Perceptual factors license vocalic contrasts in Chamorro

Introduction · Phonetic cues have been shown to condition the merger and preservation of vowel contrasts (Flemming, 1995; Steriade, 1997). Chamorro provides supportive evidence for the claim that phonetic factors related to perception may license otherwise neutralized vowel contrasts. The *patterned exceptionality* (Zuraw, 2000, 2010) of mid vowels before intervocalic laryngeal consonants in Chamorro arises from the availability of distinct acoustic cues to vowel quality, enabling the perception of underlying contrast.

The pattern · The phonemic vowel inventory of Chamorro consists of six vowels /i, u, e, o, a, ɑ/. The basic distribution of mid and high vowels is: *mid vowels surface in closed stressed syllables, and high vowels occur elsewhere* (Chung, n.d., 1983; Topping & Dungca, 1973). Mid vowels are derived via lowering of underlying high vowels in closed stressed syllables (Chung, 1983). This analysis is supported by evidence from: (1) regular alternations of raising (underlined) and lowering (bolded) in native forms and (2) the neutralization of unstressed mid vowels in loan words to their corresponding high vowel (underlined).

(1) a. [g**é**k.pu] ∼ [g̲ik.p**ó**k.ku] 'my flyer' b. [m**é**t.gut] ∼ [m̲it.g**ó**t.ɲa] 'stronger'

(2) a. [bé:l̲u] < [βélo] *Spanish* 'veil' b. [lénti̲] < [lénte] *Spanish* 'lens'

However, exceptions to this generalization exist even in native Chamorro forms, in which mid vowels appear to occur outside of closed stressed syllables.

(3) a. [bé:ʔi] 'wrapping, bandage' c. [bó:han] 'hand-fan'
b. [gó:fis] 'lungs' d. [sé:ha] 'back-up'

Furthermore, exceptional mid vowels seem to surface more often than expected before intervocalic laryngeals (Chung, n.d.). Expected frequencies are filled in proportionally based on the observed frequency totals. So, in total, 77/552 (14%) of the forms have an intervocalic laryngeal, and 19 (14% of 136) of the 136 forms with a mid vowel are expected to have a following intervocalic laryngeal.

Observed	[e,o]	[i,u]	Total
V[h,ʔ]V	29	48	77
$VC_{oral}V$	107	368	475
Total	136	416	552

Expected	[e,o]	[i,u]	Total
V[h,ʔ]V	19	58	77
$VC_{oral}V$	117	358	475
Total	136	416	552

A chi-squared (χ^2) test on the observed frequencies of native Chamorro words of the form CVCV(C) (retrieved from the Revised Chamorro-English dictionary database) reveals that mid vowels occur before intervocalic laryngeals, and high vowels occur before intervocalic oral consonants, more frequently than would be expected by chance ($\chi^2 = 7.38$, df = 1, p < .01). This suggests a systematicity that has not yet been captured among words that have been called exceptional.

Exceptional coda hypothesis · Treating intervocalic laryngeals as codas or ambisyllabic (Borroff, 2007; Kahn, 1976) would explain the licensing of mid vowels before laryngeals, but is ultimately unsustainable. Two alternations dependent on syllable structure demonstrate that the intervocalic laryngeals in (3) cannot be treated as codas. The first is the gemination of certain -CV suffixes in Chamorro. Gemination follows two conditions: (i) the stem, in its bare isolation form, must have a closed primary-stressed syllable, and (ii) the stem must end in an open syllable (Chung, 1983).

(4) [gék.pu] ∼ [gik.póŋ.ɲa] 'her flyer'

(5) [bé:.ʔi] ∼ **[be.ʔí.ɲa]/*[be.ʔíŋ.ɲa]** 'her bandage'

The example in (5) shows no licensing of gemination, indicating the laryngeal does not act as a coda. The second alternation is the lengthening of vowels in stressed open penultimate syllables (Chung, 1983; Crosswhite, 1998). Evidenced by the average vowel lengths (number of tokens in parentheses) in (6), lengthening applies to forms regardless of the orality of the intervocalic consonant, further confirming that laryngeals are not syllabified as codas in this position.

