TONE DOMAINS IN TONGA[1]

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0 Introduction

The study of tone has brought one of the most important insights of generative phonology: the lack of a one-to-one correspondence between segments and features borne by those segments. The work of Leben (1973) and Goldsmith (1976) has shown that a feature realized on several consecutive segments may behave as a unit phonologically. For example, in Shona, the rule lowering a high tone after a high tone prefix (Meeussen's rule, see below) applies not only to the vowel in the syllable immediately following the prefix triggering the rule, but to the sequence of adjacent high tone syllables following that prefix (data from Myers 1997).

(1) a. /ndi-chá-téng-es-a/ → *ndi-chá-teng-es-a* 'I will sell'
b. /í-bángá/ → *í-banga* '(it) is a knife'
c. /vá-sékúru/ → *vá-sekuru* 'grandfather (honorific)'

This observation led to the development of autosegmental phonology, which expoits the many-to-many relationships between features and feature-bearing elements.

Optimal Domains Theory (ODT, Cassimjee and Kisseberth 1998) is a recent attempt within OT to elaborate the relationship between features and spans of segments where those features are realized. The central insight of ODT is that the construction of feature domains is in part independent of the phonetic realization of the features themselves. The domain of a feature is thought of as a "plan for the articulation of the feature" (C&K: 38), which may not be executed perfectly due to "external pressures", i.e. considerations like articulatory effort. ODT recasts the conflict between effort and distinctiveness in a new light: pressures of distinctiveness force domains to be maximal, since a feature realized on several segments is more perceptible than a feature realized on one segment, while effort militates against unwarranted spread of features.

The goals of this paper are twofold. First, I show that the complex tone system of Tonga can be described in a quite simple way as long as tone realization is independent of the construction of tone domains. Second, I take up one issue that C&K leave open in their study—whether tone domains can be present in the underlying representation. C&K suggest that this question is analogous to whether syllable structure should be allowed in underlying representations. It seems to me that this analogy does not go through. The reason why syllable structure is usually prohibited from underlying representations—in OT this means that there are no faithfulness constraints referring to it—is to prevent spurious contrasts like

[1] Thanks to Will Leben for help with this difficult set of data and for teaching tone to me. This material is based upon work supported under a National Science Foundation Graduate Research Fellowship.

ap.ra vs. *a.pra*. This reasoning does not apply to feature domains, since contrasts like (*áprá*) vs. (*á*)*pra* are possible, so it is natural to expect faithfulness constraints to refer to domain boundaries and hence it is natural to find domain boundaries in the underlying representations. I will show that underlying domain boundaries are necessary in several cases in Tonga.

1 Tone alternations in the Tonga verb

In this section I will summarize Meeussen's (1963) classic analysis of the Tonga verb morphotonology. Tonga verbs have the morphological structure shown in (2). Preinitials, which are clitic-like elements, mark a combination of tense, mood, aspect, and polarity. Their tonal behavior differs from the other morphemes in the verb complex, and I will not discuss it in this study (see McCawley 1973).

(2) Preinitial-Subject-Tense-Object-ROOT-Final

Subject and object prefixes are shown below for reference.

(3)
<table>
<tr><th></th><th>1SG</th><th>2SG</th><th>3SG</th><th>1PL</th><th>2PL</th><th>3PL</th></tr>
<tr><td>SUBJ</td><td rowspan="2">ndi</td><td>u</td><td>u</td><td rowspan="2">tu</td><td rowspan="2">mu</td><td rowspan="2">ba</td></tr>
<tr><td>OBJ</td><td>ku</td><td>mu</td></tr>
</table>

The following paradigm exemplifies the present indicative (T8[2]) forms of two verbs, *lang* 'look at' and *bon* 'see'. The tense marker in all forms is -*la*-.

(4)	*tu-la-lang-a*	*tu-la-mu-lang-a*	*tu-la-ba-lang-a*
	ba-la-lang-a	*ba-la-mu-lang-a*	*ba-lá-ba-lang-a*
	tu-la-bon-a	*tu-la-mu-bon-a*	*tu-la-ba-bon-a*
	ba-lá-bon-a	*ba-lá-mú-bon-a*	*ba-lá-ba-bon-a*

It is apparent from the paradigm in (4) that there is no self-evident generalization about the appearance of high tone in these forms. Based on his reconstruction of Proto-Bantu tone, Meeussen observed that morphemes in Tonga fall in one of two classes, roughly corresponding to the historical H and L tone morphemes. On the one hand, the elements *ba*- (both as a subject and object prefix) and *bon* are always low, and may stand next to a high when low. These morphemes come from Proto-Bantu H tone elements. On the other hand, *la*- and *mu*- can be high or low, and may not stand next to a high when low. These were originally L-tone.

The present perfective indicative (T54) further illustrates this division of morphemes into two classes. The perfective marker is -*ide*, the tense marker is *li*-, the root *si* means 'leave', and the subject prefix *ndi*- is 1SG.

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[2] From here on by T*n* I mean '*n*th tense in the description of Carter 1962 and Meeussen 1963'.

(5) *ndi-li-si-ide* *ndi-li-mu-si-ide* *ndi-li-ba-si-ide*
ba-lí-si-ide *ba-lí-mú-si-ide* *ba-lí-ba-si-ide*
ba-lí-láng-ide *ba-lí-mú-láng-ide* *ba-lí-ba-láng-ide*[3]

Once again, some morphemes such as *lang*, *mu*, and *li* can be either high or low, while *ba*, *si*, and *ide* are always low. Meeussen observed that a high tone appears on morphemes of the former kind standing between morphemes of the latter kind. He called morphemes that are always low DETERMINANTS, and all other morphemes NEUTRALS. In the paradigms below, determinants are underlined. The high tone appears on all and only non-underlined morphemes standing between underlined morphemes.

