Tagalog /u/-lowering:
An instrumental study of spontaneous speech

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The standard characterization of Tagalog /u/-lowering as a phonological process triggered in the final syllable of a prosodic word fails to capture the entire picture of the domain in which lowering applies: problems arise, specifically, for cases in which optionality is apparently at issue. Kaufman (2007) argues for a prosodic structure for Tagalog hosts and clitics that utilizes recursion. Such a structure may provide the details needed to capture the variability observed in /u/-lowering. The current instrumental study, examining realizations of native Tagalog forms in spontaneous speech, tested predictions that follow from Kaufman’s hypothesized structure. The data provided evidence for the lowering process, but show that /u/ does not lower all the way to the mid vowel, contrary to the description in the literature. More crucially, the findings to some extent support the idea that previously unexplained variability has an account that depends on a two-way distinction among prosodic domains (although they are also not entirely incompatible with a three-way distinction, as per Kaufman's analysis). The prosodic categories under investigation in the current study are the minimal prosodic word, the maximal prosodic word, and the phonological phrase.

1 Introduction

Tagalog is commonly known to have a phonological process of /u/ lowering in native forms. Traditional accounts (Schachter & Otanes, 1972; Ramos, 1990; Zuraw, 2006) suggest that this lowering occurs when /u/ is in the final syllable of a prosodic word or phrase. Kaufman (2007), however, argues that such accounts are overly simplistic and demonstrates that the notion of the prosodic word must be modified in order to capture the facts of Tagalog lowering. The current study tests Kaufman’s predictions that /u/-lowering is variable and conditioned by the type of the prosodic word, using a corpus of natural spoken Tagalog speech.

1.1 Tagalog vowel system

Historically, Tagalog[1] had a three-vowel system: a high front vowel /i/, a high back vowel /u/, and a low central vowel /a/. Following sustained contact with the Spanish language from the late 16th to the 19th centuries, and sporadic contact with English (Zuraw, 2007) and other languages,[2] Tagalog's vowel inventory expanded to include the mid vowels /ɛ, ɔ/, so that modern Tagalog offers a vowel inventory as follows:

(1)		Front	Central	Back
	High	i		u
	Mid	ɛ		ɔ
	Low		a	

This paper follows Kaufman (2007) in representing the mid vowels as lax. Schachter & Otanes (1972) observe that /o, ɔ/ and /e, ɛ/ are allophones in free alternation for some speakers; as such, either allophone may represent the underlying phoneme. The data below, adopted from Ramos & Cena (1990) and Schachter & Otanes (1972), illustrate the contrast between the high vowels typically but not exclusively occurring in native forms, and the mid vowels that occur in loanwords. Such minimal pairs provide evidence that /i, ɛ/ and /u, ɔ/ contrast in contemporary Tagalog:[3]

[1] The name used for the national language of the Philippines has changed from *Tagalog* (1936) to *Pilipino* (1959) to the current label *Filipino* (1973). It is uncontroversial to assume that Filipino is based mostly on Tagalog grammar and syntax. Filipinos, both within the Philippines and abroad, refer to the language as Tagalog. This paper follows common practice in naming the national language, and as such, the terms *Tagalog* and *Filipino* will be treated as synonyms.

[2] Other language contact that may have favored the inclusion of the mid vowels includes earlier lexical borrowings from Malay (Wolff, 1976) and Hokkien Chinese (Chang-Yap, 1980).

[3] This paper employs conventional Tagalog orthography in presenting examples, unless otherwise noted.

(2)

/i/		/ɛ/	
misa	Sp. ‘mass’	*mesa*	Sp. ‘table’
tila	‘maybe’	*tela*	Sp. ‘cloth’
binta	‘moro canoe’	*benta*	Sp. ‘sale’
parti	Eng. ‘party’	*parte*	Sp. ‘part’
/u/		/ɔ/	
uso	‘fad’	*oso*	Sp. ‘bear’
butas	‘hole’	*botas*	Sp. 'boots’
kuro	‘think’	*koro*	Sp. ‘choir’
bukal	Sp. ‘fountain’	*bokal*	Sp. ‘vowel’

1.2 Tagalog vowel lowering

An alternation between high and mid vowels is well attested in native forms. Broadly, the generalization is that in the final syllable of a prosodic word,[4] the mid vowel surfaces; elsewhere, the high vowel is predicted to occur (Schachter & Otanes, 1972; Ramos, 1990; Zuraw, 2006; Kaufman, 2007). For Tagalog /u/ in particular, the lowering process might be given a preliminary characterization as follows:

(3) $$\begin{bmatrix} +\text{high} \\ +\text{back} \end{bmatrix} \rightarrow [\text{-high}] \quad / \quad \_\_\_ C_o\ ]_{\omega}$$

The alternation is apparently reasonably regular in the back vowels (Gonzalez, 1970), but it has been suggested that the corresponding alternation in front vowels is more complicated (Zuraw, 2006; D. Kaufman, personal communication, March 15, 2011). Characterizations of the [i]~[ɛ] alternation in native forms usually note that the pattern of lowering is more variable than that for [u]~[ɔ]. Thus [u] in the final syllable rarely (if ever) occurs in native words, although it does occur in that position in loans such as *konsul* ‘consul’ and *honeymoon* ‘honeymoon’ (Schachter

[4] For models of syntax-phonology interaction, discussion of prosodic domains usually arises when referring to phonological processes across word boundaries. For a discussion of the properties of the prosodic hierarchy, see, e.g., Selkirk, 1980; Nespor & Vogel,1986; Truckenbrodt, 1999.

& Otanes, 1972); however, final-syllable [i] occurs often in native forms, e.g., *kali* 'peace, quiet', as well as in loan forms, e.g., *parti* ‘party’. Because Kaufman’s (2007) predictions hold for both the front and the back vowels, and the front vowels involve additional complicating factors, the focus of this paper will be the alternation between the back vowels [u, ɔ].

Schachter & Otanes (1972) also observe that in phrase-final syllables, the alternation appears more invariant in Spanish and English loanwords than in native Tagalog forms: to the extent that the mid vowel [ɔ] occurs word-finally in native forms, Schachter & Otanes may assume that it is realized as such via the phonological process of lowering. But although the alternation *appears* invariant in loan forms, it may be the case that these were borrowed and lexicalized with the mid vowel. In short, there may not be a productive phonological process driving the realization of the mid vowel in borrowed forms; rather, this may be lexically specified, not only in forms like *toro* 'bull' from Spanish *toro*, but also in forms like *pinto* 'door' from Malay *pintu*, and *bundok* 'mountain' from Kapampangan *bunduk*. Thus within back vowels, the focus will be on native Tagalog forms, where the process is more obviously productive. In the remainder of this section, Kaufman's (2007) analysis of the lowering process will be briefly sketched to illustrate problems arising with the simple characterization of lowering offered in (3). Examples are also adopted from Kaufman (2007; personal communication, May 2011).

Consider the native root morpheme *bato* /batu/ 'stone' occurring in two different environments, shown in examples (4) and (5) (Kaufman, 2007, p. 29), which show the contrast between citation pronunciation of an unsuffixed single word (4) versus pronunciation in a suffixed form (5).[5]

(4)	*bato*	[batɔ]	cf.	*[bat**u**]
	/batu/			
	'stone'			
(5)	*batuhin*	[bat**u**hin]	cf.	*[bat**ɔ**hin]
	/batu-hin/			
	'to throw stones at SUBJ'			

These examples illustrate cases in which the alternation is straightforward. Specifically, /u/ surfaces as [ɔ] in the final syllable of a single word utterance as in (4); in this environment, lowering is obligatory and always follows the /u/ lowering rule. Under suffixation as in (5), the vowel is always predicted to occur as [u] in the final syllable; lowering is blocked because /u/ is no longer in the final syllable of the prosodic word, i.e., the suffix *-(h)in* is incorporated into the same (minimal) prosodic word as the root *bato*. Details about how the prosodic structure is determined will be provided in §2.1. Note that in examples (4) and (5), the orthography reflects the facts of surface pronunciation, but this is not true for all cases.

While cases such as (4) and (5) are regular, the back vowel alternation can also be variable, as shown in the examples below (Kaufman, 2007, p. 30):

(6)	*batu-bato*	[bat**u**-bat**ɔ**]	cf.	*[bat**u**-bat**u**]
	bato-bato[6]	[bat**ɔ**-bat**ɔ**]		*[bat**ɔ**-bat**u**]
	/batu≈batu/			
	'bunch of stones'			

[5] Tagalog has only two suffixes: /-*in*/ signifies object-focus, and /-*an*/ object and beneficiary focus. There is an attested alternation involving the glottal fricative [h], which is present in the suffixed forms and absent in the unsuffixed form. For a discussion of that alternation see, e.g., Schacter & Otanes (1972) and French (1988).

