Word-level prosody of Samoan*

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This paper documents and analyzes stress and vowel length in Samoan words. The domain of footing, the prosodic word, appears to be a root and a "close" (usually monosyllabic) suffix; prefixes and most disyllabic suffixes form a separate domain. Vowel sequences that disrupt the normal stress pattern require constraints matching sonority prominence to metrical prominence, sensitive to degree of mismatch and to the number of vowels involved. Two suffixes unexpectedly have an idiosyncratic footing constraint, observable only in a limited set of words. We also discuss trochaic shortening and its asymmetrical productivity, and marginal contrastiveness of some features in loans. While Samoan does not appear to be typologically unusual, it does offer arguments (i) in favour of alignment constraints on prosodic words rather than only on feet directly, and (ii) against simple cyclicity, and some of the strongest evidence for these arguments come from stress patterns of the rich inventory of vowel sequences phonotactically licit in Samoan.

0. Introduction

This paper describes and analyzes the word-level prosody of contemporary Samoan, an Austronesian language from the Independent State of Samoa and the (U.S.) Territory of American Samoa, with about 370,000 speakers in all countries (Ethnologue 2005). We focus on stress placement and vowel length.

Samoan presents a case where morpheme boundaries disrupt a word's prosody, and mono- and disyllabic suffixes behave differently. Monosyllabic suffixes join the stem's footing domain, while prefixes and certain disyllabic suffixes do not. We also show that cyclicity alone doesn't suffice to explain stress in affixed words, and argue for ALIGN constraints requiring morphemes to initiate prosodic domains. In these respects, Samoan resembles other languages that have been analysed previously (see section 1), but we draw evidence not only from typical sequences of CV syllables, but also from Samoan's rich inventory of licit vowel sequences.

These vowel sequences complicate patterns of stress assignment in Samoan. We show that some vowel sequences disrupt the normal stress pattern, requiring constraints on the association of sonority prominence and metrical prominence. These constraints must be sensitive both to the degree of prominence mismatch and to whether the mismatch is over a pair or a triplet of adjacent vowels.

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Three-vowel sequences further require an unexpected morpheme-specific prosodic constraint, whose effects are observable only in a small set of words.

A further point of interest concerns length alternations characterisable as trochaic shortening. For our consultants, there is an inviolable restriction against long-vowel penults if the ultima is light. This restriction triggers length alternations, as well as avoidance of one affix. But, alternations that require positing an underlying form different from the unaffixed surface form appear less productive, suggesting that they are less learnable. Finally, we find sensitivity in loanwords to features not normally contrastive in Samoan, in secondary stress and in vowel/glide distribution.

In section 1 below, we review four previous theoretical approaches that have been taken to explain similar effects in other languages; the one we adopt uses alignment constraints within Optimality Theory (Prince & Smolensky 1993/2004) to generate prosodic word structure. Section 2 provides background information on Samoan and our data-collection methods. In section 3, we present stress in monomorphemic words, including its phonetic realization. In section 4 we treat stress under compounding, suffixation, prefixation, and reduplication. We then turn to complications in the basic stress system and what they tell us about footing domains: sections 5 and 6 deal with trochaic shortening and restrictions on long vowels or sequences of identical vowels, and section 7 deals with the special stress behaviour of some vowel sequences (including an unexpected stress requirement for certain suffixes). Sections 4 through 7 show that affix-size differences cannot be accounted for by cyclicity alone; rather, ALIGN constraints are needed. Samoan therefore not only constitutes unambiguous evidence for suffix-size/stress interactions in an Austronesian language, but provides further evidence for existing approaches to stress assignment. In section 8 we present speculative description of glide formation and insertion, and section 9 summarizes and concludes.

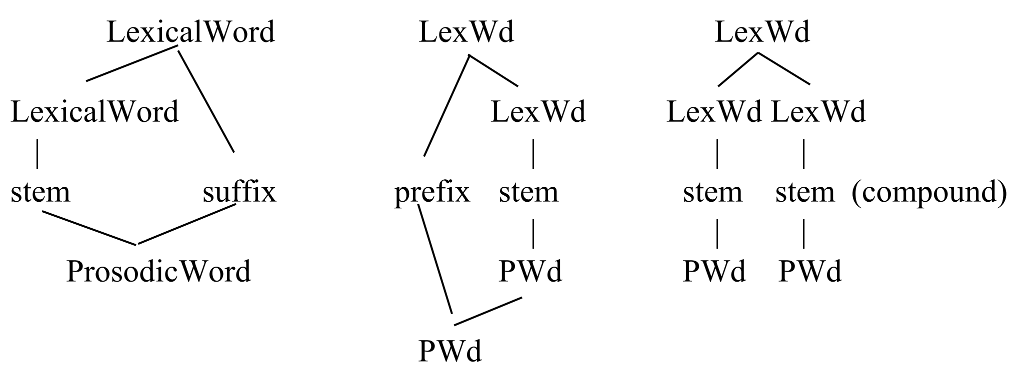
1. Previous approaches to morphological effects on word prosody

This section reviews previous accounts of how morpheme boundaries and affix size affect word prosody.

1.1. Boundaries as disruptors of word prosody

In the theory of prosodic domains of Selkirk 1978, Selkirk 1980, Nespor and Vogel 1986, and elsewhere, morphological and syntactic structure project prosodic structure, which affects phonological rule application. For example, a rule might insert a prosodic-word (p-word) boundary at the beginning of every lexical word, resulting in schematic prosodic structures such as in (1). We assume that one p-word can dominate another (Ito & Mester 1992).

(1) Schematic prosodic structure projected by morphological structure



Adaptations of this approach into Optimality Theory, such as Peperkamp 1997, use ALIGN constraints (McCarthy & Prince 1993b) to derive these prosodic structures. For example, ALIGN(LexWd, L; PWd, L) requires the left boundary of every lexical word to coincide with the left boundary of some p-word.

The prosodic word is generally assumed to be the domain of footing. Therefore, p-word boundaries disrupt the footing pattern. For the structures in (1), a disruption will occur between prefix and stem, and inside a compound. A stem and suffix, on the other hand, will have the same footing as a monomorphemic word. It is also possible that morphological boundaries project feet directly, without the intermediary of the prosodic word, as assumed in Kager 1997 for Sibutu Sama. Finally, some authors have argued for multiple domain types that are approximately word-sized, including Rice (1992), who argues that three labels are required to account for the domains of various phonological processes found in Slave (Rice 1989) and some other Athapaskan languages.

An alternative to prosodic domains is offered in Lexical Phonology, which cyclically interleaves affixation and stress rules (Siegel 1974, Kiparsky, 1983). For the example in (1), the footing difference would be due to the order suffixation, then footing, then prefixation and compounding. This interleaved approach allows further distinctions between, say, early and late suffixes. Hargus (1988), for example, argues for a rich system of levels in Sekani/Tsek'ene. A related approach to interleaving uses Optimality Theoretic output-output correspondence constraints (among others, Kenstowicz 1995, Benua 1997, Burzio 1997): different affixes are subject to higher- or lower-ranking faithfulness to the base's prosody.

A third major approach to explaining morphological effects on prosody has been the use of different boundary types. Chomsky and Halle (1968) (who do not use feet) treat English *–(i)an* as bearing a "+" boundary, and *–ism* a "#" boundary. If prefixes bear a # boundary, and suffixes a + boundary, then stress rules can ignore + but be sensitive to #. Selkirk (1980) argues that this theory is excessively powerful, allowing a language to have a footing rule sensitive to + but not to #.

Prosodic domains, morphology/phonology interleaving, output-output correspondence, and boundary types are not inherently in conflict—Inkelas (1989), for example, develops a theory that employs the first two—but these approaches usually provide competing explanations of the same facts. Section 9.2 compares our account of Samoan word prosody using prosodic domains to the alternatives.

1.2. Affix-size differences

As will be seen in sections 4.2 and 4.3, in Samoan the size of a suffix is crucial for whether it disrupts word prosody. Reports of a prosodic distinction between mono- and disyllabic suffixes or enclitics abound, although the distinction does not always imply that either type of suffixation is treated differently from a monomorphemic word. For example, Anderson and Otsuka (2006) treat the monosyllabic demonstratives of Tongan (Churchward 1953) as enclitics, because they shift stress to the right (*móko* 'gecko', *mokó-ni* 'this gecko'), and the disyllabic demonstratives as separate words (*mòko éni* 'this gecko'). However, the stress data are also consistent with right-to-left footing of the noun+demonstrative sequence: *mo(kó-ni)*, *(mòko)-(éni)*—in both cases, the stress pattern is the same as in a monomorphemic word. Suffixation in Fijian follows the same pattern (Scott 1948, p. 744, Dixon 1988). Similarly, in Rotuman (Austronesian; closely related to Polynesian), Hale, Kissock and Reiss (1998) leave open whether disyllabic suffixes form a separate *domain* of footing or merely form a separate foot, as they would in the absence of a morpheme boundary. McCarthy (2000) analyzes the distinction between monosyllabic and disyllabic suffixes in Rotuman in prosodic-word terms by having an ALIGN constraint that prefers the stem and suffix to form separate p-words, overridden by the higher-ranked requirement of foot binarity, so that monosyllabic suffixes join the stem's p-word.

In several Australian languages, however, there is a clearer stress distinction between mono- and disyllabic suffixes, such as in Warlpiri (Nash 1980), Yidiny (Dixon 1977a, Dixon 1977b), Diyari (Austin 1981), Dyirbal (Dixon 1972), and Ngalakgan (Baker & Harvey 2003, Baker 2008). In Ngalakgan a disyllabic suffix (underlined in (2)) restarts the left-to-right footing pattern. As shown in (2), the stress patterns of suffixed words are different from those of monomorphemes, and also different from what would be expected if every disyllabic suffix initiated a new footing domain:

(2) Ngalakgan stress (Baker 2004, p. 5)

actual stress pattern	(ʈótoyʔ)-ki	(ʈótoyʔ)-(kì-kkaʔ)	(ʈótoyʔ)-ki-p(pùlu)	(ʈótoyʔ)-ki-p(pùlu-k)kaʔ
pattern if monomorphemic	*same as attested*	*same as attested*	*(ʈótoyʔ)-(kì-ppu)lu	*(ʈótoyʔ)-(kì-ppu)(lù-kkaʔ)
pattern if each suffix initiates footing domain	*same as attested*	*(ʈótoyʔ)-ki-kkaʔ	*same as attested*	*same as attested*
	'aunt-your'	'aunt-your-LOC'	'aunt-your-PL'	'aunt-your-PL-LOC'

Most accounts employed to explain such affix-size differences are domain-based. As Baker (2004) discusses, merely interleaving suffixation and stress assignment wrongly predicts that after *(ʈótoyʔ)-ki* is suffixed with *-ppulu*, there is enough material to form a new foot, left-to-right as usual, yielding **(ʈótoyʔ)-(kì-ppu)lu*. He instead uses domains: every morpheme prefers to be a separate foot, but not at the expense of creating a subminimal foot. When two monosyllabic suffixes are adjacent, PARSE-σ (Prince & Smolensky 1993/2004) breaks the tie and foots the two syllables together.

McCarthy and Prince (1994) also use domains to treat similar facts in Diyari. In Diyari, a monosyllabic suffix can't initiate a foot even if another monosyllabic suffix follows: *(máda)-la-ntu* 'hill-characteristic-proprietive'. McCarthy and Prince adopt the footings of Poser's (1989) rule-based analysis, but use ALIGN constraints to establish the domain of footing (p. A6). The end of every stem closes off a prosodic word, *[[[mada]-la]-ntu]*, preventing footing of subminimal *–la* or *–ntu*. This has similar effects as Poser's (1989) analysis, which foots each affix independently, then removes monosyllabic feet. Alderete (2009) extends the ALIGN-based analysis to Dyirbal, Warlpiri, and Pintupi, giving further arguments for the recursive prosodic-word structure.

Crowhurst (1994) analyzes Diyari in terms of direct morpheme-to-foot alignment constraints. ALIGN(Morpheme,L; Foot,L) instructs every morpheme to initiate a foot, though not at the cost of subminimal feet (**(máda)-(là)-(ntù)*) or of a foot that contains a morpheme boundary (**(máda-(là-ntù)*). Crowhurst shows that Dyirbal (Dixon 1972), by contrast, allows a foot to span a morpheme boundary, so two successive monosyllabic suffixes are footed together. (Kager (1997) analyzes Dyirbal in terms of p-word structure: the root ends with a p-word boundary, but there are no p-word boundaries within the sequence of suffixes, so the suffixes form a single footing domain.) Crowhurst further contrasts Gooniyandi (McGregor 1990), where a root plus any number of monosyllabic suffixes behaves as though monomorphemic (whereas a disyllabic suffix always initiates a new foot). Kenstowicz (1997b) analyzes Diyari, Dyirbal, and other related languages in terms of violable paradigm uniformity: Diyari *(*máda*)-(*là-ntu*) is ruled out because the grammar prefers the suffix to have the same (unstressed) realization everywhere.

In summary, accounts of affix size differences have largely used ALIGN constraints either to place foot boundaries at morpheme boundaries directly or to establish the p-word as a domain of footing; the size differences themselves emerge from interactions with minimum foot-size requirements. Some of the data are not explainable with cyclicity alone, though the literature generally does not fully explore all the analytic possibilities.

Affix-size differences in Samoan will be treated in sections 4 through 7. The basic stress data are compatible with multiple analyses, but we will conclude from words with two suffixes that cyclicity alone is inadequate and ALIGN constraints are needed.

2. Language Background and Data Collection

2.1. Language Background

All data in this paper are from the *tautala lelei* register of speech (which preserves more segmental contrasts than the other register, *tautala leaga*), described in most other work on Samoan. The phoneme inventory is shown in (3). The symbols have their IPA (International Phonetic Association 1999) values, except that /t/ is usually heavily affricated ([t^s]). The phonemes in parentheses are restricted to loanwords.

(3) Samoan phoneme inventory

p	t	(k)	ʔ	i, iː		u, uː
f, v	s		(h)	e, eː		o, oː
m	n	ŋ			a, aː	
	l, (ɹ)					

Samoan phonotactics require every consonant to be followed by a vowel, yielding syllables like (C)V, (C)Vː, and possibly (C)VV, but not *(C)VC. We assume that (C)Vː and (C)VV are bimoraic.

2.2. Data Collection

All transcriptions in this paper are of our consultants' speech. Data were collected in one- to two-hour sessions from September 2007 to November 2008 with one main consultant, age 19, who was born and raised in Upolu and had moved to the Los Angeles area 4 years previously. Elicitation items were often found using Milner (1993) or Mosel and Hovdhaugen (1992). The consultant was given the Samoan written form and asked to confirm that he was familiar with the word, to pronounce the word a few times, and to check the gloss. All words were elicited in isolation, where the stress patterns were the clearest to our ears (see Sections 3.2, 3.5), though some morphologically complex words, such as inflected verbs, were first elicited in sentences.

Critical items were also elicited and recorded from six consultants in Apia, Samoa in November 2011, and our primary consultant again in Los Angeles. Recordings were made with a head-mounted microphone (Shure SM10A). The consultants in Samoa included 4 men and 2 women, aged 27.3 ± 6.9 (SD) years, from the capital city of Apia and other areas of Upolu and Savai'i. All of them spoke primarily Samoan in daily life and were literate in Samoan, but also spoke English as a second language with some fluency. English was used as the contact language. In these sessions, each Samoan word was presented to the consultant on a slide on the computer screen, usually with a picture representing the meaning. For some morphologically complex words, such as verbs with the ergative *-a* suffix in the Appendix, we sometimes presented both a base and derived form and elicited the word in a sentence frame.

The consultant was asked to confirm familiarity with the word and was recorded pronouncing the words and sentences. To elicit judgments about stress patterns other than the one originally pronounced by the consultant, the investigator uttered a pronunciation with an alternate stress pattern and asked if the alternate pronunciation was acceptable. Then, the consultant was asked to pronounce it him/herself and to confirm that it indeed sounded acceptable/unacceptable. Consultants often volunteered pronunciations with alternate stress patterns. We did not ask consultants to abstract stress patterns away from the pronunciation of the word, such as by hand-tapping on the stressed syllable.

3. Stress in monomorphemes

In this section we describe the stress pattern in monomorphemic words, not including underlying long vowels in penults (see section 5) and certain vowel sequences (see section 7). We look at primary stress and secondary stress, including their phonetic realization, and give an analysis in Optimality Theory (Prince & Smolensky 1993/2004).

3.1. Primary stress in monomorphemes

The basic primary stress pattern of Samoan is simple: a moraic trochee at the right edge of the word (Homer 2007a). Stress is on the last vowel if long, and otherwise on the second-to-last. Examples are given in (4), with parentheses enclosing presumed feet, and acute accent marking primary stress.

(4) Basic primary stress pattern: moraic trochee at right edge

...V́ː#		...V́V#		...V́CV#			
la(váː)	‘energized’	le(léi)	‘good’	(mánu)[1]	‘bird’	ma(nóŋi)	‘to smell good’
				(sámi)	‘sea’	pu(líŋi)	‘pudding’
				(áta)	‘picture’	i(ŋóa)	‘name’

Samoan primary stress is similar to Fijian (Dixon 1988; Schütz 1978, 1985), where, in Hayes’s (1995) analysis, a word ends with a moraic trochee. In both Fijian and Samoan, there are no surface forms with a short final vowel and a long penultimate vowel (e.g., *[máːnu])—see Section 5. We will see a systematic set of exceptions to the basic pattern in Section 7.