(6) *tu-la-lang-a* *tu-la-mu-lang-a* *tu-la-ba-lang-a*
ba-la-lang-a *ba-la-mu-lang-a* *ba-lá-ba-lang-a*
tu-la-bon-a *tu-la-mu-bon-a* *tu-la-ba-bon-a*
ba-lá-bon-a *ba-lá-mú-bon-a* *ba-lá-ba-bon-a*

ndi-li-si-ide *ndi-li-mu-si-ide* *ndi-li-ba-si-ide*
ba-lí-si-ide *ba-lí-mú-si-ide* *ba-lí-ba-si-ide*
ba-lí-láng-ide *ba-lí-mú-láng-ide* *ba-lí-ba-láng-ide*

A further complication appears when several determinants stand next to each other. This occurs in many tenses, among which the hesternal past (T18). In the forms below I abstract from vowel contraction and tonal rules associated with it. It suffices to say that in V_1V_2 it is the second vowel and its tone that survives. Thus, the output of a form such as *ba-á-ká-ba-lang-a* is *bákábalanga*. The tense marker in T18 is -*a*-*ka*-. The determinant/neutral status of the first element of the tense marker -*a*- is the conundrum in these forms.

(7) *ndi-a-ka-lang-a* *ndi-a-ka-ku-lang-a* *ndi-a-ká-ba-lang-a*
ba-a-ka-lang-a *ba-a-ka-ku-lang-a* *ba-á-ká-ba-lang-a*
ndi-a-ká-bon-a *ndi-a-ká-kú-bon-a* *ndi-a-ká-ba-bon-a*
ba-á-ká-bon-a *ba-á-ká-ndí-bon-a* *ba-á-ká-ba-bon-a*

The majority of the forms in (7) are consistent with *a* being determinant. For example, the high tone of *ndi-a-ká-ba-lang-a* 'I looked at them' can only be explained if a determinant precedes the neutral *ka*. However, the four boxed forms in (7) point to the contrary: in these forms, *a* itself bears high tone when standing between two determinants. Meeussen noted that in all such cases *a* directly follows another determinant element, in this case *ba*. He then proposed that a determinant after a determinant is treated as a neutral. He called the former kind PRIMARY and the latter, 'neutralized' determinants SECONDARY. The paradigms are repeated below with secondary determinants indicated with a subscript dot.

[3] The output form is actually *ba-lí-ꜜbá-láng-ide*. HLH is exceptionlessly realized with downstep as HꜜHH, so I will ignore this rule and show the intermediate representations with HLH throughout.

(8)	*ndi-a̲-ka-lang-a*	*ndi-a̲-ka-ku-lang-a*	*ndi-a̲-ká-ba̲-lang-a*
	ba̲-ạ̲-ka-lang-a	*ba̲-ạ̲-ka-ku-lang-a*	*ba̲-ạ̲́-ká-ba̲-lang-a*
	ndi-a̲-ká-bo̲n-a	*ndi-a̲-ká-kú-bo̲n-a*	*ndi-a̲-ká-ba̲-bo̲n-a*
	ba̲-ạ̲́-ká-bo̲n-a	*ba̲-ạ̲́ -ká-ndí-bo̲n-a*	*ba̲-ạ̲́-ká-ba̲-bo̲n-a*

Further support for this generalization comes from the hodiernal conditional negative (T47). The negative marker is the determinant *ta̲*-, the tense marker is also determinant, *a̲*-. The preinitial in this tense is *ni*-.

(9)	*ni-ndi-a̲-tạ̲-lang-a*	*ni-ndi-a̲-tạ̲-mu-lang-a*
	ni-ndi-a̲-tạ̲-bọ̲n-a	*ni-ndi-a̲-tạ̲́-mú-bo̲n-a*

In the last row the high tone appears on the span between *a̲*- and *bo̲n* in *ndi-a-tá-mú-bon-a* (the second form) but not in *ndi-a-ta-bon-a* (the first form). This can only be explained if *ta*- is a determinant neutralized following another determinant.

Recall that the determinant elements are the etymological sources of H tone, subject to lowering when preceded by another high tone. This means that the rule turning a determinant into a neutral when preceded by a determinant corresponds to the pan-Bantu generalization known as Meeussen's rule, which takes a H to a L when preceded by H.

2 McCawley, Goldsmith, and Pulleyblank

The crucial insight offered by McCawley (1973) is the treatment of neutrals rather than determinants as the underlying sources of tones. Assuming that neutrals supply a H tone, McCawley shows that the alternations can be captured in a simple way by deleting all sequences of H tones adjacent to the word edge. This rule must be of course combined with Meeussen's rule, which now takes the form L → H / L__.

(10)	túlábalángá	balábalángá	baakándíboná	UR
	n/a	n/a	baákándíboná	Meeussen's
	tulabalanga	balábalanga	baákándíbona	Peripheral H deletion
	tulabalanga	*balábalanga*	*baákándíbona*	SR

In my analysis I will also assume that a tone reversal has taken place, and that in synchronic Tonga it is the neutrals, not the determinants, that bear undelrying high tone.

The analysis proposed in Goldsmith 1984 treats Tonga tone alternations as an accentual phenomenon. Determinant elements are lexically specified with an accentual diacritic. Meeussen's rule is reinterpreted as a clash-avoiding strategy: an accent is eliminated when immediately preceded by another accent. The output of Meeussen's rule and some other accentual rules is subjected to a tonal interpretation of accent, which amounts to linking a HL* melody to the prominent syllables of the word. Subsequently, the H tone is associated by regular autosegmental conventions, resulting in a H-tone span located between two underlying accents. This rule also results in H-tone spreading to the left of the first accent of the word. While in nouns this yields the correct output form, in most verb forms there is no H tone surfacing at the left periphery of the word. To account for this, Goldsmith posits the rule of initial H-deletion. The rules and sample derivations are provided below.

