Deriving bounded tone with layered feet in Harmonic Serialism: the case of Saghala

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Abstract

This paper proposes an approach to bounded tone shift and spread in Bantu languages. Its core intuition is that the bounding domain is delimited by foot structure. The approach uses layered foot representations to capture ternary phenomena, following Martínez-Paricio and Kager (forthcoming). A set of licensing and structural constraints regulate tone-feet interactions. Harmonic Serialism is adopted as the grammatical framework, to allow for an account of opaque patterns (Prince and Smolensky 1993; McCarthy 2010).

The present approach improves on previous accounts in two ways. Firstly, the size of the tonal bounding domain follows from independently motivated foot representations, rather than being stipulated in the constraint set. Secondly, the approach obviates the need for markedness constraints that refer to underlying structure, because all relevant lexical information is reflected in foot structures.

The approach is demonstrated on Saghala (Patin 2009). Saghala shows both shift and spread in a trisyllabic domain. There are six tone patterns, dependent on the contact or near-contact of tones, and the position of word boundaries. An analysis is presented which accounts for all patterns. The success of the analysis shows that the foot-based approach is equipped to deal with a variety of bounded tone phenomena.

1 Introduction*

Some Bantu languages display tone shift or spread, but only over a short distance. That is, the target syllable for the shift or spread is always a small number of syllables away from the underlying position of the tone. The syllable hosting the tone in the underlying form is here termed the sponsor syllable. The syllable span across which tonal activity takes place is termed the bounding domain. An overview of attested bounded tone patterns is shown in Table 1.

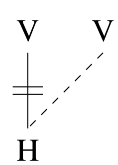
Pattern	**UF**	**SF**	**Example attestation**
Binary spreading	..$\acute{\sigma}\sigma$..	..$\acute{\sigma}\acute{\sigma}$..	Ekegusii (Bickmore 1996)
Ternary spreading	..$\acute{\sigma}\sigma\sigma$..	..$\acute{\sigma}\acute{\sigma}\acute{\sigma}$..	Copperbelt Bemba (Bickmore and Kula 2013)
Binary shift	..$\acute{\sigma}\sigma$..	..$\sigma\acute{\sigma}$..	Rimi (Olson 1964; Schadeberg 1979; Myers 1997)
Ternary shift	..$\acute{\sigma}\sigma\sigma$..	..$\sigma\sigma\acute{\sigma}$..	Sukuma (Sietsema 1989)
Bin. shift + bin. spread	..$\acute{\sigma}\sigma\sigma$..	..$\sigma\acute{\sigma}\acute{\sigma}$..	Saghala (Patin 2009)

Table 1: A typology of attested bounded tone patterns.

The crosslinguistic generalization from Table 1 is that the bounding domain is maximally three syllables in size, counting from the sponsor syllable to the last syllable of the surface tonal span. That is, there are no attested cases of e.g. quaternary shift or spread.

In autosegmental literature, most instances of bounded tone phenomena could straightforwardly be accounted for with locally defined rules. For example, (1) shows a typical definition of a tone shift rule, taken from Kenstowicz and Kisseberth (1990).

(1) Tone Shift



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In Optimality Theory ('OT', Prince and Smolensky 1993), reference to underlying structure is largely abandoned, and the account in (1) is unavailable. Despite this, OT is an appealing option for typological research, because it relates analytic choices to explicit typological predictions. Consequently, various OT approaches to the typology of Bantu bounded tone have since been proposed. Bickmore (1996) uses alignment constraints to derive a variety of bounded tone patterns. Furthermore, two approaches explore the merits of alternative tonal representations: Optimal Domains Theory (Cassimjee and Kisseberth 1998), and Headed Spans (Key 2007).

However, the above approaches suffer from two problems. As will be argued in section 5.2, all three approaches use well-formedness constraints that run counter to the OT tenet of output-orientedness. Furthermore, the representational approaches stipulate the size of the bounding domain.

This paper presents a new OT approach to bounded tone that avoids the above problems. Its core intuition is that the bounding domain is defined by foot structure. For example, a language with binary spreading would map /$\sigma\acute{\sigma}\sigma\sigma$/ to [$\sigma(\acute{\sigma}\acute{\sigma})\sigma$], using a foot to determine the spreading domain.

The idea of relating metrical structure to tone is already present in autosegmental literature (see Sietsema 1989; Bickmore 1995 for overviews). However, it was applied mainly to unbounded tone phenomena; tone was analysed as being attracted to metrically prominent positions near word or phrase edges. A foot-based approach to bounded tone was first considered, and rejected, in an OT proposal by Bickmore (1996). In particular, Bickmore noted that the ternary nature of some bounded tone patterns posed a problem for binary feet.

Apart from Bickmore's study, the foot-based approach has remained underexplored. This may have been due in part to the complexity of accounting for tonal shift. A foot-based approach to tone shift would need multiple steps: first a foot should be placed relative to a tone, and only then could the tone be shifted with reference to the foot. This is an opaque pattern, i.e. it requires intermediate forms. However, evaluation in standard OT is parallel, so it does not allow for intermediate forms.

Recent research provides answers to both the ternarity and opacity problem. Based on independent work on stress and foot representations, a layered, ternary foot was proposed by Kager (2012); Martínez-Paricio (2013); Martínez-Paricio and Kager (forthcoming) *et seq.*, hereafter 'MPK'. The ternary foot provides a natural way of defining the bounding domain for ternary tone phenomena.

The opacity problem is not unique to bounded tone, and research on accounting for opacity in OT has spawned a rich inventory of analytical tools. The present foot-based approach is couched in the Harmonic Serialism framework ('HS', Prince and Smolensky 1993; McCarthy 2010). HS is a variation on OT that employs derivations. It will be shown that HS lends itself particularly well to the present case, because the derivations are independent from morphological cycles.

It is beyond the scope of this paper to account for the full typology of bounded tone. Rather, the foot-based analysis is demonstrated for Saghala, as described by Patin (2002, 2009). Saghala is a complex bounded tone system; it contains most of the phenomena seen in other bounded tone languages. In the default pattern, underlying /$\acute{\sigma}\sigma\sigma$/ maps to [$\sigma\acute{\sigma}\acute{\sigma}$]. This means Saghala shows both shift and spread characteristics, and covers a trisyllabic domain. Furthermore, as will be detailed below, the tonal pattern is sensitive to a number of factors. Specifically, one of five deviating patterns may arise depending on tonal adjacency or near-adjacency and the position of word boundaries.

No previous OT analysis of Saghala exists.[1] Consequently, the present goal is twofold. First, this paper will present the first OT account of Saghala tonology. Second, through giving this account, the paper aims to demonstrate the general ability of the present proposal to deal with the complexities of trisyllabic domains, opaque patterns like tone shift, and interactions between metrically driven tone behavior and other tonal phenomena.

The next section outlines the foot-based Harmonic Serialism approach to bounded tone. Section 3 presents the data of Saghala, followed by an analysis in Section 4. Section 5 discusses the proposal in the context of previous literature, and section 6 concludes the paper.

[1]Patin (2009) provides a descriptively adequate analysis that uses rule-based theory. Since the present focus is on developing an OT account of the typology of bounded tone, this paper refrains from drawing a comparison to Patin's analysis.

2 The foot-based approach in Harmonic Serialism

This section will outline a foot-based approach to Bantu bounded tone in an OT context. First, the following subsection will discuss the layered foot representations assumed here. Then, section 2.2 details the constraint set used to relate tones and feet to each other. Section 2.3 describes the Harmonic Serialism architecture adopted here. The representations, constraints, and grammatical framework are put together in section 2.4, which demonstrates the approach with a toy example of binary rightward tone shift.

2.1 Layered feet

Following MPK, who build on Selkirk (1980), Prince (1980), and Kager (1994), it is assumed that feet may be layered. That is, a flat, binary foot may combine with an unfooted syllable to form a layered, trisyllabic foot. This paper does not consider unary feet. Figure 1 shows examples of these foot structures.

(a) A flat, binary foot. (b) A layered, ternary foot.

Figure 1: Binary and ternary foot types in the MPK framework.

Constraints can make reference to specific types of feet by referring to their (non)minimality and maximality. A foot is maximal if it is not dominated by another foot. This holds for binary feet that are not part of a layered foot, such as in Figure 1a, and for the outer foot layer of ternary feet, as in Figure 1b. A foot is minimal if it does not dominate another foot. This holds for all and only binary feet. A foot is nonminimal or nonmaximal if it does not have the relevant property.

Adopting a layered foot is advantageous for the analysis of Bantu bounded tone. Specifically, it allows for a straightforward definition of the bounding domain in ternary tonal patterns, such as ternary spread, ternary shift, and the Saghala mixed pattern of binary shift and binary spread.

In the present approach, there is no role for foot headedness or stress, so their implementation for layered feet is not discussed here. Section 5.4 of the discussion returns to the issue of foot headedness.

The next section will discuss the constraints that are needed to derive tonal activity within the bounding domain.

2.2 Constraints

This section presents a constraint set to regulate the relationship between tone and feet. A major previous work on this topic is De Lacy (2002). Comparison between the present proposal and De Lacy's is taken up in section 5.4.

The relationship between tone and feet is an indirect one, as tone does not link directly to foot nodes, but rather to smaller tone-bearing units ('TBUs'). This section takes the syllable as the TBU.[2] Consequently, the constraints presented here bear on the autosegmental links between tones and footed syllables.

It is proposed here that CON needs to allow for two effects: attraction, where the grammar promotes a tone-foot association, and repulsion, where the grammar militates against such an association. Examples of attraction are cases of tone-driven stress, where feet are ideally placed so that they overlap with a (high) tone (De Lacy 2002, p. 2*ff*). An example of repulsion is found in Lamba, where tone shifts away from its sponsor if the sponsor is in a rhythmically weak position (Bickmore 1995; De Lacy 2002, p. 18*f*).

To drive the association between tones and feet, the present proposal adopts a set of licensing constraints (Zoll 1996, especially pp. 147-152). Crucially, these constraints can take either the tone or the foot as the locus of violation. In other words, there are tone-licensing constraints and foot-licensing constraints. Both types are exemplified below by

[2] This is not a claim about the universal nature of TBUs, but rather a choice made to simplify the presentation, as there are no moraic effects discussed in the present paper.

License(H, Ft) and License(Ft, H), respectively. In general, License(X,Y) here means that an element of type X should be licensed by an element of type Y.

(2) License(H, Ft)
For each H tone, assign one violation mark if it is not associated to a footed syllable.

(3) License(Ft, H)
For each foot, assign one violation mark if none of its syllables are associated to a H tone.

For a given candidate, these two constraints may assign different numbers of violation marks. To demonstrate this, Tableau 2 shows the violation counts of various forms for License(H, Ft) and License(Ft, H).

	License(H, Ft)	License(Ft, H)
a. $(\sigma\sigma)(\sigma\sigma)$ H H		
b. $(\sigma\sigma)(\sigma\sigma)$ H H	**	**
c. $(\sigma\sigma)(\sigma\sigma)$ H H		*
d. $(\sigma\sigma)(\sigma\sigma)$ H	*	**

Tableau 2: Tone and foot licensing violations.

Candidate 2a shows perfect one-to-one association between tones and feet, and candidate 2b shows complete nonassociation. For these candidates, the violation profiles are symmetrical. However, there are ways in which the violations assigned by the licensing constraints can differ. One example is in cases of multiple linking, as shown in 2c. Both tones have been licensed by a foot, satisfying License(H, Ft), but only the leftmost foot has been licensed by a tone, causing a violation of LICENSE(FT, H). Moreover, candidate 2d shows that even in complete nonassociation, the violation counts can be different if the number of tones does not equal the number of feet. LICENSE(H, FT) is violated once because there is one unlicensed tone, while LICENSE(FT, H) is violated twice for two unlicensed feet.

The second tone-foot interaction that needs to be modeled is repulsion. A naive implementation is to posit a negated version of each attraction constraint. For example, the repulsion variants of LICENSE(H, FT) and LICENSE(FT, H) could be as below:

(4) NON-LICENSE(H, FT)
Assign one violation mark for each H that is associated to a footed syllable.

