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Source: *Phonology*, Vol. 32, No. 1, Constituent structure in sentence phonology (2015), pp. 147-176
Published by: Cambridge University Press
Stable URL: https://www.jstor.org/stable/43865845
Accessed: 30-05-2021 16:38 UTC

Phonology **32** (2015) 147–176. © Cambridge University Press 2015
doi:10.1017/S095267571500007X

*Phrasal phonology in Copperbelt Bemba**

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Copperbelt Bemba exhibits several rightward spreading tonal processes which are sensitive to prosodic phrase structure. The rightmost H tone in a word will undergo unbounded spreading if the word is final in a phonological phrase (φ). In an intonational phrase consisting of several single-word φ's, the rightmost H in the first word will spread through all following toneless φ's. From a rule-based perspective, this can only be accounted for by positing mutually feeding iterative rules, as a single H-tone spreading rule cannot account for the long-distance spreading. Rather, a second rule that spreads a H from the final mora of one word onto the initial mora of the following word is required, as a bridge to further unbounded spreading. Three phrase-sensitive OT constraints are proposed to account for H-tone spreading between words. One is of the domain-juncture variety, requiring the specification of two separate prosodic domains.

1 Introduction

The goal of this paper is threefold: firstly to provide a detailed description and analysis of tonal spreading rules at the phrasal level in Copperbelt Bemba, secondly to demonstrate a novel rule interaction in phrasal phonology that involves mutually feeding iterative rules and how this can be formalised within Optimality Theory, and finally to consider the phonology–syntax mapping in Copperbelt Bemba and evaluate how well current prosodic correspondence theories – here Align/Wrap theory and

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The first-named author would like to acknowledge financial support from the British Academy (grant number SG102315; 2011–13). We also acknowledge fruitful discussion with audiences at Bantu 5 (INALCO, Paris), ACAL 45 and a workshop on tone at the University of Massachusetts Amherst. We also thank the guest editors of this volume, as well as two anonymous reviewers for their useful comments and suggestions. Of course, any errors or omissions are our own.

Match theory – account for the prosodic constituent structure in Copperbelt Bemba.[1]

Building on earlier work conducted on Copperbelt Bemba tonology (Bickmore & Kula 2013), two H-tone spreading patterns will be central to the discussion of phrasal phonology in Copperbelt Bemba, namely bounded spreading and unbounded spreading. The characterisation of *φ*'s is crucial in accounting for these spreading patterns. The paper will examine H-tone spreading within a series of single-word *φ*'s occurring in particular syntactic contexts where it is observed that a single H in the initial *φ* can surface on each lexically toneless syllable of subsequent *φ*'s. We present the basic tone patterns in §2, and show in §3 that a rule-based approach is forced to analyse the long-distance spreading patterns as involving mutually feeding iterative rule interaction. In §4 we present an alternative OT account of the facts, which relies on a CrispEdge constraint that makes reference to juncture effects. §5 provides a discussion of whether constraints requiring the juncture of two smaller domains to be contained within a larger one are necessary, and what the implications of an alternative formulation might be, at least for the set of data considered here. Finally, §6 provides some concluding remarks.

2 Unbounded and bounded high spreading

Following Bickmore & Kula (2013), we can identify two main H-tone spreading processes within words in Copperbelt Bemba, namely UNBOUNDED and BOUNDED spreading. Unbounded rightward H spreading targets the rightmost H tone in a phrase-final word ('phrase' will be made more precise in §3), spreading it to the end of the word. We will show that unbounded spreading applies only within a word and not across words. (1) illustrates unbounded spreading in Copperbelt Bemba: the source/lexical H tone is on the subject marker in (a, b), on the pre-prefix in (c), on the tense/aspect/mood (TAM) marker in (d) and on the first syllable of the verb stem in (e). In all cases the H spreads to the word-final TBU.[2]

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[1] The data presented in this paper come mainly from the first author, a native speaker of Copperbelt Bemba, a Bantu language (M.42) spoken in Zambia and parts of southern Democratic Republic of Congo. Examples are presented incorporating vowel coalescence occurring between adjacent vowels in particular contexts. Underlying forms give lexical tones and forms without vowel fusion. Numbers in glosses refer to noun classes or to 1st, 2nd or 3rd person. The 'augment' is a pre-prefix that occurs preceding noun-class markers with varying functions that we abstract away from here. In Bemba it is a copy of the vowel of the noun class marker. The following abbreviations are used in glosses: APPL = applicative; AUG = augment; CONJ = conjunction; FUT = future; FV = final vowel; HAB = habitual; LOC = locative; NEG = negative; OM = object marker; PERF = perfective; PL = plural; POSS = possessive; PRN = pronoun; PROG = progressive; RECIP = reciprocal; SM = subject marker; SUBJ = subjunctive.

[2] Like many Bantu languages, Bemba exhibits a demorification process whereby an underlying preconsonantal nasal transfers its mora to the preceding vowel, rendering it long.

(1) *Unbounded spreading*
a. /bá-ka-fik-a/ bá-ká-fík-á
2SM-FUT-arrive-FV ‘They will arrive.’
b. /bá-ka-mu-londolola/ bá-ká-mú-lóóndólól-á
2SM-FUT-1OM-introduce-FV ‘They will introduce him/her.’
c. /ú-ku-londolol-a/ ú-kú-lóóndólól-á
AUG-15-introduce-FV ‘to introduce, explain’
d. /tu-lée-mu-londolol-a/ tù-léé-mú-lóóndólól-á
1PL-PROG-1OM-introduce-FV ‘We are introducing him/her.’
e. /tu-ka-páapaatik-a/ tù-kà-páápáátík-á
1PL-FUT-flatten-FV ‘We will flatten.’

Unbounded spreading occurs only if it can reach the word-final TBU. Bounded spreading, on the other hand, results in a ternary pattern in Copperbelt Bemba if the word-final TBU already has a H or if the word undergoing H spreading is not phrase-final. Bounded ternary spreading is shown in (2).

(2) *Bounded spreading*
a. /ta-tú-luk-il-an-ilé/ tà-tú-lúk-íl-èèné
NEG-1PL-plait-APPL-RECIP-PERF ‘We didn’t plait for each other.’
b. /bá-londolol-é/ bá-lóóndólòl-é
2SM-explain-SUBJ ‘Let them explain.’
c. /bá-ka-pat-a=kó/ bá-ká-pát-à=kó
2SM-FUT-hate-FV=17.LOC ‘They will hate a bit.’
d. /bá-mu-luk-il-a=kó/ bá-mú-lúk-ìl-à=kó
2SM-1OM-plait-APPL-FV=17.LOC ‘They plait a bit for him.’

In these examples, the first lexical H in the word does not undergo unbounded spreading, as it cannot reach the final TBU of the word, due to the presence of another H. It undergoes ternary spreading instead. In (2a, b) a melodic H is realised on the word-final TBU, blocking unbounded spreading.[3] In (2c, d) the verb is followed by the locative enclitic /kó/.[4]

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[3] Bemba, like most Bantu languages, has lexical H tones (associated underlyingly to various morphemes), as well as melodic H tones, contributed by various TAMs. In this regard, TAMs can be divided into four types: those with (i) no melodic H, (ii) melodic H realised on the final vowel, (iii) melodic H realised on all TBUs from the peninitial syllable up to and including the final vowel and (iv) melodic H on the second syllable of the verb stem. See Bickmore & Kula (2013) for detailed discussion.

[4] The ending /kó/ is treated as an enclitic on the verb in the Bantu literature (see Marten & Kula 2014). Phonologically, based on its tonal interaction with the verb stem where it patterns with H-toned suffixes, it is part of the same prosodic word as the verb.

The examples in (3) show that a H tone does not undergo unbounded spreading across a word boundary to the end of a phrase, demonstrating that unbounded spreading is restricted to words.

(3) a. /tu-ka-lás-il-a kombe/ tù-kà-láʃ-íl-à kòòmbè
1PL-FUT-hit-APPL-FV Kombe 'They will hit for Kombe.'
b. /bá-ka-salul-a buino/ bá-ká-sálùl-à bwììnò
2SM-FUT-fry-FV well 'They will fry well.'
c. /ú-ku-luk-il-a kombe/ ù-kú-lúk-ìl-à kòòmbè
AUG-15-plait-APPL-FV Kombe 'to plait for Kombe'

In these cases the H in the first word will not undergo unbounded spreading to the end of the phrase, even though all subsequent TBUs within the phrase are toneless. This is because, while unbounded spreading always targets the final TBU of the phrase, it applies only *within* a word, never crossing a word boundary. As seen, in (3a) and (b) the H undergoes bounded spreading instead. In (c) the H on the pre-prefix undergoes ternary spreading, but a subsequent tone rule delinks the H from a word-initial onsetless syllable after it has undergone ternary spreading. The application of Unbounded Spreading can be characterised as in (4).

(4) *Unbounded Spreading*
The rightmost H in a word spreads to the end of that word if (i) the final TBU of the word in question is toneless and (ii) the word is phrase-final (i.e. Unbounded Spreading applies to the rightmost H in a phrase-final word).

The examples in (5) show that a H tone surfacing on a word-final TBU will ultimately spread to the final TBU of a following toneless word.