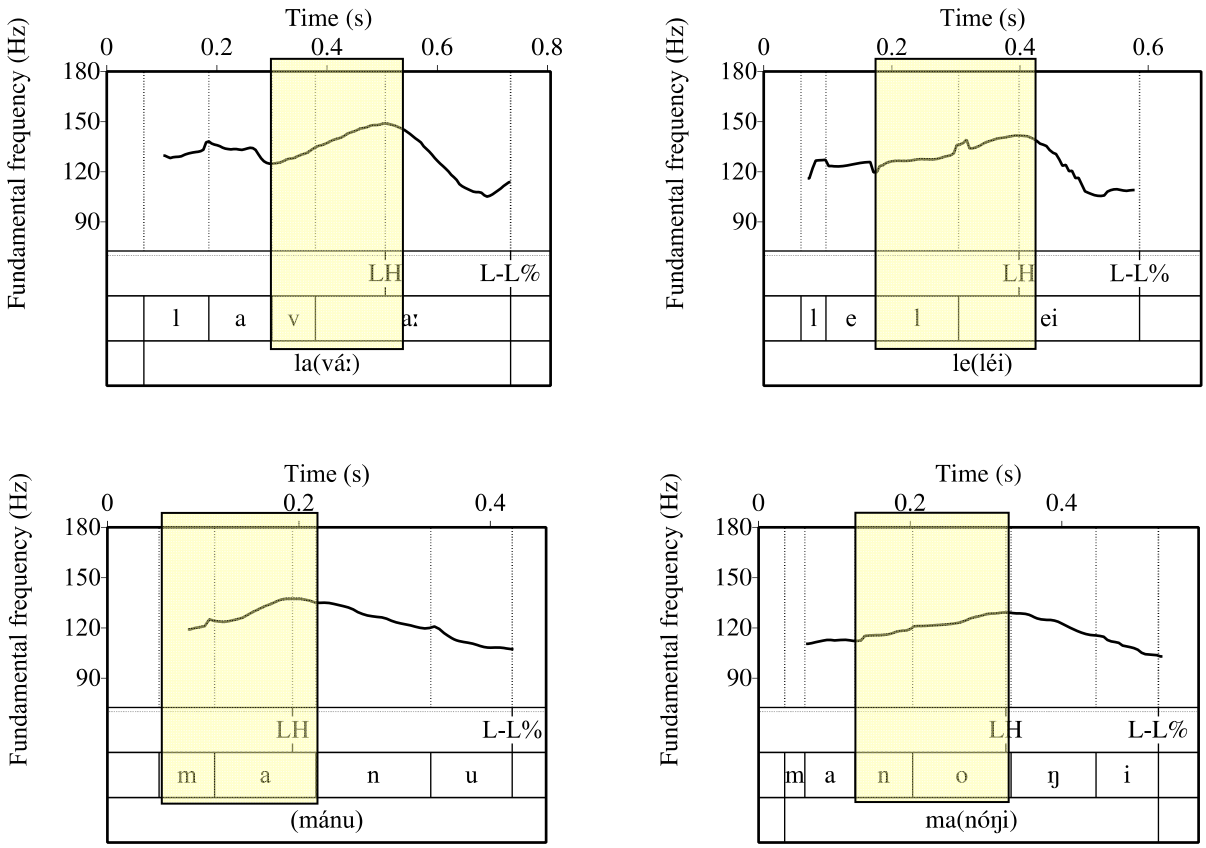
3.2. Phonetic realization of primary stress

Samoan primary stress appears to be realized with three primary acoustic features: amplitude, duration, and fundamental frequency (f0). Amplitude and duration were not investigated systematically; all else being equal, stressed syllables seem louder than unstressed, and the consonant after the stressed vowel may be lengthened (see footnote 1). We have investigated f0 systematically (Orfitelli & Yu 2009): f0 rises on the stressed mora, shown in the pitch tracks in (5). We label this rise as an LH pitch accent, without notating tonal association (i.e., L*+H or L+H*), since we have no evidence for a difference in

[1] We typically perceived and transcribed post-stress consonants as long or half-long ([mánˑu], [manóŋˑi], etc.), but we omit those marks from the transcriptions here because we did not carry out a systematic study.

stability of tonal alignment of the L or H target, nor for a meaning contrast based on tonal alignment (Arvaniti, Ladd, & Mennen 2000; Pierrehumbert & Steele 1989). Shaded boxes in (5) highlight the stressed mora (and preceding consonant) and its f0 rise, which is followed by an utterance-final fall. The f0 rise of a stressed long vowel, e.g. la(váː), is over its first half.

(5) Pitch tracks for first row of items in (4)



3.3. Analysis of basic primary stress

Our analysis of primary stress is straightforward: a bimoraic foot is required at the end of the word. The can be captured in Optimality Theory with Prince & Smolensky's (1993/2004) constraints EDGEMOST (p. 35), FOOTBINARITY (p. 50), and RHYTHMTYPE (p. 56). The definitions we assume are given in (6), and (7) illustrates the pattern with a tableau.

(6) Constraint definitions for basic primary stress

EDGEMOST(F';R;Word), abbreviated EDGEMOST-R: the end of the prosodic word must coincide with the end of a primary-stressed foot

FOOTBINARITY: a foot must contain exactly two moras

RHYTHMTYPE=TROCHEE: a foot must have stress on its initial mora, and its initial mora only (we assume that in a stressed long vowel, the stress belongs to the first mora)

(EDGEMOST-L AND RHYTHMTYPE=IAMB are ranked too low to be active.)

(7) Tableau for basic primary stress

/ iŋoa / ‘name’	FOOTBINARITY	RHYTHMTYPE= TROCHEE	EDGEMOST-R
☞ *a* i(ŋóa)			
b i(ŋoá)		*!	
c iŋo(á)	*!		
d (íŋo)a			*!

While the data presented thus far support don’t support any ranking arguments for these three constraints, we will see in Section 7 that EDGEMOST-R is dominated.

3.4. Secondary stress in monomorphemic loans

It’s difficult to find convincingly monomorphemic native words with four or more moras. Some examples are given in (8) (grave accent marks secondary stress), but, as is typical, they seem to be reduplicated (if not productively); to contain a sequence that can be an affix, such as [maː-]; or to possibly have undergone vowel lengthening.

(8) Secondary stress in native words

(vào)(váo)	‘restrain’	(màː)(lòː)(lóː)	‘rest’
(lèː)(múː)	‘gentle, slow’	cf. ŋaːlemulemu ‘soft’ (Milner 1993)	
(tàli)(éː)	‘laugh’	cf. maːlie ‘funny’ (Milner 1993)	
fo(láu) ~ (fòː)(láu)	‘travel by sea’		

Long monomorphemes tend to be English loans. In 5-mora loans where neither of the first two vowels is epenthetic (as compared to the English), secondary stress falls on the first mora (9). In Prince’s (1983), terms, Samoan displays an initial dactyl effect. In (9), vowels with stressed English correspondents are underlined, and those with no English correspondent are bold. Even when the first vowel does not correspond to a stressed English vowel (‘democracy’, ‘Olympics’), it bears stress. The sole exception is ‘philosophy’ (no underlining, because final [ia] makes the source language unclear).

(9) 5-mora loans, first two vowels non-epenthetic—items to elicit drawn from Cain 1986

(tèmo)k**a**(lási)	*te(mòk**a**)(lási)	‘democracy’
(ʔòli)m**i**(pík**a**)	*ʔo(lim**i**)(pík**a**)	‘Olympics’
(màte)ma(tík**a**)	*ma(tèma)(tík**a**)	‘mathematics’
(mìli)o(néa)	*mi(lìo)(néa)	‘millionaire’
(kèmi)s**i**(**té**ɹi)	*ke(mìs**i**)(**té**ɹi)	‘chemistry’
(hèmi)s**i**(fía)	*he(mìs**i**)(fía)	‘hemisphere’
(mìni)s**i**(táː)	*mi(nìs**i**)(taː)	‘minister’
(kìlo)k**a**(lám**a**)	*ki(lòk**a**)(lám**a**)	‘kilogram’
(pàki)s**i**(tán**a**)	*pa(kìs**i**)(tán**a**)	‘Pakistan’
(pàle)s**i**(tín**a**)	*pa(lès**i**)(tín**a**)	‘Palestine’
(vìe)t**i**(nám**e**)	* vi(èt**i**)(nám**e**)	‘Vietnam’
(mèla)ne(sía)	*me(làne)(sía)	‘Melanesia’
(mìsi)o(náɹe)	*mi(sìo)(náɹe)	‘missionary’

(vè̲ne)su(é̲la)	*ve̲(nèsu)(é̲la)	‘Venezuela’
*(filo)so(fía)	fi(lòso)(fía)	‘philosophy’

Unsurprisingly, when the second vowel is epenthetic, secondary stress remains on the first vowel:

(10) 5-mora loans, second vowel epenthetic (and our only 7-mora word)

(kòm**i**)pi(ú̲ta)	*ko(m**ì**pi)(ú̲ta)	‘computer’
(tèɹ**e**)mo̲(méta)	*te(ɹ**è**mo̲)(méta)	‘thermometer’
(ʔìn**i**)s**i**(ú̲a)	*ʔi(n**ì**s**i**)(ú̲a)	‘insurance’
(ʔì̲n**i**)si(ní̲a)	*ʔi(n**ì**si)(ní̲a)	‘engineer’
(kò̲n**e**)ti(nét**a**)	*ko̲(n**è**ti)(nét**a**)	‘continent’
(pè̲n**e**)te(kó̲s**o**)	*pe̲(n**è**te)(kós**o**)	‘Pentecost’
(ʔà̲s**i**)pu(lín**i**)	*ʔa̲(s**ì**pu)(lín**i**)	‘aspirin’
(pè̲n**i**)si(óː)		‘banjo’
(ʔàf**a**)(kà̲ni)s**i**(tá̲n**a**)[2]	*ʔa(f**à**ka̲)(nìs**i**)(tá̲n**a**)	‘Afghanistan’
	*(ʔàf**a**)ka̲(nìs**i**)(tá̲n**a**)	

When the *first* vowel is epenthetic, stress usually falls on the second, as shown in (11). Similar avoidance of stress on epenthetic vowels in loans has been discussed for Fijian (Hayes 1995; Kenstowicz 2007; Schütz 1978, 1999) and Selayarese (Broselow 1999, 2008). When the footing requires it, it is possible for epenthetic vowels to bear secondary or even primary stress (12).

(11) 5-mora loans, first vowel epenthetic

*(p**à**la̲)n**i**(kék**e**)	p**a**(là̲n**i**)(kék**e**)	‘blanket’
*(p**ù**ɹi̲)n**i**(sé̲s**e**)	p**u**(ɹì̲n**i**)(sés**e**)	‘princess’
*(s**ì**a̲)m**u**(pín**i**)	s**i**(à̲m**u**)(pín**i**)	‘champion’
*(s**ì**ko̲)t**i**(lán**i**)	s**i**(kò̲t**i**)(lán**i**)	‘Scotland’
*(p**è**le̲)si(kéŋ**i**)	p**e**(lè̲si)(kéŋ**i**)	‘president’
*(f**à**ɹa̲)n**i**(sés**e**)	f**a**(ɹà̲n**i**)(sés**e**)	‘Francis’
*(p**ò**ɹo̲)s**e**(tán**o**)	p**o**(ɹò̲s**e**)(tán**o**)	‘Protestant’
*(s**ì**ko̲)la(sí̲p**i**)	s**i**(kò̲la)(síp**i**)	‘scholarship’
*(k**à**la̲)(ìs**i**)(kék**e**)	k**a**(là̲i)s**i**(kék**e**)	‘Christchurch’
(k**ì**ɹi̲)s**i**(más**i**) ~	k**i**(ɹì̲s**i**)(más**i**)	‘Christmas’
(p**ò**lo̲)k**a**(lám**e**)	*p**o**(lò̲k**a**)(lám**e**)	‘program’
(k**è**ɹi̲)s**i**(án**o**)	*k**e**(ɹì̲s**i**)(án**o**)	‘Christian’

(12) Stressed epenthetic vowel examples

(sìk**a**)(lá̲m**u**)	‘scrum’	(sìku)(é̲a)	‘square’
(p**è**ɹo̲)(fét**a**)	‘prophet’	(pìː)(n**í**k**i**)	‘pink’

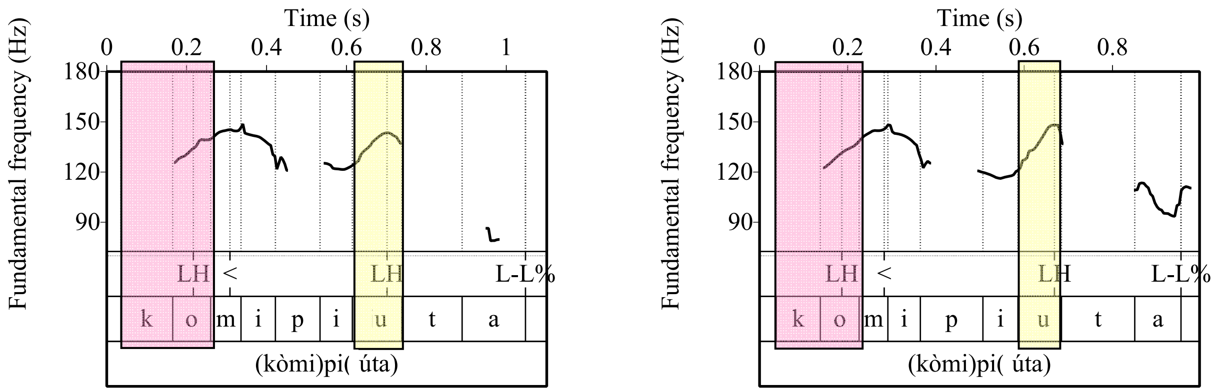
3.5. Phonetic correlates of secondary stress

Phonetic correlates of secondary stress are similar to those for primary stress, but less stable. In a sentence context, there is often no pitch event marking secondary stress, only interpolation between

[2] With the second and fifth vowels often devoiced or absent. A true initial dactyl pattern would yield *(ʔàf**a**)ka̲(nìs**i**)(tá̲n**a**).

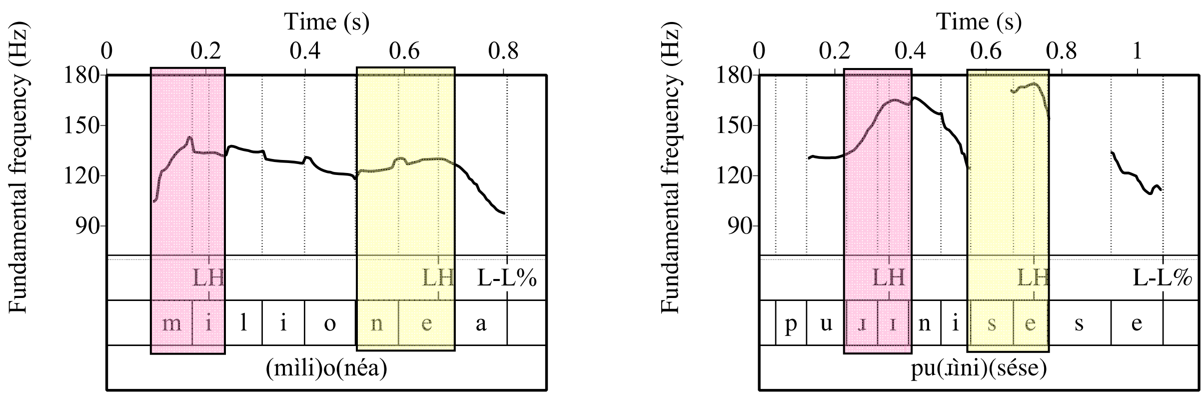
surrounding events. In citation form, a pitch rise (LH) on the secondary-stressed syllable is often smaller than the primary-stress rise for the primary stress. In (13) we show two pitch tracks for ‘computer’ (with considerable peak delay for the first rise). On the left, pitch rises are similar on both stressed moras; on the right, the primary-stress rise is sharper.

(13) Variation in relative size of pitch rise between secondary and primary stress: [(kòm**i**)pi(ú̲ta)]



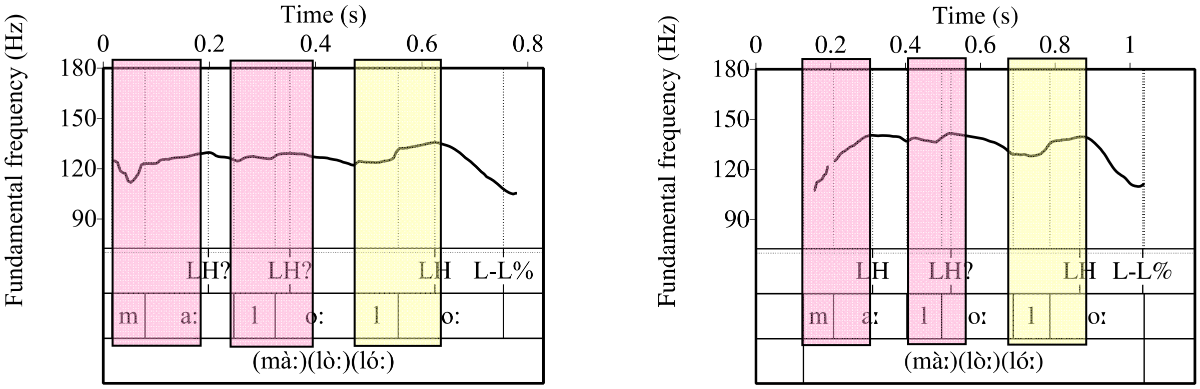
In (14) one can see the difference between initial and peninitial secondary stress.

(14) Initial vs. peninitial secondary stress: [(mì̲li)o(né̲a), p**u**(ɹì̲n**i**)(sés**e**)]



Finally, (15) shows two tokens of *(mà:)(lò:)(ló:)*. On the left, we see little pitch rise for either of the putative secondary stresses; on the right we see a clear rise for the first stress, but not the second.

