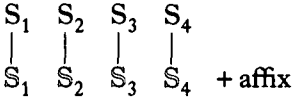
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Segmental vs. *prosodic correspondence in Chamorro**

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1 Introduction

In all human languages, we find words that are similar in some respect or another – usually because they are morphologically related. If speakers wish to determine the degree of similarity between two morphologically related forms, they must decide which elements to compare. Perhaps the most intuitive approach would be to compare the segments, and determine the degree of featural similarity they display. This approach might be thought of as 'segmental comparison'. A schematic representation for two forms undergoing segmental comparison is given below.

(1)


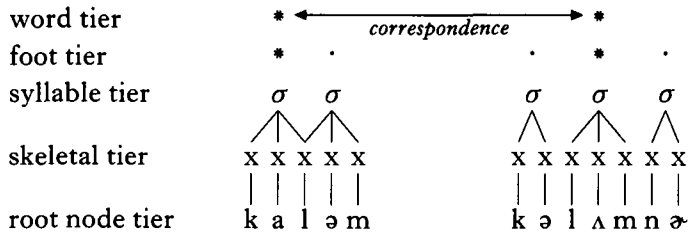
An equally plausible although less intuitive alternative is also available – prosodic elements could be compared. For example, the most prominent syllable node of each form might be compared, or the main-stressed nucleus of each form might be compared. This approach might be called 'prosodic comparison'. Importantly, prosodic comparison might result in the comparison of elements that are associated with very different segmental melodies – for example, imagine a pair of words in which a given prosodic role (for example, head of prosodic word) has a different location in each form. Such a situation might occur in a language where stress shifts under affixation; in such a case, the linear order of segments would remain the same in both words, but the location of the prosodic

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heads would differ. A schematic representation of this sort of situation is given below.

(2)



In this paper, I will consider just such a language – the Saipanese dialect of Chamorro – and demonstrate that the phonology of this language requires *both* segmental and prosodic comparison. This characteristic of the sound pattern of Chamorro holds great significance for theories which attempt to formalise phonological similarity effects, such as Steriade's (1996) theory of Paradigm Uniformity, Kenstowicz's (1995) theory of Uniform Exponence and McCarthy & Prince's theory of Correspondence (McCarthy & Prince 1993, 1994, 1995, McCarthy 1995). For simplicity of exposition, from this point on my analysis will be cast in terms of the theoretical framework of correspondence (discussed below). It should be remembered, however, that the main result of this analysis – the existence of *prosodic* phonological comparison – is relevant to any theory which seeks to give a comprehensive treatment of phonological similarity effects.

A secondary result of this analysis is the claim that the various relations where phonological similarity effects are observed (input–output, base–reduplicant, base–affixed form, etc.) are in fact strict limiting factors on correspondence. In particular, I will demonstrate that when correspondence involves morphologically complex items, each constituent morpheme of S_1 and S_2 is subject to this limitation. This result is consistent with Steriade's (1996) Paradigm Uniformity hypothesis and Kenstowicz's (1995) theory of Uniform Exponence. Both these theories explicitly maintain that phonological similarity effects exist to enhance transparency of relatedness and decrease dissimilarity within a given paradigm.

My analysis will focus on two phonological processes of Saipanese Chamorro: vowel lowering and gemination. I will show that one of these processes (vowel lowering) requires comparison of segments, whereas the other (gemination) requires comparison of prosodic elements.

The current analysis was inspired by Chung's (1983) analysis of Saipanese Chamorro, and is based on data from Chung, as well as from Topping & Dungca (1973), Topping *et al.* (1975) and fieldwork with native speakers of Saipanese Chamorro. The current analysis of vowel lowering and gemination owes a great deal to previous rule-based analyses of Chamorro by Chung (1983), Kiparsky (1986) and Halle & Vergnaud (1987). Note that these previous analyses focused mostly on the difficulties

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in deriving both the similarity effects (= cyclicity effects) and the systematic optionality found in Saipanese Chamorro. The current analysis focuses only on the similarity effects, and attempts to show that an optimality-theoretic analysis of these processes requires the coexistence of two different methods for comparing morphologically related forms. For an optimality-theoretic account of Chamorro stress and umlaut (which are not dealt with in this paper), see Klein (1995).

2 Correspondence theory

The theory of correspondence was first developed by McCarthy & Prince (1993) for use in explaining certain phenomena observed in reduplicative processes. Since then, correspondence has been extended to account for input–output faithfulness effects (McCarthy & Prince 1994, 1995) as well as surface–surface similarity effects (Benua 1995, 1997, McCarthy 1995). The basic idea behind correspondence is that the elements (usually segments) of a given form can be formally paired with the elements of a related form. The two forms might be related as input–output, base–reduplicant, base–derivative, etc. Furthermore, constraints can impose requirements on this pairing, and on the identity of the elements that are paired. To formalise this concept, correspondence is defined as follows:

(3) *Correspondence* (McCarthy & Prince 1993)
Given two strings S_1 and S_2, CORRESPONDENCE is a relation $\mathfrak{R}$ from the elements of S_1 to those of S_2. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as CORRESPONDENTS of one another when $\alpha \mathfrak{R} \beta$.

The output generator GEN supplies all possible pairings between the elements of S_1 and S_2. This pairing is often represented typographically through the use of indexation. Taking an example from McCarthy (1995), the input form /$p_1u_2r_3e_4$/ 'to rule' in Rotuman corresponds to the surface form [$p_1\acute{u}_2r_3e_4$] straightforwardly. On the other hand, surface [$p_1\acute{u}_2r_3e_4$] corresponds to the morphologically related surface form [$p_1\acute{u}_2e_4r_3$] 'to rule' (INCOMPLETE PHASE) less straightforwardly – as indicated by the indices, metathesis has occurred. The same correspondence relations can be represented graphically, as below.

(4) *Graphical representation of some correspondence relations in Rotuman*

a. input–output

/p u r e/
 | | | |
[p u r e]

b. surface–surface
(complete *vs.* incomplete phase)

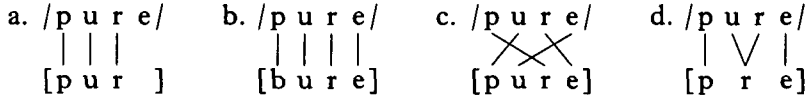
/p u r e/
 | | ×
[p u e r]

In (4), each line unites two corresponding segments. It is important to note, however, that (4) represents the correspondence relations of two

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successful output forms. The output generator GEN could have created any possible correspondence relation between these forms. Some unsuccessful pairings are given in (5).

(5) *Some correspondence relations for failed Rotuman output candidates*



It is assumed that the types of pairings depicted in (5) are possible – nothing prevents GEN from creating them. However, constraints on correspondence will keep these sorts of candidates from surfacing. For example, McCarthy & Prince develop the following constraints:

(6) *Some constraints on correspondents* (McCarthy & Prince 1994, 1995)

MAX	Every element of S_1 has a correspondent in S_2.
DEP	Every elements of S_2 has a correspondent in S_1.
UNIFORMITY	No element of S_2 has multiple correspondents in S_1.
IDENT(F)	Correspondent segments have identical values for the feature F.
LINEARITY	S_1 is consistent with the precedence structure of S_2, and *vice versa*.

Going back to the figures in (5), relation (a) violates MAX since the input segment /e/ lacks a correspondent in the output; relation (b) violates IDENT(F) since the initial correspondent pair (p,b) does not agree in voicing features; relation (c) violates IDENT(F) and LINEARITY; relation (d) violates UNIFORMITY. One of the successful forms shown in (2) also violates LINEARITY – the metathetic form [púer] has a precedence structure distinct from that of [púre]. However, this violation is necessary to meet certain requirements on the prosodic shape of the incomplete phase in Rotuman. This situation is in accord with one of the main tenets of Optimality Theory (Prince & Smolensky 1993) – that phonological constraints are violable.

I hope to show that the phonology of Chamorro simultaneously requires two different types of correspondence: one that compares segmental elements, and one that compares prosodic elements.

3 Chamorro vowel lowering

Chamorro is an Austronesian language spoken in the Mariana islands. The Saipanese dialect is spoken on the island of Saipan, which is located to the north-east of Guam. I will begin with an account of Chamorro vowel lowering, in order to demonstrate the existence of the familiar type of (segmental) correspondence in the language. In §4, I will compare this with an analysis of Chamorro gemination, where an additional type of (prosodic) correspondence will be required.

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3.1 Vowel lowering on primary stresses

In Chamorro, mid vowels are found only in stressed, closed syllables. High vowels are found elsewhere.[1] Chung (1983) describes this distribution, exemplified in (7), using a rule of vowel lowering.[2]

(7) *Vowel lowering* (Chung 1983; notations for vowel length added)

'metgut	'strong'	'poddun	'fall'
ma'neŋŋiŋ	'cold'	'tsoʔg^{w}i	'do'
'pi:saw	'fishing line'	'u:tsan	'rain'
im'pattsu	'bored'	'mu:mu	'fight'
dis'pasyu	'slow'	gub'yetnu	'governor'
'la:pis	'pencil'	la'pessu[3]	'my pencil'
hu'gandu	'play'	ˌhugan'doŋŋa	'his playing'
ma'læ:guʔ	'wanting'	ˌmalæ'goʔmu	'your wanting'

Notice that the distribution is not static – the last three examples in (7) show vowel-height alternations caused by shifts in stress. This type of vowel-height alternation is commonplace in Chamorro.

Since vowel height in non-low vowels is predictable in Chamorro, I will assume that [high] is not crucially specified for these vowels at the underlying level. More specifically, *any* underlying specification for [high] on non-low vowels can be assumed, and the correct vowel height will emerge from the interaction of constraints on the distribution of vowel features (with FAITH constraints playing no role). Since underlying specifications for vowel height have such a negligible effect on surface non-low vowels, we can assume that IDENT-IO(high) must be a low-ranking constraint in Chamorro. Additionally, since low vowels do not

[1] There are two types of exceptions to this generalisation. There is a small class of words where high vowels appear in stressed closed syllables, and a slightly larger class where mid vowels occur in stressed *open* syllables. The first type of exception is never found in native content-words – only in borrowed words (such as ['muntun] 'swarm', ['listu] 'ready', [a'sut] 'blue', ['diŋki] 'flashlight', ['nutci] 'night') or non-content words (the only two examples are ['huŋgan] 'yes' and ['muŋŋa] 'negation'). The second type of exception occurs exclusively in borrowings (such as ['pegu] 'glue, attach', ['sebu] 'grease', ['neni] 'baby', [sit'besa] 'beer'). Apart from ['huŋgan] and ['muŋŋa], both types of exceptionality indicate incomplete assimilation of a loanword. There are two independent sources of support for this claim: (i) Witucki (1973) states that exceptions of the type ['neni] 'baby' are unassimilated loans – she also reports fully assimilated alternatives where the exceptionality has been avoided through gemination: ['nenni], etc.; (ii) anecdotally, during elicitation sessions my informants would often volunteer the information that a given exceptional form was borrowed. This is how I learned that ['diŋki] 'flashlight' is a borrowing from Japanese, for example.

[2] Note that the main-stressed syllable in Chamorro is always heavy – i.e. either CVC or CVV. It was previously reported by Witucki (1973) that only open *penultimate* syllables displayed vowel lengthening. I have been unable to reproduce this finding in fieldwork with native speakers, and instead find that all stressed, open syllables undergo lengthening.

