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The incoherent stress of Kuikuro

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Abstract
We present an analysis of stress and tone in Kuikuro (Cariban) at the word and phrase levels. Metrically, iambs are assigned left-to-right, with final trochaic reversal. Tone surfaces on the rightmost syllable in a domain that includes the primary stress of the phrase and any following unstressed syllables, i.e., a tone that is a correlate of stress may appear displaced from its stressed syllable. This work adds to the typology of tone/prominence, expanding the definition of "incoherent" stress (Gordon 2016) to include tone that is imperfectly aligned to metrical prominence, and situating Kuikuro and other languages in this typology.

Keywords Metrical phonology · Incoherent stress · Tone shift · Tone domains

1 Introduction

This article describes the word-level and phrase-level prosody of Kuikuro (Cariban) based on the distribution of vowel length and tone. These two correlates of stress reveal two aspects of Kuikuro prosody: on the one hand, an iambic stress system that is familiar from other languages in the same family and region, and on the other

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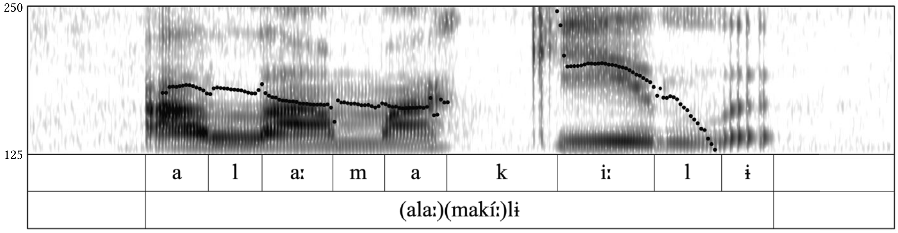
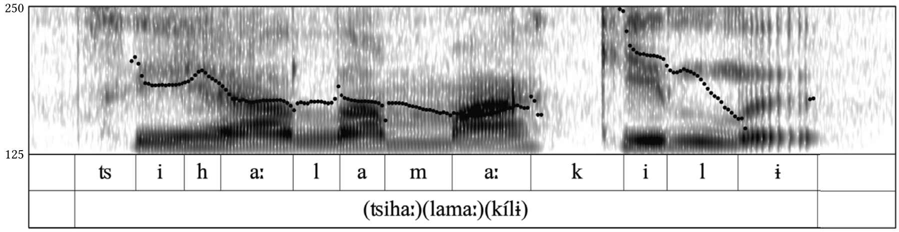


/∅-ɛC-ʀamaki-lɨ/ → [(alaː)(makíː)lɨ]
'3SG-DTR-fall-PNCT', 's/he fell'

Fig. 1 Default lengthening and tone in an odd-parity word



/t͡sih-ɛC-ʀamaki-lɨ/ → [(t͡sihaː)(lamaː)(kílɨ)]
'1.3-DTR-fall-PNCT', 'we (exclusive) fell'

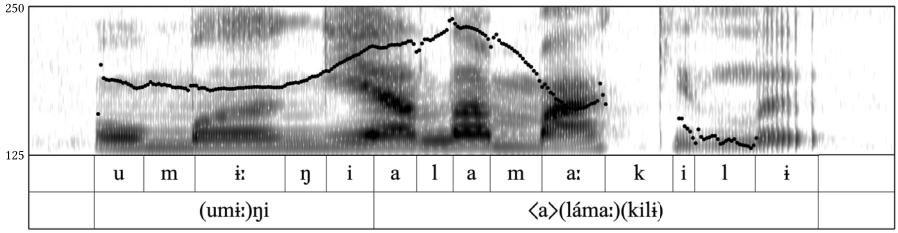
Fig. 2 Default lengthening and tone in an even-parity word

hand, High tone shift, a pattern that is familiar from Bantu languages. While the combination is unusual, it is predicted from existing theories of stress and tone. We use familiar constraints on foot structure (Hayes 1995; Prince and Smolensky 1993/2004) paired with familiar constraints on tone domains (Cole and Kisseberth 1994; Cassimjee and Kisseberth 1998; McCarthy 2004), together with a newly proposed constraint, CULMINATIVITY-H, which penalizes tone domains that include more than one foot head.[1]

We start here with an overview of the core findings and analysis. Figure 1 (made in Praat, Boersma and Weenink 2015) shows a word with an odd number of syllables, where the default left-to-right iambic parse lengthens the second and fourth syllables. The default phrasal High tone docks on the head of the rightmost foot in [(alaː)(makíː)lɨ] 's/he fell'. The final remaining syllable is unparsed. Here and throughout, parentheses mark foot boundaries. This example and all of the other examples in this article come from our original fieldwork.

Figure 2 shows the same verb with an overt prefix, making the number of syllables even in [(tsihaː)(lamaː)(kílɨ)] 'we fell'. Again, the second and fourth syllables

[1]We follow the Leipzig glossing conventions/abbreviations, with these additions: 1.2 1st person inclusive dual, 1.3 1st person exclusive, ANA anaphoric, DTR detransitivizer, NTM nominal tense marker, PNCT punctual aspect, TEMP temporal adverbializer, VERB verbalizer.



/umɨŋi εC-ʀamaki-lɨ/ → [(umɨː)ŋi ⟨a⟩(lámaː)(kilɨ)]
'annatto DTR-fall-PNCT', '(the) annatto fell'

Fig. 3 Default lengthening and tone in a two-word phrase

are lengthened. The vowels in the last two syllables are both phonologically short.[2] We propose that the last two syllables are parsed into a trochee (*trochaic reversal*, Hayes 1995§5.3b, Vaysman 2009; Bennett 2013; Bennett and Henderson 2013; Gordon 2016), and that this trochee is the head foot of the word.

Regardless of the number of syllables in the word, the default phrasal High tone docks on the head of the rightmost foot. Assuming a final trochee allows us to derive two generalizations: (1) the lack of lengthening and (2) the position of the High tone, which uniformly docks on the penultimate stressed syllable. Here and throughout, a stressed syllable is defined as the head syllable of a foot, and the primary stress of a word is defined as the head of the head foot of the word.

As for High tones, we assume that they are organized into High tone domains (Cole and Kisseberth 1994; Cassimjee and Kisseberth 1998; McCarthy 2004), marked with an underline. In addition to the High tones we marked in our transcriptions, and depending on one's theoretical assumptions, the representations might include additional Low tones at the left edges of the High tone domains, e.g., accounting for the low pitch on the pretonic syllables in Figs. 1 and 2. Here, we follow Cole and Kisseberth (1994) and others who assume sparse surface representations with High tones only.

Figure 3 exemplifies the form of phonological phrases. We take the familiar verb [(alaː)(makɨ́ː)lɨ] 's/he fell' (Fig. 1), and add the internal argument noun 'annatto', which has the isolation form [(umɨ́ː)ŋi]. The two words together make the phrase [(umɨː)ŋi ⟨a⟩(lámaː)(kilɨ)], where the verb shows neither the tone nor the long vowels it has in the isolation form. The initial vowel of the verb is left unparsed (§4.3), and the default parsing (iambic with final reversal) applies to the remaining four syllables, lengthening the second syllable [maː]. The High tone is found on the syllable before this lengthened [maː].

We propose that a tone domain left-aligns to the primary stressed syllable of the noun [(umɨː)ŋi], which is also the primary stress of the phrase, and extends maximally rightward up to (but not including) the following foot head. The tone domain

[2]While the final vowel in Fig. 2 is phonetically a little longer than the final vowel in Fig. 1, our speakers are confident that both should be transcribed as short. More generally, our speakers judge all phrase-final vowels as short (except in monosyllables) regardless of their surface realization, which may include lengthening and/or creaky voice.

is marked with an underline. In our transcriptions, we mark the syllable that has the highest pitch, or the H tone target, with an acute accent. As the pitch track shows, pitch rises gradually through the tone domain, and then falls into a Low tone on the following syllable.[3] Here, we see the incoherence of Kuikuro stress: the strongest syllable of the phrase, i.e., the primary stress, is the syllable [mɨː], but the tone that is one of the correlates of this primary stress is pronounced on a later unstressed syllable, dissociating the metrically most prominent syllable from the high-toned phonetically salient syllable.

When the noun [(umɨ́ː)ŋi] is followed by a disyllabic word such as the postposition [ʀɛ́pɔ] 'next to', the tone domain extends rightward up to but not including the head of the final trochee, as in [(umɨː)ŋí (ʀɛpɔ)] 'next to the annatto' (a pitch track for this type of phrase is given in Fig. 11 below). We now see the third reason for assuming final trochaic reversal: the trochee not only accounts for the lack of iambic lengthening and the presence of a High tone on the penult of words in isolation — the trochee also accounts for the blocking of tone domain expansion in the phrasal context. The expansion of tone domains is not blocked only by long vowels, but also by a short phrasal penult. In our analysis, we unify the two types of blockers: tone domains expand up to (but not including) the head of a foot, either an iamb or a trochee.

The paper is organized as follows. In §2 we provide background information on Kuikuro and on the languages that are geographically proximate and/or genetically related. We then survey the metrical and tonal structure of Kuikuro, starting with words in isolation (one-word phrases) in §3, then multiple-word phrases in §4, and finally lexical tone in §5. In §6, we situate two aspects of Kuikuro phonology in their typology: first, foot reversal, with the range of documented triggers for it. Second, tone shift, more familiar from Bantu languages, is seen here in an unrelated language family. We conclude in §7.

2 Language background

Kuikuro is a southern Cariban language, agglutinative and head-final, spoken by about 600 people in a few villages in the southern part of the Xingu Indigenous Land and in nearby towns, in the southern edge of the Amazon basin (Mato Grosso, Brazil). The main village, Ipatse, is at 12°21'20"S 53°12'40"W. Several languages in the Cariban family, spoken over a vast geographical area in South America, are known to be left-to-right iambic, most famously Hixkaryana (Derbyshire 1985, Hayes 1995 §6.3.1, Kager 1999), but also Tiriyó (Meira 1998), Ikpeng (Campetela 2002), and several others. Not all Cariban languages are iambic: Bakairi (Meira 2005) has penultimate stress and would seem to be trochaic.

This work adds Kuikuro to the list of Cariban iambic languages, and additionally shows that in Kuikuro the default penultimate tone on words in isolation is due to a left-to-right iambic parse with final trochaic reversal. Previous work on Kuikuro prosody is found in da Silva and Franchetto (2011); these authors did not describe

[3]In terms of autosegmental-metrical theory, a plausible analysis would have to use two different pitch accents: H* in one-word phrases, and L*H in longer phrases. In comparison, the tone domain analysis uniformly puts a High tone on the domain's final syllable.

the distribution of long vowels in the language, and were therefore unable to observe the dependence of High tones on the distribution of long vowels.

Regarding the metrical foot type of languages that form the linguistic environment of the Kuikuro people, we survey here the little that is known. There are indigenous languages from three families spoken in the area: Cariban, Tupian, and Arawakan. There is also of course Brazilian Portuguese, which many Kuikuros speak fluently.