(11) a. Meeussen's Rule: $\overset{*}{V} \rightarrow \overset{o}{V} \;/\; \overset{*}{V}\, C_0 \_\_$

b. Initial H-deletion: $H \rightarrow \varnothing \;/\; [_{Verb}\# \_\_$

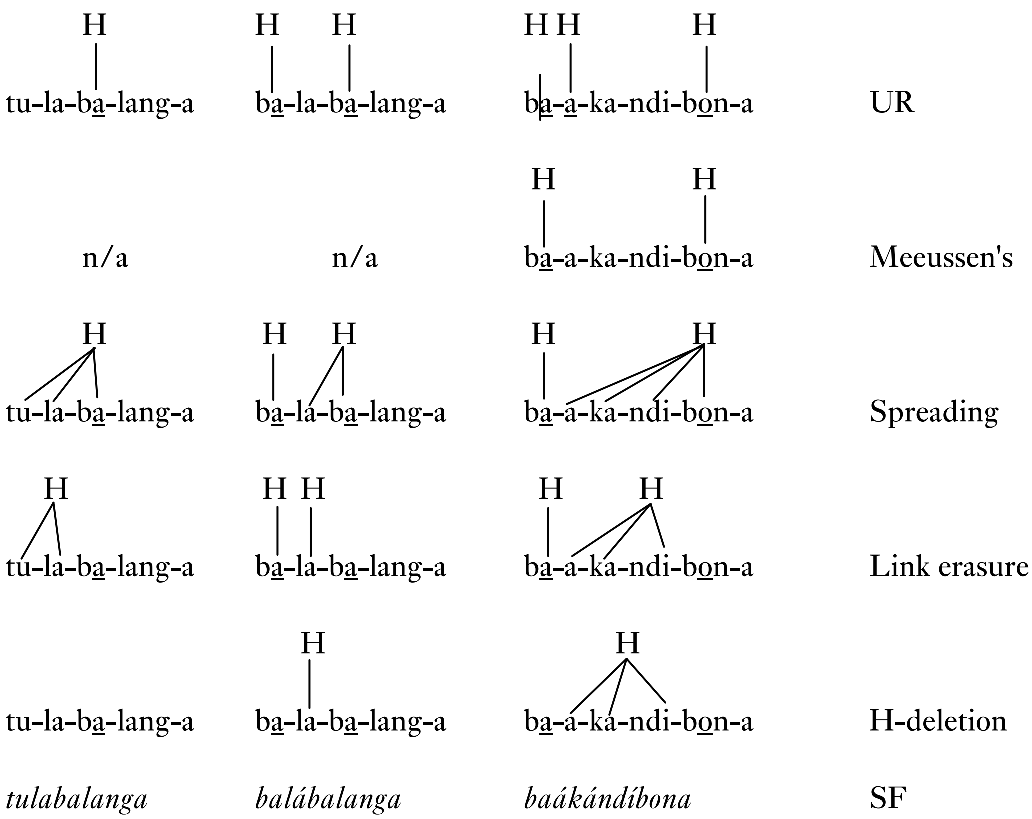
(12)

tu-la-ba*-lang-a	ba*-la-ba*-lang-a	ba*-a*-ka-ndi-bo*n-a	UR
n/a	n/a	ba*-a-ka-ndi-bo*n-a	Meeussen's
H L: tu-la-ba-lang-a	H L H L: ba-la-ba-lang-a	H L H L: ba-a-ka-ndi-bon-a	Tone linking
H L: tu-la-ba-lang-a	H L H L: ba-la-ba-lang-a	H L H L: ba-a-ka-ndi-bon-a	Tone spreading
L: tu-la-ba-lang-a	L H L: ba-la-ba-lang-a	L H L: ba-a-ka-ndi-bon-a	H-deletion
tulabalanga	*balábalanga*	*baákándíbona*	SF

We will see below that the accentual approach, while permitting a relatively simple account of the basic facts, runs into difficulties when extended to other tenses in the Tonga system and is forced to resort to arbitrary rules which the domain-based analysis is able to avoid. The problem, as we will see, was to choose determinants rather than neutrals as the underlying source of tone.

Unlike Goldsmith, Pulleyblank treats the phenomenon as tonal, not accentual, but follows Goldsmith in assuming that determinants are carriers of tone. On his approach, the determinants come with prelinked H tones, and are subjected to a tonal version of Meeussen's rule, removing a H preceded by another H. The tones subsequently spread leftward as far as the next associated TBU, and another rule removes the last association line of a multiply linked tone, as well as the word-initial tone in verbs. This is illustrated below.

(13)



A important feature of Pulleyblank's analysis is a peculiar conspiracy between the rules of spreading and deletion: it turns out that, modulo Meeussen's Rule, all underlyingly high-toned vowels surface with low tones.

3 Tone domains

I depart from Goldsmith's and Pulleyblank's analyses of Tonga in treating NEUTRALS as underlying sponsors of H tone, following the idea first expressed by McCawley. The general strategy I adopt here is to separate domain construction principles from tone realization rules. As I will attempt to show, the two sets of generalizations become quite simple when stated separately from each other. For example, Meeussen's rule will follow automatically from the analysis.

As I will show in this and the following sections, the proposal also allows for a simple treatment of the difference in tone behavior between finite verbs and other forms. The behavior of word-final determinants also follows from the analysis with little additional stipulation. Finally, the proposal allows us to treat exceptions such as the behavior of the past hodiernal (T15) marker -*a*-, which on other analyses undergoes but does not trigger Meeussen's rule.

I propose the domain construction principles informally shown in (14) below. These principles are meant as a first approximation to be refined in the discussion below.

(14) a. The rightmost element of a domain must be a sponsor.[4]
b. Sponsors are not followed by non-sponsors within a domain.
c. Domain edges do not abut.
d. Domains are maximal.

Assume that neutrals (Ns) are sponsors of H tone, while determinants (Ds) are underlyingly toneless. Then (DN), (DDNN), and (NN) are licit domains according to the principles in (14), while (D), (DD), and (DNDN) are not. (D) and (DD) violate (14)a, and (DNDN) violates (14)b. Domain maximality ensures that for a string like DDNN, the parse (DDNN) is preferred over other parses which accord with the principles in (14)a,b, e.g. D(DN)N. These four principles yield the following optimal domains for the basic data from (6) and (8), repeated below in a schematic format.

(15) a. (NNNN) *tu-la-lang-a* b. (NN)D(N) *tu-la-bo̲n-a* c. (NN)D(DN) *tu-la-ba̲-bo̲̣n -a*

d. (N)D(Ń)D(N) *ndi-a̲-ká-bo̲n-a* e. (N)D(Ń)D(DN) *ndi-a̲-ká-ba̲-bo̲̣n-a* f. (NN)D(D́Ń)D(N) *ni-ndi-a̲-tá̲̣-mú-bo̲n-a*

In the example (15)a, where no D appears in the word, the domain spans the entire word. In (15)b, two domains are built, separated by D to satisfy (14)c. When two Ds are adjacent, as in (15)c, the first one is not incorporated in a domain, also due to (14)c. The examples (15)d-e show the principle (14)b at work: it forces the sequence DNDN to be parsed as D(N)D(N) rather than D(NDN). The final example (15)f illustrates all of the principles combined.