[6] Kaufman (2007) points out that lowering in a reduplicated form is attested in informal written language, but that it remains unclear if this represents an optional pronunciation or is instead no more than an orthographic convention.

(7) *amoy-tsiko* [ʔam**u**j tʃik**ɔ**] cf. *[ʔam**u**j tʃik**u**]
[ʔam**ɔ**j tʃik**ɔ**] *[ʔam**ɔ**j tʃik**u**]
/amuj tʃiku/
'a sopadilla (alcohol) smell'

These examples suggest that lowering is optional at word-internal junctures that involve reduplication and compounding, respectively. We therefore see that lowering is optional in the first morpheme of a reduplicated form or a compound, while in the final syllable of the entire word it is obligatory. Kaufman (2007) argues that if lowering is indeed triggered by having an /u/ as the final syllable in a prosodic word, then lowering in the first morphological constituents suggests that they are parsed as prosodic words in their own right. On the other hand, the fact that lowering is optional rather than obligatory suggests that these morphemes are in some sense both final *and* non-final within the prosodic domain. For example, in (7) above, /u/ in *amoy* is in the final syllable of the first prosodic word but non-final in the entire word. Thus the dual status of /u/ may explain the variable outcomes for lowering. The contributing constituents in each example are themselves minimal prosodic words that are subsumed by a larger (maximal) prosodic word, i.e., the grammatical word. Examples (6) and (7) are repeated in (8) and (9) below with an hypothesized prosodic parsing added (Kaufman, 2007, p. 31). Under this analysis, lowering would be obligatory in the second instance, as it is always final (i.e., it is final both in the local prosodic word and in the maximal prosodic word), but would be optional in the first instance, as it may variably be considered final (within its local prosodic word) and non-final (within its maximal prosodic word).

(8) *batu-bato* [[bat**u**]$_{\omega}$ [bat**ɔ**]$_{\omega}$]$_{\omega\text{-max}}$
bato-bato [[bat**ɔ**]$_{\omega}$ [bat**ɔ**]$_{\omega}$]$_{\omega\text{-max}}$

(9) *amoy-tsiko* [[ʔam**u**j]$_{\omega}$ [tʃik**ɔ**]$_{\omega}$]$_{\omega\text{-max}}$
[[ʔam**ɔ**j]$_{\omega}$ [tʃik**ɔ**]$_{\omega}$]$_{\omega\text{-max}}$

This optionality pattern holds also for the example in (10) (Kaufman, 2007, p. 32) below, in which /u/ in the final syllable of *bato* may lower or not, because the morpheme is simultaneously final and non-final within the prosodic domain. However, /u/ in the morpheme *ko* obligatorily lowers because it is definitively final in the domain; morphemes of this kind and their prosodic parsing will be discussed in greater detail in §2.1.

(10)	*bato ko*	[[bat**u**]$_{\omega}$ k**ɔ**]$_{\omega\text{-max}}$	cf.	*[[bat**u**]$_{\omega}$ k**u**]$_{\omega\text{-max}}$
	/batu ku/	[[bat**ɔ**]$_{\omega}$ k**ɔ**]$_{\omega\text{-max}}$		*[[bat**ɔ**]$_{\omega}$ k**u**]$_{\omega\text{-max}}$
	stone 1S.GEN			
	'my stone'			

Note that if *ko* were incorporated into the same minimal prosodic word as the root, lowering in *bato* would be blocked, as it was in the illustrative example of a suffixed form in (5). The prosodic parsing illustrates that both /u/'s are adjacent to the right edge of a prosodic word, and that these constituents together comprise a maximal prosodic word, as in (8) - (10). Kaufman (2007) argues that such examples necessitate a representation involving an embedded structure in which additional material is adjoined to the morpheme host, thus triggering recursion of the category. Specifically here, the monosyllabic morpheme *ko* is hypothesized to be an adjunct to the host *bato*. Positing recursion in a prosodic domain is not an uncontroversial notion. For a discussion on adjunction/recursion in prosodic structures, see, e.g., Nespor & Vogel (1983), Ladd (1986), and Ito & Mester (2009).

Example (10) illustrates a case in which /u/ at the right edge of a maximal prosodic word must lower; however, there are cases in which lowering is also optional in this domain. Again appealing to the notion of recursion within prosodic structure, but at a higher level still (that of the phonological phrase), Kaufman points to cases in which the maximal prosodic word may be internal *or* adjacent to the phonological phrase; thus there may be optional or obligatory lowering, respectively. Embedded structures such as these will be used to investigate Tagalog /u/-lowering and will be further explored in §2.1.

These considerations, taken together, exemplify the problem with any simple characterization of Tagalog /u/-lowering as a process triggered in the final syllable of a prosodic word. Blind application of the rule that was initially sketched for these examples predicts that the /u/ of the root morpheme must always lower — and that prediction does not match the pronunciation pattern. The very fact of optional lowering for *bato* in *bato ko* sets up the analytic problem; in some sense, the right edge of the prosodic word is relevant (whether minimal or maximal), but it does not capture the entire picture of the environment for the phonological process. However, an analysis of the alternation in terms of a hierarchical prosodic structure similar to that suggested in (10) may be the route to resolving the analytic problem, and to capturing a more accurate characterization of the process.

1.3 Goals of the paper

The facts presented above for Tagalog /u/-lowering have been based on impressionistic data that indicates that /u/ (optionally) lowers to [ɔ] in prosodically final positions. Furthermore, even these basic facts have called into question the type of finality that is at issue. Kaufman (2007) proposes the recursive structure sketched in the previous section, but similarly relies on impressionistic data to determine whether lowering happens or not in each proposed domain. The current study therefore tests the claims of both basic /u/-lowering and Kaufman's proposed prosodic structure by investigating the process of, and variability in, /u/ lowering across different morpheme combinations in naturally occurring spoken speech. The overall goals of this analysis are thus to investigate: a) whether lowering occurs, and if so, whether /u/ lowers all the way to the mid-vowel [ɔ] (i.e., whether the process is categorical), as assumed in the literature; and b) if lowering indeed occurs, to find evidence bearing on whether the phonological process should be described in terms of domains larger than the (minimal) prosodic word. As far as is known, it is the first study to provide an analysis of the Tagalog lowering process in terms of prosodic domains, based on instrumental techniques.

2 Background

2.1 Prosodic parsing: Tagalog hosts and clitics

This sub-section provides the details of Kaufman's (2007) analysis of the Tagalog prosodic structure that are relevant for determining predicted domains for /u/-lowering: the minimal prosodic word, the maximal prosodic word, and the phonological phrase. It is beyond the scope of this paper to discuss the optimality theoretic well-formedness constraints that govern Tagalog morphosyntax-prosody correspondences (in other words, the formation of the prosodic tree itself); for the details of Kaufman's analysis regarding these, see Kaufman (2007, pp. 23–29). The three types of prosodic domains that Kaufman (2007) identifies can most reliably be distinguished by the presence of various types of clitics and, more specifically, their syllabicity, which determines how they are parsed into the prosodic structure.

Clitics are traditionally characterized by their syntactic dependency, and by the fact that their surface realization lacks phonological status or independent accent. In Tagalog, there are pronominal and adverbial clitics. The pronominal clitics, a comprehensive list of which is found in Appendix A, are classified as nominative and genitive, and have corresponding free forms. The pronominal subsets are distinguished by their sentential position: clitics must follow some other morpheme or morpheme group, such as *ko* of *bato ko* in example (10) above, while their corresponding free forms may appear in clause-initial position. Unlike the pronominal clitics, fewer than half of the adverbial clitics have a corresponding free form; see Appendix B.

The Tagalog clitics, whether pronominal or adverbial, vary in their syllabicity: they may be either monosyllabic, e.g., *ka* 2S.NOM, *na* 'already, now, yet'; or disyllabic, e.g., *niya* 3S.GEN, *muna* 'for a while'. On the other hand, the free form variants are never monosyllabic, e.g., *sana* (optative), *ikaw* 2S.NOM, *talaga* (emphasis). Examples (11) and (12) (from Kaufman, 2007, p. 21), illustrate these positional and syllabic properties with *ka* 2S.NOM and *sana* (OPT).[7] In (11), monosyllabic *ka* may only occur after the prosodic word *nagluto*; however, in (12), *sana* may also appear in clause-initial position.