(5) NON-LICENSE(FT, H)
Assign one violation mark for each foot that contains a H-toned syllable.

Although the formulation of these constraints is analogous to that of licensing constraints, their behavior is not the inverse of the licensing constraints. The non-licensing constraints allow for potentially undesirable typological predictions.[3] Evaluating these predictions is beyond the scope of the present paper.

Here, the repulsion effect will instead be modeled using structural constraints. These constraints militate against an association between a H tone and a foot. An example is *H/FT:

(6) *H/FT
Assign one violation mark for each association between a H tone and a footed syllable.

[3]Since an association link necessarily involves both a tone and a foot, any candidate that violates a tone-non-licensing constraint will also violate its commensurate foot-non-licensing constraint at least once. In effect, then, both a gradient and a categorical non-licensing constraint are part of the grammar. The categorical version allows for two potentially undesirable effects. Firstly, it may create a magnet effect, causing all tones to associate to one violating foot. Secondly, in derivational frameworks such as Harmonic Serialism it may cause a situation where repair strategies are only available to candidates with a minimal number of violating association links. For cases where a full repair would take multiple steps, e.g. multiple applications of delinking, no repair is started on, because a partial repair does not lead to a reduction in violation marks.

In the case of structural constraints, the locus of violation is the association itself. Consequently, there is no distinction between a tone-version and a foot-version of the structural constraints.

The above definitions are the general forms of the proposed constraints. The full power of the constraint set is activated by instantiating these constraints to target specific layers of the foot and specific edges of feet. For example, the following three constraints show instantiations of the constraint types for the right edges of minimal feet ('MinFt'):

(7) LICENSE(H, MIN-R)
For each H, assign one violation mark if it is not associated to a syllable that is rightmost in a MinFt.

(8) LICENSE(MIN-R, H)
For each MinFt, assign one violation mark if its rightmost syllable is not associated to a H tone.

(9) *H/MIN-R
Assign one violation mark for each association between a H tone and a syllable that is rightmost in a MinFt.

With the use of these fine-grained constraints it is possible to model attraction and repulsion in specific contexts. Moreover, a grammar can now mix repulsion in one context with attraction in another. It is essential that the grammar has this flexibility, because this is exactly the type of situation that causes tone shift.

The use of the constraints will be demonstrated with a toy example at the end of this section, and with the realistic case of Saghala in section 4. First, section 2.3 will discuss Harmonic Serialism, the grammatical framework within which the constraints are employed.

2.3 Harmonic Serialism

Harmonic Serialism ('HS') is a variation of Optimality Theory. Like OT, it evaluates candidates through interaction of a ranked set of violable constraints. However, HS changes

OT in two ways. Firstly, GEN is limited to generating candidates that differ minimally from the input. Secondly, an evaluation happens serially: the output form of one tableau becomes the input form of another tableau. This repeats until the fully faithful candidate is optimal. At that point, further evaluation would not yield any change, and so the winning form is the final result of the evaluation.

Candidates in HS can only differ from the input form by the application of one operation. The exact nature of the set of operations that a learner may acquire or carry innately is an open research question. This article will make use of operations in (10):

(10)
1. Link a tone to a TBU.
2. Delink a tone from a TBU.
3. Merge two tones into one (‘tone fusion’).
4. Build a foot.

The construction of a layered foot takes two steps: first, two syllables combine into a flat foot. Then, the flat foot and a third syllable combine into a layered foot. An application of the foot-building operation can correspond to either of these steps (Martínez-Paricio and Kager 2013).

The operations in (10) suffice for the arguments made in this paper, but it is not claimed that these must be the only operations that may apply to tone and feet. For example, other grammars may make use of operations to delete, insert, or modify tones. The above conceptions of the operation set closely follow previous work on this topic. Specifically, see Pruitt (2012) for an in-depth treatment of implementing metrical structure and stress in HS, and see McCarthy et al. (2012) for previous work on tone.[4] This paper further follows previous work in assuming that a tone shift operation is not part of GEN (McCarthy et al. 2012, 267ff, but see Gietz et al. 2015 for an opposing view).

The derivational nature of evaluation in HS is reminiscent of pre-OT analyses based on rule ordering. However, translating rule-based analyses to HS is nontrivial because HS is constraint-based. This means that HS cannot refer to the structure of the input as is

[4] A major conclusion made by McCarthy et al. (2012) is that in HS, tone cannot be lexically linked in any language. This is at odds with the present approach, where lexical linking is assumed. Resolving this conflict is a matter for future research.

possible in rule-based approaches, but must formulate the forces of the grammar in terms of surface-oriented wellformedness constraints. A second consequence is that the order in which operations are applied cannot be freely stipulated, as is the case with rule ordering. Rather, the priority of operations in HS is a result of the ranking of the constraints. The operations that are applied first are those that can alleviate violations of the highest-ranked constraints.

HS is particularly suitable for the present purposes because a foot-based analysis of bounded tone may involve several intermediate steps between underlying and surface levels. Specifically, foot placement needs to be relative to the position of tone, after which tone association must readjust itself to the presence of feet. Furthermore, nothing suggests that these steps are related to different morphological cycles, which could have provided another source of derivationality. Consequently, the amorphological derivationality provided by HS is ideally suitable for a foot-based analysis of bounded tone.

A comparison of HS to other derivational frameworks is offered in section 5.3. The next section will demonstrate the foot-based HS approach to bounded tone on a toy example.

2.4 Example: binary tone shift using feet in Harmonic Serialism

This section will demonstrate the foot-based approach to bounded tone in HS using an abstract example of rightward binary tone shift. This pattern is attested among others in Rimi (Olson 1964), Kikuyu (Clements 1984), and Zululand Zulu (Downing 1990). The example will serve both as an elaboration of the approach and as the foundation for the analysis of Saghala in section 4.

In rightward binary tone shift, a tone surfaces on the TBU to the right of its sponsor. Concretely, this section will derive the mapping of /$\sigma\acute{\sigma}\sigma\sigma$/ to [$\sigma\sigma\acute{\sigma}\sigma$].

In a foot-based account, four types of effects must be modeled: foot creation, foot directionality, tone attraction and repulsion, and faithfulness. The constraint responsible for foot creation is LICENSE(H, FT); this drives the grammar to license underlying H tones with a foot.

Foot directionality refers to the tendency of feet to be positioned as close as possible to either the left or right edge of the domain. A matter of longstanding debate is the formulation of constraints to account for this tendency. The present paper adopts the constraints proposed in Martínez-Paricio and Kager (forthcoming), which are formulated in terms of non-intervention. Specifically, this example will model rightward foot directionality using CHAIN-L:

(11) CHAIN-L(σ_ω)
"For every unfooted syllable [σ_i], assign a violation mark if some foot intervenes between σ_i and the left edge of its containing prosodic word." (Martínez-Paricio and Kager forthcoming)

The constraints for tone attraction and repulsion also contribute to a rightward orientation. The two constraints below are needed:

(12) LICENSE(H, MIN-R)
For each H, assign one violation mark if it is not associated to a syllable that is rightmost in a MinFt.

(13) *H/MINFT-L
Assign one violation mark for each association between a H tone and a syllable that is leftmost in a MinFt.

These constraints will drive tone towards right foot edges, and away from left foot edges.

Finally, faithfulness effects must be modeled. Faithfulness to association links should be low, so that tone is free to link and delink. Link faithfulness will be represented here by a general FAITH-LINK constraint that can penalize both tone linking and delinking (Morén and Zsiga 2006). Faithfulness to tone correspondence should be high, so that tone is not deleted before it can position itself optimally. To save space, the tableaux below do not include candidates that are the result of a tone deletion or tone insertion operation. This choice is not problematic, because such operations can be ruled out by high-ranking MAX-T and DEP-T constraints. Candidates with gapped autosegmental structures or floating tones are also left out of consideration. These candidates may be ruled out with markedness constraints (see e.g. McCarthy et al. 2012).

The derivation is presented below, starting with Tableau 3. Some of the constraint names have been abbreviated for reasons of space. In particular, for licensing constraints the word LICENSE is abbreviated to $\mathcal{L}$. Furthermore, in this and the following tableaux, the fully faithful candidate is always listed first, and the winning candidate either first or second. Finally, adjacent high tones indicate spreading. That is, $\sigma\acute{\sigma}\acute{\sigma}\sigma$ denotes a form with one H tone, linked to two syllables. If adjacent syllables link to different tones, this will be indicated with subscript indices. For example, $\acute{\sigma}\acute{\sigma}_1\acute{\sigma}_2\acute{\sigma}$ denotes a form with two H tones each linked to two syllables. Since this paper does not consider gapped autosegmental constructions, a form like $\acute{\sigma}\sigma\acute{\sigma}$ necessarily contains two H tones, and does not need to be explicitly marked with indices.

$\sigma\acute{\sigma}\sigma\sigma$	$\mathcal{L}$(H, FT)	CHAIN-L	$\mathcal{L}$(H, MIN-R)	*H/MIN-L	FAITH-LINK
a. $\sigma\acute{\sigma}\sigma\sigma$	*!		*		
b. ☞ $\sigma(\acute{\sigma}\sigma)\sigma$		*	*	*	
c. $(\sigma\acute{\sigma})\sigma\sigma$		**!			
d. $\sigma\acute{\sigma}(\sigma\sigma)$	*!		*		
e. $\sigma\acute{\sigma}\acute{\sigma}\sigma$	*!		*		*

Tableau 3: Binary rightward shift in HS, step 1.

Here, because LICENSE(H, FT) is top-ranked, the most urgent thing for the grammar to do is to license the H tone. This is achieved by placing a foot over the sponsor syllable. Both candidates 3b and 3c do so. However, the exact placement of the foot is left to CHAIN-L, which pulls unparsed syllables to the left, and hence feet to the right. This makes 3b the optimal candidate.

Candidate 3d has placed the foot so far to the right that it does not dominate the high-toned syllable. This favors foot directionality, but under the present constraint ranking it is suboptimal. Candidate 3e demonstrates that tone spreading is in no way beneficial at this point in the derivation; there is no valid spreading target to satisfy LICENSE(H, MIN-R) yet.

Tableau 4 shows the next step in the derivation.

$\sigma(\acute{\sigma}\sigma)\sigma$	$\mathcal{L}$(H, FT)	CHAIN-L	$\mathcal{L}$(H, MIN-R)	*H/MIN-L	FAITH-LINK
a. $\sigma(\acute{\sigma}\sigma)\sigma$		*!	*	*	
b. ☞ $\sigma((\acute{\sigma}\sigma)\sigma)$			*	*	
c. $(\sigma(\acute{\sigma}\sigma))\sigma$		*!	*	*	
d. $\sigma(\acute{\sigma}\acute{\sigma})\sigma$		*!		*	*
e. $\acute{\sigma}(\acute{\sigma}\sigma)\sigma$		*!	*	*	*

Tableau 4: Binary rightward shift in HS, step 2.

Now that the tone has been licensed, CHAIN-L(σ_ω) is the most important constraint to satisfy. This is done by reducing the number of unparsed syllables that are not in a sequence at the left edge of the domain. Candidate 4b shows how: building a layered foot to incorporate the last unparsed syllable at the right.

Candidate 4c shows another way of expanding the binary foot into a ternary one, but in the wrong direction, yielding no reduction in violation marks. Candidate 4d shows an instance of premature spreading, ignoring the urgency of CHAIN-L(σ_ω).

Another spreading candidate is 4e. Although spreading outside the foot does not satisfy any constraint, it does not incur additional violations of any markedness constraint either. Specifically, spreading outside the foot does not violate LICENSE(H, FT). This is because the constraint is satisfied as soon as the H tone is licensed anywhere; it evaluates at the level of the tone, and not at the level of the syllable. Consequently, it does not require that every TBU carrying the H is in a licensed position, but just that one of them is.

In tableau 5, footing is complete, and the grammar can attend to the position of tone within the foot. The winning move is to simply spread rightward, reaching the right edge of the minimal foot, as shown in candidate 5b. This takes away the violation of LICENSE(H, MIN-R).

