*LONG-C 制約を用いた南琉球八重山波照間方言の語頭帯気音に関する考察
The *Long-C Constraint and Word-Initial Aspirates in Hateruma Yaeyama, a Southern Ryukyuan Language

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ABSTRACT

　波照間方言は，沖縄県八重山郡竹富町に属する波照間島で話されている言語である。波照間方言の特徴として，語頭の無声阻害音に強い帯気が報告されている。この帯気は，フットに関する韻律条件，すなわちフットには必ず重音節が必要であるという条件を満たすために実現していると考えられる。本論文では，強い帯気が観察されるパターンを概観し，*Long-C 制約の適用を提案する。*Long-C 制約とは，音声的に長い区間を持つ子音を禁止する制約である。本制約と韻律条件の結果，代替操作として頭子音がモーラを担い，強い帯気が実現すると考える。

Hateruma Yaeyaman is an endangered southern Ryukyuan language spoken in the Hateruma island. In Hateruma, there is a limited distribution of strong aspiration in disyllabic words which is argued to be the result of a prosodic condition for a foot: all feet must have at least one heavy syllable. After presenting the distribution of strong aspiration in Hateruma, we propose the *Long-C constraint that is violated when a

consonant is phonetically lengthened. The prosodic requirement for a heavy syllable in a foot, coupled with the *Long-C constraint results in a repair strategy that associates an epenthetic mora with an onset consonant that is realized with strong aspiration.

1. Introduction

Hateruma is spoken on the Hateruma island, which is the southernmost inhabited island of Japan. Hateruma belongs to the Yaeyaman language family that forms part of the southern Ryukyuan languages; the decrease of the number of speakers has resulted in an endangered status of Hateruma. One of the phonetic characteristics of Hateruma that has been reported in various previous descriptions (Kamei, Kōno, & Chino, 1996, p. 793; Aso, 2015, among others) is strong aspiration in plosive-initial words.

In Lee and Aso (2019), the aspiration pattern is analyzed as a prosodic requirement in which all feet must have at least one heavy syllable. Although aspirating onset consonants as a repair strategy for a prosodic requirement is cross-linguistically not common, similar patterns have been reported in works on Cypriot Greek (Topintzi & Davis, 2018) where geminate onset is reported to contribute to the syllable weight.

The distribution of aspiration in Hateruma demonstrates how the phonological grammar applies a repair strategy only when it is required by other parts of the grammar: the weight requirement in a foot. The goal of this paper is to provide a constraint-based analysis (Prince & Smolensky, 1993/2004) where an interaction between a prosodic markedness constraint and a phonetically motivated constraint result in strong aspiration. The phonetically motivated *Long-C constraint is violated when a plosive has long voice onset time (VOT). When this *Long-C constraint is dominated by a set of other prosodic constraints, the result is strong aspiration.

After presenting the distribution of strong aspiration in Hateruma in section 2, the status of *Long-C is explored by focusing on VOT in section 3. In section 4,

the ranking argument is established for the strong aspiration in disyllabic words in Hateruma.

2. Distribution of Strong Aspiration

Hateruma has no contrastive aspiration. Nonetheless, strong aspiration is audible in some Hateruma words beginning with plosives. The strong aspiration appears when a disyllabic word consists of two open syllables (CV.CV) or an open syllable followed by a closed syllable (CV.CVC). Disyllabic words with an initial long vowel or an initial closed syllable, however, are not pronounced with strong aspiration.

In (1), the aspiration of a plosive in syllables with strong aspiration can be seen as pervasive as it devoices a following vowel. In some cases, the third nasal segment is also partially devoiced due to the influence of the aspiration. Syllable boundaries are marked with a period.

(1) a. CV.CV
    [pʰḁ.na] 'a flower'
    [kʰḁ.ni] 'a crab'
  b. CV.CVC
    [pʰḁ.ton] 'a dove'

When the first syllable of a disyllabic word has a long vowel or a coda consonant, strong aspiration is not observed as in (2).

(2) a. CV:.CV
    [ka:.ra] 'a roof tile'
    [pa:.cï] 'a bee'
  b. CVC.CVC
    [kan.gan] 'a mirror'
    [tok.kin] 'a guava'

Lee and Aso (2019) report acoustic data of this strong aspiration from two speakers of Hateruma. Impressionistic descriptions of the strong aspiration were borne out by the VOT measurements. VOT values in disyllabic words in (1) are nearly twice as long as those words in (2).