[3] The suffix /-hu/ surfaces as [-su] when attached to a form that ends in *s*.

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participate in this alternation, we might expect that IDENT-IO(low) will be high-ranking or even undominated.[4]

The vowel-lowering generalisation can be restated as a condition on stressed vowels – the only vowels found in the main-stressed syllable of a (non-reduplicated)[5] Chamorro word are /i: u: e o a a: æ æ:/. In particular, the short high vowels /i u/ are never found in the main-stressed syllable. This situation is reminiscent of the cases described in Kenstowicz (1994), where certain vowels are constrained from appearing as foot-peaks (stressed) or foot-margins (unstressed). Kenstowicz develops an analysis for these situations which is similar to Prince & Smolensky's (1993) analysis of syllable margins and peaks. In particular, more sonorous vowels are constrained from appearing in stressless positions, and less sonorous vowels are constrained from appearing in stressed positions. Kenstowicz suggests the following universal hierarchies and rankings:

(8) *Universal hierarchies and rankings for foot-peaks and foot-margins* (Kenstowicz 1994)

a. $\text{peak}_{\text{foot}}$: á > é, ó > í, ú > ə́
b. $\text{margin}_{\text{foot}}$: ə̆ > ĭ, ŭ, > ĕ, ŭ > ă
c. peak prominence for metrical feet:
*P/ə ⩾ *P/i,u ⩾ *P/e,o ⩾ *P/a
d. margin prominence for metrical feet:
*M/a ⩾ *M/e,o ⩾ *M/i,u ⩾ *M/ə

The harmony scales given in (a, b) and the dominance hierarchies in (c, d) are formed using the mechanism of PROMINENCE ALIGNMENT discussed in Prince & Smolensky (1993: ch. 5). In particular, Kenstowicz aligns a segmental prominence scale (or sonority scale: a > e, o > i, u) with a foot-prominence scale (foot-peak > foot-margin). Kenstowicz utilises the constraints shown in (c, d) to analyse languages where stress is attracted to certain vowels based on their sonority. For example, in the Mokshan dialect of Mordwin discussed by Kenstowicz, stress is attracted by the mid and low vowels /e o æ a/; the vowels /i u ə/ will be stressed only if the word does not contain a high-sonority mid or low vowel. In Chamorro, a reversal of sorts occurs – the sonority of a vowel is manipulated to be consistent with its prosodic role. Descriptively, Chamorro long vowels (of any quality) are sonorous enough to bear main stress, but short vowels must be either low (/a æ/) or mid (/e o/). That is, the short high vowels (/i u/) cannot bear main stress. This is expected since low vowels are the most sonorous vowels, and mid vowels are next in line. *Long* high vowels can also bear main stress, but short high vowels cannot. This situation suggests a Kenstowicz-style constraint family. However, whereas Kenstowicz's constraints are formulated for the prosodic category of 'foot',

[4] Actually, in completely unstressed syllables, the low vowels surface as [ə] – indicating that IDENT-IO(low) must be dominated by at least one other constraint.

[5] As noted by von Costenoble (1940) and Chung (personal communication), stressed [i u] can appear without lengthening in reduplicated words, since Chamorro uses a light-syllable reduplicative template.

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my constraint family will operate at the prosodic level of 'word'. In other words, Kenstowicz's constraints tell us which vowels are good or bad foot-peaks (= bearers of any degree of stress), whereas the constraint formalisation presented below tells us which vowels are good or bad word-peaks (= primary stressed):

(9) *The word-peak constraint family in Chamorro*

$*P_{Wd}/i,u \gg *P_{Wd}/e,o \gg *P_{Wd}/a,æ \gg *P_{Wd}/V:$

It should be noted that the dominance hierarchy shown in (9) adds a constraint that deals with long vowels without regard for vowel quality ($*P_{Wd}/V:$), which is not discussed by Kenstowicz – this constraint can be thought of as a convenient abbreviation for all word-peak constraints that refer to long vowels. Since Chamorro phonology does not require prominence gradations among long vowels, I will utilise this abbreviated constraint name (except in tableau (14), where I briefly consider the ranking of $*P_{Wd}/V:$ with other constraints). Also, the remaining constraints ($*P_{Wd}/i,u$, $*P_{Wd}/e,o$, $*P_{Wd}/a,æ$) are understood in this analysis to refer only to short vowels. These modifications add an extra dimension to the word-prominence family – the dimension of vowel length. As such, it would be appropriate to think of this particular prominence family as a conjoined family of constraints, such that $*P_{Wd}/i,u$ would correspond to conjunction of $*P_{Wd}/[i,u]$ with $*P_{Wd}/\mu$, for example.[6] In the interests of simplifying the exposition of my analysis, I will use the simple (non-conjoined) constraint names given in (9).[7]

Given the word-prominence hierarchy shown above, we might expect all stressed vowels in Chamorro to undergo lengthening. Indeed, many stressed vowels do undergo lengthening (see note 2) – but only in open syllables. In other words, vowel lengthening under stress cannot occur in closed syllables. Assuming that coda consonants in Chamorro are moraic, this generalisation can be accounted for by postulating a constraint against trimoraic syllables:

(10) *TRIMORAIC

Syllables may not have more than two moras.

With the correct ranking of *TRIMORAIC, lengthening under stress will be limited to those syllables that lack a coda consonant. The exact ranking of *TRIMORAIC will be established shortly (see (11) below) – but at the present time, let us consider how the word-peak constraint family derives vowel lowering in closed stressed syllables in general.

The word-peak family indicates that more sonorous vowels make better word-peaks. Specifically, after the long vowels, lower vowels make better

[6] I would like to thank an anonymous *Phonology* reviewer for pointing this out.

[7] Presumably, the fully expanded version would be:

(i) $[*P_{Wd}/i,u \;\&\; *P_{Wd}/\mu] \gg [*P_{Wd}/e,o \;\&\; *P_{Wd}/\mu] \gg [*P_{Wd}/a,æ \;\&\; *P_{Wd}/\mu] \gg [*P/i,u \;\&\; *P/\mu\mu] \gg [*P_{Wd}/e,o \;\&\; *P_{Wd}/\mu\mu] \gg [*P_{Wd}/a,æ \;\&\; *_{Wd}/\mu\mu]$

This family of conjoined constraints would be the result of combining a quality-based word-peak family ($*P_{Wd}/i,u \gg *P_{Wd}/e,o \gg *P_{Wd}/a,æ$) with a quantity-based word-peak family ($*P_{Wd}/\mu \gg *P_{Wd}/\mu\mu$).

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word-peaks. Therefore, in cases where lengthening under stress is not an option, we expect to find vowel lowering in Chamorro. As shown above in (7), we do find this phenomenon. However, one might wonder why vowel lowering in Chamorro is limited only to mid ~ high alternations – the word-peak family indicates that low vowels are better word-peaks than mid vowels, so we might expect that vowel lowering in Chamorro would produce stressed [a æ] rather than stressed [e o] in closed syllables. If it weren't for the intervention of other constraints, we might expect all stressed short vowels in Chamorro to surface as low vowels, since [a æ] are the most sonorous of the short vowels. However, high ranking of the constraint IDENT-IO(low) will limit the vowel-lowering process to high ~ mid alternations by preventing underlying high (or mid) vowels from lowering to [a æ], as shown in the partial tableau in (11).

(11)

/mitgut/ *or* /metgut/	IDENT-IO(low)	*TRIMORAIC	*P_{Wd}/i,u	*P_{Wd}/e,o	*P_{Wd}/a,æ	*P_{Wd}/V
☞ 'metgut				*		
'mitgut			*!			
'mi:tgut		*!				*
'mætgut	*!				*	

In this tableau, if IDENT-IO(low) were ranked below *P_{Wd}/e,o, we would expect the incorrect surface form *['mætgut] to emerge, since in that case the winning candidate would be determined by the word-peak constraints – that is, since *['mætgut] has a more sonorous stressed vowel (violating only the low-ranked *P_{Wd}/a,æ), it would incorrectly be chosen as the winner. Returning now to the ranking of *TRIMORAIC, we can see that the tableau in (11) also requires *TRIMORAIC ⩾ *P_{Wd}/e,o. The opposite ranking would choose the incorrect form *['mi:tgut] as the winner, since the stressed vowel [i:] is more sonorous than the stressed [e] of the correct output form. Since ['metgut] is the actual output form, we know that *TRIMORAIC and IDENT-IO(low) must both outrank *P_{Wd}/e,o. The tableau in (11) also demonstrates how the word-peak family correctly predicts vowel lowering – the correct form ['metgut] beats the incorrect form *['mitgut] due to the ranking *P_{Wd}/i,u ⩾ *P_{Wd}/e,o. In other words, ['metgut] is the correct output form because it provides the most sonorous vowel possible without changing any underlying specifications for the feature [low] and without creating a trimoraic syllable.

Now let us turn to the issue of vowel lowering in open syllables. As shown by the data in (7) above, vowel lowering does not occur in open syllables. In fact, mid vowels cannot occur in open syllables in Chamorro (except in lexical exceptions or reduplicated forms – see note 1), whereas high vowels *can* occur in stressed open syllables. For example, we have the surface form ['pi:saw] 'fishing line', and not *['pe:saw]. Since vowel height is completely predictable for Chamorro non-low vowels, there must be some constraint that limits vowel lowering even more by favouring the presence of [i: u:] in stressed open syllables rather than the

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presence of [e: o:]. Since the peripheral vowels [i u a] are the most extreme vowel articulations and therefore presumably the most distinctive, a possible constraint punishing occurrences of mid vowels would be as follows:

(12) PERIPHERAL
Vowels are peripheral.

This is a context-free markedness constraint which favours peripheral vowels in all positions. By combining this constraint with the word-peak family, the occurrence of long high vowels in open stressed syllables can be derived.

(13) *Ranking of* PERIPHERAL *with the word-peak constraint family*

$$\left\{\begin{array}{c}\text{PERIPHERAL}\\ *P_{Wd}/i,u \gg *P_{Wd}/e,o \gg *P_{Wd}/a,æ\end{array}\right\} \gg *P_{Wd}/V:$$

As shown in the following tableau, the ranking PERIPHERAL $\gg$ $*P_{Wd}/V:$ ensures that the correct form [pi:saw] beats the incorrect form *['pe:saw]. Note that in the tableau, the constraint $*P_{Wd}/V:$ is expanded into two of its subconstituents: $*P_{Wd}/i:,u:$ and $*P_{Wd}/e:,o:$. This expansion of $*P_{Wd}/V:$ allows the ranking PERIPHERAL $\gg$ $*P_{Wd}/V:$ to be more easily ascertained.

(14)

/pisaw/ *or* /pesaw/	$*P_{Wd}/i,u$	PERIPHERAL	$*P_{Wd}/i:,u:$	$*P_{Wd}/e:,o:$
☞ 'pi:saw			*	
'pe:saw		*!		*
'pisaw	*!			

