable with which that tone is associated. The peak may appear sometime late in the host syllable, or it may appear in the following syllable—i.e., the f_0 target for a high tone need not fall within the (phonologically)

high-toned syllable. (All studies of peak delay that I am aware of focus on high tones.) Both patterns may occur in a language. As I describe below, in both English and Chichewa, a high tone's peak by default appears in the syllable after the stressed or high-toned syllable, but under certain circumstances, it falls within the high-toned syllable itself.

Peak delay has been reported for a variety of languages, including English (Silverman & Pierrehumbert 1990, Steele 1986), certain dialects of Swedish (Bruce & Gårding 1978), Danish (Thorsen 1978), Navajo (deJong & McDonough 1993), Spanish (Prieto et al. 1995), Mandarin (Li 2003), and Chichewa (Myers 1999). See also Ladd (1983) for explicit discussion and analysis of delayed peaks. Morén & Zsiga (2006) find perseverative coarticulation of tones in Thai that resembles peak delay, although they argue against peak delay as an explanation for that particular phenomenon. In this section I discuss the English and Greek cases. Chichewa is discussed in §4.3.

Silverman & Pierrehumbert (1990) investigate the timing of prenuclear H accents in English. They find that the corresponding f_0 peak appears at some regular interval after the beginning the stressed syllable (or more accurately, the beginning of the rime) with which the H is associated. The precise length of the delay depends on various factors. First, speech rate affects peak delay: When the stressed syllable is shortened in fast speech, peak delay is also shortened. Likewise, when slow speech increases the syllable's length, peak delay is also increased.

Second, word boundaries and stress clash affect peak delay. Word-final syllables are systematically lengthened, as are syllables at other syntactic and prosodic boundaries (e.g. Horne et al. 1995, Lehiste 1972, Lehiste et al. 1976, Lunden 2006,

Oller 1973, Wightman et al. 1992), and a stressed syllable that immediately precedes another stressed syllable is lengthened. But whereas lengthening caused by speech rate increases peak delay, lengthening caused by word boundary-adjacency and clash result in a proportionally shorter delay. While the reason for word-final peak delay reduction is not immediately clear, reduction due to clash is plausibly a result of the need to articulate two pitch targets in close succession. This can be facilitated if the first of these targets is shifted leftward. (This explanation, called "tonal crowding" by Myers (1999), is among the ones that Silverman & Pierrehumbert accept as a possible model of their findings.) One of the two subjects in the Silverman & Pierrehumbert study showed a gradient effect of clash: the closer the following stressed syllable was, the greater the reduction in peak delay.

If the stressed syllable is neither word-final nor subject to clash, the f_0 peak typically falls in the syllable after the stressed syllable. Both word boundaries and clash can push the peak leftward, back into the stressed syllable.

Arvaniti et al. (1998) find that the high-tone target of Greek's prenuclear accent, which they conclude is best represented as L+H*, "is very precisely aligned just after the beginning of the first postaccentual vowel" (23). They show that peak timing is correlated with the duration of the interval from the onset of the accented syllable to the beginning of postaccentual vowel. That is, in ... [CV́C]V..., where V́ is the accentual vowel, the peak's timing is correlated with the bracketed interval. Arvaniti et al. argue this this model is better than a model that ties peak timing to the duration of the postaccentual vowel itself. The superiority of the first model over the second indicates that even though the tone's peak appears after the accented syllable, it is still timed with respect to (and perhaps associated

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with) that syllable. That is, we have a case of peak delay. Arvaniti et al. also argue that the peak's "alignment is probably phonologically, rather than phonetically, conditioned" (17) since it is aligned with respect to a phonological unit (the accented syllable) rather than a phonetic property of the utterance.

They also find tonal crowding for some speakers, whereby the prenuclear H is articulated earlier or with an attenuated pitch rise when another accent follows closely. Closeness of the following accent is determined by the number of intervening unaccented syllables, not a phonetic temporal measurement. Arvaniti et al. again point out that articulation of the prenuclear H is affected by phonological, not phonetic, factors. Their results are important for the analyses presented below because they establish that attributes that might be extra-grammatical artifacts of phonetic implementation (a lag in producing the target pitch or adjustments in the articulation of one pitch target to facilitate articulation of the following target) are sensitive to phonological properties and may therefore be governed by the phonology itself. This is the position I take later in this chapter.

Why does peak delay occur? Articulatory and perceptual answers are found in the literature. Myers (1999:224) speculates that "the vocal fold adjustments that determine f_0 modulation are more sluggish than the supralaryngeal gestures that define the syllable." In other words, executing a high tone's f_0 rise is inherently harder (as measured by the time required for the gesture) than gestures associated with other phonological units. Other researchers (Ohala & Ewan 1973, Sundberg 1979) offer similar physiological explanations.

Myers also cites work showing that the rise in pitch, as opposed to the f_0 peak itself, is an important perceptual cue to the presence of a high tone. He notes that

"f_0 cues are more easily perceived in regions of relative spectral stability, as in the midpoint of a vowel" (Myers 1999:224). Coordinating the f_0 rise with the end of the syllable places an important perceptual cue in a position that maximizes its perceptual salience. A side effect of this alignment is that the f_0 peak occurs late in the syllable or even in the next syllable.[5]

If either hypothesis is correct, we have an answer to a puzzle: Why are apparently noniterative processes particularly common for tone compared to other domains? That is, why do we find many cases of tone shift/spread by one syllable, but so few cases in which, say, vowel height spreads or moves by just one syllable? If noniterative tone spread/shift is a consequence of peak delay, then the answer is that only tone is subject to the articulatory or perceptual factors that give rise to a lag in timing, or at least that these factors are greater for tone than for other phonological entities. The hypotheses sketched above predict either that the articulators that control pitch are more sluggish than those that control vowel height, or that perception of vowel height is less dependent upon alignment with some other acoustic unit.

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[5]Evidence, perhaps weak, for this hypothesis comes from the observation in Prieto et al. (1995) that when factors like clash and word or phrase boundaries trigger a reduction of peak delay in Spanish, rather than the whole f_0 articulation being shifted leftward, the beginning of the pitch rise is held constant and the rising slope becomes steeper. This means that under pressure, the f_0 rise is executed more quickly, showing that the normal, unshifted peak delay doesn't represent the speaker's fastest possible f_0 rise. However, this could also mean only that the default tonal articulation is comparatively sluggish but, like other gestures, can be sped up if necessary (e.g. under fast speech).

4.3 Peak Delay in Chichewa

4.3.1 Tone Spread as Peak Delay

Myers (1999) applies the findings summarized in the previous section to purported tone spread in Chichewa. This language has a privative tonal contrast between H and ∅ (Kanerva 1990, Myers 1999); Myers (1999) notes that non-high-toned syllables have no pitch target, and instead acquire their pitch properties through interpolation from surrounding high-tone targets.

Both Kanerva (1990) and Myers (1999) take the TBU of Chichewa to be the mora, yet the latter showed that tones are most reliably timed with respect to syllables. Mtenje (1987) adopts syllables or vowels as the TBU. I will adopt a compromise: The mora is the TBU, but constraints can make demands about tones' (and their corresponding phonetic implementations') syllabic constituency—i.e., constraints can require or prevent association with (moras in) particular syllables. Also, throughout the analysis, I distinguish abstract tones (H, L, M, etc.) with formal autosegmental associations to TBUs from their phonetic pitch implementations, which have no formal autosegmental associations (although they "belong" to particular tones, of course) but merely temporally coincide with other elements such as syllables.

The data from (4), repeated and expanded in (7), illustrate the spreading of high tones one syllable rightward from a syllable that is not one of the last three syllables in a phrase.

(7)   a.   mtsíkaana   'girl'
              mtsíkána uuyu   'this girl'

b. chigawéeⁿga   'terrorist'

    chigawéⁿgá iichi   'this terrorist'

c. zidzábeera   'they will steal x for/with you'

    zidzábéraana   'they will steal x for each other'

d. mteⁿgo wá deeⁿgu   'price of basket'

    mteⁿgo wá déⁿgu iili   'price of this basket'

    mteⁿgo wá ⁿthíwatiiwa 'price of ostrich'

e. tinabá deeⁿgu   'We stole the basket.'

    tinabá déⁿgu iili   'We stole this basket.'

    tinabá ⁿthíwatiiwa   'We stole the ostrich.'

The data in (8) further illustrate the lack of spreading from the last three syllables in a phrase. No examples of phrase-final tones are available because such tones retract to the penultimate syllable.

(8) dzíina   'name'

     mtéeⁿgo   'tree'

My understanding is that Kanerva's (1990) Focal Phrase is the relevant phrasal category. Aside from the lack of tone spread, two processes are characteristic of the right edge of this phrase. First, phrase-penultimate vowels are lengthened,

as can be seen in the data above. Second, phrase-final tones are retracted to the penultimate syllable:

(9) a. mle^{n}dó uuyu   'this visitor'

        mleé^{n}do   'visitor'

     b. pezá nyaama   'find the meat!'

        peéza   'find!'

Both Myers (1999) and Kanerva (1990) transcribe retracted tones over the second half of (lengthened) penultimate vowels as in (9). Kanerva explicitly claims that this is the position to which tones retract (as opposed to the first half of the vowel), but Myers mentions some variability. He notes that two of his subjects produced retracted tones early in the penultimate syllable and thus exhibited neutralization with lexical penultimate tones such as those in (8). The third subject's retracted tones were instead articulated later in the penultimate syllable. Myers suggests that the third subject retracted tones to the penultimate syllable's second mora, which would motivate his and Kanerva's transcriptions. The issue makes little difference for the analysis developed here, and I give transcriptions as they are provided by each author. But for simplicity, I adopt in my analysis the timing of Myers's first two subjects with retraction to the first half of the long vowel. I will note analytical adjustments that are required by the other pattern (which I assume is a different dialect) where applicable. (See also Hyman & Mtenje (1999). While silent on the specific question at hand, they note that at least one dialect of Chichewa lacks retraction altogether.)

Myers's experimental data suggest that "high tone spread" is better characterized as peak delay.[6] For high-toned medial syllables (i.e. those from which H can spread), the tone's peak is regularly achieved only in the following syllable (i.e. the target of spreading). But the timing of the peak is still correlated with properties of the first syllable, primarily that syllable's duration. Furthermore, if Chichewa has genuine (phonological) tone spread, we might expect peak duration to be longer in spreading contexts than in non-spreading contexts since tones in the former context are, by hypothesis, linked to two syllables while the latter are linked to just one. Myers points out that while one of his two subjects show this pattern, the difference in duration (26.2ms in spreading contexts, 21.3ms in non-spreading contexts) does not approach the 2:1 ratio that would be naively expected of H linked to two TBUs versus H linked to one TBU. For the other subject, these tones' durations were 23.0ms in spreading contexts and 25.1ms in non-spreading contexts. This difference trends in the wrong direction, but it is not statistically significant. The importance of the second subject's data is that it does not remotely exhibit the expected timing difference.

Thus Myers identifies two measurable properties that might be expected of spreading tones—articulations that are timed with respect to their new hosts and greater durations compared to non-spreading tones—and he finds neither. From these data, Myers concludes that H does not in fact spread. It is formally associated only with its original host syllable, but phonetic implementation of the H leads to the impression that spreading has occurred.

Myers also has explanations for the lack of (supposed) spreading from the final

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[6]DeJong & McDonough (1993) make the same conjecture about Navajo.

three syllables in a phrase. First, spreading from phrase-penultimate syllables is not reported by transcribers because these syllables are lengthened. This means that even with peak delay, a penultimate high tone's peak is contained within its host syllable. That is, with penultimate lengthening, peak delay does not result in the peak falling in the following syllable. Furthermore, both Silverman & Pierrehumbert (1990) and Myers (1999) found a reduction of peak delay in lengthened syllables, a pattern which would increase the likelihood that a penultimate H's peak would appear in that syllable.[7]

Spreading from phrase-final syllables is unattested because H in this position is retracted to the penultimate syllable (see (9) above). An explanation of these tones reduces to the explanation given in the previous paragraph. (The same sort of measurements that lead Myers to conclude that spreading doesn't occur leads him to the conclusion that retraction is a real phonological process: Phrase-final H is timed with respect to the penult.)

Finally, Myers (1999) speculates that the lack of spreading from antepenultimate syllables is due to "tonal crowding." Other researchers (Arvaniti et al. 1998, Silverman & Pierrehumbert 1990) have found that "peak delay is reduced if another f_0 target immediately follows" (Myers 1999:225). Boundary tones at the end of the phrase could lead to a reduction of peak delay in nearby syllables. Since Silverman & Pierrehumbert (1990) observed tonal crowding even when the two high tones were not syllable-adjacent, it is not unreasonable to think that it is applicable to Chichewa's antepenultimate syllables. See Myers (2004) for discussion

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[7]For the dialect with retraction to the penultimate syllable's second mora, the lack of spreading can be attributed to tonal crowding (see below) and the reduction of peak delay in lengthened syllables.

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of the long-distance effects of boundary tones. Since boundary tones mark phrase boundaries, it is important that their articulations not stray too far from these boundaries. So when lexical and boundary tones are too close together, adjusting the articulations of the lexical tones (which mark lexical contrasts, not prosodic landmarks) might be less deleterious than adjusting the boundary tones. Tonal crowding may also contribute to the lack of spreading from penultimate syllables.