(11a)	**Ka*	*ay*	*nag - luto*	*ng*	*ampalaya*	
	2S.NOM	TOP	AV.PRF - cook	GEN	bitter melon	
	for, 'You cooked bitter melon'					
(b)	*Nag - luto*	*ka*	*ng*	*ampalaya*		
	AV.PRF - cook	2S.NOM	GEN	bitter		
	'You cooked bitter melon'					
(12a)	*Sana*	*ay*	*mag - luto*	*sila*		
	OPT	TOP	AV - cook	3P.NOM		
	'Hopefully, they will cook.'					
(b)	*Mag - luto*	*sana*	*sila*			
	AV - cook	OPT	3P.NOM			
	'Hopefully, they will cook.'					

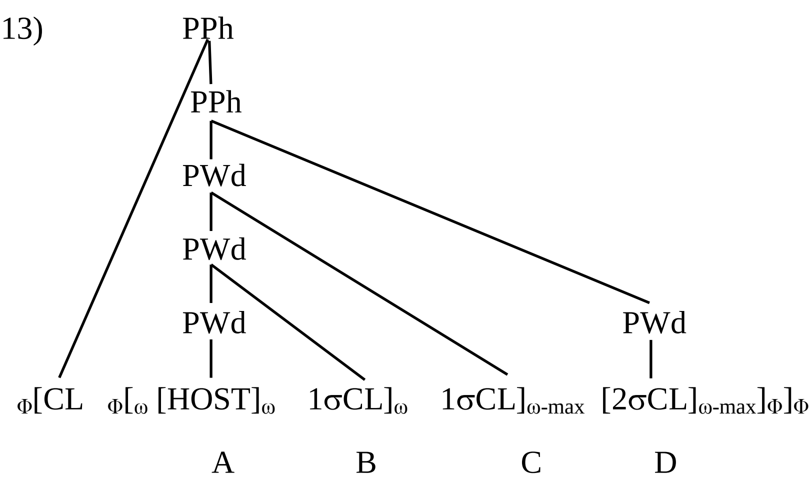
In a departure from the general analysis of clitics as syntactically and prosodically deficient, Kaufman argues that Tagalog clitics may be characterized as syntactically dependent only, and not necessarily prosodically dependent; thus some are able to assume prosodic status.[8]

[7] Morphological abbreviations not appearing in Appendices A and B are as follows: *ay* is an inversion marker used to signal non-initial predicates; *mag* is an actor-focused verbalizing prefix; *nag* is a *realis* form of *mag* (Rubino, 2004).
[8] For other viewpoints, see, e.g., Selkirk (1995) and Anderson (2008).

A clitic comprising more than one syllable, such as *sana* in (12b), may receive prosodic status and be parsed as its own prosodic word. In (12), there is no prosodic difference between the free and clitic versions of *sana*: in either position within the sentence, they satisfy Tagalog's minimality condition on prosodic words, and the difference between the two variants is that the clitic is syntactically free in (12a), but attaches to the host to its left, (*magluto* in (12b)) as a reflex of its syntactic dependency.

Recall from §1.2 that Kaufman proposes a prosodic structure in which certain morphemes are treated as adjuncts to a prosodic domain. Given their prosodic deficiency, monosyllabic clitics such as *ka* in (11) always lack prosodic status, and as such must adjoin to a host, i.e., a minimal prosodic word. This adjunction triggers recursion of the category and creates an embedded structure. On the other hand, disyllable clitics are themselves prosodic words and are thus parsed as adjuncts to the next hierarchical level, the phonological phrase. The complete structure as proposed by Kaufman (2007, p. 20) is presented below:

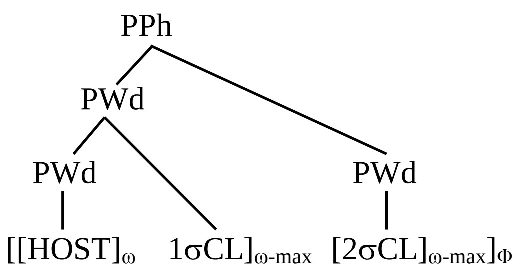
(13)



Note that Kaufman's fully expanded structure acknowledges the possibility of the proclitic, which he argues attaches as recursive adjuncts to the phonological phrase, as illustrated above. Also note that the complete structure shows that consecutive monosyllabic clitics may follow a host (A), but the status of each one refers to differing levels of a prosodic word: the first monosyllable clitic (B) occurs at the right edge of a *minimal* prosodic word, and the second clitic (C) at the right edge of a *maximal* prosodic word; the right edges of both the host and the first monosyllabic clitic are positioned at the right edges of a minimal prosodic word. Furthermore, Kaufman argues that no ambiguity arises in categorizing the two instances of maximal prosodic word in (13); only the second one (D), which constitutes a prosodic word itself, is adjacent to the right edge of a phonological phrase. Thus, in determining the prosodic domain, both A and B occur at the right edge of a minimal prosodic word, while C occurs at the right edge of a maximal prosodic word, and D at the right edge of a phonological phrase.

An abbreviated version of Kaufman's prosodic structure is presented in (14), followed by concrete representations of the structure in (15) (Kaufman, 2007, p. 33):

(14)



(15) *Pinalo* *mo* *ako*
V.PRFT - beat 2S.GEN 1S.NOM
'You beat me.'

(a) *[pinalu mu aku] *no lowering*
(b) [pinalu mu ak**ɔ**] *lowering domain*: $]_{\Phi}$
(c) [pinalu m**ɔ** ak**ɔ**] *lowering domain*: $]_{\omega\text{-max}}$
(d) [pinal**ɔ** m**ɔ** ak**ɔ**] *lowering domain*: $]_{\omega}$

As shown by their notation for grammaticality in (15b-d), lowering may be licensed in any of three domains: the minimal prosodic word, the maximal prosodic word, and the phonological phrase. In (15b), lowering occurs only at the right edge of a phonological phrase. Example (15c) shows that the domain for lowering may also be the maximal prosodic word, where the structure includes an intervening monosyllabic clitic between the host and other phonological material that is adjacent to the right edge of the phonological phrase; and (15d) shows that lowering can take a domain as small as the minimal prosodic word. Note that there are three different right-edge domains here, and that lowering occurs in all three.

In determining additional prosodic domains not represented in (13), a single word utterance that is a lexical morpheme is also phrase final. However, function words, e.g., *pero* ‘but, however’, would be considered a maximal prosodic word in all cases because second position clitics can never attach to function words; morphemes of this kind typically adjoin to a following prosodic phrase, and would thus never form an independent phonological phrase (D. Kaufman, personal communication, February 16, 2012).

In this current study, we will investigate properties of the realizations of domain-final /u/'s that will be categorized into one or other of three types, as demanded by Kaufman’s (2007) hypothesized prosodic structure: the minimal prosodic word, the maximal prosodic word, and the phonological phrase.

2.2 Predictions for Tagalog /u/-lowering

On the basis of Kaufman's (2007) prosodic analysis of Tagalog hosts and clitics, predictions can be made about /u/-lowering, and the extent to which variability is expected in specified prosodic domains. The predictions that follow are thus described in terms of the target vowel occurring in a syllable that is *internal to the word* (i.e., not in a domain-final syllable), and in a syllable at the right edges of the prosodic word, maximal prosodic word, or phonological phrase.

Such predictions are made concrete in terms of a two-dimensional vowel space that is acoustically defined through the values taken by first and second formants. A vowel's first formant (F1) correlates inversely with its height so that greater F1 values correspond to lower placement in the vowel space. Similarly, the second formant (F2) correlates inversely with the other relevant dimension, backness: greater F2 values correspond to more forward placement in the vowel space.

2.2.1 Predictions for vowel height

As far as is known, there is very little published material on phonetic studies of Tagalog vowels. In delos Reyes, Santiago, Tadena, & Zubiri's 2009 study of acoustic characteristics of Filipino vowels, there was little observed acoustic difference between [u] and [o]. The authors thus concluded that only four sounds [i, e, a, ʊ] exist at the acoustic level, although there are five orthographic vowels. Their pedagogically oriented study was based on read speech, and apparently asked what acoustic values were associated with pronunciations of orthographic "vowel letters" *u* and *o*; their study offered few details of their methodology. delos Reyes et al's analysis of course differs from other accounts of Tagalog (for example, those described in §1), which claim not only that [u] and [ɔ] both exist in Tagalog but that there is an active phonological alternation between them. The first step in the current study, therefore, is to determine whether there is a reliable acoustic difference between [u] and [ɔ]. Assuming that the traditional accounts are accurate, and there is a difference, the first prediction is that the F1 value for /ɔ/ will be greater than for /u/.