Starting with the Cariban languages, Kalapalo is very closely related to Kuikuro. Franchetto classifies Kuikuro and Kalapalo as two dialects of Upper Xingu Carib. The Kalapalo and Kuikuro people live in close proximity and interact frequently. The foot type of Kalapalo is unknown, but an examination of a Swadesh list (Franchetto 2014) suggests that it is iambic. The Tupian languages spoken in proximity to the Kuikuro are Awetí and Kamayurá. Awetí stress is not rhythmic, aligning to the end of the stem (Drude 2011). The foot type of Kamayurá is unknown, but possibly trochaic (Gordon and Rose 2006). The Arawakan languages spoken in the area are Mehináku and Yawalapití. The foot type of these languages is unknown. Mujica (1992) shows that stress in Yawalapití is limited to one of the last two syllables.

Other Arawakan languages, spoken far away from the Kuikuro, are known to be iambic. Famously, Ajyíninka Apurucayali (pejoratively known as Axininka Campa and similar names) has left-to-right iambs with trochaic reversal, much like Kuikuro (Hayes 1995, §7.1.8). As Hayes (1995, §6.3.12) notes, most iambic languages are (or were) spoken in the Americas; we would say that most are Amazonian. However, Hayes says, "throughout the Americas the iambic languages are interspersed with great numbers of non-iambic languages, so the idea that iambic stress is an areal phenomenon of the Americas should not be taken as a certainty."

At present, Kuikuro is the dominant language in the Kuikuro villages. All of the children speak it, and many adults do not speak Portuguese. That said, the long-term survival of the language will continue to require resistance to pressure from Brazilian society, government, and the agricultural industry.

This article relies on work with our two indigenous coauthors, both men in their twenties with a long-term interest in linguistics. Vowel length and tone are not marked in the Kuikuro orthography, which was developed in the 1990s by Indigenous teachers, in collaboration with Bruna Franchetto. Therefore, we had to work to identify the long vowels using a combination of acoustic analysis in Praat (Boersma and Weenink 2015) and probing linguistic intuition. We started with minimal pairs for length in word-initial position (see Table 5 and Table 8) and later in the stressed penult (see Table 1), after which we were able to probe intuitions about vowel length fairly easily in most contexts. Tones were identified via acoustic analysis, as they eluded the intuitions of our coauthors. Our in-person meetings took place in Rio de Janeiro and in Brasília. When COVID-19 hit in March 2020, our work continued remotely.

Kuikuro syllables have neither codas nor complex onsets, and onsetless syllables are common in all positions. Vowels are the high [i ɨ u] and the low/non-high [ɛ a ɔ], with contrastive length and nasality, for a total of 24 vowels. The consonants are [p b t d ʦ ʥ ɟ k g m n ɲ ŋ s h l] + the uvular flap [ʀ] (Demolin et al. 2016); the symbol [ʀ] is used due to the lack of a dedicated IPA symbol for this sound. A few words retain the old [ɸ], now almost completely merged with [h]. Loanwords also have [f ɾ ʃ ʧ].

Table 1 Complete conjugation of two verbs with the PNCT suffix /lɨ/ and the DTR prefix /(ɛ)C/, showing the application of predictable iambic lengthening

		'pierce' /ipɔ + lɨ/	'irritate' /ikɛu + lɨ/
1SG	/u+/	(u-iː)(pɔ́-lɨ)	(u-iː)(kɛúː)-lɨ
2SG	/ɛ+/	(ɛ-iː)(pɔ́-lɨ)	(ɛ-iː)(kɛúː)-lɨ
3SG	/Ø + /	(ipɔ́ː)-lɨ	(ikɛː)(ú-lɨ)
1.2	/kuk+/	(kuk-iː)(pɔ́-lɨ)	(kuk-iː)(kɛúː)-lɨ
1.3	/tsih+/	(tsih-iː)(pɔ́-lɨ)	(tsih-iː)(kɛúː)-lɨ
1SG	/u+C+/	(u-ʀ-iː)(pɔ́-lɨ)	(u-ʀ-iː)(kɛúː)-lɨ
2SG	/ɛ+C+/	(ɛ-ʀ-iː)(pɔ́-lɨ)	(ɛ-ʀ-iː)(kɛúː)-lɨ
3SG	/Ø+ɛC+/	(ɛʀ-iː)(pɔ́-lɨ)	(ɛʀ-iː)(kɛúː)-lɨ
1.2	/kuk+ɛC+/	(kuk-ɛː)(ʀ-ipɔ́ː)-lɨ	(kuk-ɛː)(ʀ-ikɛː)(ú-lɨ)
1.3	/tsih+ɛC+/	(tsih-ɛː)(ʀ-ipɔ́ː)-lɨ	(tsih-ɛː)(ʀ-ikɛː)(ú-lɨ)

3 Words in isolation, default tone

Vowel length is contrastive in Kuikuro, e.g., [(áʀɨ)] 'seed' vs. [(áː)ʀɨ] '(type of tree)'. Consonant length is not contrastive; oral and nasal stops are optionally lengthened after a long vowel, e.g., [(^{n}dúː)ku ∼ (^{n}dúː)kːu] 'gourd.POSS', [(hiɲáː)nɔ ∼ (hiɲáː)nːɔ] 'older brother'; cf. a similar pattern in Japanese, where vowels are longer before long consonants (Kawahara 2015). In addition to the lexically long vowels, vowels are lengthened iambically from the left, leading to regular alterations based on the number of syllables provided by prefixes, as exemplified by the verbal paradigms in Table 1. Words in isolation are assigned a default penultimate High tone.

This section surveys the phonology of words in isolation (single-word phrases), starting with the default iambic lengthening and lexical long vowels in verbs (§3.1) and other parts of speech (§3.2). Other sources of long vowels in odd-numbered syllables include vowel fusion (§3.3) and the deletion of initial short vowels (3.4). Word minimality requirements are discussed in §3.5, and §3.6 summarizes the findings.

3.1 Default and lexical length in verbs

Table 1 shows how regular iambic footing impacts the vowels of the root /ipɔ/ 'pierce' depending on the amount of prefixal material: when null or disyllabic, the second syllable of the root is in an even-numbered syllable, and thus lengthened. When the prefixal material is monosyllabic, the first syllable of the root is lengthened. The same principles derive the length alternations in the trisyllabic root /ikɛu/ 'irritate'. The prefixes here include the five available person prefixes, as well as the detransitivizer /(ɛ)C/. The identity of the consonant in the detransitivizer is determined morphologically; for a thorough survey of Kuikuro morphology, see Santos (2002, 2007). The detransitivizer vowel deletes following a vowel. The segmental phonology of Kuikuro is analyzed in Franchetto (1995).

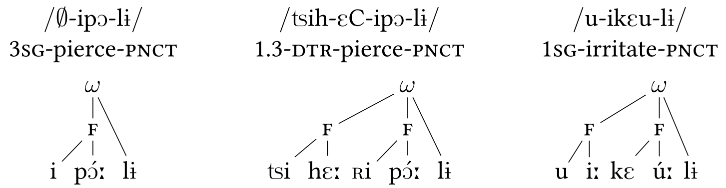


Fig. 4 Iambic lengthening in odd-parity words; last syllable left unparsed

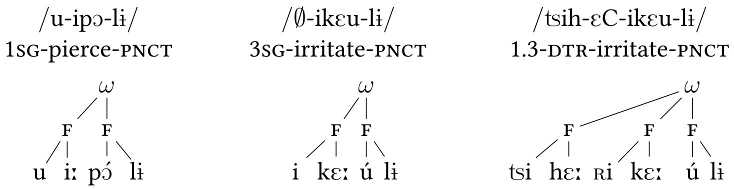


Fig. 5 Iambic lengthening in even-parity words; final trochaic reversal

Table 2 Trochaic reversal forced by a ban on final long vowels and Parse-σ

/σσσσ/	$*\text{Vː}]_\phi$	Max-μ	Parse-σ	Iamb
a. (σˌσː)(σˈσː)	*! W			L
b. (σˈσː)σσ			*!* W	L
c. ☞ (σˌσː)(ˈσσ)				*

High tones appear by default on the penultimate syllable regardless of vowel length. We derive this pattern by making three assumptions: first, when the left-to-right iambic parse leaves two short vowels at the right edge, they are footed into a trochee (trochaic reversal). Second, we assume that the last foot of the word is the head foot of the word, and third, that a High tone is assigned to the head syllable of the head foot of the word. The combination of trochaic reversal and right-headedness together ensure that the penult is the head of the word. Tone aligning to the most prominent syllable in its domain is of course well-established (Hayes 1995, §2.3.1).

The proposed prosodic structures are exemplified in Fig. 4, where an odd final syllable is left unparsed, and in Fig. 5, where the last two syllables are parsed into a trochee. Vertical lines mark heads of feet and words.

The analysis is formalized using violable constraints (Prince and Smolensky 1993/2004). Table 2 shows the derivation of trochaic reversal in a word with an even number of syllables. Rhythmic footing is promoted by Parse-σ (1), with feet required to be iambic by Iamb (2). Phrase-final long vowels are penalized by $*\text{Vː}]_\phi$ (3). Together, $*\text{Vː}]_\phi$ and Parse-σ force full parsing into disyllabic feet in violation of Iamb. Here and throughout, we assume that undominated constraints regulate prosodic wellformedness, e.g., requiring the last foot to be strongest, iambs to be headed by a long vowel and ideally including an initial light syllable, trochees to con-

Table 3 Complete conjugation of two verbs with lexical long vowels in the root that disrupt the iambic rhythm, with the PNCT suffix /lɨ/ and the DTR prefix /(ɛ)C/

		'transform' /ĩːki + lɨ/	'see' /iŋiː + lɨ/
1SG	/u+/	(u-ĩː)(kí-lɨ)	(u-iː)(ŋíː)-lɨ
2SG	/ɛ+/	(ɛ-ĩː)(kí-lɨ)	(ɛ-iː)(ŋíː)-lɨ
3SG	/∅ + /	(ĩː)(kí-lɨ)	(iŋíː)-lɨ
1.2	/kuk+/	(kuk-ĩː)(kí-lɨ)	(kuk-iː)(ŋíː)-lɨ
1.3	/tsih+/	(tsih-ĩː)(kí-lɨ)	(tsih-iː)(ŋíː)-lɨ
1SG	/u+C+/	(u-t-ĩː)(kí-lɨ)	(u-t-iː)(ŋíː)-lɨ
2SG	/ɛ+C+/	(ɛ-t-ĩː)(kí-lɨ)	(ɛ-t-iː)(ŋíː)-lɨ
3SG	/∅+ɛC+/	(ɛt-ĩː)(kí-lɨ)	(ɛt-iː)(ŋíː)-lɨ
1.2	/kuk+ɛC+/	(kuk-ɛː)(t-ĩː)(kí-lɨ)	(kuk-ɛː)(t-iŋíː)-lɨ
1.3	/tsih+ɛ+C/	(tsih-ɛː)(t-ĩː)(kí-lɨ)	(tsih-ɛː)(t-iŋíː)-lɨ

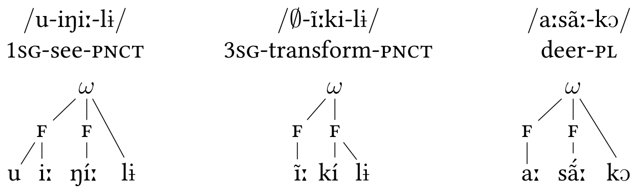


Fig. 6 Lexical long vowels may give rise to monosyllabic feet

sist of two light syllables, etc. Essentially, we are assuming that the iambic/trochaic "law" (Hayes 1995) is enforced in Kuikuro, preferring a duration contrast in head-final iambic feet and preferring equal duration in head-initial trochaic feet.

