Prosodic conditioning: An instrumental production study of Tagalog *o*/*u* variation[1]

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Abstract: In Tagalog compound reduplicated words, e.g., */pun**o**-puno/* 'overflowing,' there is an attested alternation between /u/ and /o/ occurring in the second vowel of the first copy. In Zuraw's (2009) analysis of a web-based corpus, she found lexical frequency to be a predictor in the rate of spelled "u"; however, this pattern did not carry over to the corresponding suffixed forms, e.g., */pun**o**-puno+in/* 'to be overfilled'. She proposed that the apparent lexical influence on the variable application of raising can be accounted for by lexically-sensitive prosodic structure assignment: compound reduplicants can be accessed as either single prosodic units or as separate prosodic units, both of which are sensitive to frequency. The current instrumental production study explores the acoustic details of Tagalog *u*/*o* optionality, the effects of frequency, and the role of prosody in compound reduplicants. The analyses reported here provide support for Zuraw's written corpus: *o~u* optionality in these compounds is indeed an active phonological process, and this variation is gradient. Unlike Zuraw's findings, the current study did not provide support that frequency is a predictor in determining the selection of the variant, but did support the notion that variation can be accounted for by differences in prosodic structure.

1 Introduction

Phonological variation, i.e., when an underlying representation has more than one surface form in a single environment, has been commonly characterized as conditioned by grammatical factors, as well as by non-grammatical factors. One very well-studied example of variation is t/d-deletion in English, e.g., *told a lie ~ tol' a lie*, for which the preceding and following segments (phonology) and the grammatical category (morphology) have been considered as conditioning factors for rule application. However, Bybee (2000) and Patrick (1992), among others, argue for a usage-based model: the alternation is more likely to apply to higher usage frequency words than lower frequency usage words. Other recent work on the phonological process, but also for variation in general, e.g., Coetzee (2009) and Anttila (2012), argues for a formal grammatical

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model of phonological variation that incorporates the influence of non-grammatical factors. This model should also account for where variation should be possible, and for the frequency structure of variation (Anttila, 2012).

In this paper, I explore the optional phonological process of Tagalog /o/-raising. Similar to *t/d*-deletion, /o/-raising may be characterized by grammatical and non-grammatical factors. In her analysis of data from a written corpus, Zuraw (2009) found that /u/ and /o/ are in free variation in compound (σσ-) reduplicated forms, such as *hal**u**halo* ~ *hal**o**halo* (ice dessert). Furthermore, raising of /o/ is shown to be, in part, predictable based on lexical frequency, with raising more likely to occur in high frequency compounds. When the reduplicated compounds are suffixed, however, vowel raising appears to be obligatory for the last vowel in both copies, e.g., *hal**u**hal**u**an* 'very well mixed'; in this prosodic environment, frequency is blocked by the grammar. Zuraw's findings illustrates that frequency alone cannot account for the *u*/*o* alternation; a description of the grammar that accounts for some of the distributions is still needed. Zuraw proposed that the variable rule application of raising can be accounted for by lexically-sensitive prosodic structure assignment. The current study further investigates Zuraw's (2009) findings, which were based on written data, by examining the kind of variation present, their relation to lexical frequency, and the role of prosody, using acoustic data elicited from a production task comprising σσ-reduplicated items, e.g., /halo-halo/ and /halo-halo+an/.

1.1 /u/~/o/ Alternation in Tagalog

The native Tagalog[2] 3-vowel system of /i/, /u/, and /a/ expanded to include the mid vowels /e, o/, following sustained contact with Spanish from the late 16th to the 19th centuries, and sporadic

[2] 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

contact with English (Zuraw, 2007) and other languages.[3] Modern Tagalog thus offers a vowel inventory as follows:

(1)

	Front	Central	Back
High	i		u
Mid	e		o
Low		a	

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, e/ and /u, o/ contrast in contemporary Tagalog:[4]

(2)

/i/		/e/	
misa	Sp. 'mass'	*mesa*	Sp. 'table'
tila	'maybe'	*tela*	Sp. 'cloth'
binta	'moro canoe'	*benta*	Sp. 'sale'
parti	Eng. 'party'	*parte*	Sp. 'part'

/u/		/o/	
uso	'fad'	*oso*	Sp. 'bear'
butas	'hole'	*botas*	Sp. 'boots'
kuro	'think'	*koro*	Sp. 'choir'
bukal	Sp. 'fountain'	*bokal*	Sp. 'vowel'

As (2) shows, in Tagalog, Spanish and English loans have created a contrast between two non-high back vowels, /u/ and /o/. In the native Tagalog lexicon, however, they are (with few exceptions) in complementary distribution. The native root morpheme *halo* /halo/ 'mix,'

common practice in naming the national language, and as such, the terms *Tagalog* and *Filipino* will be treated as synonyms.