(15) Example of minimal pitch rises for secondary stresses: [(mà:)(lò:)(ló:)]



Our transcriptions of secondary stress are typically based on eliciting multiple tokens of a word in citation form until we were confident of the transcription. In some of the items below, we note that we were unsure of secondary stress—it may well have been present phonologically, but its phonetic realization was not clear enough for us to confidently locate it.

3.6. Analysis of secondary stress

Although the evidence for the initial dactyl effect is limited to loans, we will tentatively assume that Samoan prefers for words to begin with a foot, as illustrated in (17) (constraint definitions in (16)).

(16) Constraint definitions for secondary stress

ALIGN(PrWd,L;Ft,L): The beginning of the prosodic word must coincide with the beginning of a foot (McCarthy & Prince 1993b)

PARSE-σ: Every syllable must be included in a foot (McCarthy & Prince 1993b)

(17) Initial dactyl effect

/ temokalasi / cf. English [dɪmɒ́kɹəsɪ][3]	EDGEMOST-R	PARSE-σ	DON'TSTRESS EPENTHETIC	ALIGN (PrWd,L;Ft,L)
☞ *a* (tèmo)ka(lási)		*		
b te(mòka)(lási)		*		*!

We lack data on longer words to confirm how medial feet align—the only good example is (ʔàf**a**)(k̠àni)s**i**(t̠án**a**) in (10).

As mentioned above, stress is avoided on epenthetic vowels (p**a**(làn**i**)(kék**e**) 'blanket' vs. *(p**à**la)n**i**(kék**e**)) unless the alternative increases the number of unparsed syllables ((s**ì**k**a**)(lám**u**) vs. *s**i**k**a**(lám**u**) 'scrum', (pì:)(ník**i**) vs. *(pí:)n**i**k**i** 'pink'). If we take this to be a synchronic pattern, we have the ranking PARSE-σ >> DON'TSTRESSEPENTHETIC[4] >> ALIGN(PrWd, L; Ft, L). We leave open whether DON'TSTRESSEPENTHETIC is synchronically active or applies only to initial loan adaptation.

[3] English pronunciations from OED (1989), with stress notation converted to accent marks, and IPA [ɹ].

[4] For contrasting proposals on the nature of such a constraint, see Kenstowicz 2007 and Boersma & Hamann 2009.

4. Stress in complex words

This section examines compounding, suffixation, prefixation, and reduplication. In general, we find that the left edge of a morpheme initiates a footing domain, subject to minimality. In Section 7 we will see that the situation is a bit more complex when certain vowel-vowel sequences are involved.

4.1. Stress in compounds

In compounds of two roots, the first ends with a foot, indicating a p-word boundary between the two roots. The examples in (18) illustrate how two compounds with the same number of syllables can have different stress patterns.

(18) Stress in compounds

a(lòfi)-(váe)	‘sole of foot’ (assembly+foot)	*(àlo)fi-(váe)
(àŋa)-le(áŋa)	‘bad behaviour’ (bad+behaviour)	*a(ŋàle)(áŋa)

We adopt Peperkamp’s (1997) Align-based approach, and propose that Samoan has high-ranking Align(Morpheme,L; PWd,L): every morpheme must initiate a prosodic word (p-word). As we will see starting in (26), this constraint is violable, and when we turn to disyllabic suffixes, we will see that the constraint should indeed refer to morphemes in general rather than only to lexical words. Because Edgemost-R and Align(PWd,L; Foot,L) refer to the p-word, Align(Morph,L; PWd,L) indirectly determines footing. The tableau in (19) illustrates /alofi+vae/. We leave open the question of whether the two p-words in (a) combine to form a larger p-word, or attach directly to the next level up, such as a phonological phrase.[5]

(19) Tableau for footing a compound

N / \\ N N alofi+vae	Align (Morph,L; PWd,L)	Edgemost-R	Parse-σ	Align (PWd,L; Ft,L)
☞ *a* PWd PWd a(lòfi)-(váe)			*	*
b PWd PWd (àlo)fi-(váe)		*!	*	
c PWd (àlo)fi-(váe)	*!		*	

We have not found prosodic differences among sub-types of compounds. As Mosel and Hovdhaugen discuss (p. 240), it is difficult to distinguish between phrases and compounds without a clear sign of compoundhood (opaque meaning; bound root; compounding affix such as *–ŋa:*). Compounds can be noun+noun or adjective+noun (18), or noun+verb (*‘ave-pasi*, ‘drive a bus’ or ‘bus driver’ (drive+bus)).

[5] We transcribe the first stress of the compound as secondary, which might suggest a single p-word. But we have no clear phonetic criteria to differentiate a secondary stress from a primary word stress that is not the strongest in its phrase.

4.2. Stress with suffixes

4.2.1 Stress with monomoraic suffixes

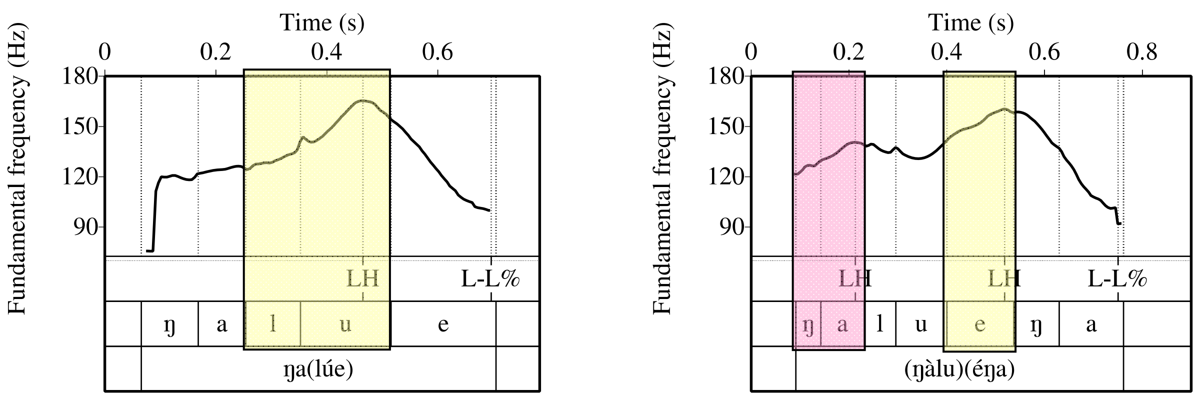
There are several monomoraic suffixes in Samoan, and they draw stress to the right (20): the domain that must end in a moraic trochee includes these suffixes. In longer items we see that secondary stress can be added when suffixation brings a word up to 4 moras, but secondary stress does not move after suffixation, whether because of faithfulness to the unsuffixed form or preference for an initial foot.

(20) Stress in words suffixes with nominalising /-ŋa/

unsuffixed		*suffixed—final foot moves to new word edge*	
(páe)	‘set out’	pa(é-ŋa)	‘presentation of food’
(tíu)	‘fish$_V$’	ti(ú-ŋa)	‘fishing trip’
(móe)	‘sleep$_V$’	mo(é-ŋa)	‘bed’
(súi)	‘change$_V$’	su(í-ŋa)	‘change$_N$’
ŋa(lúe)	‘work$_V$’	(ŋàlu)(é-ŋa)	‘work$_N$’
sa(váli)	‘walk$_V$’	(sàva)(lí-ŋa)	‘parade$_N$’
(màfa)(tía)	‘stress out$_V$’	(màfa)ti(á-ŋa)	‘distress$_N$’
(làpa)(táʔi)	‘warn’	(làpa)ta(ʔí-ŋa)	‘warning’
(<tàla>)(tála)[6]	‘discuss’	(<tàla>)ta(lá-ŋa)	‘discussion’

The pitch tracks in (21) clearly illustrate the stress shift, for ‘work’. The unsuffixed form has a single pitch rise on [lu], and the suffixed word has an added initial rise for the secondary stress, and a larger rise for the primary stress, now on [e].

(21) Pitch tracks for stress shift under suffixation: ŋa(lúe), (ŋàlu)(é-ŋa)



In (22) we see that the denominal suffix /-a/ (‘abounding in N’ or ‘having N’) behaves the same.

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[6] In the spirit of Comrie, Haspelmath, & Bickel 2008, we use angled brackets < > to enclose a reduplicant, since reduplicants are usually infixing in Samoan (though vacuously so if the stem is only bimoraic; see section 4.4).

(22) Stress in words suffixed with denominal /-a/

unsuffixed		*suffixed—final foot moves to new word edge*	
(ŋífo)	'tooth'	ŋi(fó-a)	'having teeth'
(néfu)	'dust'	(pùː)-ne(fú-a)	'dusty'
a(núfe)	'worm'	(ànu)(fé-a)	'having worms'

A homophonous suffix /-a/, with the same stress behaviour, is shown in (23). The suffix is one of the many forms of a family of verb suffixes often called ergative (productive: /-a/ and /-ina/; unproductive: /-Cia/, where C can be any consonant, and /-na/ (24)). Chung (1978) and Homer (2007b) find that these occur when an ergative subject moves over the verb, and possibly in other contexts.

(23) Stress in words suffixed with ergative /-a/

unsuffixed		*suffixed—final foot moves to new word edge*	
(fúsi)	'hug'	fu(sí-a)	'hug-A'
(ʔíni)	'pinch'	ʔi(ní-a)	'pinch-A'
(pùi)(púi)	'surround'	(pùi)pu(í-a)	'surround-A'

(24) Stress in words suffixed with ergative /-na/

(téʔe)	'reject'	te(ʔé-na)	'reject-NA'
(tìː)(máʔi)	'encourage'	(tìː)maʔ(í-na)	'encourage-NA'

The final monomoraic suffix we examine is the fairly unproductive /-Ci/, where C can be any consonant, including zero. When accompanied by /fe-/, it usually creates plural verb forms. Alone, its semantic contribution is unpredictable. Adding /-Ci/ also shifts stress to the right:

(25) Stress in words suffixed with plural /-Ci/

unsuffixed		*suffixed*	
(lólo)	'flood (archaic)'	lo(ló-fi)	'to flock, surge'
(máta)	'eye'	ma(tá-ʔi)	'keep an eye on'
a(lófa)	'love'	fe-alo(fá-ni)[7]	'harmony, getting along'

We conclude that these suffixes belong to the same prosodic word as the stem, and so are footed together with it. This violates our constraint ALIGN(Morph,L; PWd,L), which would require the suffix to initiate a new p-word. We assume however, that as a requirement of either GEN or a high-ranking constraint, every p-word must contain a foot. And feet, by FOOTBINARITY, must be bimoraic. Therefore, FOOTBINARITY must outrank that ALIGN constraint, as shown in (26). We assume that strict layering is favoured by violable constraints (Ito & Mester 1992), Selkirk's (1995) NONRECURSIVITY (in this case, a p-word should not dominate another p-word) and EXHAUSTIVITY (in this case, a syllable shouldn't be left to attach directly to the phonological phrase, but should instead belong to a p-word):

[7] Secondary stress uncertain.

(26) Tableau for footing a word with a monomoraic suffix

V / V /teʔe+na/ ‘reject+NA’	FOOT BIN	EXHAUST-IVITY	ALIGN (Morph,L; PWd,L)	NON RECURSIVE	EDGEMOST -R	PARSE -σ	ALIGN (PWd,L; Ft,L)
☞ *a* P-Word te(ʔé-na)			*			*	*
b P-Word (téʔe)-na			*		*!	*	
c P-Word P-Word (téʔe)-na			*	*!	*	*	
d P-Word (téʔe)-na		*!	*			*	
e P-Wd P-Wd (tèʔe)-(ná)	*!						

4.2.2 Stress with bimoraic suffixes

We now turn to bimoraic suffixes, which our analysis so far predicts should form their own p-word, since they are long enough to support a binary foot. As expected regardless of p-word structure, primary stress falls on the suffix’s penultimate mora, as illustrated in (27) for the regular /-ina/ form of the ergative suffix, and in (28) for the unproductive /-Cia/ form.

(27) Stress in words suffixed with ergative /-ina/

unsuffixed		*suffixed*		
na(náː)	‘hide’	na(nàː)-(ína)	‘hide-INA’	
i(lóa)	‘know’	i(lòa)-(ína)	‘know-INA’	
(màː)(lòː)(lóː)	‘rest’	(màː)(lòː)(lòː)-(ína)	‘rest-INA’	
(túʔu)	‘give’	(tùʔu)-(ína)	‘give-INA’	
(fàʔa)-le(áŋa)	‘destroy’	(fàʔa)-le(àŋa)-(ína)	‘destroy-INA’	(*faʔa-* is a prefix)

(28) Stress in words suffixed with ergative /-Cia/

unsuffixed		*suffixed*	
(páʔu)	‘shallow’	(pàʔu)-(lía)	‘be trapped, beached’
(táŋi)	‘cry’	(tàŋi)-(sía)	‘cry over’

Other bimoraic suffixes show similar stress patterns, including /-Caʔi/ (29), which Milner (1993) calls a reciprocal suffix, and /-Caŋa/ (30), an unproductive variant of nominalising /-ŋa/ (20).

(29) Stress in words suffixed with /-Caʔi/

unsuffixed		*suffixed*	
(nófo)	'sit'	(nòfo)-(áʔi)	'keep sitting in the same place'
ma(láŋa)	'ceremonial visit'	fe-ma(làŋa)-(áʔi)[8]	'travel around'

(30) Stress in words suffixed with nominalising /-Caŋa/

unsuffixed		*suffixed*	
(táfe)	'flow'	(tàfe)-(áŋa)	'castaways'
(ʔálo)	'avoid'	(ʔàlo)-(fáŋa)	'place of refuge'
a(lófa)	'love'	a(lòfa)-(ʔáŋa)	'greeting'

From primary stress assignment alone, we cannot determine whether the stem and suffix form a single p-word, or if the suffix forms its own p-word. However, the secondary stress pattern suggests that the stem does form its own p-word (and therefore that the suffix does too). For example, if the string [iloa-ina] formed a single p-word, we expect an initial dactyl, *[(ìlo)a-(ína)] (see (9)), but instead, the stem's footing is right-aligned, as in the unsuffixed form. The same lack of secondary stress shift is also seen for /-Caʔi/ and /-Caŋa/ (we found no trimoraic stems with /-Cia/).

An alternative is to claim that partial faithfulness to the unsuffixed form is at work, as has been claimed for distantly related Indonesian. (In Indonesian, suffixes are part of the footing domain. A foot is formed at the right edge of a word, so when a word is suffixed, its primary stress shifts. Secondary stress, however, does not (Cohn 1989, Cohn and McCarthy 1994).)

The data in this section are consistent with either footing domains or output-output faithfulness. However, in Sections 5 and 7, we will see clearer evidence that /-ina/ and some of the other bimoraic suffixes do form a separate prosodic domain.

4.2.3 Stress with two suffixes

It is possible for a word to end with two suffixes. The most common combination is /-Caʔi-ŋa/. Examples of /-Caʔi-ŋa/ and other sequences of a bimoraic suffix followed by a monomoraic suffix are shown in (31). The stem (underlined) ends with a foot, consistent with a p-word boundary at the end of the stem. The three suffix syllables are treated as a single p-word, with penultimate stress (unlike in some of the Australian languages discussed in 1.2). (See Section 4.3 for discussion of the prefixes.)

(31) Stress in words suffixed with /-Caʔi-ŋa/, /-Caʔi-a/, /-Caʔi-na/

(<u>tàpu</u>)-a(ʔí-ŋa) 'worship time (when no one should be outside)'
forbidden-CAʔI-ŊA *ta(pù-a)(ʔí-ŋa)

fe-<u>(làva)</u>-sa(ʔí-ŋa) 'laying (wood) on ground horizontally'
FE-lay.across-CAʔI-ŊA *fe-la(và-sa)(ʔí-ŋa)

[8] It's uncertain whether there's secondary stress on /fe/ also.

fe-(fàʔa)-u(òː)-a(ʔí-ŋa) ‘friendship’ *fe-(fàʔa)-u(ò-a)(ʔí-ŋa),
FE-FAʔA-friend-CAʔI-ŋA *fe-(fàʔa)-(ùo)(ò-a)(ʔí-ŋa)

(àlo)-a(ʔí-a), (àlo)-a(ʔí-na) ‘recognize’ *a(lò-a)(ʔí-a), a(lò-a)(ʔí-na)
face-CAʔI-A, face-CAʔI-NA

We found one example of two monomoraic suffixes /-na/ and /-ŋa/ combining, shown in (32).

(32) Stress in words suffixed with /-na-ŋa/
(fàʔa)-(tàfu)-(ná-ŋa) ‘destruction’
FAʔA-burn-NA-ŋA

There are a few other combinations of affixes possible. But because they all produce vowel sequences with special stress behaviour, we postpone their discussion to Section 7.

As the tableau in (33) shows, the constraint ranking developed so far requires that the two suffixes together form a prosodic word, separate from the stem, and is thus consistent with the data.

(33) Tableau for footing a word with two suffixes

V V /tapu+aʔi+ŋa/ ‘forbidden + CAʔI + ŋA’	FOOT BIN	EXHAUST-IVITY	ALIGN (Morph,L; PWd,L)	EDGEMOST -R	PARSE -σ	ALIGN (PWd,L; Ft,L)
a P-Word (tàpu)-a(ʔí-ŋa)			**!		*	
☞*b* P-Wd P-Wd (tàpu)-a(ʔí-ŋa)			*		*	*
c P-Wd P-Wd P-Wd (tàpu) - (áʔi) - (ŋá)	*!					
d P-Wd P-Wd (tàpu)-(áʔí)-ŋa			*	*!	*	

4.3. Stress with prefixes

Samoan has few productive prefixes. There is one bimoraic prefix, the extremely common /faʔa-/. We usually hear its stress as [fàʔa-], and never *[faʔà-], though this is hard to verify acoustically because both syllables tend to be short and the glottal stop disrupts the pitch; /faʔa-/ is often realized as simply [faː]. Examples are given in (34). The prefix /faʔa-/ is typically described as, roughly, causative.