(1) PARSE-σ: assign one violation mark syllable not dominated by a foot (Prince and Smolensky 1993/2004)

(2) IAMB: assign one violation mark to every foot that is not right-headed (Prince and Smolensky 1993/2004)

(3) $*\mathrm{V}{:}]_{\phi}$: assign one violation mark to a long vowel in the last syllable of the phrase (Buckley 1998; Myers and Hansen 2007)

In contrast to the fully predictable length in the roots /ipɔ/, /ikɛu/ (Table 1), the effect of lexically long vowels is seen in Table 3, with verbs such as /ĩːki/ 'transform', whose first vowel is long regardless of its position. The root /iŋiː/ 'see' has a fixed long vowel in its second syllable, and its first vowel alternates based on the amount of prefixal material that precedes it. In our field notes, verb roots that have a lexically long vowel are a minority (17/59, 29%), while most verb roots show completely predictable vowel length alternations as in Table 1.

Underlyingly long vowels obligatorily head an iamb on the surface (Fig. 6). When preceded by an even number of syllables, iambic lengthening creates two adjacent

Table 4 Iambic rhythm disrupted by a lexically long (underlying) vowel

/σσσːσ/	*Vː]$_\phi$	MAX-μ	PARSE-σ	IAMB
a. (σˌσː)(ˈσσ)		*! W	L	* W
b. σ(σˈσː)σ			**! W	
c. ☞ (σˌσː)(ˈσː)σ			*	

Table 5 Regular iambic lengthening in nouns, with a lexical long vowel in [áːʀɨ]

'seed/leaf'	'(type of tree)'	
(áʀɨ)	(áː)ʀɨ	(no suffix)
(aʀɨ́ː)-kɔ	(aː)(ʀɨ́-kɔ)	-PL
(aʀɨː)-(kɔ́-pɛ)	(aː)(ʀɨ-kɔ́ː)-pɛ	-PL-NTM
(aʀɨː)-(kɔ-pɛ́ː)-ki	(aː)(ʀɨ-kɔː)-(pɛ́-ki)	-PL-NTM-INS

long vowels, e.g., [(u-iː)(ŋíː)-lɨ] '1SG-see-PNCT'. Two adjacent long vowels may also arise when both are lexical, e.g., [(aː)(sã́ː)-kɔ] 'deer-PL'.

Table 4 shows the derivation of a word with an underlying long vowel in an odd-numbered syllable. Regular left-to-right parsing is prevented by MAX-μ. Footing the lexically long vowel into a disyllabic foot runs afoul of PARSE-σ. The winner satisfies MAX-μ while minimally violating PARSE-σ.

To summarize so far, we have seen that verbs in isolation always appear with a penultimate High tone. Vowel length is predictable from left-to-right iambic lengthening in the majority of verbs, but lexical long vowels can disrupt this footing. In the proposed analysis, left-to-right iambic lengthening, final trochaic reversal, and right-headedness together ensure that the penult is the head syllable of the word. The proposed prosodic structure allows us to understand the High tone on the penult as being attracted to the primary stress.

3.2 Vowel length in nouns, adjectives, and postpositions

Verbs are phonologically unmarked relative to nouns for prosodic contrasts like tone and stress in many languages (Smith 2010), and this cross-linguistic pattern is seen in Kuikuro as well. Tone is predictable in verbs, but nouns may have lexical tone (see §5 below).

In terms of vowel length, nouns and verbs pattern exactly the same. However, a rich array of suffixes on nouns makes it easier to see the resumption of regular iambic rhythm following lexically long vowels, as in Table 5, with the minimal pair [(áʀɨ)] vs. [(áː)ʀɨ]. Except for the lexical long vowel in [(áː)ʀɨ], length alternations on the roots and suffixes are predictable, as is the High tone on the primary stress penult. Lexical long vowels are also seen in adjectives and postpositions, e.g., [(hɛː)(kítɛ)] 'beautiful', [(áː)ta] 'inside'.

Phrase-finally, lexically long vowels are shortened, as in /ikuː/ → [(íku)] 'paint'; the long vowel surfaces in the possessive [(u-iː)(kúː)-sɨ] '1SG-paint-POSS', and similarly in /aːsã́ː/ → [(aː)sã́] 'deer', cf. [(aː)(sã́ː)-kɔ] 'deer-PL'. Table 6 shows that

Table 6 Lexically long vowels are shortened phrase-finally

/σσː/	*Vː]$_\phi$	MAX-μ	PARSE-σ	IAMB
a. (σˈσː)	*! W	L		L
b. ☞ (ˈσσ)		*		*

Table 7 High tone domain (underlined) left-aligns to the head syllable of the phrase

/σσσ/	ALIGN-L(Δ$_\phi$,H)	NONFIN(H)	ALIGN-R(H)
a. ☞ (σˈ<u>σ́ː</u>)σ			*
b. (σˈ<u>σː)σ́</u>		*! W	L
c. (<u>σˈσ́ː</u>)σ	*! W		*

MAX-μ is dominated by *Vː]$_\phi$, causing the shortening of all vowels phrase-finally. Long vowels are only allowed phrase-finally in monosyllables, e.g., [(íː)] 'tree', [(tɔ̃́ː)] 'emu'; this shows that feet must be minimally bimoraic (FOOTBIN).

Table 7 derives the presence of the default penultimate tone. Here, we only consider candidates with optimal foot structure, in this case, one left-aligned iambic foot that puts the primary stress on the penult. High tones are realized inside High tone domains, and the edges of tone domains are regulated by violable constraints. The left edge of the tone domain is regulated by the alignment constraint ALIGN-L(Δ$_\phi$,H), which requires every phrase head (Δ$_\phi$) to be left-aligned to a High tone domain (4). This constraint prevents the tone from appearing to the left of the primary stress of the phrase. The right edge of the tone domain is regulated by ALIGN-R(H), which promotes maximal expansion rightward (5), but ALIGN-R(H) is dominated by NONFIN(H), a constraint that penalizes phrase-final High tones (6). Together, these constraints assure that default tones are pronounced inside a domain that encompasses the penultimate syllable of a word in isolation. These constraints on tone domains presuppose the existence of the metrical or prosodic structure, specifically the primary stress of the phonological phrase and its right edge.

(4) ALIGNL(Δ$_\phi$,H): assign one violation mark to every mora that intervenes between the left edge of every phrase head (Δ$_\phi$) and the left edge of some High tone domain (Becker 2007)

(5) ALIGNR(H): assign one violation mark to every mora that intervenes between the ridge edge of every phrase and the right edge of some High tone domain (Cole and Kisseberth 1994; Cassimjee and Kisseberth 1998)

(6) NONFIN(H): assign one violation mark to every High tone that includes the final mora of the phrase (Myers 1998; Cassimjee and Kisseberth 1998)

To summarize thus far, we see that underlyingly long vowels disrupt the iambic rhythm when they surface in an odd-numbered syllable. When an underlyingly long vowel appears phrase-finally, it is shortened. An epenthetic High tone surfaces on the

Table 8 Derived long vowels via fusion (+harmony)

a.	/u-u/ → [uː]	/u-uãki-lɨ/	[(uː)(ãkíː)lɨ]	'1SG-knead-PNCT'
b.		/ɛ-uãki-lɨ/	[(ɛuː)(ãkíː)lɨ]	'2SG-knead-PNCT'
c.		/∅-uãki-lɨ/	[(uãː)(kílɨ)]	'3SG-knead-PNCT'
d.		/u-ɔpi-pɨʀɨ/	[(uɔː)(pipɨ́ː)ʀɨ]	'1SG-return-PRF'
e.	/ɛ-ɔ/ → ɔ-ɔ → [ɔː]	/ɛ-ɔpi-pɨʀɨ/	[(ɔː)(pipɨ́ː)ʀɨ]	'2SG-return-PRF'
f.		/∅-ɔpi-pɨʀɨ/	[(ɔpiː)(pɨ́ʀɨ)]	'3SG-return-PRF'

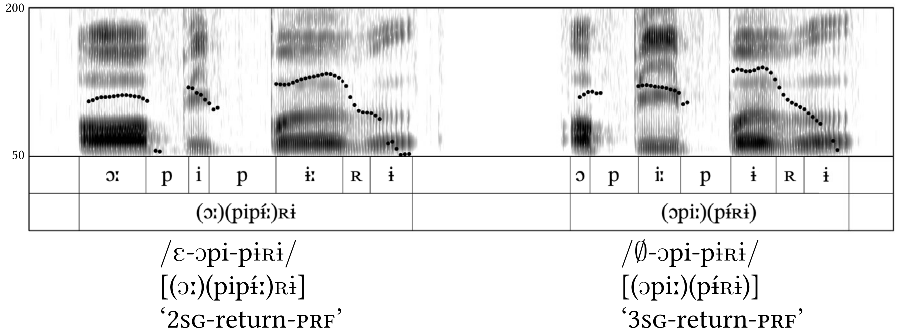


Fig. 7 Derived long vowel via harmony+fusion vs. default length

penult of words in isolation due to constraints that require a High tone domain to include the head of the phrase.

3.3 Hiatus and derived long vowels

Kuikuro is rich in vowel–vowel sequences that are treated as separate syllables by iambic lengthening, as seen in the paradigm of /ikɛu/ in Table 1 above. However, when two identical vowels meet, they fuse into one long vowel. This happens, for example, in the juncture of the 1SG prefix /u/ with any [u]-initial root, verbal or nominal, e.g., /u-uãki-lɨ/ → [(uː)(ãkíː)-lɨ] (Table 8a); compare the unprefixed form [(uãː)(kí-lɨ)] (Table 8c). Without contraction, the two [u]'s would have given rise to *[(uuː)(ãkíː)-lɨ]. Iambic foot parsing resumes after the word-initial derived long vowel as expected. The 1SG prefix /u/ does not fuse with any other vowel, cf. lack of fusion in /u-ɨi-lɨ/ → [(uɨː)(ílɨ)] '1SG-make-PNCT'.

Similarly, the 2SG prefix /ɛ/ fuses with root-initial /ɛ/, e.g., /ɛ-ɛ-lɨ/ → [(ɛ́ː)lɨ] '2SG-kill-PNCT', rather than the ill-formed *[(ɛɛ́ː)lɨ] without fusion.

Fusion is fed by vowel harmony of the 2SG prefix /ɛ/. This prefix regularly harmonizes in backness/rounding with the non-low [a] and [ɔ] (Franchetto 1995), as seen across a root-initial consonant in [(a-t͡saː)(kú-lɨ)] '2SG-run-PNCT', [(ɔ-hɔː)(tɛ́-lɨ)] '2SG-burn-PNCT'. In vowel-initial roots, this harmony feeds fusion, e.g., /ɛ-ahu-lɨ/ → a-ahu-lɨ → [(aː)(húlɨ)] '2SG-punch-PNCT', /ɛ-ɔpi-pɨʀɨ/ → ɔ-ɔpi-pɨʀɨ → [(ɔː)(pipɨ́ː)ʀɨ] (Table 8e). Figure 7 and Table 8e,f show how the contrast between the 2SG and 3SG is expressed by vowel length. More broadly in the language, non-identical vowels do not fuse, e.g., adjacent [a] and [ɛ] may surface in either order, as in [(ɛʀɛ́ː)a] 'thus', [(aɛ́ː)tsi] 'one'. Fusion only applies between vowels of identical quality, and fusion is fed by the independently observed harmony of the 2SG prefix.