(5) a. /tu-ka-lí-a ʧitundu/ tù-kà-lj-á ʧítúúndú
1PL-FUT-eat-FV 1.Chitundu 'We will eat Chitundu.'
b. /luk-á buino/ lùk-á bwíínó
plait-FV well 'Plait well!'

While it might *prima facie* seem that the H at the end of the first word is spreading in an unbounded fashion to the end of the phrase, this is actually not the case. We analyse these forms as undergoing two tone rules. The first is Interword Doubling, which spreads a word-final H onto the initial TBU of a following word. This feeds Unbounded Spreading, which spreads the H, now on the initial TBU of the second word, to the end of the second word, which is final in the phrase. The examples in (6) show that Interword Doubling is an independently attested process.

(6) a. /í-ʧi-paapá ʧi-sumá/ ì-ʧí-páàpá ʧí-sùmá
AUG-7-rind 7-good 'good rind'
b. /ú-lu-tandá lu-sumá/ ù-lú-táàndá lú-sùmá
AUG-14-star 14-good 'good star'
c. /pat-á kapembuá/ pàt-á kápèèmbwá
hate-FV 1.Kapembwa 'Hate Kapembwa!'
d. /béleng-il-á kapembuá/ bélééng-èl-á kápèèmbwá
read-APPL-FV 1.Kapembwa 'Read for Kapembwa!'

These examples illustrate that a word-final H tone spreads to the initial TBU of the following word. However, since the final TBU of the second word has a H, the H which has spread onto the initial TBU of the second word cannot then undergo unbounded spreading. The rule of Interword Doubling is thus defined as in (7).

(7) *Interword Doubling*
A H on the final TBU of one word spreads onto the initial TBU of a following word.

Next, let us consider the examples in (8), where an underlying H on the penult spreads into a following word, and subsequently spreads to the end of the following word if it is completely toneless.

(8) a. /tu-ka-lás-a kapembuá/ tù-kà-lás-á kápèèmbwá
1PL-FUT-hit-FV 1.Kapembwa 'We will hit Kapembwa.'
b. /tu-ka-lás-a ʧitundu/ tù-kà-lás-á ʧítúúndú
1PL-FUT-hit-FV 1.Chitundu 'We will hit Chitundu.'

We argue that the H on the penult in the first word of both (a) and (b) will undergo Bounded Spreading (as it is not the rightmost H of a phrase-final word). Since the H is now linked to the word-final TBU, it will subsequently undergo Interword Doubling onto the initial TBU of the second word. In (8b), where the following word is completely toneless, Unbounded Spreading will apply, spreading the H to the word-final TBU of the second word, which is the end of the phrase.

To generalise thus far, a H tone will ultimately spread to the end of a phrase in three cases: (i) if it is underlyingly in a phrase-final word followed by a string of toneless TBUs extending to the end of that word (e.g. (1)), (ii) if it originates on the final TBU of a word followed by a completely toneless word (in the same phrase) (e.g. (5)) and (iii) if it originates on the penultimate TBU of a word where the final TBU is toneless and there is a following completely toneless word in the same phrase (e.g. (8b)).

If the H in the first word is in antepenultimate position (as in (3) above), the H does not spread to the end of the second word, but instead undergoes bounded spreading. Given this, one might wonder why the H on the antepenult of the first word in (3a) does not spread to the end of the word, given that we have characterised bounded spreading in Copperbelt Bemba as ternary. To account for this, we must examine the process of bounded spreading more closely.

Bickmore & Kula (2013) argue that the ternary spreading pattern is formally accomplished by the application of two distinct rules – distinct in that they are motivated by and subject to different constraints, but related because they have a dependency relation; the application of the second rule requires the application of the first. The two rules are summarised in (9).

(9) *Bounded spreading*
a. *High Doubling*
A H spreads onto the following mora (High Doubling is not subject to the OCP, and can target a word-final TBU).
b. *Secondary High Doubling*
A H continues to spread onto the first mora of the following syllable (Secondary High Doubling is subject to the OCP, and never spreads a H onto a word-final TBU).

The two rules can be distinguished by their OCP requirements and their ability to spread a H onto a word-final TBU. High Doubling spreads a H onto a following TBU, even if that produces an OCP violation, as can be seen in the examples in (10). These derived OCP violations result in phonetic downstep.[5] In each case the rightmost lexical or melodic H is downstepped after it becomes adjacent to a following lexical H as a result of High Doubling. Example (10a) (like (8b))) demonstrates that High Doubling can target word-final TBUs.

(10) a. /bá-ka-lás-a sáaná/ bá-ká-ꜜlás-á sáàná
2SM-FUT-hit-FV a.lot 'They will hit a lot.'
b. /ú-ku-léet-il-a/ ú-kú-ꜜléét-él-á
AUG-15-bring-APPL-FV 'to bring for'
c. /kálip-á/ kálíꜜp-á
be.angry-FV 'be angry!'

The application of High Doubling contrasts with that of Secondary High Doubling, in which additional H spreading is blocked to avoid an

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[5] Whether the downsteps are triggered by a floating L tone, or are just the result of two adjacent TBUs linked to distinct Hs (adopting Odden's 1986 proposal for Kishambaa), is somewhat orthogonal to our concerns here. What is important, however, is to note that downsteps only result from the effects of High Doubling, as well as Interword Doubling (/ʧuulá mu-kúlu/ → [ʧúùlá mú-ꜜkúlú] 'big frog'). In addition, downsteps occur only word-internally, never across a word boundary. No downstep results from underlyingly adjacent Hs, e.g. /bá-ka-já-lás-il-a/ → [bá-ká-ꜜjá-láʃ-íl-á] 'they will hit for them', where no downstep is found between [já] and [láʃ]. If L is underlyingly underspecified, as we assume here, then underlyingly adjacent Hs fuse.

OCP violation, as the examples in (11) show. In these cases the leftmost H is followed by another H within the word, which blocks ternary spread so as to avoid an OCP violation. These data demonstrate that the OCP does not in fact apply across the board to all tone-spreading rules, but only constrains certain spreading processes.

(11) a. /bá-ka-mu-lás-a/ bá-ká-mù-lás-á
2SM-FUT-1OM-hit-FV 'They will hit him/her.'
b. /tú-luk-il-é/ tú-lúk-ìl-é
1PL-plait-APPL-SUBJ 'that we plait for'
c. /kálip-il-á/ kálíp-ìl-á
be.angry-APPL-FV 'Be angry at!'

We provide derivations for (2c), (10b) and (11a) in (12).

(12) *underlying*	a. bá-ka-pat-a=kó	b. ú-ku-léet-il-a
High Doubling	bá-ká-pat-a=kó	ú-kú-ꜜléét-el-a
Secondary High Doubling	bá-ká-pát-a=kó	ú-kú-ꜜléét-él-a
Unbounded Spreading	*n/a*	ú-kú-ꜜléét-él-á
surface	bá-ká-pát-à=kó	ú-kú-ꜜléét-él-á
underlying	c. bá-ka-mu-lás-a	
High Doubling	bá-ká-mu-lás-á	
Secondary High Doubling	*blocked by OCP*	
Unbounded Spreading	*n/a*	
surface	bá-ká-mù-lás-á	

The second distinction between High Doubling and Secondary High Doubling is that the latter never spreads a H onto a word-final TBU, even in cases where the following word begins with a TBU which is unspecified for tone. This is illustrated in (13).

(13) a. /tu-ka-lás-il-a ka-fúndiʃa/ tù-kà-láʃ-íl-à kà-fúúndíʃá
1PL-FUT-hit-APPL-FV 1a-teacher 'We will hit for the teacher.'
b. /tu-ka-bá-pat-a buino/ tù-kà-bá-pát-à bwììnò
1PL-FUT-2OM-hate-FV well 'We will hate them well.'

In the examples above, the rightmost H in the first word in each case only spreads once onto the following TBU, and not to the final vowel. This, then, serves to explain why only a H on the penultimate or final vowel will ultimately spread into a following word. A H in antepenultimate position will not spread into the following word, since it never spreads to the final TBU of the word that it occurs in. If it is on the antepenultimate TBU (of a non-phrase-final word) it will not undergo ternary spreading. If the H is in pre-antepenultimate position, full ternary spreading will only reach the penultimate TBU, and if it is in antepenultimate position, it will not reach the final TBU, due to a prohibition on Secondary High Doubling spreading a H to a word-final TBU.

Now that we have examined High Doubling and Secondary High Doubling in some detail, it is important to highlight that each of these differs from Interword Doubling. One might, for instance, ask whether the spreading across words exemplified in (6) and (8) might be the result of High Doubling. The first indication that it is not is that we saw in examples such as (2) that High Doubling feeds Secondary High Doubling, yet this is not attested in (6c) or (d). Second and most importantly, we see in (8) that High Doubling must be able to feed Interword Doubling.

To illustrate the rule interaction involved in generating these forms, we provide derivations below for (6c), (8a) and (8b).