[3] 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).

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

occurring in two different environments, illustrates the contrast between citation pronunciation of an unsuffixed single word (3) versus pronunciation in a suffixed form (4) (English, 1986).[5]

(3) *halo* [hal**o**] cf. *[hal**u**]
/halo/
'mix'

(4) *haluin* [hal**u**in] cf. *[hal**o**in]
/halo-hin/
'to mix together'

Here, the alternation is straightforward: [o] surfaces in the final syllable of a monomorphemic word, as in (3); in this environment, raising is blocked. In the suffixed form shown in (4), [u] is predicted to occur in the final syllable of the stem; in this environment, raising is obligatory. Note that in examples (3) and (4), the orthography reflects the facts of surface pronunciation, but this is not true for all cases.

While /o/ is predictable in environments found in (3) and (4), there are cases for which /o/-raising does not apply straightforwardly, resulting in optionality. Zuraw (2009) found evidence from a written corpus that the back vowels are variable in σσ-reduplicated forms, as illustrated in (5) below. Furthermore, Zuraw's analysis of the written corpus provided evidence that usage frequency influences the likelihood of /o/-raising: raising is more likely to apply to words that have higher usage occurrences. When the σσ-reduplicant is suffixed, however, shown in (6), vowel raising appears to be obligatory for the last vowel in both copies, as is the case with other suffixed forms, cf. *haluin* above. Thus, raising can be said to apply to the last vowel in a prosodic unit, here the (prosodic) word (Schachter & Otanes 1972; Ramos & Cena 1990).

(5) *halu-halo* "hal**u**-hal**o**" cf. * "hal**u**-hal**u**"
halo-halo "hal**o**-hal**o**" * "hal**o**-hal**u**"

[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).

/halu≈halu/
'ice dessert'

(6) *halu-haluan* "hal**u**-hal**u**an" cf. * "hal**o**-hal**u**an"
/halu-haluan/
'very well mixed'

1.2 Prosodic Conditioning

The apparent optionality just described has been found to correlate with frequency. Using a web-based corpus of Tagalog words (described in §3.1 and §3.2, but in full detail in Zuraw (2006), Zuraw (2009) investigated occurrences of "u" and "o" in σσ-reduplicated words. In words with a frequency of 10 and above, she found "o" to occur in the largest group of words, "u" in the second largest, but that many reduplicants contained variable spelling. Dividing the σσ-reduplicants into further frequency ranges from as low as 2 to >100 provided more detail, showing that "o" occurred more often in words with frequency up to 15, and "u" was more evenly distributed in higher-frequency words. Figure 1 shows this corpus pattern.

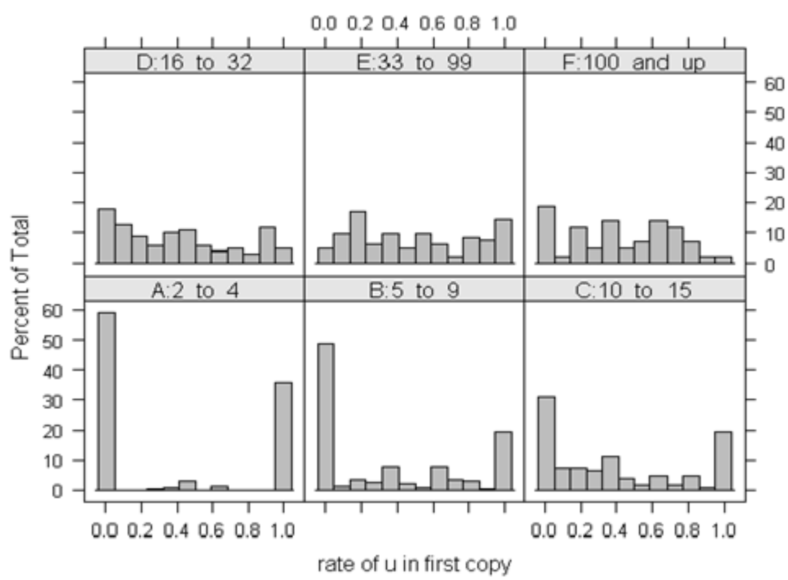
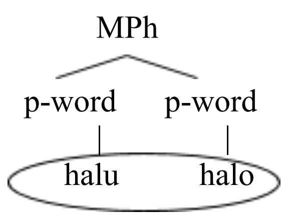


Figure 1. (from Fig. 9 in Zuraw (2009). Rate of "u" in the first copy of σσ-reduplicated words, grouped by frequency ranges, showing that most "o" spellings occurred in the lower frequency ranges (bottom half), and the rate of spelled "u" is distributed evenly in the higher frequency ranges (upper half).