(34) Stress in words prefixed with /faʔa-/

(fàʔa)-(táu)	‘buy’ (/tau/ ‘price’)
(fàʔa)-ma(óni)	‘loyal’ (/maoni/, ‘true’)
(fàʔa)-ko(lúse)	‘crucify’ (/koluse/ ‘cross’)

Our constraint grammar so far predicts that /faʔa-/ forms its own p-word, because ALIGN(Morph, L; PWd, L) requires /faʔa-/ and the root morpheme to each initiate a p-word. The data in (34) are consistent with /faʔa-/ forming its own p-word, though they are also what we expect if the whole word is a single p-word, because of the initial dactyl effect.

There is also a monomoraic prefix /fe-/, used in plural forms of many verbs and illustrated in (35). It is usually accompanied by a suffix.

(35) Stress in words prefixed with /fe-/

(mísa)	‘fight’	fe-(mìsa)-(áʔi)	‘not getting along’
		fe-(sùi)-(áʔi)	‘change’ (FE+change+A‘I)
		fe-(ùi)-a(ʔí-ŋa)	‘taking time’ (FE+go+A‘I+GA)

The grammar predicts that /fe-/ should be adjoined to the root’s p-word ([fe $[\text{root}]_{\text{p-wd}}$ $]_{\text{p-wd}}$), because it is not big enough to form a p-word of its own. This means that /fe-/ should not receive secondary stress, even if the root is longer than two syllables. We found very few examples where the root was long enough for /fe-/ to potentially be stressed and were unable to confidently transcribe secondary stress:

(36) Stress when /fe-/ attaches to a longer root

ma(láŋa)	‘ceremonial visit’	fe-ma(làŋa)-(áʔi) or (fè-ma)(làŋa)-(áʔi)?	‘travel around’
a(lófa)	‘lover’	(fè-a)lo(fá-ni) or fe-(àlo)(fá-ni)?	‘harmony, getting along’

The prefixes /fe-/ and /faʔa-/ can combine. The grammar predicts that /fe-/ is adjoined to /faʔa-/’s p-word ([fe $[\text{faʔa}]_{\text{p-wd}}]_{\text{p-wd}}$ $[\text{root}]_{\text{p-wd}}$), yielding the secondary-stress pattern [fe(fàʔa)-...]. Though we have few examples, they match this prediction, as shown in (37), although the pattern is also consistent with the two prefixes’ forming a single p-word. If the prefixes were inside the root’s p-word, we would expect *[(fè-fa)ʔa-....]. The stress in [fe-faʔa] is thus weak evidence for a p-word boundary between [faʔa] and the root; we will see stronger evidence in sections 6 (59) and 7.2 (76).

(37) Stress in words prefixed with /fe-faʔa-/

fe-(fàʔa)-u(òː)-a(ʔí-ŋa) ‘friendship’ (/uoː/ ‘friend’)

We also have a few examples for /faʔa-/ followed by /fe-/. The grammar predicts a separate p-word for /faʔa-/, with /fe-/ adjoined to the root’s p-word: $[\text{faʔa}]_{\text{p-wd}}$ [fe $[\text{root}]_{\text{p-wd}}]_{\text{p-wd}}$. The predicted stress pattern is [(fàʔa)-fe...]. As shown in (38), this is what we find, not *[fa(ʔà-fe-)...], which we would expect if the two prefixes form a single p-word.

(38) Stress in words prefixed with /faʔa-fe/

(fàʔa)-fe-(ìlo)-(áʔi) ‘greet’ (/ilo/ ‘know’)

We return to the prosodification of prefixes in Section 7.2.

4.4. Stress with reduplication

Reduplication in Samoan occurs mostly in verbs. There are two types of reduplication: CV reduplication, typically for plural agreement, and two-mora reduplication, typically with a pluractional, frequentative, or intensified meaning. Both types of reduplication can occur with the same root.

CV reduplication doubles the initial CV of the primary-stressed foot.[9] As shown in (39), the resulting stress pattern looks the same as for a monomorpheme, suggesting that the reduplicant is integrated into the root's p-word. (In Section 5, however, we examine some more complex cases.) The CV reduplicant often sounds shorter than a typical unstressed syllable, as Mosel and Hovdhaugen (1992) note (p. 34), but still counts as moraic, since it allows a preceding mora to bear secondary stress.

(39) Stress with CV reduplication

Unreduplicated		*Reduplicated*	
(véla)	'hot'	<ve>(véla)	'hot-*plural'*
a(lófa)	'love'	(à<lo>)(lófa)	'love-*plural'*
sa(váli)	'walk'	(sà<va>)(váli)	'walk-*plural'*
(péː)	'die'(nonhuman)	<pe>(péː)	'die(nonhuman)-*plural'*
móe	'sleep'	<mo>(móe)	'sleep-*plural'*

Two-mora reduplication typically copies the primary-stressed foot. In this case, we perceive no particular shortening, so the choice of which copy to designate as the reduplicant is arbitrary. Typical examples are shown in (40), along with an example, 'messy', in which a non-final foot is copied (this is less common, and unpredictable). When the root is trimoraic, secondary stress does not fall on the initial syllable, as would be expected under an initial-dactyl preference (*[(sà<ʔe)u>ʔéu]), but instead falls on the reduplicant ([sa<(ʔèu)>(ʔéu)]), suggesting a p-word break after the reduplicant, though there are few examples.

(40) Stress in two-mora-reduplicated words

(típi)	'cut'	<(tìpi)>(típi)	'cut-*pluractional*'
(màː)(náva)	'breathe'	(màː)(<nava>)(náva)[10]	'pant'
(ŋào)(sáː)	'messy'	<(ŋào)>(ŋao)(sáː)	'very messy'
sa(ʔéu)	'stir'	sa<(ʔèu)>(ʔéu)	'stir'

When a monomoraic suffix is added, the footing of the second copy changes, but that of the first copy does not, as illustrated in (41). This is again consistent with a p-word boundary between the two copies, though also consistent with a preference for initial dactyls (we found no examples where the root was trimoraic), or partial faithfulness to the unsuffixed form. Further evidence that the reduplicant forms its own p-word is discussed in section 5.

(41) Stress in suffixed, two-mora-reduplicated words[11]

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[9] We found no cases of vowel-initial verbs undergoing CV reduplication. They usually mark plurality with /fe-/ or /ta-/ instead. See section 5 for why hypothetical [<i>inu] would be phonologically dispreferred.

[10] There is no clear stress on the medial foot in 'pant' or 'very messy'.

unsuffixed		*suffixed*	
<(tàla)>(tála)	‘chatV’	<(tàla)>ta(lá-ŋa)	‘discussion’
<(tàlo)>(tálo)	‘hopeV’	<(tàlo)>ta(ló-ŋa)	‘hopeN’
(ʔèle)>(ʔéle)	‘ground’	<(ʔèle)>ʔe(lé-a)	‘dirty’

4.5. Summary of stress in complex words

In this section we’ve shown that suffixes shift primary stress to the right; in the case of monomoraic suffixes, this means that the stem and suffix must be in the same prosodic word. We found evidence for a prosodic-word boundary between prefix and stem, between certain prefixes, between reduplicant and base, and between stems in a compound. We found evidence against a p-word boundary between a stem and a monomoraic suffix, with the status of bimoraic suffixes remaining open so far.

We now turn to other diagnostics of footing domains, which will give us additional evidence about the prosodic structure of morphologically complex words.

5. Trochaic shortening

In the previous sections, we used stress shift and vowel length to show that monosyllable suffixes are part of the same p-word as the stem, while disyllabic suffixes form a separate p-word. Now, we will see this analysis reinforced by the behavior of long vowels that are in the “wrong” place underlyingly.

Samoan appears to avoid feet consisting of a long-vowel syllable plus a light syllable, by shortening the long vowel. This phenomenon, called trochaic shortening, is described in detail in Hayes 1995, and is also found in other trochaic languages, including ones closely related to Samoan. For example, given an input /maːbi/, such a language would ban *[(máː.bi)] and unaligned *[(máː)bi], and would instead shorten the first vowel, yielding the light-light foot [(má.bi)]. Samoan also avoids heavy-light feet through shortening and other means, at least when the heavy syllable contains a long vowel (for heavy syllables containing two vowels, see Section 7).

Although Milner (1993) lists many words with a long vowel in the penult and a short final vowel, our consultants produced them all (if known) with a short penult instead. Examples are given in (42), with the last two examples being loans. In Milner’s spellings, the macron (¯) indicates a long vowel, and *g* spells [ŋ].

(42) Lack of long vowels in penults

Milner spelling	*consultant pronunciation*	
pēsi	(pési)	‘rageV (of epidemic)’
ōi	(ói)	‘groan’
punāfu	pu(náfu)	‘sweat coming out of pores’
āfu	(áfu)	‘sweat’
nāmu	(námu)	‘smell’
tāne	(táne)	‘husband’

[11] Suffixed reduplicated words in Samoan are an instance of the *bracketing paradoxes* found in compounding and reduplication in many languages (see, e.g., section 4.2 of Nespor & Vogel 1986, Cohn 1989, and Buckley 2001). The morphological bracketing is [[reduplicant-base]-suffix], but the phonological bracketing is [reduplicant]-[base-suffix].

pāsi	(pási)	‘pass’
pāga	(páŋa)	‘partner’

The language is presumably undergoing a change from what was recorded in Milner’s dictionary, which was compiled in the 1960s, and our consultants, whose ages range from 18 to 39, are at the more innovative end of the change. Mosel and Hovdhaugen, writing in 1992, seem to observe an intermediate stage: they note that (C)Vː(C)V words are rare, but that those that exist are pronounced with a long vowel, with stress on the first half in ordinary speech ([táane]) and optionally on the second half in very careful speech ([taáne]) (p. 30).

We found the same mismatch between pronunciations and Milner’s spellings in two-mora reduplicated words (43) and in compounds (44). In addition to the evidence discussed in section 4.4, these shortenings suggest that the reduplicant does form its own p-word: if both copies belonged to a single p-word, *[(pòː)le(póle)] would be well footed.

(43) Lack of long vowels in penults of reduplicants

Milner spelling	*consultant pronunciation*	
pōlepole	<(pòle)>(póle)	‘worried’
pūlepule	<(pùle)>(púle)	‘spotted’
pūlupulu	<(pùlu)>(púlu)	‘shawl’
vāivai	<(vài)>(vái)	‘weak’
vālevale	<(vàle)>(vále)	‘stupidity’
vāevaeina	<(vàe)>(vàe)-(ína)	‘divide’

(44) Lack of long vowels in penults of stems in compounds

Milner spelling	*consultant pronunciation*	
vāiʻaiga	(vài)-(ʔái)-ŋa[12]	‘snack (between+eat+GA)’
vāiʻaʻai	(vài)-ʔa(ʔái)	‘neighbourhood (between+village)’
vālalua	(vàla)-(lúa)	‘divided in twos (divide+two)’
tāfafā	(tàfa)-(fáː)	‘four-sided (side+four)’

The second piece of evidence for avoidance of heavy-light feet comes from length alternations. When a monomoraic suffix that shifts stress is added to a stem, the stem’s penult vowel that was short in the unsuffixed form sometimes becomes long. We can analyse the difference between the words on the left in (45), with no length change, and those on the right, with a length change, as a difference in underlying form, surfacing only under suffixation. The underlyingly short /u/ of /fusi/ ‘hug’ remains short under suffixation, but the /uː/ of /tuːsi/, must shorten if there is no suffix. All suffixed forms with long penult vowels in (45) are spelled as such in Milner (1993), and none of the corresponding roots are spelled with long penults—Milner lists roots that always have a short vowel (like *fusi*, *fusi-a*), roots that alternate (like *tusi*, *tūsi-a*), and words that always have a long vowel (like *pāsi, pāsi-a*), but our consultants lack this third type).

[12] See section 7 for an explanation of why primary stress is antepenultimate.

(45) Lengthening under suffixation

alone		*suffixed*		*alone*		*suffixed*	
(fúsi)	'hug'	**fu**(sí-a)	'hug-A'	(túsi)	'write'	(**tù:**)(sí-a)	'write- A'
(ʔíni)	'pinch'	**ʔi**(ní-a)	'pinch- A'	(láu)	'say'	(**là:**)(ú-ŋa)	'speech'
(móe)	'sleep'	m**o**(é-ŋa)	'bed'	(lói)	'ant'	(l**ò:**)(í-a)	'overrun w/ ants'
(táo)	'cover'	t**a**(ó-mi)	'hold down'	(máŋa)	'fork'	(fâʔa)-(m**à:**)(ŋá-i)	'sit astride'
(lólo)	'flood'	lo(l**ó**-fi)	'surge'	(nófo)	'stay'	(n**ò:**)(fó-i)	'colonize, settle'
--		fe-t**o**(ló-fi)	'pinch-*pl*'	(sólo)	'wipe'	(s**ò:**)(ló-i)	'wipe dry'
a(lófa)	'love'	fe-(àl**o**)(fá-ni)	'respect e.o.'	<(sìʔu)>(sìʔu)	'tail'	(s**ì:**)(ʔú-i)	'very tip'
(léle)	'fly'	fe-le(l**é**-i)	'fly-*pl*'	(táŋi)	'cry'	fe-(t**à:**)(ŋí-si)	'cry-*pl*'

Because these alternations are also found in earlier descriptions that report long penults as possible (Milner 1993, Mosel & Hovdhaugen 1992), we conjecture that even when long penults were permitted in some unsuffixed words, they had been shortened in many others.

The tableaux in (47) illustrate the analysis. We are agnostic as to whether the long vowels are really a single segment associated to two moras or a sequence of two identical segments (see Taumoefolau 2002 for this issue in Tongan). For the sake of Richness of the Base, we show in (47) that whether the input is /tu:si/ or /tuusi/, the output will be [(túsi)]. FOOTBINARITY, together with the requirement of right-aligned main stress (EDGEMOST-R), rules out a long or double vowel in the penult (47)e, k; NOBREAKING, defined in (46), rules out stressing the second half of a double vowel (47)m—cf. related Tongan, where this candidate is the winner (Churchward 1953, Poser 1985). Because shortening is preferred to lengthening (candidate (d) vs. (g)), we split faithfulness to length into two constraints, DON'TSHORTEN and DON'TLENGTHEN. (We assume that the winning output for /tuusi/ is [tú$_{1,2}$si], with fusion, penalized by McCarthy and Prince's (1995) UNIFORMITY, rather than [tú$_1$si], with deletion, because data discussed in Section 7 show that MAX-V is ranked high.)

(46) NOBREAKING: adjacent identical vowels must be in the same foot.[13]

(47) Tableaux for length alternations

/fusi/	FT BIN	DON'T LENGTHEN	MAX -V	EDGEMOST -R	NO BREAKING	UNIFOR-MITY	DON'T SHORTEN	PARSE-SYLL
☞ a. (fúsi)								
/fusi + a/	FT BIN	DON'T LENGTHEN	MAX -V	EDGEMOST -R	NO BREAKING	UNIFOR-MITY	DON'T SHORTEN	PARSE-SYLL
☞ b. fu(sí-a)								*
c. (fù:)(sí-a)		*!						

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[13] The results would be equivalent here if NOBREAKING required adjacent identical vowels to be in the same *syllable* (and GEN or the grammar prevents a syllable from containing a foot boundary). As will be seen in section 7, under either definition this constraint must apply only to *identical* adjacent vowels. This is why we cannot use ONSET.

We have no cases of morphemes that begin with a light-heavy sequence, followed by at least two more moras, such as hypothetical /teno:vete/ or /tenoovete/. If NOBREAKING >> ALIGN(PWord,L; Foot,L), the second syllable will draw stress, [te(nò:)(véte)]=[te(nòo)(véte)], and under the opposite ranking stress will be initial, [(tèno)o(véte)].

/tu:si/	Ft Bin	Don't Lengthen	Max -V	Edgemost -R	No Breaking	Unifor-mity	Don't Shorten	Parse-Syll
☞ d. (túsi)							*	
e. (tú:)si				*!				*
f. (tú:si)	*!							
g. tu(úsi)					*!			*
h. (tù:)(sí:)		*!						
/tu$_1$u$_2$si/	Ft Bin	Don't Lengthen	Max -V	Edgemost -R	No Breaking	Unifor-mity	Don't Shorten	Parse-Syll
☞ i. (tú$_{1,2}$si)						*		
j. (tú$_1$si)			*!					
k. (túusi)	*!							
l. (túu)si				*!				*
m. tu(úsi)					*!			*
/tu:si-a/	Ft Bin	Don't Lengthen	Max -V	Edgemost -R	No Breaking	Unifor-mity	Don't Shorten	Parse-Syll
n. tu(sí-a)							*!	*
☞ o. (tù:)(sí-a)								

In addition to roots like /fusi/, whose penult is always short, and those like /tu:si/, which alternates predictably, there are those with both a long and a short /–ŋa/ form (Mosel & Hovdhaugen 1992, pp. 195-196). In almost every case given by Mosel and Hovdhaugen it seems that the lengthened noun has a more opaque meaning.[14] We speculate that the lengthened noun is a fossilized derivative of a root whose vowel is now underlyingly short (and thus whose productive derivatives show a short vowel). A sample of Mosel and Hovdhaugen's doublets are listed in (48).