Another factor that Myers doesn't consider is the phrase boundary itself. Prieto et al. (1995) report that in Spanish, the closer a stressed syllable is to the end of a phrase, the shorter the observed peak delay becomes. Perhaps similar facts hold in Chichewa and contribute to the lack of tone spread at phrases' right edges.

If we take the relationship between tones' formal associations and their phonetic realizations to be non-arbitrary, Myers's data indicates that there is no tone spread in Chichewa to be analyzed. Only tones' retraction from final syllables is a phonologically real phenomenon, and that is analyzable as a Non-Finality effect. This means that Chichewa presents no counterexample to the ENH.

Of course, it remains to be seen if other cases of noniterative tone spread have similar phonetic properties. Citing data similar to the results he presents for Chichewa, Myers (2003) argues that leftward tone spread in Kinyarwanda is also a phonetic phenomenon. This time, a high tone's peak is not delayed to the following syllable, but its "onset"—the rise in pitch at the beginning of its articulation—falls in the preceding syllable. This is anticipatory coarticulation, Myers argues, not typologically unusual leftward tone spread.[8] As mentioned

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[8]Although this paragraph—and Myers's research—suggests a close connection between leftward and rightward tone spread, others, such as Hyman (2007), argue that these processes result

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above, deJong & McDonough (1993) suggest that peak delay may be responsible for tone spread in Navajo.

Cassimjee & Kisseberth (1998:28) report informal anecdotal evidence for other languages that points toward a PDT analysis of these languages. Citing personal communication with David Odden, they state that in Kijita, which has rightward tone shift like Kikuyu, the original tone's host "is not fully low – rather, just not as high in pitch as the second mora." This is clearly reminiscent of Myers's (1999) description of Chichewa: The high tone hasn't moved (as evidenced by the onset's alignment with the original host), but its peak is simply delayed to the following syllable. Cassimjee & Kisseberth go on to say that they noticed something similar in the Imitthupi dialect of Emakhuwa, but in the Eerati dialect of Emakhuwa, the original host syllable is "fully low" and the following syllable is "fully high." Also, Michael Marlo (p.c.) reports similar observations for Lumarachi that may also be manifestations of peak delay. Myers's (1999, 2003) experimental results suggest that impressionistic data about tonal affiliation is unreliable, so these claims require further study. But they indicate that PDT may be applicable beyond the two languages that Myers has investigated.

Adopting a PDT treatment of Chichewa is not merely an analytical shortcut. As explained in the next section, it permits a better understanding of other tonal phenomena in the language. Nor is a PDT treatment of Chichewa necessarily a claim that there is nothing phonologically real about the phenomenon that has been called tone spread. I argue in §4.4 that it is possible to incorporate peak delay into a formal analysis; The account of Kikuyu developed there is extendable
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from quite different factors.

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in obvious ways to Chichewa. A formal analysis of Chichewa is not presented here, as it would bog down the discussion and detract from the larger goal of this chapter, which is to offer possible analyses of tonal phenomena that do not invoke noniterativity. See Kaplan (2008b) for this analysis.

4.3.2 Peak Delay and the OCP

Evidence that Chichewa's tone spread is phonetic comes from its interaction with the OCP. As Kanerva (1990) shows, adjacent high tones are generally not permitted in Chichewa. Like many other Bantu languages, Chichewa has a process, known as Meeussen's Rule, by which the second of two high tones that are linked to adjacent TBUs is deleted.[9] This (as Kanerva points out) is probably best understood as a product of the OCP (Leben 1973). (10) illustrates the deletion pattern.[10]

(10)   a.   on-aan-a   'see each other'

              on-aán-e   'see each other (subjunctive)'

        b. ^{n}d-aa-dya   'I-Perf-eat'

              ^{n}d-a-líi-dya   'I-Perf-5OM-eat'

        c. ^{n}di-líi-dy-e   'I-5OM-eat-subjunctive'

The data in (10a) show that the subjunctive -é is high-toned. (Since these are citation forms and hence phrase-final, this H retracts.) Next, (10b) shows that

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[9]In certain conditions, the second H instead shifts rightward. I do not discuss this process here; see Chapter 6 of Kanerva (1990).

[10]Glosses follow those in Kanerva (1990). Numerals represent subject or object noun classes. For example, the morpheme *lí* '5OM' (which undergoes penultimate lengthening) is the noun-class 5 object marker.

the object marker *-lí* is also high-toned. But when these morphemes appear in adjacent syllables, as in (10c), only the object marker's H surfaces. We might expect a form like *^{n}di-líí-dy-e*, where the subjunctive morpheme's tone retracts to the penultimate vowel, but since this results in two high tones on adjacent moras, the second one deletes.

As another example, (11a) shows that the reflexive object marker *-dzi-* carries a high tone (which undergoes the expected spreading) and assigns another high tone to the stem-penultimate syllable. But as (11b) shows, when the verb stem is monosyllabic, only the morpheme's own H surfaces. The one it assigns to the stem deletes because it is adjacent to the first H, either before penultimate lengthening (/y-a-dzí-dyá/) or after retraction (/y-a-dzíí-dya/). Kanerva (1990:§2.2.4) provides ample additional evidence for OCP-induced deletion.

(11)   a.   l-a-lemekeeza   '5-Perf-respect'

              l-a-dzí-lémekéeza   '5-Perf-Refl-respect'

    b.   y-a-dzíi-dya   '9-Perf-Refl-eat'

              z-a-dzíi-pha   '10-Perf-Refl-kill'

              u-ka-dzíi-^{m}va   '3-Cond-Refl-hear'

However, when two high tones occupy adjacent TBUs as a consequence of tone spread, no deletion occurs:

(12)   a.   /bírimá^{n}khwi/   → bírímáa^{n}khwi

              'chameleon'

b. /ⁿdí-ta-phíka/ → ⁿdí-tá-phíika

   'I-sequence perf.-cook'

c. /ch-a-dzí-sekétsa/ → ch-a-dzí-sékéetsa

   '7-Perf-Refl-laugh.Caus'

d. /mteⁿgo wá galú uuyu/ → mteⁿgo wá gálú uuyu

   'price of this dog'

e. /y-á-i-kúlu/ → y-á-í-kúulu

   '4-Asc-4-big'

The noun in (12a) has underlying initial and penultimate high tones. In (12b), the tense marker *ta* assigns high tones to both the preceding and following syllables (indicated above as underlying tones). In (12c) the reflexive morpheme *-dzí-* bears H itself and assigns another H to the verb stem's penultimate syllable. In (12d), the associative marker *wá* and the following noun each has a lexical H. Finally, (12e) is an adjective, and I have been unable to find the details of its derivation or a full explanation of its gloss in Kanerva (1990), from which this form is taken. Nonetheless, Kanerva gives *y-á-i-kúlu* as the form's representation before spreading and penultimate lengthening occur. In all of these examples, the first H spreads to the syllable immediately before the second H. The resulting ostensible OCP violation is not rectified.

The analysis of tone spread adopted here predicts these facts. Rather than exhibiting (formal, phonological) tone spread, the examples in (12) display peak delay: The peak of the first high tone has been pushed into the syllable preceding the second high tone. The first high tone is not formally associated with the syllable before the second high tone, so there is no OCP violation, and deletion

is not motivated. The representations in (13) show the forms in (12) as they are produced by PDT. Underlining marks the extent of the phonetic implementation of the tone from onset to peak, with the peak marked by double underlining.

(13) a. <u>bí<u>ri</u></u>máa^{n}khwi

   b. ^{n}<u>dí-<u>ta</u></u>-phíika

   c. ch-a-<u>dzí-<u>se</u></u>kéetsa

   d. mte^{n}go wá <u><u>ga</u>lú</u> uuyu

   e. y-<u>á-<u>i</u></u>-kúulu

In a derivational approach, the correct tone patterns can be produced by ordering Meeussen's Rule before tone spread (i.e. in a counterfeeding relationship). But this ordering is arbitrary[11]—the tone retraction rule could just as well be ordered after Meeussen's Rule instead, and we'd find forms like *y-a-dzíí-dya instead of (11b). For the peak delay approach, there is a principled reason that tone spread doesn't trigger Meeussen's Rule while tone retraction does: Only the latter actually manipulates tones' associations, so of the two processes, it is the only one that might produce a configuration with two high tones formally associated with adjacent syllables.

Alternatively, the OCP violation caused by high tone spread could be resolved via fusion of the adjacent tones. But this solution seems unlikely in light of the evidence of above that OCP violations are resolved by deletion in Chichewa.

Kanerva (1990) posits another rule that is puzzling from the point of view of the OCP. When two high tones are separated by one mora, the first spreads to

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[11]It is also opaque, making it a marked ordering under the assumptions of Kiparsky (1971, 1973).

the intervening mora to create a plateau. In support of this, Kanerva (1990:65) gives data such as the following:

(14) a. /mte^{n}go wá galú/→ mte^{n}go wá gáálu 'price of the dog'

b. /tinabá galú/ → tinabá gáálu 'We stole the dog.'

c. /ti-dzá-pezá/ → ti-dzá-pééza 'we-Fut-find'

In each case, the final H retracts to the penultimate mora, and the first H spreads. This is not the same as the tone spread phenomenon considered above. The plateau process occurs even in the final three syllables of a phrase, and it requires an H after the spreading tone. Its effect is to create two high tones that are associated with adjacent TBUs, in direct contravention of the OCP. We seem to have a contradiction: Chichewa schizophrenically both actively eliminates such configurations (via Meeussen's Rule) and actively produces them (via plateau).

Myers (1999) notes, however, that there are no low-pitch targets in Chichewa (hence the H vs. $\emptyset$ rather than H vs. L tonal distinction). Syllables that are not specified as high-toned acquire their pitch values through interpolation. A toneless syllable between high tones will not have a pitch trough that is as pronounced as the trough in a similar syllable that is between other toneless syllables. In fact, one interpretation of the data in (14) is that a toneless syllable between two high-toned syllables shows sufficiently little pitch decrease as to be (impressionistically?) indistinguishable from a high-toned syllable. That is, the two high-pitch targets are not sufficiently separated to permit a noticeable descent toward neutral pitch. The plateau phenomenon is not a phonological rule, but a product of interpolation caused by two nearly adjacent high-tone targets and no intervening

low pitch target. This interpretation resolves the conflict mentioned in the previous paragraph by relegating the apparently OCP-flouting tone spread process to a non-phonological status. That is, by invoking interpolation, we can eliminate the rule that creates configurations that the language otherwise avoids. The forms in (14) comply with the OCP because there is in fact a mora separating the two high tones.

This is not the only possible characterization of plateau, of course. The OCP violation may be resolved by fusing the two high tones (as suggested by the lack of downstep between them; Bickmore (2000), Odden (1982)), although, as with the fusion approach to tone spread mentioned above, it is not clear why plateau induces fusion but other OCP violations trigger deletion. In other languages such as certain dialects of Emakhuwa (Cassimjee & Kisseberth 1999a,b), plateau effects are sensitive to morphological and moraic structure, and they can trigger or block other phonological processes. Such behavior points strongly toward a phonological plateau and away from interpolation.

In any case, the interest of these plateaus in the present context is that they do not surface when the configuration that triggers them is produced by tone spread. That is, high-tone spreading could in principle feed plateau creation, but it does not (cf. Lukhayo (Michael Marlo p.c.), where such feeding does occur). This is shown in (15).

(15)   a.   /tinabá kalulú/   → tinabá káluúlu   'We stole the hare.'

         b.   /mu-ná-lemerá/   → mu-ná-lémeéra   'you.pl-past-be heavy'

Even though tone spread and retraction create two high-toned syllables that are separated by just one toneless mora, no plateau appears. This is not unexpected if both spreading operations involve manipulations of pitch contours rather than formal tone associations. If tone spread is just peak delay, then the two high-pitch targets are separated by two syllables. This means that pitch interpolation will not give rise to the appearance of a plateau: With more than one syllable between the two pitch targets, there is time for the pitch to drift toward the neutral position between these targets. Even if we take plateaus to be phonological, PDT can explain (15) because the two high-toned syllables are separated by two other syllables.

A derivational approach can account for (15) by ordering tone spread after creation of the plateau. But once again, this ordering is arbitrary and opaque, whereas no comparable arbitrary assumptions are needed under the peak delay analysis.

4.4   Peak Delay in Kikuyu

In this section I apply the PDT approach to Kikuyu. Recall that a pervasive characteristic of Kikuyu is the shifting of tones one syllable to the right of their underlying hosts. The data from (2) and (3) are repeated below. The tone of each morpheme varies according to the identity of the preceding morpheme. We can tell that morphemes such has -*ma*- and -*tom*- are lexically specified with high tones, even though -*ma*- and -*tom*- may themselves surface low-toned, because when these morphemes appear, the following morpheme is always high-toned.