In tableau 6, there are several linking and delinking options. The winning candidate, 6b, demonstrates the satisfaction of *H/MIN-L through delinking of tone from the left foot edge. Candidate 6c shows a ternary high tone span covering the entire layered foot. Although it is not optimal with the given constraint ranking, it could be made optimal

$\sigma((\acute{\sigma}\sigma)\sigma)$	$\mathcal{L}$(H, FT)	CHAIN-L	$\mathcal{L}$(H, MIN-R)	*H/MIN-L	FAITH-LINK
a. $\sigma((\acute{\sigma}\sigma)\sigma)$			*!	*	
b. ☞ $\sigma((\acute{\sigma}\acute{\sigma})\sigma)$				*	*

Tableau 5: Binary rightward shift in HS, step 3.

with some different choices of tone-foot constraints. This shows the framework is able to account for ternary spread patterns, as attested in Copperbelt Bemba (Bickmore and Kula 2013).

$\sigma((\acute{\sigma}\acute{\sigma})\sigma)$	$\mathcal{L}$(H, FT)	CHAIN-L	$\mathcal{L}$(H, MIN-R)	*H/MIN-L	FAITH-LINK
a. $\sigma((\acute{\sigma}\acute{\sigma})\sigma)$				*!	
b. ☞ $\sigma((\sigma\acute{\sigma})\sigma)$					*
c. $\sigma((\acute{\sigma}\acute{\sigma})\acute{\sigma})$				*!	*

Tableau 6: Binary rightward shift in HS, step 4.

Tableau 7 shows the last step of the derivation. The faithful candidate, 7a, has no violation mark for any constraint. Since it is optimal to make no further changes, the evaluation terminates here and the output form of the derivation is [$\sigma((\sigma\acute{\sigma})\sigma)$], which is equal to the desired [$\sigma\sigma\acute{\sigma}\sigma$], modulo foot structure.

$\sigma((\sigma\acute{\sigma})\sigma)$	$\mathcal{L}$(H, FT)	CHAIN-L	$\mathcal{L}$(H, MIN-R)	*H/MIN-L	FAITH-LINK
a. ☞ $\sigma((\sigma\acute{\sigma})\sigma)$					
b. $\sigma((\sigma\acute{\sigma})\acute{\sigma})$					*!

Tableau 7: Binary rightward shift in HS, step 5.

Candidate 7b shows that further spreading is unnecessary with the current constraint set. However, inclusion of an additional tone-foot constraint could turn this into the optimal candidate, making the binary shift plus binary spread pattern derivable. This pattern is the default behavior of tone in Saghala, which is the topic of the next section.

3 Saghala tone

This and the following section provide an in-depth case study for the foot-based HS framework. The case at hand is the tonology of noun phrases in Saghala (Guthrie's E74b), spoken in southeastern Kenya. All data here are transcriptions taken from Patin (2002) and Patin (2009), which are based on Patin's fieldwork.

Saghala has several properties that make it a suitable test case. Firstly, it features both tone shift and tone spread. Secondly, this tonal activity takes place in a trisyllabic domain. Thirdly, there is no involvement of morphology in the tonal patterns. Finally, the tonal pattern is complex: there are six subpatterns, depending on the phonological context.

The above properties warrant the adoption of a framework that can define ternary domains and has an amorphological source of derivationality, such as the metrical HS framework. Furthermore, given the complexity and variety of the patterns, a successful analysis gives faith in the ability of the framework to account for a variety of bounded tone patterns. This will be the objective of section 4, which presents the foot-based HS analysis of Saghala.

This section describes the six subpatterns of Saghala noun phrase tonology. The presentation essentially follows that of Patin (2009), although the patterns have been renamed and a sixth subpattern has been added. Further following Patin, since there seems to be no role for low tone in the language, a privative analysis is pursued. That is, it is assumed that all syllables are phonologically either H-toned or toneless, and that toneless syllables receive a default low pitch only after the phonological derivation.

The differences between the patterns are reducible to differences in the phonological context. Specifically, Saghala is sensitive to the proximity of tones to each other, and to the position of word boundaries.

The nature of the Saghala lexicon precludes the attestion of certain data. Specifically, all words in Saghala carry at most one H. Furthermore, all words in the sample are either two or three syllables in length.[5] Lastly, only determiners can carry H on a word-final syllable.

[5] Patin (2002) contains one instance of a quadrisyllabic word, *nizamɲaŋge* 'white PL.'. In some attestations containing this word, the coda [m] is marked with surface H tone. Since the role of coda [m] here is not well understood, this word has been excluded from consideration.

Default context

The default pattern in Saghala is the following: the two syllables following a sponsor receive high tone, while the sponsor itself is low-toned at the surface. The term ‘default pattern’ is defined as the tonal pattern displayed when there is no effect of tonal proximity or word boundaries.

The location of sponsors is an analytical claim. To support this claim, the data in (14) show alternation of a toneless noun in isolated context with two contexts where it is preceded by determiners. In this and the following examples, proposed sponsor syllables are indicated by underlining.

	a.		nɟovu	‘elephant(s)’
(14)	b.	izí	nɟóvu	‘that elephant’
	c.	ilya	nɟóvú	‘these elephants’

The bare noun in (14a) is toneless, but tone can be contributed to the noun from preceding determiners in (14b,c). This suggests that tone was specified on the determiners. Furthermore, the determiners differ in terms of onset of the tonal span and, relatedly, the degree to which the span crosses into the next word. This suggests that tone in Saghala is linked underlyingly, and can be linked to different places in a word.

The tone shifting nature of Saghala is apparent from (14c). Here, tone was contributed by the determiner, yet surfaces exclusively on the noun, suggesting a rightward shift. Another observation confirming the notion of rightward shift is that phrase-initial syllables never surface with high tone.

In summary, (14b,c) are examples of the Saghala default pattern, where an underlying tone maps to surface tone on the two following syllables. In the following, variations on the default pattern are discussed.

Long Spreading

In a specific context, surface tone may span three syllables, rather than the default two. This pattern is dubbed ‘Long Spreading’. Examples of Long Spreading and its non-application are shown in (15). The string *aa* denotes two syllables; length is not contrastive in Saghala.

(15) a. i. ivilya vóŋgó víbwaa 'those heads are big'
ii. ilya mbúlá mbwáa 'that big nose'
iii. ilya mízí míbwaa 'those villages are big'

b. i. ivilya vítánda vibwaa 'those big beds'
ii. izí nɟóvu 'that elephant'

In the cases in (15a) the tonal span is extended to a third syllable. Crucially, this third syllable is word-initial. There is no tone span extension if the third syllable is not word-initial. Examples of this are in (15b), where tone shows a binary spread, rather than a ternary spread or even a quaternary spread to reach a word-initial syllable.

The second example, (15b.ii), repeated from (14b), shows that the tonal span remains binary even if that causes it to end in a word-initial syllable. This means that the word-initial syllable high is a goal, not a means; it is not used as a stepping stone to form a ternary span, e.g. *izí nɟóvú. Furthermore, as noted above, phrase-initial syllables are never high-toned at the surface, despite the present observation that word-initial syllables may warrant a larger tone spread. Moreover, Long Spreading will never motivate a tone to surface on its sponsor syllable. This suggests that the drive for tone shift in Saghala is stronger than that of associating H to word-initial syllables.

Summarizing so far, Saghala shows a ternary span following the sponsor if the third syllable following the sponsor is word-initial, and a binary span in other cases. The following discussion will delve into contexts containing more than one tone in close proximity.

Adjacent Sponsors

If a word with a word-final sponsor is followed by a word with a word-initial sponsor, this is termed an 'Adjacent Sponsors' context. In such contexts, high tone surfaces only on the second sponsor. Strikingly, there is no tonal span of two or three syllables. Examples are shown in (16).

(16) i. ilya mbúzi 'that goat'
ii. ilya ʃímba 'that lion'
iii. uɣulya mwézi mbwaa 'that moon is big'

The adjacency of TBUs linked to different tones here leads to an outcome that is highly different from the patterns seen so far. In line with this, some of the following subpatterns display a strategy of avoiding adjacent tone spans.

Incomplete Spreading

When sponsors are separated by a single syllable, one of two scenarios can occur. In the default case, both tones can shift, but the left H tone cannot spread, in effect keeping its one-syllable distance to the following tone. This is referred to as the 'Incomplete Spreading' context. Incomplete Spreading is demonstrated in (17).

	i. ihí mbuzí	'this goat'
(17)	ii. ihí mezí míbwaa	'these moons are big'
	iii. awá waná wálelé	'these tall children'

Examples (17i,iii) also demonstrate the behavior of tone that is near the right edge of the domain. In these cases too, the tone will shift, despite the lack of opportunity for spreading.

The Incomplete Spreading context shows that the language may preserve some distance between tones. If the tones operated completely independently from another, then the first tone should be able to spread to the second sponsor syllable, resulting in a potential four-syllable tone span, e.g. *ihí mézí míbwaa.

Surrounded Word-Initial Syllable

A different scenario applies when the syllable in between the two sponsors is word-initial. This context is called 'Surrounded Word-Initial Syllable' or 'SWIS'. This is the second context that is dependent on a specific position of the word boundary, along with the Long Spreading context discussed above.

In SWIS contexts, the surface form looks as if the second tone was never there; tone surfaces on the two syllables to the right of the first sponsor, and there is no trace of tone from the second sponsor. This is shown in (18).

(18)
i. ilya záwádi 'that gift'
ii. ilyilya ízíso ibwaa 'that eye is big'
iii. walye wálúme walelé 'those men are big'

If this context followed the Incomplete Spreading pattern above, then the two tones should have shifted separately, e.g. showing *ilya záwadí. Instead, the surface span resulting from the two tones covers a smaller domain than expected, reminiscent of the Adjacent Sponsors context. Patin (2009) reports no indication that the surface tone span consists of two parts, which could for example be signalled by a downstepped second high syllable. Moreover, his analysis treats the surface tonal span as representing a single tone. Consequently, this paper assumes that a single surface tone is an appropriate representation for the SWIS data.

Together, the Incomplete Spreading and SWIS contexts cover all outcomes for sponsors that are one syllable apart. For contexts with a two-syllable distance between sponsors, there should generally be no expectation of tonal interaction, since both sponsors have enough room to shift and spread. However, there is one plausible exception: if the first tone is in a position to trigger Long Spreading, it is possible that the resulting three-syllable span causes tonal contact. The discussion of the sixth subpattern below tests this scenario.

Blocked Long Spreading

Although rare in the data sample, there is an instance of the context hinted at above. It is shown in (19).

(19) i. izilya ŋgúkú nɟacé 'those little chickens'

If the Long Spreading pattern applied here, the first tone could cover a ternary span, because the third syllable after the sponsor is word-initial. Combined with the influence of the second tone, this could result in a quaternary surface span: *izilya ŋgúkú nɟácé. This is not the case, but the attested form does show the influence of both tones independently of each other. Consequently, this subpattern is most comparable to the Incomplete Spreading pattern, rather than the contracted cases of Adjacent Sponsors and SWIS.

Overview

The six patterns are listed in table 8 below. The context descriptions have been schematized. Word boundaries are only shown where relevant to the description of the context. All descriptions use enough syllables to show the end of the tone span, as indicated by a following low-toned syllable, but this final low syllable is not essential to the context; Saghala does not repel tones from the right phrase edge.