(14)	*underlying*	a.	pat-á kapembuá
	High Doubling		*n/a*
	Secondary High Doubling		*n/a*
	Interword Doubling		pat-á kápeembwá
	Unbounded Spreading		*n/a*
	surface		pàt-á kápèèmbwá
	underlying	b.	tu-ka-lás-a kapembuá
	High Doubling		tu-ka-lás-á kapeembwá
	Secondary High Doubling		*n/a*
	Interword Doubling		tu-ka-lás-á kápeembwá
	Unbounded Spreading		*n/a*
	surface		tù-kà-lás-á kápèèmbwá
	underlying	c.	tu-ka-lás-a ʧitundu
	High Doubling		tu-ka-lás-á ʧituundu
	Secondary High Doubling		*n/a*
	Interword Doubling		tu-ka-lás-á ʧítuundu
	Unbounded Spreading		tu-ka-lás-á ʧítúúndú
	surface		tù-kà-lás-á ʧítúúndú

In (14a) neither High Doubling nor Secondary High Doubling applies, as these are both word-level rules. Interword Doubling does apply, spreading the H onto the initial TBU of the following word. Unbounded Spreading does not continue to spread that H, since there is a subsequent H in the second word. In both (b) and (c), High Doubling applies to spread the root H onto the word-final TBU. Secondary High Doubling again does not apply, as it is strictly a word-level process. Interword Doubling then spreads the H onto the initial TBU of the following word. In (c), Unbounded Spreading also applies, since no other H follows, spreading the H to the final TBU of the second word.

We have shown that Unbounded Spreading only applies to the rightmost H in a phrase-final word. Unbounded Spreading does not apply in (14a) or (b), because the H is not rightmost. But we predict that it should also fail to apply if yet another word follows in the same phrase, even if the H is rightmost within its word. That this is true is illustrated in (15), where the postverbal object nouns are modified by an adjective.

(15) a. /pat-á ʧaŋga mu-sumá/
hate-FV 1a.bushbaby 1-good
pàt-á ʧáàŋgà mù-sùmá
'Hate the good bushbaby!'
b. /tu-ka-lí-a kalukuluku mu-sumá/
1PL-FUT-eat-FV 1a.turkey 1-good
tù-kà-lj-á kálùkùlùkù mù-sùmá
'We will eat the good turkey.'

In both cases in (15), the H in the first word spreads onto the initial mora of the following word, by Interword Doubling. However, it does not continue to spread as a result of Unbounded Spreading. This is because the H, now on the initial mora of the second word, does not meet the structural description of Unbounded Spreading, which requires the H to be the rightmost H of a phrase-final word. Since another word follows in the phrase, no additional spreading occurs, even though all the following moras in that second word are toneless.

We will now look at the spreading processes discussed above, with the goal of better understanding the contexts in which they apply and specifically defining the syntactic contexts which have an effect on H-tone spreading in Copperbelt Bemba.

3 Phrasal domains in Copperbelt Bemba

3.1 Theories of prosodic phrasing

We assume that phrasal phonological processes make reference to prosodic constituents, which, in turn, are determined by various aspects of the syntax. We first list the four central prosodic domains we assume, following the work of Selkirk (1984) and Nespor & Vogel (1986).

(16) phonological word (ω)
phonological phrase (φ)
intonational phrase (ι)
utterance (U)

These domains are motivated in particular languages when a phonological process applies within certain groups of words, but not others. In Copperbelt Bemba, for example, we have claimed that unbounded spreading affects the rightmost H in a 'phrase-final word'. We must now describe and formalise exactly what this phrase is. In the discussion that follows we make reference to two current approaches to prosodic phrasing.[6] The first is the Align approach presented in Selkirk (1984, 1995), where prosodic phrase edges are found at either the left or right edges of maximal projections. As part of this first approach we include Truckenbrodt's (1999) proposal, which presents WRAPXP, a constraint which demands that each syntactic maximal projection be contained within a φ. Thus, a VP with two objects, [V [NP][NP]], without WRAPXP or where WRAPXP is low-ranked, would be prosodically phrased (if alignment is to the right) as in (17a), whereas when WRAPXP outranks ALIGN(XP) it would be phrased as in (17b). And whereas both (a) and (b) respect the Strict Layer Hypothesis (Selkirk 1981), the introduction of a NON-RECURSIVITY constraint (Selkirk 1995) allows for additional phrasings. If WRAPXP and ALIGN(XP) outrank NON-RECURSIVITY, then the phrasing would be as in (17c).

(17) *Possible prosodic phrasings of* [V [NP][NP]]$_{VP}$ *in an Align/Wrap analysis with* NON-RECURSIVITY
a. $(\text{V NP})_\varphi (\text{NP})_\varphi$
b. $(\text{V NP NP})_\varphi$
c. $((\text{V NP})_\varphi (\text{NP})_\varphi)_\varphi$

The second approach to prosodic phrasing that we will consider is Selkirk's (2011) Match theory. This theory proposes that syntactic constituents are matched (on both the right and left edges) by a corresponding prosodic constituent. Specifically, a syntactic clause is matched by an ι, a syntactic phrase by a φ and a syntactic word by a ω. In brief, given these assumptions, assuming no higher-ranked constraints intervene, Match theory will generate only the prosodic phrasing shown in (18). Selkirk therefore argues that Match theory is more restrictive than Align/Wrap theory.

(18) *Possible prosodic phrasings of* [V [NP][NP]]$_{VP}$ *in a Match analysis without* NON-RECURSIVITY
$((\text{V NP})_\varphi (\text{NP})_\varphi)_\varphi$

With these brief descriptions as background, let us now focus on an examination of the Copperbelt Bemba phrasal patterns.

3.2 Motivating and defining phonological phrases in Copperbelt Bemba

The phrases that we have examined thus far have contained words in a fairly close syntactic relationship to each other, for example verb–adverb

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[6] We are aware of 'direct' approaches to the interface that have no recourse to prosodic constituents, but do not consider these in the current paper. See Kaisse (1985), Kula (2007) and Scheer (2012) for discussion.

(e.g. (3b), (10a)), verb–object (e.g. (3a, c)) and noun–adjective (e.g. (6a, b)). As has been shown for a variety of other languages (see e.g. Selkirk 1984, Nespor & Vogel 1986 and McHugh 1990, as well as many of the papers in Inkelas & Zec 1990, Dehé *et al.* 2010 and Vincent & Mycock 2010), we propose that these sequences of words belong to the same φ. In each case the first word is not in phrase-final position and the rightmost H in that word never undergoes unbounded spreading. Apart from the fact that the words in question have a close syntactic relationship, we will show that there is also strong phonological evidence supporting this phrasing.

In all of the φ-comprising verb–adverb, verb–object and noun–adjective sequences given above, H spreading within the first word of the phrase is bounded. This contrasts with unbounded spreading, which is found when the word is phrase-final (1). The question then arises: what happens to the rightmost H in one word when it is followed by another word that is *not* in the same φ (i.e. where the two words have a less close syntactic relationship)? To answer this, let us examine the case where the two words consist of a subject–verb sequence.[7] As seen below, in this case the rightmost H in the first word undergoes unbounded spreading rather than bounded spreading, even though another word follows.

(19) a. /í-m-balaminue ʃí-ka-pón-a/
AUG-9-ring 9SM-FUT-fall-FV
(ì-m-bálámínwé)$_\varphi$ (ʃí-ká-ꜜpón-á)$_\varphi$
'The rings will fall.'
b. /á-ba-limi bá-ka-léet-a/
AUG-9-farmer 2SM-FUT-bring-FV
(à-bá-límí)$_\varphi$ (bá-ká-ꜜléét-á)$_\varphi$
'The farmers will bring.'

These examples can be accounted for straightforwardly if we assume that unbounded spreading indicates the fact that the word is in final position within a φ. The verb in (19) constitutes its own φ, and exhibits unbounded spreading of its rightmost H. We assume that these two φ's combine to form an ι and ultimately an utterance.

We have proposed that in cases of a verb + object the verb is not in phrase-final position, while the subject in a subject + verb sequence is, as it constitutes a separate φ. Given the behaviour of the examples in (2), (6) and (13) (where the rightmost H in the first word undergoes bounded spreading), as opposed to those in (19) (where the rightmost H in the first, non-phrase-final word undergoes unbounded spreading), we now examine a fuller set of Copperbelt Bemba examples to determine

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[7] Bantu languages show subject–verb agreement, with the verb carrying subject concord depending on the noun class of the subject noun. They are therefore pro-drop languages, and it has been argued on the basis of this that subjects are topics in Bantu. See for some discussion Bresnan & Mchombo (1987) and Morimoto (2002), among others.

which syntactic contexts behave like the former and which like the latter. In each case, the presence of unbounded spreading will diagnose a following $)_\varphi$ (the right edge of a φ), and bounded spreading will indicate the absence of a following $)_\varphi$. We will then return to the question as to whether Align/Wrap theory or Match theory better represents the prosodic phrasing necessary to account for the presence or absence of unbounded spreading.

In each of the examples in (20), the rightmost H in the first word undergoes bounded (ternary) spreading, and is therefore diagnosed as not being at the end of a φ. In each case we show the first and second words as belonging to a φ that comprises both words, i.e. $(\omega_1–\omega_2)_\varphi$. While this is predicted by both Align/Wrap theory and Match theory, we note here that the latter theory also predicts that the second word, being a syntactic phrase, constitutes its own φ, i.e. $(\omega_1–(\omega_2)_\varphi)_\varphi$.