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(16) a. to rɔr aɣ a   'we look at'

         to mo rɔr aɣ a   'we look at him/her'

         to ma rɔ́r aɣ a   'we look at them'

         má rɔ́r aɣ a   'they look at'

         má mó rɔr aɣ a   'they look at him/her'

         má má rɔ́r aɣ a   'they look at them'

     b. to tom áɣ a   'we send'

         to mo tom áɣ a   'we send him/her'

         to ma tóm áɣ a   'we send them'

         má tóm áɣ a   'they send'

         má mó tom áɣ a   'they send him/her'

         má má tóm áɣ a   'they send them'

This is simple enough to account for in rule-based terms. The analyses of
Clements & Ford (1979) and Clements (1984) are grounded in a rule whose effect
is shown in (17), where 'τ' represents TBUs and 'T' represents tones.

$$(17) \quad \left[\begin{array}{c} \tau \quad \tau \\ \diagdown \diagup \\ T \end{array} \right]$$
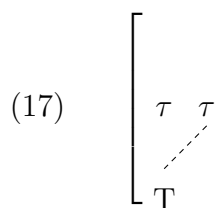
This rule, which is the first tone rule that applies in their derivations, links
the first tone to the second TBU. As subsequent tones link to available TBUs to
the right of the second TBU, the eventual effect of (17) is to link tone n to TBU
$n+1$; that is, each tone appears one TBU to the right of its expected placement.

We cannot easily translate (17) into an OT constraint. The constraint producing tone shift must be a markedness constraint (since tone shift is clearly not the exponent of some faithfulness imperative), but there is no obvious markedness consideration that would motivate the first tone associating with the second TBU.

Fortunately, the peak delay facts discussed in §4.2 afford a solution. Without detailed phonetic information for Kikuyu of the sort that Myers (1999, 2003) brings to bear on Chichewa and Kinyarwanda, it is impossible to know whether Kikuyu's tone shift is phonetic or phonological in nature. Consequently, this section briefly considers two PDT analyses of Kikuyu tone shift, one that takes shifting to solely reflect peak delay, and another that produces phonological shifting of tones from one TBU to the next.

It is also here that we see how PDT can be implemented phonologically. Recall that tone shift leads to floating low tones in some cases, so if shifting is really just peak delay, the phonology must be aware of peak delay so that these low tones can be prevented from associating with TBUs. Under the hypothesis that Kikuyu's tone shift is an artifact of peak delay, the floating tones show that peak delay is not merely a low-level, extra-grammatical process.

The section proceeds as follows: §4.4.1 presents additional data to be accounted for. §4.4.2 presents the PDT analysis, and §4.4.2.2 shows how this analysis can produce the downstep facts illustrated in (5). §4.4.3 presents a revision of the PDT analysis that takes tone shift to be phonological, and §4.4.4 briefly shows how the formal PDT analysis is applicable to other tonal phenomena.

4.4.1 Tone Shift in Kikuyu

Unlike Chichewa, Kikuyu has a phonological low tone: H contrasts with L rather than with the absence of tone. (Not every morpheme contributes a tone, so there are still toneless morphemes. But every syllable surfaces with some tonal specification.) The data below are taken from Clements & Ford (1981, 1979) and Clements (1984). For simplicity, I only indicate high tones except where this would create ambiguity.

Clements & Ford (1979) and Clements (1984) develop rule-based analyses of tone assignment in Kikuyu that are centered around tone shift. In this section I follow the latter's discussion of the data. I also follow Clements (1984) in adopting the syllable as the TBU (see also Kaplan (2007)).

The verbs in (16) illustrate tone shift, as do the nouns below:[12]

(18) a. LL   kemore   'torch'

      b. LH   moɣatĕ   'bread'

      c. HL   moɣɛká   'rug'

      d. HH   maɣɔkɔ́   'bark'

      e. LHL   kaɲamŏ   'small animal'

      f. HLHL   karání   'clerk'

Each noun stem contributes a specific tone pattern (indicated in the leftmost column in (18)), and the noun-class prefix—the initial CV sequence in these examples—contributes an additional low tone. Tone assignment proceeds as fol-

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[12]Clements (1984:284) states that the tone patterns illustrated in (18) "appear sentence-finally after affirmative verb forms that do not induce H Tone Spread upon following words." Some of these patterns are changed in other contexts by rules that are not relevant here.

lows: The first tone—the L of the noun-class prefix—associates with the second syllable of the noun as required by (17). Subsequent tones associate to each of the following TBUs in a one-to-one, left-to-right fashion, with the last tone spreading to excess TBUs. The first tone spreads leftward, back to the word-initial syllable that was originally skipped. If there is a free H after all TBUs have been assigned a tone, this H docks on the final syllable, creating a contour as in (18b) and (18e). Free low tones remain floating and induce downstep, as was shown in (5) above. See also §4.4.2.2. To illustrate the tone-assignment schema, these rules yield the structure in (19) for (18e).

(19)   ka   ɲa   mo

              L   L   H   L
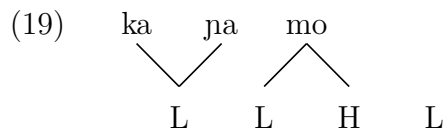
The exceptional behavior of *karání*, which we would expect to be (something like) **karaní*, comes from an underlying association between the second H and the final syllable. Therefore, after the noun-class marker's L associates with the second syllable and spreads back to the first, we have the representation in (20).

(20)   ka   ra   ni

              L H L H L
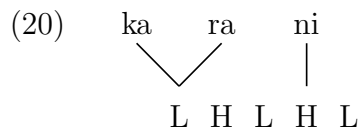
The first H then links to the second syllable by the same rule that creates a contour in (18b). This triggers delinking of the initial L from this syllable because contours are not allowed word-internally. Thus we end up with (21). As a full analysis of Kikuyu's tonal system would stray too far from the goals of this chapter, I will not consider exceptional cases like *karání* any further.

(21)   ka   ra   ni

                \ | |

            L H L H L
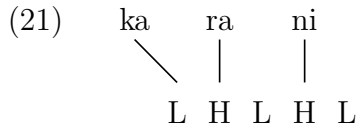
The verbal system is similar to the nominal system in terms of peak delay, but there are additional complexities. More morphemes are involved, and not all morphemes contribute a tone. The clearest evidence for tone shift was already presented in (16a) and (16b), and I will not recapitulate that here. The same principles are at work: The first TBU is skipped and is subsequently the target of leftward spreading, and other TBUs receive their tones via standard association rules. Excess low tones float, but excess high tones do not.

Before beginning the peak delay analysis, some technical issues must be dealt with. Since the analysis below takes tone shift to reflect peak delay, an unshifted representation is adopted for each form. For example, *kaɲamŏ* is assumed to have the structure in (22) instead of (19). Because of peak delay, though, it appears that the first two low tones are associated one syllable rightward.

(22)   ka   ɲa   mo

            | | |

           L   L   H   L
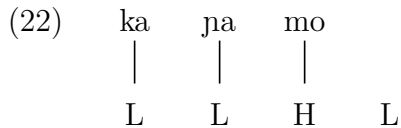
Also, I assume that a tone's phonetic onset begins as soon as the preceding tone's peak or trough is reached and thus coincides with the same mora that the preceding peak/trough coincides with. This is obviously an idealization since f_0 targets can be maintained for some duration, but this assumption will streamline the analysis below and is necessary because of the lack of phonetic data about Kikuyu.

4.4.2 Tone Shift as a Phonetic Phenomenon

This section discusses Kikuyu tone shift under the assumption that this is a phonetic phenomenon in which the peak or trough of each tone appears on the syllable to the right of the one that hosts the corresponding H or L. Tones themselves do not shift. Obviously the viability of this analysis is contingent on verification of the phonetic nature of tone shift.

4.4.2.1 Peak Delay and Tone Shift

The claim advanced here is that what has been called tone shift in Kikuyu is really the same as tone spreading in Chichewa: both are grounded in peak delay. From a theoretical basis, Philippson (1998), e.g., argues that tone shift is just tone spread with an extra step: After a tone spreads to the adjacent TBU, its original association line is delinked. Beyond this representational connection, evidence that spreading and not shifting occurs in Kikuyu comes from word-initial syllables. In all of the examples given above in (16) and (18), the first syllable has the same tonal specification as the second syllable. This is expected under a spreading approach: The first syllable simply spreads its tone to the second syllable. But under a tone shift approach, where the first syllable is skipped altogether, this first syllable should surface either with an invariant default tone (if shifting is phonological; i.e. driven by (17)) or some neutral pitch level (if shifting involves displacement of the peak belonging to the first syllable's tone). That Kikuyu exhibits spreading is revealed by Clements's (1984) rule that spreads the initial tone leftward back to the syllable that was originally skipped (see (19)). This rule undoes the effect of tone shift; we might as well associate the first tone to the first

TBU and then spread that tone instead.

Under the analysis developed here, the details of the first two syllables of a word in Kikuyu are identical to the characterization of Chichewa's tone spread. The tone's onset appears on the first syllable, and Peak Delay requires the peak to be postponed until the next syllable.

Why, then, don't we find (reports of) spreading with all tones in Kikuyu? Since Kikuyu has phonological low tones, there are increased pressures in this language to avoid stretching out a tone's articulation for too long. Overextended articulations encroach upon neighboring tones and their own implementational requirements.

More specifically, consider the diagram in (23), which is a highly schematized representation of the pitch track for a Kikuyu word. Approximate locations of onsets are marked with ◇, and approximate locations of peaks are marked with ●. These markers are merely an expository convenience and should not be interpreted as formal claims about where tonal articulations begin and end. In the first syllable, which is formally associated with a high tone, the onset for the tone begins in that syllable. Peak delay ensures that the peak is not reached until the second syllable. Once the peak is reached, the articulation for the low tone can begin immediately. The onset for the second syllable's low tone appears in that syllable, just after the first H's peak. This might mean that the trough associated with this L may appear in the third syllable while still providing sufficient distance between the onset and trough in accordance with peak delay—the low tone's trough is reached in the syllable after the one with which the L is associated.

Articulation of the third syllable's H cannot begin until this trough is reached.

This means that the onset for the H occurs in the third syllable, but again peak delay forces the peak into the fourth syllable. In the fourth syllable, the onset for the tone associated with this syllable again cannot begin until the peak from the first tone is reached. Peak delay forces the trough for the fourth syllable's L into the fifth syllable. In this syllable, which is the last in the form, the high tone's onset begins once the preceding L's trough is reached, at which point a steep rise is required: with no following syllable to host the H's peak, peak delay must be disregarded if the H's peak is to be articulated.

(23)
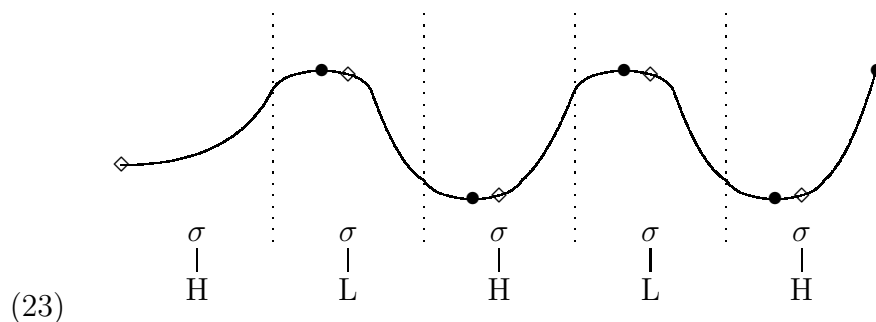
(It's important to keep in mind that this diagram and the ones below are merely idealizations that illustrate only the possible relative timing of peaks, onsets, and TBUs in a coarse way. I abstract away from factors like downdrift (Hyman & Schuh 1974). See, e.g., Myers (1999, 2003) for actual pitch tracks— from Chichewa—whose details I abstract away from here.)

Except for the first and last syllables, two important events occur in each syllable: the peak for the tone of the preceding syllable, and the onset for that syllable's own tone. The final syllable must also host its own tone's peak since there is no following syllable in which this peak can appear. These properties

give the impression of tone shift on each non-initial syllable, the appearance of a contour tone on the last syllable, and the impression of tone spread in the first syllable. The principles that drive this displacement are the same as the ones that drive peak delay in Chichewa, but "shifting" instead of "spreading" occurs because of the higher tonal density in Kikuyu.

(It is tempting to suggest that this reasoning holds universally: When there's an H/∅ contrast we find spreading, and when there's an H/L contrast we find shifting. But there is no such crosslinguistic correlation. Jita, for example, has a H/∅ contrast with tone shift (Downing 1996). Perhaps for Jita it is more accurate to claim that tone shift involves alignment of the tone's onset with the end of the high-toned syllable. I won't make this move for Kikuyu, however: Word-initial syllables are described as having the same tonal specification as the following syllable, so it is necessary to have some part of the high tone on the initial syllable.)

The first syllable is not preceded by another syllable, so it doesn't host a preceding tone's peak. In this way it is comparable to tones' host syllables in Chichewa, where the OCP and lack of a phonological L ensure that tone-bearing syllables are never adjacent. This means that the entire duration of each tone-bearing syllable in Chichewa is available for the onset of that syllable's tone. Similarly, a word-initial syllable in Kikuyu isn't preceded by another tone-bearing syllable and therefore can devote its entire duration to its tone's onset. In Chichewa and word-initial syllables in Kikuyu, similar tonal environments lead to impressionistic tone spread. Initial syllables in Kikuyu are reported as high-toned for the same reason tones' original hosts are reported as high-toned in Chichewa: although the peak isn't reached in that syllable, enough of the tone's articulation—

i.e. its onset and rise—appear in there to signal the presence of a high tone.