A closer look at the distribution suggests that a prosodic requirement plays a role in accounting for the distribution of the strong aspiration: initial open syllables in disyllabic words result in strong aspiration. In section 4, an analysis demonstrates that a prosodic requirement at the foot-level is responsible for the emergence of strong aspiration. Before moving onto an analysis, the markedness constraint *Long-C requires further discussion in the next section.

3. The *Long-C Constraint

The markedness constraint *Long-C is violated when a surface consonant has an audible long acoustic signal such as long VOT. The input-output pairs in (3) and (4) illustrate how *Long-C is evaluated in comparison with other constraints. The input in (3) has a short vowel and the input in (4) has a long vowel.

(3)   Input with a short vowel

	/pa/	Id(LO)-V	*Long-C	*Gem
a.	pa			
b.	pa:	*		
c.	ppa			*
d.	pʰa̠		*	

The faithfulness constraint Ident(Long)-V is violated only when a vowel is lengthened or shortened. We propose that the Ident(long)-V constraint targets only moraic vowels, but markedness constraints *Long-C and NoGeminate target consonants, regardless whether a mora is associated or not.

(4)   Input with a long vowel

	/pa:/	Id(LO)-V	*Long-C	*Gem
a.	pa	*		
b.	pa:			
c.	ppa	*		*
d.	pʰa̠	*	*	

Support for this proposal is found in literature on consonant-tone interaction (Lee 2008 among others). In Lee's (2008) xTBU theory, consonants can be tonal (and thus interact with tonal processes), but no faithfulness constraints preserve a tone on a consonant; no language shows contrast between a tonal consonant and a non-tonal consonant.

This idea is extended to the analysis of Hateruma. Phonetic realization of a long consonant is by means of longer closure duration (geminates) or longer VOT (strong aspiration), but no faithfulness constraints directly preserve a consonantal length from the input. Underlying consonantal length contrasts are preserved via the presence of a prosodic unit such as a mora, and faithfulness constraints target those moras. Only markedness constraints restrict the distribution of such phonetic realization of consonants.

Whether a consonant can have longer acoustic cues or not depends on the characteristics of a consonant. Longer plosives either have longer closure duration or longer VOT. Longer fricatives have longer frication noise. An affricate can be lengthened by longer closure duration, longer VOT or longer frication noise. In the constraint system proposed here, long closure duration is violated by NoGeminate, long VOT is violated by *Long-C.

Long frication noise violates both *Long-C and NoGeminate, which is also the case when sonorants such as nasals or laterals become longer by increasing the length of the nasal part or the lateral part.

The evaluation of *Long-C is based on the duration

of the acoustic signal, but phonologically, the lengthened duration is a reflex of an association with a mora.

Disyllabic words in Hateruma display four major patterns: /CVCV/, /CVCVC/, /CV:CV/ and /CVCCVC/. If a higher-ranked markedness constraint induces the violation of IDENT(LONG)-V, and if only such a violation is possible, the repair strategy will result in a long vowel of the first syllable; both /CVCV/ and /CV:CV/ disyllabic words would become neutralized to [CV:.CV], but this is not the case. /CVCV/ words are realized as [C^{h}V.CV].

We propose that Hateruma speakers employ a repair strategy that associates a mora to an onset consonant in the form of strong aspiration by increasing the VOT of the obstruent. This type of association results in the violation of the *LONG-C constraint.

It is possible to postulate that the *LONG-C constraint is also violated when an onset consonant becomes a geminate. This is not surprising because gemination is commonly associated with a longer duration. The major difference between a geminate and strong aspiration is what is being lengthened. While a plosive geminate lengthens the closure duration, the strong aspiration lengthens VOT.

The *LONG-C constraint is phonetically grounded and we argue that it is only violated when a lengthened consonant has an acoustic signal corresponding to such a duration. Using VOT as a means to signal the association to a mora in Hateruma, thus, shows that acoustic salience such as VOT is favored as a repair strategy to the lengthened closure duration in geminates.

In most languages, the *LONG-C constraint would be highly ranked, and that is why the repair strategy is not commonly observed cross-linguistically. Hateruma data shows that the phonetically grounded *LONG-C constraint is nonetheless part of a set of constraints (CON) that is violable and plays an active role in providing an alternative repair strategy.

An additional argument for *LONG-C comes from

perception. It is not surprising that the presence of acoustic signals is perceptually more salient than the absence of such signals. The proposed *LONG-C constraint formalizes this perceptual preference since Hateruma actively incorporates the perceptual salience in enforcing prosodic requirement in the surface forms (cf. Flemming, 2002).