The tone realization rules become immediately apparent given the structures in (15). First, if there are any tones in a domain, they are borne by all of the domain's elements. Second, tones on word-initial and word-final domains are not realized. Although these domains are not manifest on the surface through their tones, we have direct evidence for at least the word-initial 'toneless' domain: it causes the domain following it to be separated by a D. If there had been no word-initial domain, the string NDNDN in words like *ndi-a̲-ká-bo̲n-a* would have been parsed N(DN)D(N), giving **ndiákábona*, rather than the correct (N)D(N)D(N) *ndiakábona*. I will discuss further evidence for these domains in the section below dealing with tone on non-finite verb forms and nominals.[5] The principles of tone realization are given below.

(16) a. All members of a domain surface with high tone.
b. Tone is not realized in domains incorporating a word-initial element.
c. Tone is not realized in domains incorporating a word-final element.

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[4] A SPONSOR of a feature is the element that bears it in the underlying representation.

[5] Although for the data in (15) it is sufficient to replace the tone realization principle for word-final domains simply with a prohibition against domains incorporating a word-final element, this alternative does not work for longer sequences of word-final Ns: DNDNNN would then be incorrectly parsed as D(N)D(NN)N.

Thus, given the data in (15), tone will only appear if there are at least two Ds separated by an N. Note that Meeussen's rule follows from this analysis automatically, as a consequence of (14)c: the first D in a string of Ds will not be parsed by a domain, since only that D is adjacent to another domain. This expresses the intuition behind Meeussen's rule, that Ds preceded by other Ds behave like Ns.

Now I turn to the OT implementation of the domain construction principles in (14). The domains built according to these principles are right-headed, since the tone sponsors gravitate toward the right edge of the domain. The undominated constraint HEADS-R places the domain's head at its right periphery.

The constraints below will be necessary to account for the basic data. Most are adopted from Cassimjee and Kisseberth.

(17) a. INCORPORATE 'sponsors are in a domain'
b. UNIQUE 'each domain contains at most one sponsor'
c. *AE 'no adjacent domain edges'
d. *INIT 'domains are not word-initial'
e. ALIGN-S-R 'sponsors are rightmost in a domain'
f. PARSE-σ 'each syllable is part of a domain'[6]

In order to ensure the correct behavior of domains word-internally, *AE must rank above PARSE-σ, UNIQUE, and AL-S-R. This is illustrated below. To avoid confusion with the underlined determinants in (6), I use double underlining for tone sponsors, which are neutrals.

(18)

			*AE	PARSE-σ	UNIQUE	AL-S-R
ba-li-ba-lang-ide	☞	ba(li)ba(lang)id(e)		***		
		ba(li)(balang)id(e)	*!	**		
ba-la-mu-bon-a	☞	ba(lamu)bon(a)		**	*	*
		ba(la)(mu)bon(a)	*!	**		

The principle (14)b can be captured with the ranking AL-S-R above PARSE-σ.

(19)

			AL-S-R	PARSE-σ
ba-li-ba-lang-ide	☞	ba(li)ba(lang)id(e)		***
		ba(libalang)id(e)	*!*	**
		ba(libalangide)	*!*****	*

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[6] This constraint seems somewhat peculiar in the context of feature domains, since it is in a way an 'effort-forcing' constraint. As far as I can see, it can be replaced without any detriment to the analysis by AL(D,L,PRWD,L) 'align the left edge of the domain with the left edge of the prosodic word.

A slightly more complicated case involves several consecutive Ds at the left periphery. So far the principles predict the wrong result.

(20) *ba̲-ạ̲́-ká-bo̲n-a*

*(D́D́Ń)D(N)	predicted parse
D(D́Ń)D(N)	actual parse

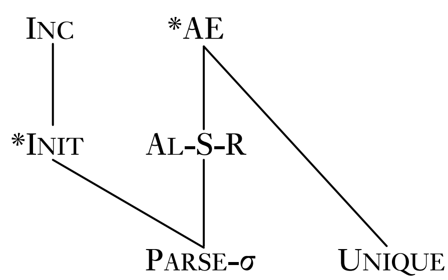
The solution, I believe, is quite straitforward. Since domains are only word-initial when the word-initial element is an N, the constraint against word-initial elements being parsed by a domain must be high-ranked but dominated by the constraint requiring tone sponsors to be parsed by a domain. In other words, the constraint INC(ORPORATE) must rank above *INIT. *INIT must in turn rank above PARSE-σ. This is illustrated in the tableau below.

(21)

			INC	*INIT	PARSE-σ
ba-a-ka̳-bon-a̳	☞	ba(áká̳)bon(a̳)			**
		(baaka̳)bon(a̳)		*!	*
tu̳-la̳-bon-a̳	☞	(tu̳la̳)bon(a̳)		*	*
		tu̳(lá̳)bon(a̳)	*!		**

The ranking arguments from the tableaux (19)-(21) are summarized below.

(22)



Tone realization is quite simple, given this analysis of domain construction presented above. Recall that if there is any high tone at all in a domain, it will be realized on all syllables of the domain. Thus, the constraint EXPRESS, requiring each member of a domain to realize the domain's feature, is high-ranked. Word-initial and word-final domains are excluded from tone realization by the constraints NONINIT-T and NONFIN-T. No tableau should be necessary here.

4 Problem cases

4.1 The left periphery: finite verbs vs. other forms

As I mentioned in the discussion of Goldsmith's analysis, finite verb forms differ from the rest of the vocabulary in that there is no H tone surfacing before the first determinant. On Goldsmith's and Pulleyblank's analysis this generalization was expressed by a rule deleting word-initial H tones in verbs. On the approach adopted here, the difference is in whether or not tone is realized on a word-initial domain.