Non-initial syllables in Kikuyu cannot make their whole durations available to the onsets of their tones because they must also cope with peaks from tones of preceding syllables. It is not surprising that this situation has been identified by transcribers and analysts as tone shift instead of tone spread. Since each tone's onset is necessarily relegated to some rightward portion of a syllable, it can reasonably be interpreted as anticipatory coarticulation (the speaker is preparing for the tone that has shifted to the next syllable) rather than an indication that the onset's tone has simply spread to the next syllable.

A proponent of PDT could stop here were it not for the floating low tones that become downstep operators. These tones show that if Kikuyu's tone shift is really just peak delay, then the phonology must be aware of peak delay, and consequently PDT must be implemented formally. The next section shows how this can be done.

4.4.2.2   Tone Shift and Downstep

Certain words in Kikuyu trigger downstep on the following word. Examples of this were given in (5), repeated in (24).[13]

(24)   moaɣáhiɲá ˈné moɛɣá   'the weakling is good'

        kariokí ˈné moɛɣá   'Kariũki is good'

        keaɣárarɔ ˈné keɛɣá   'the stile is good'

        βiriβiri ˈné ɲjɛɣá   'chillies are good'

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[13]This downstep may be displaced to the right in certain contexts such as the one illustrated in (6); see Clements & Ford (1981) for a detailed discussion.

Clements & Ford (1979) and Clements (1984) explicitly connect these down-steps to the presence of a floating low tone. In each form, the result of tone shift is that after each TBU has been assigned a tone, there is a low tone left over that cannot be assigned to an unoccupied TBU, and this floating tone triggers downstep.

There is other evidence that this L floats and survives stray erasure. For example, a process called tonal flattening by Clements & Ford (1981) lowers a sentence-final H to L. The process holds for citation forms and certain kinds of sentences. Flattening is illustrated in (25). In each pair, the first form is a sentence type that is not subject to flattening. The final noun in each case ends with a high tone. But when this noun is in isolation, the high tone disappears.

(25) a. nderaːrɔ́rirɛ keŋaɲí   'I watched the crocodile'
          keŋaɲi   'crocodile'

      b. nderaːrɔ́rirɛ ŋgiŋgɔ́   'I watched a neck'
          ŋgiŋgɔ   'neck'

      c. nderaːrɔ́rirɛ moβakĕ   'I watched the tobacco-plant'
          moβake   'tobacco-plant'

      d. nderaːrɔ́rirɛ moɣɛraniá   'I watched the examiner'
          moɣɛrania   'examiner'

Contrast these examples with those in (26). In these cases, the sentence-final nouns come from the set of nouns that induce downstep as in (24). Flattening does not affect their citation forms.

(26)   a.   nderaːrɔ́rirɛ moaɣáhiɲá   'I watched the weakling'

              moaɣáhiɲá   'weakling'

       b.   nderaːrɔ́rirɛ kariokǐ   'I watched Kariũki'

              kariokǐ   'Kariũki'

       c.   nderaːrɔ́rirɛ ihóá   'I watched the flower'

              ihóá   'flower'

   d.   nderaːrɔ́rirɛ ŋgǒ   'I watched the firewood (pl.)'

              ŋgǒ   'firewood'

The reason these nouns are impervious to flattening is that the final high tones are not in fact final. The same floating L that caused downstep in (24) protects the words in (26) from flattening. Both downstep and flattening are explained if certain words possess floating low tones at their right edges.

Producing these floating tones seems to crucially rely on the tone shift rule in (17). For example, according to Clements (1984), the noun *moɣɛká* 'rug' contains a stem characterized by the tonal pattern HL. Adding the noun-class prefix's L, we have LHL, and applying the normal tone-association conventions without (17) yields (27).

(27)   mo   ɣɛ   ka
           | | |
          L   H   L

There is no floating L in this structure and therefore no indication that this form induces downstep and blocks flattening. With the tone-shift rule added, we get (28), which does have a floating low tone because, once it comes time to

associate the rightmost L, all TBUs are already occupied.[14]

(28)   mo   ɣɛ   ka

         L   H   L
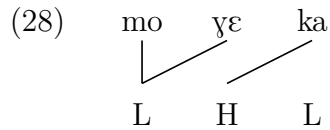
From this point of view it seems as though the traditional tone shift analysis is superior to PDT since the latter is committed to the structure in (27). But it is simple to grant peak delay admission into the phonological grammar where it will have the power to set certain tones afloat.

If peak delay is to be implemented formally, we need a constraint that motivates it. The constraint in (29) does this. This constraint ensures that an output allots enough time for a tone's rise or fall in pitch to be successfully executed. An effect of this constraint is that the onset of the pitch excursion (the point at which the rise or fall in f_0 begins) and the f_0 peak are sufficiently separated. If the onset is anchored to the tone's host syllable, this produces peak delay because the f_0 peak must be held back until PEAK DELAY is satisfied. In some respects, this constraint is a more nuanced version of Hyman's (2005) LAG, which requires a tone's target to be reached in the syllable after the tone's host; see §4.7.2. See also Li (2003), whose RISETIME and FALLTIME families of constraints are similar to PEAK DELAY in that they favor the allotment of certain durations for phonetic rises and falls.

(29)   PEAK DELAY: The f_0 rise or fall for a tone must be allotted an adequate duration.

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[14]The rule that associates floating tones to already occupied TBUs as in (19) doesn't apply here because that rule is specific to floating H.

I am aware of no studies that have found "trough delay" for low tones, but there are several potential justifications for defining PEAK DELAY so that it affects both H and L. First, the same perceptual justification for peak delay given at the end of §4.2 holds here: with the f_0 fall occurring late in the syllable, it is more likely to be reliably heard. Articulatorily, we can also suppose that if articulation of pitch excursions is sluggish for pitch rises, it may also be sluggish for pitch falls, although this sluggishness may be different for rises and falls.

Alternatively, if learners encounter a language that has peak delay for just high tones, they may extrapolate to all tones and thus posit a constraint like the one in (29).

What is "an adequate duration?" With respect to Chichewa, Myers (1999:222) states that peak delay "varies systematically as a function of syllable duration," and he gives linear regression models that formalize this function. The model in (30), for example, is the model that (according to Myers) best accounts for the data from his subject SM.

(30)   Peak delay $= (((-.88P) + 1.43) * S) - 3.89$

    where P = syllable position (0 for medial, 1 for penult) and S = syllable duration

I'll assume that PEAK DELAY references a function such as this one and assigns violations to candidates whose peak delay is not within some window around this function's output. For a more nuanced view of how this sort of timing requirement might be modeled, see Byrd (1996) and Browman & Goldstein (1986). It might also be possible to build the timing specifications directly into the constraints

themselves, as Li (2003) does.[15] To simplify Tableaux, I will make the idealistic assumption that a violation is incurred when the peak and onset are contained within the same light syllable or the same half of a heavy syllable. Equivalently, the onset and peak must not coincide with the same mora.[16]

The function in (30) comes from a study of Chichewa and is surely incorrect for Kikuyu, but to my knowledge no appropriate phonetic studies have been conducted on Kikuyu, so there is no way to know what the correct function should look like. It also seems reasonable to suppose that pitch rises and falls might be subject to different functions; again, I know of no relevant data, but Ohala & Ewan (1973) and Sundberg (1979) report that pitch rises take longer to execute than equivalent falls. The simplifying rubric for assigning violations from the previous paragraph permits an analysis of Kikuyu despite these empirical gaps.

PEAK DELAY says nothing about where the pitch excursion occurs with respect to the larger phonological structure. There are a number of imaginable strategies that would or would not satisfy this constraint. For example, the peak could overlap with the tone's host syllable, forcing the pitch excursion's onset leftward into the preceding syllable to comply with PEAK DELAY. This is apparently what happens in Kinyarwanda, according to Myers (2003). Strictly speaking, to decide between shifting the peak rightward and shifting the onset leftward, we

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[15]However, Li's constraints, which mention specific intervals such as 120ms, lose the connection that peak delay has to factors such as syllable duration. And since those constraints specify minimum durations, another constraint is needed to prevent excessively long rises and falls. The windowed approach of PEAK DELAY simplifies matters by building maximum and minimum durations into one constraint.

[16]In languages that lack tone spread/shift of the sort discussed here, PEAK DELAY may not be ranked high enough to trigger displacement (see §4.4.4), or the separation between onsets and peaks required by that language's version of PEAK DELAY may not be long enough to move these landmarks into neighboring syllables.

need constraints like those in (31) (cf. Li's (2003) ALIGN-LO and ALIGN-HI constraints).

(31)   a.   COINCIDE(Peak, $\acute{\sigma}$): Every f_0 target coincides with a syllable with which the target's tone is associated.

       b.   COINCIDE(Onset, $\acute{\sigma}$): Every pitch excursion's onset coincides with a syllable that hosts the target peak's tone.

In Kinyarwanda, COINCIDE(Peak) outranks COINCIDE(Onset), meaning that a tone's peak remains with the tone and the onset is displaced, and in Kikuyu and Chichewa we have the opposite ranking with the opposite effect. To simplify Tableaux, I will not show these constraints and will not consider candidates that have leftward displacement of a tone's onset. See Zsiga & Nitisaroj (2007) for evidence from Thai that alignment of tones' peaks with certain (sub)syllabic landmarks plays an important role in listeners' perceptions of tones. This result suggests that grammars have reason to enforce such alignments, and therefore the constraints in (31) (among other possibilities) are warranted.

The studies cited above that investigate peak delay report that the f_0 peak is delayed with respect to some prosodic landmark such as the beginning of the tone's host syllable or a segmental landmark like the onset or nucleus of some syllable. But the definition of PEAK DELAY used here takes peak delay to be timed with respect to the beginning of the articulation of the tone, i.e. the onset. This discrepancy might be explained by a high ranking of COINCIDE(Onset) in the languages for which peak delay has been investigated. With the tone's onset fixed with respect to prosodic and segmental landmarks, it is no surprise that the

tone's peak is timed with respect to these landmarks, even if PEAK DELAY is defined as in (29).

The schematic pitch track for (27) as predicted by the peak delay approach is given in (32), with each tone's peak/trough appearing in the syllable after the one the tone is associated with, except for the last tone.

(32)

$$
\begin{array}{ccc}
\sigma & \sigma & \sigma \\
| & | & | \\
L & H & L
\end{array}
$$
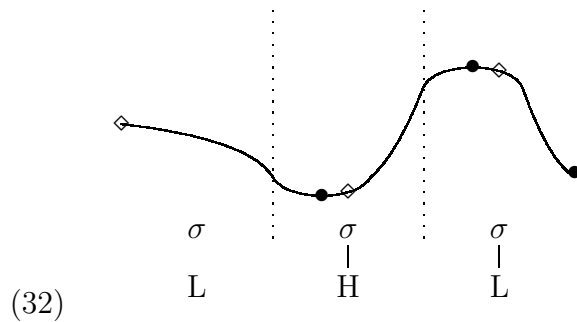
This configuration incorrectly predicts a falling pitch on the last syllable: *moɣɛkâ. In fact, to my knowledge, falling contours do not appear in Kikuyu at all. Under the peak delay approach, this means that Kikuyu does not allow a high pitch target to be followed by a low pitch target in one syllable. We could adopt a constraint banning such configurations outright while still allowing rising contours, but this would contradict other research showing that rising contours are more marked than falling contours (e.g. Zhang 2001). Instead, I adopt the constraint in (33), which bans all phonetic contours (on the grounds that they're more marked than level pitch specifications).

(33)   *MULTI-PEAK: Multiple pitch targets on one syllable are disallowed.

Although this constraint may seem to duplicate the effect of PEAK DELAY in that both constraints favor greater spacing between f_0 landmarks, the two constraints are quite different. PEAK DELAY requires sufficient space between onsets and their corresponding peaks, no matter where they fall with respect to syllable boundaries.[17] *MULTI-PEAK is more like a constraint against contour tones (although I do not use *CONTOUR for reasons that will become clear below) in that it penalizes multiple peaks/troughs on one syllable, no matter how far apart they are. Whereas PEAK DELAY cares about timing but not coincidence with prosodic elements, *MULTI-PEAK cares about prosodic coincidence and not phonetic timing.

We can now see the impetus for setting certain low tones afloat: PEAK DELAY requires an L's f_0 trough to appear in the syllable after the tone's host. When the low tone is associated with the word-final syllable, PEAK DELAY cannot be satisfied, and the trough must appear on the final syllable along with the preceding H's peak. However, this runs afoul of *MULTI-PEAK. To avoid violating both PEAK DELAY and *MULTI-PEAK, the tone is set afloat and not pronounced.
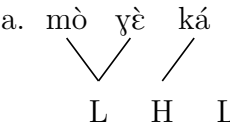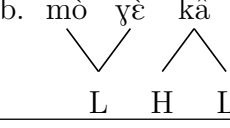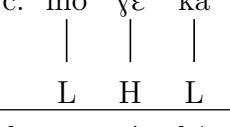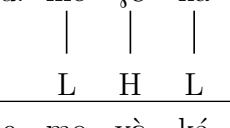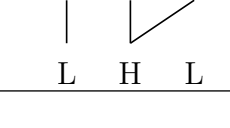
In addition, constraints requiring one-to-one, left-to-right association of tones to TBUs are needed. I will use ASSOCIATE to represent this set of constraints. It assigns a violation for every tone that is not associated with its "expected" host under a one-to-one, left-to-right system. E.g., if the third tone in a form does not associate with the third syllable, a violation is incurred. A more nuanced approach to tonal association is obviously desirable, but the simplification that ASSOCIATE provides will allow the current analysis to focus on more important

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[17]Recall that the practice adopted here of assessing violations of PEAK DELAY according to whether or not the onset and peak are on the same mora is just a convenient shortcut.

issues. See Yip (2002) for an overview of other possibilities and Kaplan (2008b) for a more explicit approach within PDT.