The same fusion of the 1SG and 2SG prefixes with stem-initial vowels is also observed in nouns, e.g., /u-uika-Ø/ → [(uː)(íka)] '1SG-pequi.orchard-POSS', cf. [(uíː)ka] 'pequi.orchard'. In both nouns and verbs, then, person prefixes are often only expressed by vowel length differences. Non-high vowels are fused (with backness harmony) in /ɛ-aʀɨ-Ø/ → [(áː)ʀɨ] '2SG-seed-POSS', which is homophonous with the monomorphemic [(áː)ʀɨ] '(type of tree)'. This last example further shows that the result of fusion is indistinguishable from a lexically long vowel.

The 2SG prefix also fuses with lexically long vowels, e.g., /ɛ-ɛːʀɛpɛ-ʀɨ/ → [(ɛː)(ʀɛpɛ́ː)-ʀɨ] '2SG-humus-POSS'. Harmony followed by fusion with a long vowel is seen in /ɛ-ɔ̃ː-lɨ/ → ɔ̃-ɔ̃ː-lɨ → [(ɔ̃́ː)lɨ] '2SG-reject-PNCT'. The 2SG and 3SG forms are homophonous in these cases, e.g., [(ɔ̃́ː)lɨ] '2SG-reject-PNCT' is homophonous with /Ø-ɔ̃ː-lɨ/ → [(ɔ̃́ː)lɨ] '3SG-reject-PNCT'. This homophony is further evidence for the lack of distinction between a long vowel (Vː) and a putative overlong (*VVː).

Given that adjacent identical vowels fuse to one long vowel, lexically long vowels could be represented as vowel sequences underlyingly. For example, the noun [áːʀɨ] '(type of tree)' could be derived equally from either /aːʀɨ/ or /aaʀɨ/. Similarly, the root 'see' (Table 3) could be underlyingly /iŋiː/ or /iŋii/. The choice of underlying representation in these cases depends on the analyst's theoretical assumptions. Fusion to one long vowel could apply either before or after iambic lengthening; surface forms with two adjacent identical vowels, e.g., *[aaːʀɨ] must be blocked either way.

While Kuikuro is extremely tolerant of vowel hiatus, there are two morphologically limited cases of hiatus avoidance. First, the detransitivizer prefix /ɛC/ loses its vowel when it is preceded by the 1SG prefix /u/ or the 2SG prefix /ɛ/ (see Table 1). Second, the 3SG verbal prefix is [i-] when attaching to consonant-initial roots and null otherwise. We presented this prefix above as /Ø/ for convenience; presumably the full analysis includes /Ø/ and /i/ as allomorphs, or the prefix could have a representationally deficient underlying vowel, along the lines of Smolensky and Goldrick (2016).

3.4 Post-lengthening phonology

There are two deletion processes that interact opaquely with iambic lengthening, creating long vowels in odd-numbered syllables. First, word-initial short unstressed vowels are often/usually deleted, creating a word with a long vowel in the newly initial syllable.[4] For example, [(ihṹː)bɛ] 'coal' is usually pronounced as [(hṹː)bɛ] and written ⟨humbe⟩, without its initial vowel. The root-initial vowel is obligatorily pronounced when protected by a prefix, e.g., [(u-iː)(hũbɛ́ː)-ʀɨ] '1SG-coal-POSS', *[(u-hũː)(bɛ́-ʀɨ)]. As the vowel length alternations between the prefixed and prefixless forms show, the long vowel of [(hṹː)bɛ] should not be construed as underlying, but should rather be derived from /ihũbɛ/ via regular footing followed by initial vowel deletion. Transparent iambic lengthening creates long vowels in even-numbered syllables, whereas initial vowel deletion obscures the output of this process and creates a long vowel in an odd-numbered syllable.

[4] Figure 15 below shows the word /itɔtɔ/ 'man' pronounced [(tɔ́ː)tɔ] with a deleted initial vowel.

Table 9 Minimality requirements by part of speech

category	minimal size			
	moras	syllables	example	
interjection	μ	σ	(kɔ́)	'I don't know!'
verb root	—	—	/∅/	'say'
verb (surface)	μμ	σ	(t-íː)	'ANA-fight-PTCP'
noun	μμ	σ	(háː)	'woven bag'
postposition	μμ	σσ	(ʀɛ́pɔ)	'next.to'

Foot heads are protected from initial vowel deletion, i.e., deletion does not apply to long vowels, e.g., [(ĩː)(ki-pɨ́ː)ʀɨ] '3SG-transform-PRF' *[(ki-pɨ́ː)ʀɨ], nor to phrasal penults, as in [(átɔ)] 'friend', *[tɔ].

Another rule that obscures the effect of iambic lengthening is the optional reduction of the 1.2 prefix /kuk-/ to [k] before a vowel-initial stem, e.g., [(kuk-iː)(pɔ́-lɨ)] '1.2-pierce-PNCT' is usually reduced to [(k-iː)(pɔ́-lɨ)], in speech and in writing. Here too, the long vowel that was created in an even-numbered syllable by iambic lengthening surfaces in an odd-numbered syllable.

Both deletion processes apply in casual or informal speech and informal writing, regardless of speech rate. The full forms are reserved for formal occasions, such as language documentation or the preparation of pedagogical materials.

3.5 Minimality requirements

Having surveyed the prosodic structure of words in isolation, we take a detour to document the minimal size requirements on words. Minimality requirements differ by part of speech. These are summarized in Table 9, and surveyed here in increasing order of strictness. The least restricted are interjections, which may be monomoraic on the surface, e.g., [(kɔ́)] 'I don't know!'. Note the monomoraic foot, which occurs nowhere else in the language. Interjections are known to be the least phonologically restricted in many languages, cf. the subminimal interjection [ˈmɛ] 'meh' in English.

Verbs are all minimally bimoraic on the surface, e.g., [(t-íː)] 'ANA-fight.PTCP'. But verb roots may be monomoraic, or even phonologically null, with the bimoraic minimum ensured on the surface via affixation, e.g., [(i-ɲɨ́ː)ʀɨ] 'become-PNCT' from the monomoraic root /i/ 'become', [(tu-ɛ́)] 'ANA-kill.PTCP' from the monomoraic root /ɛ/ 'kill', and [∅-(nɨ́ʀɨ)] 'say-PNCT' from the null root /∅/ 'say'.

Nouns are similarly minimally bimoraic on the surface, e.g., [(háː)] 'woven bag', [(ɨ́ː)] 'axe', [(átɔ)] 'friend' (recall that monosyllables resist final shortening, §3.2). For nouns, however, the bimoraic minimality holds even at the root level; there are no known nominal roots with fewer than two moras (see also Buckley 1998 on the related language Carib).

Postpositions are minimally disyllabic, and therefore also minimally bimoraic, e.g., [(káɛ)] 'on', [(ʀɛ́pɔ)] 'next.to'. There are no monosyllabic postpositions as independent phonological words.

To summarize, minimality restrictions are strongest on postpositions, which are minimally disyllabic, while nouns, verbs, and interjections may be monosyllabic.

Nouns are subject to a minimality requirement of two moras, both at the word and the root level. Verbs must be minimally bimoraic on the surface, but verb roots can be monomoraic or even null. Interjections may be monomoraic on the surface.

Smith (2010) provides a typological survey of category-specific phonological effects, and finds a few languages in which nouns are subject to stricter minimality restrictions compared to verbs, just like Kuikuro. Smith does not survey prepositions, postpositions, or interjections.

3.6 Local summary

Long vowels appear predictably in even-numbered non-final syllables, which we attributed to a left-to-right iambic parse. Lexical long vowels may appear in the roots of nouns, verbs, adjectives and postpositions, with regular iambic lengthening up to and following the arhythmic lexical vowels (§3.1, §3.2).

In addition to lexical long vowels, which may appear in any position in a root, there are two sources for long vowels in word-initial syllables: fusion of a prefix vowel with a root-initial vowel (§3.3) and deletion of an initial unstressed light syllable (§3.4).

Word-minimality requirements differ by part of speech, with the strongest restrictions on postpositions, followed by nouns, verbs, and interjections (§3.5).

A default High tone appears on the penultimate syllable, which we attributed to a combination of an iambic parse, final trochaic reversal, the last foot of the word being strongest, and the attraction of the High tone to the metrically strongest syllable. Lexical tone, which may appear on nouns, adjectives, and postpositions, will be discussed in §5. But first we turn to the phrasal phonology in §4.

4 Phrasal phonology

Phrases in Kuikuro have exactly one High tone that appears on or shortly after the first word of the phrase. We analyze phrases as being headed by their first word, with a tone domain that starts at the primary stressed syllable of the first word and includes all following unstressed syllables up to (but not including) a following stressed syllable. In this analysis, the grammar creates a maximal tone domain subject to a limit of one stressed syllable per domain.[5] The position of the tone domain depends on the metrical structure; in a serial theory, the metrical structure would be built first, and the tone domain would be built next based on the word-level and phrase-level metrical structure.

As an example, repeated from §1, the noun [(u<u>mɨ́ː</u>)ŋi] ‘annatto’ and verb [alaːma<u>kɨ́ː</u>lɨ] ‘s/he fell’ combine to make the phrase [(u<u>mɨː)ŋi ⟨a⟩(lá</u>maː)(kilɨ)] ‘the annatto fell’ (see the pitch track in Fig. 3), with the underline marking a tone domain that begins at the primary stress of the phrase (= the primary stress of the first word of the phrase), and extends maximally rightward up to (but not including) the following foot head [maː]. The acute accent marks the position of highest pitch (the location of the High tone target), with pitch rising gradually to it from the beginning of the domain.

[5] The position of the High tone can equivalently be described in terms of autosegmental theory: the High tone docks to the primary stressed syllable of the phrase and then shifts up to (but not including) the following stressed syllable.

Table 10 Examples of syntactically binary phrases, combining two words or a word with a phrase

a.	[internal argument + verb]	‘(the) friend (was) injured’ [(a<u>tɔ́ː</u>) (hɛlɨ)]
b.	[verb + postposition]	‘before (s/he was) injured’ [(i-<u>hɛː)lɨ ⟨i⟩(ʀá</u>kaː)hɔ]
c.	[noun + postposition]	‘next.to (the) friend’ [(a<u>tɔ́ː</u>) (ʀɛpɔ)]
d.	[noun + noun]	‘shoe’, lit. ‘foot cover’ [(ta<u>pɨː)ʀɨ́</u> (iŋɨ)]
e.	[[noun + noun] + verb]	‘(the) shoe fell’, lit. ‘foot cover fell’ [(ta<u>pɨː)ʀɨ́</u> (iŋɨ) ⟨a⟩(lamaː)(kilɨ)]
f.	[noun + [noun + noun]]	‘(the) man’s shoe’, lit. ‘man foot cover’ [(i<u>tɔː)tɔ (tá</u>pɨː)ʀɨ (iŋɨ)]

As this example shows, the syllable with highest pitch, which is phonetically prominent, does not *cohere* with the phonologically most prominent syllable of the phrase. We thus describe Kuikuro stress as “incoherent”, to borrow Gordon’s (2016) term. This discrepancy, or incoherence, was first noted in da Silva and Franchetto (2011), but without a description of the distribution of long vowels. Here, we provide the first description of vowel length in Kuikuro and the first grammar that generates the distribution of tone and its reliance on the iambic parse.