(20) a. [V O]$_{\text{VP}}$
/bá-ka-luk-il-a kombe/
2SM-FUT-plait-APPL-FV 1.Kombe
(bá-ká-lúk-ìl-à kòòmbè)$_\varphi$
'They will plait for Kombe.'
/ú-ku-béleŋg-il-a mulámu/
AUG-15-read-APPL-FV 1.brother.in.law
(ú-kú-ꜜbélééŋg-él-à mùlámù)$_\varphi$
'to read for the brother-in-law'
b. [V Adv]$_{\text{VP}}$
/bá-ka-salul-a buino/
2SM-FUT-fry-FV well
(bá-ká-sálùl-à bwììnò)$_\varphi$
'They will fry well.'
/tu-lée-mu-ʃiik-il-a buino/
1PL-PROG-1OM-bury-APPL-FV well
(tù-léé-mú-ʃììk-ìl-à bwììnò)$_\varphi$
'We are burying well for him.'
/ú-ku-béleŋg-il-an-a sáaná/
AUG-15-read-APPL-RECIP-FV a.lot
(ú-kú-ꜜbélééŋg-él-àn-à sáàná)$_\varphi$
'to read a lot for each other'
c. [N A]$_{\text{DP}}$
/í-n-balaminue ʃi-sumá/ (ì-m-bálámìnwè ʃì-sùmá)$_\varphi$
AUG-9-ring 9SM-good 'good rings'
/ú-mu-sukupala mu-sumá/ (ù-mú-súkùpàlà mù-sùmá)$_\varphi$
AUG-3-bottle 3-good 'good bottle'
/ú-ku-tálantant-a ku-kúlu/ (ú-kú-ꜜtáláántáànt-à kù-kúlú)$_\varphi$
AUG-15-stumble-FV 15-big 'the big stumbling'

d. [N Poss]$_{\text{DP}}$
/í-n-balaminue i-obe/ (ì-m-bálámìnwè j-òòbè)$_{\varphi}$
AUG-9-ring 9-2SG.POSS 'your ring'
/í-ʧi-sote ʧi-andi/ (ìʧí-sótè ʧ-ààndì)$_{\varphi}$
AUG-7-hat 7-1SG.POSS 'my hat'

These examples contrast with those in (21), where the rightmost H in the penultimate word undergoes unbounded spreading. We account for this by assuming that this word is in φ-final position, and that the following word begins a new φ. In cases where the first φ consists of two words (21b, c), unbounded spreading is, as expected, observed on the final word (i.e. the second word) of the first φ.

(21) a. [Subj]$_{\text{DP}}$ [V]$_{\text{DP}}$ (= (19))
/í-n-balaminue ʃí-ka-pón-a/
AUG-9-ring 9SM-FUT-fall-FV
(ì-m-bálámínwé)$_{\varphi}$ (ʃí-ká-ꜜpón-á)$_{\varphi}$
'The rings will fall.'
/á-ba-limi bá-ka-léet-a/
AUG-9-farmer 2SM-FUT-bring-FV
(à-bá-límí)$_{\varphi}$ (bá-ká-ꜜléét-á)$_{\varphi}$
'The farmers will bring.'

b. [[V O]$_{\text{VP}}$ Adv]$_{\text{VP}}$
/ú-ku-pat-a í-n-balaminue sáaná/
AUG-15-hate-FV AUG-9-ring a.lot
(ùkú-pát-è è-m-bálámínwé)$_{\varphi}$ (sáàná)$_{\varphi}$
'to hate the rings a lot'
/bá-ka-pat-a í-n-pelembe sáaná/
2SM-FUT-hate-FV AUG-9-antelope a.lot
(bá-ká-pát-è è-m-péléémbé)$_{\varphi}$ (sáàná)$_{\varphi}$
'They will hate the antelopes a lot.'

c. [[V O]$_{\text{VP}}$ O]$_{\text{VP}}$
/ú-ku-ʃiik-il-a í-n-pelembe í-fí-ntu/
AUG-15-bury-APPL AUG-9-antelope AUG-8-thing
(ùkú-ʃíìk-ìl-è è-m-péléémbé)$_{\varphi}$ (éfíí-ntú)$_{\varphi}$
'to bury the things for the antelope'
/bá-ka-ʃiik-il-a ú-mu-limi búupe/
2SM-FUT-bury-APPL-FV AUG-1-farmer Bupe
(bá-ká-ʃíìk-ìl òò-mú-límí)$_{\varphi}$ (búúpè)$_{\varphi}$
'They will bury Bupe for the farmer.'

d. *conjoined NPs:* [[NP]$_{\text{DP}}$ [Conj=NP]$_{\text{PP}}$]$_{\text{DP}}$[8]
/í-n-balaminue na=mubaŋgá/
AUG-9-ring CONJ-1.Mubanga
(ì-m-bálámínwé)$_{\varphi}$ (ná=mùbààŋgá)$_{\varphi}$
'the ring and Mubanga'
/í-n-pelembe na=ʧuulá/
AUG-9-antelope CONJ-1a.frog
(ì-m-péléémbé)$_{\varphi}$ (ná=ʧùùlá)$_{\varphi}$
'the antelope and the frog'

e. *preposed contrastively focused object:* [NP-O]$_{\text{DP}}$ [V]$_{\text{VP}}$[9]
/ú-mu-limi bá-la-pat-a/
AUG-1-farmer 2SM-HAB-hate-FV
(ù-mú-límí)$_{\varphi}$ (bá-lá-pát-á)$_{\varphi}$
'The farmer, they hate.'
/í-n-balaminue bá-ka-ʃiik-a/
AUG-9-ring 2SM-FUT-bury-FV
(ì-m-bálámínwé)$_{\varphi}$ (bá-ká-ʃíík-á)$_{\varphi}$
'The rings, they will bury.'

f. [V-OM]$_{\text{VP}}$ [O]$_{\text{DP}}$[10]
/ú-ku-mu-béleŋg-el-a ú-mu-limi/
AUG-15-1OM-read-APPL-FV AUG-1-farmer
(ù-kú-mú-ꜜbélééŋg-él-ó)$_{\varphi}$ (ó-mú-límí)$_{\varphi}$
'to read to the farmer'
/tu-lée-mu-londolol-a búupe/
1PL-PROG-1OM-introduce-FV Bupe
(tù-léé-mú-lóóndólól-á)$_{\varphi}$ (búúpè)$_{\varphi}$
'We are introducing Bupe.'
/bá-ka-mu-londolol-a ʃiŋaŋga/
2SM-FUT-1OM-introduce-FV 9.doctor
(bá-ká-mú-lóóndólól-á)$_{\varphi}$ (ʃííŋááŋgà)$_{\varphi}$
'They will introduce the doctor.'

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[8] The 'conjunction' marker /na/ is a proclitic that treats the following noun as prosodic host. It functions as a preposition ('with'), which can also be used to mean 'and', as in (21d). For this reason we treat the /na=mubaŋgá/ constituent as a PP that is a complement to the preceding NP, and hence assume the phrasing here.

[9] As noted, these examples require a contrastive focus reading and are used in a context such as 'the farmer they hate but the teacher not'.

[10] The object marker within the verb in Bantu is treated as pronominal, with the following object no longer within the same clause as the verb, and has been analysed (together with subject marking) as licensing the relatively free word order in Bantu (see Bresnan & Mchombo 1987, among others), making Bantu languages discourse-configurational (Morimoto 2002). Similar patterns are seen in a number of Bantu languages, including Cilungu (Bickmore 2007). Object marking in Bemba is severely restricted, and is generally ungrammatical with non-animate objects (Marten *et al.* 2007, Marten & Kula 2012).

g. *postposed subject:* $[\text{V}]_{\text{VP}}$ $[\text{NP-Subj}]_{\text{DP}}$
/bá-ka-páapaatik-il-an-a á-ba-limi/
2SM-FUT-flatten-APPL-RECIP-FV AUG-2-farmer
(bá-ká-ꜜpáápáátík-íl-án-á)$_\varphi$ (á-bá-límí)$_\varphi$
'They will flatten for each other, the farmers that is.'
/bá-lée-lim-a á-ba-limi/
2SM-PROG-farm-FV AUG-2-farmer
(bá-léé-lím-á)$_\varphi$ (á-bá-límí)$_\varphi$
'They are farming, the farmers that is.'

Based on the patterns of bounded and unbounded spreading in the above examples, we are able to determine the presence *vs.* absence of a $)_\varphi$ between the two words in question.[11] We conclude this section by noting that both Align/Wrap theory and Match theory clearly distinguish the prosodic phrasing in the relevant two-word sequences in (20) from those in (21). Both theories predict that the first word in these sequences is not φ-final in the former, but is in the latter. We note again that Match theory also predicts that the second word in sequence in (20) constitutes its own (recursive) φ. We conclude, then, that the prosodic phrasing necessary to account for the H-tone spreading in Copperbelt Bemba is adequately established by both theories and thus the data does not decide between them.