Without the ranking PERIPHERAL $\gg$ $*P_{Wd}/V:$, the incorrect output candidate *['pe:saw] would be chosen as the winner since [e: o:] are more prominent than the peripheral long vowels [i: u:]. As we shall see in §3.2, the PERIPHERAL constraint is also necessary to explain some further complications concerning Chamorro vowel lowering which involve secondary stress. Also note that in (14), PERIPHERAL and $*P_{Wd}/i,u$ do not need to be ranked with respect to one another. However, if we return momentarily to the case of vowel lowering in closed stressed syllables, we can see that in adding the constraint PERIPHERAL to the tableau for ['metgut], we must also specify the ranking $*P_{Wd}/i,u \gg$ PERIPHERAL. This is demonstrated in (15) below:

(15)

/mitgut/ *or* /metgut/	IDENT-IO(low)	*TRI-MORAIC	$*P_{Wd}/i,u$	PERI-PHERAL	$*P_{Wd}/e,o$	$*P_{Wd}/a,æ$	$*P_{Wd}/V:$
☞ 'metgut				*	*		
'mitgut			*!				
'mi:tgut		*!					*
'mætgut	*!					*	

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In this tableau, the constraints IDENT-IO(low), *P_{Wd}/i,u, *P_{Wd}/e,o and *P_{Wd}/a,æ are shown in the same relative positions they occupy in tableau (11). Note that if PERIPHERAL had been added to the left of *P_{Wd}/i,u instead of to its right, the correct form ['metgut] would have been incorrectly blocked, and *['mitgut] would have appeared. We can therefore infer the ranking *P_{Wd}/i,u ≫ PERIPHERAL (as well as IDENT-IO(low), *TRIMORAIC ≫ PERIPHERAL).

3.2 Vowel lowering on secondary stresses

Up until this point, vowel lowering has only been discussed with respect to main stress. However, Chamorro also has secondary stress. In particular, an initial syllable in Chamorro will bear secondary stress if the word would otherwise begin with two or more unstressed syllables. Chung (1983) refers to this type of stress as 'rhythmic' secondary stress. Vowel lowering is optional on rhythmic secondary stresses:

(16) *Optional vowel lowering on 'rhythmic' secondary stresses*

tin'ta:guʔ	'messenger'
ˌtinta'goʔta *or* ˌtenta'goʔta	'our (INCL) messenger'
mun'doŋgu	'cow's stomach'
ˌmundoŋ'goɲɲa *or* ˌmondoŋ'goɲɲa	'his cow's stomach'

I wish to claim that vowel lowering on rhythmic secondary stresses in Chamorro is entirely parallel to vowel lowering on primary stresses, only weaker (thus allowing variability in the output forms). In order to capture this generalisation, I will use a foot-peak constraint family:[8]

[8] As with the word-peak family, this should also be understood as a conjoined constraint family. Also, two anonymous *Phonology* reviewers have pointed out that it may seem redundant to have both a word-peak constraint family and a foot-peak constraint family. Indeed, the word-peak and foot-peak constraint families vary only with respect to the prosodic categories they make reference to. However, I would maintain that such redundancy is inescapable, or, in fact, desirable. For example, the syllable-prominence constraint family postulated by Prince & Smolensky (1993) is also largely redundant with the word-peak and foot-peak families discussed here. It seems as though the redundancy embodied in these constraint families is an artefact of the Prominence Alignment mechanism (Prince & Smolensky 1993) used to produce such dominance hierarchies. As mentioned above, the Prominence Alignment mechanism allows for two inherently ranked phonetic scales (such as segmental prominence (sonority) and foot prominence) to be combined into a single, inherently ranked harmony scale, corresponding to an inherently ranked constraint family. Syllable prominence combines sonority (a, æ > e, o > i, u > sonorant consonants > obstruents) with syllable prominence (nucleus > margin); word-peak combines sonority with word prominence (word-peak > word-margin); and foot-peak combines sonority with foot prominence (foot-peak > foot-margin). It is likely that the different types of prominence are part of a larger prominence hierarchy (word-peak > foot-peak > syllable-peak > margins), especially since they exist in a set∼subset relation (syllable-peaks ⊃ foot-peaks ⊃ word-peaks). This suggests that the constraint families for syllable prominence, word-peak and foot-peak might be collapsed into a single huge constraint family with inherently ranked constraints on syllable nuclei, foot-peaks and word-peaks. However, since the Chamorro data do not crucially depend on rankings between the word-prominence and foot-prominence constraint families, I will not extensively develop this idea at the current time.

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(17) *The foot-peak constraint family in Chamorro*

$*P_{Ft}/i,u \gg *P_{Ft}/e,o \gg *P_{Ft}/a,æ \gg *P_{Ft}/V:$

This constraint family is entirely parallel to the word-peak constraint family discussed in (9), but the foot-peak constraint family applies at a lower prosodic level – the level of 'foot'. Note that the foot-peak constraint family will be relevant for both secondary stresses and primary stresses – assuming the Continuous Column Constraint of Hayes (1995), we can assume that any word-peak must also be a foot-peak. To phrase this in terms of a grid-based theory of prominence, any syllable which bears a grid mark in row n must also bear a grid mark at row $n-1$. This entails that any syllable which is prominent at the level of 'word' is also prominent at the level of 'foot'. Therefore, the foot-peak family will apply to syllables that bear any degree of stress, while the word-peak family will apply only to a *subset* of stressed syllables – those which bear primary or 'word-level' stress.

The variability of vowel lowering on rhythmic secondaries can be derived if the constraints $*P_{Ft}/i,u$ and PERIPHERAL are tied – crucially not ranked with respect to each other. Anttila (1995) proposes that tied constraints result from a grammar where constraints are only partially ordered. Following Anttila, I will assume that partially ordered constraints will generate multiple tableaux – one tableau for each ranking that could be imposed on the tied constraints. In the case of Chamorro vowel lowering, there are two possible rankings between $*P_{Ft}/i,u$ and PERIPHERAL; each is shown in (18). In this and subsequent tableaux, tied constraints will be indicated by the absence of an intervening line between two constraint columns, as between $*P_{Ft}/i,u$ and PERIPHERAL in (18).

(18) a.

/tintagoʔ-ta/ *or* /tentagoʔ-ta/	$*P_{Wd}/i,u$	$*P_{Ft}/i,u$	PERIPHERAL
☞ ˌtentaˈgoʔta			**
ˌtintaˈgoʔta		*!	*

b.

/tintagoʔ-ta/ *or* /tentagoʔ-ta/	$*P_{Wd}/i,u$	PERIPHERAL	$*P_{Ft}/i,u$
ˌtentaˈgoʔta		**!	
☞ ˌtintaˈgoʔta		*	*

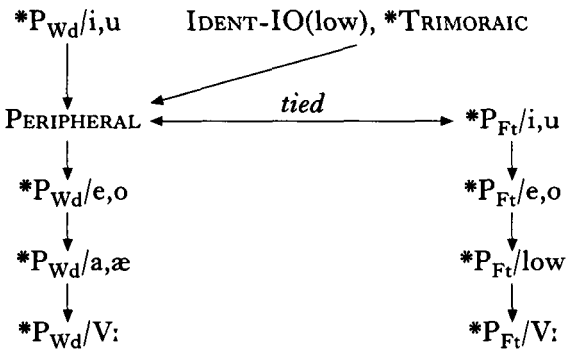
At this time, it may be helpful to compare tableaux (18) and (15). In (15), I demonstrated that $*P_{Wd}/i,u$ must outrank PERIPHERAL. In (18), I demonstrate that PERIPHERAL must be co-ranked with $*P_{Ft}/i,u$ (in order to produce variable surface forms). By transitivity of dominance, this indicates that $*P_{Wd}/i,u$ outranks $*P_{Ft}/i,u$. As noted above, the families for word-peak and foot-peak apply in a set∼subset relationship. Therefore, in accordance with Pāṇini's theorem (see Prince & Smolensky 1993), the ranking $*P_{Wd}/i,u \gg *P_{Ft}/i,u$ is the expected result since the subset con-

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straint (*P_{Wd}/i,u) *is* active in Chamorro grammar. So far, the following constraint rankings have been claimed:

(19) *Constraint rankings*

ranking	*motivation*
*P_{Wd}/i,u ≫ *P_{Wd}/e,o ≫ *P_{Wd}/a,æ ≫ P_{Wd}/V:	sonority universals
*P_{Ft}/i,u ≫ *P_{Ft}/e,o ≫ *P_{Ft}/a,æ ≫ P_{Ft}/V:	sonority universals
IDENT-IO(low) ≫ *P_{Wd}/e,o	'metgut ≫ 'mætgut (11)
*TRIMORAIC ≫ *P_{Wd}/e,o	'metgut ≫ 'mi:tgut (11)
PERIPHERAL ≫ *P_{Wd}/e,o	'pi:saw ≫ 'pe:saw (14)
*P_{Wd}/i,u ≫ PERIPHERAL	'metgut ≫ 'mitgut (15)
IDENT-IO(low) ≫ PERIPHERAL	'metgut ≫ 'mætgut (15)
*TRIMORAIC ≫ PERIPHERAL	'metgut ≫ 'mi:tgut (15)
*P_{Ft}/i,u and PERIPHERAL are tied	ˌtenta'goʔta, ˌtinta'goʔta (18)



To review the analysis of vowel lowering so far: (i) feature specifications for [high] are completely predictable in Chamorro; (ii) the short high vowels [i u] are not sonorous enough to bear stress in Chamorro – instead, the long high vowels [i: u:] or the mid vowels [e o] occur; (iii) the long high vowels are preferred over mid vowels since [i: u:] are peripheral and therefore more distinctive; (iv) mid vowels occur in those stressed syllables where [i: u:] are disallowed because they would create trimoraic syllables.

3.3 Vowel lowering on derived secondary stresses

This analysis must be complicated slightly by the introduction of surface–surface correspondence constraints on the feature [high]. These are the effects which will require *segmental* surface–surface correspondence, and which will later be compared with the *prosodic* correspondence relations required by the process of gemination.

When a word is affixed in Chamorro, the main stress of the base form is retained in the derived form as a secondary stress (assuming retention of the stress will not cause a stress clash). These types of secondary stresses

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are termed 'derived' or 'cyclic' secondary stresses by Chung (1983). With this type of secondary stress, vowel lowering is obligatory (cf. rhythmic secondary stresses, where vowel lowering is optional):

(20) *Obligatory vowel lowering on derived secondary stresses*

'ettigu	'short'	ˌetti'goŋŋa	'shorter'	*ittigóŋŋa
i'neŋŋuluʔ	'peeping'	iˌneŋŋu'loʔhu	'my peeping'	*inìŋŋulóʔhu
'ottimu	'end'	ˌotti'moŋŋa	'his end'	*ùttimoŋŋa

The analysis above would derive *optional* vowel lowering on these forms (see (18)). From this fact, it seems clear that the grammar of Chamorro treats rhythmic and derived secondary stresses differently with respect to vowel lowering. I will formalise this difference by claiming that optional vowel lowering on rhythmic secondary stresses results from Chamorro phonotactics (as described in the analysis developed above), while obligatory vowel lowering on derived secondary stresses results from a surface–surface IDENTITY constraint for [high]. This constraint will be similar to those discussed in Benua (1995, 1997) and McCarthy (1995), in that it will utilise surface–surface correspondence. It will also be similar to those discussed in Alderete (1995), in that it gives special status to segments appearing in prosodic heads.

(21) HD-IDENT-BA(high)

For $\alpha \in$ base and $\beta \in$ affixed form, if α is contained in a prosodic word-head and is [γhigh], and if $\alpha \mathfrak{R} \beta$, then β is [γhigh].

i.e. base/affixed-form correspondent segments in the prosodic head of the word agree in value for [high].