Syntactically, phrases are head-final and maximally binary (Franchetto 2018), joining a variety of elements, such as an internal argument with a following verb, two nouns in a compound or possessive construction, etc.; see Table 10a–d. Bigger syntactic phrases may be formed recursively by combining a phrase and a word, as in Table 10e,f; see Franchetto (2018) for an overview. We found no phonological differences between these different syntactic structures.

Phonologically, phrases are always headed by their linearly first word. This phonological left-headedness is diagnosed by the appearance of tone on or shortly after the first word of the phrase, the regular deletion of lexical tone from non-initial words (see §5 below), and the irregular shortening of lexically long vowels in non-initial words (see §4.4 below). Since phrases have exactly one tone each, we don’t examine the height of High tones, either absolutely or relatively.

This section surveys the phrasal facts, starting with the distribution of final shortening in §4.1, the position of default tones in §4.2, the effect of initial vowels in §4.3, the shortening of lexically long vowels in §4.4, and a summary in §4.5.

4.1 Final shortening is phrasal

Phrase-medially (= non-finally), the iambic parse can cover the entire word and lengthen word-final vowels, i.e., final shortening does not apply to words but rather to phrases. Our description assumes a bare-bones prosodic hierarchy (Selkirk 1995) where words (ω) are dominated by phrases (ϕ).

Figure 8 shows how the word /atɔ/ ‘friend’ surfaces with short vowels when phrase-final, either in isolation $[[(\text{atɔ})]_\omega]_\phi$ or with a preceding word $[[...]_\omega\ [(\text{atɔ})]_\omega]_\phi$,

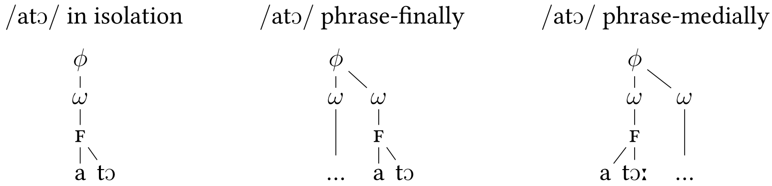
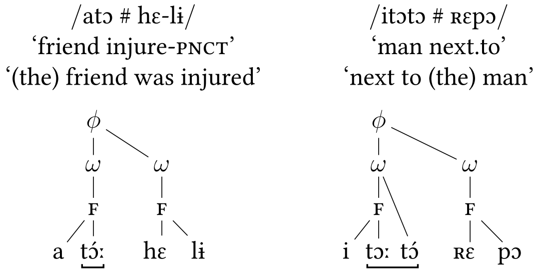


Fig. 8 Iambic lengthening blocked phrase-finally

Fig. 9 Tone domains extend up to the head of a trochee



but iambic lengthening applies phrase-medially in [[(atɔː)]$_{\omega}$ [...]$_{\omega}$]$_{\phi}$. Unlike phrase-final words, which have uniform penultimate stress by default, stress in non-phrase-final words is variable: the primary stress is penultimate in odd-parity words, e.g., [(ihũː)bɛ] 'coal', and final in even-parity words.

As discussed in §3.2, phrase-final shortening also impacts lexically long vowels, e.g., [[(aː)sã́]$_{\omega}$]$_{\phi}$ 'deer' from /aːsã́ː/; both root vowels surface faithfully phrase-medially, or with a suffix, as in [[(aː)(sã́ː)-kɔ]$_{\omega}$]$_{\phi}$ 'deer-PL'.

4.2 Tone domains extend up to a stressed syllable

Each phonological phrase in Kuikuro is pronounced with one High tone. In terms of tone domains (Cole and Kisseberth 1994; Cassimjee and Kisseberth 1998; McCarthy 2004), a tone domain starts from the primary stress of the phrase (i.e., the final or penultimate syllable of the initial word) and extends maximally rightward to include any unstressed syllables. In this subsection, we will see how this plays out in three situations: when the second word of the phrase begins with a trochee, when it begins with an iamb, and when it begins with a monosyllabic foot (lexical long vowel). The examples are limited to second words that are consonant-initial, while vowel-initial cases will be discussed in §4.3 below.

Phrases with a trochee-initial second word are seen in Fig. 9, exemplified with a noun followed by a trochaic verb and a noun followed by a trochaic postposition. The tone surfaces on the last syllable before the trochee, which is the last syllable of the first word (head word) of the phrase. The proposed tonal domains are marked with an underline. Further examples are given in Table 11.

Phrases with an iamb-initial second word are seen in Fig. 10, where nouns are internal arguments for verbs with three, four, and five syllables. In these cases, the tone domain extends to the unstressed initial syllable of the second word of the phrase, crossing the word boundary. Further examples are given in Table 12.

Table 11 Examples of tone domains extending up to the head of a trochee

N + V	(itɔː)(tɔ-pɛ́ː) (ta-lɨ)	'man-NTM hear-PNCT'
		'the former man was heard'
	(kaʀaː)(mukɛː)-kɔ́ (hɛ-lɨ)	'child.PL injure-PNCT'
		'the children were injured'
N + P	(ĩdaː)(ʀɨpɛ́ː) (huɟa)	'riparian.woodland inside'
		'in the riparian woodland'
	(ɔtɔ́ː) (ʀɛpɔ)	'master next.to'
		'next to the master'
N + ERGATIVE	(itãː)ɔ̃́ (hɛkɛ)	'woman ERGATIVE'
	(aː)(sã́ː) (hɛkɛ)	'deer ERGATIVE'

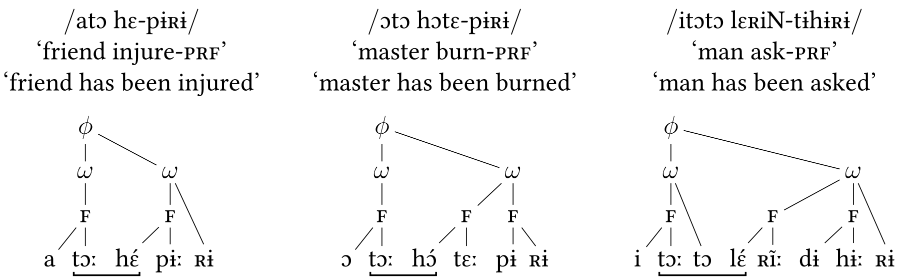


Fig. 10 Tone domains extend up to the head of an iamb

Table 12 Examples of tone domains extending up to the head of an iamb

N + V	(itɔː)tɔ (tá-piː)ʀɨ	'man hear-PRF'
		'the man has been heard'
	(itɔː)(tɔ-kɔː)-pɛ (lɛ́ʀiː)-(nɨʀɨ)	'man-PL-NTM ask-PNCT'
		'the former men were asked'
N + P	(ĩdaː)(ʀɨpɛː) (húɟaː)-ti	'riparian.woodland inside-to'
		'into the riparian woodland'
	(ɔtɔː) (ʀɛ́pɔː)-ŋɔ	'master next.to-NOMINALIZER'
		'that which is next to the master'
N + N	(itɔː)tɔ (tápiː)-ʀɨ	'man foot-POSS'
		'the man's foot'
	(itãː)ɔ̃ (kúiː)(ʀi-sɨ)	'woman manioc-POSS'
		'the woman's manioc'
V + P	(ku-tɛː)-lɨ ⟨i⟩(ʀákaː)hɔ	'1.2-go-PNCT before'
		'before we go'

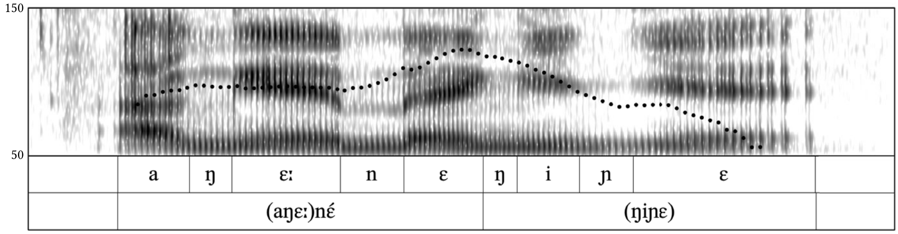


Fig. 11 Tone blocked by the head of a trochee in [(aŋɛː)nɛ́ (ŋiɲɛ)] 'animal behind', 'behind the animal', from /aŋɛnɛ ŋiɲɛ/

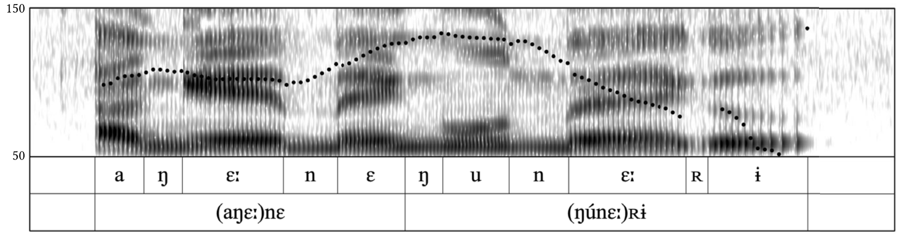


Fig. 12 Tone blocked by the head of an iamb in [(aŋɛː)nɛ (ŋúnɛː)-ʀɨ] 'animal moon-POSS', 'the animal's moon', from /aŋɛnɛ ŋunɛ-ʀɨ/

Table 13 Examples of tone domains extending up to the head of a monosyllabic foot

N + N	(itɔː)tɔ ⟨í⟩(saː)(ki-sɨ)	'man (type of tree)-POSS'
		'the man's (type of tree)'
	(kaŋaː)(mukɛ́ː) (aː)(ʀɨ-lɨ)	'child (type of tree)-POSS'
		'the child's (type of tree)'

Compare how the same short vowel of the root [hɛ] 'injure' blocks the spread of tone in [(atɔ́ː) (hɛ-lɨ)] (Fig. 9) but not in [(atɔː) (hɛ́-piː)ʀɨ] (Fig. 10). The assumption that disyllables such as [(hɛ-lɨ)] are parsed as trochees when phrase-final provides a unified account of three different facts: the lack of iambic lengthening, the attraction of the phrasal tone to the penult in isolation, and the blocking of the same phrasal tone when phrased with a preceding word.

The pitch tracks and spectrograms in Figs. 11 and 12 show tone domain expansion being blocked by the head of a trochee and by the head of an iamb, respectively. Obstruent-free words were selected to show an unperturbed F_0.

Phrases with a second word that begins with a monosyllabic foot are seen in Fig. 13. Here, tone surfaces on the last syllable of the first word, blocked by the head of a monosyllabic foot. Further examples are given in Table 13.