3.3 Mutually feeding spreading rules

Let us now examine some additional Copperbelt Bemba phrases. The examples in (21d) reveal something interesting about the interaction between Interword Doubling and Unbounded Spreading. The former rule was shown to feed the latter in (5). The H on the pre-prefix AUG in the first noun in the examples in (21d) undergoes Unbounded Spreading, as it is the rightmost H in a φ-final word. But as can be seen, that process then *feeds* Interword Doubling, as the H then spreads onto the toneless proclitic conjunction /na/, which is part of the following word. The interaction between these two rules is pushed even further in the examples below, where Interword Doubling spreads onto a following completely toneless word, in which case Unbounded Spreading applies a second time.

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[11] Functionally, the presence of bounded *vs.* unbounded spreading of the rightmost H of ω_1 in any ω_1–ω_2 sequence helps to identify whether ω_1 and ω_2 belong to the same φ or to different ones. This diagnostic always works when the H in ω_1 occurs before the penultimate. (Recall from the examples in (8) that an antepenultimate H in a φ-final word undergoes binary rather than ternary spreading.) When the H in ω_1 is on the penultimate or final TBU, the H will spread into the next word, via High Doubling and/or Interword Doubling, rendering the sequence ambiguous as to whether there is a φ boundary between the two words.

(22) a. /bá-ka-ʃiik-il-a ú-mu-limi ʧitundu/
2SM-FUT-bury-APPL-FV AUG-1-farmer 1.Chitundu
(bá-ká-ʃíìk-ìl òò-mú-límí)$_\varphi$ (ʧítúúndú)$_\varphi$
'They will bury Chitundu for the farmer.'

b. /í-n-pelembe na=ʧaŋga/
AUG-9-antelope CONJ-1a.bushbaby
(ì-m-péléémbé)$_\varphi$ (ná=ʧááŋgá)$_\varphi$
'the antelope and the bushbaby'

In these examples, the H on the pre-prefix in the φ-final word in the first φ spreads to the end of the word via Unbounded Spreading, as it is the rightmost H in a φ-final word. That H then undergoes Interword Doubling (as it did in (21d)). Then, since the H, now on the first mora of the final word, is again the rightmost H in a φ-final word, it yet again undergoes Unbounded Spreading.

In a rule-based approach we conclude that the rules of Interword Doubling and Unbounded Spreading are mutually feeding processes. It does not seem possible to account for the totality of the spreading in (21d) or (22) with a single rule. The examples in (20), where the two words are not separated by a $)_\varphi$, show that it is certainly not the case that there is unbounded H spreading through toneless syllables across word boundaries.

On the assumption that these two rules are mutually feeding and iterative, our analysis then predicts that in a sequence of ω_1, ω_2, … ω_n, where a $)_\varphi$ follows each word in the sequence, and all TBUs in ω_2, … ω_n are toneless, the rightmost H in ω_1 will ultimately spread to the very end of ω_n. This can be seen in the examples in (23).

(23) a. $[[\text{Pro}]_{\text{DP}}\ [\text{Conj=NP}]_{\text{DP}}]_{\text{DP}}\ [\text{V}]_{\text{VP}}$
/íne na=ʧisaŋga tu-ka-ʃiik-a/
1PRN CONJ-1.Chisanga 1PL-FUT-bury-FV
(íné)$_\varphi$ (ná=ʧísááŋgá)$_\varphi$ (tú-ká-ʃíík-á)$_\varphi$
'Chisanga and I will bury.'

b. $[\text{V OM}]_{\text{VP}}\ [\text{O}]_{\text{DP}}\ [\text{O}]_{\text{DP}}$
/bá-ka-mu-ʃiik-il-a ʧitundu ʧaŋga/
2SM-FUT-1OM-bury-APPL-FV 1.Chitundu 1a.bushbaby
(bá-ká-mú-ʃíík-íl-á)$_\varphi$ (ʧítúúndú)$_\varphi$ (ʧááŋgá)$_\varphi$
'They will bury the bushbaby for Chitundu.'

c. $[\text{V OM}]_{\text{VP}}\ [\text{O}]_{\text{DP}}\ [\text{Adv}]_{\text{AdvP}}$
/bá-ka-mu-ʃiik-il-a ʧitundu buino/
2SM-FUT-1OM-bury-APPL-FV 1.Chitundu well
(bá-ká-mú-ʃíík-íl-á)$_\varphi$ (ʧítúúndú)$_\varphi$ (bwíínó)$_\varphi$
'They will bury well for Chitundu.'

d. $[\text{V OM}]_{\text{VP}}\ [\text{O}]_{\text{DP}}\ [\text{O}]_{\text{DP}}\ [\text{Adv}]_{\text{AdvP}}$
/bá-ka-mu-ʃiik-il-a ʧitundu ʧaŋga buino/
2SM-FUT-1OM-bury-APPL-FV 1.Chitundu 1a.bushbaby well
(bá-ká-mú-ʃíík-íl-á)$_\varphi$ (ʧítúúndú)$_\varphi$ (ʧááŋgá)$_\varphi$ (bwíínó)$_\varphi$
'They will bury the bushbaby well for Chitundu.'

In all these examples, each word consists of its own *φ*, as demonstrated by the presence of unbounded spreading, which for example has the effect that all three toneless constituents following the verb in (23d) surface with H. A derivation of (23d) in a rule-based approach, detailing each step of the process and the rule interaction involved, is given in (24).

(24) *underlying* /bá-ka-mu-ʃiik-il-a ʧitundu ʧaŋga buino/

a. *Unbounded Spreading*
(bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧituundu)$_{\varphi}$ (ʧaaŋga)$_{\varphi}$ (bwiino)$_{\varphi}$

b. *Interword Doubling*
(bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧítuundu)$_{\varphi}$ (ʧaaŋga)$_{\varphi}$ (bwiino)$_{\varphi}$

c. *Unbounded Spreading*
(bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧítúúndú)$_{\varphi}$ (ʧaaŋga)$_{\varphi}$ (bwiino)$_{\varphi}$

d. *Interword Doubling*
(bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧítúúndú)$_{\varphi}$ (ʧáaŋga)$_{\varphi}$ (bwiino)$_{\varphi}$

e. *Unbounded Spreading*
(bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧítúúndú)$_{\varphi}$ (ʧááŋgá)$_{\varphi}$ (bwiino)$_{\varphi}$

f. *Interword Doubling*
(bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧítúúndú)$_{\varphi}$ (ʧááŋgá)$_{\varphi}$ (bwíino)$_{\varphi}$

g. *Unbounded Spreading*
(bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧítúúndú)$_{\varphi}$ (ʧááŋgá)$_{\varphi}$ (bwíínó)$_{\varphi}$

surface (bá-ká-mú-ʃíik-íl-á)$_{\varphi}$ (ʧítúúndú)$_{\varphi}$ (ʧááŋgá)$_{\varphi}$ (bwíínó)$_{\varphi}$

The underlying representation of the sentence contains a single H on the subject marker /bá-/, all the other TBUs in the sentence being toneless. Unbounded spreading indicates that there is a *φ* boundary after each word. The mapping of the three syntactic junctures, from left to right, was motivated in (21f), (c) and (b) respectively. In (24a) the H on the subject marker undergoes Unbounded Spreading, as it is the rightmost H in a *φ*-final word. In (b) we see that Interword Doubling has spread the H from the final TBU of the first word onto the initial TBU of the following word. The H is now the rightmost one in the last (and only) word in its *φ*, and hence undergoes Unbounded Spreading again, as in (c). This feeds Interword Doubling (d), which feeds Unbounded Spreading (e), which again feeds Interword Doubling (f), which again feeds Unbounded Spreading (g). The ultimate effect is that the H has spread over twelve syllables, to the end of the utterance.

It is appropriate to stress again that this is not a process that simply spreads a H onto as many subsequent toneless syllables as possible. This can be clearly seen by contrasting the spreading behaviour in (24) with that in (25), where the latter is the very same sentence, but without an object marker in the verb. Recall that the reason there is a *φ* boundary between the first two words in (24) is due to the presence of an object marker in the verb (as illustrated in (21f)). If we remove the object marker, then the verb and the following object will be part of the same *φ* (as seen in (20a)). This has drastic effects on the spreading of the H, as seen below.

(25) $[[[\text{V O}]_{\text{VP}}\ \text{O}]_{\text{VP}}\ \text{Adv}]_{\text{VP}}$
/bá-ka-ʃiik-il-a ʧitundu ʧaŋga buino/
2SM-FUT-bury-APPL-FV 1.Chitundu 1a.bushbaby well
(bá-ká-ʃíik-ìl-à ʧìtùùndù)$_{\varphi}$ (ʧààŋgà)$_{\varphi}$ (bwìinò)$_{\varphi}$
'They will bury the bushbaby well for Chitundu.'

Even though the H on the subject marker /bá-/ is followed by all toneless TBUs, the H spreads only in a bounded fashion. This is because Unbounded Spreading only occurs if the H is the rightmost H in a φ-final word. While this is true for the H on /bá-/ in (24), it is not the case in (25), since there is another word (/ʧitundu/) following in the same φ. As bounded spreading does not spread the H to the final TBU of the word, the structural description of Interword Doubling is not met, and hence the spreading stops.[12] A second example illustrating the same point is given in (26), where the object noun is modified by an adjectival phrase.