(48) Doublets, Mosel & Hovdhaugen (1992) pp. 195-196

Unsuffixed		*unlengthened*		*lengthened*	
pule	'authorise, power, control, authority'	pulega	'authority, power, control'	pūlega	'LMS [London Missionary Society] unit of church administration'
savali	'walk'	savaliga	'walk, march'	sāvaliga	'people on march'
toso	'pull, draw, drag'	tosoga	'pulling'	tōsoga	'tug-of-war'
tu'u	'put, leave, give'	tu'uga	'share (of food)'	tū'uga	'race (e.g. of horses)'

These doublets suggest that the mere existence of an alternating pair such as *tóso – tò:só-ŋa* is not sufficient to guarantee that speakers learn to derive both from an underlying form /to:so/. It is unknown, however, whether it was semantic change that severed the tie between the bare and affixed forms, or a separate lexical entry for the suffixed form that allowed the semantic drift. There are unpredictable or morphological length alternations in Samoan, which might encourage learners to treat length alternations as not reflecting underlying length of a shared root morpheme (49). The doublets are also

[14] Mosel & Hovdhaugen (1992) characterise the difference instead as one of plurality.

expected if Samoan learners treat the unaffixed surface form as the "base" in Albright's (2002) sense, so that both alternating and non-alternating words are listed as having short penults, and lengthening under suffixation is an exceptional property of some paradigms.

(49) Unpredictable length alternations (MH = Mosel & Hovdhaugen 1992)

va‘ai	‘sit’	vā‘ai	‘sit-*plural*’ (MH p. 78)	length marking plural
alofa	‘love’	ālolofa	‘love-*plural*’ (MH p. 221)	length accompanying reduplication
‘umi	‘long’	‘umī	‘very long’ (MH p. 239)	length marking emphasis

Although Fijian is probably the most-discussed case of trochaic shortening, the evidence is far less clear than it is in Samoan. Word-final long vowels are reported to shorten in Fijian when a monomoraic pronominal or transitive suffix is added (Dixon 1988 p. 26, Schütz 1985 p. 528; see Hayes 1995 for discussion), as in *caa* ‘bad’ *vs. ca-ta* ‘consider bad’. The four such verbs listed by Dixon are all monosyllabic, so, as he discusses, a possible counteranalysis is that the underlying vowel is short (/ca/), and it lengthens to satisfy a bimoraic word minimum.[15] As for nouns, Dixon's mini-dictionary lists 20 with final long vowels, of which only 6 clearly involve a root of more than one syllable, e.g. *'olii* ‘dog’. Pronominal suffixes seem to be quite productive, so presumably these words do undergo shortening when suffixed, yielding a few clear cases of trochaic shortening.

"Undoing" of shortening under suffixation seems to be weak in Fijian. Dixon's mini-dictionary lists only one example: *sivi* ‘pass, exceed’ vs. *siivi-ta* ‘pass, exceed—transitive’, forming a minimal pair with *sivi* ‘carve, craft in wood’, *sivi-ta* ‘carve, craft in wood—transitive’. Scott (1948) identifies "three unusual cases" (p. 743, fn. 1), two where the suffixed form optionally has a long vowel and one where it obligatorily has a long vowel: *donu* and *doonu-ya* ~ *donu-ya*, *leve* and *leeve-a* ~ *leve-a*, *dravu* and *draavu-ya* (Scott does not include glosses). We speculate that these alternations are at least as variable or lexicalized as in Samoan.

Our analysis of Samoan lengthening, or rather prevention of shortening under suffixation, depends on the suffix's belonging to the stem's p-word. What about disyllabic suffixes? As shown in (50), we have one example of lengthening under /-Caʔi/ suffixation, suggesting that /-Caʔi/ can belong to the stem's p-word; by contrast, for /-Caŋa/ and /-Cia/-suffixed forms that Milner (1993) lists as lengthened, our consultant did not produce lengthening.

[15] Dixon cites the reduplicated form *ca-caa* ‘lots of bad things’ as evidence for /caa/ rather than /ca/, but it is possible that reduplicant or other prefix material does not contribute towards the word-size minimum.

(50) Lengthening with disyllabic suffixes?

suffix	*dict. spelling*		*consultant pronunciation*	
/-Caʔi/	(none)	‘circulate	fe-(tàː)fe-(áʔi)	from (táfe) ‘flow’
/-Caʔi/	(none)	‘castaways’	fe-(tàfe)-(áʔi)	
/-Caŋa/	tāuaga	‘strainer’	(tàu)-(áŋa)	from <ta>(táu) ‘wring’
/-Caŋa/	valusaga	‘taro-peeling stick’	(vàlu)-(sáŋa)	from (válu) ‘scratch’
	vālusaga	‘vegetable peelings’	(vàlu)-(sáŋa)	
/-Caŋa/	vālo‘aga	‘prophecy’	(vàlo)-(ʔáŋa)	
/-Caŋa/	vālo‘ia	‘prophesy’	(vàlo)-(ʔía)	

Similarly, Mosel and Hovdhaugen (1992) report no length alternation under suffixation with *-ina*, *-Cia*, or *-Caŋa* (p. 202), even when another suffixed form indicates an underlying long vowel (<fa>(fáŋu) ‘wake’, (fàː)(ŋú-a) ‘wake-*A*’, (fàŋu)-(ína) ‘wake-*INA*’ rather than *(fàː)ŋu-(ína)). They find that the only bimoraic suffix that allows length alternation is *-Caʔi*. All of this suggests that while most bimoraic suffixes form a separate p-word, *-Caʔi* merely forms a foot, the same as if it were part of the root morpheme.

Our third piece of evidence for avoidance of heavy-light feet comes from the converse alternation: when a root ending in a long vowel acquires a monomoraic suffix, the root-final vowel is now in the penult and therefore can’t be long. There are two possible repairs. One is shortening, and the other is what has been called breaking in Tongan (Poser 1985): stress falls on the second half of the long vowel. In (51) we give all the cases we could find. Some repair always occurs; sometimes our primary consultant accepted both shortening and breaking, and sometimes he accepted only one option.

(51) Shortening under suffixation

unsuffixed		*suffixed—shortened*	*suffixed—breaking*	
(màː)(lòː)(lóː)	‘rest$_{\text{V}}$’	(màː)(lòː)(ló-a)		‘rest’
		(màː)(lòː)(ló-ŋa)		‘rest$_{\text{N}}$’
(tòː)(fáː)	‘sleep (polite)’	(tòː)(fá-ŋa)		‘bedding’
(lùː)(lúː)	‘shake’	(lùː)(lú-ŋa)		‘shaking action’
(sàu)(áː)[16]	‘cruel’	(sàu)(á-ŋa)		‘act of cruelty’
(fàʔa)-(sàu)(áː)	‘cruelty’	(fàʔa)(sàu)(á-ŋa)		‘cruelty’
(fàʔa)-o(táː)	‘ripen (bananas)’	(fàʔa)-o(tá-ŋa)		‘hung-up bunch of bananas’
(tàu)-(tóː)	‘swear’	(tàu)-(tó-ŋa)		‘oath’
(tàu)-(sini)(óː)	‘compete’	(tàu)-(sini)(ó-ŋa)		‘competition’
(tàu)-(váː)	‘compete for’	(tàu)-(vá-ŋa)		‘competition’
(sàː)(óː)	‘be quiet’	(sàː)(ó-ŋa)		‘quieting’
(ʔéː)	‘yell’	fe-(ʔé-i)		‘shout-*pl*’
su(súː)	‘come/go (pol.)’	su(sú-ŋa)		‘Your Honour’
pe(léː)	‘cards’	pe(lé-ŋa)	(pèle)(é-ŋa)	‘card game’
(tàː)li(éː)	‘laugh’	(tàː)li(é-ŋa)	(tàː)lie(é-ŋa)	‘laughing’
(mùː)(múː)	‘red’	(mùː)(mú-a)	(mùː)mu(ú-a)	‘red-A’
(ʔòː)(náː)	‘drunk’	(ʔòː)(ná-ŋa)	(ʔòː)na(á-ŋa)	‘group of drunk people’
u(óː)	‘friend’	(fàʔa)-u(ó-ŋa)	(fàʔa)-uo(ó-ŋa)[17]	‘making friends’
(póː)	‘slap’		po(ó-a)	‘slap-A’
ta-(péː)	‘kill’		ta-pe(é-a)	‘kill-A’
pa(ʔúː)	‘fall’		paʔu(ú-ŋa)	‘falling

Transcriptions like [(pèle)(é-ŋa)] are not meant to imply a phonetic break between the [e]s—we observe no medial dip in amplitude or change in formants—merely that the pitch rise is on the second half of the long [eː]. This requires us to place the two halves of the /eː/ in separate feet.

We saw in (47) that NOBREAKING >> DON’TSHORTEN, explaining the absence of sequences like [aá] within the prosodic word. To accommodate the one type of exception that we’ve just seen, we must assume a constraint variably ranked with NOBREAKING that applies only under suffixation. Here we are forced to depart from our reliance on p-word structure alone, and adopt an output-output correspondence constraint (52) against shortening under suffixation (level-ordering would also be possible). The jagged line between the two crucial constraints in (53) indicates their variable ranking.[18]

(52) DON’TSHORTENV́ː-BaseAffixed: assign a violation if a short vowel in an affixed form corresponds to a long, primary-stressed vowel in the affixed form’s base

(A constraint against shortening a root-final vowel would also work.)

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[16] Or possibly [(sàː)u(áː)], and, for the next item, [(fàʔa)-(sàː)u(áː)].

[17] See Section 8 on glide formation for why /u/ might not be stressed; our narrow transcription was [(fàʔa)-wo(ó-ŋa)].

[18] We model this as a case of free variation even though some lexical items seem to allow only one variant.

(53) Tableau for breaking/shortening variation

/pele: + ŋa/ base pe(lé:)	FTBIN	DON'TSHORTENV́:-BaseAffixed	NOBREAKING	DON'T SHORTEN
☞ a pe(lé-ŋa)		*		*
☞ b (pèle)(é-ŋa)			*	
c pe(lé:-ŋa)	*!			

There are no doublets here—no related pairs like *péle* and *pelé:*. This supports the idea that vowel length in unaffixed forms is reliably learned, unlike "lengthening" under suffixation.

Our fourth and final piece of evidence for the avoidance of word-final heavy+light is that when the penult begins with a vowel, CV- reduplication cannot be used to mark plural (Mosel & Hovdhaugen, p. 220). The 248 verbs in Milner 1993 with both a freestanding plain form and a listed plural form use various morphology, illustrated in (54). The most common plural type involves CV reduplication, but never if the primary-stressed foot is V-initial. If CV reduplication did apply to a verb like /oso/, the result would be *[o(óso)] (violating NOBREAKING) or *[(óo)so]/*[(ó:)so] (violating EDGEMOST-R), so one of the less-common plural morphologies is used instead.

(54) Patterns of plural marking in dictionary

plural type	examples (orthography plus morpheme boundaries; presumed primary-stressed foot underlined)	# items where 1ary-stressed foot C-initial	# items where 1ary-stressed foot V-initial	%V-initial primary-stressed foot
CV redup., with or without lengthening	lafi, <la>lafi 'hide' mafai, ma<fa>fai 'be able to' savali, sā<va>vali 'walk'	**122**	**0**	**0%**
bimoraic redup., w/ or w/out lengthening	motu, <motu>motu 'break' sāuni, sā<uni>uni 'prepare'	17	1	6%
fe- and/or –Ci, w/ or w/out lengthening	togi, fe-togi 'throw' sele, sele-i 'cut one's hair' oso, fe-oso-(f)i 'jump'	19	8	30%
ta-	sulu, ta-sulu 'insert' ili, ta-ili 'blow'	16	4	20%
CV redup. or ta-	tanu, ta-tanu 'cover over'	13	NA	NA
first syll. lengthened	palalū, pālalū 'flap' falute, fālute 'gather' gaosi, gāosi 'prepare food'	11	3	21%
zero	sili, sili 'put something up' ulu, ulu 'go into'	12	3	20%
other (variation, removal of redup., multiple marking)	sui, fe-sui~ta-sui 'change' uliuli, uli 'be black' 'ote, fe-<'ote>'ote-i 'scold'	15	3	17%
no listed plural	vase 'draw'	804	145	15%
total		*1030*	*167*	*14%*

The next section examines cases where morpheme concatenation creates a sequence of identical vowels, yielding evidence about the prosodic effects of various morpheme boundaries.

6. Sequences of identical vowels (V_iV_i)

Section 5 showed that within a morpheme, heterosyllabic $V_i.V_i$ sequences are not allowed (except for suffixed forms of certain long-vowel-final stems). In this section, we show that heterosyllabic $V_i.V_i$ sequences are possible across a morpheme boundary. These provide evidence for disruption of footing domains.

When a V_iV_i sequence is created across a compound boundary, it does not attract stress as long vowels in monomorphemes do, nor undergo trochaic shortening, at least in careful speech.[19] Examples are shown in (55).

(55) /...V_i/+/V_i.../ compounds

(mèa)-a(ʔó-ŋa)	'homework	*me(àː)(ʔó-ŋa), *(mèa)(ʔó-ŋa)
/mea/ 'thing' /aʔo/ 'learn'		
(vài)-(ínu)	'drinking water'	*va(íi)nu, *va(ínu)
/vai/ 'water', /inu/ 'drink'		

Why are vowels at the compound boundary exempt from NOBREAKING, which prohibits identical adjacent vowels from being separated by a foot boundary? We propose that each part of the compound forms a separate p-word (section 4.1), and that the domain of NOBREAKING is the p-word.

When /-a/ is added to a stem ending in /a/, the result is a stressed long vowel (56), consistent with our previous arguments that a monomoraic suffix belongs to the stem's p-word. We have no phonetic diagnosis for whether the correct analysis is monosyllabic [áː] or disyllabic [á.a]—either way, the pitch rise will be on the first half of the sequence. We observed no phonetic difference between the ends of these words and the ends of monomorphemes ending in presumed /aː/.

(56) /...a/ + denominal or ergative /-a/

unsuffixed		*suffixed—identical Vs fuse*		
(<pàla>)(pála)	'dirt'	(<pàla>)pa(l**áː**)	'dirty'	
u(íŋa)	'meaning'	u(ìː)(ŋ**áː**)	'meaningful'	(/uiːŋa/)
(lóka)	'arrest'	lo(k**áː**)	'arrest-A'	
(tála)	'open'	<ta>(tàː)(l**áː**)	'open-A'	(/taːla/)

In Section 4.2.2 we had only weak evidence that the ergative suffix /-ina/ forms a separate p-word. However, when /-ina/ is suffixed to an /i/-final stem, no fusion or shortening occurs; the /i/s remain in separate feet, in violation of NOBREAKING, as shown in (57).. A *stem+ina* behaves like a compound, supporting a separate p-word for [-ina], as predicted by ALIGN(Morpheme,L; PWord,L) when foot binarity is not at issue. As we will see in section 7.3, unproductive suffixes seem to be exempt from ALIGN(Morpheme, L; PWord, L); perhaps they are not recognized as morphemes.

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[19] Mosel & Hovdhaugen 1992, p. 33-34, give examples where stress does shift.

(57) /...i/ + ergative /-ina/

unsuffixed		*suffixed*		
(kíki)	‘kick’	(kìki)-(ína)	‘kick-INA’	*ki(kína)
(píki)	‘pick’	(pìki)-(ína)	‘pick-INA’	
(típi)	‘cut’	(tìpi)-(ína)	‘cut-INA’	
(túsi)	‘read’	(tùsi)-(ína)	‘read-INA’	
(túi)	‘stab’	(tùi)-(ína)	‘stab-INA’	
(fàsi)(óti)	‘kill’	(fàsi)(òti)-(ína)	‘kill-INA’	

A V_iV_i sequence can also be created across a suffix-suffix boundary if /-Caʔi/ is followed by /-ina/. We failed to elicit any such words, but a few are listed in Milner (1993), and all are spelled with the sequence “ii”, Milner’s notation for a long vowel or V_iV_i sequence stressed on the second half, again supporting a p-word boundary before /-ina/. Some of Milner’s examples are given in (58).

(58) dictionary entries for words suffixed with /-Caʔi-ina/

a‘o	‘learn; train’	a‘o-a‘i-ina	‘be admonished’
sou	‘(sea) be rough’	fe-sou-a‘i-ina	‘be tossed to and fro’
u‘u	‘oil’	u‘u-na‘i-ina	‘be pushed; be encouraged’
galue	‘work’	galue-a‘i-ina	‘set in motion’

A V_iV_i sequence occurs across a prefix-stem boundary when the causative prefix /faʔa-/ attaches to an /a/-initial stem. As shown in (59), no stress shift or shortening occurs across this boundary, further strengthening evidence in Section 4.3 for a p-word boundary between /faʔa-/ and its stem. (We found no examples of plural /fe-/ attaching to an /e/-initial stem.)

(59) causative prefix /faʔa-/ + /a.../

(fàʔa)-(àlo)-(álo)	‘respectful’ (/alo/ ‘face’)	*fa(ʔàː)lo-(álo)	*fa(ʔàlo)-(álo)
(fàʔa)- (ào)(ŋáː)	‘use’ (/aoŋaː/ ‘use, useful’)	*fa(ʔàː)o(ŋáː)	*fa(ʔào)(ŋáː)
(fàʔa)-a(lí-ŋa)	‘procession’ (/aliŋa/ ‘visible’)	*fa(ʔàː)(lí-ŋa)	*(fàʔa)(lí-ŋa)

V_iV_i data also further strengthen evidence from Section 4.4 that there is a p-word boundary between the two copies in two-mora reduplication (though we found few relevant cases—the primary-stressed foot of the root must be vowel-initial, and its two vowels must have the same quality.)

(60) V_iV_i in reduplication

<(ìfi)>(ífi)	‘tree species’	*i(fífi)
(fàʔa)-(<ète>)(éte)	‘be careful’	*(fàʔa)-e(téte)
(<ùsu>)(úsu)	‘sing all day’	*u(súsu)

7. VV and VVV sequences

This section builds on our understanding of the stress domain, by describing how stress assignment is affected by two-vowel (VV) and three-vowel (VVV) sequences. Certain VV sequences produce stress on the antepenultimate rather than penultimate mora: [máile] rather than *[maíle] ‘dog’ (Section 7.1). We refer to this phenomenon as diphthong formation, following earlier authors, but are agnostic as to what “diphthong” means—that is, whether the [ai] in [maile] counts as a single segment, two segments in the same syllable, or segments in separate syllables. Diphthong formation provides more evidence for p-word boundaries before each stem in a compound and before ergative /–ina/ (Section 7.2). Section 7.3 turns to VVV sequences, especially VVa, where the diphthong-forming inventory broadens, and where the ergative and denominal /–a/ suffixes seem to have an idiosyncratic stress requirement.