In addition to this baseline difference between /u/ and /ɔ/, the current study also investigates the predicted variability within the /u/ category. In the environment of a word-internal syllable, /u/ is not predicted to lower, while /u/ occurring at the right edge of any of the three prosodic domains is predicted to lower, at least occasionally. Therefore, for /u/ occurring at any relevant right edge, it is predicted that the F1 value will be greater than for /u/ occurring word-internally; in other words, /u/ in a word-internal environment will sit higher in the vowel space than the /u/'s at the right edges of a prosodic domain.

Furthermore, because /u/ at the right edge of a phonological phrase is predicted to lower without exception, F1 values for /u/ at the phonological phrase are predicted to be the same as those for /ɔ/ in a word-internal position, if lowering is categorical. But since /u/ at the right edge of a prosodic word and a maximal prosodic word may optionally lower (in other words, variability within a category results in a smaller mean value), F1 values will be greater for /ɔ/ in a word-internal syllable.

Further predictions can be formed specifically for comparisons of F1 values across instances of /u/ occurring at the three prosodic category edges: F1 values for /u/ at prosodic word and maximal prosodic word edges should be the same because both have the option to lower or not; for this same reason, /u/ in both of these domains will be expected to have a smaller F1 value than the F1 value for /u/ at the right edge of a phonological phrase, in which /u/ obligatorily lowers.

2.2.2 Predictions for vowel backness

Vowel backness has not yet been investigated in the literature on Tagalog /u/-lowering, either as a related or separate phonological process which might or might not be sensitive to prosodic domains. Therefore, there are no *a priori* predictions formed. However, the necessity to evaluate this dimension follows from previous studies of vowel realizations, which generally include an investigation of F2. It remains possible that F2 is another variable that could distinguish among prosodic categories.

2.2.3 Predictions for variability

A further set of predictions can be formed on the basis of Kaufman's (2007) hypothesized structure, regarding variability among realizations of /u/. Euclidean distances will be calculated to quantify the degree of variability, where mean distances amount to the approximate radius of the vowel space occupied by /u/, for any domain. Note that the distance is not directly utilized *per se* to distinguish among prosodic categories. In a word-internal environment, a vowel is expected to show least variability (because there is no option of lowering in this domain), and therefore the Euclidean distance in this position establishes the baseline for comparisons. In the cases where the vowel undergoes optional lowering, the distance measure is predicted to be greater than for word-internal cases, reflecting more variation within the category. The assumption is that the variation arises from the fact that /u/ is sometimes realized as [u] and sometimes as [ɔ], i.e., there are two vowel categories within the domain. In contrast, if all /u/ tokens lower (or all do *not* lower), the tokens should cluster together more tightly in the vowel space. Thus, where the average Euclidean distance is similar to that for the baseline case, the same extent of variability would indicate a single surface vowel category.

Therefore, mean distances for /u/ at the right edge of a prosodic word and a maximal prosodic word, in which there is optionality, are predicted to be greater for /u/ occurring word-internally; distances for /u/ in a phonological phrase are predicted to display the same extent of variability as the baseline, since in both cases they display obligatory behavior. Along those same lines, distances in a prosodic word and a maximal prosodic word should be similar, and both exhibiting greater distances than for /u/ in a phonological phrase, in which there is obligatory lowering.

3 Methods

3.1 The Filipino Speech Corpus

The Filipino[9] Speech Corpus (FSC) is a database of recordings by native Filipinos comprising, for each speaker, read speech relating to various situations plus five minutes of spontaneous speech. The complete FSC includes a total of 100 participants (50 male, 50 female). Recordings took place at the Digital Signal Processing Laboratory in the Electrical and Electronics Engineering Department of the University of the Philippines in Diliman. The participants were recorded in a soundproof booth at a sampling frequency of 44.1 kHz, subsequently down-sampled to 16 kHz. All the speech data examined in the current study were drawn from the spontaneous speech subset of the FSC, and the analyses reported were undertaken over vowel tokens within the speech files of six speakers, three male and three female.[10] In this paper, speakers are identified by codes MS1, MS2, MS3, and FS1, FS2, FS3.

The spontaneous speech recordings used in this study mentioned the following topics: life as an engineering student, the weather, a grandfather's experience during Japanese occupation of the Philippines, post-graduate career plans, family, favorite academic subjects, movies, public transportation, and the experience of providing recordings for the FSC. Information available about individual participants comes solely from their own reports during the course of the recording; no additional demographic information is provided with the corpus. Two male speakers and one female subject explicitly stated that they were students in the Electrical and Electronics Engineering Department. One female subject stated that she was 20 years old and

[9] Recall from §1 that *Filipino* and *Tagalog* are treated as synonymous in the current study.
[10] I thank Daniel Kaufman for sharing his data files.

another that she was a native speaker of Bisayan, a major language of the Philippines. Two male subjects were 20 and 23 years old.

The FSC is transcribed in conventional orthography using *Transcriber* (Barras et al, 1998). Accompanying the transcription file for each speaker is a separate audio file (WAV format). In the current study, Praat speech processing software (Boersma & Weenink, 2010) was used to segment audio files and to measure formant frequencies for target vowels. The speech analysis and transcription software *Elan* (Hellwig & Uytvanck, 2004) was used to export the transcription files as Praat text grids.

3.2 Vowel token selection

Tokens of two kinds were selected: the first set, used to derive an average vowel space, targeted word-internal occurrences of the vowels /i, e, a, u, ɔ/, and the second set specifically targeted occurrences of vowel /u/ (of native forms) across the relevant prosodic domains, as described in §2.1.

The vowel tokens used to establish an average vowel space over the six Tagalog speakers were drawn from full, non-reduced vowels that were in syllables internal to the word, in most instances. However, for some speakers, recordings included frequent pauses and hesitations (sometimes lasting over three seconds each), which resulted in fewer token opportunities than might have been anticipated. Therefore, to ensure there were sufficient representative tokens for each speaker, some full, non-reduced vowels occurring in a word-final syllable were also identified for measurement, e.g., [e] in *magtext* 'to text' was included to increase the token count for this vowel quality; one token each from this context increased the count for speakers FS2, MS2, and MS3. Vowels uttered in the context of an acronym, e.g., E.C.E. (Electronics and Communications Engineering), were also included because they were clearly stressed with a steady, easily measurable formant structure. Speaker MS1 provided eight tokens that occurred as part of an acronym, three were selected from MS2, and seven from FS3. A final total of 223 tokens were used to create the mean vowel space.

To collect data for the second set, an exhaustive search was undertaken for /u/ tokens occurring in the final syllable for each five-minute speech recording. Each /u/ token was preliminarily examined and subsequently included for analysis if the following criteria were met:

- The vowel's duration was sufficient to obtain reliable measurements, and the audio file clearly confirmed that the vowel was not reduced.
- The vowel was not creaky-voiced or notably "noisy". For the latter instances, formant tracks for F1 and F2 of excluded vowels were not clearly discernible even after adjustment of parameter settings.
- The vowel's onset and offset could be distinguished from the preceding and following consonants. This criterion excluded mostly tokens flanked by approximants, which were more challenging to isolate because formant transitions are difficult to discern. Less frequently, this criterion excluded cases in which the vowel was "absorbed" by the preceding consonant, in which case it was not possible to extract measurements.
- The prosodic domain of the token could be determined based on the prosodic parsing of Tagalog hosts and clitics as proposed by Kaufman (2007; p. 20). Tokens were thus excluded if their prosodic domain categorization was ambiguous. For example, a string of three prosodic words can be parsed either as [PWd_1 PWd_2] [PWd_3] or as [PWd_1 PWd_2 PWd_3]. Although the second parsing would be preferred, in general, both parsings are possible with the choice depending on speech rate and register. Specifically, the ambiguity arises in the instance of an /u/ token in the final syllable of PWd_2, for which an ambiguity exists about the categorization of the prosodic domain, i.e., in the first parsing, but not the second, the prosodic domain would be "phonological phrase".

The search yielded a total of 242 analyzed tokens, the distribution of which over categories and speakers is summarized in Table 1 below, together with data for word-internal tokens.[11]

[11] Data cleanup procedures, aimed at limiting the distorting influence of outlying values (see § 3.4), eliminated 12 additional tokens initially identified in this set; and two from the first set.

Table 1. Distribution of analyzed vowel tokens within two vowel sets, for each of six speakers. The left panel summarizes tokens for final-syllable /u/, categorized by prosodic domain, and the right panel, tokens for word-internal vowels differing in quality.