This constraint gives privileged status to vowels that are main-stressed in a base form and allows them to 'pass on' their feature specification for [high] to corresponding vowels in affixed forms. This usage of prosodic heads varies somewhat from Alderete's (1995), in that my usage claims privileged status for S_1 elements that are contained within a prosodic head. Alderete's theory of faithfulness to prosodic heads specifically claims privileged status for S_2 elements that are contained within prosodic heads. However, Alderete was examining input–output relations, where S_1 would not normally have prosodic structure. In work dealing with surface–surface similarity phenomena, Steriade (1996) and Kenstowicz (1995) both suggest constraints similar to the one I propose. Specifically, Kenstowicz (1995) proposes that 'identity with respect to certain salient positions in the *base*... may be ranked higher than the requirement of complete identity' (Kenstowicz 1995: 18; emphasis added). Similarly, in an analysis of Palestinian Arabic, Steriade (1996) proposes a Paradigm Uniformity (PU) constraint – PU (stress) – which prevents deletion of unstressed vowels in derived forms if they were stressed in the related base form.

An example of how my constraint HD-IDENT-BA(high) operates may be useful at this time. Consider, for example, the base form ['dæŋis] 'candle'

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and its suffixed form [dæ'ŋessu] 'my candle'. The figure in (22) portrays some correspondence relations between the segments of these two forms.

(22) d æ ŋ i s
| | ⋮ ⋮ ⋮
d æ ŋ e s s u

In (22), each segment of the base is linked to a segment of the affixed form via a line. Broken lines are used for those segments of the base that are *not* contained in a prosodic head (prosodic head = stressed syllable). Solid lines are used for those segments of the base that *are* contained in a prosodic head. The correspondences indicated with solid lines are the ones relevant for HD-IDENT-BA(high). In this particular case, the stressed vowel of the base ['dæŋis] is low and therefore immune to the vowel-lowering process and unaffected by HD-IDENT-BA(high). However, if the stressed vowel of the base had been a mid vowel, HD-IDENT-BA(high) would be at odds with PERIPHERAL – the constraint HD-IDENT-BA(high) would motivate the presence of an unstressed mid vowel in the affixed form (for purposes of identity), but this mid vowel would violate PERIPHERAL. This situation is demonstrated in the tableaux in (23). Note that all tableaux utilising BA-correspondence constraints list the base form immediately above the tableau.

(23) *base:* i'neŋŋuluʔ

a.

/ineŋŋuluʔ-ŋa/ *or* /iniŋŋuluʔ-ŋa/	*P_{Wd}/i,u	HD-IDENT-BA(high)	PERIPHERAL	*P_{Ft}/i,u
☞ i,neŋŋu'loʔŋa			**	
i,niŋŋu'loʔŋa		*!	*	*
i,niŋŋu'luʔŋa	*!	*		*

b.

/ineŋŋuluʔ-ŋa/ *or* /iniŋŋuluʔ-ŋa/	*P_{Wd}/i,u	HD-IDENT-BA(high)	*P_{Ft}/i,u	PERIPHERAL
☞ i,neŋŋu'loʔŋa				**
i,niŋŋu'loʔŋa		*!	*	*
i,niŋŋu'luʔŋa	*!	*	*	

In the tableaux above, we see that the constraint HD-IDENT-BA(high) must outrank the tied constraints PERIPHERAL and *P_{Ft}/i,u. Without this ranking, we might expect the incorrect form *[i,niŋŋu'loʔŋa] to emerge as an optional winner – it has fewer violations of the tied constraint PERIPHERAL than does the correct output form [i,neŋŋu'loʔŋa]. In other words, the ranking HD-IDENT-BA(high) ⩾ {*P_{Ft}/i,u,PERIPHERAL} guarantees that the same candidate output will emerge in both the tableaux in (23). Without this ranking, we would expect variation. Since we don't find variation with derived secondary stresses, this is a desired effect.

However, as mentioned above, variation does occur with rhythmic secondary stresses. Let us re-examine a case of rhythmic secondary stress

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to verify that the additional constraint HD-IDENT-BA(high) and its proposed ranking do not alter the analysis for these forms.

(24) *base:* tin'ta:guʔ

a.

/tentagoʔ-ta/ *or* /tintagoʔ-ta/	*P_{Wd}/i,u	HD-IDENT-BA(high)	*P_{Ft}/i,u	PERIPHERAL
☞ ˌtenta'goʔta				**
ˌtinta'goʔta			*!	*

b.

/tentagoʔ-ta/ *or* /tintagoʔ-ta/	*P_{Wd}/i,u	HD-IDENT-BA(high)	PERIPHERAL	*P_{Ft}/i,u
ˌtenta'goʔta			**!	
☞ ˌtinta'goʔta			*	*

In (24), we see that the correct outcomes are generated: two surface variants are predicted, due to the tied constraints PERIPHERAL and *P_{Ft}/i,u. This result is due to the fact that HD-IDENT-BA(high) is unviolated by either candidate. Since the vowels carrying rhythmic secondary stress in [ˌtenta'goʔta] and [ˌtinta'goʔta] correspond to unstressed vowels in the base [tin'ta:guʔ], HD-IDENT-BA(high) is vacuously non-violated.

One last phenomenon concerning vowel lowering indicates that there is one more constraint to be added to the analysis for a complete account of vowel lowering. In Chamorro, a main-stressed vowel can become completely unstressed under affixation if retention of the base stress would cause a clash. In these situations, vowel lowering is optional on the destressed syllable.

(25) *Optional vowel lowering on destressed syllables*

'kwentus	'to speak'	kwin'tusi *or* kwen'tusi	'to speak to'
'lokluk	'to boil'	luk'lokŋa *or* lok'lokŋa	'it's boiling'
'sensin	'flesh'	sin'seŋŋa *or* sen'seŋŋa	'his flesh'

As illustrated by the tableaux below, the analysis as developed above would not account for these data:

(26) *base:* 'sensin

a.

/sensiŋ-ŋa/ *or* /sinsiŋ-ŋa/	*P_{Wd}/i,u	HD-IDENT-BA(high)	PERIPHERAL	*P_{Ft}/i,u
sin'seŋŋa		*!	*	
👎 sen'seŋŋa			**	

b.

/sensiŋ-ŋa/ *or* /sinsiŋ-ŋa/	*P_{Wd}/i,u	HD-IDENT-BA(high)	*P_{Ft}/i,u	PERIPHERAL
sin'seŋŋa		*!		*
👎 sen'seŋŋa				**

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In (26), the thumbs-down symbol points to a form which would incorrectly emerge from the tableaux as the optimal candidate – [sen'seɲɲa] *is* a correct possible output form, but it is not an invariant winner, as indicated in (26). In fact, the losing candidate in (26), [sin'seɲɲa], is also a possible surface form – it should emerge as the winner in one of the tableaux in (26). This situation can be rectified by adding a constraint against the appearance of sonorous vowels in unstressed positions. Recall that Kenstowicz (1994) also develops constraints on possible foot-margins (see (8)). Therefore, we can use the following constraint family on margin-prominence:

(27) *The margin-prominence constraint family in Chamorro*
*M/V: ≫ *M/a,æ ≫ *M/e,o ≫ *M/i,u

This family of constraints indicates that high vowels are the preferred unstressed vowels in Chamorro – unstressed mid and low vowels are dispreferred.[9] If *M/e,o is tied with HD-IDENT-BA(high), optional vowel lowering on destressed syllables will result:[10]

(28) *base:* 'sensin

a.

/sensiɲ-ɲa/ *or* /sinsiɲ-ɲa/	*P_{Wd}/i,u	*M/e,o	HD-IDENT-BA(high)	PERI-PHERAL	*P_{Ft}/i,u
☞ sin'seɲɲa			*	*	
sen'seɲɲa		*!		**	

b.

/sensiɲ-ɲa/ *or* /sinsiɲ-ɲa/	*P_{Wd}/i,u	HD-IDENT-BA(high)	*M/e,o	PERI-PHERAL	*P_{Ft}/i,u
sin'seɲɲa		*!		*	
☞ sen'seɲɲa			*	**	

The complete analysis of Chamorro vowel lowering is summarised below, adding in the constraints used for the secondary-stress facts. The

[9] In fact, long vowels and low vowels would be even more dispreferred in unstressed position in Chamorro, according to this constraint family. This is an advantageous result, since neither long nor low vowels occur in unstressed positions in Chamorro. As explained above, lengthening only occurs in open syllables under stress, and as explained note 4, unstressed /a æ/ reduce to [ə]. This process implies the ranking *M/a,æ ≫ IDENT-IO(low), which is compatible with the overall ranking of constraints necessary for Chamorro vowel lowering.

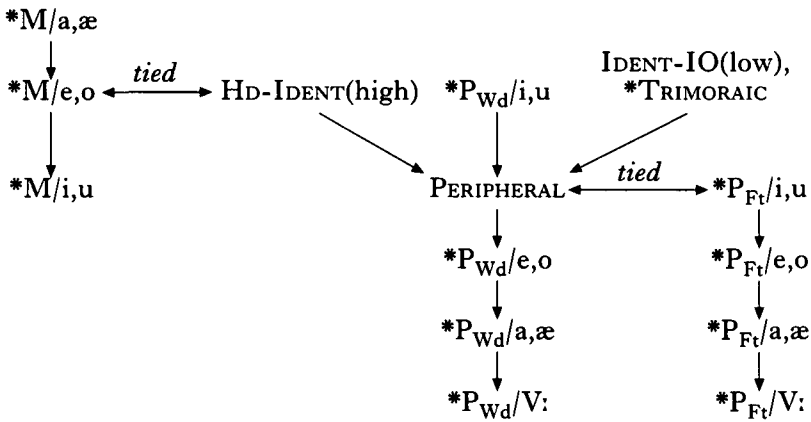
[10] Those familiar with Chung (1983) will recall that there is also an optional process of degemination in Chamorro (dealt with in §4) which interacts with vowel lowering. Namely, if a closed destressed syllable becomes open due to degemination of the following consonant, vowel lowering is no longer an option: cf. [leb.'bloɲ.ɲa], [lib.'bloɲ.ɲa], [li.'bloɲ.ɲa] 'his book', but *[le.'bloɲ.ɲa]. This phenomenon involves constraints on the distribution of lax/tense vowels in open and closed syllables in Chamorro, and will not be dealt with in this paper.

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only constraints that have been added since (19) are HD-IDENT-BA(high) and the margin-prominence constraint family.

(29) *Additional constraints and rankings for Chamorro vowel lowering*[11]

ranking	*motivation*
*M/a,æ ≫ *M/e,o ≫ *M/i,u	sonority universals
*M/e,o and HD-IDENT-BA(high) are tied	sin'seŋŋa, sen'seŋŋa (28)
HD-IDENT-BA(high) ≫ {PERIPHERAL, *P_{Ft}/i,u}	iˌneŋŋu'loʔŋa ≫ iˌniŋŋu'loʔŋa (23)



The point I would like to emphasise about this analysis of vowel lowering is that it requires the main-stressed vowel of a base form to stand in correspondence with a given vowel of an associated affixed form – for example, the HD-IDENT-BA(high) constraint compares the main-stressed vowel [e] of ['sensin] 'flesh' with the [i] of [sin'seŋŋa] and the first [e] of [sen'seŋŋa] (both variants mean 'his flesh'). These pairings of vowels between base and affixed forms are intuitive – in a traditional derivational approach, they would be considered the 'same' vowel. In the next section, we will see that the process of gemination requires comparison of prosodic elements.