7.1. Basic diphthong formation

Certain VV sequences disrupt the normal stress pattern, as in [máile] 'dog'. Unlike in Fijian (Schütz 1978, 1985; Dixon 1988; Hayes 1995), Samoan sequences like the [ai] in 'dog' do not sound shortened.

The stress disruption occurs when the first vowel is non-high and the second is high. Of the twenty possible sequences of nonidentical vowels, diphthong formation occurs (in monomorphemic words) for [ai], [au], [ei], and [ou], and not for [ae], [ao], [ea], [eo], [oa], [ia], [ie], [iu], [ua], and [uo]. (We find no suitable items for [eu], [oe], [oi], [io], [ue], [ui].[20])

(61)

diphthongising: ai, au, ei, ou			*non-diphthongising:* ae, ao, ea, eo, oa, ia, ie, iu, ua, uo	
(mái)le	'dog'	cf.	ma(éla)	'hollow'
(fái)va	'fishing trip'		pa(élo)	'barrel'
u(ái)na	'wine'			
(pàɹa)(tái)so	'paradise'			
(pái)pa	'pipe'			
(ʔái)sa	'ice, fridge'			
(tái)si	'hit'			
(fili)(pái)ŋa	'Philippines'			
(máu)ŋa	'mountain'	cf.	ma(óta)	'pastors house'
(páu)ta	'powder'		pa(óŋo)	'tree sp.'
(táu)te	'eat/drink *respectful*'		pa(ólo)	'shady'
(páu)na	'pound (weight)'		ma(óŋi)	'smell'
(táu)si	'look after'		(fàʔa)-ma(óni)	'loyal'
(téi)ne	'girl'	cf.	ie(óva)[21]	'Jehovah'
(péi)si	'base'			
(lóu)ni	'loan'	cf.	(kòmi)pi(úta)	'computer'
			le(áŋa)	'bad'
			mo(ána)	'fish sp'
			si(ápo)	'bark cloth'
			si(éni)	'Jenn'
			pu(áʔa)	'pig'
			tu(óta)	'be all new'

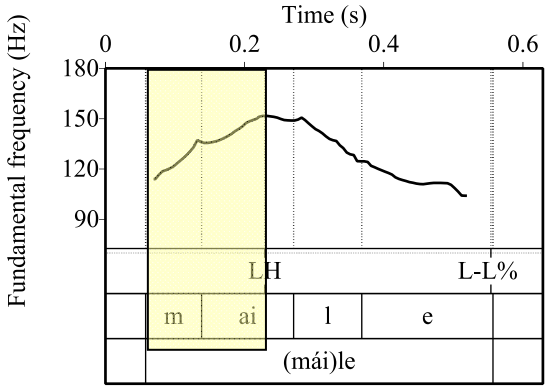
[20] Except [u(íla)] 'lightning' or 'wheel', which we transcribe more narrowly as [wíla]. See Section 8 for discussion of gliding.

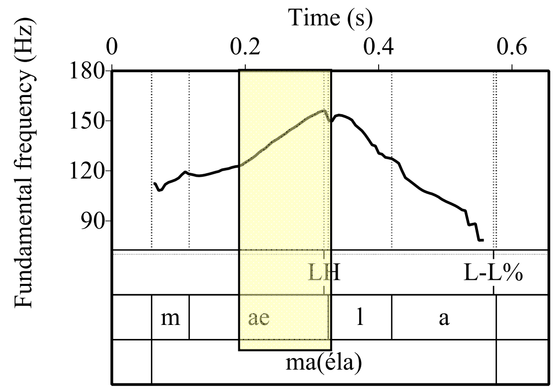
[21] Which we've transcribed more narrowly as [jeóva].

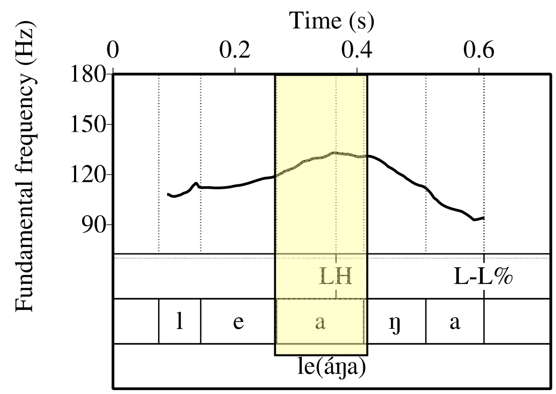
We illustrate near-minimal sets with pitch tracks in (62). In the words on the left (e.g, [máile]), the rise is over the first half of the VV sequence, whereas on the right (e.g., [maéla]), the rise is over the second half.

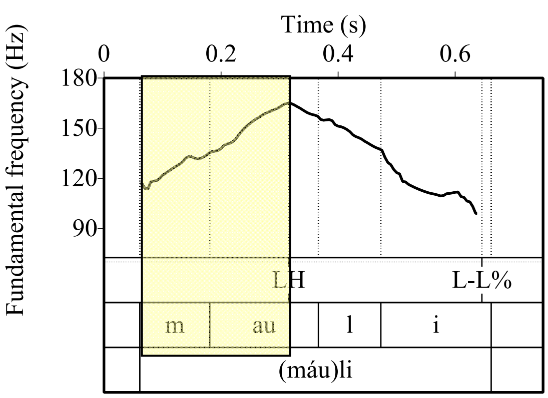
(62) VV sequences

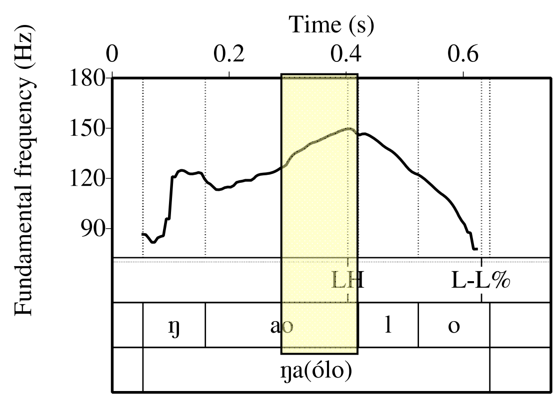
diphthong-forming sequences *non-diphthong-forming sequences*

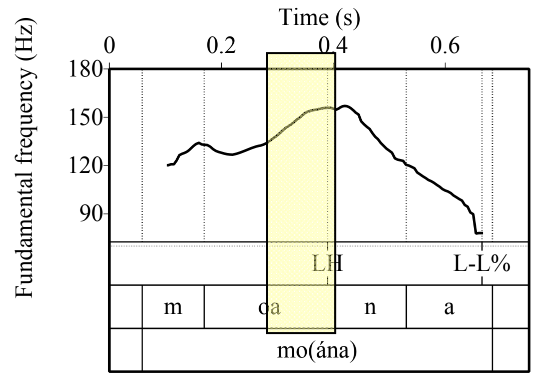












We propose a penalty on prominence mismatches: if the first vowel in a VV sequence is more prominent in sonority, it should also be more prominent metrically (e.g., Hayes 1995, Anttila 1997, Kenstowicz 1997, Crosswhite 2001). Our constraint is limited to cases where the second vowel is high:

(63) *Aí: an unstressed non-high vowel should not be followed by a stressed high vowel[22]

Tableau (64) shows the default pattern, when *Aí is not relevant:

(64) Non-diphthongising VV sequences

	/maela/	FtBin	Don't Lengthen	Max-V	*Aí	Edgemost -R	Parse-σ
☞ *a*	ma(éla)						*
b	(máe)la					*!	*
c	(mála)			*!			
d	(mà:)(éla)		*!				
e	(máela)	*!					

As shown in (65), *Aí can force a violation of Edgemost-R (or of FootBinarity, if we took (e) to be the winning candidate). *CompressedDiphthong rules out shortening the /ai/ sequence to count as monomoraic. We proposed in section 5 that Uniformity is violable in Samoan, allowing the rich-base input /tu$_1$u$_2$si/ to map to fused [tu$_{1,2}$si]; so it is not fusion itself that rules out candidate (g), but rather the fusion of non-identical vowels, in violation of Ident(Vfeatures). For underlying long vowels, /tu:si/, a right-aligned, binary foot can be achieved by violating only Don'tShorten (47). But for /maile/, higher-ranked faithfulness constraints are at stake: *CompressedDiphthong, Ident(Vfeatures), and Max-V. The result is a faithful outcome with a non-aligned foot.

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[22] At least for /ai, au, ei, ou/. As seen in (85), /oi/ may not be subject to this constraint, suggesting a more complicated formulation such as "an unstressed low vowel should not be followed by a stressed high vowel, and an unstressed mid vowel should not be followed by a stressed high vowel of the same height and backness".

(65) Diphthongising VV sequences

	/ma$_1$i$_2$le/	FtBin	*Compressed Diphthong	Ident(Vfeatures)	Don’tLengthen	Max-V	*Aí	Edgemost-R	Uniformity	Parse-σ
	a ma(íle)						*!			*
☞	*b* (mái)le							*		*
	c (mále)					*!				
	d (mà:)(íle)				*!					
	e (máile)	*!								
	f (mǎĭle)		*!							
	g (mé$_{1,2}$le)			*!					*	

In words ending ...V:VCV, primary stress is on the penultimate mora as usual (66). There is no need to violate Edgemost-R, because both vowels are stressed, satisfying *Aí (67).

(66) No diphthongisation if V$_1$ is long

(à:)(íŋa)	‘family’	
(mà:)(úi)	‘subside (of swelling, tide, etc.)’	
(lò:)(ía)	‘lawyer’	(although we have no short /...oia/ words for comparison)
(sò:)(ía)	‘stop’	

(67) No diphthongisation if first vowel is long

	/a:iŋa/	FtBin	*Aí	Edgemost-R	Don’t Shorten	Parse-σ
☞	*a* (à:)(í.ŋa)					
	b (ái)ŋa			*!	*	*
	c (á:i)ŋa	*!		*		*

7.2. VV sequences at morpheme boundaries

We have seen that a monomoraic suffix is included in the prosodic word and normally shifts stress (Section 4.2.1). When a monomoraic suffix is added to a stem ending in [ai], [au], or [ei], stress fails to shift, as shown in (68) through (70). This is expected under the p-word structures developed above: a stem ending in [ai], [au], or [ei] followed by a monomoraic suffix simply behaves like a monomorphemic word (cf. [máile] ‘dog’), because it forms a single p-word.

(68) Nominalising suffix /-ŋa/

diphthongising sequences: ai, au, ei

va(ʔái)	‘look’	(<vàʔa>)va(ʔái)-ŋa	‘looking after’
(fàʔa)-(sàla)(láu)	‘broadcast’	(fàʔa)-(sàla)(láu)-ŋa	‘broadcast announcement’
le(léi)	‘good’	(fàʔa)-le(léi)-ŋa	‘making peace’

non-diphthongising sequences: ae, ao, eu, oe, ia, iu, ue, ui

(páe)	‘set out’	pa(é-ŋa)	‘presentation of food’
ta(fáo)	‘wander’	(tàː)fa(ó-ŋa)	‘trip’
(<tèu>)(téu)	‘decorate’	(<tèu>)te(ú-ŋa)	‘decoration’
(séu)	‘catch in net’	se(ú-ŋa)	‘catching in net’
(móe)	‘sleep’	mo(é-ŋa)	‘bed’
(màfa)(tía)	‘stress out$_V$’	(màfa)ti(á-ŋa)	‘distress$_N$’
(tíu)	‘fish$_V$’	ti(ú-ŋa)	‘fishing trip’
ŋa(lúe)	‘work$_V$’	ŋalu(é-ŋa)	‘work$_N$’
(súi)	‘change$_V$’	su(í-ŋa)	‘change$_N$’

There is one example with ergative /-na/, and one with a different /-na/; both behave as expected:

(69) Ergative suffix /-na/

(ʔái)	‘eat’	(ʔái)-na	‘eat-NA’
tu(lóu)	‘beg pardon’	tu(lóu)-na	‘pleasantries’

We have two examples for the suffix /-Ci/. The stress is as in a monomorpheme, shifting to penultimate for /ao/ but not for /au/:

(70) Suffix /-Ci/

<ta>(táo)	‘cover’	ta(ó-mi)	‘hold down’
<ʔa>(ʔáu)	‘swim’	fe-(ʔáu)-si	‘swim-*plural*’

As expected, when a stem’s penult appears as long under suffixation, there is no diphthongisation, because both vowels in the VV sequence now bear stress, and *Aí is not violated:

(71) No diphthongisation when first vowel is long

(láu)	‘say’	(làː)(ú-ŋa)	‘speech’	presumably reflects /laːu/

In Section 6 we argued that the ergative suffix /-ina/ forms a separate p-word. Diphthongisation offers further support: just as the sequence /i+i/ does not shorten when the second /i/ belongs to /-ina/, there is also no diphthongisation in /a+i/ or /e+i/ when the /i/ belongs to /-ina/:

(72) No diphthongisation across /-ina/ boundary

(lòka)-(ína)	‘arrest-INA’	cf. (mái)le	‘dog’
ti(tìna)-(ína)	‘turn off (pl).-INA’		
(<tàla>)(tàla)-(ína)	‘express-INA’		

(fàʔa)-le(áŋa)-(ína) ‘destroy-INA’
(kùka)-(ína) ‘cook-INA’

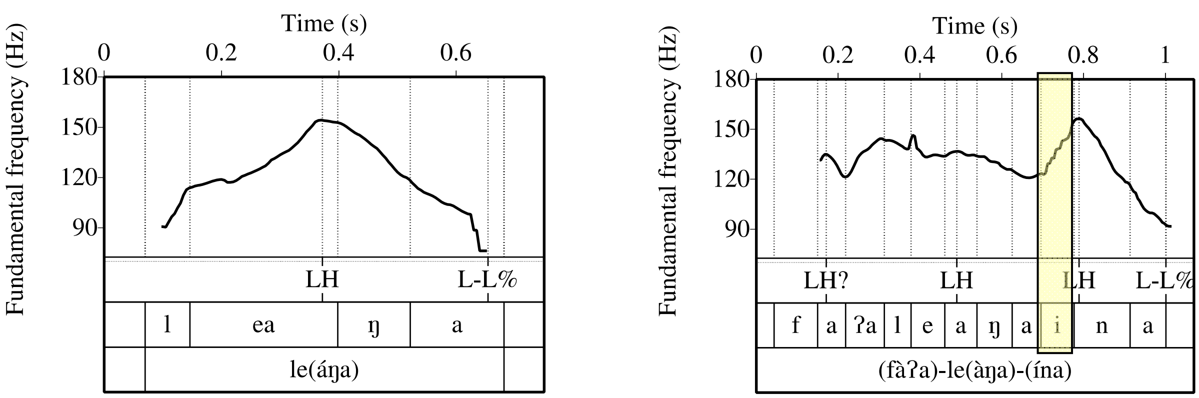
(vàne)-(ína) ‘carve-INA’ cf. (téi)ne ‘girl’
(<vàe>)(vàe)-(ína) ‘divide-INA’

Diphthongisation is also blocked when /-ina/ attaches after another suffix that ends in /a/:

(73) No diphthongisation between suffixal /a/ and /-ina/
(màu)-a-(ína) ‘get-A-INA’
(tàli)-a-(ína) ‘answer-A-INA’
a(lòfa)-(ŋìa)-(ína) ‘love-CIA-INA’
ʔa(màna)-(ʔìa)-(ína) ‘pay attention-CIA-INA’
(sìʔo)-(mìa)-(ína) ‘cover-CIA-INA’
ma(nàʔo)-(mìa)-(ína) ‘want-CIA-INA’
(fàʔa)-i(lò-ŋa)-(ína) ‘mark (as on boxes when moving)’ from /ilo/ ‘perceive’

The pitch track on the right in (74) shows a clear pitch rise on the [i] of [-ina], instead of on the preceding [a].

(74) Separately footed suffix /-ina/: pitch rise on [i] instead of preceding [a] ([leáŋa, fàʔa-leàŋa-ína])



The lack of diphthongisation with /-ina/ is expected under our analysis, so long as *AÍ is ranked lower than the ALIGN constraints governing p-word formation, as shown in the tableau in (75). (We assume that feet can’t straddle p-word boundaries, either as a property of GEN or because of a high-ranking constraint.)

(75) No diphthongisation with /-ina/

/loka+ina/	ALIGN (Morph,L; PWd,L)	*AÍ
☞ *a* P-Wd P-Wd (lòka) (ína)		*
b P-Wd lo(kái)na	*!	

In Sections 4.3 and 6 we argued that a prefix is not part of the stem's prosodic word—it forms its own p-word or is adjoined to the stem's. Here we see stronger support for this prosodification: diphthong formation is blocked across a productive[23] prefix-stem boundary. This is illustrated in (76) for [au], [ai], and [ei].

(76) No diphthongisation at prefix-stem boundary

(fàʔa)-(ùlu)-(úlu)	'be subject to' (*ulu* 'head')	*fa(ʔà-u)(lu)-(úlu)
(fàʔa)-(ùlu)-u(lú-ŋa)	'chief'	
(fàʔa)-(ìpo)-(ʔípo)	'marry'	
(fàʔa)-(ìpo)-i(pó-ŋa)	'wedding'	
fe-(íta)	'angry-*pl.*'	*(fé-i)ta
fe-(ínu)	'drink-*pl.*'	*(fé-i)nu
te-(ísi)	'a little'	

Once again, if we assume that a foot can't straddle a p-word boundary, this is expected.