	Final syllable tokens			**Word-internal tokens**				
	PWd	MaxPWd	PhonPh	/i/	/e/	/a/	/u/	/ɔ/
FS1	2	13	10	5	2	5	11	3
FS2	8	17	10	5	2	5	5	6
FS3	6	30	11	21	13	23	7	6
MS1	8	15	9	15	8	6	11	1
MS2	7	9	7	15	6	9	5	2
MS3	11	35	34	2	2	2	13	7
Total	*42*	*119*	*81*	*63*	*33*	*50*	*52*	*25*

3.3 Measurement extraction

The audio files were viewed in Praat as time-aligned oscillographic and wide-band spectrographic displays. Both of these presentation modes were used to locate the target vowel's onset and offset. Measures were extracted using the Burg LPC algorithm (part of the Praat software), and checked by superimposing the formant tracks on the spectrogram. The default spectrogram settings were used throughout the entire data analyses. They were set to a range of 0 to 5000 Hz, a window length of 0.005 seconds, and a dynamic range of 50 dB. The default formant settings, a maximum formant value of 5500 Hz and five formants, were also used to analyze the target vowels. If there was a mismatch between algorithmic values and the formant band visible in the spectrogram, the formant settings were changed until a proper match was obtained. For example, speaker MS3's formant values became measurable for about half the tokens only after increasing the number of formants from five to six.

For the purposes of this study, the relevant acoustic measurements for distinguishing vowels were the first and second formant frequencies, F1 and F2 (Peterson and Barney, 1952;

Patterson et al; 2000; see also §2.2). F1 and F2 values, and vowel duration, were extracted from labeled intervals demarcating the vowel. If there was any movement of the formant tracks, particularly for the higher formants, the vowel was labeled as diphthong; both vowel types were included in the analysis. For monophthongs, measures were taken at the 50% point of the vowel's duration, and for diphthongs, at the 25% point. The boundary between a preceding or following stop, fricative, nasal, or tap and the vowel onset and offset was placed at a point where there was an abrupt change in the amplitude in the waveform and the spectrogram. The presence of a vowel was indicated by an increase in the amplitude in the waveform and a darkening on the spectrogram. The boundary between an approximant and the vowel was more difficult to determine. Further analyses for such cases required inspecting the spectrogram for an increase in intensity, and repeatedly playing the sound in the audio file to confirm that the approximant was excluded from segmentation.

Figure 1 below is a sample Praat screenshot from speaker FS1 illustrating the segmentation of the native form *nakatutok* is 'aimed, focused' as it occurred in the utterance *dalawang elektrik fan ang nakatutok sa 'yo* 'two electric fans are aimed towards you' . There are two instances of underlying /u/ in this prosodic word. Word-internal /u/ is demarcated on the left, and this token was labeled monophthong. On the right is /u/ in the final syllable of a maximal prosodic word that is also adjacent to the right edge of a phonological phrase (though note that it is in the same lexical item), labeled as diphthong.

(16) *nakatutok*
/naka-tutuk/[12]
PRF - aim
'is aimed, focused'

[12] *naka* is an adjectival prefix meaning 'state or position'

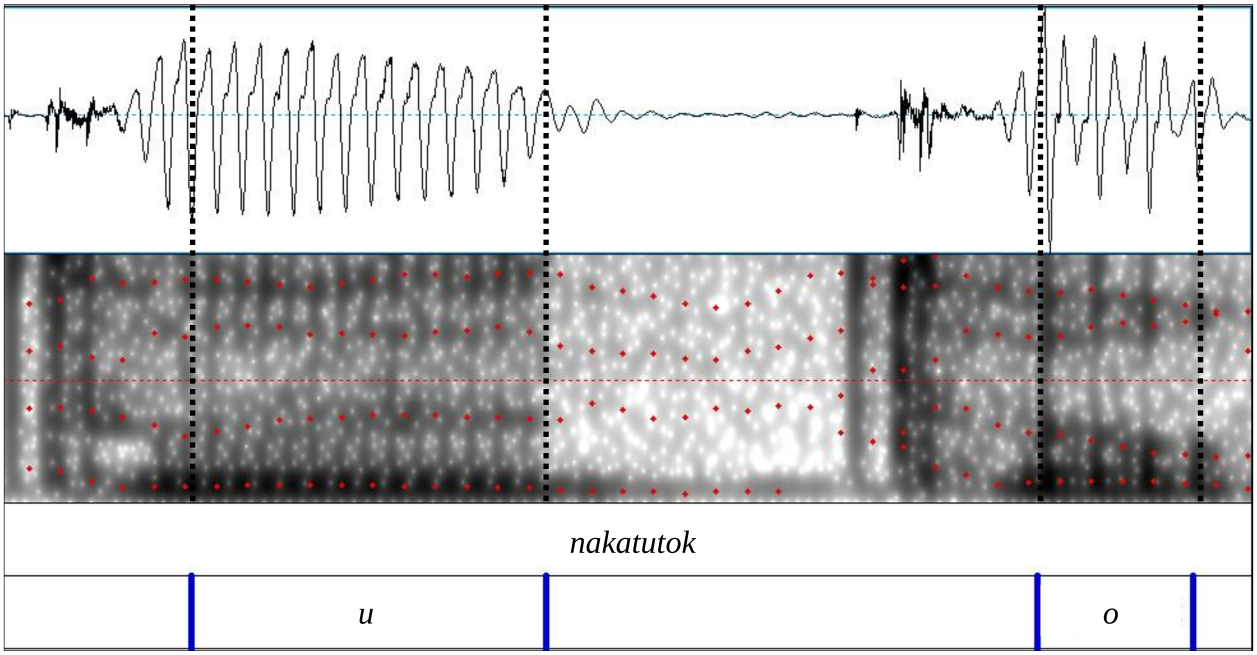


Figure 1. Segmentation of word-internal and final-syllable /u/ in *nakatutok*, from speaker FS1. The visible window is 26 milliseconds long.

3.4 Data analyses

For each prosodic domain, (raw) data falling outside a range defined as mean ± 1 standard deviation were re-checked in Praat. Mismatches between the extracted measurements and reported values in Praat were manually corrected in the database. To allow pooling of data across speakers, raw F1 and F2 values (expressed in Hertz) were then normalized using Lobanov's (1971) extrinsic-vowel normalization method (essentially a z-score normalization), on the basis of its utility as described in Adank (2004). As with the raw Hertz values, it is the case that greater normalized F1 values indicate a lower vowel, and greater normalized F2 values indicate a more front vowel. *R* software was used to conduct F-tests and t-tests.[13] An F-test evaluated variances in the two samples that were subjected to the t-test. If the F-test was significant (the variances were significantly different), then the more conservative Welch's t-test

[13] I thank Kathleen Currie Hall (College of Staten Island, and Graduate Center, CUNY) for creating the initial Praat and *R* scripts for this study.

was used, which among other things re-estimates to the degrees of freedom. If the F-test was not significant, standard Student t-test was used. The results of each F-test are not reported here. Unpaired, two-tailed t-tests were conducted to compare F1 and F2 across prosodic categories, and Euclidean distances. Recall from §2.2.3 that Euclidean distances provide a means for estimating variability in tokens of a given type; distances were calculated between the center point (normalized average value) and the individual data points for /u/ within each prosodic environment.

4 Results and discussion

4.1 Vowel height

The results reported in this sub-section refer to the data summarized in Table 2 below, which presents the mean z-score normalized F1 values for /u/ at the right edge of the prosodic word, the maximal prosodic word, the phonological phrase; and for /u/ and /ɔ/ in word-internal position. See Appendices C and D for a full compilation of data, listing values for individual speakers. The results reported for *prosodic word*, *maximal prosodic word*, and *phonological phrase* will imply that the specific environment under discussion is the right edge of the domain, and the reported formant values are the mean values across all speakers.

Table 2. Mean F1 values, pooled over Tagalog speakers. The left panel summarizes values for final-syllable /u/, categorized by prosodic domain, and the right panel, values for word-internal /u/ and /ɔ/.

	Final syllable			**Word-internal**	
	PWd	MaxPWd	PhonPh	/u/	/ɔ/
Mean F1	-0.24	-0.10	0.03	-0.70	0.39
N	42	119	81	52	25

4.1.1 Vowel height results

An initial t-test comparing F1 values of word-internal /u/ and word-internal /ɔ/ confirmed that F1 for /u/ was reliably less than for /ɔ/, $t(75) = 7.51$, $p < .001$, indicating that /u/ was higher than /ɔ/ in this domain, as suggested by most descriptions of Tagalog, but in contrast to delos Reyes et al's (2009) study.