(6) a. [dí:.su?] 'squat' [i] = 98ms (7)
b. [tú:.gi?] 'write' [u] = 109ms (5)
c. [bó:.han] 'fan' [o] = 116ms (8)
d. [té:.?uk] 'thick' [e] = 112ms (3)

Phonetic licensing · Laryngeals in Chamorro provide an environment for increased perceptibility of F1, the primary cue for vowel height. Laryngeals lack an oral component of articulation, and intervocalic glottal stop in Chamorro is typically realized with creakiness and a lowering of pitch/intensity, rather than full stop closure. These qualities lead to preceding vowel formants persisting through the laryngeal gesture (Fig. 1), providing more vowel steady state and formant transition information to properly cue vowel contrast. In contrast, vowel formants do not persist through oral consonants (Fig. 2). Vowel steady state and formant transition length is severely reduced compared to the laryngeal environment.

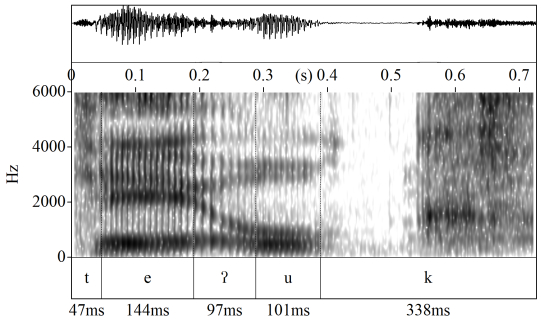

Figure 1: [té:?uk]

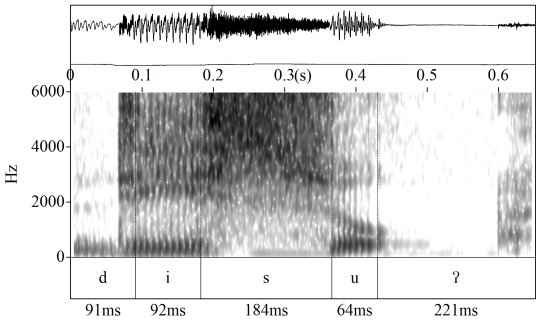

Figure 2: [dí:.su?]

Formal analysis · The phonetic licensing of height contrast from laryngeals may be cashed out through evaluating the perceptual distance between formant levels. Each vowel is assigned an abstract F1 level corresponding to height: i (1) > ɪ (2) > e (3) > ɛ (4) > a (5). Constraints on the dispersion of vowels in the F1 x F2 perceptual space evaluate surface contrasts in specific environments. A minimum distance constraint (M.D:F1:2) (Flemming, 1995) requires the perceptual distance between F1 levels to be greater than 2. Phonetic context in output candidates scales the perceptual distance between F1 levels based on perceptible vowel formant length. Laryngeals scale the perceptual distance up by 1.5 due to the steady state, and transition, of F1 cuing contrast through the laryngeal. Oral consonants (C) do not scale perceptual distance, as no perceivable F1 cues persist through the oral gesture. The maximization of contrasts is captured through a restriction on the merger of contrast (*MERGE). Finally, the language-internal, and typological, preference for a maximally dispersed vowel inventory is represented by a constraint penalizing mid vowels (*MID).

í:$_x$?~ é:$_y$?	M.D:F1:2	*MERGE
☞ a. í:$_x$?~ é:$_y$?	3≥2 ✓	
b. í:$_{x,y}$?		*!
c. é:$_{x,y}$?		*!

í:$_x$C ~ é:$_y$C	M.D:F1:2	*MERGE	*MID
☞ a. í:$_{x,y}$C		*	
b. í:$_x$C ~ é:$_y$C	2=2*!		
c. é:$_{x,y}$C		*	*!