Diphthong formation is blocked across compound boundaries, consistent with the evidence in Sections 4.1 and 6 for a p-word boundary between the two stems:

(77) No diphthongisation at compound boundary

(tàpa)-(ípu)	'call out names of those to be served *'ava*' (ask.for+cup)	*ta(pá-i)pu
(fàna)-(íʔa)	'dynamite for fishing' (shoot + fish)	
(pòna)-(úa)	'Adam's apple' (knot + neck)	
(ào)-a-(úli)	'noon' (day-A + dark) = noon'	

There is one morphological pattern that behaves a bit differently. When the C in semi-productive /-Ci/ is zero, the preceding vowel is non-high, and another suffix follows, the conditions for diphthongisation are in place. We find that stress does fall on the antepenultimate vowel in these cases, just as if the string were monomorphemic:

[23] We have an example where it does occur with an unproductive prefix: [(má-u)lu] 'dash in', from /ulu/ 'enter', suggesting that the word is not recognized as morphologically complex.

(78) Diphthongisation with /-Ci-a/, /-Ci-ŋa/

ta(ʔé-i)-ŋa	‘broken pieces’	from /taʔe/ ‘break’
a(ŋá-i)-ŋa	‘people in an *‘ava* ceremony’	from /aŋa/ ‘face’
fe-a(ŋá-i)-ŋa	‘agreement’	from /aŋa/ ‘face’
(fàʔa)-fe-a(ŋá-i)-ŋa	‘relationship’; ‘minister’	from /aŋa/ ‘face’
fe-ta(lá-i)-ŋa	‘orator (respectful)’	from /tala/ ‘tell’
ti(né-i)-a	‘turn off-I-A’	from /tina/ ‘turn off’ with *a>e* change

This is to be expected if the *stem+suffix+suffix* forms a single p-word. However, our grammar predicts that the two suffixes should form their own p-word, to satisfy ALIGN(Morph, L; PWord, L) at least partially (see (31)). We conclude that only productive morphemes are subject to ALIGN(Morpheme, L; PWord, L), perhaps because the grammar doesn’t treat unproductive affixes such as /-Ci/ as real morphemes. (See end of section 7.3 for a VVV example.)

7.3. Final VVV sequences

In words ending $V_1V_2V_3$, when V_3 is not [a] the diphthongisation behaviour of V_1V_2 is as before: stress is penultimate as usual, unless V_1 is non-high and V_2 is high:

(79) $V_1V_2V_3$# when V_3 is not [a]

V_2 not high: penultimate stress as usual

sa(éi)	‘tear’
ŋa(ói)	‘thief’
pe(áu)	‘wave’
fu(áo)	‘be excellent’
pu(áo)	‘fog’
lu(ái)	‘spit’
su(ái)	‘dig up’
u(ái)	‘chief’s walking stick’
tu(ái)	‘late’
pu(óu)	‘breadfruit sp.’
ʔi(áo)	‘type of bird’

V_1 non-high, V_2 high: antepenultimate stress, as is typical for these V_1V_2 sequences

(táu)i	‘repay’
pe(láu)e	‘tuxedo jacket’
(mái)o	‘fatty part of pig’
pe(léu)e	‘coat, jacket’

However, if V_3 is [a], we see diphthongisation even when V_1 is low and V_2 is mid:

(80) V_1V_2a#

V_1 non-high, V_2 high: antepenultimate stress, as typical for these V_1V_2 sequences

(maː)(nái)a	‘nice’
(ʔáu)a	‘don’t’

(t<u>áu</u>)a 'war, fight'; 'Taua *[district name]*'
u(<u>áu</u>)a 'vein'
(<u>éi</u>)a 'That's it!'
i(uː)(t<u>ái</u>)a 'Jewish'
(m<u>áu</u>)a 'kite'
(s<u>áu</u>)a 'fern'

V_1 low, V_2 <u>mid</u>: antepenultimate stress also

(m<u>áe</u>)a	'rope'	*cf.* m<u>a(é</u>la)	'hollow'
u(<u>áe</u>)a	'wire'		
pa(l<u>áe</u>)a	'pliers'		
(liː)(táe)a	'retire'		
(v<u>áe</u>)a	'Vaea *[a mountain]*'		
(l<u>áo</u>)a	'choke'; 'talking-chief's house'	*cf.* p<u>a(ó</u>lo) 'barrel'	
(p<u>áo</u>)a	'power'		
(t<u>áo</u>)a	'Taoa *[placename]*'		
fa(l<u>áo</u>)a	'flour, bread'		

To account for the [áea] and [áoa] patterns, we propose an additional prominence-matching constraint. While *Aí (repeated in (81)) penalizes a prominence mismatch of a certain size, *ValleyAsPeak penalizes a mismatch of any size, if it occurs on both sides of the vowel in question (*ValleyAsPeak is therefore applicable only to VVV sequences):

(81) Two prominence mismatch constraints
*Aí: an unstressed non-high vowel must not be *followed* by a stressed high vowel
*ValleyAsPeak: a stressed vowel must not be *flanked* by lower, unstressed vowels (that is, a peak of stress should not be a valley of sonority)

The tableaux in (82) illustrate how diphthongisation of low-mid sequences is possible only in VVa.

(82) Illustration of *ValleyAsPeak

/maela/	*Aí	***ValleyAsPeak**	Edgemost-R	Parse-σ
a (máe)la			*!	*
☞ *b* ma(é.la)				*
/maea/				
☞ *c* (máe)a			*	*
d ma(é.a)		*!		*

The sonority-stress mismatch constraints in (81) resemble those in previous analyses of sonority-driven stress, such as Kenstowicz's (1997a, p. 162) *PEAK/i,u and de Lacy's (2002, p. 15) $*\Delta_{Foot}/\{ə,i/u\}$ (e.g. "don't stress a high vowel"), or the SONORITYPEAK constraint of Clements (1997) and Dell and Elmedlaoui (2002) (a sonority peak within a syllabification domain must be a nucleus). Neither of these approaches entirely captures the Samoan data. If ranked correctly in relation to EDGEMOST-R, "don't stress [i,u]" and "don't stress [e,o]" can capture [(mái)le] and [ma(éla)], but some additional mechanism is needed to account for the difference between [maéla], where mid-vowel stress is tolerated, and [máea], where it is not. And while a stress version of SONORITYPEAK could work for sequences like /aia/ and /aea/, in /maile/ the /i/ is not a sonority minimum, because it is followed by even less sonorous /l/. An additional mechanism would be needed to prefer [máile] over [maíle].

What do /VVa/ sequences tell us about prosodic-word structure? The first relevant case occurs when the final /a/ is a suffix. In Section 4.2.1 we saw that the ergative /–a/ and denominal /–a/ suffixes both shift stress rightward, putting them in the same prosodic word as the stem. Thus, we expect /VV-a/ to behave the same as monomorphemic /VVa/.

Elicitations with our primary consultant yielded variable data, so we elicited and recorded representative words from 6 additional consultants in Samoa. Full results are shown in the Appendix (section 11): for each word, we show how many consultants had each pattern. The data confirm that stress is consistently antepenultimate for tautomorpheme /aia, aua, aea, aoa/. When the final /-a/ is the ergative suffix, we see variation for /aua, aia/, and for /aea, aoa/ variation with a tendency towards penultimate stress. When final /–a/ is the denominal suffix, we see a strong tendency towards penultimate stress for /aua, aia, aea, aoa/.

The table in (83) schematizes the /VVa/ results. The suffixed cases with penultimate stress are very surprising. If the ergative and denominal suffixes are treated as part of the root's prosodic domain, stress should be the same as in monomorphemes—antepenultimate. If they are treated as outside the domain, stress should remain where it was in the unsuffixed form—yielding, again, antepenultimate stress: [áV-a]. The puzzle persists if we employ ordering, as in Lexical Phonology and Morphology: if the suffixes are added before stress is assigned, stress should be the same as in monomorphemes. If the suffixes are added after stress is assigned, stress should remain on the root's penult: either way, [áV-a]. Likewise, output-output faithfulness to the unsuffixed form can't explain the [aV́-a] pattern.

(83) Elicitation results for VVa# words

	monomorphemic	ergative –*a*[24]	denominal –*a*
aia, aua	áVa	áV-a ~ aV́-a	aV́-a
aea, aoa	áVa	(?áV-a ~) aV́-a	aV́-a

The vast majority of data that a Samoan learner encounters for these suffixes is from stems that end in CV (and even among stems that end VV, most don't end in the crucial sequences such as /ai/). We have assumed that the grammar explains the stress shift in these cases by putting the root and suffix in

[24] When ergative -*a* was followed by another suffix, we did not observe similar variation (73): [(màu)-a-(ína)] but not *[ma(ù-a)-(ína)] and [(tàli)-a-(ína)] but not *[ta(lì-a)-(ína)]; we would attribute this to a p-word boundary before –*a* (see (33)). However, there were few such words and we elicited them only from our primary consultant. Perhaps a larger dataset would have revealed these variants.

the same p-word. But learners could also learn stress shift as a (redundant) property of each suffix, conflicting with stress constraints only for the crucial VV-final roots.

We sketch a way to capture these suffix-specific stress shifts, using a proposal from Buckley's (1998) analysis of similarly problematic stress data in distantly related Manam. Buckley appeals to low-ranked ALIGNHEAD, requiring the end of any prosodic word to be the end of the main-stressed foot, and high-ranked ALIGNHEAD$^{\{SUF\}}$, which applies only to the ends of suffixes. For Samoan, we need constraints that are even more specific, referring to just these two suffixes, although we do not need to refer to the main-stressed foot specifically:

(84) Special alignment constraints for two suffixes

ALIGN$^{\text{Ergative-}a}$ = ALIGN(Ergative –*a*, R; Foot, R): the right edge of ergative –*a* must coincide with the right edge of a foot

ALIGN$^{\text{Denominal-}a}$ = ALIGN(Denominal –*a*, R; Foot, R): the right edge of denominal –*a* must coincide with the right edge of a foot

The difference between ergative and denominal /–a/ is in the conflict between each suffix's ALIGN constraint and the prominence-matching constraints *AÍ and *VALLEYASPEAK: denominal /-a/'s alignment requirement is ranked high, but ergative /–a/'s is optionally outranked by *AÍ, so that we see variation for /ai-a$_{erg}$, au-a$_{erg}$/, but hardly ever for /ai-a$_{denom}$, au-a$_{denom}$/. We have no explanation for why the difference between the two morphemes should be in this direction rather than the opposite.

We saw at the end of section 7.2 that the semi-productive suffix /-Ci/ does not initiate a p-word, even when another suffix follows, allowing FOOTBINARITY to be satisfied. The unproductive /–ia/ ergative suffix provides a similar example for VVV sequences. We were able to gather several examples with /a/- or /o/-final stems. As shown in (85), the /...a-ia/ data, with one variable exception ('shine on-IA'), indicate that /–ia/ is included in the stem's prosodic word, because it does not bear its own stress, but rather stress falls on the antepenult. This is in contrast with the behaviour we have observed for productive /–ina/, which does bear stress even after stem-final /a/. Once again, it seems that unproductive suffixes are not subject to ALIGN(Morpheme, L; PWord, L).

(85) Unproductive ergative suffix /-ia/ (see Appendix for full elicitation results)

(tála)	'thorn, spike'	ta(lá-i)a	'scratch, stab- IA'
(tála)	'unfold'	ta(lá-i)a	'open- IA'
(mála)	'plague, scourge'	(maː)(lá-i)a	'be unlucky- IA'
(táː)	'hit'	(tá-i)a ~ (tàː)-(ía)	'hit- IA'
(séŋa)	'glare'	(sèŋa)-(ía) ~ se(ŋá-i)a	'shine on-IA'
cf. non-diphthongising /oi/			
(sólo)	'move forward'	(sòlo)-(ía)	'move forward-IA'
(ólo)	'rub'	(òlo)-(ía)	'brush against-IA'
(nófo)	'dwell'	(nòfo)-(ía)	'dwell-IA'

Although we have no other data on the diphthongisability of /oi/, the /–ia/ data in (85) suggest that /oi/ does not pattern with /ai/.

To summarize this section, we have seen that prominence mismatches cause stress to deviate from its normal penultimate position, but not at the cost of a foot straddling a p-word boundary. Under this analysis, we have additional evidence that the productive ergative suffix /–ina/ forms its own p-word, and for a p-word boundary inside a compound. We also saw that a strong prominence mismatch is required to shift stress in ...VVCV# sequences, but even a weak prominence mismatch shifts stress in ...VVV#. The ergative and denominal /–a/ suffixes seem to have developed an idiosyncratic pre-stressing requirement, which we capture by requiring them to be foot-final; this requirement is normally redundant, since it doesn't conflict with the stress pattern otherwise expected, but in /...VV-a#/ cases the suffix-specific constraints prevail.

8. Glide formation (speculative)

Before concluding the paper, we mention one area of Samoan word prosody where our findings are more tentative. In our narrow transcriptions, we often transcribed /u, i/ as the glides [w] and [j], or as [uw], [ij]. Mosel and Hovdhaugen (1992) also note these allophones (pp. 25-26). The environments in (86) are typical ones where we transcribed [w, j] (unstressed, followed by a vowel, and not preceded by a consonant) or [uw, ij] (between V́[u, i] and a vowel).

(86) /i,u/ transcribed as glides or with a following glide

	presumed underlying form	
[w, j]		
(**w**íla)	/uila/	'lightning'
(**j**áː)	/iaː/	*Preposition*
[uw, ij]		
(wá**u**)**w**a	/uaua/	'vein'
(màː)(ná**i**)**j**a	/maːnaia/	'nice'
(tà**u**)(**w**í-a)	/taui+a/	'repay-A'
(pà**i**)(**j**éː)	/paieː/	'lazy'

By contrast, as shown in (87), we typically did not transcribe /i,u/ as glides when stressed, preceded by a consonant, or not followed by a vowel:

(87) /i,u/ not transcribed as glides

	presumed underlying form	
(**ù**a)(ŋáni)	/uaŋani/	'(tree sp.)'
s**u**(ái)	/suai/	'dig up'
i(lóa)	/iloa/	'know'
(ló**i**)	/loi/	'ant'
(má**u**)ŋa	/mauŋa/	'mountain'

It was difficult to establish objective criteria for classifying a sound as [i,u] or [j,w]. In some tokens, the transcription of a glide seems justified by a sharp dip in amplitude, but others lack such evidence.[25] We therefore do not attempt a full analysis, but note two tendencies. First, many vowel-to-glide changes provide an onset to a foot-initial syllable, as in [a(wéː)] vs. *[(àu)(éː)]. Second, glide *insertion* occurs mainly after [V́u] or [V́i] sequences ([(máu)wa]). This may be akin to the partial lengthening that we have (unreliably but saliently) observed after stressed vowels, as in [fúsˑi], and may also maintain contrast between /au, ai/ and /ao, ae/: /maua/ → [(máu)wa] vs. /paoa/ → [(páo)a].

We also note two observations suggesting that gliding cannot be simply postlexical. The first observation concerns reduplication. Under a broad transcription, the reduplications in (88) would be puzzling, because three moras are copied rather than the usual two. But the narrow transcriptions make more sense: /u/ has become an onset glide, so it copies along with the following long vowel.

(88) Reduplication cannot precede gliding

broad transcription

auéː	'alas!'	a<uèː>uéː	'bitter, sad'
uóː	'friend'	fàʔa-<uòː>uóː	'putting arms around e. o.'

narrow transcription, with footing

a(wéː)	'alas!'	a<(wèː)>(wéː)	'bitter, sad'
(wóː)	'friend'	(fàʔa)-<(wòː)>(wóː)	'putting arms around e. o.'

Gliding must precede reduplication (literally or through output-output correspondence) or occur in parallel with it, and therefore can't be postlexical.

The second observation concerns loanwords. In the native-word data above, it appeared that stress bleeds gliding: applying stress yields [(**ù**a)(ŋáni)], preventing (potentially post-lexical) gliding to*[wa(ŋáni)]. In some loans (and one native word), however, glides occur in positions where we would have expected stress to fall (89). We surmise that even though the distinction between high vowels and glides is not normally contrastive in Samoan, a glide in the foreign form should correspond to a glide in the Samoan form (or at least repel stress, as in [k**u**(ìni)si(láni)] 'Queensland', instead of *[(k**ù**i)(nìsi)(láni)]). Thus, again, gliding cannot be purely postlexical.