(26) $[[\text{V}]_{\text{VP}}\ \text{N-A}]_{\text{VP}}$
/bá-ka-mu-ʃiik-a ʧaŋga mu-sumá/
2SM-FUT-1OM-bury-FV 1a.bushbaby 1-good
(bá-ká-mú-ʃíik-á)$_{\varphi}$ (ʧááŋgà mù-sùmá)$_{\varphi}$
'They will bury the good bushbaby.'

Here the H on /bá-/ spreads to the final TBU, as it is the rightmost H in a φ-final word. This then feeds Interword Doubling, which doubles the H onto the initial TBU of the following object. But while that H is now rightmost in the object, the object is not phrase-final, due to the following adjective, which groups with it in the same φ (as in (20c)). Therefore no additional spreading occurs, even though the following four TBUs in the utterance are toneless.[13]

To conclude the descriptive analysis of the above examples, the full array of Copperbelt Bemba phrasal patterns can be accounted for within a rule-based framework by the interaction of three spreading processes: Bounded Spreading, Unbounded Spreading and Interword Doubling. This analysis, however, demands that Unbounded Spreading and Interword Doubling be mutually feeding rules that apply iteratively in order to account for the full array of surface phrasal patterns. It is not

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[12] Note that the proposed analysis of phonological phrasing and the syntax–phonology mapping proposed for Copperbelt Bemba will place /ʧaŋga/ and /buino/ in two separate φ's in (25), despite the absence of unbounded spreading. We take up this issue in §5.

[13] If the OM /mu-/ is removed from (26), all three words become part of the same φ, and no unbounded spreading is attested: ([bá-ká-ʃíik-à ʧààngà mù-sùmá]).

evident to us how one could dispense with or complicate either of these rules such that an iterative application would not be necessary.

4 An optimality-theoretic analysis

Having described the spreading patterns and shown that a rule-based approach requires a mutually feeding iterative rule interaction, we now turn to an OT analysis of the same patterns. We begin by accounting for bounded spreading at the prosodic word level, which, as described above, is generally ternary, as in (2), unless this would cause an OCP violation, in which case it is binary, as in (11). We model spreading with the constraint in (27).[14]

(27) *MONOMORAICHTS

Assign a violation to any monomoraic H-tone span.

This constraint will force spreading, and is satisfied with any amount of spreading. The constraint penalising spreading is *H, given in (28).[15]

(28) *H

Assign a violation to each H-toned TBU in the output.

Ranking *MONOMORAICHTS above *H predicts spreading to a single TBU – i.e. doubling.[16] But since spreading is optimally ternary in Copperbelt Bemba, we need an additional constraint. While this could be accomplished in different ways, we will assume a constraint which forces additional spreading, formulated in (29).

(29) *BIMORAICHTS

Assign a violation to any bimoraic H-tone span.

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[14] There have been a number of proposals for constraints to account for bounded spreading in OT. Others include LOCAL (Yip 2002), EXTEND (Bickmore 1999) and SPANBINARITY (McCarthy 2004).

[15] As formalised here, *H would be categorised as a markedness constraint. It would also be possible to use a faithfulness constraint of the IDENT type to penalise spreading, but the penalty for an input toneless TBU becoming H cannot be conflated with that for an input H TBU becoming toneless, as the latter is a much more severe violation in Copperbelt Bemba. In this paper, we will assume that IDENT(H), undominated in all our examples, penalises an input H which surfaces as toneless (e.g. through the delinking of a H autosegment). This, for example, will prevent any kind of H-tone shift. DEP(H), preventing the insertion of new H autosegments, and MAX(H), preventing their deletion, are also undominated. This leaves *H to penalise the spreading of an input H onto toneless TBUs. Violations are assigned by counting H-toned TBUs, not H autosegments.

[16] While we focus on the constraints that crucially interact for the patterns presented here, a number of other constraints, tangential to our concerns, are also at play, for example one (from the ANCHOR or ALIGN family) that forces rightward rather than leftward spreading.

The final constraint needed here is an OCP constraint, since, as shown in (10) and (11) above, it has differential effects on binary *vs.* ternary spreading.

(30) ObligatoryContourPrinciple (OCP)
Assign a violation in each instance where adjacent TBUs are members of distinct H tone spans (i.e. are linked to distinct Hs).

The proposed ranking of these four constraints is given in (31).

(31) *MonomoraicHTS ≫ OCP ≫ *BimoraicHTS ≫ *H

*MonomoraicHTS will force a H to spread even if it violates OCP, and therefore must be ranked above OCP. *BimoraicHTS attempts to spread the H onto a second TBU, but will fail to do so if it would cause an OCP violation, and is therefore ranked below OCP. Both *MonomoraicHTS and *BimoraicHTS force spreading, which results in violations of *H. *H plays an important role in penalising any spreading which is not necessary to satisfy the higher-ranked constraints which ensure ternary spread. We exemplify the constraint interaction in the schematic tableaux below.

We first consider the case of full ternary spreading. This is schematised in (32), where a H in a non-φ-final word undergoes ternary spreading (illustrated in (2) above).

(32)

CV́CVCVCVCV)$_\omega$ (CV	*MonoHTS	OCP	*BiHTS	*H
a. CV́CVCVCVCV	*!			*
b. CV́CV́CVCVCV			*!	**
☞ c. CV́CV́CV́CVCV				***
d. CV́CV́CV́CV́CV				****!

In (32), the correct surface form is the one in which the only (and therefore rightmost) H in the input undergoes bounded spreading (ternary in this case) because it does not occur in a φ-final word. Candidate (a) is maximally faithful, but violates *MonomoraicHTS, which insists that the H undergo some spreading so as not to surface as a H-tone span of a single TBU. Candidate (b) satisfies *MonomoraicHTS, but violates *BimoraicHTS, as it contains a H-tone span comprising exactly two TBUs. The optimal candidate, (c), where the H has spread to the following two moras, avoids both *MonomoraicHTS and *BimoraicHTS violations. This is also true of candidate (d), but (c) is preferred over (d), which violates *H more egregiously; the spreading in (c) is the minimum necessary to satisfy the higher-ranked constraints.

The tableau in (33) illustrates the configuration that results in a phonetic downstep between syllables (cf. the data in (10) above).

(33)

CV́CVCV́	*MonoHTS	OCP	*BiHTS	*H
a. CV́CVCV́	**!			**
☞ b. CV́CV́ꜜCV́	*	*	*	***

The input in (33) has an underlying H–toneless–H sequence. The faithful candidate, (a), violates *MonomoraicHTS twice, as both the first and last moras in the word constitute monomoraic H-tone spans. In (b), the word-initial H has undergone spreading to the following TBU, creating a bimoraic H-tone span, and thus only the H on the last mora violates *MonomoraicHTS. While this candidate violates OCP, this constraint is ranked lower than *MonomoraicHTS, and therefore (b) is optimal.[17]

Finally, we consider forms where two toneless TBUs intervene between two Hs, as in (11) above.

(34)

CV́CVCVCV́	*MonoHTS	OCP	*BiHTS	*H
a. CV́CVCVCV́	**!			**
☞ b. CV́CV́CVCV́	*		*	***
c. CV́CV́CV́ꜜCV́	*	*!		****

While *MonomoraicHTS is violated by all candidates, due to the H on the word-final TBU, candidate (a) violates it twice, as the word-initial H has not spread. Candidate (b), where the H has spread to just the following TBU, violates *BimoraicHTS but not OCP. Candidate (c), where the H has spread two TBUs to the right, satisfies both *MonomoraicHTS and *BimoraicHTS, but violates OCP. The optimality of candidate (b) is accounted for by ranking OCP above *BimoraicHTS but below *MonomoraicHTS.

Let us now turn to unbounded spreading. We account for unbounded spreading by positing a constraint that penalises a *φ*-final toneless TBU, as formalised in (35). This constraint will force the *φ*-final TBU to surface as H. Since we assume that both Max(H) and Ident(H) constraints are undominated in Copperbelt Bemba, satisfaction of this constraint will never result in a H being added, or an input H being displaced to the *φ*-final TBU. Thus it will have no effect on phrases with no H, nor any discernible effect on phrases in which the final TBU is already H. But in a phrase where the final TBU in the input is toneless and there is a H on some other TBU within the phrase, this constraint compels H to become multiply linked, up to and including the *φ*-final TBU.

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[17] Again, one can imagine other candidates, requiring additional constraints which are only tangentially relevant to the main points being made here. For example, a candidate with three level H tones (with no downstep) would need to be ruled out by a Uniformity constraint penalising fusion of non-adjacent Hs.

(35) $*\varphi_{\mathrm{fin}}$-L

Assign a violation to any φ-final toneless TBU.

The effects of this constraint are illustrated in the tableau in (36).

(36)

CV́CVCVCV$)_\varphi$	*MonoHTS	*BiHTS	$*\varphi_{\mathrm{fin}}$-L	*H
a. CV́CVCVCV	*!		*	*
b. CV́CV́CVCV		*!	*	**
c. CV́CV́CV́CV			*!	***
☞ d. CV́CV́CV́CV́				****

The fully faithful candidate in (a) violates *MonomoraicHTS. The candidate in (b), where the H has spread over one TBU, creating a binary HTS, violates *BimoraicHTS. While candidate (c) satisfies both *MonomoraicHTS and *BimoraicHTS, it violates $*\varphi_{\mathrm{fin}}$-L, as the final TBU is not H. Candidate (d) is optimal, as it satisfies this constraint, at the expense of more violations of lower-ranked *H.