This is illustrated in (34). The following notation is used. Association lines mark formal phonological associations. Diacritics mark the location of each tone's peak. For clarity, indices in subsequent Tableaux identify which tone's peak is hosted by which syllable. Onsets are not marked explicitly, but they should be assumed to appear in the most advantageous location immediately after the previous tone's peak. This means wherever possible, an onset appears in the syllable before its corresponding peak. Of course, if a peak is in the initial syllable, its onset must also be in that syllable. Likewise, when two peaks share a syllable, the onset for the second peak must of course also be in that syllable.

(34)

/mo-ɣɛka LHL/	Peak Delay	*Multi	Assoc	*Float
a. mò ɣɛ̀ ká \\ / L H L			**!	*
b. mò ɣɛ̀ kâ \\ /\ L H L	(*!)	*!	*	
c. mò ɣɛ́ kà | | | L H L	*!			
d. mo ɣɛ̀ kâ | | | L H L		*!		
☞ e. mo ɣɛ̀ ká | \\ L H L			*	*

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I assume that tones are floating but ordered in the input. Under the traditional analysis in which each tone is linked to the syllable to the right of its otherwise expected host, candidate (a) is the expected form. It is ruled out here because of excessive violations of ASSOCIATE: The high tone, which is the second tone, is not associated with the second syllable, and the last tone is not associated with any syllable. That is, the traditional form is eliminated by the constraints that enforce the standard association conventions.

Candidate (b) violates *MULTI-PEAK because of the phonetic contour on the last syllable. It may also violate PEAK DELAY if, as shown in the Tableau, the first L's trough appears on the first syllable. Candidate (c) obeys the standard association conventions, but it loses because the peaks are not delayed. Candidate (d) is similar except that it has delayed peaks: Each tone's peak or trough appears on the following syllable wherever possible. But this form loses because of the final contour. Candidate (e) avoids the problems that doom the other candidates by obeying the normal association conventions but leaving the final L floating. Both PEAK DELAY and *MULTI-PEAK are satisfied because this candidate essentially reduces the number of tones that must be pronounced. Even though this form differs from the traditional form in terms of the formal associations of tones, it matches the traditional analysis in terms of the phonetic pitch profile, as indicated by the diacritics.[18]

Candidate (d) shows why *CONTOUR cannot be used. *CONTOUR is typically invoked to prevent multiple tones from being linked to one syllable, so it would not

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[18]To be thorough, we may need another constraint preventing associated tones from being unpronounced, which would be another way to satisfy *MULTI-PEAK and PEAK DELAY. Other constraints are needed to ensure that the last L floats, not some other L in the form. I will not consider these complications here.

penalize this candidate because each syllable is formally linked to just one tone. Consequently, a constraint like *Multi-Peak, which deals with tones' phonetic implementations rather than their formal associations, is required.

Given free rein, *Multi-Peak would correctly ban the falling contour in *moɣɛkâ but also incorrectly ban the rising one in moɣatɛ̆ 'bread.' The difference between these forms, in terms of the tone shift analysis, is that whereas the leftover H from moɣatɛ̆ associates with the already occupied final syllable as in (35), the same does not happen when a low tone is leftover. Although I adopt a different configuration here, the insight that this analysis reveals is worth retaining: Kikuyu allows floating L but not floating H. By splitting *Float into two constraints, one banning floating H and one banning floating L, we can capture this difference. *Float-H outranks *Multi-Peak, but *Float-L does not.[19]

(35)   mo   ɣa   tɛ
        \ /   \ /
         L   L   H
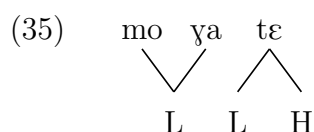
Adding these constraints to the ranking, we can produce both moɣɛká and moɣatɛ̆. *Float-H prevents the final H in moɣatɛ̆ from floating. Consequently, the strategy for satisfying both Peak Delay and *Multi-Peak is unavailable, and one of these constraints must be violated. Since this form has a rising phonetic contour, it must be *Multi-Peak that is violated. We therefore have evidence that both *Float-H and Peak Delay outrank *Multi-Peak. *Float-L is ranked below all of these constraints. The Tableau and moɣatɛ̆ given below. The

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[19]Splitting *Float in this way might also shed light on karání 'clerk' (18f), which was labeled exceptional above because although the root's lexical tones are HLHL, the first L is skipped by the tone mapping system. Notice that skipping this L ensures that both Hs can be associated, leaving only Ls floating. This state of affairs is favored by the ranking *Float-H ≫*Float-L.

new Tableau for *moɣɛká* is essentially the same as (34), so it is not recapitulated here.

(36)

/mo-ɣatɛ LLH/	*Fʟ-H	PD	*Mᴜʟᴛɪ	Assoc	*Fʟ-L

☞ a. mo ɣà$_1$ tɛ̆$_2$
      | | |
     L$_1$ L$_2$ H
			*		

b. mò$_{(1)}$ ɣà$_1$ tɛ̆$_2$
      ∨   ∧
      L$_1$ L$_2$ H
		(*!)	*	*!*	

c. mò$_1$ ɣà$_2$ té
     | | |
     L$_1$ L$_2$ H
		*!			

d. mo ɣà$_1$ tɛ̆$_2$
     | ∨
     L$_1$ L$_2$ H
	*!			*	

Candidate (b), which is the traditional tone-shift form, loses for two reasons. First, it violates the constraints enforcing the standard association conventions represented by Aꜱꜱociate. It could also be eliminated by Peak Delay depending on which of the first two syllables the first L's peak appears on. Candidate (c) obeys the association conventions, but it loses because the peaks and troughs aren't delayed. Candidate (d) leaves the H unassociated and thereby fatally violates *Fʟᴏᴀᴛ-H. Candidate (a) wins: All tones are associated in a way that obeys the association conventions, and peaks and troughs are delayed wherever possible. A violation of *Mᴜʟᴛɪ-Peak is incurred by this form under pressure from Peak Delay and *Fʟᴏᴀᴛ-H.

It might be objected that candidate (a) violates PEAK DELAY because the onset and peak of the final H necessarily appear in that syllable. One response might be that due to final lengthening (e.g. Horne et al. 1995, Lehiste 1972, Lehiste et al. 1976, Lunden 2006, Oller 1973, Wightman et al. 1992), these syllables are long enough to host this onset with an appropriately delayed peak. Kaplan (2008b) fleshes out this strategy in detail.

This section has shown that when implemented formally, PDT (which is an inherently phonetic approach to tonal phenomena) is capable of producing the floating low tones that are traditionally considered a product of Kikuyu's tone shift. I argued above that PDT offers an elegant and insightful way to understand tone spread in Chichewa, and here we see that it can be a powerful tool in phonology. If PDT finds experimental support in Kikuyu and other languages, it adds to the growing body of evidence that phonological grammars may not be so distantly removed from measurable articulatory, acoustic, and phonetic facts.

This analysis follows Morén & Zsiga (2006) in that it proposes a phonological account of what is, at heart, a phonetic phenomenon. In Morén & Zsiga's analysis of Thai, they argue that pitch peaks are right-aligned with moras and develop an OT account that positions tones on the moras with which their peaks are aligned. The analysis developed here takes this a step farther by adding the alignment of pitch landmarks to the phonology.

However, I noted above that there is no experimental evidence (that I am aware of) showing that Kikuyu's tone shift is a phonetic phenomenon of the sort that Myers (1999, 2003) argues Chichewa's and Kinyarwanda's tone spread to be. Obviously, phonetic facts in Kikuyu that mirror Myers's results would support

PDT. But in the next section I show that PDT is also capable of producing phonological tone shift. By requiring tones' formal associations to follow their delayed peaks, PDT can produce the phonological structures that are traditionally posited for Kikuyu.

4.4.3 Tone Shift as a Phonological Phenomenon

This section shows how the PDT analysis developed in the previous section can be amended to produce phonological tone shift. Here I discard the assumption that tone shift is purely phonetic, and in this section I will treat it as a genuine phonological phenomenon in which each tone associates with the syllable to the right of the one it would be expected to associate with under normal tone association conventions. I will call this analysis the phonological analysis and the analysis from the previous section the phonetic analysis.

The constraint ranking adopted in §4.4.2.1 is repeated in (37).

(37)   *FLOAT-H, PEAK DELAY ≫*MULTI-PEAK ≫ASSOCIATE ≫*FLOAT-L

Recall that a more elaborated version of PDT must adopt constraints like those in (31) to account for the fact that tones' peaks appear after their phonological hosts in languages like Chichewa (and Kikuyu, under the assumptions of the preceding section), but in Kinyarwanda, peaks stay put and onsets are shifted leftward. In Chichewa and Kikuyu, PEAK DELAY and COINCIDE(Onset) outrank COINCIDE(Peak): To ensure that (i) sufficient time is given for a tone's f_0 excursion and (ii) this excursion begins in the tone's host syllable, peaks are shifted to the following syllable. But in Kinyarwanda, PEAK DELAY and COINCIDE(Peak)

outrank COINCIDE(Onset). In this language, a sufficient time for the excursion is provided by shifting the onset under pressure from COINCIDE(Peak) to keep tones' peaks in their host syllables.

COINCIDE(Peak) has other applications though. By ranking it above the constraints that produce the normal left-to-right, one-to-one tone association pattern, tones' formal associations can follow their delayed peaks. PEAK DELAY is still ranked high enough to produce the pitch contours generated by the phonetic analysis, but now COINCIDE(Peak) ensures that tones' formal associations mirror these delayed peaks.

This is illustrated in (38). Compare this Tableau with (36) above. Whereas candidate (b) would have been eliminated by ASSOCIATE above, here it is the winner. This is because of the influence of COINCIDE(Peak): Candidate (a), which was the winner above under the assumption that tone shift was purely phonetic, now loses because there is a mismatch between tones and the alignment of their peaks.

There are two choices at this stage. Peaks can be retracted so that they line up with their tones' hosts, as in candidate (c), or peaks can be left where they are and the tones can be formally shifted, as in candidate (b), so that there is again a match between formal associations and peaks' positions. The first option runs afoul of PEAK DELAY. It is possible for the non-initial tones' onsets to shift leftward as in the Kinyarwanda pattern, but the initial tone's onset has nowhere to go because there is no syllable preceding this tone's host. Candidate (b) avoids this violation by instead disregarding the lower-ranked ASSOCIATE.[20]

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[20]I assume that the first tone associates with the first syllable—and not just the second—to satisfy a constraint requiring all TBUs to be associated with some tone.

(38)

/mo-ɣatɛ LLH/	*Fʟ-H	PD	Coin(Pk)	*Multi	Assoc

a. mo ɣà$_1$ tɛ̌$_2$
 	
      | | |
 	
     L$_1$ L$_2$ H
			!	*	

☞ b. mo ɣà$_1$ tɛ̌$_2$
 	
       ＼／   ／＼
 	
     L$_1$ L$_2$ H
				*	**

c. mò$_1$ ɣà$_2$ tɛ́
 	
      | | |
 	
     L$_1$ L$_2$ H
		*!			

This result is important: We saw above for both Chichewa and Kikuyu that PDT can cause mismatches between tones' formal associations and their phonetic implementations, and now we see that a high-ranking Peak Delay does not necessarily require such mismatches. With Peak Delay and Coincide(Peak) outranking Associate, the normal tone association desiderata take a back seat to pitch timing requirements so that the formal tone configuration is partly dependent on the pitch profile. The interaction between tones and their phonetic implementations is a two-way street: Tones affect a form's phonetic pitch, but pitch considerations can also influence the tonal configuration.

This concludes the PDT analysis. We've seen how a phonetic approach to noniterative tone spread and shift can cope with the facts. For Chichewa, the situation as Myers (2003) describes it is simple: tones do not spread, but their peaks are reached in the syllable after the one their tones are associated with. For Kikuyu, a similar situation holds, but with one complication. PDT must be implemented phonologically so that floating low tones can be produced. Simply adding constraints like Peak Delay and *Multi-Peak to the grammar is

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sufficient to produce these floating tones.

But PDT can be understood in an even more phonological way. We can use constraints like PEAK DELAY and COINCIDE(Peak), which are primarily concerned with the phonetic implementation of a phonological structure, to generate a traditional tone-shift representation. This is a natural consequence of admitting PDT into the formal phonology, a move which was independently necessitated by Kikuyu's floating tones. The result is that PDT provides an analysis of Kikuyu tone shift whether or not this is a purely phonetic phenomenon.