A remaining question concerns the IDENT (LONG) constraint. We suggest that this constraint only targets vocalic segments such as vowels. As such, forming a geminate or strong aspiration does not violate the faithfulness constraint that preserves the vowel length between corresponding input and output segments.

Limiting the definition of IDENT (LONG) to vowels is grounded from other work on moras. Vowels are moraic, but consonants are not. If consonants are moraic, they are so due to markedness constraints that prefers a moraic consonant. The consequence is that vowels are cross-linguistically mora bearing, but consonants are contextually mora bearing (cf. Hayes, 1995; Morén, 2013).

4. Analysis

4.1 Constraints

In addition to the *LONG-C constraint, the phonological grammar of Hateruma has constraints that conspire together for the pattern that we observe. The following constraints are proposed for an analysis of disyllables in Hateruma. The markedness constraints are shown in (5) and the faithfulness constraints are shown in (6).

(5) Markedness constraints
a. FOOT-HEAD (FTHD)
   Assign a violation mark when a foot only has light syllables.
b. TROCHEE (TR)
   Assign a violation mark when a foot has a light syllable followed by a heavy syllable.
c. FOOT-BINARITY-SYLLABLE (FTBINSYL)
   Assign a violation mark when a foot does not

have two syllables.

d. NoGeminate (*Gem)

Assign a violation mark for every geminate in the output.

e. Iamb

Assign a violation mark when a foot has a heavy syllable followed by a light syllable.

f. *Long-C

Assign a violation mark to long consonants that are realized with acoustically audible cues.

The Foot-Head constraint in (5a) requires that no foot has light syllable only. Although Foot-Binarity-Syllable (5c) is satisfied when two syllables form a single foot, this Foot-Head constraint is what requires a foot to have a heavy syllable. In disyllabic words with two light syllables, either the first syllable or the second syllable can then become heavy to satisfy the Foot-Head constraint. The first syllable is preferred as a locus of the heavy syllable due to the Trochee constraint (5b) being ranked above the Iamb constraint (5e).

Hateruma does not allow geminates in general; the NoGeminate constraint is undominated (5d). The *Long-C constraint in (5f) is a phonetically grounded constraint that distinguishes segments with strong aspiration from geminate plosives. The longer VOT in surface forms with strong aspiration is a salient acoustic cue that is actively realized in the grammar of Hateruma.

Both gemination and strong aspiration in plosives can appear due to an additional mora, however Hateruma prefers acoustic cues that are more salient. Acoustic cues for geminates are longer closure duration, devoid of salient acoustic signal. In particular, in the word-initial position, satisfying the prosodic requirement with a silent duration of a sound is less salient since it is not audible. Hateruma opts for the longer VOT option, which violates the markedness constraint *Long-C instead.

Two faithfulness constraints are considered for the analysis of Hateruma. The Ident(long)-V constraint only targets vowels (6a). Additionally, the Dep-mora constraint (6b) is violated when a mora is inserted in the output in order to meet a higher ranked prosodic requirement. All feet must have a heavy syllable.

(6) Faithfulness constraints

a. Ident(long)-V (Id(Long)-V)

For corresponding vowels in the input and the output, assign a violation mark when the vowels do not have the same moraic association.

b. Dep-mora (Dep-μ)

For corresponding segments in the input and the output, assign a violation mark when the segment in the output is associated with a mora that is not present in the input.

In Hateruma, the ranking of these constraints results in a unique system where strong aspiration that is realized with a longer VOT is the optimal form.

4.2 Ranking Hierarchy

The optimal output for the input /CVCV/ has the strong aspiration in the first syllable: [C^{h}V.CV]. The tableau in (7) shows how this candidate is optimal under the constraint ranking. The faithful candidate in (7d) violates the higher ranked constraint FootHead because the foot does not contain a heavy syllable. A heavy syllable may be formed by gemination (7c) or by lengthening a vowel (7b), but these candidates violate the NoGeminate constraint and the Ident(long)-V constraint, respectively. All repair strategies in (7a, b, c) violate the Dep-mora constraint, but the optimal candidate violates the *Long-C constraint as well.