(23)

	Verbs	Nouns
Initial N	(NN)D(Ń)D(N)	(ŃŃ)D(Ń)D(N)
Initial D	D(Ń)D(Ń)D(N)	

The difference can be captured by splitting the constraint NONINIT-T into two variants, a strict one NONINIT-T$_{\text{Verb}}$ applying only to verbs, ranked higher than EXPRESS, and the general one NONINIT-T ranked lower than EXPRESS.

4.2 The right periphery: determinant finals

The next challenge is accounting for cases where the word-final syllable is a determinant. Phonologically, there are three kinds of final elements. First, there are neutrals, e.g. *-a* of the present tense which we have already seen in (6). These are unproblematic from the point of view of the analysis as presented so far. When the final is a determinant, however, its behavior is unexpected. First, consider the forms of the Present Negative (T10).

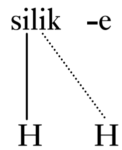
(24)

tu̲-ká-láng-e̲	*tu̲-ká-mú-láng-e̲*	*tu̲-ká-ba̲-láng-e̲*
tu̲-ká-bo̲n-ẹ̲	*tu̲-ká-mú-bo̲n-ẹ̲*	*tu̲-ká-ba̲-bọ̲n-ẹ̲*
tu̲-ká-tóbe̲l-ẹ̲	*tu-ká-mú-tóbe̲l-ẹ̲*	*tu-ká-ba̲-tóbe̲l-ẹ̲*
tu̲-ká-si̲lị̲k-ẹ̲	*tu̲-ká-mú-si̲lị̲k-ẹ̲*	*tu-ká-ba̲-sị̲́lị̲k-ẹ̲*

The forms in the first two lines, where the root is a monosyllabic *lang* or *bo̲n*, the surface forms are exactly what we would expect given the status of *-e̲* as determinant. When the root is bisyllabic, i.e. contains an 'extension' in Meeussen's terminology, that extension unexpectedly turns up as determinant. In tenses where the final is a neutral, the extensions are also clearly neutral, as evidenced by the present (T8) forms like *ba̲-lá-ba̲-tobel-a*: a determinant extension here would give incorrect **ba̲-lá-ba̲-tóbe̲l-a*.

Pulleyblank's solution to this problem of determinant extensions was to suggest that tones are not underlyingly associated with the morphemes that bear them, but the association lines are created by a rule. More precisely, tones associate to the leftmost eligible TBU in the appropriate domain, provided that the association rules apply cyclically. This move ensured that tones that come from prefixes are associated to those prefixes on the cycle when they are attached, while suffix tones migrate as far to the left as possible. This entails that the high tone of the negative suffix -*e* will be associated to the second vowel of H-tone stems like /sílik/, since the first vowel of the stem is already 'taken' by its own high tone, so the association conventions will place the suffix high on the second vowel.

(25)



The flaw of this analysis, however, is that it predicts that the suffix high will associate to the FIRST, not the second vowel of toneless stems like /tobel/, eventually producing incorrect surface forms such as **tu-ká-tobel-e* instead of the needed *tu-ká-tóbel-e*. Pulleyblank's solution was to stipulate that the first syllable of toneless stems like /tobel/ is 'extratonal'. It is then surprising that there are no bisyllabic toneless roots whose first syllable is NOT extratonal.

The idea behind this solution is unavailable in the analysis I am developing, because determinant elements are assumed to be toneless, so the final -*e* comes with no tone to be manipulated by rules/constraints.

In domain-based terms, the descriptive generalization about the data in (24) is the following: the element immediately preceding the suffix -*e* cannot be part of a domain UNLESS it is the leftmost (and, *a fortiori*, the only) syllable of the verb root. Given the analysis as it stands, it is very simple to formally capture this generalization: all we need to do is to stipulate that -*e* is, first, part of a domain, and second, must not share its domain with any other element. This can be implemented, for example, by supplying the element -*e* with an underlying domain boundary to its left, -(*e*. Assuming that underlying domain boundaries are always realized faithfully, the constraint ranking already developed will take care of the rest, with one small addition to the system.

The tableau below presents all the cases except those involving the monosyllabic neutral root *lang*, which will require special treatment. Note that we now have evidence for a ranking between a pair of previously unranked constraints, *AE and INC. The crucail idea is that because of the high-ranking constraint *AE, the underlying domain boundary of -(*e* forces the preceding syllable, even if it is an N, not to be parsed by a domain, in violation of INC. This shows that *AE >> INC.[7]

[7] The analysis is compatible with treating the morpheme -(*e* as a neutral rather than a determinant—since it is word-final, its tone will never be realized anyway. I am not aware of evidence that would decide between the two alternatives.

(26)

			*AE	Inc	Al-S-R	Parse-σ	Unique
tu-ka̳-bon-(e	☞	tu(ká̳)bon(e)				**	
		tu(ká̳bon)(e)	*!		*	*	
tu-ka̳-to̳be̳l-(e		tu(ká̳tó̳bé̳l)(e)	*!		***	*	**
	☞	tu(ká̳tó̳)be̳l(e)		*	*	**	*
tu-ka̳-sili̳k-(e		tu(ká̳)si(lí̳k)(e)	*!			**	
		tu(ká̳sí)li̳k(e)		*	*!	**	
	☞	tu(ká̳)sili̳k(e)		*		***	

Now let us consider the forms that involve the monosyllabic N root *lang*. The surface forms are repeated below.

(27) *tu̳-ká-láng-e̳* *tu̳-ká-mú-láng-e̳* *tu̳-ká-ba̳-láng-e̳*

Here -*e* acts like a regular determinant. If we are to keep to our assumption that -*e* is always in a domain of its own, the parses required for the data in (27) are as follows. The N of the verb root is indicated with a subscript *R*.

(28) $D(NN_R)(D)$ $D(NNN_R)(D)$ $D(N)D(N_R)(D)$

These forms violate *AE. However, satisfying the constraint in each case would leave the first and only syllable of the root unparsed.

(29) $D(N)N_R(D)$ $D(NN)N_R(D)$ $D(N)DN_R(D)$ *or* $D(ND)N_R(D)$

This suggests that there is a high-ranking constraint which requires that root-initial toned syllables (i.e. root-initial Ns) be incorporated into domains. I will call it Inc$_{R\text{-}In}$. This constraint, in fact, is the familiar Root Faithfulness constraint from McCarthy and Prince 1993, albeit in a new guise. It must rank above *AE and thus be undominated.