Giving control of peak delay to the phonological grammar results in a theory in which phonetics and phonology are not wholly distinct. Much recent work (such as Dispersion Theory (e.g. Flemming 2002, Padgett 2003)) has argued for a phonetically sophisticated phonological grammar in which acoustic, articulatory, and perceptual factors play direct roles in the formal phonology. The analyses proposed here obviously support this view, but they are not incompatible with the view that "phonological constraints must in some cases operate at a level distinct from the phonetics" (Morén & Zsiga 2006:172). I have argued here that separate, independent constraints may exist for phonological elements and their phonetic exponents. In this way, phonetics and phonology interact but are not conflated.

The greatest drawback for PDT is the lack of phonetic evidence supporting it. Myers (1999, 2003) gives strong evidence in favor of PDT for two languages, but for this approach to be viable more broadly, experimental work on more languages is necessary. We might also ask how deeply phonetics and phonology are connected. The PDT analysis of Kikuyu makes the very strong claim that there is essentially no difference between phonetics and phonology in that even an

undeniably phonetic process like peak delay can be under grammatical control. I am not in a position to say whether or not this is a good result, but it must be kept in mind as PDT is evaluated.

Another concern is the factorial typology predicted by PDT. The constraints used above predict many tonal patterns. Most of these may be reasonable, but there are some that seem unusual. A complete factorial typology is not germane to the goals of this chapter, so I will mention just one predicted language. Consider a language with Kinyarwanda-style onset anticipation. In this language, PEAK DELAY, COINCIDE(Peak), and constraints for the language's association conventions outrank COINCIDE(Onset). If DEP-μ (or another constraint that prevents lengthening syllables) also outranks COINCIDE(Onset) and is ranked below the other constraints, then this language will exhibit initial-syllable lengthening when this syllable hosts a tone. This is because the normal onset-anticipation strategy is unavailable word-initially, so to have a delayed peak and conventionally associated tones, the first syllable must lengthen. I am unaware of any language like this, and if it is indeed unattested, it casts doubt on PDT.

4.4.4 Other Tonal Alignment Patterns in PDT

This section very briefly illustrates how other tonal patterns can be produced in PDT. The preceding sections have shown how PDT can produce languages in which a tone spreads rightward by one syllable, but this is just one of the systems that PDT can generate. Languages with no tone spread or shift are produced with the ranking in (39).[21] This example, from Ruciga (Cassimjee & Kisseberth 1998),

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[21]This is not to deny that a language may have "faithful" tone in general with specific movement, shifting, etc., operations in particular contexts. In such languages, the ranking in

contains one high tone. There is no spreading or shifting of this tone. (Cassimjee & Kisseberth (1998:16) state that the output in (39) is correct when this word stands in "medial position before a toneless modifier.") The onset and peak are indicated with underlining, just as in (13).

(39)

/e-ságama/ 'blood'	Id-T	Coin(Onset)	Coin(Peak)	PD
a. eságama			*!	
☞ b. eságama				*
c. eságama		*!		
d. eságáma	*!			

Under this ranking, it is more important for the onset and peak to be contained within the host syllable than to have an adequate peak delay. Alternatively, it seems plausible to suppose that the function that informs Peak Delay is determined on a language-particular basis. This means that Peak Delay might be less stringent in other languages so that it is satisfied by configurations in which the onset and peak are tautosyllabic, so even a language with a highly ranked Peak Delay might exhibit no spreading or shifting.

For Kinyarwanda, where a tone's onset appears in the syllable before the one with which the tone is associated, Coincide(Peak) and Peak Delay must outrank Coincide(Onset):

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(39) holds, but higher constraints can subvert the faithfulness that this ranking promotes.

(40)

/umusóre/ 'youth'	Id-T	Coin(Peak)	PD	Coin(Onset)
a. umus<u>óre</u>		*!		
b. umus<u>óre</u>			*!	
☞ c. umus<u>óre</u>				*
d. um<u>ús</u><u>óre</u>	*!			

As these Tableaux show, PDT has applications beyond the rightward tone spread and shift of Chichewa and Kinyarwanda.

4.5   Optimal Domains Theory

4.5.1   Chichewa in ODT

The first part of this chapter presented a phonetically oriented approach to non-iterativity in tone. The rest of this chapter deals with Optimal Domains Theory, a far more abstract and representationally oriented theory that can also make sense of these phenomena. I follow here the particular version of ODT developed by Cassimjee & Kisseberth (1998), who aim to account for exactly the kind of phenomenon under discussion here.

In ODT, phonological strings are parceled into domains. Each domain corresponds to one feature or tone. Thus a segment may belong to many domains, each of which may or may not be coextensive with the next domain. In this theory, every feature is privative, so, for example, a form with all non-nasal segments need not have a domain for nasality at all. On the other hand, there may be a [nasal] domain, but the [nasal] feature might not be realized ("expressed" in the ODT terminology) on any segment in that domain. In other words, domains

specify a string of segments that may legitimately express a certain feature, and it is up to constraints to determine the number and extent of the domains, as well as whether and where a feature will be expressed in its domain.

Let's begin with the first task. In ODT, there are two kinds of Alignment constraints that regulate domain size. The first is Basic Alignment (BA), which is responsible for building a domain around a feature or tone's underlying host (the feature or tone's "sponsor"). The constraints in (41), adapted from Cole & Kisseberth (1994), are BA constraints. Each requires one edge of a sponsor to be aligned with the same edge of some domain for the relevant feature.

(41)   BA-Left: Align(Sponsor,L; F-domain,L)

         BA-Right: Align(Sponsor,R; F-domain,R)

Left to their own devices, these constraints prohibit spreading or shifting of features/tones. Wide-Scope Alignment (WSA) is responsible for extending a domain's reach. WSA constraints are simply standard Alignment constraints (McCarthy & Prince 1993) that require one or the other edge of a domain to coincide with some edge of a morphological or prosodic category. When a WSA constraint for one edge of a domain outranks the BA constraint for that same edge, spreading of the domain is produced. This is illustrated schematically in (42). Parentheses show domain edges, and the sponsor is underlined.

(42)

/xx<u>x</u>xx/	BA-Left	Align-R	BA-Right	Align-L
a. xx(<u>x</u>)xx		*!*		**
b. (xx<u>x</u>)xx	*!			**
☞ c. xx(<u>x</u>xx)			*	**

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BA-Left requires the left edge of the sponsor to be aligned with the left edge of the domain, so leftward spreading is not permitted. But since Align-R outranks BA-Right, spreading the domain to the right edge of the word is favored over limiting the domain to the sponsor.

The winner from (42) is a form in which the feature or tone spreads or shifts to the right edge of the word. Whether we get spreading or shifting is dependent on other constraints. The constraint Express requires every feature in a domain for the feature F to express F. In the context of (42), Express produces spreading: xx(x́x́x́) fully satisfies Express, assuming we're dealing with a high-tone domain.

Another constraint, *(F,nonhead) discourages expression of domain's feature on all elements except the domain's head. Cassimjee & Kisseberth (1998) assume that the head of a domain is correlated with the direction of spreading: If a domain extends rightward, the rightmost element in the domain is the head. If the domain spreads leftward, the leftmost element is the head. Thus *(H,nonhead) (the version of this constraint for high tones) favors shifting over spreading: xx(xxx́) is preferred over xx(x́x́x́) because the latter has two non-heads that express the high tone.

There are other constraints that ensure that each sponsor projects a domain and is included in that domain, but I will not discuss them here.

Obviously, WSA constraints do not produce spreading or shifting by just one unit unless the sponsor happens to be one unit away from the domain edge specified by WSA. Cassimjee & Kisseberth (1998) posit the constraint in (43) to produce noniterativity. (This constraint is virtually identical to Multi-TBU Span, which is used by Kaplan (2007) to similar effect.)

(43)   *MONOHD: A high-tone domain must not be monomoraic/monosyllabic.

In a language in which the BA constraints outrank WSA, *MONOHD can still trigger spreading a high tone's domain beyond the sponsoring syllable. Making the domain just two syllables long satisfies this constraint. The relative rankings of EXPRESS and *(H,NONHEAD) determines whether the result is spreading by one syllable or shifting by one syllable.

*MONOHD is very similar to the constraint MINIMALITY adopted by Zerbian (2006) in an analysis of languages in the Sotho family of Bantu. MINIMALITY, however, explicitly demands a binary tonal domain. These constraints encounter conceptual problems that I discuss at the end of this section, but for the time being I adopt *MONOHD without comment.

We are now in a position to account for Chichewa's tone spread. Recall that in this language H spreads one syllable rightward. Consequently, BA and *MONOHD must outrank WSA. Also, since Chichewa has rightward spreading, *MONOHD must outrank BA-RIGHT. The Tableau in (44) illustrates the analysis with the form *zidzábéraana* 'they will steal x for each other.'

(44)

/zidzáberaana/	BA-L	*MONOHD	EXPRESS	BA-R	ALIGN-R	ALIGN-L	*(H,NONHEAD)
a. zi(dzá)beraana		*!			***	*	
☞ b. zi(dzábé)raana				*	**	*	*
c. zi(dzabé)raana			*!	*	**	*	
d. (zídzá)beraana	*!				***		*
e. zi(dzábérááná)				**!*		*	*

Candidate (a) is the faithful candidate with a high domain built around just the H's underlying host. It loses because it does not satisfy *MONOHD. Candidates (b) and (c) both extend the domain one syllable rightward to satisfy *MONOHD. The former expresses the high tone on both syllables. The latter expresses the tone on just the domain's head, so it fatally violates EXPRESS. Candidate (d) shows that BA-LEFT must be high-ranked to prevent leftward spreading under pressure from *MONOHD. Also, BA-RIGHT must outrank ALIGN-R to produce minimal rather than unbounded rightward spreading, as candidate (e) shows. *(H,NONHEAD) must be low-ranked in Chichewa (specifically, it must be ranked below EXPRESS) to generate spreading rather than shifting.

This is the core of the ODT analysis of Chichewa. There are two remaining pieces. First, recall that phrase-final H is retracted to the penultimate syllable. Cassimjee & Kisseberth (1998) account for this kind of phenomenon with a NONFINALITY constraint preventing a phrase-final mora or syllable from being included in a high domain.

Second, we must block spreading from the last three syllables of a phrase. In the analysis of Cassimjee & Kisseberth (1998), AVOID PROMINENCE prevents a prominent syllable from being part of a high domain. Many researchers (e.g. Cassimjee & Kisseberth 1998, Philippson 1998) identify the lengthened phrase-penultimate syllable in Chichewa and other Bantu languages as stressed or otherwise prominent. So AVOID PROMINENCE will block spreading to this syllable:

(45)

/zidzábeera/	BA-L	AVOID	EXPRESS	*MONOHD	BA-R	ALIGN-R	ALIGN-L	*(H,NONHEAD)
☞ a. zi(dzá)beera				*		***	*	
b. zi(dzábée)ra		*!		*		**	*	*
c. (zídzá)beera	*!					***		*
d. zi(dzabée)ra		*!	*!		*	**	*	
e. zi(dzábee)ra		*!	*!	*		**	*	

In this form, which means 'they will steal x for/with you,' a unary high tone domain is required by AVOID PROMINENCE. Candidate (b) has the normal tone spread, but it loses because the penultimate syllable—which is prominent—is part of a high tone domain. Candidate (c) spreads in the other direction, where a prominent syllable is not encountered. This fatally violates BA-LEFT. The remaining candidates show that abstaining from expressing the high tone on one syllable or another doesn't save the normal rightward spreading: AVOID PROMINENCE penalizes any form with a domain that includes the penultimate syllable, even if the high tone is not expressed on that syllable. (However, since BA-LEFT

outranks Avoid Prominence, a form with an underlying penultimate H will surface faithfully.)

4.5.2 Kikuyu in ODT

In the ODT system developed by Cassimjee & Kisseberth (1998), tone shift is a very close relative of tone spread. *MonoHD again requires a binary domain, but instead of Express requiring all syllables in that domain to express the high tone, *(H,nonhead) prevents all but one of the syllables from expressing the tone. Therefore, an analysis of Kikuyu should be simple now that an analysis of Chichewa is in place. We will see, perhaps surprisingly, that this is not so.

First, (46) shows a Tableau adapted from Cassimjee & Kisseberth (1998) that illustrates tone shift in Kijita (see Downing 1996). In this language, H shifts one syllable rightward. For example, in *okuβon̲ána* 'to see one another,' the underlined vowel underlyingly hosts the high tone, but the following syllable surfaces with the tone.

(46)

/okuβón̲ana/	BA-L	*(H,nonhead)	*MonoHD	BA-R
a. oku(βó̲)nana			*	
b. oku(βó̲na)na		*!		*
c. oku(βó̲ná)na		*!		*
☞ d. oku(βo̲ná)na				*
e. o(kúβo̲)nana	*!			

Just as in Chichewa, BA-Left and *MonoHD require the high tone's domain to expand rightward so that it includes the syllable following the sponsor. Now

that Express is replaced by *(H,nonhead), it is better to express the high tone on just the head of the domain (which is the rightmost syllable since we have rightward spreading) instead of throughout the domain. Therefore, candidate (d) wins.