4 Gemination

In this section, I show that an OT account of Chamorro gemination requires that prosodic elements stand in correspondence relations. Before investigating the details of this process, I will go over the distribution of geminates in Chamorro in general.

[11] Please note that this summary of constraints and rankings only includes those elements which are necessary for deriving vowel lowering. A full account of all vowel-related phenomena in Chamorro would also need to include, for example, the ranking *M/a,æ ≫ IDENT-IO(low), as observed in note 9. Indeed, further inspection of the vowel-related phonology of Chamorro may reveal additional constraints not shown in this summary, or additional rankings between the constraints shown.

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4.1 The distribution of geminates

Geminate consonants in Chamorro are not freely distributed. Contrasts in consonant length are restricted to post-stress position. Since the occurrence of geminates after stressed vowels is not predictable, I assume that geminate consonants occur underlyingly in Chamorro, and that they are eliminated in all but post-stress positions. This suggests that geminate consonants are dispreferred – I will represent this dispreference with the constraint *GEMINATE.

(30) *GEMINATE
Consonants must be singletons.

This constraint will be at odds with a FAITH constraint that demands the preservation of input geminates. McCarthy (1995) suggests the following constraint:

(31) WT-IDENT
If $\alpha \Re \beta$
and α is monomoraic, then β is monomoraic (no lengthening).
and α is bimoraic, then β is bimoraic (no shortening).

However, since geminates undergo length neutralisation only when they do not close a stressed syllable, it is necessary to limit the effects of this constraint to prosodic heads. Again utilising the theory of prosodic faithfulness (Alderete 1995, Beckman 1995, McCarthy 1995), I suggest the following constraints for Chamorro:

(32) a. HD-WT-IDENT(C): For $\alpha \in$ Input and $\beta \in$ Output,
If β is a consonant contained in a head and $\alpha \Re \beta$
and if α is geminate, β is geminate (no shortening)
and if α is singleton, β is singleton (no lengthening).
b. HD-WT-IDENT(V): For $\alpha \in$ Input and $\beta \in$ Output,
If β is a vowel contained in a head and $\alpha \Re \beta$
and if α is bimoraic, β is bimoraic (no shortening)
and if α is monomoraic, β is monomoraic (no lengthening).

These are variations on Alderete's (1995) HD-WT-IDENT constraint: the present version is bifurcated to provide consonant-specific and vowel-specific constraints.

Since all stressed syllables in Chamorro are heavy (they all have either a coda consonant or a long vowel) the generalisation about the surface distribution of geminates could be restated as 'underlying geminates undergo length neutralisation *except* when their presence would obviate vowel lengthening under stress'. With this in mind, I will add a constraint to my analysis which requires stressed syllables to be heavy:

(33) STRESS-TO-WEIGHT (SWP)
The head of the prosodic word should be a heavy syllable.

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This constraint is a transparent borrowing of Prince's (1990) Weight-to-Stress Principle (WSP) with a slight modification. Prince's WSP states that prominent (i.e. heavy) syllables should be prosodically prominent – in other words, the WSP says that stress is attracted to heavy syllables. In Chamorro, we see a slight turn-around on this relationship: stress placement causes changes in syllable weight.

To recapitulate: geminate consonants will appear randomly in underlying forms (this distribution must be learned); constraints will ensure that post-stress geminates emerge unchanged and that the remaining geminates undergo length neutralisation. The four constraints discussed so far in this section are *GEMINATE, HD-WT-IDENT(C), HD-WT-IDENT(V) and SWP. In the underlying forms shown in (34), I assume Chamorro speakers must learn that the form ['tommu] 'knee' has an underlying geminate but the form ['fi:nu] 'smooth' does not.

(34)

a. /finu/	SWP	HD-WT-IDENT(C)	HD-WT-IDENT(V)	*GEMINATE
☞ 'fi:nu			*	
'finnu		*!		*
'finu	*!			
b. /tommu/				
☞ 'tommu				*
'to:mu			*!	
'tomu	*!			

In this tableau, we see that SWP and HD-WT-IDENT(C) must dominate HD-WT-IDENT(V) in order to ensure that the incorrect forms *['finnu] and *['finu] do not emerge. Also, we see that HD-WT-IDENT(V) must dominate *GEMINATE so that the correct form ['tommu] will beat the competitor *['to:mu].

The same constraints and rankings will also derive length neutralisation for geminates that are not in post-stress position, as shown in (35). Note that for this form, [bu'ni:ta][12] 'pretty' we can assume that the non-post-stress consonant [n] is either geminate or singleton underlyingly – both alternatives are shown in (35).

[12] Note that in this form, the [n] *does* occur in the head of the word: it is the *onset* of the stressed syllable. As a member of the prosodic head of the surface form, this [n] *should* be subject to the HD-WT-IDENT(C) constraint. However, this would have the undesirable effect of incorrectly ruling out this candidate in this tableau. Since the ranking of the constraints cannot be changed (see tableau (34)), I will assume that the answer to this quandary is definitional. That is, I will assume that the 'head' referred to in the definition of HD-WT-IDENT is not the 'stressed syllable' of a word, but the head (rhyme) of the stressed syllable. Therefore, the onset [n] in this form is exempt from HD-WT-IDENT(C), and the violation marks are correct as given in tableau (35).

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(35) a.

/bunnita/	SWP	Hd-Wt-Ident(C)	Hd-Wt-Ident(V)	*Geminate
☞ 'bu'ni:ta			*	
bun'ni:ta			*	*!
bu'nita	*!			

b.

/bunita/				
☞ 'bu'ni:ta			*	
bun'ni:ta			*	*!
bu'nita	*!			

Finally, geminates also show surface–surface similarity effects in Chamorro – if stress shifts away from an underlying geminate due to suffixation, the geminate optionally simplifies to a singleton consonant. For example, the form ['tommu] 'knee' can be suffixed with [-ɲa] 'his' to form either [tum'moŋŋa] or [tu'moŋŋa] 'his knee'. Geminate simplification would be expected, based on the preceding discussion of length neutralisation non-post-stress situations. The optional retention of consonant length would not be expected. I believe that the motivation for this optional retention of consonant length is a surface–surface correspondence constraint on consonant length. McCarthy's (1995) Wt-Ident constraint (quoted above) will again serve as the model for this constraint. Since it needs to compare base and affixed-form pairs, the necessary constraint will be similar to the Hd-Ident(high) constraint in that both are Ident(BA) constraints, and it will also be similar to the Hd-Wt-Ident(C) constraint, in that both are identity constraints on consonant length. I will refer to this constraint as Geminate-BA, which is stated below.

(36) Geminate-BA: For $\alpha \in$ base and $\beta \in$ affixed form,
If α is a consonant and $\alpha \Re \beta$
and if α is geminate, then β is geminate (no shortening).

This constraint will be tied with the constraint *Geminate, as shown in (37).[13]

(37) *base:* 'tommu

a.

/tommu-ɲa/	SWP	Hd-Wt-Ident(C)	Hd-Wt-Ident(V)	Geminate-BA	*Geminate
☞ tum'moŋŋa		*			**
tu'moŋŋa		*		*!	*

b.

/tommu-ɲa/	SWP	Hd-Wt-Ident(C)	Hd-Wt-Ident(V)	*Geminate	Geminate-BA
tum'moŋŋa		*		**!	
☞ tu'moŋŋa		*		*	*

[13] The violations for Hd-Wt-Ident(C) in (37) are incurred due to the gemination of the initial consonant of the suffix. The gemination of the suffix /ɲ/ is dealt with in the next section.

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In this example, the constraint SWP and the input–output HD-WT-IDENT constraints do not play a role in deriving the two surface variants. This is because the part of the word displaying variation does not bear stress, and the constraints SWP and HD-WT-IDENT necessarily apply only to stressed syllables.

4.2 The process of gemination

Note that the forms in (37) unexpectedly display geminate [ɲɲ].[14] These geminates are formed by a process referred to by Chung (1983) as gemination. This process will geminate the initial consonant of a -CV suffix if needed to provide a coda for a preceding stressed syllable.[15] This process occurs only if there was a closed, stressed syllable elsewhere in the base. Therefore, gemination in Chamorro helps ensure that any base form with main stress on a closed syllable will continue to have main stress on a closed syllable in derivatives.

(38) *Gemination harmony in Chamorro*

base		*suffixed form*	
'mampuʔlu	'place'	ˌmampuʔ'loɲɲa	'its place'
'daŋkulu	'big'	ˌdaŋku'loɲɲa	'bigger'
'lebblu	'book'	leb'bloɲɲa	'his book'
		leb'blokku	'my book'
'tommu	'knee'	tom'moɲɲa	'his knee'
		tom'mommu	'your (SG) knee'
'fi:nu	'smooth'	fi'nu:ɲa	'smoother'
bu'ni:ta	'pretty'	ˌbuni'ta:ɲa	'prettier'
man'ti:ka	'fat'	ˌmanti'ka:ɲa	'his fat'
		ˌmanti'ka:mu	'your (SG) fat'
'tsu:pa	'packet of cigarettes'	tsu'pa:ɲa	'his packet of cigarettes'
		tsu'pa:hu	'my packet of cigarettes'
ˌatma'go:su	'bitter melon'	ˌatmago'su:ɲa	'his bitter melon'

For example, in the forms shown in (38), we see geminate [ɲɲ] in [ˌmampuʔ'loɲɲa], but singleton [ɲ] in [ˌbuni'ta:ɲa]. This difference is due to the fact that the base form ['mampuʔlu] has a *closed* stressed syllable, while [bu'ni:ta] has an *open* stressed syllable. In other words, the base form ['mampuʔlu] satisfies the conditioning environment for gemination due to the presence of a stressed, closed syllable; the base form [bu'ni:ta]

[14] Phonetically, geminate [ɲɲ] is realised as [nɲ].

[15] The phoneme /h/ geminates to /kk/ in Chamorro. According to Chung (personal communication), /h/ in Chamorro corresponds historically to singleton /k/.

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does not. Note that gemination is not sensitive to the *location* of stress in the base form. For example, in [tom'moŋŋa] (from base ['tommu]), the syllable that is closed by gemination in the derivative immediately follows the syllable that bore stress in the base form – stress has merely shifted one syllable to the right. However, this is not the case in [ˌmampuʔ'loŋŋa] (from base ['mampuʔlu]) or [ˌdaŋku'loŋŋa] (from base ['daŋkulu]). In these forms, it is obvious that the 'trigger' for gemination (a stressed, closed syllable in the base form) need not be adjacent to the syllable that is closed by gemination in the derived form. Similarly, gemination is sensitive only to the stressed/unstressed status of syllables in the base form, not in the derived form. For example, in some forms showing gemination, the syllable that was stressed in the base form retains secondary stress (cf. [ˌmampuʔ'loŋŋa], [ˌdaŋku'loŋŋa]), and in other cases, it is completely destressed (cf. [tom'moŋŋa], [leb'bloŋŋa]). Finally, note that secondary stress cannot trigger gemination, even if located on a closed syllable – consider [ˌatmago'su:ŋa] (base [ˌatma'go:su]), for example.