(30)

			Inc$_{R\text{-}In}$	*AE	Inc	Al-S-R
tu-ka̳-la̳ng-(e	☞	tu(ká̳lá̳ng)(e)		*		*
		tu(ká̳)la̳ng(e)	*!		*	
tu-ka̳-ba-la̳ng-(e	☞	tu(ká̳)ba(lá̳ng)(e)		*		
		tu(ká̳)bala̳ng(e)	*!		*	
		tu(ká̳bá)la̳ng(e)	*!		*	*
		tu(ká̳bálá̳ng)(e)		*		*!*

Now let us consider the second type of final determinants, here exemplified with the Present Hortative-1 (T2).

(31)			
	ka-mu̱-lím-a̱	*ka-mu̱-ndí-láng-a̱*	*ka-mu̱-bạ̱́-láng-a̱*
	ka-mu̱-tóbél-a̱	*ka-mu̱-ndí-tóbél-a̱*	*ka-mu̱-bạ̱́-tóbél-a̱*
	ka-mu̱-bọ̱́n-a̱	*ka-mu̱-ndí-bọ̱n-ạ̱́*	*ka-mu̱-bạ̱́-bọ̱́n-a̱*
	ka-mu̱-sị̱́lík-a̱	*ka-mu̱-ndí-sị̱lík-a̱*	*ka-mu̱-bạ̱́-sị̱́lík-a̱*

The behavior of all forms except those in the third row is as expected: the final determinant is not incorporated in a domain, but neutrals that precede it are, and thus bear high tone. However, when the final is immediately preceded by a determinant, that determinant receives high tone. Consider the forms *kamubóna* and *kamubábóna*: the final element -*a* cannot be a determinant, since it would undergo Meeussen's rule and no tone would surface: **kamubona* and **kamubabona* would be the predicted outcomes for (N)DDD and (N)DDDD. If -*a* is a neutral, however, exactly the same incorrect outcome is predicted, given our assumption that domains incorporating word-final elements are not tone-bearing; the parses would be (N)D(DN) and (N)D(DDN).

In analyses such as Pulleyblank's, which treat determinant elements as toned, the solution is straightforward: by stipulation, these word-final determinants are not subject to Meeussen's rule. Meeussen's own solution was an abstract underlying representation of the final -*aa̱*, where the first vowel makes the final determinant not adjacent to the determinant root and thus not eligible for Meeussen's rule, while other rules remove the unneeded -*a* from the representation and reassociate or delete its tone in the appropriate way.

Let us consider the problematic cases, setting aside for the moment the form that has an unexpected high tone on its final syllable, *kamundíboná*. The other forms are given below together with the tone domains necessary to account for them.

(32)			
	ka-mu̱-tóbél-a̱	*ka-mu̱-ndí-tóbél-a̱*	*ka-mu̱-bạ̱́-tóbél-a̱*
	(N)D(ŃŃ)D	(N)D(ŃŃŃ)D	(N)D(D́ŃŃ)D
	ka-mu̱-sị̱́lík-a̱	*ka-mu̱-ndí-sị̱lík-a̱*	*ka-mu̱-bạ̱́-sị̱́lík-a̱*
	(N)D(D́Ń)D	(N)D(Ń)D(Ń)D	(N)D(D́D́Ń)D
	ka-mu̱-bọ̱́n-a̱	*ka-mu̱-bạ̱́-bọ̱́n-a̱*	
	(N)D(D́)D	(N)D(D́D́)D	

What is common between the 'regular' forms in the first two lines of (32) and the 'irregular' forms in the last line is that the word-final determinant is always preceded by a right domain boundary. This opens up the obvious possibility that just as the morpheme -*e* was underlyingly supplied with a left domain boundary, the morpheme -*a* is underlyingly supplied with a right domain boundary, -)*a*. Once again, the constraints as they stand will do the rest of the job, with one small addition to the system. No tableau should be necessary for regular forms, where the final determinant is preceded by a neutral. The following illustrates forms like *kamubábóna*.

(33)			*AE	AL-S-R	PARSE-σ
	ka-mu-ba-bon-)a	☞ (ka)mu(bábón)a			**
		(ka)muba(bón)a			***!
		(kamubabon)a		*!**	*
		(ka)(múbábón)a	*!		*

Now what about the form *kamundíboná*—the only form in the entire conjugation where the word-final syllable is high-toned?[8] The datum is repeated below from (31), along with what appears to be its domain structure.

(34) *ka-mu-ndí-bon-á*

(N)D(Ń)D(D́)

There are two things problematic with the parse (N)D(Ń)D(D́). First, this appears to be the only form where the underlying right domain boundary of the final *-a* does not surface. Second, this is the only form where a word-final domain is not toneless—recall that in forms like D(NNNN), e.g. *ba*(*lamulanga*), the word-final domain is toneless even if it incorporates as many as four sponsors. These two problems indicate that the parse (N)D(Ń)D(D́) is simply incorrect. I suggest two alternatives in (35) below.

(35) *ka-mu-ndí-bon-á*

a. (N)D(Ń)(D)D́

b. (N)D(Ń)D()D́

In the alternative (35)a, the domain is counstructed on the syllable immediately preceding the final determinant, but its tone is realized on the final syllable. This could be due to a high-ranking constraint such as the OCP, prohibiting tones on adjacent domains. In the alternative (35)b, the domain is also constructed immediately to the left of the final determinant, but this domain does not incorporate the determinant that precedes it, in order to satisfy the constraint *AE.[9] Independent principles then determine the realization of tone in such 'empty' domains. At the moment I will not make a decision between these two alternatives, but the discussion of T15 forms below will show that the alternative (35)b is the correct one.

To summarize this section, there are three kinds of finals.

[8] The apparent final highs in the so-called 'weak' tenses (T9,11,13,16,19,20) are actually not word-final, since the domain of tone assigment in these tenses in not the prosodic word but a larger constituent like the phrase. See Goldmith 1984 for discussion.

[9] The constraint INC$_{R\text{-}In}$ is irrelevant here, because it only regulates tone sponsors that are in root-initial position, while *bon* is clearly not a sponsor.