A series of t-tests evaluated height differences between /u/ in each targeted prosodic domain and the baseline set by word-internal /u/. F1 for /u/ in the prosodic word was greater than in a word-internal environment, $t(92) = 3.52$, $p < .001$, as was F1 for /u/ in a maximal prosodic word, $t(169) = 5.49$, $p < .001$; and F1 for /u/ in a phonological phrase, $t(131) = 6.46$, $p < .001$. In other words, the average /u/ vowel in each of the three prosodic domains of interest was a lower vowel than the average /u/ that occurs word-internally.

A series of t-tests indicated also that F1 for /ɔ/ in a word-internal environment was greater than for /u/ in each of the relevant prosodic category edges: the prosodic word, $t(65) = 3.66$, $p < .001$; the maximal prosodic word, $t(142) = 3.30$, $p < .001$; and the phonological phrase, $t(104) = 2.40$, $p < .05$. Therefore, the average /u/ vowel in each the three prosodic domains was a higher vowel than the average /ɔ/ that occurs word-internally.

Comparisons for /u/ among the three targeted prosodic domains revealed mixed results. Mean F1 values for /u/ in a prosodic word and in a maximal prosodic word did not differ, $t(159) = 1.08$, $p > .05$, and there was also no difference between the F1 values for /u/ in a maximal prosodic word and for /u/ in a phonological phrase, $t(198) = 1.33$, $p > .05$. However, F1 for /u/ in a prosodic word was less than F1 for /u/ in a phonological phrase, $t(121) = 2.04$, $p < .05$). In other words, /u/ in the prosodic word was the highest vowel, and /u/ in the phonological phrase was the lowest vowel; /u/ in the maximal prosodic word was between these two, but not significantly different from either.

4.1.2 Vowel height discussion

Recall from §2.2.1 that the prediction for vowel height was that F1 for /u/ in each domain would be greater than for /u/ in a word-internal environment, indicating that lowering occurs in each prosodic domain. It was also predicted that there would be different degrees of lowering across the prosodic domains, because under Kaufman's analysis lowering is optional at prosodic word and maximal prosodic word edges, but obligatory at a phonological phrase edge. Due to the optional or obligatory nature of lowering, it was therefore predicted that F1 values for /u/ in a prosodic word and a maximal prosodic word would not differ, and that both of these would be greater than for /u/ in the phonological phrase.

Overall, the results support these predictions. The baseline test showed that /u/ was significantly higher in the vowel space than /ɔ/ in a word-internal environment, indicating that they were categorically different, and that the chosen measurements were capable of distinguishing between surface realizations of these two vowels. In line with the general description in the literature and the predictions in the current study, the phonological process of /u/-lowering occurs in the final syllable, as shown by the fact that /u/ in the three domains is lower in the vowel space than /u/ in word-internal positions. However, the results also showed that there was a statistically significant difference in height for /u/ in each of the three prosodic domains compared to word-internal /ɔ/. This finding is contrary to the description for lowering in the literature (with the exception of Bloomfield (1917), who describes the high back vowel lowering to “almost" as low as the mid back vowel); elsewhere in the literature, /u/ is described as lowering to the mid vowel, e.g., Schachter & Otanes (1972); Zuraw (2006); Kaufman (2007).

For the prosodic word and the maximal prosodic word, the fact that the average value did not reach the average value for /ɔ/ could be attributed to the fact that lowering is optional, such that these categories consist of both non-lowered [u]'s and fully lowered [ɔ]'s. However, /u/ in a phonological phrase was also higher than word-internal /ɔ/, which is unexpected because lowering is thought to be obligatory in this domain. Given the fact that the /u/'s in these domains are lower than word-internal /u/, and the lowest /u/ (i.e., in the phonological phrase) was not as low as word-internal /ɔ/, the overall results suggest that when /u/ does lower, it does not undergo categorical lowering, as previously assumed.

The results comparing /u/ in a prosodic word to /u/ in a maximal prosodic word supported the prediction that they would not be different, indicating that /u/'s in both domains have the option to lower. Also in support of the predictions, /u/ in the prosodic word and in the phonological phrase were different; this was predicted to occur because /u/-lowering is optional in the former domain, and obligatory in the latter. This result provides evidence that /u/ in a prosodic word is less affected by lowering than /u/ in a phonological phrase.

The comparison of F1 for /u/ in the maximal prosodic word and the phonological phrase, however, showed no significant difference, resulting in an indeterminate outcome, particularly since F1 in the maximal prosodic word was also not significantly different from that in the prosodic word. It was predicted that the /u/'s in the maximal prosodic word and the phonological phrase would differ, since /u/ in a maximal prosodic word optionally lowers, whereas /u/ in the phonological phrase is always predicted to lower. In investigating interpretations of this result, it is possible that there were not enough data to drive a robust result; however, the sample size was relatively large. Another, and perhaps more interesting, possibility could be that even though it was predicted that there would be no difference between the /u/'s in the prosodic word and the maximal prosodic word (which was supported by the t-test), and it was predicted that there would be a difference between the /u/'s in the maximal prosodic word and the phonological phrase (which was *not* supported by the t-test), it may still be the case that there is a difference among all three prosodic domains. Statistically, /u/ in the maximal prosodic word is the same as each of the /u/'s in the prosodic word and the phonological phrase, even though the two most extreme of the three differ from each other. Numerically, however, the /u/'s did differ: the value of F1 for /u/ in the maximal prosodic word was intermediate to the /u/'s in the prosodic word and the phonological phrase.

Although lowering is optional in both the minimal and maximal prosodic word cases, this does not necessitate that they have the same degree of optionality. The intermediate value for /u/ in the maximal prosodic word may indicate that lowering is optional in both domains, but that /u/ simply lowers more often in the maximal prosodic word. If a prediction were to be made for which of the two domains would show more instances of lowering, the maximal prosodic word would be the natural candidate. For example, in cases where a prosodic word is followed by a maximal prosodic word, but *not* by a phonological phrase, then there is obligatory lowering in the maximal prosodic word but optional lowering in the prosodic word. There are thus more instances where /u/-lowering occurs in the maximal prosodic word than in the prosodic word; this could explain why the /u/'s in a maximal prosodic word are numerically lower than in the prosodic word and thus not statistically different from those in the phonological phrase.

Even though there are as yet no statistical grounds for claiming a difference between /u/ in the maximal prosodic word and each of the /u/'s in the prosodic word and the phonological phrase, the numerical gradience of average F1 values for /u/ across the three prosodic categories is not incompatible with Kaufman's notion of a three-way distinction. Thus, these results may provide support for a lowering process that affects the three prosodic domains differentially, but the question remains unresolved. The results do show, however, that lowering occurs in all three prosodic domains; the /u/'s are not positioned as low in the vowel space as word-internal /ɔ/; and that the most extreme /u/'s at the right prosodic edges (i.e., the prosodic word and the phonological phrase), are significantly different.

4.2 Vowel backness

Table 3 below, to which the results reported in this sub-section refer, presents the F2 values for /u/ at the right edge of the prosodic word, the maximal prosodic word, the phonological phrase; and for /u/ and /ɔ/ in word-internal position. See Appendices C and D for a full compilation of data, listing values for individual speakers.

Table 3. Mean F2 values, pooled over six Tagalog speakers. The left panel summarizes F2 values for final-syllable /u/, categorized by prosodic domain, and the right panel, values for word-internal /u/ and /ɔ/.

	Final syllable			**Word-internal**	
	PWd	MaxPWd	PhonPh	/u/	/ɔ/
Mean F2	-0.13	-0.34	-0.63	-0.67	-0.54
N	42	119	81	52	25

4.2.1 Vowel backness results

A t-test comparing F2 values for word-internal /u/ and /ɔ/ indicated that they were not significantly different, $t(75) = 1.11$, $p > .05$. A series of t-tests were conducted to compare /u/ at each of the three prosodic category edges and word-internal /u/. F2 values for /u/ in a prosodic word and a maximal prosodic word were greater than for word-internal /u/, $t(92) = 3.83$, $p < .001$; $t(169) = 2.75$, $p < .01$, respectively. However, F2 for /u/ in a phonological phrase was not significantly different than for word-internal /u/, $t(90) = 0.37$, $p > .05$. A similar series of t-tests comparing F2 values for /u/ in the relevant domains and word-internal /ɔ/ yielded a similar pattern: F2 values for /u/ in a prosodic word and a maximal prosodic word were greater than the F2 value for word-internal /ɔ/, $t(61) = 3.39$, $p < .001$; $t(91) = 2.24$, $p < .05$, respectively, while F2 for /u/ in a phonological phrase did not differ significantly from that for word-internal /ɔ/, $t(69) = 0.99$, $p > .05$. In other words, both series of tests indicated that the /u/'s in the prosodic word and maximal prosodic word cases were more central in the vowel space in comparison to either of the word-internal cases, whereas there was no evidence for centralization for /u/ in a phonological phrase.