Clearly, the gemination process is an interesting and unusual phonological process. The observations noted above suggest that the gemination process of Chamorro works to provide some sort of base–derivative similarity related to phonological weight. However, a number of possible formalisations for this process can be envisioned. The exact nature of the IDENT constraint that is necessary to account for this process will be discussed in §5, where the concept of prosodic correspondence in general will be considered in more detail, along with some possible alternative analyses for Chamorro gemination. For the time being, I will present the following constraint statement:

(39) NUCLEUS-IDENT-BA(μ)

For α, a stressed nucleus of the base, and β, a stressed nucleus of the affixed form, where $\alpha \Re \beta$,

if α is monomoraic, β must be monomoraic (no lengthening).

This constraint sets up a correspondence relation between the nucleus positions in the stressed syllables of the base and the affixed form, and requires that these positions have the same moraic status (long *vs.* short). In order to assist the reader in understanding how violation marks are assessed for this constraint, it may be useful to consult the following diagram – while bearing in mind that the exact formalisation of this constraint will be further elaborated in the subsequent section.

(40) *Correspondence between stressed nuclei* (*first approximation*)

lébblu	'short'	fi:nu	'smooth'
lebblóŋŋa	'shorter'	finú:ŋa	'smoother'

This constraint is demonstrated in the following tableaux, which also utilise the constraints formulated to describe the distribution of geminates in Chamorro and the optional process of degemination (both discussed above).

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(41) *base:* 'tommu

a.

/tummu-ɲa/	SWP	NUC-ID-BA(μ)	HD-WT-IDENT(C)	HD-WT-IDENT(V)	GEMINATE-BA	*GEMINATE
☞ tum'moɲɲa			*			**
tu'moɲɲa			*		*!	*
tum'mo:ɲa		*!		*		*

b.

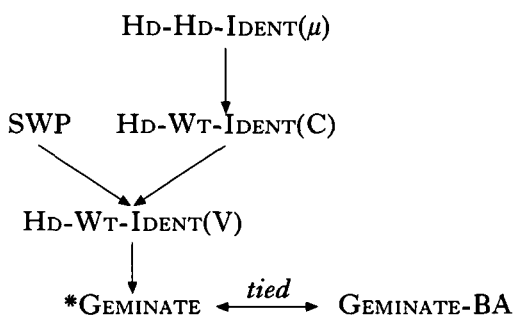
/tummu-ɲa/	SWP	NUC-ID-BA(μ)	HD-WT-IDENT(C)	HD-WT-IDENT(V)	*GEMINATE	GEMINATE-BA
☞ tu'moɲɲa			*		*	*
tum'moɲɲa			*		**!	
tum'mo:ɲa		*!		*	*	

As shown in (41), NUC-IDENT-BA(μ) must outrank HD-WT-IDENT(C). Otherwise, it would be impossible for an underlyingly singleton consonant to surface as a geminate, and the incorrect form [tum'mo:ɲa] would be expected to surface.

For a complete account of all the gemination facts of Chamorro, a few refinements need to be made concerning the NUC-IDENT-BA(μ) constraint. These will be discussed in §6, and additional discussion of the concept of 'correspondence between stressed nuclei' will be presented in §5. Before proceeding to these sections, I present a summary of the six constraints used to account for Chamorro geminates and gemination, and the ranking of these constraints.

(42) *Chamorro geminate-related constraints and their rankings*

ranking	*motivation*
SWP, HD-WT-IDENT(C) ≫ HD-WT-IDENT(V)	'fi:nu ≫ *'finu, *'finnu (34)
HD-WT-IDENT(V) ≫ *GEMINATE	'tommu ≫ *'to:mu (34)
GEMINATE-BA and *GEMINATE tied	tum'moɲɲa *and* tu'moɲɲa (37)
NUC-IDENT-BA(μ) ≫ HD-WT-IDENT(C)	tum'moɲɲa, tu'moɲɲa ≫ *tum'mo:ɲa (41)



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5 Correspondence between prosodic positions

In the previous section, I postulated the constraint NUC-IDENT-BA(μ), which requires a correspondence relation between the 'stressed nuclei' of a base and its affixed form. In this section, I will discuss the idea of correspondence between stressed nuclei (and other prosodic positions). I will also consider a number of possible alternative analyses for Chamorro gemination. Before addressing these issues, however, I would like briefly to go over some terms that are used to refer to IDENT constraints (and other constraints) in preparation for the ensuing discussion.

5.1 Anatomy of an IDENT constraint

As discussed in Crowhurst & Hewitt (1997), optimality-theoretic constraints can be understood as consisting of various components. Crowhurst & Hewitt define a number of such components, including the components of 'primary argument' and 'secondary argument' (defined below):

(43) *Constraint components* (Crowhurst & Hewitt 1997)

The PRIMARY ARGUMENT of any constraint is:

i. The linguistic object upon which some condition of maximum harmony is predicated.

ii. Always interpreted with universal scope.

The SECONDARY ARGUMENT of any constraint is:

i. Identified with the condition on the primary argument.

ii. Always interpreted with existential scope.

For an IDENT constraint, the 'primary argument' or 'focus' is a segment or other unit that is specified (named) in the constraint statement, and the 'secondary argument' is a corresponding element of an identical nature. Let us return to the statement provided in §4 for the IDENT constraint utilised in Chamorro gemination:

(44) NUC-IDENT-BA(μ)

For α, a stressed nucleus, where $\alpha \Re \beta$,

if α is monomoraic, β must be monomoraic (no lengthening).

In this constraint, the primary argument/focus is the stressed, monomoraic nucleus α, and the secondary argument is the corresponding stressed, monomoraic nucleus β. Using propositional logic, NUC-IDENT-BA(μ) could be restated as follows:

(45) NUC-IDENT-BA(μ)

$\forall\ \alpha$, α a stressed, monomoraic nucleus,

$\exists\ \beta$, β a stressed monomoraic nucleus, $\ni\ \alpha \Re \beta$

Alternative analyses of Chamorro gemination are available that use different approaches to both the primary and secondary arguments of the NUC-IDENT-BA(μ) constraint. These alternatives are discussed below. In discussing these possible alternative analyses, the nature of prosodic correspondence in general will also be investigated.

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5.2 Alternative arguments for NUC-IDENT-BA(μ)

As mentioned above, the Chamorro gemination process could be formalised in many different ways. As I noted in §4, I have chosen to state the NUC-IDENT-BA(μ) constraint using the linguistic element 'stressed monomoraic nucleus' as the primary argument; however, other possibilities exist. I believe that the 'stressed monomoraic nucleus' focus of NUC-IDENT-BA(μ) is superior to the alternatives in that it provides a more accurate and precise characterisation of the gemination process. A list of the alternatives I have considered is given below, including both the alternative primary arguments and the secondary argument that would be needed to make the constraint work:

(46)	*Alternative primary arguments*	*Secondary arguments*
	a. stressed foot	corresponding (CV.CVC) or (CVC.CVC) stressed foot
	b. main-stressed syllable	corresponding CVC main-stressed syllable
	c. rhyme of main-stressed syllable	corresponding VC main-stressed rhyme
	d. nucleus of main-stressed syllable	corresponding V main-stressed nucleus, i.e. corresponding *monomoraic* main-stressed nucleus

Although any of the possibilities listed above could be used to formalise an analysis for Chamorro gemination, I have concluded that (46d) (focused on the main-stressed nucleus) is more likely than the remaining three possibilities. My reasons for preferring correspondence between stressed nuclei are summarised below:

(i) *Stressed foot as focus*: The structure of the weak member of the foot is irrelevant for gemination – for purposes of gemination, the foot structure CVC.CVC is a perfect match for CV.CVC. Also, it is necessary to state the secondary argument in terms of Cs and Vs instead of weight – CV.CVC is *not* a good match for CV.CVV as far as gemination is concerned.

(ii) *Stressed syllable as focus*: The presence *vs.* absence of an onset consonant is irrelevant for gemination: a stressed, onsetless syllable of the type VC would be a good match for a stressed syllable of the type CVC as far as gemination is concerned. As above, the secondary argument must be stated in terms of Vs and Cs instead of in terms of weight – a stressed CVV syllable is *not* a good match for a stressed CVC syllable.

(iii) *Stressed rhyme as focus*: As with the two preceding items, if the primary argument is the stressed rhyme, the secondary argument must be stated in terms of Vs and Cs instead of in terms of moraicity – a stressed rhyme of the type VC is not a good match for a stressed rhyme of the type VV.

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(iv) *Stressed nucleus as focus*: This formalisation is the most specific – it does not unnecessarily involve weak syllables or onset consonants. Furthermore, the distinction between a VV nucleus and a V nucleus is statable in terms of moraicity (monomoraic *vs.* bimoraic) – statement in terms of Vs and Cs is not necessary.

It should be emphasised that the considerations listed above do not provide an unambiguous argument for correspondence between stressed nuclei. In fact, it may be that yet other alternatives could be added to those possibilities I have considered. However, for concreteness, I will choose to formalise my gemination constraint using only one of the possibilities discussed – correspondence between stressed nuclei.

5.3 Prosodic *vs.* segmental correspondence

Another possible alternative analysis involves the idea of prosodic correspondence in general. As explained in the introductory section of this paper, the main focus of this paper is the existence of two types of correspondence in Chamorro – one that compares segmental elements, and one that compares prosodic elements. However, a possible alternative analysis is available that relies on Raimy & Idsardi's (1996) analysis of reduplication. In their analysis, Raimy & Idsardi suggest that a segment (or segments) of a base form can have multiple correspondents in the reduplicated form. They represent this situation with an example from Bella Coola, where the form *kap'ayi* undergoes reduplication (and vowel deletion) to yield *kakp'ayi*:

(47) *Multiple correspondences under reduplication* (Raimy & Idsardi 1996)



According to Raimy & Idsardi's analysis, the segment *k* of the input (base form) has undergone a process they refer to as 'fission' – it has divided into two separate (but identical) output segments. Is it possible that the Chamorro case utilises a similar 'one-to-many' correspondence relation? I will argue that the fission-based account of reduplication by Raimy & Idsardi cannot be extended to the Chamorro data.

If the fission-based approach were applied to Chamorro gemination, the *e* of ['lebblu] would be viewed as having divided into two separate elements, one which retains the *vowel quality* of *e* and one which retains the *moraic status* of *e* (i.e. short). This is distinct from the reduplication cases considered by Raimy & Idsardi in an important way: in examples like *kap'ayi* ~ *kakp'ayi*, the postulated one-to-many relationship is uniform – the output *k* segments are identical.[16] Presumably, this is due to the

[16] One could imagine a reduplication pattern where one *k* is always affricated or otherwise manipulated, so that the output segments would not be the same – but this would presumably be due to additional constraints that require alteration of only one of the output segments for phonotactic considerations.

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fact that both reduplicant *k* segments are subject to the same base–reduplicant identity constraints – that is, there are IDENT constraints that regard both output *k*'s as primary arguments and the base *k* as the secondary argument (or *vice versa*). In Chamorro, the situation is quite different. In the Chamorro gemination and vowel-lowering processes, it is imperative that *only* the 'segmental' correspondents participate in vowel lowering, while *only* the 'prosodic' correspondents participate in gemination. In order to illustrate this situation, let us consider a case from Chamorro using the one-to-many correspondence approach. Consider a word such as [bá:gu] 'lazy' and its affixed form [bagú:ɲa] 'more lazy'. A one-to-many mapping between these two words could be represented as in (48):

(48) *base* b a: g u 'lazy'

affixed form b a g u: ɲ a 'more lazy'

In this representation, the lines indicate that the stressed [a] in the base form corresponds to both the unstressed [a] of the affixed form as well as the stressed [u] of the affixed form. The only problem is that the constraint rankings discussed earlier for vowel lowering would predict the incorrect form *[ba'go:ɲa] (or possibly *[ba'goɲɲa]) if this representation were used. That is, the HD-IDENT-BA(high) constraint would mandate that the stressed non-high vowel in the base form should 'pass on' its [−high] specification to its correspondent in the affixed form. Since the base-form vowel [a] has two correspondents in this representation, we might expect that HD-IDENT-BA(high) would apply to both of them. However, as illustrated by this example, it does not apply to the *prosodic* correspondent in actuality. A similar problem is encountered with exceptional borrowed forms like [né:ni] 'baby' (see note 1) – the one-to-many mapping would predict *[ni'ne:hu] 'my baby' instead of the actual form [ni'ni:hu].