(89) Unexpected initial glides

je(óva)	'Jehovah'
wi(síla)	'fish sp.' (non-loan)
(jùni)(vèsi)(téː)	'university'
(wàka)(fóni)	'walkathon'
(wèle)ŋi(tóŋe)	'Wellington'
ju(nài)te si(téte)	'United States'

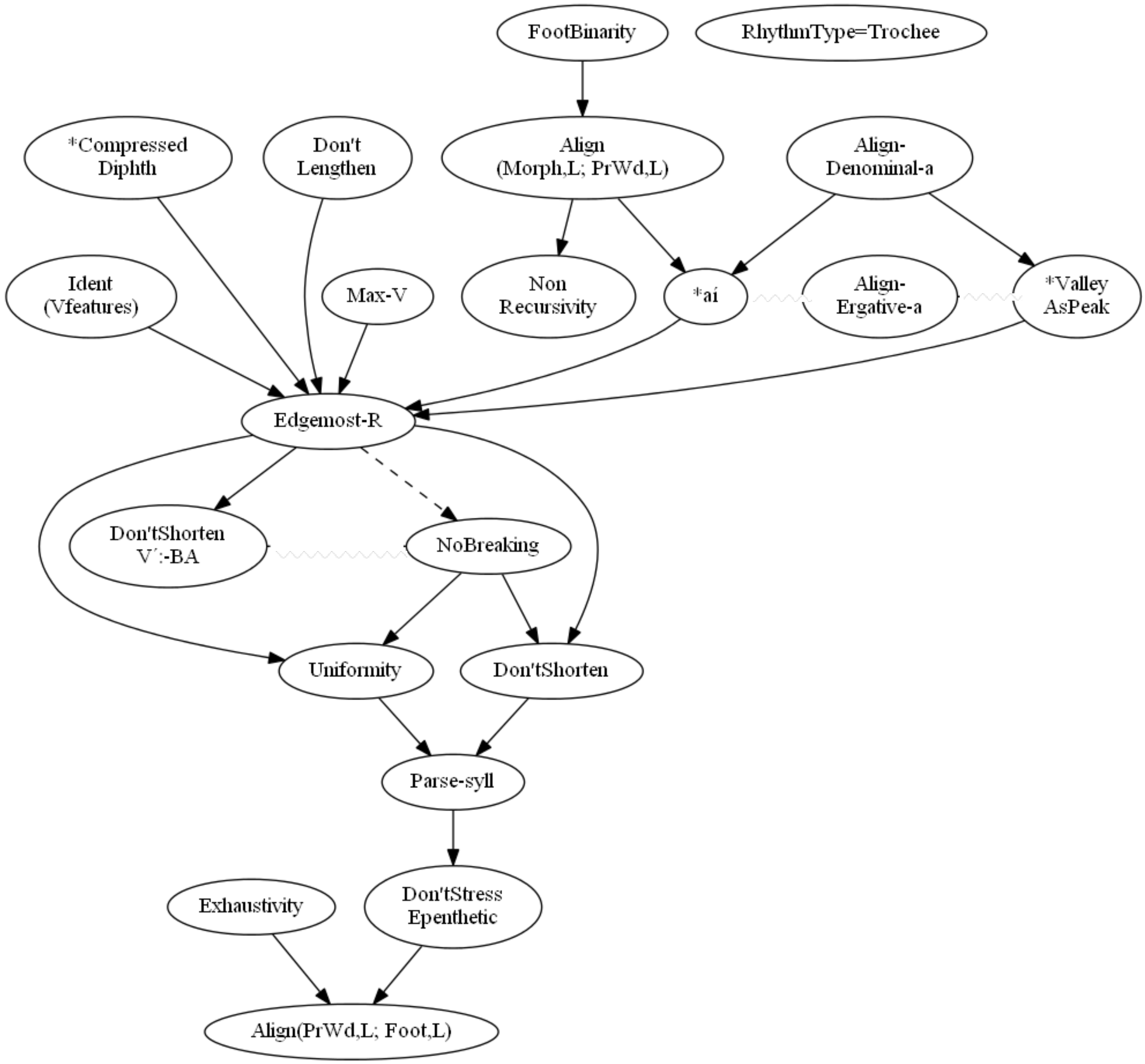
[25] As a reviewer suggests, it would be useful in future work to obtain better data on Samoan glides by validating and carrying out a task, such as finger-tapping, through which speakers can judge or indicate the number of syllables in a word. For example, does 'Jehovah' have 3 syllables, supporting the transcription [jeova], or 4, supporting [ieova]?

9. Summary and conclusion

9.1. Summary

This paper has covered several aspects of the word-level prosody of Samoan. The Hasse diagram in (90), made with OTSoft (Hayes, Tesar, & Zuraw 2003) and GraphViz (Ellson & al. 2004), shows the constraint rankings required in our analysis.

(90) Hasse diagram of constraint rankings



In (90), arrows indicate crucial constraint rankings. For example, FOOTBINARITY >> ALIGN(Morph,L; PWd,L). The jagged line between DON'TSHORTENV́:-BA and NOBREAKING indicates a variable ranking: if DON'TSHORTENV́:-BA >> NOBREAKING, final long vowels break when suffixation makes them penultimate, and if NOBREAKING >> DON'TSHORTENV́:-BA, they shorten (see section 5). The line between EDGEMOST-R and NOBREAKING is dashed to indicate that although that ranking is required for the breaking variant, the ranking of those two constraints is irrelevant for the shortening variant; the rankings EDGEMOST-R >> DON'TSHORTEN and EDGEMOST-R >> UNIFORMITY are required for either variant, either directly or by transitivity.

The two jagged lines connected to FAITH-stress(ergative) in (90) also indicate variable ranking. If ALIGN$^{\text{Ergative-}a}$ >> {*AÍ, *VALLEYASPEAK}, then the ergative suffix *-a* is foot-final, and thus preceded by stress: [fa(í-a)], [va(é-a)] (see section 7.3). Under the less-frequent ranking *VALLEYASPEAK >> ALIGN$^{\text{Ergative-}a}$, regardless of the ranking of *AÍ, words with the ergative suffix *–a* are stressed the same as monomorphemes: [(fái)-a] 'do-*erg*', [(váe)-a] 'kick-*erg*'. And if *AÍ >> ALIGN$^{\text{Ergative-}a}$ >> *VALLEYASPEAK, then stress in these words depends on the height of the stem-final vowel: [(fái)-a], [va(é-a)].

We have seen that in monomorphemic words there is a final moraic trochee bearing primary stress, and possibly a preference for a word-initial trochee bearing secondary stress if the word is long enough. Long vowels or sequences of identical vowels are not allowed in penultimate position if the final vowel is short, and we see alternations reflecting trochaic shortening. Stem-final long vowels also shorten or break when suffixation makes them penultimate. When monomoraic reduplication would create a long vowel in the penult, different morphology is used.

We have also proposed that the beginning of a lexical word projects the beginning of a p-word. Based on stress, monomoraic suffixes are included in the domain of footing, or prosodic word—that is, they shift stress to the right. The diagnostic that the penult of the p-word is the position where a long vowel is not allowed also supports the inclusion of monomoraic suffixes in the domain of footing, and suggests that there is a p-word boundary between the following: stems and /-ina/, prefixes and stems, stems in a compound, and a bimoraic reduplicant and its base.

Finally, certain vowel sequences disrupt the normal stress pattern. We propose that a prominence-matching constraint prohibits an unstressed non-high vowel followed by a stressed high vowel: *AÍ. Such sequences are allowed across p-word boundaries, however, because a foot can't straddle a p-word boundary. Notably, the evidence from these sequences supports the p-word boundaries proposed. Another prominence-matching constraint applies to three-vowel sequences: there, even if the middle vowel is only mid, rather than high, it can't be stressed if surrounded by unstressed, low vowels (that is, [áea, áoa], not *[aéa, aóa]): *VALLEYASPEAK.

9.2. Comparison to other approaches

In Section 1 we reviewed existing approaches to phenomena similar to those observed in Samoan. The approach we have pursued throughout the paper uses ALIGN constraints to impose prosodic-word boundaries, with the p-word as the domain of footing. Here we consider how other approaches fare.

A close cousin to the approach taken here is one in which ALIGN constraints place feet directly at morpheme boundaries, without the p-word as an intermediary (Crowhurst 1994). The main challenge we see for applying this approach to Samoan involves words with monomoraic suffixes. In /lolo+fi/ (25), for example, as shown in (91), the incorrect footing **(lólo)-fi* is if anything preferred by direct morpheme-foot alignment constraints, because at least the stem morpheme begins with a foot. Some constraint is needed to prefer *lo(ló-fi)*, such as a preference for the word to end in a foot—in which case we still need a prosodic word, though perhaps a simpler one.

(91) Direct morpheme-to-foot constraints alone fail to prefer (a)

/ lolo+fi /	ALIGN (Morpheme, R; Foot, R)	ALIGN (Morpheme, L; Foot, L)	ALIGN (Foot, R; Morpheme, R)	ALIGN (Foot, L; Morpheme, L)
actual output *a* lo(ló-fi)	*	*		*
b (lólo)-fi	*			

On the other hand, an advantage of the morpheme-foot alignment is that morpheme-specific ALIGN constraints can capture the idiosyncratic behaviour of certain morphemes: we analysed the pre-stressing behaviour of denominal *–a*, and, to a lesser extent, ergative *–a* (section 7.3) with constraints like ALIGN(Denominal *-a*, R; Foot, R), which requires a foot boundary after denominal *–a*—an even more specific version of Buckley's (1998) ALIGNHEAD$^{\{SUF\}}$.

Output-output faithfulness can handle some aspects of the Samoan data. Some form of output-output faithfulness is needed to deal with the different treatment of underlying penultimate long vowels in unsuffixed versus suffixed words, as discussed in section 5: in unsuffixed forms, a long penult obligatorily shortens, whereas in suffixed forms there is variation between shortening and breaking, which we attributed to variable faithfulness to the unsuffixed form (*pe(lé-ŋa) ~ (pèle)(é-ŋa)*, from *pe(léː)*). Moreover, the lack of secondary stress shift under suffixation (section 4.2) could be attributed to faithfulness to the unsuffixed form. The lack of diphthongisation (section 7.2) and vowel coalescence (section 6) before *–ina* could have also been attributed to high-ranking faithfulness of *–ina*-suffixed forms to their base words: non-diphthongised *(lòka)-(ína)* is more faithful to its base *(lóka)* than **lo(ká-i)na* is; non-coalesced *(kìki)-(ína)* is more faithful to *(kíki)* than **ki(k-ína)/ki(kí-na)* is. Similarly, the lack of length alternation with *–ina* and other bimoraic suffixes (except *–Caʔi*) (section 5) could have been explained by subjecting these suffixations to stronger output-output faithfulness constraints on vowel length. However, the fact that suffixes divide into two faithfulness groups almost entirely along prosodic lines (monomoraic suffixes and *-Caʔi* vs. other bimoraic suffixes) would be accidental.

Interleaving affixation and phonological operations, as in Lexical Phonology, can also handle some of the data. Suppose that *loka* is prosodified before being suffixed, as *(lóka)*. If faithfulness to existing footing outranks *AÍ, suffixing *–ina* will just add a foot, *(lòka)-(ína)*. Monomonoraic suffixes can still shift stress if EDGEMOST-R outranks faithfulness to existing feet: *(lólo)*, after being suffixed with *–fi*, changes to *lo(ló-fi)*. The problem that this approach faces for Samoan is similar to the one that Baker (2004) points out for Ngalakgan: suffixing *(máu)-a* 'get-A' with *-ina* should provide enough unfooted material to yield **(màu)-(á-i)na*, but the result is instead *(màu)-a-(ína)* (73), with a new foot initiated by *–ina*, in violation of *AÍ. The failed derivation in (92) illustrates:

(92) Failed derivation for /mau+a+ina/, [(màu)a(ína)]

root	mau
phonology applies	(máu)
suffix *–a*	(máu)a
phonology: because *AÍ >> EDGEMOST-R, no change in footing	(máu)a
suffix *–ina*	(máu)aina
phonology: *AÍ >> EDGEMOST-R	*(màu)(ái)na

To deal with trochaic shortening in Lexical Phonology, it would be necessary to group suffixes into levels. Those that can bleed trochaic shortening (monomoraic suffixes and –*Caʔi*) would be attached before shortening, and those that counterbleed it (the other bimoraic suffixes) would be attached afterward, and the fact that the partitioning of suffixes into levels is almost entirely determined by suffix size would be accidental:

(93) Affix differences in trochaic shortening

	/faːŋu/	/faːŋu/	
-*a* suffixation	faːŋua	--	
phonology	(fàː)(ŋúa)	(fáŋu)	*trochaic shortening*
-*ina* suffixation	---	(fàŋu)ína	
phonology	---	(fàŋu)(ína)	

Both Lexical Phonology and output-output faithfulness provide no natural solution to the problem of prestressed denominal –*a* (and to a lesser extent ergative –*a*) (section 7.3). Suffixed *va(í-a)* is not faithful to its base or earlier derivational stage *(vái)*; nor does ordering suffixation before prosodification help, since the result should be the same prosody as a monomorpheme, **(vái)-a*. As in our ALIGN approach, an additional stipulation is required for these suffixes

Finally, we consider an approach based on boundary symbols. As with output-output faithfulness or Lexical Phonology, affixes' lexical entries must specify which of two groups they belong to. The monomoraic suffixes and –*Caʔi* would be preceded by the boundary +, and the other bimoraic suffixes by #. Footing rules or constraints would ignore + boundaries. For example, /#loka#ina#/ is footed as *#(lòka)#(ína)#*, with a foot preceding each non-initial #, but /#lolo+fi#/ is footed as *#lo(ló+fi)#*, with a single foot preceding the single non-initial #. All prefixes would bear #, to prevent diphthongisation or vowel coalescence: *#fe#(íta)#* (assuming that footing rules/constraints prevent a foot from taking material from both sides of a # boundary).

Given that a difference in prosodic behaviour between monomoraic and bimoraic affixes exists in many other language (see Section 1.2 for examples), we believe it is an advantage of the two ALIGN approaches that this difference is captured in the grammar rather than being an accidental property of affixes' lexical entries, as in the output-output, Lexical-Phonology, and boundary-symbol approaches.

9.3. Conclusions

We have provided a description of Samoan word prosody and an analysis supported by evidence from stress and vowel length that uses morphology-sensitive ALIGN constraints to impose prosodic words, which are the domain of footing. The alternative of ALIGN constraints that bypass the prosodic word and impose feet at morpheme boundaries would require an additional mechanism to handle our data. Simple cyclicity cannot account for all of the data, and Lexical-Phonology, Output-Output Correspondence, and boundary-symbol approaches miss the correlation between affix size and behaviour. Additional points of interest include asymmetrical productivity in length alternations (section 5), length restrictions affecting affix choice (section 5), sonority/prominence-matching constraints sensitive to degree of mismatch and vowel sequence length (section 7), morpheme-specific stress/footing constraints in a small number of words (section 7.3), and marginal contrasts that emerge only in loans, for secondary stress (section 3.4) and glide/vowel distribution (section 8).

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11. Appendix: Elicitation results for VVa# words

morph-ology	*VVV*	*antepen. stress*	*penult stress*	*offer antepen., (& reject pen.)*	*offer antepen., accept pen. after prompting*	*offer antepen. and pen.*	*offer pen., accept antepen. after prompting*	*offer pen., , (& reject antepen.)*	*not elicited , reject word, or antepenult is long*	
Mono	/aia/	(màː)(nái)a	*	7						‘nice’
Mono	/aia/	(mái)a	*	6					*1*	‘(*emphasis*)’
Mono	/aua/	(máu)a	*	7						‘catch, get’
Mono	/aua/	(táu)a	*	7						‘war’
Mono	/aea/	(máe)a	*	7						‘rope’
Mono	/aea/	(váe)a	*	6					*1*	‘Vaea Mountain’
Mono	/aoa/	(láo)a	*	7						‘house of orator’
Mono	/aoa/	(táo)a	*	7						‘Taoa’ (place)
erg. –a	/ai+a/	ta(lái)-a	(tàla)(í-a)	1	2	2		1	*1*	‘open-*erg*’
erg. –a	/ai+a/	va(ʔái)-a	?(vàʔa)-(í-a)	6	1					‘look-*erg*’
erg. –a	/ai+a/	(fái)-a	fa(í-a)	1	6					‘do-*erg*’
erg. –a	/au+a/	(máu)-a	ma(ú-a)	4(1)		2				‘get-*erg*’
erg. –a	/au+a/	(fáu)-a	fa(ú-a)		2		1	4		‘construct-*erg*’
erg. –a	/au+a/	(láu)-a	la(ú-a)			1	2	4		‘call out-*erg*’
erg. –a	/eu+a/	?(séu)-a	se(ú-a)				1	5(1)		‘steer-*erg*’
erg. –a	/eu+a/	*	te(ú-a)					6(1)		‘put away-*erg*’
erg. –a	/ou+a/	*	fo(ú-a)					5(1)	*1*	‘challenge-*erg*’
erg. –a	/ui+a/	(fúi)-a	fu(í-a)				2	4(1)		‘water-*erg*’
erg. –a	/ui+a/	(súi)-a	su(í-a)				2	3(1)	*1*	‘dilute-*erg*’
erg. –a	/ui+a/	*	tu(í-a)					6(1)		‘stab-*erg*’
erg. –a	/iu+a/	?(líu)-a	li(ú-a)				1	3(1)	*2*	‘change-*erg*’
erg. –a	/iu+a/	*	ti(ú-a)					6(1)		‘shark-fish-*erg*’
erg. –a	/ae+a/	(táe)-a	ta(é-a)				2	5		‘pick up-*erg*’
erg. –a	/ae+a/	*	va(é-a)					3(2)	*2*	‘kick-*erg*’
erg. –a	/ao+a/	?<(vào)>(váo)-a	<(vào)va(ó-a)				1	4(2)		‘restrain-*erg*’
erg. –a	/ao+a/	(fáo)-a	fa(ó-a)		1	1	1	4		‘snatch-*erg*’
erg. –ia	/o+ia/	no(fó-i)a	(nòfo)-(ía)			1	2	4		‘dwell-*erg*’
erg. –ia	/a+ia/	se(ŋá-i)a	(sèŋa)-(ía)	(1)		1		3(2)		‘shine on-*erg*’

denom. –a	/ai+a/	*	va(í-a)					6(1)		‘watery’
denom. –a	/au+a/	*	la(ú-a)					6(1)		‘leafy’
denom. –a	/oi+a/	*	lo(í-a)					6	*1*	‘ant-y’
denom. –a	/ou+a/	??a(lóu)-a	(ʔàlo)(ú-a)				1	5(1)		‘pus-y’
denom. –a	/iu+a/	*	ni(ú-a)					6(1)		‘coconut-y’
denom. –a	/ae+a/	(váe)-a	va(é-a)	1				2(1)	*3*	‘having feet’
denom. –a	/ao+a/	*	(pùa)(ó-a)					6(1)		‘foggy’
denom. –a	/ao+a/	*	va(ó-a)					6(1)		‘weedy’