Why won't this analysis succeed in Kikuyu? The reason is that beyond the first two syllables of a Kikuyu word, there is no evidence for the binary domains required by *MonoHD. Consider *totomáɣa* 'we send.' *MonoTD (*MonoHD is specific to high tone domains, so I adopt *MonoTD for all tone qualities) can correctly require the first two syllables to be parsed into a low-toned domain, but it will also penalize the monosyllabic high and low tones on the final two syllables. We therefore predict an output like *(totò)(maɣá), where diacritics reflect the fact that only the head of each domain expresses the tone. Eliminating *MonoTD is not possible because it drives tone shift in the first place.

We might argue that the effect of *MonoTD in non-initial domains is suppressed because *(toto)(máɣá) fails to preserve the second underlying L. We need unary domains in order to preserve all tones. The constraint used by Cassimjee & Kisseberth (1998) to require one domain for each underlying feature is Domain Correspondence. This constraint must outrank *MonoTD because it is responsible for the lack of non-initial binary domains:

(47)

/totomaɣa LHL/	Dom Cor	*MonoTD
a. (tòtò)(maɣá)	*!	
☞ b. (tòtò)(má)(ɣà)		**

It is simple enough to select *(tòtò)(má)(ɣà)* over *(tò)(tóma)(ɣà)* or

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*(tò)(tó)(maɣà) by invoking an Align-R constraint forcing domains to be as close to right-aligned in the word as possible. Notice also that the correct form has a low tone on both vowels in the initial domain. This indicates that in ODT, like PDT, Kikuyu's tone shift is best understood as spreading, as in Chichewa. Using Express instead of *(H,nonhead) will produce (tòtò)(má)(ɣà) instead of *(totò)(má)(ɣà), putting us back into ODT's tone-spread territory.

We are not out of the woods yet. The floating low tones still must be accounted for.[22] Recall that in the rule-based analysis, tone shift bumps these tones off the final TBU. In ODT, this means *MonoHD (which replicates tone shift) forces a violation of Dom Cor:

(48)

/mo-ɣɛka LHL/	*MonoTD	Dom Cor
☞ a. (mòɣɛ̀)(ká) L		*
b. (mò)(ɣɛ́)(kà)	*!	

We have a ranking paradox. Candidate (b) follows the same strategy that was successful before: There are too many tones for each to receive a binary domain, so it posits just enough unary domains to accommodate each tone. Candidate (a) is the correct output. It has an initial binary domain and floating L. As the Tableau shows, selecting the correct winner here requires *MonoTD ≫Dom Cor, but (47) showed that the opposite ranking is also required.

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[22]The status of the unpronounced tones in ODT is difficult to determine. ODT rejects autosegments, so it seems that this L is simply deleted if it doesn't have a domain in the output. But this is problematic because the downstep facts of Kikuyu point strongly toward the survival of this L, which means this tone must be an autosegment: It is a phonological object that is formally distinct from its host. Furthermore, it is clear that tones in Kikuyu are not underlyingly associated with their hosts, which also points to autosegmentalism. The proper account of these conflicts in ODT is unclear to me, so I will assume that floating tones are still possible in this theory.

The problem, it seems, is that *MONOTD requires binary domains for every tone, but the actual forms have binary domains only for initial tones. A scaled-back version of *MONOTD is needed, one that requires a non-unary domain for just the leftmost tone. The justification for this constraint is not obvious, though. I am aware of no evidence outside of the tone-shift facts suggesting that the first syllable or pair of syllables in Kikuyu is special, so the revised *MONOTD arbitrarily singles out these syllables. A possible solution is overlapping binary domains throughout the word (Key 2007).

The ranking paradox is a major stumbling block for ODT, but not an intractable one in principle. The revised *MONOTD allows ODT to produce Kikuyu's tone shift. This is demonstrated in (49) and (50).

(49)

/totomaɣa LHL/	EXPR	*MONO-INIT	DOM COR	AL-R
a. (tòtò)(máɣá)			*!	**
☞ b. (tòtò)(má)(ɣà)				***
c. (totò)(má)(ɣà)	*!			***
d. (tò)(tó)(màɣà)		*!		*****

(50)

/totomaɣa LHL/	EXPR	*MONO-INIT	DOM COR	AL-R
☞ a. (mòɣὲ)(ká) L			*	
b. (mò)(ɣέ)(kà)		*!		
c. (moɣὲ)(ká) L	*!		*	
d. (mò)(ɣέká) L		*!	*	

There are many reasons to be skeptical of the ODT analysis. It cannot account for Kikuyu without the sort of stipulative constraint used in (49) and (50). There

is also little evidence for the domains posited by the theory. In Chichewa and Kikuyu, this is not a significant issue since tones are expressed throughout each domain, but in languages with tone shift over longer distances, ODT posits domains that encompass large amounts of a form even though the tone is expressed on only one syllable in that domain. Cassimjee & Kisseberth (1998) offer some evidence for these domains based on what appear to be long-distance OCP effects in Isixhosa: A high tone at the right edge of a verb stem affects the realization of a prefix high tone. In ODT, this is because the left edge of the stem tone's domain abuts the prefix tone's domain. To give just one example, in *(bá)ya(boníí)sa* 'they show,' the prefix *bá-*'s high tone is prevented from shifting rightward because this would create adjacent domain edges: *(bayá)(boníí)sa*. But it is equally plausible to suppose that an OCP constraint prohibits multiple high tones within a verb stem (a morphological category that excludes subject prefixes). Verb stems in Isixhosa seem to be restricted to hosting at most one high tone anyway, so the ODT prohibition on adjacent domain edges does not achieve better empirical coverage than a non-ODT account. Better evidence for ODT's domains is desirable.

As noted above, the status of floating tones in ODT is unclear. The theory explicitly rejects autosegments, yet it seems clear that tones in Kikuyu and elsewhere can be separated from their segmental and prosodic hosts. The Basic Alignment constraints that define where each domain begins crucially rely on tones being associated (or their sponsors indicated) underlyingly. But since tones can surface on morphemes other than the ones that contributed them, the simplest analysis is one that doesn't take these tones to be linked to their contributing morphemes

in the first place.

Similarly, the representation of contour tones in ODT seems problematic. In Autosegmental Phonology, contours are simply two tones linked to one TBU, but this structure is of course unavailable in ODT. Two possibilities are immediately obvious: Either contours are formally distinct from level tones and have their own domains, or syllables that host contours belong to overlapping domains for different tone levels. The former is unappealing in light of widespread evidence that contours are composed of level tones, and in the latter approach it is not clear how to specify that overlapping H and L domains should yield a rising tone in one case and a falling tone in another. Yet another approach, adopted by Cassimjee & Kisseberth (1999b), is to use half-moras. A domain for one tone level encompasses the first half-mora of a vowel, and a domain for a different level encompasses the second half-mora. With the vowel split between two domains, a contour results. Of course, independent evidence for half-moras would be desirable.

Finally, the constraint *MonoHD is problematic. There is no clear reason why tone but not, say, vowel height tends toward binary groupings. This means that *MonoHD gives no answer to the question addressed at the end of §4.2: Why are virtually no apparent cases of noniterativity found in phonology except in tonal phenomena? For PDT, this restriction is explained if the articulatory or perceptual factors that give rise to peak delay asymmetrically affect tone as compared to other phonological units. But for *MonoHD, the answer must be that there is no *Mono constraint for other phonological entities. But since *MonoHD is grounded in abstract an notion like the desirability of binarity, which cannot be independently verified, there is no obvious explanation for why

this state of affairs should hold. An identical objection can be raised for Zerbian's (2006) MINIMALITY. Short of a stipulation about which entities can be referenced in a *MONO or MINIMALITY constraint, these analyses predict spreading or shifting by one syllable on a much larger scale than is actually attested.

Perhaps *MONOHD can be recast in metrical terms. Metrical units, after all, often exhibit binarity, so maybe noniterative tonal phenomena are metrical in nature. If this strategy works, then these phenomena can be accounted for as if they were foot-constrained phenomena. That is, we have iterative spreading/shifting throughout a binary domain (see Domain Confinement from Chapter 1), not noniterative spreading or shifting.

4.6 Comparison of PDT and ODT

We have seen in the preceding sections that two very different frameworks can account for noniterative tone spread and shift. The choice between PDT and ODT is immaterial for the purposes of this dissertation in that neither explicitly invokes noniterativity. In PDT, apparent noniterativity results from a demand that a tone's onset and peak be sufficiently separated. One result of this separation is that the peak can fall in the syllable after the one that hosts the phonological tone. In ODT, apparent noniterativity reflects the satisfaction of a constraint prohibiting unary tonal domains. Extending the tone's domain by one syllable satisfies this constraint while minimally violating the Basic Alignment constraints.

In this respect, the ODT analysis is similar to the Positional Licensing analyses of Lango and Chamorro developed in previous chapters of this dissertation. In

those languages, spreading just one syllable to the right or left is sufficient to satisfy Positional Licensing constraints that demand that the relevant feature be linked to a root segment. Since the affixes from which the features spread are adjacent to the root, spreading just once satisfies the Positional Licensing constraints and minimally violates faithfulness constraints.

PDT and ODT are quite different in an important respect. The former takes the relevant tonal phenomena to be directly driven by phonetic considerations while the latter attributes them to abstract, structural requirements. The choice between these theories comes down, in part, to decisions about how formally phonological phenomena should be tied to the articulatory, acoustic, perceptual, and diachronic facts that underly them. However, PDT and ODT share an important common theme. They both claim that tone spread and shift result from conditions that interfere with precise matches between tones' articulations and abstract phonological structures. This is obvious in PDT, and it becomes clearer in ODT if we view EXPRESS and *(H,NONHEAD) as constraints militating for or against articulations that match domains.

It is interesting to note that successful accounts of Kikuyu in both PDT and ODT must treat this language's tone shift as if it were tone spread. The first two syllables of a word in Kikuyu have the same tonal properties, so an analysis of this language cannot simply ignore the first syllable altogether. In PDT, this means the first tone's articulation begins in the first syllable, and in ODT this means EXPRESS (the spreading constraint) must outrank *(H,NONHEAD) (the shifting constraint). Even the rule-based treatment of Kikuyu posits what amounts tone spread because, while the first syllable is initially skipped, a later rule spreads the

tone of the second syllable back to the first syllable. These results suggest that there may not be as a big a difference between tone shift and tone spread as one might think. Indeed, traditional analyses (e.g. Philippson 1998) often characterize tone shift as spreading followed by delinking.

Lastly, both PDT and ODT have drawbacks. PDT lacks empirical support from a wide range of languages. If more languages are found to exhibit the timing properties of Chichewa, the range of languages for which PDT is applicable will grow, and PDT will become more plausible. ODT has theory-internal problems related to the representation of floating tones and contours, as well as certain undesirable predictions made by *Mono-style constraints. (If there are existing satisfactory solutions to the objections to ODT, I am unaware of them.) ODT also suffers from a lack of conclusive evidence for the reality of the hypothesized domains.

In sum, PDT and ODT are two promising solutions to the challenge noniterative tone spread and shift presents to the Emergent Noniterativity Hypothesis. Although I make no choice between these analyses here, I argue in favor of PDT in Kaplan (2008b). In the rest of this chapter I argue against other approaches to noniterative tone shift/spread that have been proposed within OT, and I discuss other kinds of tonal phenomena.

4.7 Other Analyses of Noniterativity in Tone

In this section I discuss competing OT analyses of noniterative tonal phenomena. I argue that they are inferior to the PDT and ODT analyses developed above on

conceptual grounds: Each opens the door to constraints that produce noniterativity in a widespread fashion, contrary to the claim of this dissertation that OT is better off for not permitting such phenomena.

4.7.1 Local

Myers (1997) adopts the constraint LOCAL to account for noniterative tone shift in Rimi. I give Yip's (2002) definition in (51) because this version is also capable of producing noniterative tone spread.

(51)   LOCAL: An output tone cannot be linked to a TBU that is not adjacent to its host.

This constraint penalizes candidates whose high tones stray too far from their input hosts. But Kisseberth (2007:663) notes that:

> The problem, however, is that in current OT, a phonological constraint such as Local can access only the output candidates to see whether they violate the constraint. However, one cannot determine whether Local is satisfied in a given output candidate ...because one cannot see which mora is the host of the H tone in the input.

Kisseberth goes on to note that faithfulness constraints *are* allowed to access the input, but LOCAL is clearly not a faithfulness constraint. Adopting LOCAL amounts to a modification of OT that permits the formalization of noniterative processes, and this is the sort of thing that I claim no language requires.

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Similar remarks could be made for Bickmore's (1998) EXTEND, but whereas LOCAL blocks spreading past the adjacent TBU, EXTEND requires featural/tonal domains to extend beyond their input boundaries. Both constraints require access to the input.

4.7.2 Lag

Hyman (2005) adopts the constraint LAG (52) to account for tone spreading. Developing and defending an account of noniterative tonal phenomena is not Hyman's central goal, so the defects of LAG discussed below reflect the preliminary nature of the proposal. Nonetheless, LAG represents a tempting analytical approach, and examining it is instructive in the present context.

(52)   LAG(αT): An input tone should reach its target on the following output TBU.

We might interpret the reference to targets to mean that this constraint cares about how tones are articulated, but Hyman's subsequent examples and discussion make clear that LAG is satisfied when an output tone is linked to the TBU after its input host. So this constraint deals with phonological representations, not their phonetic implementations.