Note that none of the constraints discussed earlier can be used to prevent vowel lowering in this situation. As explained earlier, IDENT-IO constraints for [high] are inactive in Chamorro since the distribution of [i ~ e] and [u ~ o] is predictable (indicating that any underlying value for [high] can be assumed for these vowels) – therefore, IDENT-IO constraints will not eliminate the overapplication of vowel lowering in forms like *[ba'go:ɲa] and *[ni'ne:hu]. The PERIPHERAL constraint can likewise not be used to eliminate this overapplication. To refresh the reader's memory, the PERIPHERAL constraint punishes occurrence of the less perceptually salient non-peripheral vowels, and would therefore assign a violation mark to a form like *[ba'go:ɲa] or *[ni'ne:hu] because of their non-peripheral vowel – [o] and [e], respectively. However, it was shown earlier that HD-IDENT-BA(high) must outrank PERIPHERAL (see (23)).

The only possibility that I can see for correctly eliminating this sort of overapplication would be to directly stipulate a domain of application in

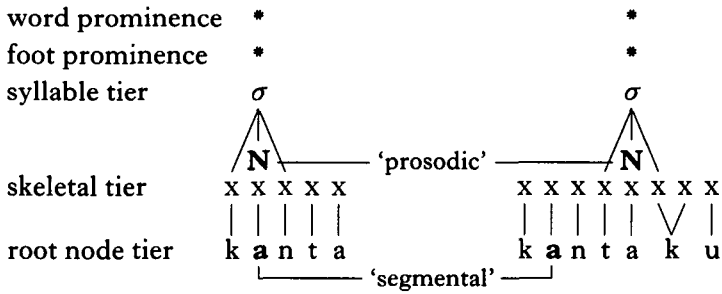
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the HD-IDENT-BA(high) constraint itself. For example, the constraint could state 'for α, a stressed vowel of the base, and β, a *non-primary-stressed* vowel of the affixed form, where $\alpha \mathfrak{R} \beta$, if α is [γhigh], then β must also be [γhigh]'. (The restriction to non-*primary* stress is necessary since HD-IDENT-BA(high) does play a role in vowel lowering with derived secondary stresses.) Clearly, this solution is stipulative – there is no independent reason why correspondence should pick out vowels of opposite prominence levels as the focus for IDENT constraints. This problem does not arise with the prosodic-correspondence approach since the IDENT-BA constraints I propose for Chamorro vowel lowering and gemination do not operate on the same arguments – HD-IDENT-BA(high) operates on segmental arguments, while NUC-IDENT-BA(μ) operates on prosodic arguments.

Another alternative to prosodic correspondence, which will shortly be rejected, is that the different pairings ('segmental' *vs.* 'prosodic') correspond to completely different mappings between a base and its affixed form. However, if we follow the standard assumption that correspondence pairings are provided by GEN as part of each candidate output (McCarthy & Prince 1995), we must conclude that this alternative is untenable – following standard assumptions, changing the correspondence relations between the base and its affixed form would be equivalent to replacing a candidate output with a new one in the middle of constraint evaluation. With this in mind, we are forced to assume that segmental and prosodic correspondence in Chamorro are simultaneous – i.e. that they are part of the same base~derivative mapping. How can these two types of correspondence be both distinct and simultaneous?

As suggested by the discussion of the NUC-IDENT-BA(μ) constraint in §4, I propose that segmental and prosodic correspondence differ from one another with respect to the identity of the primary argument – i.e. they operate upon different types of linguistic entities: segmental correspondence provides pairings of segmental positions and prosodic correspondence provides pairings of prosodic positions. This can be represented as follows:

(49) *Simultaneous prosodic and segmental correspondence*



This picture shows that the first vocalic root node of each of the forms in (49) are in correspondence, while the nuclei of the main stressed syllable

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of each form are also in correspondence. With this in mind, it becomes apparent than an IDENT constraint identifies two tokens of a single class of linguistic entity (i.e. two tokens of 'main stressed nucleus' or two tokens of 'vocalic root node'), and determines whether those two tokens are both associated with some other type of entity on a separate tier. For example, the NUC-IDENT-BA(μ) constraint identifies two main-stressed nuclei and determines whether they are both associated with only one mora on the moraic tier; the constraint HD-IDENT-BA(high) identifies two vocalic root nodes, and determines whether they are both associated with [−high] on the appropriate tier. With this in mind, it is clear that IDENT (and similar) constraints need to be stated in a manner such that the linguistic status of the primary argument is explicitly stated. In other words, it impossible to know what corresponds to the [e] of ['lebblu] 'book' unless we know whether [e] is understood as a token of the class 'root node', 'syllabic nucleus', 'carrier of main stress' or something else. As such, the Chamorro data discussed in this paper present an important case of correspondence between units larger than the segment. In McCarthy & Prince (1995), an implementational decision restricts correspondence to segments:

> Here we will assume that the structural elements in question [i.e. those referred to in correspondence] are just (tokens of) segments, but it is a straightforward matter to generalize the approach to higher-order units of prosodic structure such as moras, syllables, feet, heads of feet, as well as tones and even distinctive features or feature nodes, in support of theories of quantitative transfer, compensatory lengthening, and the effects of floating features. (McCarthy & Prince 1995: 14)

McCarthy (1995) follows the same practice, limiting correspondence to segment-sized units. However, he partially extends correspondence to deal with prosodic elements in certain manners – he allows prosodic features (such as stress or nucleus-hood) to be preserved under identity – in other words, constraints like McCarthy's HEADMATCH still utilise segments as the arguments, but they allow prosodic features (such as stress or the status 'head') to be used in naming the *specific* arguments used in a given constraint. As McCarthy (1995: 23) puts it, he assumes that 'correspondence is a relation from segment to segment only. Therefore, any aspects of prosodic faithfulness must be mediated by the segments bearing the prosodic roles'. However, the possibility of correspondence between prosodic units larger than the segment is again acknowledged by McCarthy (1995: 38):

> If segments alone stand in correspondence, then there can be no prosodic faithfulness absent the segments that stand in the prosodic role. But if prosodic constituents also stand in correspondence, then they can have a life of their own in the faithfulness universe.

McCarthy goes on to suggest that one diagnostic for prosodic correspondence would be persistence of a prosodic category under deletion

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– i.e. the preservation of a prosodic category even when the segmental material that filled that category is deleted. I believe that the Chamorro data under consideration in this paper offer a parallel opportunity to demonstrate correspondence between prosodic categories. In Chamorro gemination, the segmental material associated with the prosodic category in question (the main-stressed nucleus) is not deleted, therefore no persistence under deletion is noted. However, what we do find is a marked *dissociation* of segmental material from prosodic category: this is quite evident from the fact that the main-stressed vowel of a base in Chamorro seems simultaneously to correspond to two separate vowels in the affixed form – one of which is its segmental correspondent (understood as correspondence between segments or root nodes) and the other of which is its prosodic correspondent (understood as correspondence between stressed nuclei). As predicted by McCarthy & Prince (1995) and McCarthy (1995), the general theory of correspondence extends naturally and straightforwardly to these cases, provided that constraints dealing with correspondence explicitly state the level of prosodic category being utilised (root node, syllable, nucleus, etc.).

6 Limitations on correspondence

The existence of prosodic correspondence in Chamorro raises some interesting questions about the nature of correspondence in general. In particular, the fact that the NUC-IDENT-BA(μ) constraint of Chamorro affects vowels that are not intuitively thought of as 'the same' makes it possible to use Chamorro as a test case for limitations on correspondence. It is a standard assumption that two strings can be related using correspondence if they are related to each other in some way – such as base ~ reduplicant or input ~ output (McCarthy & Prince 1993, 1995), base ~ affixed form (Benua 1995, 1997), normal ~ argot form (Itô *et al.* 1996), etc. Based on the behaviour of gemination and the NUC-IDENT-BA(μ) constraint, I will argue that the idea of 'relatedness' is a strict limitation on correspondence that applies to every constituent morpheme of a morphologically complex string. That is, if two strings are related as base and affixed form, and one of the strings is morphologically complex (for example, it may contain an inflectional or derivational suffix), correspondence can only relate those elements of S_1 and S_2 that could *independently* enter into correspondence relations as non-complex strings. As a case in point, consider the base form ['lebblu] 'book' and the affixed form [leb'bloɲɲa] 'his book'. The suffixal morpheme [-ɲa] is not related in any way to the free morpheme {lebblu} – independently, these two morphemes could not stand in correspondence to one another. Therefore, when the forms ['lebblu] and [leb'bloɲɲa] are compared for the evaluation of IDENT-BA constraints, no pairings between segments (or other units) of [-ɲa] and ['lebblu] will be considered. Indeed, I will make an even stronger claim – that such pairings cannot be created by GEN. This

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hypothesis is in accord with the idea that surface–surface similarity constraints are motivated by the need to limit allomorphy and increase the phonological transparency between related lexical items (Kenstowicz 1995, Steriade 1996). Simply put, data from Chamorro indicate that the gemination process does not occur if the 'triggering' vowel and the 'targeted' vowel are in unrelated morphemes.[17] Two types of evidence for this hypothesis are discussed below.

The first example of a limitation on prosodic correspondence in Chamorro involves disyllabic suffixes. Recall that the gemination facts presented in the preceding section all involved monosyllabic suffixes such as *-hu* 'my', *-mu* 'your' and *-ɲa* 'his, comparative'. There are also disyllabic suffixes, including *-niha* 'their' and *-mami* 'our (EXCLUSIVE)'. Since stress in Chamorro is generally penultimate, the initial syllable of the disyllabic suffixes will (almost) always bear main stress. Given the characterisation of gemination in the preceding section, we expect to find geminated variants such as *-nikka* and *-mammi*, which would only attach to base forms that use geminated suffixes. This does not happen. Forms which require the geminated suffixes *-kku*, *-ɲɲa* or *-mmu* forego gemination with disyllabic suffixes. For example, ['kanta] 'song' shows gemination in [kan'takku] 'my song', [kan'tammu] 'your song' and [kan'taɲɲa] 'his song'; it does not show gemination in [ˌkantan'niːha] or [ˌkantan'maːmi] (note that the double [nn] in [ˌkantan'niːha] is *not* due to gemination).[18] In these examples, the stressed, short [a] of ['kanta] corresponds prosodically with stressed *long* vowels in [ˌkantan'niːha] and [ˌkantan'maːmi] – in seeming contradiction to the generalisations about gemination that have already been discussed.