(36) a. Neutral finals: -<u>*a*</u> (T8)
b. Left-bracket determinant finals: -(*e* (T10)
c. Right-bracket determinant finals: -)*a* (T2)

It is then natural to ask why there are no 'plain' determinant finals. My analysis has no explanation for this (but other analyses do not do any better). However, this gap is not as glaring as it first appears. In order to see this, consider the following table, which shows the distribution of finals in the Tonga tense system. I have omitted the weak tenses (on which see fn. 8), the inceptive tenses, which appear to involve compounding of a bound verb stem -*ning*- with another verb form, and the perfect tenses which have regular-behaving polysyllabic finals.

(37)

<table>
<tr><th></th><th>PRES/FUT</th><th>PRES/FUT NEG</th><th>HODIER</th><th>HODIER NEG</th><th>HESTER</th><th>HESTER NEG</th></tr>
<tr><td>IMPER</td><td rowspan="2">-)a</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HORT 1</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>HORT 2</td><td rowspan="2">-)e *or* -(e</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>SUBJ</td><td rowspan="5">-(i</td><td></td><td></td><td>-(e</td><td>-(i</td></tr>
<tr><td>INDIC</td><td>-<u>a</u></td><td>-<u>a</u></td><td rowspan="4">-)a</td><td>-<u>a</u></td><td>-)a</td></tr>
<tr><td>CONJ</td><td rowspan="4">-)a</td><td rowspan="4">-)a</td><td></td><td></td></tr>
<tr><td>DIR REL</td><td rowspan="3">-)a</td><td rowspan="2">-)a</td></tr>
<tr><td>INDIR REL</td></tr>
<tr><td>TEMPOR</td><td></td><td></td><td></td></tr>
<tr><td>CONDIT</td><td></td><td></td><td rowspan="2">-<u>a</u></td><td rowspan="2">-<u>a</u></td><td rowspan="2">-<u>a</u></td><td rowspan="2">-<u>a</u></td></tr>
<tr><td>POTENT</td><td></td><td></td></tr>
</table>

This table shows that only a few morphemes are involved here, not forty four as one might surmise by looking at Meeussen's tense table. The conjunctive, relative, and temporal tenses, which mark subordination, form a natural class I will call Subordinate. Conditional and potential tenses, which mark conterfactual situations, form a natural class I will call Irrealis. I will call its complement set Realis. Hortative 2 and Subjunctive appear to be the same tense, distinguished only by a preinitial, hence I will refer to it as Subjunctive. Hortative 1 and Imperative also form a natural class, which I will call Imperative The distribution of the morphemes can be described as follows. Note that we in effect have only seven morphemes, some of which are homophonous. This makes the non-occurrence of determinant finals not as surprising.

(38) a. -)*a* Imperative, Subordinate, Negative Realis
b. -(*i* Present negative, Hesternal Negative Subjunctive
c. -(*e* Subjunctive
d. -<u>*a*</u> Elsewhere

Goldsmith and Pulleyblank accounted for the peculiar distribution of the finals with ad-hoc rules and exceptions, such as the extratonality of the first syllable of the root *tobel*. The behavior of the final -)*a* was described by both researchers as involving an exceptional non-application of Meeussen's rule. On the domain-based analysis, both types of exceptions can be encoded in the representaitons themselves, utilizing the features of the theory and the constraint rankings which are needed for independent reasons.

4.3 The marker of the Hodiernal Indicative (T15)

The marker of the hodiernal indicative *a*- has very peculiar tonal behavior. Sometimes it behaves like a neutral, sometimes like a deterimnant, and sometimes like neither. Meeussen observed that its behavior can be described by assuming that (a) it is underlyingly represented as a double element *a̲a*, implying that it undergoes but does not condition Meeussen's rule, and (b) a sequence of contraction and tone reassociation rules apply to give the right output. Goldmith's analysis sought to unify the two properties of this prefix—its unusual behavior with respect to Meeussen's rule and its tone-shifting properties. He argued that (a) the hodiernal indicative prefix *a*- is associated with an accent-shifting rule, forcing the accent of deteriminants that follow it to be shifted one syllable to the right, and (b) that it is not eligible for Meeussen's rule because of a technical reformulation of the Elsewhere Condition.[10]

Let us flesh out this discussion with some examples. First, suppose that *a*- is determinant. This allows us to account for exactly half of the forms: only those where *a*- is followed by a neutral. The forms where treating *a*- as determinant predicts the wrong result are boxed. [11]

(39)	*ndi-a̲-lang-a*	*ndi-a̲-ku-lang-a*	*ndi-a̲-bạ̲́-lang-a*
	ndi-a̲-bọ̲́n-a	*ndi-a̲-kú-bo̲n-a*	*ndi-a̲-bạ̲́-bọ̲n-a*
	u̲-ạ̲-lang-a	*u̲-ạ̲-ndi-lang-a*	*u̲-ạ̲́-bạ̲-lang-a*
	u̲-ạ̲́-bọ̲n-a	*u̲-ạ̲́-ndí-bo̲n-a*	*u̲-ạ̲́-bạ̲-bọ̲n-a*

Second, assuming that *a*- is neutral solves some of the probles above but introduces others. The forms where the neutral *a*- makes the wrong predictions are again boxed, and the forms explained by neither neutral nor determinant *a*- are preceded by #.

[10] Goldmith's amendment to the Elsewhere Condition gave the grammar the 'look-ahead' power: it said that the more general rule must not apply if the more specific rule's conditioning environment is met—no matter what the ordering, and even if the output of the more general rule removes that conditioning environment.

[11] I abstract away from the rule that turns *u* to *w* when followed by a vowel. Thus, /u-a-bon-a/ actually surfaces as *wábona*.