Context	UF	SF
Default		
Surface high tone on the two syllables following sponsor.	$..\acute{\sigma}\sigma\sigma\sigma..$	$..\sigma\acute{\sigma}\acute{\sigma}\sigma..$
Long Spreading		
Surface high tone on the three syllables following sponsor if the final syllable is word-initial, and not a sponsor syllable.	$..\acute{\sigma}\sigma\sigma\#\sigma\sigma..$	$..\sigma\acute{\sigma}\acute{\sigma}\#\acute{\sigma}\sigma..$
Adjacent Sponsors		
A single surface high tone on the rightmost of two sponsor syllables.	$..\acute{\sigma}\#\acute{\sigma}\sigma..$	$..\sigma\#\acute{\sigma}\sigma..$
Incomplete Spreading		
Surface high tone only on the first syllable following sponsor if the syllable after that is also a sponsor (tone from this second sponsor also shifts away at SF).	$..\acute{\sigma}\sigma\#\acute{\sigma}\sigma\sigma\sigma..$	$..\sigma\acute{\sigma}\#\sigma\acute{\sigma}\acute{\sigma}\sigma..$
Surrounded Word-Initial Syllable		
Surface high tone on the two syllables following the leftmost of two sponsors, if those sponsors are separated only by a word-initial syllable.	$..\acute{\sigma}\#\sigma\acute{\sigma}\sigma..$	$..\sigma\#\acute{\sigma}\acute{\sigma}\sigma..$
Blocked Long Spreading		
No Long Spreading if the third syllable of a potential ternary tone span is itself a sponsor.	$..\acute{\sigma}\sigma\sigma\#\acute{\sigma}\sigma\sigma\sigma..$	$..\sigma\acute{\sigma}\acute{\sigma}\#\sigma\acute{\sigma}\acute{\sigma}\sigma..$

Table 8: Six tonal patterns in Saghala.

4 A foot-based HS analysis of Saghala tone

This section will account for all the Saghala subpatterns described in the previous section. First, the constraint ranking for Saghala is presented. Then, HS derivations are presented for all subpatterns.

4.1 Constraint ranking and definitions

The core of the constraint set is shown in (20).

(20)
1. LICENSE(H, FT)
   Assign one violation mark for each H that is not associated to a footed syllable.
2. CHAIN-L(σ_ω)
   For every unfooted syllable [σ_i], assign a violation mark if some foot intervenes between σ_i and the left edge of its containing prosodic word.
3. *H/MIN-L
   Assign one violation mark for each association between a H and the leftmost syllable of a Min foot.
4. LICENSE(H, MIN-R)
   Assign one violation mark for each H tone that is not associated to the rightmost syllable of a Min foot.
5. LICENSE(H, NONMIN-R)
   Assign one violation mark for each H tone that is not associated to the rightmost syllable of a NonMin foot.
6. UNIFORMITY(H), MAX-LINK, DEP-LINK

This constraint set is similar to the one presented for the binary rightward shift example in section 2.4. As was the case there, the reader may further assume top-ranked constraints to rule out candidates displaying tone deletion or insertion, gapped autosegmental structures, or floating tones.

The main addition is another licensing constraint: LICENSE(H, NONMIN-R). This constraint promotes association of H to the rightmost syllable of a layered foot. As a result, the grammar may associate a H to two locations: the right edge of the minimal and of the nonminimal foot.

The toy example mapped /$\sigma\acute{\sigma}\sigma\sigma$/ to [$\sigma((\sigma\acute{\sigma})\sigma)$]. With the inclusion of LICENSE(H, NONMIN-R), the grammar will instead settle on [$\sigma((\sigma\acute{\sigma})\acute{\sigma})$]. This is exactly the result found in the Saghala default pattern, which will be derived below.

At the bottom of the ranking are the faithfulness constraints against tone linking, tone delinking, and tone fusion. The bottom-ranked position of these constraints means that the related operations may be applied to satisfy any markedness constraint in the ranking.

Some further additions to the constraint set are needed to account for the other sub-patterns. Firstly, it was apparent from the Long Spreading and SWIS contexts that word-initial syllables have a special status in Saghala. This is modeled in the grammar with LICENSE(PRWD-L, H):

(21) LICENSE(PRWD-L, H)
For each PrWd, assign one violation mark if its leftmost syllable is not associated to a H tone.

As will be discussed below, this constraint must be quite low-ranked. This is supported by the observation that not all word-initial syllables in the language are high-toned, and that tone can shift away even from word-initial sponsors.

A further addition to the grammar is the OCP (Myers 1997). The constraint is here defined as follows:

(22) OCP-H
For each pair of H tones, assign one violation mark if they are associated to the same or adjacent syllables.

Although surface forms in Saghala never violate OCP-H, it does not have a high rank. This is because, as will be shown below, tonal contact must be allowed during the derivation of the SWIS context, so OCP-H should not rule this out. Furthermore, most of the avoidance of tonal contact is already achieved by the tone shifting behavior.

A third addition is LICENSE(FT, H). This constraint militates against tonally 'empty' feet. In practice, this has two effects. Firstly, feet are not created in positions where there is no H-toned syllable. This runs counter to foot directionality constraints such as CHAIN-L, which promotes foot building to avoid unfooted syllables in certain positions. The second effect is that tone cannot delink from a syllable if that were to cause a toneless foot. In this sense, LICENSE(FT, H) acts as a faithfulness constraint; licensed feet cannot lose their license. The definition of the constraint is as follows:

(23) LICENSE(FT, H)
For each foot, assign one violation mark if none of its syllables are associated to a H tone.

The final addition to the constraint set involves several constraints meant to regulate the timing and direction of foot expansion. For the default pattern, the rightward expansion $((\sigma\sigma)\sigma)$ is correct and could be constructed right away. However, to account for some of the other subpatterns, the grammar must be able to delay foot expansion, and even be able to expand leftward. Three constraints are adopted to achieve this extra flexibility. The first is CHAIN-R(σ_ω):

(24) CHAIN-R(σ_ω)
For every unfooted syllable [σ_i], assign a violation mark if some foot intervenes between σ_i and the right edge of its containing prosodic word.

CHAIN-R(σ_ω) is the counterpart of previously seen CHAIN-L(σ_ω). It has the effect of pulling feet to the left, which means that it favors leftward foot expansion.

The other two constraints place demands on the presence or absence of tones with regards to layered feet:

(25) *H/NONMIN-L
Assign one violation mark for each association between a H and the leftmost syllable of a NonMin foot.

(26) LICENSE(NONMAX-R, H)
Assign one violation mark for each NonMax foot if its rightmost syllable is not associated to a H tone.

Crucially, these constraints only come into action in the context of layered feet, since flat binary feet are neither nonminimal nor nonmaximal. Consequently, the grammar is free to place flat binary feet, but must pass the criteria of the two constraints above before being allowed to expand. The criteria are demonstrated by means of Tableau 9.

	*H/NONMIN-L	LICENSE(NONMAX-R, H)	CHAIN-L	CHAIN-R
a. ☞ $\sigma((\sigma\acute{\sigma})\sigma)$				*
b. $(\sigma(\sigma\acute{\sigma}))\sigma$			*!	
c. $\sigma((\acute{\sigma}\sigma)\sigma)$	*!	*		*
d. ☞ $(\sigma(\acute{\sigma}\sigma))\sigma$		*	*	
e. $\sigma((\acute{\sigma}\acute{\sigma})\sigma)$	*!			*
f. ☞ $(\sigma(\acute{\sigma}\acute{\sigma}))\sigma$			*	

Tableau 9: Violations of foot expansions.

The tableau is split into three parts: candidates 9a,b show leftward and rightward expansion from $\sigma(\sigma\acute{\sigma})\sigma$; 9c,d from $\sigma(\acute{\sigma}\sigma)\sigma$; and 9e,f from $\sigma(\acute{\sigma}\acute{\sigma})\sigma$. The default pattern of rightward expansion is only optimal from a $\sigma(\sigma\acute{\sigma})\sigma$ starting point. In the case of candidates 9c,e, rightward expansion is blocked by *H/NONMIN-L because it situates a H tone at the left edge of a nonminimal foot.

LICENSE(NONMAX-R, H) does not favor either leftward or rightward expansion. However, it can serve as a deterrent from foot expansion in general; candidates 9c,d both incur violations from this constraint. This way, the constraint allows for a delay in foot expansion until a tone has reached the right edge of a prospective nonmaximal foot.

The full ranking, shown in (27), consists of the core constraint set and the additions discussed above.

(27) 1. MAX-T, DEP-T, NOFLOAT, NOGAP,
*H/NONMIN-L
Assign one violation mark for each association between a H and the leftmost syllable of a NonMin foot.

LICENSE(H, FT) (abbreviated $\mathcal{L}$(H, FT))

Assign one violation mark for each H that is not associated to a footed syllable.

LICENSE(FT, H) (abbreviated $\mathcal{L}$(FT, H))

For each foot, assign one violation mark if none of its syllables are associated to a H tone.

LICENSE(NONMAX-R, H) (abbreviated $\mathcal{L}$(NONMAX-R, H))

Assign one violation mark for each NonMax foot if its rightmost syllable is not associated to a H tone.

2. CHAIN-L(σ_ω) (abbreviated CHAIN-L)

   For every unfooted syllable [σ_i], assign a violation mark if some foot intervenes between σ_i and the left edge of its containing prosodic word.

3. *H/MIN-L

   Assign one violation mark for each association between a H and the leftmost syllable of a Min foot.

4. CHAIN-R(σ_ω) (abbreviated CHAIN-R)

   For every unfooted syllable [σ_i], assign a violation mark if some foot intervenes between σ_i and the right edge of its containing prosodic word.

5. LICENSE(H, MIN-R) (abbreviated $\mathcal{L}$(H, MIN-R))

   Assign one violation mark for each H tone that is not associated to the rightmost syllable of a Min foot.

6. LICENSE(H, NONMIN-R) (abbreviated $\mathcal{L}$(H, NONMIN-R))

   Assign one violation mark for each H tone that is not associated to the rightmost syllable of a NonMin foot.

7. LICENSE(PRWD-L, H) (abbreviated $\mathcal{L}$(PRWD-L, H))

   For each PrWd, assign one violation mark if its leftmost syllable is not associated to a H tone.

8. UNIFORMITY(H), MAX-LINK, DEP-LINK,

OCP-H
For each pair of H tones, assign one violation mark if they are associated to the same or adjacent syllables.

The composition of the above constraint set is principled, despite its size. About half of the constraints are instantiations of the constraint format put forth in section 4.1. The remaining constraints are taken from previous literature, and are established in mainstream OT literature. The only potential exception to this are the CHAIN commands, which are an innovation of Martínez-Paricio and Kager (forthcoming). However, the general concept of foot directionality constraints is also an established part of OT literature, and nothing in the present proposal depends on the novel aspects of the CHAIN commands as compared to e.g. ALL-FEET-LEFT/RIGHT (McCarthy and Prince 1993, in Kager 1999).

4.2 Derivations

Default context

In the default context, tone surfaces on the two syllables following the sponsor. The relevant examples from section 3 are repeated below.

(14)
b. i̲zí ɲɟóvu ‘that elephant’
c. ilya̲ ɲɟóvú ‘these elephants’

The derivation of the Saghala default pattern will be shown for a five-syllable form with H tone linked to the second syllable underlyingly: /$\sigma\acute{\sigma}\sigma\sigma\sigma$/. From a five-syllable form it can be seen that the algorithm is not dependent on the proximity of a tone to a word edge. The five-syllable string is an abstraction; words in Saghala are usually shorter, so the five-syllable string represents an assumption that there are no word boundaries in crucial places. Given the underlying form, the desired surface form is tone only on the third and fourth syllables: [$\sigma\sigma\acute{\sigma}\acute{\sigma}\sigma$], which is indeed the output of the derivation, modulo foot structure. The steps followed by the derivation are shown in (28).

(28) 0. $\sigma\acute{\sigma}\sigma\sigma\sigma$
Underlying Form

1. $\sigma(\acute{\sigma}\sigma)\sigma\sigma$
   Foot placement.
2. $\sigma(\acute{\sigma}\acute{\sigma})\sigma\sigma$
   Spreading to the right edge of MinFt.
3. $\sigma(\sigma\acute{\sigma})\sigma\sigma$
   Delinking from the left edge of MinFt.
4. $\sigma((\sigma\acute{\sigma})\sigma)\sigma$
   Rightward foot expansion.
5. $\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma$
   Spreading to the right edge of NonMinFt.
6. $\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma$
   Convergence of the HS algorithm; this is the output form.

The following tableaux will show each of the steps in detail. The top-ranked and bottom-ranked faithfulness constraints are left out of the tableaux. Candidates involving deletion or insertion of tones will not be considered, nor will gapped or floating tone configurations. Furthermore, LICENSE(PRWD-L, H) and OCP-H are irrelevant to the derivation of the default pattern and left out of the tableaux for space.