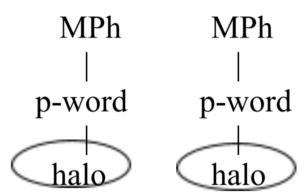
Zuraw (2009) also examined the corresponding suffixed words, which revealed a reduplicative identity effect: the vowel in the second copy was almost always spelled as “u” (c.f. (4) above). The vowel in the first copy also had a strong tendency to be “u”, regardless of the frequency range, but for unsuffixed items, there was a strong tendency toward “o”. Thus, Zuraw concluded that raising is obligatory, and frequency effects were overridden by the grammar. The remainder of this section describes Zuraw’s analysis.

Zuraw proposed that the apparent lexical influence on the variable application of raising can be accounted for by lexically-sensitive prosodic structure assignment, i.e., the grammar restricts where frequency can have an affect. She argues that compound reduplicants like *haluhalo* ~ *halohalo* can be stored in the lexicon in two forms: as single prosodic units as in (7), or as separate prosodic units, as in (8). While the prosodic word was proposed as the domain for tapping, she proposes that the relevant level of structure for /*o*/-raising is higher than the prosodic word - here referred to as the Minor Phrase (MPh):

(7)



(8)



In particular, lexical frequency influences which of the two above structures is accessed: high frequency compounds are more likely to be accessed as single prosodic units (and therefore raising applies to the /o/ in the first copy), as in (7); low frequency words are more likely to be accessed compositionally, as separate prosodic units (and therefore raising does not apply to the /o/ in the first copy, since, like the /o/ in the second copy, it is final in the prosodic unit), as in (8).

1.3 The Present Study

Zuraw's (2009) proposal suggests that both grammar (affixing) and processing (morphological access) influence rule application, via prosodic structure. However, at present there are no instrumental acoustic data that (i) support/corroborate Zuraw's written corpus data; (ii) describe the phonetic details of the phonological alternation in Tagalog generally; or (iii) provide independent (i.e., suprasegmental) support for the presence of the prosodic boundary that determines the (non)application of /o/-raising. The present study thus seeks to address these issues, which will be explored via the following specific research questions: (**Q1**) Is there evidence for variation? Does /u/ or /o/ surface? (**Q2**) Is there gradience? (**Q3**) Are there frequency influences on this gradience? (**Q4**) Is there evidence for a relation with prosody?

The current study examines these research questions using elicited productions of Tagalog σσ-reduplicated structures in low, mid, and high frequency ranges (henceforth LOW, MID, HIGH, respectively; these ranges will be discussed in further detail in §2.1.1.1). Also for the sake of brevity, the specific segments in question will be referred to in this paper using the subscript labels shown in (9) and (10) below. The two segments that will be discussed in the greatest detail are the second vowel of the first copy of σσ-reduplicated words, and the second vowel of the first copy of their corresponding suffixed forms, i.e., V_1, and V_{1s}, respectively.

(9)	C_1	V	C	V_1	-	C_2	V	C	V_2	(test condition)
(10)	C_{1s}	V	C	V_{1s}	-	C_{2s}	V	C	V_{2s} - suffix	(baseline condition)

Example compounds used in the elicitation task, for each frequency range, are shown in (11):

(11)	Freq. range	Baseline condition	Test Condition
	LOW	buhuk-buhukan *'play or fake hair'*	buhuk-buhok ~ buhok-buhok *'lots of hair'*
	MID	bungkus-bungkusin *'to make into a wad'*	bungkus-bungkus ~ bungkos-bungkos *'bunch/wad'*

HIGH	dugu-duguhin *'to make bloody'*	dugu-dugo ~ dugo-dugo *'very bloody'*

General predictions for the current study can be formed based on Zuraw's (2009) analysis of the alternation described in the previous sections, which will be discussed in the following section.

1.4 Predictions

1.4.1 Is there evidence for variation? Does /u/ or /o/ surface? (Q1)

Zuraw's (2009) written corpus showed a significant difference between the vowel that surfaces in V_1 and V_{1s} positions, i.e., the corpus served as written evidence for the completeness of the /o/-raising phonological process. If Zuraw's findings, and the general descriptive literature are accurate, then it is predicted that a comparison of second vowels in first copies of suffixed and unsuffixed compounds will show a reliable difference in the rate of [u]-use; specifically, it is predicted that V_{1s} will have more instances of [u] than V_1.