The analysis in terms of violable constraints at the phrase level is seen in Table 14. We examine candidates that have the correct metrical structure, which is ensured by higher ranking constraints and/or earlier in the derivation. As before, ALIGN-L(Δ_ϕ,H) requires a tone domain to left-align to the head syllable of the phrase (see

/atɔ hɛːtsɛ-lɨ/ /itɔtɔ hɛːtsɛ-pɨʀɨ/
'friend trip-PNCT' 'man trip-PRF'
'the friend was tripped' 'the man has been tripped'

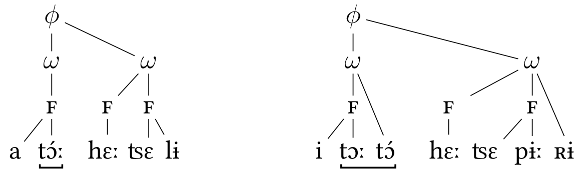


Fig. 13 Tone domains extending up to the head of a monosyllabic foot

Table 14 High tone domain left-aligns to the head syllable of the phrase, and expands rightwards maximally up to the next foot head

/σσσ # σσσ/	ALIGN-L(Δ_{ϕ},H)	NONFIN-H	CULM-H	ALIGN-R(H)
a. ☞ (σˈσː)σ (σ́ˈσː)σ				**
b. (σˈσː)σ (σˈσ́ː)σ			*!	*
c. (σ́ˈσː)σ (σ́ˈσː)σ	*!			**

Table 7 above), preventing leftward expansion. The tone domain expands rightward to minimize the violations of ALIGN-R(H), subject to CULMINATIVITY-H (7), which penalizes tone domains that don't have exactly one stressed syllable in them (see §6.1 for further discussion of this constraint). NONFINALITY-H is vacuously satisfied in phrases, since the phrasal tone can never reach the phrase-final syllable.

(7) CULMINATIVITY-H: assign one violation mark to every High tone domain that includes more than one foot head.

To summarize, when multiple words are joined into a phonological phrase, and the second word begins with a consonant, default tone appears on the final syllable of the first word, or on the first syllable of the second word. The position of the tone depends only on the footing of the second word: when the second word starts with a stressed syllable, either the head of a trochee or the head of a monosyllabic foot, tone appears on the syllable before it. When the second word begins with an iamb, tone appears on the initial unstressed syllable of the iamb. In the proposed analysis, tone domains left-align to the strongest syllable of the phrase and expand rightward to include any available unstressed syllables. The generalizations above hold when the second word begins with a consonant, and no lexical tones are present. Vowel-initial words and lexical tones will be taken up in §4.3 and §5 below.

4.3 Initial unstressed vowels are unparsed

Vowel-initial words offer a little surprise when preceded by another word in the same phrase: iambic parsing starts one syllable later than otherwise expected, leav-

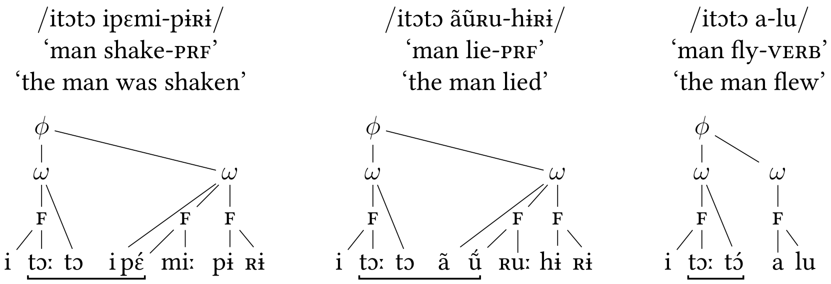


Fig. 14 Initial vowels are unparsed phrase-internally, minimality allowing

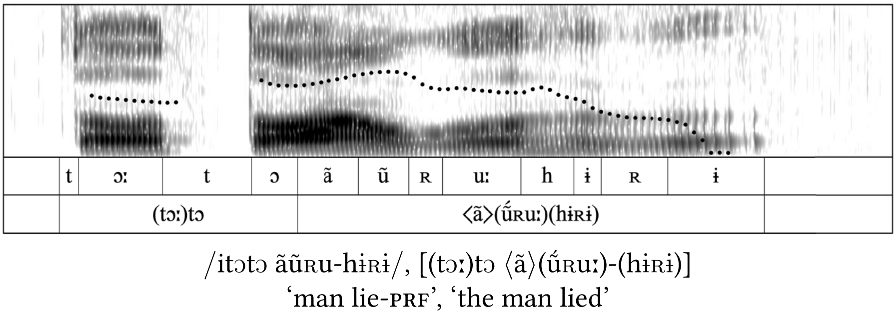


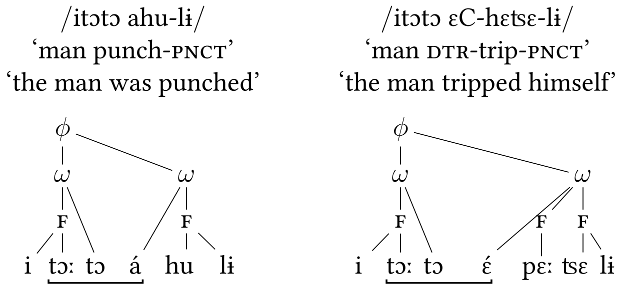
Fig. 15 Phrase-medially, an initial unparsed vowel leads to later iambic lengthening and later tone

ing the initial vowel unparsed. The High tone can then extend one syllable further, blocked by the later foot head. For example, the verb that appears in isolation as [Ø-(aʀ-aː)(kãdɔː)(tɛ-pɨ́ː)ʀɨ] '3SG-DTR-give.bench-PRF', with long vowels in the second, fourth, and sixth syllables, appears with a preceding internal argument as [... ⟨a⟩(ʀ-ákãː)(dɔtɛː)-(pɨʀɨ)], with long vowels in the third and fifth syllables. Figure 14 shows the same pattern with the verb [... ⟨i⟩(pɛ́miː)(pɨʀɨ)] 'shake-PRF', cf. the isolation form [(ipɛː)(mi-pɨ́ː)ʀɨ]. The tone domain extends two syllables into the second word of the phrase, as expected when the first two syllables are unstressed. Pitch tracks for this pattern are shown in Fig. 3 above and Fig. 15.

Leaving initial vowels unparsed does not necessarily provide a consonantal onset, as in the second example in Fig. 14 and the pitch track in Fig. 15, where the initial vowel of [... ⟨ã⟩(ṹʀuː)-(hɨʀɨ)] 'lie-PRF' is unfooted even when followed by another vowel, cf. isolation form [(ãũː)(ʀu-hɨ́ː)ʀɨ]. Skipping an initial vowel is obligatory regardless of syllable structure, i.e., it is not necessarily phonologically optimizing. In rule-based terms, initial unparsing is non-iterative: initial unparsing applies only once, even if it creates a new environment for initial unparsing (see discussion in Ampofo and Rasin 2021 and references therein). Initial unparsing applies to all parts of speech, e.g., the initial vowel is unparsed in the noun [... ⟨u⟩(íkaː)-(kɔ-ki)] 'pequi.orchard-PL-INS', cf. the isolation form [(uiː)(ka-kɔ́ː)-ki].

The final example in Fig. 14 shows that the unparsing of an initial vowel is subject to disyllabic minimality, as evidenced by the blocking of tone by the initial vowel of

Fig. 16 Initial unparsed vowels followed by a trochee or a monosyllabic foot



[(a-lu)] 'fly-VERB'. Similarly, unparsing does not impact initial lexically long vowels, e.g., [(itɔː)tɔ́ (ĩː)(ki-pɨː)Rɨ] '(the) man has been transformed', [(atɔ́) (aː)(Rɨ-lɨ)] '(the) friend's (type of tree)-POSS'.

Downing (1998) discusses the stress patterns of several languages that skip an initial onsetless syllable (see also Post 2000, §4.2), subject to minimality. Kuikuro is unlike these languages in two respects: first, it skips an initial onsetless syllable regardless of the presence of an onset in the following syllable, and second, it skips an initial onsetless syllable only in non-phrase-initial words. One possible account might use a version of the markedness constraint PARSE-σ that is specific to phrase-initial syllables. See Flack (2009) for a survey of stronger markedness pressures in phrasal-initial contexts.

When the non-parsing of word-initial vowels leaves two syllables available for parsing, they are parsed into a trochee, as seen in Fig. 16, and the head of the trochee blocks the spread of tone, e.g., [... ⟨á⟩(hu-lɨ)] 'punch-PNCT', cf. the isolation form [Ø-(ahúː)-lɨ] '3SG-punch-PNCT'. With a longer suffix, the same verb allows the parsing of an iamb in the phrasal form [... ⟨a⟩(hú-pɨː)Rɨ] 'punch-PRF'. The same short vowel in [hu] blocks the expansion of the tone domain when it is the head of a trochee, but not when it is the dependent of an iamb.

Figure 16 also shows an unparsed word-initial vowel followed by a lexically long vowel in the verb [... ⟨έ⟩-(pεː)(tsε-lɨ)] 'DTR-trip-PNCT', from /εC-hεːtsε-lɨ/ (with the regular strengthening of [h] to [p] after the detransivitizer, Franchetto 1995). To see that this root starts with a lexically long vowel, compare with [(tsih-εː)-(pεː)(tsέ-lɨ)] '1.3-DTR-trip-PNCT', and with the root-initial forms of the same verb in Fig. 13.

Like other initial unstressed vowels, unparsed vowels are optionally deletable (see §3.4). Deletion is possible both phrase-initially and phrase-medially, and has no effect on footing in either environment. Thus, the isolation form [(ipεː)(mi-pɨ́ː)Rɨ ∼ (pεː)(mi-pɨ́ː)Rɨ] has a long [pεː] regardless of the presence of the initial [i], and the phrasal form [... ⟨i⟩(pέmiː)(pɨRɨ) ∼ ... (pέmiː)(pɨRɨ)] has a long [miː] regardless of the presence of the initial [i]. Deletion is blocked in disyllables such as [... (alu)] and in initial long vowels, as expected from their analysis as heading a trochee and a monosyllabic foot, respectively.

To summarize, this subsection provided further support for the dependence of tone on the metrical parse: when word-initial vowels are unparsed, tone surfaces one syllable later than otherwise expected. Tone is not blocked by long vowels, but rather by foot heads: the head of a trochee blocks tone just like the head of an iamb or the head of a monosyllabic foot. The unparsed vowel is optionally deletable, as are initial unstressed vowels more generally.

Unparsing applies to initial short vowels that are followed by two or more syllables. The motivation for unparsing word-initial vowels is unknown; it does not necessarily improve syllable/foot structure, as it applies whether the following segment is a consonant or a vowel. Initial unparsing applies regardless of segmental quality, regardless of the structure of the preceding word, and regardless of part of speech.

4.4 Shortening of lexical long vowels

Lexically long vowels are generally maintained anywhere in the phrase, except for the absolute phrase-final position (e.g., /ikuː/ → [(íku)] 'paint'). However, a few native roots keep their lexically long vowel only in the head position of the phrase (= the initial word of the phrase). When these roots are not in the phonological head of the phrase, the lexical long vowel is shortened.

For example, the nouns [(ɛː)(ʀɛ́pɛ)] 'humus' and [(ⁿdúː)ku] 'gourd.POSS' have underlyingly long vowels in their initial syllables. When phrased with an overt possessor, the initial long vowel is shortened: [(itɔː)tɔ ⟨ɛ⟩(ʀɛ́pɛː)ʀɨ] 'the man's humus', [(itɔː)tɔ (ⁿdúkuː)-ʀu] 'the man's gourd', and similarly in a few other nouns. Most nouns, however, maintain their lexically long vowels, e.g., the long vowel of [(aː)(ʀɨ-lɨ)] '(type of tree)-POSS' surfaces faithfully in [(itɔː)tɔ́ (aː)(ʀɨ-lɨ)] 'the man's (type of tree)'.