Firstly, Tableau 10 shows the first step taken from the underlying form. This step is similar to the first step of the toy example in Tableau 3. Because of high-ranking LICENSE(H, FT), it is optimal to construct a foot in such a way that it contains the high-toned syllable. The decision between having this syllable at the left or right edge of the foot is left to CHAIN-L, which prefers having feet pulled rightward. Consequently, candidate 10b is optimal, since it incurs less violations of CHAIN-L than 10c. Candidate 10d is ideal in terms of CHAIN-L, but fails to satisfy the high-ranking licensing constraints, because it leaves the H tone unlicensed, and fails to license the newly created foot with a tone. Finally, candidate 10e shows that spreading is premature, since the tone needs to be licensed first.

The derivation diverges from the toy example in tableau 11. Despite high-ranking CHAIN-L, it is not possible to expand the foot at this point. An attempt at foot expansion

$\sigma\acute{\sigma}\sigma\sigma\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $\sigma\acute{\sigma}\sigma\sigma\sigma$		*!					*	*
b. ☞ $\sigma(\acute{\sigma}\sigma)\sigma\sigma$				**	*	*	*	*
c. $(\sigma\acute{\sigma})\sigma\sigma\sigma$				***!				*
d. $\sigma\acute{\sigma}\sigma(\sigma\sigma)$		*!				***	*	*
e. $\sigma\acute{\sigma}\acute{\sigma}\sigma\sigma$		*!					*	**

Tableau 10: Default context, step 1.

is shown in candidate 11c, but it runs into violations of the anti-expansion constraints *H/NonMin-L and License(NonMax-R, H). The leftward expansion attempted by candidate 11d fails as well because it does not license the nonmaximal foot, i.e. the binary foot within the layered foot, with a H tone on its rightmost syllable. Consequently, the winning candidate 11b is optimal because it has selected to spread tone to the right edge of the minimal foot, satisfying License(H, Min-R).

An alternative candidate not shown in Tableau 11 is $\sigma(\acute{\sigma}\sigma)(\sigma\sigma)$. This candidate creates an extra foot, but the foot does not dominate any high-toned syllable. Consequently, it is ruled out by high-ranking License(Ft, H), which is not shown in the tableau. For the following tableaux, candidates with unlicensed feet are not considered, except for the Long Spreading derivation.

Tableau 12 shows that after the spreading step, rightward expansion as in 12c is still blocked by *H/NonMin-L, but leftward expansion is possible. The higher permissibility of leftward expansion compared to rightward expansion will be crucial in deriving the Adjacent Sponsors pattern. For the present case, the left-expanding candidate, 12d, is suboptimal. Its expansion step satisfies Chain-R, but there is a more important constraint that

$\sigma(\acute{\sigma}\sigma)\sigma\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $\sigma(\acute{\sigma}\sigma)\sigma\sigma$				**	*	*	*!	*
b. ☞ $\sigma(\acute{\sigma}\acute{\sigma})\sigma\sigma$				**	*	*		*
c. $\sigma((\acute{\sigma}\sigma)\sigma)\sigma$	*!		*	*	*	*	*	*
d. $(\sigma(\acute{\sigma}\sigma))\sigma\sigma$			*!	**	*		*	*

Tableau 11: Default context, step 2.

can be satisfied: *H/Min-L. This is achieved by the winning candidate 12b, by delinking from the left edge of the minimal foot.

Tableau 13 shows that rightward expansion, in 13b, is now the optimal move. This is because tone has moved away from the left foot edge and positioned itself at the right edge, passing the criteria of both anti-expansion constraints. Candidate 13c shows leftward expansion. This is suboptimal because Chain-L outranks Chain-R, causing the grammar to value rightward expansion over leftward expansion.

After foot expansion, the second spreading target has become available - the right edge of the nonminimal foot. Spreading is applied as the winning strategy in Tableau 14 by candidate 14b.

After reaching both its spreading targets and delinking from the sponsor, the derivation is complete. Tableau 15 shows the convergence of the algorithm as the faithful mapping is the optimal candidate. Candidate 15b shows that further delinking is unwarranted, as it causes tone to no longer be licensed by the rightmost syllable of a minimal foot.

After Tableau 15, the derivation is finished. The output is $\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma$, with surface tone at the two syllables following the sponsor, as desired.

$\sigma(\acute{\sigma}\acute{\sigma})\sigma\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $\sigma(\acute{\sigma}\acute{\sigma})\sigma\sigma$				**	*!	*		*
b. ☞ $\sigma(\sigma\acute{\sigma})\sigma\sigma$				**		*		*
c. $\sigma((\acute{\sigma}\acute{\sigma})\sigma)\sigma$	*!		*	*	*	*		*
d. $(\sigma(\acute{\sigma}\acute{\sigma}))\sigma\sigma$				**	*!			

Tableau 12: Default context, step 3.

$\sigma(\sigma\acute{\sigma})\sigma\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $\sigma(\sigma\acute{\sigma})\sigma\sigma$				**!		*		*
b. ☞ $\sigma((\sigma\acute{\sigma})\sigma)\sigma$				*		*		*
c. $(\sigma(\sigma\acute{\sigma}))\sigma\sigma$				**!				

Tableau 13: Default context, step 4.

$\sigma((\sigma\acute{\sigma})\sigma)\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $\sigma((\sigma\acute{\sigma})\sigma)\sigma$				*		*		*!
b. ☞ $\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma$				*		*		

Tableau 14: Default context, step 5.

$\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. ☞ $\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma$				*		*		
b. $\sigma((\sigma\sigma)\acute{\sigma})\sigma$				*		*	*!	

Tableau 15: Default context, step 6.

Long Spreading

In Long Spreading, there is a ternary surface span ending in a word-initial syllable. The relevant examples from section 3 are repeated below.

(15a)	i. ivilya vóŋgó víbwaa	'those heads are big'
	ii. ilya mbúlá mbwáa	'that big nose'
	iii. ilya mízí míbwaa	'those villages are big'

In the present account, the difference between the default pattern and Long Spreading is encoded solely in the constraint promoting word-initial H tone: LICENSE(PRWD-L, H). Because this constraint is near the bottom of the ranking, it could not have affected the derivation of the default context even if a word boundary is in the relevant position. Consequently, a derivation for Long Spreading will initially go through the same steps as the default context. However, instead of terminating, the derivation will go through two extra steps.

For the Long Spreading derivation, the form used in the default context will be changed to include a word boundary between the second and third syllable after the tone sponsor. It will also be lengthened further. The new underlying form is /$\sigma\acute{\sigma}\sigma\sigma$#$\sigma\sigma$/. The derivation will pick up at the end of the default pattern, with the intermediate form $\sigma((\sigma\acute{\sigma})\acute{\sigma})$#$\sigma\sigma$.

The steps of the Long Spreading derivation are shown in (29).

(29)

5. $\sigma((\sigma\acute{\sigma})\acute{\sigma})$#$\sigma\sigma$
   (*previous steps collapsed*) Default pattern.

6. $\sigma((\sigma\acute{\sigma})\acute{\sigma})$#$\acute{\sigma}\sigma$
   Spreading to word-initial syllable.

7. $\sigma((\sigma\acute{\sigma})\acute{\sigma})$#$(\acute{\sigma}\sigma)$
   Footing.

8. $\sigma((\sigma\acute{\sigma})\acute{\sigma})$#$(\acute{\sigma}\sigma)$
   Convergence.

The last three steps are shown in tableaux, starting with tableau 16. CHAIN-R and the anti-expansion constraints are irrelevant here and have been taken out. LICENSE(FT, H), LICENSE(PRWD-L, H), and DEP-LINK are relevant here and have been added to the constraint set.

In tableau 16, faithful candidate 16a has two word-initial syllables without H tone. In comparison to winning candidate 16b, this is one too many; extending the tonal span to a third syllable is optimal. Note that the two violations of CHAIN-L cannot be repaired here, since the extra foot would be unlicensed, as shown in 16c.

$\sigma((\sigma\acute{\sigma})\acute{\sigma})\#\sigma\sigma$	$\mathcal{L}$(FT, H)	$\mathcal{L}$(H, FT)	CHAIN-L	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	$\mathcal{L}$(H, NONMIN-R)	$\mathcal{L}$(PRWD-L, H)	DEP-LINK
a. $\sigma((\sigma\acute{\sigma})\acute{\sigma})\#\sigma\sigma$			**				**!	
b. ☞ $\sigma((\sigma\acute{\sigma})\acute{\sigma})\#\acute{\sigma}\sigma$			**				*	*
c. $\sigma((\sigma\acute{\sigma})\acute{\sigma})\#(\sigma\sigma)$	*!						**	

Tableau 16: Long Spreading, step 1 (post-default).

In tableau 17, the foot placement has become a valid option since tone has spread, potentially licensing the foot in its new position. This development is leveraged by the winning candidate, 17b. The new footing does come at the cost of violating *H/MIN-L, since there is now an association between a H tone and a syllable that is leftmost in a minimal foot.

Finally, the Long Spreading derivation terminates in tableau 18. Candidate 18b shows that further spreading is suboptimal; it incurs a violation of DEP-LINK because it introduces another association link, but this comes at no gain. None of the other constraints motivate additional spreading. This is because the grammar is centered on tone licensing. Since the tone is already licensed by the layered foot on the left, it does not need to seek further validation from the newly created foot on the right.

The output form is [$\sigma((\sigma\acute{\sigma})\acute{\sigma})\#(\acute{\sigma}\sigma)$], showing a trisyllabic tonal span following the sponsor, with the third syllable from the sponsor being a word-initial syllable. This

$\sigma((\sigma\acute{\sigma})\acute{\sigma})\#\sigma\sigma$	$\mathcal{L}$(FT, H)	$\mathcal{L}$(H, FT)	CHAIN-L	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	$\mathcal{L}$(H, NONMIN-R)	$\mathcal{L}$(PRWD-L, H)	DEP-LINK
a. $\sigma((\sigma\acute{\sigma})\acute{\sigma})\#\acute{\sigma}\sigma$			*!*				*	
b. ☞ $\sigma((\sigma\acute{\sigma})\acute{\sigma})\#(\acute{\sigma}\sigma)$				*			*	

Tableau 17: Long Spreading, step 2 (post-default).

$\sigma((\sigma\acute{\sigma})\acute{\sigma})\#\sigma\sigma$	$\mathcal{L}$(FT, H)	$\mathcal{L}$(H, FT)	CHAIN-L	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	$\mathcal{L}$(H, NONMIN-R)	$\mathcal{L}$(PRWD-L, H)	DEP-LINK
a. ☞ $\sigma((\sigma\acute{\sigma})\acute{\sigma})\#(\acute{\sigma}\sigma)$				*			*	
b. $\sigma((\sigma\acute{\sigma})\acute{\sigma})\#(\acute{\sigma}\acute{\sigma})$				*			*	*!

Tableau 18: Long Spreading, step 3 (post-default).

matches the description of the Long Spreading pattern.

Adjacent Sponsors

In the Adjacent Sponsors context, two adjacent syllables from different words are both sponsors. At the surface, this results in H tone only on the second sponsor. The examples from section 3 are repeated below:

(16)
i. ilya mbúzi — 'that goat'
ii. ilya ʃímba — 'that lion'
iii. uɣulya mwézi mbwaa — 'that moon is big'

The derivation will account for the abstract case of /$\sigma\acute{\sigma}_1$#$\acute{\sigma}_2\sigma$/ mapping to [$\sigma\sigma$#$\acute{\sigma}\sigma$]. As before in section 2, here and in the following, subscripts indicate tone indices. That is, a string $\acute{\sigma}_1\acute{\sigma}_2$ denotes two different tones associated to adjacent syllables, while $\acute{\sigma}\acute{\sigma}$ denotes a single tone spread to two syllables. The steps of the derivation are shown in (30).