Having illustrated how these constraints work at the word level, we are ready to move to phrases. First, we must account for interword doubling, illustrated in (5), (6) and (8), where the H on a word-final TBU of one word spreads onto the first TBU of the following word. We account for this by positing the domain-juncture constraint in (37), which penalises a configuration where the final TBU of one word is H and the initial TBU of the following word is toneless.[18]

(37) *InterwordHL

$$*((\ldots \underset{\substack{|\\ \mathrm{H}}}{\mu})_\omega\ (\mu \ldots)_\omega)_\iota$$

Assign a violation when the final TBU of one ω is H, the initial TBU of the immediately following ω is L and both belong to the same ι.

With regard to the prosodic domain that both TBUs must belong to, the process of interword doubling was seen to operate over a word boundary in (5), (6) and (8), and over a φ boundary in (22) and (23). The minimal tonal pairs of phrases in (38) and (39) below show that while this process does in fact operate across a φ juncture, it does not operate across an ι juncture – i.e. the two TBUs in question must belong to the *same* ι. For this reason, we formulate *InterwordHL as a domain-juncture constraint, introduced as one of three types of phrasal rules in Selkirk (1980), where the larger domain is indicated by the outer brackets. We take up this issue again below.

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[18] See also a similar formulation of a domain-juncture constraint for ATR harmony (*Interword[−ATR][+ATR]) in Kügler (2015).

(38) a. /ú-mu-limi tu-ka-pat-a/
AUG-1-farmer 1PL-FUT-hate-FV
((ù-mú-límí)$_{\varphi}$ (tú-ká-pát-á)$_{\varphi}$)$_{\iota}$
'The farmer, we will hate.' (contrastive focus)
b. /ú-mu-limi tu-ka-pat-a/
AUG-1-farmer 1PL-FUT-hate-FV
((ù-mú-límí)$_{\varphi}$)$_{\iota}$ ((tù-kà-pàt-à)$_{\varphi}$)$_{\iota}$
'As for the farmer, we will hate (him).' (topic)

In (38a) the object NP is contrastively focused by being preposed to the left of the verb. Additional examples of this construction were given in (21e). In rule-based terms, the pre-prefix H undergoes unbounded spreading to the end of the word, which feeds Interword Doubling, which in turn feeds Unbounded Spreading again. In (38b), however, the preposed object is topicalised. Here we assume the word is part of a different *ι* from the word that follows. This is supported not only by the lack of spreading of the H, but also by the fact that there is an audible pause between the two words. In this case, while the pre-prefix H does undergo Unbounded Spreading (as it is *φ*-final), Interword Doubling does not apply, since the two words are not part of the same *ι*. The examples in (39) show that even when the H is underlyingly word-final, it will only spread onto the initial TBU of the following word if the two words belong to the same *ι* (39a), but not if they belong to separate *ι*'s (39b).

(39) a. /ʧuulá tu-ka-pat-a/
1a.frog 1PL-FUT-hate-FV
((ʧùùlá)$_{\varphi}$ (tú-ká-pát-á)$_{\varphi}$)$_{\iota}$
'The frog, we will hate.' (contrastive focus)
b. /ʧuulá tu-ka-pat-a/
1a.frog 1PL-FUT-hate-FV
((ʧùùlá)$_{\varphi}$)$_{\iota}$ ((tù-kà-pàt-à)$_{\varphi}$)$_{\iota}$
'As for the frog, we will hate (it).' (topic)

The *INTERWORDHL constraint is illustrated in the tableau in (40), where a H in one word spreads onto the initial TBU of the following word, but no further.

(40)

(CV́CV CVCVCVCV́)$_{\varphi}$	*MONOHTS	*INTERWORDHL
a. (CV́CV CVCVCVCV́)	*!*	
b. (CV́CV́ CVCVCVCV́)	*	*!
☞ c. (CV́CV́ CV́CVCVCV́)	*	

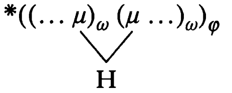
While all candidates violate *MONOMORAICHTS, because the word-final H in the second word has nowhere to spread, the candidate in (40a) violates this constraint a second time, since the H in the first word has not spread. Candidate (b), where the H has spread just one TBU to the right onto the word-final TBU, violates *INTERWORDHL, since the word-initial TBU of the following word is toneless. Candidate (c), where spreading has reached into that word-initial TBU, is therefore optimal.

We now need a way to account for the long-distance spreading patterns seen in (21)–(23). Specifically, in a ω_1–ω_2 sequence where there is a single H in ω_1 and no H in ω_2, we must ensure that the H in ω_1 undergoes bounded spreading when the first word is not itself final in a φ (41a), but unbounded spreading to the end of ω_2 when the words are part of different φ's (41b).

(41) a. (CV́CVCVCV CVCVCVCV) → CV́CV́CV́CV CVCVCVCV
or (CV́CVCVCV (CVCVCVCV)) (e.g. (20))
b. (CV́CVCVCV) (CVCVCVCV) → CV́CV́CV́CV́ CV́CV́CV́CV́ (e.g. (21)–(23))

We propose to account for this difference by positing a second domain-juncture constraint, formalised in (42). This one penalises spreading between two words belonging to the same φ. As we will show below, this constraint will penalise phrases of the type in (41a), but not those of the type in (41b).

(42) CRISPEDGE



$$*((\ldots\,\mu)_{\omega}\,(\mu\,\ldots)_{\omega})_{\varphi}$$

This constraint is a member of the CRISPEDGE family, as proposed by Itô & Mester (1999) and employed by Selkirk (2011), which insists that some feature not be shared across a prosodic juncture (demanding instead that it be crisply aligned with a single edge of a prosodic domain). If ranked above *φ_{fin}-L, this CRISPEDGE constraint will block unbounded spreading in cases such as (41a), where the spreading would generate the illicit structure in (42). This is illustrated in (43).

(43)

(CV́CVCVCV CVCVCVCV)$_{\varphi}$	*MONO HTS	*BI HTS	CRISP EDGE	*φ_{fin}-L
a. (CV́CVCVCV CVCVCVCV)	*!			*
b. (CV́CV́CVCV CVCVCVCV)		*!		*
☞ c. (CV́CV́CV́CV CVCVCVCV)				*
d. (CV́CV́CV́CV́ CV́CV́CV́CV́)			*!	

The faithful candidate in (a) violates *MONOMORAICHTS, while (b) violates *BIMORAICHTS. The candidate in (d), where H spreads to the very end of the phrase, is the only one which satisfies *φ_{fin}-L. But this spreading violates CRISPEDGE, since a single H is linked to TBUs of two words belonging to the same φ. The optimal candidate in (c), where the spreading is ternary, violates *φ_{fin}-L, but satisfies CRISPEDGE, which is higher-ranked.

Of course, CRISPEDGE will be violated by the optimal candidate in cases such as (40), where an input H on the penultimate or final vowel spreads into the following word (even when the two words are part of the same φ). We account for this by ranking *INTERWORDHL above CRISPEDGE, as shown in (44).

(44)

(CV́CV CVCVCVCV́)$_\varphi$	*MONOHTS	*INTERWORDHL	CRISPEDGE
a. (CV́CV CVCVCVCV́)	**!		
b. (CV́CV́ CVCVCVCV́)	*	*!	
☞ c. (CV́CV́ CV́CVCVCV́)	*		*

The candidate in (b), where the H has undergone binary spreading, violates *INTERWORDHL, but not CRISPEDGE. Candidate (c), where the H has spread to the initial TBU of the following word, violates CRISPEDGE, but not the higher-ranked *INTERWORDHL.

Let us now examine the form in (41b), where the H must spread to the end of the entire utterance. It was examples such as this, presented and discussed at the end of §2, which motivated the mutually feeding iterative rules in the derivational account.

(45)

(CV́CVCVCV)$_\varphi$ (CVCVCVCV)$_\varphi$	*MONO HTS	*BI HTS	*INTER-WORDHL	CRISP EDGE	*φ_{fin}-L
a. (CV́CVCVCV) (CVCVCVCV)	*!				**
b. (CV́CV́CVCV) (CVCVCVCV)		*!			**
c. (CV́CV́CV́CV) (CVCVCVCV)					**!
d. (CV́CV́CV́CV́) (CVCVCVCV)			*!		*
e. (CV́CV́CV́CV́) (CV́CVCVCV)					*
☞ f. (CV́CV́CV́CV́) (CV́CV́CV́CV́)					

Candidates (a) and (b) each violate one of the highest-ranking constraints, which force spreading to at least two additional TBUs. Candidate (c) incurs two violations of *φ_{fin}-L, since there are two toneless φ-final TBUs in this utterance. Candidate (d) spreads H to the end of the first ω (and φ), thus incurring only a single *φ_{fin}-L violation, but also incurs a *INTERWORDHL violation. Candidate (e) spreads H one TBU further, onto the initial TBU of the second word. This avoids the *INTERWORDHL violation, but it still violates *φ_{fin}-L, as the second φ-final TBU is not H. The optimal candidate, (f), satisfies *φ_{fin}-L, since each of the two φ-final TBUs in the utterance is H-toned. Crucially, CRISPEDGE is not violated in (f). This is because even though the H has spread from the first word into the second, CRISPEDGE is specifically formalised to penalise this only if the two words in question are part of the *same* φ. In (f) (as well as (e)), however, the words are part of different φ's, and therefore no penalty is assigned.