Among the verbs in our field notes, only the verb /iŋiː/ 'see' shortens its lexical long vowel when outside of the phrasal head, e.g., /itɔtɔ iŋiː-lɨ/ → [(itɔː)tɔ ⟨í⟩(ŋilɨ)] 'the man was seen', cf. [(u-iː)(ŋíː)lɨ] 'I was seen'. All of the other verbs in our notes maintain their lexical long vowels, e.g., [(itɔː)tɔ ⟨í⟩(ʀiː)ɲu] 'the man sang' cf. [(u-iː)(ʀíː)ɲu] 'I sang'.

The stronger faithfulness to lexical length in the initial word of the phrase provides further support for the identification of the phrase-initial word as the phonological head word of the phrase. We will see in §5 that lexical tone is also maintained only in the phrase initial word.

4.5 Local summary

This section presented the metrical structure and the distribution of default tone in phonological phrases. When the second word of the phrase is consonant-initial (Table 15a), tone appears on the first syllable of the second word when it begins with an iamb, otherwise it appears on the last syllable of the first word of the phrase. When the second word of the phrase begins with a vowel, the initial vowel is unparsed (Table 15b), and tone appears one syllable later compared to Table 15a. Unparsing is blocked by minimality and by initial long vowels (Table 15c).

Default tone appears one syllable before the first foot head of the second word of the phrase. We analyzed the pattern using tone domain theory, proposing that a tone domain starts with the primary stressed syllable of the phrase, and extends rightwards up to (but not including) a following foot head. Foot heads block tone whether the head vowel is short or long.

Table 15 Footing and tone in phonological phrases

ω+ C-initial ω	a.	iamb	... $]_\omega$ [(CV́ σː) ...
		trochee	... ´ $]_\omega$ [(CV σ) $]_\omega$
		monosyllabic foot	... ´ $]_\omega$ [(CVː) ...
ω+ V-initial ω	b.	V + iamb	... $]_\omega$ [⟨V⟩ (σ́ σː) ...
		V + trochee	... $]_\omega$ [⟨V́⟩ (σ σ) $]_\omega$
		V + monosyllabic foot	... $]_\omega$ [⟨V́⟩ (σː) ...
	c.	trochee	... ´ $]_\omega$ [(V σ) $]_\omega$
		monosyllabic foot	... ´ $]_\omega$ [(Vː) ...

Table 16 Nouns with lexical tone, by position

a.	...σ	takí	'cricket'	
		sahũːdú	'peacock bass'	
b.		aːmá	'my mother/maternal aunt'	
		kɔːpɔtaːdɔ́	'computer'	<BrP [kõputaˈdoɦ]
c.	...σσ	kutíːʀu	'spatula'	
		gasuːlína	'gasoline'	<BrP [gazoˈlinɐ]
d.		bɔ́ːlu	'cake'	<BrP [ˈbolʊ]
		nɔːfɛ́ːla	'soap opera'	<BrP [noˈvɛlɐ]
e.	...σσσ	tsúpiːku	'skinny guy'	
		paʀaːbɔ́liːka	'satellite dish'	<BrP [paɾaˈbɔlikɐ]
f.		áːɟahi	'potoo (bird)'	
		ɟiaːʀíːsita	'housecleaner'	<BrP [ʤiaˈɾistɐ]

5 Lexical tone

Lexical tone is found in the roots of nouns, adjectives, and postpositions, usually on their final or antepenultimate syllable; see the bare nouns in Table 16. Lexical tone is found in words with predictable vowel length (Table 16a,c,e) or in words with lexical long vowels (Table 16b,d,f). Tone domains are marked with an underline, as in §4. Lexical tone is absent from verb roots (see Smith 2010 for a cross-linguistic survey). Final lexical tone is quite common in names of animals and plants and in proper nouns. We compiled a list with the names of 119 Kuikuro people; in this list, 72% of the names have final lexical tone.

Loanwords from Brazilian Portuguese generally have a lexical tone on the syllable that is stressed in Portuguese (Mehinaku 2010, §5), and sometimes also a lexically long vowel. Further investigation of Kuikuro loanword phonology is left for future work.

Lexical tones can be distinguished from default tones based on their distribution. In words in isolation, lexical tone is trivial to diagnose when it appears in a non-default position: final (Table 16a,b) or antepenultimate (Table 16e,f). Diagnosing penultimate tone requires a neutral suffix, such as the plural [-kɔ]: compare

Table 17 Lexical tone domains expand just like default tone domains

a.	(takíː)-(kɔ-pɛ)	'cricket-PL-NTM'
	(takiː)-(kɔ́-pɛː)-ki	'cricket-PL-NTM-INS'
b.	(áː)(ɟahi)	'potoo'
	(aː)(ɟáhiː)-kɔ	'potoo-PL'
c.	(pa ʀaː)(bɔ́ liː)ka	'satellite.dish'
	(u-paː)(ʀa bɔː)(lí kaː)-sɨ	'1SG-satellite.dish-POSS'

Table 18 Lexical tone deletes from non-head words

a.	toneless + lexical tone			
	/itɔtɔ # taki+sɨ/	→	(itɔː)tɔ (tákiː)-sɨ	'(the) man's cricket'
	/itɔtɔ # sahũdu+sɨ/	→	(itɔː)tɔ (sáhũː)(du-sɨ)	'(the) man's bass'
b.	lexical tone + lexical tone			
	/aːɟahi # taki+sɨ/	→	(aː)(ɟáhiː) (takiː)-sɨ	'(the) potoo's cricket'
	/aːɟahi # sahũdu+sɨ/	→	(aː)(ɟáhiː) (sahũː)(du-sɨ)	'(the) potoo's bass'

the non-default position of tone in [(bɔ́ː)lu ∼ (bɔ́ː)(lu-kɔ)] 'cake(s)' vs. the default penultimate tone in [(ⁿdúː)ku ∼ (ⁿduː)(kú-kɔ)] 'gourd(s).POSS'. Lexical tones can also be diagnosed with two neutral suffixes, e.g., non-default tone in [(takíː)-(kɔ-pɛ)] 'cricket-PL-NTM' vs. default penultimate tone in [(katɨː)-(kɔ́-pɛ)] 'grease-PL-NTM'.

Just like the default tones seen in §4 above, lexical tones are pronounced inside tone domains that include following unstressed syllables, as seen in Table 17. Lexical tones are pronounced inside monosyllabic domains when followed by the head of a trochee, or in disyllabic domains when followed by the dependent of an iamb (Table 17a,b). The context for tone domain expansion may also be created by the addition of a prefix that changes the locus of lengthened vowels (Table 17c).

In phonological phrases, lexical tone is maintained only when its domain starts with the initial word of the phrase, confirming that phrases are phonologically head-initial. This is seen in Table 18, where lexical tone is deleted from non-initial words, regardless of whether the initial word has lexical tone. Tone domains must start from or overlap with the head word of the phrase. Due to tone domain expansion, the syllable that bears the High tone is not necessarily in the initial word of the phrase, as in [(takiː) ⟨i⟩(pɛ́miː)(pɨʀɨ)] '(the) cricket has been shaken'.

Since the domains of lexical tones expand rightward just like domains of default tones, the distinction between lexical and default tone may be neutralized. For example, the distinction between toned /takí/ 'cricket' and toneless /katɨ/ 'grease' is neutralized with any following verb, e.g., [(katɨː) ⟨i⟩(pɛ́miː)(pɨʀɨ)] '(the) grease has been shaken' is exactly parallel to the previous example. Lexical tone remains distinct from default tone phrasally when it originates from an antepenultimate syllable or a short penult, e.g., [(aː)(ɟáhiː) ⟨i⟩(pɛmiː)(pɨʀɨ)] '(the) potoo has been shaken'; here the tone surfaces on the penult of the first word of the phrase, where default phrasal tone never surfaces.

Penultimate lexical tone is rare in the native phonology; [(kutíː)ʀu] 'spatula' (Table 16c), plural [(kutíː)(ʀu-kɔ)], is the only native example we have. In contrast, penultimate lexical tone is very common in loanwords from Brazilian Portuguese.

The proposed analysis does not account for the rarity of penultimate lexical tone in the native phonology, yet surely it is not a coincidence that lexical tone is rare in the position of default tone. A similar antagonism between default stress and lexical stress is seen in Turkish, where final stress must be default and cannot be lexical (Inkelas 1999). Inkelas proposes that final lexical stress is impossible because the final syllable cannot host the binary trochaic foot that encodes stress. But this explanation does not extend to Kuikuro, where lexical tone is dispreferred on a penult, which is guaranteed to be a part of a binary foot.

Another limitation of the analysis proposed here is that nothing prevents the occurrence of lexical tone on the preantepenultimate syllable of a root. Note that tones are not limited to the last foot of bare roots, e.g., [(áː)(ɟahi)] ‘potoo’, and tones may surface arbitrarily far away from the right edge under suffixation, e.g., [(aː)(ɟáhiː)-(kɔ-pɛː)-ki] ‘potoo-PL-NTM-INS’. However, since roots with four or more syllables are rare, this might be a lexical gap.

To summarize, the distribution of lexical tone is limited to the last three syllables of the root in nouns, adjectives, and postpositions. When a word with a lexical tone is phrase-initial, a tone domain left-aligns to the syllable that the tone is associated with, and the domain expands rightward to include any following unstressed syllables, just like a domain that starts with a default tone. Tone domain expansion applies uniformly to all tones, lexical or default, and regardless of word boundaries. The requirement that lexical tones be in the initial word of a phrase confirms that phrases are head-initial, and lends support to the proposal in §4 that tones are associated with the head word of the phrase, even when they surface phonetically on the second word of the phrase.

6 Typology of prosodic structure and tone

In this section, we situate the observations about the prosody of Kuikuro in the known typology of tone domain expansion (also known as tone shift), foot reversal, and stress. Section 6.1 looks at cases of tone domain expansion that is blocked by a stressed syllable. Section 6.2 discusses foot reversal, which is observed with a variety of foot types and triggers. Section 6.3 problematizes the definition of stress in languages where the correlates of stress may be arbitrarily far away from their source.

6.1 Culminativity in the tone domain

Tone domain expansion in Kuikuro is similar to Bantu tone domain expansion, where in several Bantu languages tones spread or shift up to (but not including) a prominent position. One such example comes from Zigula (Chizigula, Kenstowicz and Kisseberth 1990), where the prominent/stressed penultimate position both attracts tone and blocks tone. In this language, phrases may surface toneless, e.g., [ku-soŋgo(loza) matu(ŋguɟa)] ‘to avoid tomatoes’ lit. ‘INFINITIVE-avoid PL-tomato’. Following Kenstowicz and Kisseberth (1990), we assume that each word ends in a trochee. The 3SG prefix provides an underlying High tone, which surfaces on the penult in isolation, [a-soŋgo(lóza)] ‘3SG-avoid’. When an object follows, the single underlying tone is pronounced from the penult of the first word up to (but not including) the penult of the following word, as in [a-soŋgo(lóz-á) má-tú(ŋguɟa)] '3SG-avoid PL-tomato'. In terms of tone domain theory, domains are limited to one stressed syllable, as in Kuikuro, enforced by the constraint CULMINATIVITY-H (§4.2). Kenstowicz and Kisseberth (1990, 176) explicitly attribute the pattern to metrical prominence, saying that the grammar "may not spread a High tone onto the head of a metrical foot". Notice that in Zigula, the blocker of the High tone is not itself a carrier of a High tone; merely being metrically strong is sufficient.