(30)

0. $\sigma\acute{\sigma}_1$#$\acute{\sigma}_2\sigma$
   Underlying form.
1. $\sigma(\acute{\sigma}_1$#$\acute{\sigma}_2)\sigma$
   Foot placement around both tones.
2. $(\sigma(\acute{\sigma}_1$#$\acute{\sigma}_2))\sigma$
   Leftward foot expansion.
3. $(\sigma(\acute{\sigma}$#$\acute{\sigma}))\sigma$
   Tone fusion.
4. $(\sigma(\sigma$#$\acute{\sigma}))\sigma$
   Tone delinking.
5. $(\sigma(\sigma$#$\acute{\sigma}))\sigma$
   Convergence.

The adjacency of the two sponsors causes two crucial deviations from the default pattern. Firstly, the binary foot is placed over both tones. Secondly, foot expansion is leftward, rather than rightward. The differences in foot structure then lead to the singly-linked tone, rather than the default binary tone span.

Tableaux 19 through 23 will show how the constraint set motivates the steps in (30).

In Tableau 19, the optimal move is to place a foot over both sponsors, as shown in 19b. This is the only way to avoid both violations of LICENSE(H, FT).

An alternative is to first resolve the clash between the two tones through tone fusion, shown by 19c. This has several benefits: since there is only one tone now, all the tone licensing constraints are only violated once, instead of twice. Furthermore, although not shown, this also resolves the violation of low-ranked OCP-H. However, this candidate still incurs a violation of LICENSE(H, FT), which makes it suboptimal.

$\sigma\acute{\sigma}_1$ # $\acute{\sigma}_2\sigma$	*H/NONMIN-L	$\mathcal{L}$(H, FT)	$\mathcal{L}$(NONMAX-R, H)	CHAIN-L	*H/MIN-L	CHAIN-R	$\mathcal{L}$(H, MIN-R)	$\mathcal{L}$(H, NONMIN-R)
a. $\sigma\acute{\sigma}_1$ # $\acute{\sigma}_2\sigma$		*!*					**	**
b. ☞ $\sigma(\acute{\sigma}_1$ # $\acute{\sigma}_2)\sigma$				*	*	*	*	**
c. $\sigma\acute{\sigma}$ # $\acute{\sigma}\sigma$		*!					*	*
d. $\sigma\acute{\sigma}_1$ # $(\acute{\sigma}_2\sigma)$		*!			*	**	**	**

Tableau 19: Adjacent Sponsors, step 1.

The result of placing the foot more to the right is shown in 19d. With this rightmost foot, the first H tone is not licensed, and so the candidate incurs a violation of LICENSE(H, FT). Consequently, the usual tendency of the language to pull feet rightward is not followed here.

In Tableau 20, resolving the OCP situation is still not urgent enough, ruling out 20d. The highest markedness constraint that is violated is CHAIN-L. However, satisfying it, as shown in candidate 20c, incurs a violation of high-ranked *H/NONMIN-L, because it situates a H tone at the left edge of a nonminimal foot. The next highest violated constraint, *H/MIN-L, can also not be satisfied, because there is no means of moving away the first H tone from the left edge of the minimal foot. This is because tone deletion and floating tone have been assumed to be ruled out by top-ranked constraints, and a tone shift operation is not part of GEN. Instead, the winning candidate 20b removes a violation of CHAIN-R by expanding to the left. Leftward expansion is sometimes blocked by LICENSE(NONMAX-R, H), but is allowed here because the second H tone is situated at the right edge of the potential nonmaximal foot.

A crucial result of leftward expansion is that it lines up the two spreading targets in Saghala. That is, the right edge of the minimal and nonminimal foot coincide on the same

$\sigma(\acute{\sigma}_1 \# \acute{\sigma}_2)\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $\sigma(\acute{\sigma}_1 \# \acute{\sigma}_2)\sigma$				*	*	*!	*	**
b. ☞ $(\sigma(\acute{\sigma}_1 \# \acute{\sigma}_2))\sigma$				*	*		*	*
c. $\sigma((\acute{\sigma}_1 \# \acute{\sigma}_2)\sigma)$	*!				*	*	*	**
d. $\sigma(\acute{\sigma} \# \acute{\sigma})\sigma$				*	*	*!		*

Tableau 20: Adjacent Sponsors, step 2.

syllable. This is also why candidate 20b incurs one less violation of License(H, NonMin-R) than the faithful candidate; by virtue of the foot placement, the tone is now licensed by a rightmost syllable in a nonminimal foot. Because the two spreading targets are on the same syllable, there is no binary tone span at the surface; associating to the single syllable satisfies both tone licensing constraints already, so further spreading is unwarranted. This will be shown in the following tableaux.

In tableau 21, satisfaction of neither Chain-L nor *H/Min-L is possible. Consequently, at this stage the fusion of the two tones is optimal. This is shown by winning candidate 21b. The resulting fused tone is licensed by right edges of both the minimal and nonminimal foot, so this operation removes violations from both tone licensing constraints.

With tone fusion applied, there is an opportunity for tone to move away from the left edge of the minimal foot. This is what takes place in tableau 22, in candidate 22b.

After delinking, the resulting form cannot be further improved, and the derivation terminates, as shown in tableau 23. The single violation of Chain-L cannot be remedied because any further foot placement would be unlicensed and consequently blocked by $\mathcal{L}$(Ft, H).

$(\sigma(\acute{\sigma}_1 \# \acute{\sigma}_2))\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $(\sigma(\acute{\sigma}_1 \# \acute{\sigma}_2))\sigma$				*	*		*!	*
b. ☞ $(\sigma(\acute{\sigma} \# \acute{\sigma}))\sigma$				*	*			

Tableau 21: Adjacent Sponsors, step 3.

$(\sigma(\acute{\sigma} \# \acute{\sigma}))\sigma$	*H/NonMin-L	$\mathcal{L}$(H, Ft)	$\mathcal{L}$(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	$\mathcal{L}$(H, Min-R)	$\mathcal{L}$(H, NonMin-R)
a. $(\sigma(\acute{\sigma} \# \acute{\sigma}))\sigma$				*	*!			
b. ☞ $(\sigma(\sigma \# \acute{\sigma}))\sigma$				*				

Tableau 22: Adjacent Sponsors, step 4.

In conclusion, the derivation produces the surface form $[(\sigma(\sigma\#\acute{\sigma}))\sigma]$. This fits the description of Adjacent Sponsors: tone surfaces solely on the second sponsor syllable.

(σ(σ # σ́))σ	*H/NonMin-L	ℒ(H, Ft)	ℒ(NonMax-R, H)	Chain-L	*H/Min-L	Chain-R	ℒ(H, Min-R)	ℒ(H, NonMin-R)
a. ☞ (σ(σ # σ́))σ				*				

Tableau 23: Adjacent Sponsors, step 5.

Incomplete Spreading

In Incomplete Spreading, two tones separated by a single syllable will both shift, but the leftmost tone will not show a binary tone span. Examples from section 3 are repeated in (17).

(17)
- i. ihí mbuzí — 'this goat'
- ii. ihí mezí míbwaa — 'these moons are big'
- iii. awá waná wálelé — 'these tall children'

The derivation of the Adjacent Sponsors pattern above has shown that the grammar is likely to apply tone fusion to tones that are in contact. Since the Incomplete Sponsors pattern shows two independent tones at the surface, the grammar should avoid creating a situation of tonal contact, to prevent tonal fusion. This is achieved in the derivation by letting the tones shift one at a time, beginning with the rightmost tone. The steps of the derivation are shown in (31) below.

(31)

0. σ́σ # σ́σ
   Underlying Form
1. σ́σ # (σ́σ)
   Foot placement, rightmost.
2. (σ́σ) # (σ́σ)
   Foot placement.

3. $(\acute{\sigma}\sigma)$ # $(\acute{\sigma}\acute{\sigma})$
   Spreading to the right edge of a minimal foot.

4. $(\acute{\sigma}\sigma)$ # $(\sigma\acute{\sigma})$
   Delinking.

5. $(\acute{\sigma}\acute{\sigma})$ # $(\sigma\acute{\sigma})$
   Spreading to the right edge of a minimal foot.

6. $(\sigma\acute{\sigma})$ # $(\sigma\acute{\sigma})$
   Delinking.

7. $(\sigma\acute{\sigma})$ # $(\sigma\acute{\sigma})$
   Convergence.

The order of foot placement in steps 1 and 2 is due to rightward foot directionality, enforced by CHAIN-L(σ_ω). A layered foot encompassing both tones, e.g. $((\acute{\sigma}\sigma)\#\acute{\sigma})\sigma$, takes two steps to construct in Harmonic Serialism. Since the first step places a foot rightmost, the only possible layered structure after step 1 would be $\acute{\sigma}(\sigma\#(\acute{\sigma}\sigma))$, which does not cover both sponsors. Consequently, layered feet are ruled out for Incomplete Spreading.

The tableaux of the derivation will skip the footing steps, and start from step 3, in tableau 24. Since there is no room for layered feet in these examples, the constraints referring to layered feet are not shown in the tableaux.[6] Furthermore, since the domain is completely footed, foot directionality constraints are also left out.

At step 3, in Tableau 24 the highest markedness constraint that the grammar can satisfy is LICENSE(H, MIN-R). There are two ways this can be achieved: spreading either the left or right tone. The optimal choice is to spread the right tone, as shown by candidate 24b. Candidate 24c demonstrates why spreading the left tone is suboptimal: it creates tonal contact in violation of OCP-H.

[6]In contexts with more room preceding or following the sponsors, the foot licensing the left tone may expand leftward, and the foot following the right tone may expand rightward. This does not affect the association of tone. This also holds for the Surrounded Word-Initial Syllable context.

$(\acute{\sigma}\sigma)$ # $(\acute{\sigma}\sigma)$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. $(\acute{\sigma}\sigma)$ # $(\acute{\sigma}\sigma)$	**	**!		
b. ☞ $(\acute{\sigma}\sigma)$ # $(\acute{\sigma}\acute{\sigma})$	**	*		
c. $(\acute{\sigma}\acute{\sigma}_1)$ # $(\acute{\sigma}_2\sigma)$	**	*		*!

Tableau 24: Incomplete Spreading, step 3.

The tone spreading in step 3 opens up an opportunity for delinking. At the next step, in Tableau 25, this opportunity is taken right away by winning candidate 25b. Candidate 25c shows the result of performing more tone spreading. Although this satisfies LICENSE(H, MIN-R), it is suboptimal because it does not reduce the violation of higher-ranked *H/MIN-L.

$(\acute{\sigma}\sigma)$ # $(\acute{\sigma}\acute{\sigma})$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. $(\acute{\sigma}\sigma)$ # $(\acute{\sigma}\acute{\sigma})$	**!	*		
b. ☞ $(\acute{\sigma}\sigma)$ # $(\sigma\acute{\sigma})$	*	*	*	
c. $(\acute{\sigma}\acute{\sigma}_1)$ # $(\acute{\sigma}_2\acute{\sigma})$	**!			*

Tableau 25: Incomplete Spreading context, step 4.

After this initial delinking step, the process is repeated for the left tone. Steps 5 and 6 in tableaux 26 and 27 mirror the preceding two steps: tone spreads and then immediately delinks.

$(\acute{\sigma}\sigma)$ # $(\sigma\acute{\sigma})$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. $(\acute{\sigma}\sigma)$ # $(\sigma\acute{\sigma})$	*	*!	*	
b. ☞ $(\acute{\sigma}\acute{\sigma})$ # $(\sigma\acute{\sigma})$	*		*	

Tableau 26: Incomplete Spreading context, step 5.

$(\acute{\sigma}\acute{\sigma})$ # $(\sigma\acute{\sigma})$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. $(\acute{\sigma}\acute{\sigma})$ # $(\sigma\acute{\sigma})$	*!		*	
b. ☞ $(\sigma\acute{\sigma})$ # $(\sigma\acute{\sigma})$			**	

Tableau 27: Incomplete Spreading context, step 6.

Tableau 28 shows the convergence step. The tendency shown in Long Spreading to continue spreading to reach a word-initial syllable is not displayed in Incomplete Spreading. Candidate 28b shows why: spreading the left tone to the word-initial syllable causes it to cross over into the next foot. As a consequence, it creates a violation of *H/MIN-L. This makes it suboptimal compared to the faithful candidate.