Another seeming contradiction to the generalisations about gemination concerns prefixes. Since stress in Chamorro is generally penultimate and since there are few monosyllabic base forms, prefixes in Chamorro

[17] It has been suggested by an anonymous associate editor for *Phonology* that this restriction would prevent base–reduplicant correspondence because the reduplicant and the base would be independent morphemes. However, I would like to emphasise that I am not proposing that correspondence can only occur between tokens of the *same* morpheme. As stated in the text, I am proposing that correspondence can occur only between *related* morphemes. One type of relatedness is base∼reduplicant. However, this 'relatedness' is required of every subconstituent of a morphologically complex item. To give an example from English, correspondence could not be used to induce IDENT effects between the base *cat* and the suffix *-ly* in the affixed form *catly* since the morphemes *cat* and *-ly* do not fulfil the requirement for relatedness. However, in a reduplicated form like *cat-shmat*, the suffix *-schmat* (a reduplicant) *can* correspond to the base *cat* because they are related as base∼reduplicant. In other words, base∼affixed form is a type of relatedness, but base∼affix is not.

[18] Note that for all vowel-final forms, an epenthetic /n/ appears before the suffixes *-niha* and *-mami*. In particular, the double [nn] in [ˌkantan'niha] is *not* due to gemination. Appearance of the epenthetic /n/ also occurs with vowel-final forms before addition of the suffix *-midzu* 'your (PL)' ([ˌkantan'midzu]) and in certain phrasal contexts (['kantan ʧa'muru 'Chamorro song'). See Topping & Dungca (1973) for more details.

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generally bear no stress (as in [naʔ'kanta] 'cause to sing', from ['kanta] 'sing'), or bear only secondary stress (as in [ˌnaʔkan'taʒi] 'cause to sing to', from [kan'taʒi] 'sing to'). However, there is a class of inherently stressed prefixes in Chamorro. These include *'æ-* 'reciprocal', *'gof-* 'very', *'ʧæt-* 'not very, derogatory', *'kæ-* 'having', *'keʔ-* 'about to', *'læ-* 'more' and *'mi-* 'abounding in'. Given the analysis of gemination discussed above, we would expect that some of the stressed prefixes would have geminated variants. For example, we might expect a vowel-final stressed suffix such as *'mi-* to alternate with *'me*C- when attached to a base form that uses geminated suffixes. Therefore, we might expect the Chamorro word for 'abounding in books' to be *['melˌlebblu] (< 'mi- + 'lebblu). In fact, the correct surface form does not undergo gemination: ['miːˌlebblu]. The failure of gemination to occur with either the vowel-final stressed prefixes or the disyllabic suffixes can be accounted for if correspondence is limited by relatedness. If correspondent pairs must have a qualifying relationship in order to be paired by correspondence, it is easy to see why a base-vowel may not be paired with a suffix-vowel – there is no relationship such as base∼reduplicant that qualifies this pair for correspondence. In other terms, since the prefix *'mi-* could not *independently* stand in correspondence with the base ['lebblu], it is not surprising that *'mi-* cannot stand in correspondence with ['lebblu] when part of a larger string. Gemination cannot occur to provide a coda for a main-stressed affixal vowel when the 'triggering' vowel belongs to the base. In other words, I assume that correspondence relations such as those shown below cannot be created by GEN.

(50) *Some correspondence relations that* GEN *cannot create*

{'lebblu}	'book'	{'lebblu}	'book'
{'mi} + {lebblu}	'abounding in books'	{lebblu} + {'nmami}	'our (EXCL) book'

This hypothesis about the 'relatedness' requirement placed on correspondence is supported by two further observations. First, lexicalised prefix+stem combinations *are* subject to gemination (whereas non-lexicalised prefixed forms are not, as seen above). Second, gemination sometimes shows unusual behaviour with respect to multiply affixed forms – in pretheoretical terms: it sometimes seems as though gemination 'skips a cycle' in multiply affixed forms. That is, gemination does not occur under affixation if stress is drawn onto a prefix, but gemination can 'reappear' if subsequent suffixation draws main stress back onto the base. These two phenomena are given a formal analysis below.

The lexicalisation of prefix+base combinations is generally accompanied in Chamorro by certain phonological processes – one of which is deletion of the first vowel of the original base. This phonological change

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will cause an original open-syllable prefix to become closed. Examples are given in (51).

(51) *Lexicalised prefix + base combinations*

a. *prefix* 'mi 'abounding in'

base		*combination*	
'finuʔ	'word'	'mefnuʔ	'talkative'
'hagaʔ	'blood'	'mehgaʔ	'bloody'
hi'nælum	'knowledge'	'mehnælum	'wise'
'hutu	'lice'	'mehtu	'lousy'
'pulu	'hair'	'mepplu	'hairy'

b. *prefix* ma (PASSIVE)

'funut	'tighten'	'mafnut	'tight'
'ipiʔ	'cut open'	'maʔpiʔ	'cracked'

c. *prefix* CV-REDUP (AGENT)

'gupu	'fly'	'gekpu	'flyer'
'kannuʔ	'eat'	'kaknuʔ	'glutton'
'gimin	'drink'	'gekmin	'drinker'

Several of the forms listed in (51) also have non-lexicalised counterparts, such as ['mihitu] 'abounding in lice', ['mipilu] 'abounding in hair' or ['gigipu] 'flyer.'[19] Topping & Dungca (1973: 193) consider words of the type in (51) to contain 'fossilised' prefixes – prefixes that 'can no longer be separated and identified as a separate morpheme'. All of these lexicalised forms bear main stress on a closed syllable and, if they end in a vowel, show gemination: [gik'poɲɲa] 'his flyer', [mih'toɲɲa] 'more lousy'. This contrasts with the behaviour of the prefixed forms which are not lexicalised, where no gemination occurs. Compare, for example, lexicalised ['mehtu] 'lousy', which undergoes gemination ([mih'toɲɲa] 'more lousy'), but non-lexicalised ['mi:ˌlebblu] 'abounding in books', which does not (*['melˌleblu]).[20]

The second piece of supporting evidence involves examples where gemination does not apply as expected in multiply affixed forms – i.e.

[19] Note that the prefix /mi-/ 'abounding in' and CV- reduplication both cause fronting of the following stem vowel.

[20] I believe a similar correlation between lexicalisation and occurrence of gemination can be made on the basis of consonant-final stressed prefixes such as *'gof-* 'very', *'ʧæt-* 'not very', etc. However, my data on this topic is incomplete. Certain words with these prefixes show gemination, whereas others do not. For example, ['gofsaga] 'wealthy' (< 'gof- 'very' + 'saga 'rest') and ['ʧætsaga] 'difficult' (< 'ʧæt- 'not very' + 'saga 'rest') show gemination when affixed ([ˌgofsa'gaɲɲa], [ˌʧætsa'gaɲɲa]), but not all words with *'gof-* and *'ʧæt-* do. My suspicion is that the prefix + stem combinations that show gemination have been lexicalised. This suspicion is supported to a certain extent, in that the geminating forms such as ['gofsaga] sometimes have idiosyncratic meanings (cf. 'very' + 'rest' = 'wealthy'), and do not show the secondary stress placement patterns expected for prefixed words (cf. *['gofˌsaga], *['ʧætˌsaga]). The apocope process discussed above as a diagnostic for lexicalisation never occurs if it will create a cluster of three consonants, so this process is unenlightening with respect to this example. I thank Sandra Chung (personal communication) for pointing out the existence of this sort of geminating form.

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those cases which I informally described above as gemination 'skipping a cycle'. As pointed out previously, the open-syllable stressed prefixes do not undergo gemination: *['mel,lebblu] (cf. correct ['mi:,lebblu]). This was explained by pointing out that gemination in such cases would involve comparing vowels from unrelated morphemes. However, if the prefixed form is further modified with a monosyllabic suffix and stress is concomitantly drawn back onto a vowel of the base, gemination applies as expected: [,milib'blonna] 'more abounding in books'. That is, in the comparison between ['lebblu] and ['mi:,lebblu], the main-stressed [e] of the base form cannot be paired with the main-stressed [i] of the derived form since these vowels occur in unrelated morphemes. Therefore, the constraint NUC-IDENT-BA(μ) is vacuously non-violated and gemination is not expected in the derived from ['mi:,lebblu]. In a comparison between ['lebblu] and [,milib'blonna], the main-stressed [e] of the base form *can* be paired with the stressed [o] of the derived form since both vowels are in the same morpheme, and gemination occurs as expected. This sort of example strongly supports the claim that correspondence cannot relate vowels in unrelated morphemes, even if they are part of a larger string that bears some relation (overall) with another form, and it also provides a good example for demonstrating a possible motivation of the 'requirement of relatedness' seen with correspondence. Steriade (1996) claims that surface–surface similarity constraints are the result of a desire for paradigm uniformity – that morphologically related forms should be phonologically similar. She formalises Paradigm Uniformity constraints as in (52):

(52) *Formula for Paradigm Uniformity constraints* (Steriade 1996)
All surface realisations of μ, where μ is the morpheme shared by the members of paradigm X, must have identical features for property P.

In the case of gemination, the property P is moraicity of the main-stressed nucleus – this property must be shared by all the surface allomorphs of a given morpheme. As an example, the gemination found in the forms [leb'blonna] 'his book' and [,milib'blonna] 'more abounding in books' ensures that the allomorphs of /lebblu/ present in these forms have main-stressed vowels that are short, just like the simplex form ['lebblu]. In other words, gemination in these forms makes the /lebblu/ parts of these words more similar to the non-affixed surface form ['lebblu], thus increasing the uniformity found within the paradigm for this morpheme. The non-occurring gemination shown in the incorrect form *['mellebblu] would attempt to change the /mi/ of the derived form to make it more similar to ['lebblu]. This would not increase uniformity within the paradigm of ['lebblu], and would decrease uniformity within the paradigm for /mi/ 'abounding in' by introducing an allomorph with a non-high vowel – [me]. Similar arguments can be made for the other types of relatedness (input ~ output, normal ~ argot, etc.): any two strings which can be understood as exponents of a specific category should be uniform.

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7 Conclusion

In the preceding sections, I have presented an optimality-theoretic account of Chamorro vowel lowering and gemination which makes use of Correspondence theory for both input–output and surface–surface comparisons. The goal of this paper has been to demonstrate that these two processes of Chamorro demand surface–surface correspondence relations both between segmental positions and between prosodic positions. This situation is necessitated by the fact that IDENT-BA affects a single element of the segmental melody in two distinct manners – one IDENT-BA constraint affects the main-stressed vowel as a segment, and another IDENT-BA constraint affects the main-stressed vowel as mediated through its association with the main-stressed nucleus position. The two IDENT effects under consideration are sensitive to the difference between segmental and prosodic element – this is shown by the fact that one IDENT-BA effect (for [high]) only affects segmental correspondents, while the other (for vowel length) only affects prosodic correspondents. This stable, one-to-one relationship between the elements manipulated and the two sorts of IDENT-BA effects requires that two different types of BA correspondence be established – one between segments and one between main-stressed nuclei. This requires that correspondence between prosodic categories larger than the segment be accommodated within Correspondence Theory (or other theories of phonological similarity). Furthermore, the establishment of prosodic correspondence brings to light certain restrictions on correspondence in general – i.e. that the members of correspondent pairs must belong to related morphemes. These observations provide strong secondary support for theories such as Steriade's (1996) Paradigm Uniformity theory and Kenstowicz's (1995) Uniform Exponence theory, which claim that surface–surface similarity effects are motivated by the desire to decrease the amount of variation shown between related morphemes.

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