(7) FtHd, *Gem, Id(L)-V >> *Long-C, Dep-μ

	/pana/ 'flower'	FtHd	*Gem	Id(Long)-V	*Long-C	Dep-μ
a.	(pʰa̰.na)_Ft				*	*
b.	(paː.na)_Ft			*W	L	*
c.	(ppa.na)_Ft		*W		L	*
d.	(pa.na)_Ft	*W			L	L

(9) Trochee, Ft-Bin-Syl
   >> Iamb, *Long-C, Dep-μ

	/paton/ 'dove'	Trochee	Ft-Bin-Syl	Iamb	*Long-C	Dep-μ
a.	(pʰa̰.ton)_Ft			*	*	*
b.	pa.(ton)_Ft		*W	L	L	L
c.	(pa.ton)_Ft	*W		L	L	L

The ranking hierarchy in the tableau in (8) shows that the optimal candidate in (8a) violates the Iamb constraint, but satisfies the higher ranked Trochee constraint. The candidate in (8c) that only parses the first syllable into a foot violates Foot-Binarity-Syllable, which is also harmonically bounded by the optimal candidate in (8a).

(8) Trochee, Ft-Bin-Syl
   >> Iamb, *Long-C, Dep-μ

	/pana/ 'flower'	Trochee	Ft-Bin-Syl	Iamb	*Long-C	Dep-μ
a.	(pʰa̰.na)_Ft			*	*	*
b.	(pa.naː)_Ft	*W		L	L	*
c.	(pʰa̰)_Ft.na		*W		*	*

The proposed ranking hierarchy also generates an optimal output when other inputs are considered. A /CVCVC/ input has a competition because it has a second syllable that is heavy.

The tableau in (9) illustrates this ranking. The faithful candidate in (9c) violates Trochee even though it satisfies Iamb, *Long-C and Dep-μ. The candidate in (9b) has a foot that is not binary by underparsing the first syllable. This candidate does not violate any of the lower ranked markedness constraints, but the requirement for a foot size is rendering it as non-optimal.

The proposed ranking must be checked against surface forms that do not show strong aspiration. In the tableau in (10), a disyllabic word /CV:CV/ is analyzed. If everything is equal, the optimal candidate (10a) does not violate any constraints while the candidate with strong aspiration (10b) violates Ident(long)-V because the long vowel is short, and *Long-C because the aspirated onset consonant has longer VOT. Note that (10b) does not violate Dep-μ because the moraic profile is identical in the input and the non-optimal candidate in (10b).

(10) No strong aspiration: /CV:CV/

	/kaːra/ 'a roof tile'	FtHd	*Gem	Id(Long)-V	*Long-C	Dep-μ
a.	(kaː.ra)_Ft					
b.	(kʰa̰.ra)_Ft			*W	*W	

Given the Richness of the Base (ROTB), which assumes that there is no restriction on an input, an input form with aspiration should also be considered as in (11). The optimal candidate in (11a) violates the lower ranked Max-μ constraint, but it fares better on the *Long-C constraint, which is violated in the faithful candidate in (11b).

(11) No strong aspiration: /CʰV:CV/

	/kʰaːra/	F-THD	ID(LONG)-V	*LONG-C	DEP-μ	MAX-μ
a.	(kaː.ra) ₍Ft₎					*
b.	(kʰạː.ra) ₍Ft₎			*W		L

The tableau in (12) demonstrates the optimal candidate for an input that has two closed syllables. The closed syllables may form a single foot, or each closed syllable may form a foot on their own. The optimal candidate in (12a) violates IAMB because the disyllabic foot has the foot head on the first syllable. One way to repair this violation is grouping each closed syllable into a single foot as in (12b), but this will incur a violation of the FOOT-BINARITY-SYLLABLE constraint, which must be dominated above IAMB, as shown in (9). Thus, the grammar of Hateruma predicts that a prosodically ambiguous input as in (12) will nonetheless favor a foot that has two syllables due to the higher ranked binarity constraint.

(12) No strong aspiration: /CVCCVC/

	/kan.gan/ 'a mirror'	TROCHEE	FT-BIN-SYL	IAMB	DEP-μ
a.	(kan.gan) ₍Ft₎			*	
b.	(kan) ₍Ft₎.(gan) ₍Ft₎		*W	L	
c.	(kan.gan) ₍Ft₎	*W		L	

In this section, a constraint-based analysis of strong aspiration in Hateruma has been presented. The prosodic requirement that a foot must have a heavy syllable generates an optimal output with strong aspiration, in the absence of possible repair strategies (such as vowel lengthening or gemination).

5. Discussion

5.1 Alternative Analyses

The analysis proposed in this paper requires an assumption that a phonological weight (a mora) be realized with an audible acoustic signal such as VOT, which incurs violation of a phonetically motivated constraint *LONG-C. This unique analysis of strong aspiration in Hateruma is strengthened if alternative analyses fail to unify the pattern.