$(\sigma\acute{\sigma})$ # $(\sigma\acute{\sigma})$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. ☞ $(\sigma\acute{\sigma})$ # $(\sigma\acute{\sigma})$			**	
b. $(\sigma\acute{\sigma})$ # $(\acute{\sigma}_1\acute{\sigma}_2)$	*!		*	*

Tableau 28: Incomplete Spreading, step 7.

In summary, in Incomplete Spreading the two tones avoid contact at all times. This is achieved by having the right tone spread and delink first, before spreading the left tone. The left tone does not show a binary span at the surface because to do so would mean crossing into another foot, which goes against the tendency of the language to avoid foot-initial high-toned syllables.

As will be shown below, the situation is different for SWIS: tone does cross into the next foot, and the tones do come into contact.

Surrounded Word-Initial Syllable

In the SWIS context, two sponsors separated by a word-initial syllable cause tone to surface on the two syllables following the first sponsor. The examples from section 3 are repeated in (18).

(18) i. ilya záwádi — ‘that gift’
ii. ilyilya ízíso ibwaa — ‘that eye is big’
iii. walye wálúme walelé — ‘those men are big’

At the surface, SWIS looks exactly like a default context pattern, assuming only 1 sponsor. However, the foot structure reflects the fact that SWIS has two sponsors underlyingly. The foot structure, and the steps to construct it, are shown in (32).

(32)
0. $\acute{\sigma}$ # $\sigma\acute{\sigma}\sigma$
   Underlying Form
1. $\acute{\sigma}$ # $\sigma(\acute{\sigma}\sigma)$
   Foot placement, rightmost.
2. ($\acute{\sigma}$ # $\sigma)(\acute{\sigma}\sigma)$
   Foot placement.
3. ($\acute{\sigma}$ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$
   MinFt spreading across a word boundary.
4. (σ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$
   Delinking.
5. (σ # $\acute{\sigma})(\acute{\sigma}\sigma)$
   Fusion.
6. (σ # $\acute{\sigma})(\acute{\sigma}\sigma)$
   Convergence.

As in Incomplete Spreading, foot construction proceeds in right-to-left fashion. The crucially different step is step 3: in SWIS, the left tone spreads first. This sets SWIS on a different derivational path since it includes tonal contact. Tableaux for the derivations pick up at this spreading step, starting with tableau 29.

Tableau 29 shows that after footing, it is optimal to spread to the syllable separating the two tones, as shown by 29b.[7] This is because this syllable is word-initial, so spreading

[7] Candidate 29b achieves this goal by spreading the left tone. The same violation profile is achieved by spreading the right tone leftward, i.e. $(\acute{\sigma}_1\#\acute{\sigma}_2)(\acute{\sigma}\sigma)$. There is no constraint in the set that distinguishes

$(\acute{\sigma}$ # $\sigma)(\acute{\sigma}\sigma)$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. $(\acute{\sigma}$ # $\sigma)(\acute{\sigma}\sigma)$	**	**!	*	
b. ☞ $(\acute{\sigma}$ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$	**	*		*
c. $(\acute{\sigma}$ # $\sigma)(\acute{\sigma}\acute{\sigma})$	**	*	*!	

Tableau 29: Surrounded Word-initial context, step 3.

to it satisfies LICENSE(PRWD-L, H). Since LICENSE(PRWD-L, H) outranks OCP-H, spreading here is applied despite creating tonal contact.

As was the case for Incomplete Spreading, the spreading step is followed by a delinking step, shown in tableau 30. Any other operations, such as more spreading in 30c or tone fusion in 30d, are suboptimal because they do not resolve the violation of high-ranking *H/MIN-L.

$(\acute{\sigma}$ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. $(\acute{\sigma}$ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$	**!	*		*
b. ☞ $(\sigma$ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$	*	*	*	*
c. $(\acute{\sigma}$ # $\acute{\sigma}_1)(\acute{\sigma}_2\acute{\sigma})$	**!			*

Tableau 30: Surrounded Word-initial context, step 4.

The tonal contact is resolved in the next step, shown in tableau 31. The winning candidate 31b fuses the tones, reducing licensing violations, including that of unshown LICENSE(H, NONMIN-R), in addition to satisfying OCP-H. Candidate 31c shows the suboptimality of spreading the right tone rightward.

Tableau 32 shows the convergence step. The derivation has reached a similar point as at the end of Long Spreading: a single violation of *H/MIN-L remains, but delinking tone to solve it would cause an unlicensed foot. Further spreading is also not warranted;

between these two candidates, so the are tied. The tie is inconsequential; derivations for both forms converge on the same output. Readers that prefer a situation without ties may assume a bottom-ranked constraint that militates against spreading across a foot boundary or against a foot containing multiple H tones.

$(\sigma$ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. $(\sigma$ # $\acute{\sigma}_1)(\acute{\sigma}_2\sigma)$	*	*!	*	*
b. ☞ $(\sigma$ # $\acute{\sigma})(\acute{\sigma}\sigma)$	*		*	
c. $(\sigma$ # $\acute{\sigma}_1)(\acute{\sigma}_2\acute{\sigma})$	*		*	*!

Tableau 31: Surrounded Word-initial context, step 5.

LICENSE(H, MIN-R) has been maximally satisfied. Consequently, the faithful candidate is optimal, completing the derivation.

The result, as attested, has surface H tone on the two syllables following the left sponsor.

$(\sigma$ # $\acute{\sigma})(\acute{\sigma}\sigma)$	*H/MIN-L	$\mathcal{L}$(H, MIN-R)	LICENSE(PRWD-L, H)	OCP-H
a. ☞ $(\sigma$ # $\acute{\sigma})(\acute{\sigma}\sigma)$	*		*	

Tableau 32: Surrounded Word-initial context, step 6.

Blocked Long Spreading derivation

Blocked Long Spreading involved two tones, where Long Spreading for the first tone was blocked because it would cause tonal contact. It was exemplified in the previous section by the data repeated in (19) below.

(19) i. izilya ŋgúkú nɟacé ‘those little chickens’

The derivation of Blocked Long Spreading does not involve any novel processes. Consequently, the derivation is not presented with a full set of tableaux, but only outlined by the steps in (33).

(33) 0. $\sigma\acute{\sigma}$ # $\sigma\sigma$ # $\acute{\sigma}\sigma$
Underlying Form

1. $\sigma(\acute{\sigma}$ # $\sigma)\sigma$ # $(\acute{\sigma}\sigma)$
Foot placement, collapsed (right-to-left).

2. $\sigma(\acute{\sigma} \# \acute{\sigma})\sigma \# (\acute{\sigma}\sigma)$
   MinFt spreading across a word boundary.

3. $\sigma(\sigma \# \acute{\sigma})\sigma \# (\acute{\sigma}\sigma)$
   Delinking.

4. $\sigma((\sigma \# \acute{\sigma})\sigma) \# (\acute{\sigma}\sigma)$
   Rightward foot expansion.

5. $\sigma((\sigma \# \acute{\sigma})\sigma) \# (\acute{\sigma}\acute{\sigma})$
   MinFt spreading.

6. $\sigma((\sigma \# \acute{\sigma})\sigma) \# (\sigma\acute{\sigma})$
   Delinking.

7. $\sigma((\sigma \# \acute{\sigma})\acute{\sigma}) \# (\sigma\acute{\sigma})$
   NonMinFt spreading.

8. $\sigma((\sigma \# \acute{\sigma})\acute{\sigma}) \# (\sigma\acute{\sigma})$
   Termination.

4.3 Summary

The data for Saghala were presented in section 3. It characterized Saghala as a tone shift language that usually had binary or ternary tonal spans. Furthermore, unexpectedly short tone spans appeared to be a result of tonal contact. On the other hand, in some cases it seemed tonal contact was avoided. Finally, there was some role to be played by word-initial syllables.

This section gave a formal account of these observations. Firstly, the tone shift process was modeled as an interaction between rightward foot directionality and tone repulsion from leftmost positions in feet. Secondly, the observation of surface tonal spans was also reinterpreted through the lens of foot structure. That is, in the account presented in 4, there is nothing explicitly stating that Saghala should have surface tone spans. Rather, there are simply two targets for tone to spread to, and these targets are usually adjacent. In other words, the generalization in Saghala is that tone is always licensed by the rightmost syllable of a minimal foot, and of a nonminimal foot where possible.

The shortness of tonal spans in tone contact situations, i.e. in Adjacent Sponsors and SWIS cases, is accounted for by the combination of foot structure and tone licensing effects. In both cases, tones have merged, and the resulting tone requires association to only one rightmost syllable each of minimal and nonminimal foot. Once such a position is associated to, spreading requirements have been satisfied. Consequently, there is no drive to create long tonal spans.

Avoidance of tonal contact, where applicable, was due in part to the effect of OCP-H. It was also due to the tone repulsion from left foot edges; tones were discouraged from entering into the next tone's foot domain by *H/MIN-L.

The significance of word-initial syllables was expressed by LICENSE(PRWD-L, H). Although low-ranked, this constraint caused the priority of spreading across word boundaries. This resulted in ternary spreading in Long Spreading contexts, and tonal contact in SWIS contexts.

The UF to footed SF mappings for all cases are listed in Table 33.

Type	**UF**	**SF**
Default	$..\acute{\sigma}\sigma\sigma..$	$..((\sigma\acute{\sigma})\acute{\sigma})..$
Long Spreading	$..\acute{\sigma}\sigma\sigma\#\sigma\sigma..$	$..((\sigma\acute{\sigma})\acute{\sigma})\#(\acute{\sigma}\sigma)..$
Adjacent Sponsors	$..\sigma\acute{\sigma}_1\#\acute{\sigma}_2..$	$..(\sigma(\sigma\#\acute{\sigma}))..$
Incomplete Spreading	$..\acute{\sigma}\sigma\#\acute{\sigma}\sigma\sigma..$	$..(\sigma\acute{\sigma})((\#\sigma\acute{\sigma})\acute{\sigma})..$
Surrounded Word-Initial Syllable	$..\acute{\sigma}\#\sigma\acute{\sigma}\sigma..$	$..(\sigma\#\acute{\sigma})(\acute{\sigma}\sigma)..$
Blocked Long Spreading	$..\acute{\sigma}\sigma\sigma\#\acute{\sigma}\sigma\sigma..$	$..((\sigma\acute{\sigma})\acute{\sigma})\#((\sigma\acute{\sigma})\acute{\sigma})..$

Table 33: The underlying and footed surface forms for the six Saghala contexts.

In conclusion, this section gave a descriptively adequate account of Saghala Noun Phrase tonology based on three factors. Firstly, the analysis used layered feet to define the shifting and spreading domain. Secondly, a principled constraint set regulated tone-foot interactions. Finally, the Harmonic Serialism framework enabled opaque analyses such as the tone shift and tonal contact cases.

The next section will discuss this approach and compare the choices made here to other approaches taken in the literature.

5 Discussion

5.1 Acoustic evidence for foot structure in Saghala

The foot structures proposed here for Saghala are based on phonological arguments. Further support for the presence of feet might be found by inspecting the acoustics. Specifically, feet might be signalled by differences in pitch, amplitude, duration, or vowel quality of the syllables involved. The ideal test cases are those contexts where the analysis predicts identical surface tones with different foot structures. An example of this is shown in (34).

(34)
a. Default $\sigma((\underline{\sigma}\#\acute{\sigma})\acute{\sigma})\sigma$
b. Surrounded Word-Initial Syllable $(\sigma(\underline{\sigma}\#\acute{\sigma}))(\underline{\acute{\sigma}}\sigma)$

In (34a), foot structure follows the default dactylic pattern starting from the sponsor, which is word-final. In (34b), tone comes from two sponsors underlyingly, and this is reflected in the foot structure, with each sponsor syllable contained in a different foot. Crucially, the forms are otherwise equal; in both cases, high tone surfaces only on the two syllables following the word boundary. Hence, (34) shows a metrical minimal pair, and it is possible that this metrical difference is reflected in the acoustics.