A comparison of /u/ among the three prosodic domains revealed mixed results. There was no difference between F2 values for /u/ in a prosodic word and a maximal prosodic word, $t(159) = 1.60$, $p > .05$). However, the F2 value for /u/ in a prosodic word was greater than for /u/ in a phonological phrase, $t(66) = 4.13$, $p < .001$), as was the F2 value for /u/ in a maximal prosodic word, $t(198) = 3.24$, $p < .001$. In other words, the average /u/ values in the prosodic and maximal prosodic word cases did not differ from each other in terms of centralization, but both were more centralized vowels than the average /u/ at the edge of a phonological phrase.

4.2.2 Vowel backness discussion

There were no *a priori* predictions formed for F2 because centralization is a process that has never been discussed in the literature around /u/-lowering in Tagalog. However, the results indicate that F2 does indeed vary. F2 values for word-internal /u/ and /ɔ/ set up the baseline for comparisons, and initial tests showed that they were not statistically different. Comparisons between either of the word-internal back vowels and /u/ in a phonological phrase produced no evidence of centralization in the latter. However, F2 values for /u/ in a prosodic word and a maximal prosodic word were reliably greater than those for the word-internal vowels, indicating that the lowered vowel was also centralized to some degree. Another series of comparisons made for /u/ among each other yielded mixed results for significance. F2 for /u/ in a prosodic word suggested centralization relative to /u/ in a phonological phrase, but it did not differ from /u/ in a maximal prosodic word. However, /u/ in a maximal prosodic word was centralized relative to /u/ in a phonological phrase. It thus appears that the /u/'s were centralized in such a way that distinguished /u/ in the phonological phrase from the /u/'s in the other two domains. One interpretation of these findings is that there is a two-way distinction.

However, another interpretation for these results mirrors that for the patterning of F1 in the three domains — it may be the case that there is a three-way distinction. Numerically, /u/ in the maximal prosodic word sits intermediate between /u/'s in the prosodic word and the phonological phrase, and as for F1, gradience in F2 values across the three prosodic categories is not incompatible with Kaufman's notion of a three-way distinction.

4.3 Variability

The reported results comparing Euclidean distances (F1-F2) refer to Table 6 below, which presents the mean distances within the category for /u/ at the right edge of the prosodic word, the maximal prosodic word, and the phonological phrase. The right panel is the mean distance of all vowel qualities in word-internal position. The distances were calculated within a category to its own center; for the word-internal case, the distances were then averaged across each of the vowel types. See Appendix E for a full compilation of data, spelling out values for individual speakers.

Table 4. Mean distance values, pooled over six Tagalog speakers. The left panel summarizes distances for final-syllable /u/, categorized by prosodic domain, and the right panel, distance for all word-internal vowel qualities.

	Final syllable			**Word-internal**
	PWd	MaxPWd	PhonPh	/i, ɛ, a, u, ɔ/
Mean Distance	0.88	0.89	0.73	0.65
N	42	119	81	223

4.3.1 Variability results

The distance measure estimated across all vowels in a word-internal environment served as the baseline. The F1-F2 distances of each /u/ token in a prosodic word from the average F1-F2 value in that environment were greater than analogous distances for vowels in a word-internal environment, $t(98) = 2.78$, $p < .01$, and the same was true for /u/ in a maximal prosodic word, $t(329) = 3.56$, $p < .001$. However, distances for /u/'s in a phonological phrase did not differ from word-internal distances, $t(247) = 1.14$, $p > .05$.

The second series of t-tests compared distances for /u/ among the three targeted prosodic domains. A comparison of distances for /u/'s in a prosodic word and those in a maximal prosodic word showed no reliable difference, $t(159) = .10$, $p > .05$. Distances for /u/'s in a maximal prosodic word were greater than those in a phonological phrase, $t(198) = 2.40$, $p < .05$. And although the test of distances for /u/'s in a prosodic word against those for /u/'s in a phonological phrase failed to reach a conventional level of significance, the statistic approached significance, $t(121) = 1.86$, $p = .065$.

4.3.2 Variability discussion

Recall from §2.2.3 that the prediction was that there would be greater variability among /u/'s in the prosodic word and the maximal prosodic word than normally occurs with vowels in a word-internal environment, because the former are cases in which there is optional lowering. The first series of tests lined up with the predictions. Both /u/ distances in a prosodic word and a maximal prosodic word were greater than for word-internal vowels, indicating that there was more variability in the former than in the latter. Comparing /u/ in a phonological phrase to a vowel in a word-internal environment revealed that they are the same, in line with the predictions; this indicates that there is no variability within either of these domains, as expected, given the obligatory nature of lowering within the phonological phrase.

The second series of tests showed that the distance for /u/ in a prosodic word and /u/ in a maximal prosodic word were the same, as predicted. In concert with the above results, this finding indicates that there is variability for /u/'s in these domains. The results also supported the prediction that the distance for /u/ in a maximal prosodic word would be greater than that for /u/ in a phonological phrase, since there is optionality of lowering in the former domain, and no optionality in the latter. Contrary to the prediction, however, /u/ in a prosodic word and /u/ in a phonological phrase were not statistically different. However, the difference did approach significance, and the direction of the raw distance was in the correct direction; the mean distance for /u/ in a prosodic word was greater, indicating there was more variability in this domain. Thus, the majority of the tests indicated that there was more variability in the realization of /u/ in the prosodic and maximal prosodic word domains as compared to either /u/ in a phonological phrase or to a baseline word-internal vowel.

5 Summary and conclusion

Figure 2 offers an illustration of the findings reported in §4.1 and 4.2 above. It is a plot of the mean values, pooled across the six speakers, for /u/ occurring at the right edge of the three prosodic categories, plotted within the mean vowel space (calculated from word-internal vowel tokens) of the six speakers.

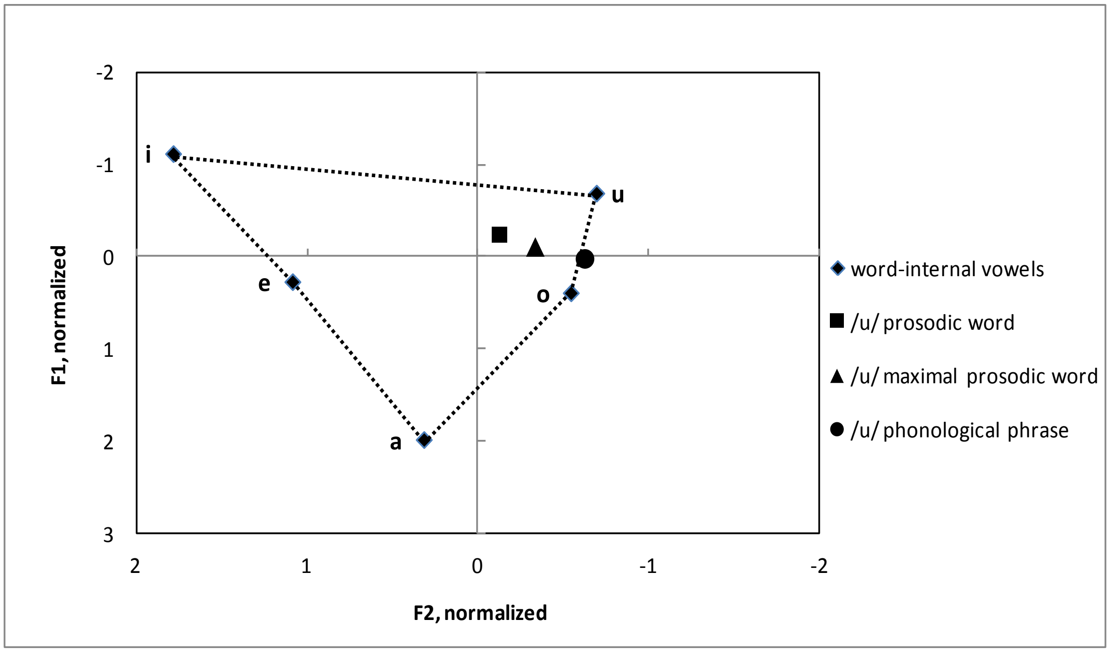


Figure 2. Average formant values for final-syllable /u/ as a function of prosodic domain, across the six speakers. For reference, the vowel space, calculated from word-internal vowel tokens.