(40)			
	ndi-a-lang-a	*ndi-a-ku-lang-a*	# *ndi-a-bá̲-lang-a*
	# *ndi-a-bó̲n-a*	*ndi-a-kú-bo̲n-a*	# *ndi-a-bá̲-bo̲̣n-a*
	u̲-a-lang-a	*u̲-a-ndi-lang-a*	*u̲-á-ba̲-lang-a*
	u̲-á-bo̲n-a	*u̲-á-ndí-bo̲n-a*	*u̲-á-ba̲-bo̲̣n-a*

Meeussen's formula -*a̲a*- predicts these forms in the following way. When preceded by a determinant, *a* undergoes Meessen's rule, but does not trigger it on determinants that follow it. This means that after a determinant *a*- behaves just like a neutral—hence no boxed forms in the last two lines of (40). Similarly, when there are only neutrals elsewhere in the forms, as in *ndialanga* and *ndiakulanga*, the determinant in *a̲a*- is simply inactive.

When following a neutral but preceding a determinant, the suffix receives high tone on the second of its two abstract elements. The intermediate representations are shown below.

(41) *ndi-a̲á-bo̲n-a* *ndi-a̲á-kú-bo̲n-a* *ndi-a̲á-ba̲-bo̲̣n-a* *ndi-a̲á-ba̲-bo̲̣n-a*

Now the vowel contraction and tone reassociation rules must pitch in. The generalization is clear: after contraction the tone of *á̲á* stays on the vowel resulting from contraction (i.e. in forms where *a*- is preceded by determinant: *u̲-á̲̣á-ndí-bo̲n-a* → *uándíbona*), but the tone of underlying *a̲á* migrates to the following vowel, as in the forms in (41).

Meeussen's analysis can be easily reconstructed in the domain-based approach, by positing the affix as underlyingly complex, *aa̳*, constructing domains, and then deleting the second *a̳*, with a simple tone reassociation rule. This is shown below.

(42)			
	(N)a(a̳NN)	(N)a(a̳NNN)	(N)a(a̳)D́(NN)
	(N)a(a̳)D́(N)	(N)a(á̳Ń)D(N)	(N)a(a̳)D́(DN)
	D(aa̳NN)	Da(a̳NNN)	D(áá̳)D(NN)
	D(áá̳)D(N)	D(áá̳Ń)D(N)	D(áá̳)D(DN)

The tonal rule needed is that after *a̳*-deletion, the tone of the empty domain () is realized on the following syllable. The only problem is that normally it is the first, not the second vowel in a sequence of two vowels that deletes; besides there is a general rule in Tonga whereby when a vowel deletes before another vowel, its tone disappears altogether and is not realized on neighboring segments, i.e. the deletion of a vowel entails the deletion of the domain which the vowel sponsors.

There is, however, an alternative solution that does not require positing the abstract 'double' morpheme *aa̳*. Rather, the ambivalent behavior of *a* as a neutral, determinant, and a more complex entity can be described in terms of allomorphy. There are three allomorphs: the determinant supplied with a domain boundary *a*), occurring between N and D, the simple determinant *a* occurring between N and N, and the neutral *a̲* occurring elsewhere.

(43) *a*) / N__D
a / N__N
a̲ / elsewhere

The last two allomorphs, *a* and *a* behave in the expected way, conditioning the same type of domains and tone realization as we have already seen with other affixes. The first allomorph, -*a*), requires some explanation (though it does not require any new theoretical machinery). The three forms where its environment N__D is met are repeated below from (40), with neutrals shown by double underlining and determinants, including -*a*), left without any underlining.

(44) *ndi-a)-bá-lang-a*   *ndi-a)-bón-a*   *ndi-a)-bá-bon-a*
Na)D́NN   Na)D́N   Na)D́DN

How are the remaining domains constructed, given the representations above? Given the constraint ranking that I already argued for, these cases are similar to the examples of finals like -)*a*. Recall from (35) that when the affix -)*a* is attached to the configuration (N)D, the tone is realized ON THAT AFFIX, whether it is because it is shifted from the domain that abuts another domain due to the OCP, or because an empty domain is constructed to satisfy *AE. The examples of T15 actually resolve the issue of which analysis is correct. Note that in (44), the tone is always realized on the syllable immediately following the *a*, indicating that the word-initial domain (N) forces either the tone or the domain boundary to shift to the right. Hence, we have the same two alternatives as in (35), shown below.

(45) *ndi-a-bá-lang-a*
a. (N)(a)D́(NN)
b. (N)a()D́(NN).

Unlike the forms with the final -)*a* in (35), T15 forms like *ndiabálanga* are compatible with only one of the two alternatives, namely (45)b. The representation in (45)a makes it unclear why the OCP should force the tone to shift: given that the tone of the word-initial domain is not realized, OCP does not apply. 'Abstract' OCP, prohibiting tone adjacent to ANY domain, including domains with no realized tone, is also inapplicable here, since the output form as shown in (45)a would violate this constraint just as well as the supposed input form (N)(á)D(NN). I conclude, therefore, that a segmentally empty domain is constructed as in (45)b under pressure from *AE, and its tone, just as in (35)b, is realized to its right. The full parses for the three forms in (44) are shown below.

(46) (*ndi*)-*a*()-*bá*-(*lang-a*)   (*ndi*)-*a*()-*bón*-(*a*)   (*ndi*)-*a*()-*bá*-(*bon-a*)
(N)a()D́(NN)   (N)a()D́(N)   (N)a()D́(DN)

The rule-based analyses of Goldsmith and Pulleyblank posited arbitrary tone-shift rules in order to account for the forms of T15. Once again, the domain-based analysis allows a natural formulation of the properties of this tense with independently needed elements of the theory.

5 Conclusion & discussion

I have shown two things in the preceding sections: first, that the theory of tone domains, with the emphasis it places on dissociating the principles of domain construction from tone realization, allows for a relatively simple account of the morphotonology of the Tonga verb. Second, I have argued for the need for incorporating underlying domain boundaries into the theory, based on the behavior of several affixes in Tonga.

Here I would like to suggest a reinterpretation of the underlying domain boundaries in terms of constraints that C&K have already introduced, by limiting the application of those constraints to specific morphemes. In particular, the ALIGN family is playing a major role in the theory, since it is responsible for feature spreading and edge effects. The behavior of the underlying tone domain boundaries can be replicated with align constraints that are morpheme-specific. In particular, if ALIGN(*a*, L, TDom, R) is undominated, we get the obligatory alignment of -*a* with a right domain boundary, i.e. the structure -)*a*. This suggests that even if not explicitly formulated, underlying domain boundaries are implicitly part of the theory of tone domains.

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