However, even if an investigation of the acoustics finds no evidence of foot structure, this is not a counterargument to a foot-based analysis. This was noted previously by Goldsmith (1992), in a footnote for his analysis of Llogoori:

> "[T]he present analysis adds to a growing body of literature that supports the position that metrical structure plays a role in the organization of language in a large number of cases in which there is no phonetic evidence of alternating stress or overt rhythm. If this is correct, as I am convinced that it is, it is more appropriate to say that metrical structure arises not when the data of a language permits it, but rather when the data of the language does not forbid it."

In summary, further research is warranted to determine if the proposed foot structure is reflected in the acoustics of Saghala. However, the absence of such acoustic evidence does not invalidate the present proposal.

5.2 Alternative Optimality Theoretic approaches to Bantu bounded tone

Within the context of OT, at least three lines of previous research on Bantu bounded tone can be recognized: Optimal Domains Theory, minimal (mis)alignment, and Headed Spans theory. In the following, these approaches are discussed and compared to the present framework.

Optimal Domains Theory ('ODT') centers around the idea of relating underlying tones to surface-level tone domains (Kisseberth 1993; Cole and Kisseberth 1994; Cassimjee and Kisseberth 1998). Bounded tone patterns then follow from restrictions on the size of such tone domains.

Bickmore's approach of minimal (mis)alignment derives surface tone patterns from a family of alignment constraints, which may cause tone to spread to TBUs at a minimal distance away from their sponsor (Bickmore 1996). The minimal distance effect is due to the gradient evaluation of the alignment constraints.

Headed spans theory proposes that surface forms are parsed exhaustively into domains for each feature ('feature spans'), notably tone (Key 2007; Key and Bickmore 2014, building on McCarthy 2004). Much like in ODT, bounded patterns are derived by placing requirements on the size of such feature spans.

Determining whether the above proposals allow for an account of Saghala tonology is beyond the scope of this paper. There are two other aspects on which the foot-based HS approach compares favorably to previous approaches. Unlike the present proposal, the above proposals suffer from the following: stipulation of domain size and use of two-level constraints. These issues are discussed below.

Stipulation of domain size

One of the goals for any account of Bantu bounded tone is to derive tonal spans over multiple TBUs starting from a tone with only a single underlying association. To this end, ODT employs a *MONOHD constraint to enforce binary domains.

(35) *MONOHD

"A HD [High tone domain] should not be monomoraic/monosyllabic." (Cassimjee and Kisseberth 1998, p. 18)

Likewise, in the Headed Spans framework, binarity is achieved through SPBIN(H).

(36) SPBIN(H)

"Assign a violation mark for each H span that does not parse some part (i.e., at least one mora) of exactly two syllables." (Key and Bickmore 2014, p. 41)

In both frameworks the impetus for binarity is stipulated; it does not follow from the theory of the representation. Furthermore, neither framework has a way of accounting for ternary domains. Ternarity could be achieved by adding constraints such as *BINHD for ODT or SPTRI(H) for Headed Spans, but this adds further stipulations. Furthermore, there is no account for the fact that there are presumably no constraints such as *TRIHD or SPQUAD(H) that could drive construction of quaternary tonal spans.

In the present approach, binarity and ternarity are linked to the nature of the foot, the size of which is motivated independently by cross-linguistic studies of stress systems and metrically driven phonological processes. A quaternary domain cannot be derived straightforwardly, matching the typological picture of Bantu bounded tone.[8]

The maximally ternary nature of the foot in the MPK framework is itself a stipulation. However, this stipulation was made based on consideration of a wider range of language phenomena, and was not motivated by the typology of Bantu bounded tone. Consequently, getting ternarity from the representation without domain-specific stipulations is an improvement over previous approaches.

[8]One case of an apparent quaternary domain is Kikuria, where one inflectional melody places H tone on the fourth syllable of the macrostem (Marlo et al. 2015). Further afield, Michael (2010) suggests a quadrisyllabic domain for the Zaparoan language Iquito. It is possible that such quaternary domains can be constructed in the present framework through the combination of multiple feet, possibly of different foot types. The point made here is that the typological rarity of such domains is reflected in the complexity of accounting for them.

Two-level constraints

The term 'two-level constraint' denotes a type of constraint that places well-formedness restrictions on the surface level, but also makes reference to structure at the input level. In the analysis of Bantu bounded tone, two-level constraints occur when constraint formulations use the concept of a sponsor. Sponsorship is a property of a TBU at the underlying level of representation. Making requirements on surface structure with reference to sponsors means that both levels of representation are involved. The previous approaches discussed here make use of such two-level constraints. One example is the ODT constraint INCORPORATE (F-SPONSOR), shown in (37). F stands for a feature in general, but for the present purpose could be instantiated as H tone.

(37) INCORPORATE (F-SPONSOR)
"[E]very F-sponsor is in a domain" (Cassimjee and Kisseberth 1998, p.12)

The evaluation of this constraint involves both levels of representation; H-domains are present only in surface forms, whereas the location of H-sponsors requires reference to the underlying location of the H tone.

The Headed Spans framework has a similar constraint FAITHHDSP(αF) to which the same reasoning applies. In minimal (mis)alignment, alignment constraints may make reference to lexical structure. An example is (*)ALIGN (H,L)-I/O:

(38) (*)ALIGN (H,L)-I/O
"The left edge of a HTS [High tone span] in the output must (not) align with the left edge of a HTS in the input" (Bickmore 1996, p. 16)

To evaluate this constraint, the grammar must compare the leftmost TBU of a tone in the input to the leftmost TBU of its corresponding tone in the output. Since both lexical and surface structure are involved in the evaluation, this is a two-level constraint.

Two-level constraints go against a core principle of OT: its surface-orientedness. Consider the following criticism on these constraints from Kager (1999):

> " [Two-level constraints] function as rules, combining a structural condition (the input structure) and a repair. A theory allowing for two-level well-formedness

constraints may stipulate any type of relation between the input and output, being equivalent in this respect to rule-based theory (Lakoff 1993). This power undermines standard OT's solutions to problems inherent to rule-based serialism, in particular *conspiracies* and the *Duplication Problem*. " (p. 381)

In conclusion, it is desirable to avoid the use of two-level constraints.[9] However, past approaches needed such constraints to account for opaque processes in standard OT. The handling of opacity in the present framework is relegated to Harmonic Serialism. Consequently, it no longer needs to be encoded in the constraint set. As a result, the present framework does not make use of two-level constraints.

5.3 Alternative derivational frameworks

In the present account, Harmonic Serialism served as the source of derivationality. HS is not the only framework that can offer such effects. Multi-level frameworks, such as Stratal OT (Bermúdez-Otero 1999; Kiparsky 2000) and cophonology theory (Inkelas and Zoll 2007 and references therein), can also model opaque phenomena.

In these frameworks, each level of a derivation is tied to a morphological or syntactic domain. Within a level evaluation follows standard OT. In Saghala, tone can freely cross word boundaries, suggesting that for a multi-level account, any tonal processes must take place at least after phonological phrase construction. Morphological frameworks might be able to derive the tone shift pattern using several levels, starting from the phonological phrase. Consequently, a matter for further research is to determine how many levels are minimally needed to account for the Saghala patterns in a foot-based framework. For the default case, two levels could be enough, as shown in Table 34.

For the default context, all that is needed is that foot construction can refer to underlying tone, and that surface tone can refer to foot structure. Additional levels may be required to account for the other subpatterns. In particular, the Surrounded Word-Initial Syllable

[9] This argument against two-level constraints leans on the assumption that the adoption of any such constraint implies that all two-level constraints could plausibly be part of a grammar. However, it may be possible to motivate the adoption of a more strictly defined subclass of two-level constraints. Further research is needed on this issue. The author thanks Marc van Oostendorp and Jochen Trommer for independently pointing this out.

/$\sigma\acute{\sigma}\sigma\sigma\sigma$/	Underlying form
$\sigma((\acute{\sigma}\sigma)\sigma)\sigma$	Lv. I: Foot construction
$\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma$	Lv. II: Tone reassociation
$[\sigma((\sigma\acute{\sigma})\acute{\sigma})\sigma]$	Surface form

Table 34: A level-based derivation for the default context.

context relies on tone contact in an intermediate form, suggesting that there may be a need for multiple tonal association steps. Another effect in the present analysis which relied on intermediate forms is the deviant foot structure in Adjacent Sponsors. This suggests foot construction may also require multiple levels.

Determining the exact requirements is left as a matter for future research. For now, it is concluded that HS is the natural choice for the present account, but other frameworks could prove to be viable alternatives.

5.4 Tone-foot constraints and headedness

A previous OT proposal for relating tone and feet is De Lacy (2002). This constraint set is centered around a tendency for H tones to avoid non-heads, and for L tones to avoid heads.

A first issue when considering De Lacy's approach for the present foot-based analysis is that the status of prominence in the layered foot needs to be clarified. The layered foot has a head syllable, which is the head of the internal foot. In addition, the satellite syllable could also be interpreted as a prominent position. Consequently, a structure such as in (39), with stress on the right syllable of the internal foot and with the satellite syllable on the right of the layered foot, would yield H tone on the last two syllables of the layered foot, as desired.

(39) $((\sigma\text{'}\sigma)\sigma)$

Two problems remain: firstly, the headedness in the structure above is based only on the fact that it is needed for an interpretation in terms of De Lacy's framework. Ideally, independent evidence should be adduced to support the left-branching amphibrach, $((\sigma\text{'}\sigma)\sigma)$, in favor of the dactyl, $((\text{'}\sigma\sigma)\sigma)$.

Secondly, the present analysis sometimes creates different foot structures too. These can cause counterexamples to the generalizations proposed above. This will be demonstrated using the data in (40).

(40)	a. Adjacent Sponsors	$(\sigma(\sigma\#\acute{\sigma}))\sigma$
	b. Surrounded Word-Initial Syllable	$(\sigma(\sigma\#\acute{\sigma}))(\acute{\sigma}\sigma)$

Firstly, if every satellite syllable should receive a H tone, the form in (40a) should surface as *[$(\acute{\sigma}(\sigma\#\acute{\sigma}))\sigma$]. Secondly, if every head syllable should receive a H tone, the form in (40b) should surface as *[$(\sigma(\sigma\#\acute{\sigma}))(\acute{\sigma}\acute{\sigma})$], assuming head syllables are always rightmost in the minimal foot. Finally, the form in (40b) surfaces with a tone linked to the non-head syllable of the second foot, which is not motivated under De Lacy's constraint set.

The complications above suggest that De Lacy's constraint set needs more flexibility. Like the structural constraints adopted here, De Lacy's constraints do not consider feet and tone as separate loci of violation. Expanding the constraint set with licensing-type constraints may solve these problems.

If the above issues can be resolved, the question remains whether it is more desirable to refer to feet edges or headedness. Foot edge constraints may differ from headedness constraints in that they allow for direction reversals, e.g. left-edge orientation in flat binary feet, but right-edge orientation in layered ternary feet. Consequently, future typological research may provide insight into the optimal formulation of a feet-and-tone constraint set.

6 Conclusion

This paper has introduced a new foot-based approach to account for bounded tone shift and spread. Key elements are the adoption of a layered foot to delimit the bounding domain, the use of Harmonic Serialism to derive local effects, and the proposal of a licensing/structure constraint family to relate tone and feet to each other.

The approach was demonstrated on Saghala. It successfully accounted for all six subpatterns. This involved dealing with the interplay of tone spread, tone shift, various cases of tonal proximity, and sensitivity to word-initial syllables. Furthermore, Saghala tonology took place in a trisyllabic domain size and with no discernible role for morphology.

The ability of the framework to deal with the Saghala patterns shows promise for its applicability to a wide range of Bantu bounded tone systems. Furthermore, the framework improved on previous OT proposals in two aspects: it does not directly stipulate the size of the bounding domain, and it does not use markedness constraints that make reference to input structure.

Future work will explore the full typological predictions of the framework. In addition to bounded tone patterns, the foot-based nature of the framework may allow the typology to include edge-based tone and rhythmic tone with minimal adaptations.

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