One alternative analysis is to consider strong aspiration as a domain-initial strengthening process (Cho & Jun, 2000; Keating, Cho, Fougeron & Hsu, 2004). In such an analysis, the first consonant must be strengthened in the form of strong aspiration in a disyllabic domain except when the word-initial syllable is bimoraic. While this alternative analysis may account for the observed pattern in Hateruma, it fails to address why the moraicity of the first syllable matters in strong aspiration. While the domain-initial strengthening analysis is a restatement of generalizations observed in Hateruma, the analysis proposed in this paper shows why a phonological grammar results in a diversion in the surface form with strong aspiration.

Another possible analysis is to entertain the idea that strong aspiration is phonemic in Hateruma. Such an analysis must stipulate that the phonemic status of strong aspiration is hinged upon the type of the first syllable in disyllabic words; the 'strongly aspirated plosive' phoneme only appears when the first syllable is monomoraic. Arguing for the phonemic status of strong aspiration is thus missing the generalization that this strong aspiration cannot co-occur with bimoraic syllables.

5.2 Non-plosives in Hateruma

So far, the analysis in this paper focuses on the plosives in Hateruma disyllabic words. One natural question that emerges is whether other types of onsets show any characteristics that are comparable to the

longer VOT in plosives. If the longer VOT is driven by a prosodic requirement, this requirement should somehow be manifested in other onsets as well.

The fricatives show a difference in frication noise as in (13). Disyllabic words with two open syllables have longer frication noise (13a), whereas disyllabic words that have a heavy initial syllable begin with less frication noise. This difference in frication noise is borne out by the proposed analysis; an acoustic feature is lengthened as a repair strategy in order to meet the prosodic requirement on the foot structure.

(13) Fricatives
a. longer frication noise (marked with ʰ)
  [sʰa̤ki] 'Japanese sake'
  [fʰṳni] 'a boat'

b. less frication noise
  [sunsu] 'soup'

Nasal-initial words in Hateruma are mostly monosyllabic and disyllabic words are infrequent. The nasal-initial words as well as disyllabic words beginning with a voiced plosive do not have discernable acoustic features that differ from the type of words in (14). Voiced plosives in CVCV words (14a), for example, do not display enhanced prevoicing compared to CVCVC words (14b).

(14) Voiced plosives
a. CVCV
  [bira] 'a leek'
b. CVCVC
  [gusiɴ] 'alcoholic beverage'

Onsetless disyllabic words in (15) also do not show any special characteristics that suggest there is a difference.

(15) Onsetless words
a. VCV

[ami] 'rain'
b. VCVC
  [ogan] 'sacred site'

Even so, notice that the limited data with voiced plosive initial and onsetless disyllabic words have the shape of (C)VCV or (C)VCVC, and both types are expected to pattern in the same way. The current database does not contain disyllabic words that begin with voiced plosives with an initial heavy syllable, which makes it difficult to have a meaningful comparison for the purpose of this study.

It may not be a coincidence that we see a restricted distribution of Hateruma disyllabic words beginning with nasals, voiced plosives and vowels. These words may not be able to satisfy the prosodic requirement "one foot, one heavy syllable" in a salient manner, and hence the lexicon of Hateruma may be avoiding the presence of such words.

The avoidance of certain disyllabic words in the lexicon may also be driven by how the *Long-C constraint works a repair strategy. In plosives, VOT is longer while fricatives show longer frication noise, both of which are auditorily salient. Non-salient acoustic features such as pre-voicing or nasal duration in the word-initial position may not be utilized as an acoustic repair strategy. It could also be the case that the definition of *Long-C must be limited to voiceless obstruents.

6. Conclusion

This article has presented a cross-linguistically uncommon pattern which occurs in Hateruma where the prosodic requirement for a heavy syllable in a foot is realized with strong aspiration of the onset. The acoustic reflex of longer VOT in these examples contrast with a foot that does not have to meet this requirement because the foot already has a heavy syllable in the form of a long vowel or a syllable with a coda consonant.

The pattern in Hateruma led to a proposal, in which the *Long-C constraint must be included in the set of universal constraints (CON). This markedness constraint is violated only when a longer duration of a segment is acoustically salient: long VOT or long frication noise.

Although Hateruma is an endangered language with only few speakers left, the strong aspiration pattern has been reported in earlier studies of Hateruma when there were still many more speakers. As such, the proposed *Long-C constraint is argued to be part of CON; examining other languages may uncover more grammatical systems with *Long-C playing an important role.

Acknowledgements

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