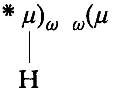
It should be evident that, even in much longer utterances, such as (23d), if each word constitutes its own φ, the optimal candidate will be the one that spreads a H to the very end of the entire utterance, as this will completely satisfy *φ_{fin}-L, and not incur any CRISPEDGE penalty. In this respect the derivational account seems to be driven by slightly different factors than the OT one. In the derivational account, the two rules which accounted for this long-distance spreading were: (i) Unbounded Spreading, a word-level process that spreads a H to the end of a word, and (ii) Interword Doubling, which spreads a H from the final TBU of one word onto the initial TBU of the following word. The most direct analogues to these two rules in the OT account are *φ_{fin}-L and *INTERWORDHL. While *φ_{fin}-L certainly motivates unbounded spreading to an often distant TBU, it is less clear that it is *INTERWORDHL which forces spreading beyond the end of the first φ, when another (single-word) φ follows. It certainly ends up preventing the spreading from stopping on the final TBU of the first φ, but, as seen in (45e), it does not play a role in preventing the spread from stopping *within* the following single-word φ. Ultimately this is prevented by *φ_{fin}-L. CRISPEDGE, as it has been formalised, ultimately determines, in a string of adjacent words, whether the spreading of the H in the first word will undergo unbounded spreading or bounded spreading. But in a configuration such as the one in (45), it plays no role in determining where the spreading will stop. Thus it seems that *φ_{fin}-L is really doing the work of forcing long-distance spreading in the OT account. In summary, were the particular OT analysis presented here cast in derivational terms, a H tone would look to find the most distant toneless φ-final TBU it can spread to (where all intervening TBUs are toneless), where that doesn't involve spreading over two words which are part of the same φ. Characterised as such, *INTERWORDHL does not play a crucial role in this long-distance spreading, whereas its rule-based counterpart, Interword Spreading, certainly does.

5 Domain-juncture effects in Optimality Theory

Both the *INTERWORDHL and CRISPEDGE constraints proposed above were formulated as domain-juncture constraints, with both outer and inner prosodic edge boundaries. Given the fact that there is not much precedent in the OT literature for such constraints, we now ask whether two sets of prosodic boundaries are in fact needed, or whether the outer set could be dispensed with.

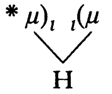
Let us begin with the *INTERWORDHL constraint. We noted above that this constraint accounts for the fact that spreading of a H across a word boundary takes place between two words when those words are part of the same *ι*, but not when the words are part of distinct *ι*'s. While the domain-juncture style formulation in (37) captures this, it would also be possible to account for the same tone patterns by using a *INTERWORDHL constraint without the outer *ι* specification, in tandem with an additional CRISPEDGE constraint which prevented spreading of a H from the final TBU of one *ι* into another *ι*. These constraints are given in (46).

(46) a. *INTERWORDHL



$$\begin{array}{l} *\ \mu)_{\omega}\ \ {}_{\omega}(\mu \\ \ \ | \\ \ \ \mathrm{H} \end{array}$$

b. CRISPEDGE-H$_{\iota}$



$$\begin{array}{c} *\ \mu)_{\iota}\ \ {}_{\iota}(\mu \\ \diagdown\ \diagup \\ \mathrm{H} \end{array}$$

We assume that the revised *INTERWORDHL constraint forces a H on the final TBU of one word to spread into the next word, regardless of whether the two words are part of the same *φ* or *ι*. However, the CRISPEDGE constraint in (46b) will prohibit such spreading from one *ι* into another. When (46b) is ranked above (46a), the attested spreading patterns in this regard are accounted for, as illustrated in (47).

(47)

	(CV́CV)$_{\varphi}$ (CVCVCVCV́)$_{\varphi}$	*MONO HTS	CRISP EDGE-H$_{\iota}$	*INTERWORD HL
a.	i. (CV́CV) (CVCVCVCV́)	**!	▨	▨
	ii. (CV́CV́) (CVCVCVCV́)	*		*!
	☞ iii. (CV́CV́) (CV́CVCVCV́)	*		
b.	(CV́CV́)$_{\iota}$ (CVCVCVCV́)$_{\iota}$			
	i. (CV́CV) (CVCVCVCV́)	**!	▨	▨
	☞ ii. (CV́CV́) (CVCVCVCV́)	*		*
	iii. (CV́CV́) (CV́CVCVCV́)	*	*!	▨

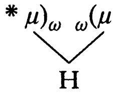
Having found an alternative to specifying outer edge prosodic boundaries in the definition of the *INTERWORDHL constraint, we now investigate if this might also be possible with regard to the CRISPEDGE constraint formalised as a domain-juncture constraint in (42). The constraint was formalised as such so that it would penalise the unbounded spreading of a H in cases such as (48a), where the two words belong to the same *φ*, but not to cases such as (48b), where the two words belong to separate *φ*'s.

(48) a. H $\ldots)_{\omega}\,(\ldots)_{\omega})_{\varphi}$
H must not undergo unbounded spreading (to the end of either *ω* or *φ*).

b. H $\ldots)_{\omega})_{\varphi}\,((\ldots)_{\omega})_{\varphi}$
H must undergo unbounded spreading to the end of *ω* (and if the following *ω* is toneless, to the end of that *ω* as well).

Removing the outer φ brackets of the CrispEdge constraint as formalised in (42) yields (49).

(49) CrispEdge (*revised*)



The revised constraint in (49) will penalise a multiply linked H between any two words in sequence, regardless of whether the words are members of the same φ or ι. This revised CrispEdge constraint makes the same, correct, prediction in the case where the two words are part of the same φ. It will, for example, assign the very same penalties that the domain-juncture CrispEdge constraint in (42) did in cases such as (43), where the two words belong to the same φ. However, the revised CrispEdge constraint in (49) makes incorrect predictions when the two words are part of *different* φ's, as shown in (50).

(50)

(CV́CVCVCV)$_\varphi$ (CVCVCVCV)$_\varphi$	*Mono HTS	*Bi HTS	*Inter-wordHL	Crisp Edge	*φ_{fin}-L
a. (CV́CVCVCV) (CVCVCVCV)	*!				**
b. (CV́CV́CVCV) (CVCVCVCV)		*!			**
☞ c. (CV́CV́CV́CV) (CVCVCVCV)					*!*
d. (CV́CV́CV́CV́) (CVCVCVCV)			*!		*
e. (CV́CV́CV́CV́) (CV́CVCVCV)				*	*
f. (CV́CV́CV́CV́) (CV́CV́CV́CV́)				*	

As can be seen, if CrispEdge, as revised in (49), penalises the spreading between any two words, then it will assign a penalty to candidates (e) and (f), but not to (c). This ultimately selects candidate (c), which exhibits ternary but not unbounded spreading, as optimal, but it is not. Given the fact that CrispEdge must be ranked above *φ_{fin}-L (required in (43)), it is not clear to us what other constraint could be invoked which, ranked above the revised CrispEdge constraint in (49), would penalise (50c) while not also penalising (50f).

We therefore conclude here that while the *InterwordHL constraint can in fact be formalised without resorting to the domain-juncture style formulation which necessitates both an outer and inner domain specification, the CrispEdge constraint in (42) does seem to require both domains in its formalisation.

6 Summary and conclusion

In this paper, we have described a wide array of phrasal tone-spreading patterns in Copperbelt Bemba. When a word has more than one H tone, all Hs before the final one undergo bounded (ternary) spreading. What is interesting is the spreading pattern of the rightmost H in a word. In some cases it undergoes bounded spreading, while in other cases it undergoes unbounded spreading. We have demonstrated that this choice is strictly determined by the prosodic phrasing. In a ω_1–ω_2 sequence, the rightmost H in ω_1 will undergo bounded spreading if ω_1 and ω_2 are part of the same φ, but it will undergo unbounded spreading if the two words are part of different φ's, i.e. when the first word is φ-final. We showed that the location of these φ boundaries correspond to the right edges of maximal projections of lexical phrases. This is consistent with the range of possible phrasings predicted by current OT-based theories of the syntax–phonology interface, such as Align/Wrap theory and Match theory. In a rule-based approach, the two processes of Unbounded Spreading and Interword Doubling turn out to stand in an iterative mutually feeding relationship. Thus, given a string of words, each of which comprises a single φ, a H in the first word will spread through the whole string of toneless words to the final TBU.

In addition to a $*\varphi_{\text{fin}}$-L constraint which accounts for unbounded spreading to the end of φ's, a second phrasal constraint, *INTERWORDHL, accounts for a process whereby a H on the final mora of a word will double onto the initial mora of the following word. We presented two possible analyses which prevent such spreading from occurring across ι. Unbounded spreading of a H from one word to the following one must be prevented when the two words belong to the same φ. This is accomplished with a CRISPEDGE constraint. We endeavoured to show, however, that in order for the constraint to only penalise spreading between words belonging to the same φ, it must be formalised as a domain-juncture type of constraint in which two prosodic domains are specified.

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