Blocking of a High tone by a toneless stressed syllable is also seen in Hebrew (Becker 2003). In this language, each word has one stressed syllable that comes with one High tone; the High tone domain expands one syllable rightward when a non-final syllable is available, creating a disyllabic tone domain. Tone domain expansion is blocked when a stressed syllable is followed by another one, e.g., [a-ʁo(ˈfá) (ˈʃaʁá)-li] 'the-doctor sang-for.me'. Following Becker, we assume that stressed syllables are in a monosyllabic or trochaic foot. In terms of tone domains, the tone cannot spread from stressed [ˈfa] to the following stressed toneless [ˈʃa] due to the ban on two stresses in a domain.

There is one difference between Kuikuro/Zigula and Hebrew. In Kuikuro and Zigula, the stressed syllable that blocks the expansion of a tone domain is toneless and does not start its own domain. In Hebrew, the stressed syllable that blocks domain expansion starts its own tone domain. Thus Hebrew is ambiguous: one could say that domain expansion is blocked by another domain (which is what Becker 2003 says), or one could say that domain expansion is blocked by a stressed syllable. As Kuikuro and Zigula show, the latter is more general, as it applies to these three languages and others.

6.2 Foot reversal

In our proposed analysis of Kuikuro, the language prefers iambic feet, i.e., the constraint IAMB dominates TROCHEE. A trochee surfaces only when an iamb would give rise to a phrase-final long vowel (see Table 2 above). This elsewhere relation between foot types is entirely expected in theories with violable constraints such as Optimality Theory (Prince and Smolensky 1993/2004).

In parametric frameworks (Hayes 1995; Prince 1990), i.e., frameworks with inviolable constraints, other mechanisms might be used. Hayes (1995, §3.10, p. 55) points out that parametric metrical theory "predicts that when more than one rule creates feet, the feet created should be the same." Instead of a rule that creates trochaic feet, Hayes analyzes languages with trochaic reversal using a monosyllabic foot and later incorporation of a following final syllable into the monosyllabic foot. The result is a trochee without a one-step rule that creates a trochee.

Foot reversals are well documented in the literature, with a variety of cases in Vaysman (2009), Bennett (2013), Bennett and Henderson (2013) and Gordon (2016). In addition to the reversal from iamb to trochee in Kuikuro and other languages, Bennett (2013) analyzes Huariapano with syllabic trochees that reverse to an iamb, and Vaysman (2009) analyzes Nganasan with moraic trochees that reverse to an iamb. It would thus seem that all logically possible reversals between iambs and trochees are attested.

Gordon (2016) focuses on cases where foot reversals are forced by a phrasally prominent syllable, usually the phrase's penult. Gordon assumes that a phrasal prominent position can attract stress and disrupt the word-level stress, but Hixkaryana (Cariban) shows that this is not universal. Derbyshire (1985) describes Hixkaryana as having a phrasal penultimate tone in declaratives, and left-to-right iambic lengthening. This language has no trochaic reversal (Kager 1999, §4.3.2), as can be deduced from the lack of words with two light syllables, e.g., [(túː)na] 'water', *[(túna)], cf. the Kuikuro cognate [(túŋa)]. In Hixkaryana, longer even-parity words therefore end in two unparsed syllables, e.g., [(æˈʧɔː)wɔ́wɔ] 'wind' (Table 2b), with the phrasal tone falling on a syllable that has no word-level stress (we thank Alessa Farinella for the discussion of this point). From the perspective of the learner or the fieldworker, a phrasal penultimate prominence does not necessarily indicate the presence of a word-level penultimate stress.

Derbyshire (1985, 182) uses the term "stress" in a way that is quite different from ours. He describes Hixkaryana as having either final or penultimate "stress" depending on the intonation. For example, he describes both "terminal" and "interrogative" intonations as having a High tone on the penult but having final and penultimate "stress", respectively. We take Derbyshire's usage of "stress" to be pre-theoretical, referring to surface phonetic prominence as heard by the fieldworker. When "stress" is taken to refer more analytically to the heads of feet, as we do here, the conclusion is that Hixkaryana has neither penultimate nor final stress. In this, we follow Hyman (2006), who warns against reading stress directly from surface phonetic prominence.

6.3 What counts as stress?

Throughout this paper, we assume that stress is a structural property: a stressed syllable is a syllable that heads a foot. Higher levels of stress come from feet heading phonological words and phonological words heading phonological phrases. The metrical structure we proposed for Kuikuro was deduced from the distribution of vowel length and tone, but at times only indirectly: not all feet have a long vowel, and tone is not always pronounced on a stressed syllable. For example, in the phrase [(itɔː)tɔ́ (ʀɛpɔ)] 'next to the man' (Fig. 9), the High tone whose domain starts with the stressed syllable [tɔː] is pronounced on the following unstressed syllable, while the stressed syllable [ʀɛ] has no correlates of stress, neither length nor tone. We analyze [ʀɛ] as stressed because it blocks the expansion of the preceding High tone domain. High tones boost the phonetic prominence of the syllable that they are pronounced on, but stress is determined by the phonological analysis rather than any given surface property. In this sense, Kuikuro isn't unusual: across languages, metrical structure is often hidden and only observed indirectly.

An anonymous reviewer helpfully points out that the bimoraic minimum of nouns and verbs in Kuikuro (§3.5) is another indication of the metrical structure we posit for the language. Indeed, phonological theory explicitly connects word minimality to foot structure, and hence to stress (Hayes 1995, §3.8.5): languages have word minima because they require a foot in every word, and this foot in turn has a minimal size.

Hyman (2006) seeks to classify languages into stress languages and tone languages. He proposes that stress has "two inviolable, definitional properties: (i) obligatoriness (every word has at least one stress accent); (ii) syllable-dependency (the stress-bearing unit is necessarily the syllable)" (p. 225). We agree; these two properties follow from the metrical structure we use here: syllables parsed into headed feet that are in turn parsed into headed words. In Kuikuro, long vowels and tones are the main indicators of stress, and both are derived from a single metrical parse; without them, the metrical structure of the language cannot be learned.

A somewhat similar situation is found in Chimwiini (Bantu, Kisseberth and Abasheikh 2011), where tone and length allow the discovery of the metrical structure indirectly. Several vowel lengthening and vowel shortening processes indicate prominence at the word level and phrase level. Tones, sensitive to a variety of morphological factors, such as negation, indicate phrase boundaries. As Hyman notes (p. 240), "culminative High tone and culminative vowel length occur in different positions in phrasal outputs in Chimwiini", and Kisseberth and Abasheikh uses both to discover a metrical structure that includes phonological words and phrases.

Our analysis of Kuikuro includes both stress and tone. Here, we accept Hyman's definition (p. 229): "a language with tone is one in which an indication of pitch enters into the lexical realization of at least some morphemes." As shown in §5, some Kuikuro morphemes do specify the location of tone underlyingly. And while Hyman aims for a separation of tone and stress, his analysis of some tone languages, such as Seneca, includes both feet and phonological phrases (but presumably without headed phonological words, and therefore without stress according to his definition). Thus, it is uncontroversial that tone and at least some metrical structure may coexist in the same language. Granted, in some languages, the word-level metrical structure might be impossible to diagnose or disambiguate, depending on one's theory of learning.

7 Conclusions

In this paper, we offered a description of the word-level and phrase-level prosody of Kuikuro. A left-to-right iambic parse triggers rhythmic vowel lengthening on even-numbered vowels, with arhythmic lexical long vowels, and with a ban on long vowels phrase-finally. Vowel sequences are treated as heterosyllabic by the iambic parse, e.g., [(ɛṹː)ɛ] 'white.clay', [(u-ɛː)(ũɛ́ː)-ʀɨ] '1SG-white.clay-POSS'. When the iambic parse leaves two syllables available phrase-finally, we assume that they are parsed into a trochee (trochaic reversal). This assumption makes the phrasal penult uniformly stressed, which in turn accounts for the penultimate default position of tone in words in isolation. In phonological phrases, which are taken to be left-headed, a tone domain extends from the primary stress of the phrase (the primary stressed syllable of the first word of the phrase) and expands rightward maximally up to a long vowel or a phrasal penult. Here again, assuming that the phrasal penult heads a trochee allows us to state that tone domains expand up to a following foot head.

We proposed that tone domains are limited to one stressed syllable, enforced by the constraint CULMINATIVITY-H (§4.2), formalizing the relationship between the stressed syllable and the High tone that is one of its correlates. However, the stress in this language is incoherent, in the sense that one of the correlates of stress does not cohere with the stressed syllable; High tones may surface up to three syllables away from their stressed syllables, putting a salient correlate of stress on an unstressed syllable. This result calls for a reassessment of proposals that assume that tone marks a foot head, as in Gordon (2016).

An unusual aspect of Kuikuro concerns the conditions on unparsing of initial vowels. Known cases of initial unparsing from other languages are motivated by a preference for syllables with onsets, where an onsetless syllable is skipped in favor of an onsetful one. Kuikuro, however, skips an initial onsetless syllable even when it is followed by another onsetless syllable. Further, Kuikuro only skips a word-initial onsetless syllable phrase-medially.

In addition to the phrase-level phenomena we described here, there are utterance-level tonal phenomena in Kuikuro that are left for future work. Preliminarily, we can point to two utterance-level tonal phenomena: the vocative ends in a low tone, shifting final tones one syllable leftwards, e.g., [(takí)] 'cricket' vs. [(táki)] 'oh cricket!' (presumably an utterance-level boundary tone), and similarly [(ipí)] 'Ipi (proper name)' vs. [(ípi)] 'oh Ipi!'. Echo questions have a final High tone, e.g., [(koʀɛ́ː)t͡si] 'tomorrow' vs. [(koʀɛː)t͡sí] 'tomorrow?'. Together, these two phenomena cause some instability of root-final lexical tone on nouns, where speakers tend to vary between [(táki)] and [(takí)] as citation forms; no such instability is encountered in proper names, however, nor in antepenult lexical tone, e.g., [(áː)(ɟahi)] 'potoo'. We suspect that in addition to the vowel length and tone we studied here, Kuikuro likely has other correlates of stress that require further work. For example, when looking at intensity, we noticed an utterance-level drop in amplitude that often impacts a few utterance-final syllables, but the exact distribution is still poorly understood.

Another area for future research is the prosodic system of the closely related language Kalapalo. A preliminary comparison of the two languages is in da Silva and Franchetto (2011). It would seem that Kalapalo might have iambic footing as in Kuikuro, but with tone that tends to align to left edges.

One broader point that came from this work is the nature of default penultimate stress, which we now understand to have at least four possible sources: a right-aligned trochee, as in Spanish and many other languages, left-to-right iambs with trochaic reversal, as in Kuikuro, a top-down phrasal penult that may disrupt word-level footing, as in Nganasan (Vaysman 2009), or a top-down phrasal penult that does not necessarily land on a word-level stressed syllable, as in Hixkaryana (Derbyshire 1985).

Declarations

Competing Interests The authors declare no competing interests.

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