The first goal of the study, to determine whether /u/-lowering in fact occurs in the spontaneous speech of Tagalog speakers, was confirmed by the results for height (turning on first formant values) and variability (turning on Euclidean distance values, for tokens within categories): lowering does occur in syllables adjacent to the right edge of the prosodic word, the maximal prosodic word, and the phonological phrase. The process, however, is not categorical, contrary to the standard characterization in the literature. That is, /u/-lowering does not produce a vowel that is identical to the realization of the word-internal mid-vowel /ɔ/, even in the case for which lowering was expected to occur with greatest consistency, at the edge of the phonological phrase.

Distance measures provided further support of this finding: /u/ in the phonological phrase exhibited variability to an extent that did not differ from that of the internal vowels. This suggests that only one vowel category was present, and the fact that /u/ did not undergo complete lowering was not an issue of optionality. Schachter and Otanes (1972) identified [u] and [ʊ] as allophones of /u/, and it is possible that the vowel that surfaces as the result of lowering is the [ʊ] variant. This question itself merits a further intensive study, preferably instrumentally based.

The second goal of the present study in effect tested whether Kaufman's (2007) proposed recursive prosodic structure for Tagalog hosts and enclitics could capture the facts around variability in the occurrence of lowering. Kaufman proposed that there are different levels within the prosodic structure, under the assumption that there can be recursion, such that one gets sub-levels within the prosodic word. The combined results of the height, backness, and distance tests were not incompatible with a three-way distinction among the minimal prosodic word, the maximal prosodic word, and the phonological phrase, as the raw results do show the vowels lining up in the expected order. However, the question remains unresolved, as not all of the raw differences were shown to be statistically significant. It is possible that there is only a two-way distinction between the prosodic domains: the results of the current study indicate a clear difference between the phonological phrase on the one hand, and the two kinds of prosodic words on the other, but not a robust distinction between the two types of prosodic words themselves. Future studies are thus required, perhaps with higher power, to determine whether these domains offer a two- or three-way distinction.

In the current study, an instrumental analysis using native Tagalog forms in spontaneous speech was conducted to test the basic claims of /u/-lowering and the predictions that followed from Kaufman's (2007) hypothesized prosodic structure. Given that the data in this study were drawn from spontaneous speech samples, it was inevitable that the vowel type and token quantity could not be controlled to produce identical sets of data from each speaker; the database was constrained by the content offered in each five-minute speech sample. Despite this seeming caveat, spontaneous speech *is* different from read speech (e.g., Laan & Bergem, 1993), as indicated by the results in this paper compared to those of delos Reyes et al's (2009) study. The combined findings of the current study for height, backness, and variability, stemming from the use of spontaneous speech, emphasizes both the shortcomings of relying solely on impressionistic judgments and the utility of investigating naturally occurring speech.

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Appendices

Appendix A. Tagalog pronominals, for the reader's convenience, as listed in Kaufman (2007, p. 19). The nominative and genitive pronouns comprise both clitics and free forms, which are distinguished by their sentential position, as noted in §2.1.

Labels	**Nominative**	**Genitive**	**Nominative**	**Genitive**	**Oblique**
	Clitic		**Free**		
1st sing.	*ako*	*ko*	*ako*	*akin*	*sa akin*
2nd sing.	*ka*	*mo*	*ikaw*	*iyo*	*sa iyo*
3rd sing.	*siya*	*niya*	*siya*	*kaniya*	*sa kaniya*
1st dual	*kata*	*nita*	*kami*	*amin*	*sa amin*
1 st pl. (excl.)	*kami*	*namin*	*kata/kita*	*kanita*	*sa kanita*
1 st pl. (incl.)	*tayo*	*natin*	*tayo*	*atin*	*sa atin*
2 nd pl.	*kayo*	*ninyo*	*kayo*	*inyo*	*sa inyo*
3rd pl.	*sila*	*nila*	*sila*	*kanila*	*sa kanila*
	[1st Gen + 2 nd Nom] *ka+ko* → *kita*				

Appendix B. Tagalog adverbials, both clitic and free forms, for the reader's convenience, as listed in Kaufman (2007, p. 20).

Clitic		**Free**	**Clitic**		**Free**
na	'already, now, yet'	Ø	*pala*	(surprise)	Ø
pa	'still, else in addition'	Ø	*kaya*	(speculation)	Ø
din	'too'	Ø	*kasi*	'because'	Ø
man	'even'	Ø	*tuloy*	'as a result'	Ø
nga	'really')	Ø	*lang* (*lamang*)	'only'; 'just'	Ø (*lamang*)
ba	(interrogative)	Ø	*baga*	(interrogative)	*baga*
daw	(reported speech)	Ø	*sana*	(optative, OPT)	*sana*
po	(politeness)	Ø	*talaga*	(emphasis)	*talaga*
ho	(politeness)	Ø	*naman*	'instead, again'	*naman*
yata	(uncertainty)	Ø	*nawa*	'hopefully'	*nawa*
muna	'for a while'	Ø			

Appendix C. Presenting mean values for /u/ in different final-syllable contexts for six Tagalog speakers, three female and three male. The left panel lists F1, F2 values for the prosodic word; the middle panel for the maximal prosodic word; and the right panel for the phonological phrase.

	Prosodic word			Max prosodic word			Phonological phrase		
	F1	F2	N	F1	F2	N	F1	F2	N
FS1	0.49	0.30	2	-0.06	-0.36	13	-0.31	-0.63	10
FS2	-0.80	0.14	8	-0.12	-0.14	17	-0.06	-0.87	10
FS3	-0.54	0.36	6	-0.14	-0.62	30	-0.01	-0.87	11
MS1	0.10	-0.46	8	0.04	-0.69	15	0.48	-0.72	9
MS2	-0.22	-0.38	7	-0.07	-0.73	9	-0.02	-0.95	7
MS3	-0.04	0.14	11	-0.23	0.08	35	0.04	-0.39	34
Mean F1	*-0.24*			*-0.10*			*0.03*		
Mean F2		*-0.13*			*-0.34*			*-0.63*	
N			*42*			*119*			*81*

Appendix D. Presenting mean values for /i, ɛ, a, u, ɔ/ occurring in a syllable internal to the word for six Tagalog speakers, three female and three male. These values were used to derive the mean vowel space.

	/i/			/ ɛ /			/a/			/u/			/ɔ/		
	F1	F2	N	F1	F2	N	F1	F2	N	F1	F2	N	F1	F2	N
FS1	-0.82	2.05	5	-0.16	1.90	2	2.57	0.76	5	-0.66	-0.62	11	-0.45	-0.75	3
FS2	-0.05	2.03	5	0.89	2.00	2	1.99	1.04	5	-0.83	-0.04	5	0.25	-0.36	6
FS3	-1.20	1.71	21	0.11	0.91	13	1.55	0.15	23	-0.85	-1.02	7	0.22	-0.84	6
MS1	-1.40	1.77	15	0.68	0.81	8	2.41	0.22	6	-0.69	-0.56	11	0.18	-0.23	1
MS2	-1.10	1.60	15	0.01	0.98	6	2.26	-0.02	9	-0.55	-1.04	5	0.15	-0.90	2
MS3	-1.78	2.77	2	0.26	1.95	2	2.81	1.19	2	-0.66	-0.71	13	1.12	-0.29	7
Mean F1	*-1.12*			*0.27*			*1.98*			*-0.70*			*0.39*		
Mean F2		*1.79*			*1.09*			*0.32*			*-0.67*			*-0.54*	
N			*63*			*33*			*50*			*52*			*25*

Appendix E. Presenting mean distance values for six Tagalog speakers, three female and six male. The left panel lists distances for final-syllable /u/, categorized by prosodic domain, and the right panel, the distance of all word-internal vowel qualities.

	Final syllable						Word-internal	
	Prosodic word		Max prosodic word		Phonological phrase		/i, ɛ, a, o, ɔ/	
	Dist.	*N*	*Dist.*	*N*	*Dist.*	*N*	*Dist.*	*N*
FS1	0.93	2	0.60	13	0.50	10	0.72	24
FS2	1.31	8	1.18	17	0.74	10	0.57	23
FS3	0.51	6	0.68	30	0.60	11	0.78	43
MS1	0.67	8	0.70	15	0.64	9	0.33	37
MS2	0.67	7	0.60	9	0.48	7	1.21	26
MS3	1.04	11	1.18	35	0.93	4	0.53	70
Mean Dist.	*0.88*		*0.89*		*0.73*		*0.65*	
N		*42*		*119*		*81*		*223*