LAG creates tone shift, but it is not a sound account. It is apparently meant to be a faithfulness constraint since the definition refers to input tones, and because '-IO' is suffixed to it in specific instances (e.g. LAG-IO(H)). But LAG does not maintain faithfulness. It states a fact about markedness instead. We can't reinterpret it as a markedness constraint because markedness constraints are barred

from access to the input, and LAG clearly requires this access.[23] Emphasizing the mention of the tone's *target* in the constraint definition, we might interpret LAG as a markedness constraint that requires a mismatch between tones and their phonetic implementations. But in this case, LAG reduces to (something like) PEAK DELAY.

One objection to the above argument is that if our theoretical assumptions render us unable to account for certain phenomena, we should modify our assumptions rather than shoehorn the phenomenon into an awkward analysis. Our theory should adapt to new phenomena, not the other way around. Perhaps the tonal phenomena considered in this chapter indicate that markedness constraints should have access to the input after all. This would mean we can adopt LAG and thereby have a simple account of noniterative tonal phenomena that doesn't require a theory of peak delay.

The problem with this move is that it admits the possibility of noniteratively oriented constraints for other phenomena. For example, we could adopt (53) to account for Lango's vowel harmony:

(53)   LAG-ATR: An input ATR feature should reach its target on the following (or preceding) output vowel.

(Where again, despite the reference to targets, we take this constraint to require ATR features to be linked to vowels adjacent to their input hosts.)

Aside from the incorrect predictions this constraint makes about progressive harmony with polysyllabic suffixes (see Chapter 2), if LAG-ATR is a full-fledged

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[23]Even if we remove the reference to inputs tones, LAG can't tell whether or not a tone appears "on the following output TBU" without seeing what the original TBU was in the input.

OT constraint on par with ones that produce iterative vowel harmony, noniterative harmony should be as common as iterative harmony: just as many grammars with a highly ranked LAG-ATR are possible as grammars with a highly ranked SPREAD-ATR, for example, are. Yet noniterative harmony is vanishingly rare, if existent at all, suggesting that constraints like LAG are superfluous. Even though LAG lets us sidestep issues like peak delay and gives us a simple account of noniterative tonal phenomena (at the cost of abandoning what might be a trivial and pedantic theoretical tenet), it sets the stage for massive overproduction for OT.

Both LOCAL and LAG are unsatisfactory because they take noniterative tone spread/shift to be purely phonological processes that involve adding exactly one association line between a tone and a TBU. Consequently, when these constraints evaluate candidates, they must know which association lines are new and which are underlying, and this is what leads to the conflict with the ban on access to the input. On the other hand, the PDT and ODT accounts proposed in the preceding sections do not have this problem. PDT takes these noniterative phenomena to reflect articulatorily motivated mismatches between phonological representations and phonetic implementations, and it doesn't need to manipulate association lines. ODT produces the correct outputs by building binary tonal domains. Both approaches stay within existing restrictions on markedness constraints. In particular they obey the restriction that prevents the formalization of noniterativity, a restriction that this dissertation argues is well-founded.

4.8 Other Tonal Phenomena

The PDT analysis takes many tonal phenomena to be artifacts of timing discrepancies between f_0 and other articulations. But this does not mean the proponent of PDT is committed to the position that all tonal phenomena are phonetic in nature. For example, in Chichewa, the infinitive/progressive marker *-ku-* induces a high tone on the following syllable. The transcriptions below follow Kanerva (1990).

(54) ku-phíika   'I am cooking'

      ku-lémeera   'I am rich'

      ku-fótókooza   'I am explaning'

The lack of spreading in the second example indicates that the tone is associated with the first stem syllable, rather than this being a case of Kikuyu-style peak delay. Furthermore, if the tone shift in (54) were merely the phonetic result of peak delay, we'd expect to see this kind of shift everywhere in the language. Also, along with the last example from (54), the data below, from Moto (1983) (who doesn't transcribe penultimate lengthening), show that the shifted tone undergoes the usual spreading that was discussed in §4.3:

(55) kuphíká ndíwo   'to cook relish'

      kulírá maliro   'to mourn'

      kupémpá ndaláma   'to ask for money'

      kusámála mkázi   'to care for a woman'

Since the tones in (55) are transcribed over the first two stem syllables, the reasonable conclusion is that the tone has shifted to the first stem syllable and then spread from that syllable. If H remained associated with the prefix, we'd expect transcriptions like *kúlíra maliro and *kúpémpha. Instead, the transcriptions are consistent with the assumption that these tones are underlyingly associated with the stem-initial vowel.

The tones in these examples phonologically shift—H is formally associated with the stem-initial syllable. Once this shift is produced, the spreading facts fall out from the analysis in §4.3. How are we to produce tone shift? Since the shift seen here is confined to specific contexts (words with the -ku- prefix, and also the recent past -na- and habitual -ma-) in contrast with the pervasive tone shift from Kikuyu, we could adopt a morpheme selection constraint like the one in (56).

(56)   H ON -ku- STEM: -ku- must affix to an H-initial stem.

This constraint encodes the observation that -ku- selects a high-toned stem allomorph. Since the prefix itself supplies a high tone, we don't have to lexically list each verb stem with a high-toned variant. Instead, the prefix's H docks onto the stem—the prefix provides the means for satisfying its own selectional requirements.

Alternatively, we could adopt an Alignment constraint like the one in (57). This requires high tones affiliated with the infinitive prefix to be left-aligned within a verb stem. Ranked over IDENT-T, this will correctly place a high tone on the stem-initial syllable.

(57)   ALIGN-L(H$_{\text{Inf}}$, Stem): The left edge of every high tone from an infinitive

morpheme is aligned with the left edge of some verb stem.

Similar constraints could be adopted for other verbal prefixes in the language, such as the present habitual -ma-, which requires two high tones, one on the preceding syllable and another on the stem-penultimate syllable.

These solutions are workable here because of the limited scope of Chichewa's tone shift. Since the prefix's H always lands in the same position in the same morphological unit, we can posit a specific constraint that produces this state of affairs. Compare this to the sweeping constraint or army of specific constraints that would be necessary under approaches based on (56) or (57) for Kikuyu.

A Positional Licensing constraint (in the style of Crosswhite (2001)) would even work. By declaring that -ku-'s H is licensed only in the stem, we can achieve tone shift similar to the way spreading to the root was produced in previous chapters.

Whatever the correct analysis is, it is clear that Chichewa's tone shift is morphologically governed. In this light, it is similar to the ATR harmony of Lango and Chamorro's umlaut in that some property of an affix is attracted to the morphological unit to which the affix attaches. While this appears to be a noniterative movement, we can appeal to other factors that don't stipulate noniterativity.

Other cases of tone shift involve high tones moving to specific position in a word or phrase. The target syllable is often a final syllable in some domain. For example, in Digo, the last H of a word moves to the final syllable (Kisseberth 1984). Kisseberth also argues that the rightmost H in a phrase moves to the phrase-final syllable in Digo. Tone shift can also reflect the pressure of a NONFINALITY

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constraint: in Nkore (Odden 2005) and Somali (Saeed 1999), H moves from the phrase-final syllable to the penultimate syllable. Also relevant is the retraction phenomenon in Chichewa discussed above and similar cases that are noted in Myers (1999).

Similarly, many researchers (e.g. de Lacy 1999, 2002b, Downing 2003, Peterson 1987) have noted that high tones often gravitate toward prosodically prominent positions. Digo's shift-to-final-syllable phenomenon may involve attraction to prominence or simply right-alignment, and Philippson (1998) argues that retraction in Chichewa is really attraction of the phrase-final H to the stressed penultimate syllable. Downing (2003), who points out many similarities between accentual systems and the tonal systems of Chichewa and Xhosa, argues that in Chichewa, when a prefix's H moves to the stem-penultimate syllable in a way comparable to -*ku*-'s placement of a stem-initial H, this is attraction to prominence. Peterson (1987), also working with Chichewa, adopts essentially the same analysis: Extra prominence (via grid marks) is assigned to certain syllables, and a rule or well-formedness principle requires tones to associate with these prominent syllables. Since specific positions are targeted in these cases, straightforward accounts that do not run afoul of the ban on markedness constraints accessing the input are available. This is even true of certain cases that involve shifting to an adjacent position, such as movement from the final to the penultimate syllable in Chichewa. Simply put, tone shift of this nature is not noniterative, so it is neither a counterexample to this dissertation's thesis nor problematic for existing OT constraints.

Shona has a particularly interesting tone spread phenomenon (Myers 1987, 1997, Odden 1981). High tones in this language can engage in unbounded rightward spreading as long as every pair of adjacent syllables in the spreading domain belongs to different morphemes. (This is far from the whole story about tone spread in Shona—see the work cited immediately above for more comprehensive discussion.) Thus we have (58a), where the high tone on the first morpheme spreads all the way to the penultimate syllable. It can reach this position because each spreading "step" crosses a morpheme boundary. Compare this to *ma-zi-mi-chero* 'Big ugly fruits,' which shows that the non-initial morphemes in (58a) contribute no high tones themselves. On the other hand, in (58b), spreading just to the antepenultimate syllable is allowed because spreading to the penultimate syllable would involve spreading within the morpheme *ðambudziko* (cf. (58c), which shows that the root has no high tone of its own).

(58) a. *Vá-Má-zí-mí-chéro*
    2a-6-21-4-fruit
    'Mr. Big-ugly-fruits' (Odden 1981:77, gloss from Myers 1997:862)

  b. *Vá-Dámbudziko*
    honorific-Dambudziko
    'Mr. Dambudziko'   (Odden 1981:76)

  c. Dambudziko (proper name)   (Odden 1981:76)

Myers (1997) accounts for this pattern by positing unbounded rightward tone spread that is reined in by a constraint requiring successive high-toned syllables to be in different prosodic or morphological domains. Although examples like (58b)

seem to show noniterative spreading, forms such as (58a) reveal this noniterativity to be a happenstance of the morphological configuration.

PDT can also interact with some of these other analytical approaches. Michael Marlo (p.c.) provides the data in (59) from Lukhayo and Lutura. In these languages, H spreads leftward to the peninitial stem syllable (stems are marked with square brackets). That is, the stem-initial syllable is off limits for spreading. But if the stem is disyllabic, the initial syllable *is* targeted. The generalization is this: spreading by one syllable is mandated, and then if there are other stem syllables available besides the initial syllable, further spreading occurs.

(59) | Lukhayo | Lutura | Gloss |
|---|---|---|
| a-li[fw-á] | a-li-[fw-á] | 'he will die' |
| a-li[xín-á] | a-li[xín-á] | 'he will dance' |
| a-li[reéβ-á] | a-li[rééβ-á] | 'he will ask' |
| a-li[βukúl-á] | a-li[βukúl-á] | 'he will take' |
| a-li[siindíx-á] | a-li[siindíx-á] | 'he will push' |
| βa-li[karaáng-ír-án-á] | βa-li[karááng-ír-án-á] | 'they will fry for each other' |

Some constraint—call it ALIGN-L—motivates spreading to the stem-initial syllable, and another constraint (say, NONINITIALITY (Bickmore 2000)) outranks ALIGN-L and prevents complete satisfaction of ALIGN-L. PEAK DELAY, when it outranks NONFINALITY, effectively produces the minimal-spreading requirement by encouraging the tone's onset and peak to appear in separate syllables. When the stem is trisyllabic, satisfaction of ALIGN-L (to the extent possible) entails the satisfaction PEAK DELAY. E.g., in *βa-li[karááng-ír-án-á]*, the high tone's domain

is long enough for the peak and onset to appear in separate syllables without either one falling outside the tone's formal, phonological domain. But when the stem is disyllabic, Peak Delay motivates the otherwise banned spreading to the initial syllable.

It is worth noting, though, that *MonoHD and the other mechanisms that produce minimal tone spread and shift in ODT can replace Peak Delay in the analysis sketched in the previous paragraph, so Peak Delay has no monopoly on the data in (59).

We've seen in this section that there are phenomena that need not (and probably should not) be accounted for under the peak delay umbrella. Phonological analyses of these phenomena are not inconsistent with my claim that noniterativity doesn't exist in phonology because even the cases of minimal tone shift (like Chichewa's -ku- morpheme) are amenable to analyses that do not require noniterativity. The prediction the Emergent Noniterativity Hypothesis makes is that all cases of seemingly noniterative tone shift/spread will target a specific position (as in many of the cases mentioned here), reflect unbounded spreading that is curtailed by other forces (as in Shona), or be the result of phonetic implementation or spreading within a small domain (as in Chichewa's spreading and Kikuyu's shifting).

4.9   Conclusion

This chapter has considered the implications of tonal phenomena for the ENH. This is an important testing ground for this dissertation's thesis because nonit-

erative tonal phenomena are widespread. I have argued that there are ways to account for these phenomena that do not explicitly invoke noniterativity. I do not claim that this chapter resolves the question of how to account for these facts once and for all, and certainly not for every language exhibiting noniterative tonal phenomena. Only a broader examination of tonal processes will determine if either of the analyses discussed here can account for every case of noniterativity. It would not be surprising to find that a variety of approaches are needed. Maybe some languages require a PDT analysis, while others are best understood with ODT. Each framework is just one of the many tools available to grammars. Some other framework may of course prove better than PDT and ODT, but the prediction of this dissertation is that the most satisfactory framework will not directly require tones to spread or move exactly once.