1.4.2 Is there gradience? (Q2)

As Zuraw's (2009) study was based on a written corpus, spelled "u" and "o" were the only two realizations that could surface for [o]. The corpus showed realizations of either one or the other surfacing for a given compound reduplicated item, but there was also a lot of within item variation. Zuraw acknowledged that the variation found in spelling could suggest phonetic gradience. However, it is possible that within-item variation in the corpus could be because an ambiguous vowel category exists. If gradience were found in the productions of the current study, then it is predicted that while there would be clear instances of either [u] or [o], there would also be cases where the vowel is not able to be categorized as either of the back vowels. It would thus be predicted that the measured phonetic dimensions of this ambiguous, "in-between" vowel would lie statistically in the middle of the two back vowels.

1.4.3 Are there frequency influences on this gradience? (Q3)

Results from Zuraw's (2009) corpus found a frequency effect for vowels in V_1 position, but not for their corresponding suffixed forms in V_{1s} (Q3). In the corpus, spelled "o" occurred more often in frequency ranges up to 15, and spelled "u" was more evenly distributed in the higher frequency ranges Thus, in the current study, it is expected that participants will produce more [u]'s for V_1 in HIGH, the least [u] tokens in LOW, and variably in MID. Additionally, if support for the web corpus were found, then there should be no frequency effect for V_{1s}.

1.4.4 Is there evidence for a relation with prosody? (Q4)

Zuraw's (2009) analysis relied on the differences in prosodic phrasing, specifically, that σσ-reduplicants are stored in the lexicon as either separate prosodic units or single prosodic units. Her corpus showed that in the former, "o" occurred more predominantly than "u", and in the latter, the opposite was found. For the purposes of the current study, I will examine segmental durations, since it is well known that segments are influenced by prosodic structure (Cho, 2002; Fougeron & Keating, 1997; Jun, 1993; Keating, 2003). If the durations are indeed acoustic correlates of prosodic structure, then the first prediction is that for items containing a realized [o] in V_1 position, that [o] will be longer than items containing [u]. In addition, it is predicted that first copy [u] productions will be shorter relative to their second copy counterparts than [o]'s relative to *their* counterparts, suggesting that [u] is produced in a single prosodic unit.

To further examine evidence of prosodic phrasing, the current study will measure consonantal durations[6] (Fougeron & Keating, 1997) for evidence of domain-initial strengthening

[6] Both consonant and formant (vowel) data are correlates of prosodic boundaries; however, the latter are not included in the analysis of the current study, and will be reserved for subsequent research.

(another duration-related phenomenon), which has been shown to correlate with the strength of a proceeding boundary (Cho, 2014). If there were initial strengthening effects correlating with vowel production, then the prediction is that the initial consonant of the second copy, C_2, following [o] productions will be longer than C_2 in items containing [u].

2 Experiment: Production of Tagalog σσ-Reduplications

2.1 Methods

2.1.1 Materials

2.1.1.1.Stimuli

To explore potential variation in Tagalog compound reduplications, a set of compounds were selected to serve as target words. These target words were drawn from Zuraw's (2006) web-based corpus[7]. As mentioned previously, this corpus is based on written materials harvested from the web, the details of which are described in Zuraw (2006). Important for the present purposes is that this corpus is of a sufficiently large size (approximately 20 million words) so as to make possible the estimation of frequency of usage of the words occurring in it, and thus to explore effects of lexical frequency on speakers' productions in the present experiment. This was an important feature of the corpus, since Zuraw (2009) found significant effects of lexical frequency on spelling variants of compounds reduplications (higher frequency compounds being more likely to be spelled with "u" in the first copy).

However, to limit the size of the present experiment (in terms of number of items in the production task), while still probing for lexical frequency effects, words were taken from a limited portion of the range of lexical frequencies. This particular decision was based on the findings of Zuraw (2009), where the biggest effects of frequency on *u~o* variation occurred. This

[7] The words chosen for this study are a subset of the corpus tagged for frequency and rate-of-u-use that was provided to Jason Bishop by Kie Zuraw, and used for this project.

was concentrated in the lower section of the distribution, as can be seen in Figure 1 (see §1.2), which summarizes "u" and "o" spelling variation for first-copy final vowels throughout a range of frequencies (from 2-4 occurrences at the lowest, and 100+ at the highest end). The figure shows the greatest disparities in the rate of *u* use is concentrated in compounds with 15 or fewer occurrences in the corpus.[8] The decision was therefore made to select compound reduplicants that fell into three groups that fell between 2 and 32 occurrences:

- LOW (2-9 occurrences)
- MID (10-18 occurrences)
- HIGH (19-32 occurrences)

Having selected a subset of compound reduplicants within the desired frequency ranges, a shorter list was selected based on the following additional criteria. First, compounds with roots that were not native of Tagalog (e.g., Spanish and English roots) were excluded, as were roots of an unknown etymology[9], and compounds whose roots ended in spelled *u*, as they were most likely from other Philippine languages, since very few native Tagalog words end in /u/ (Schachter & Otanes, 1972).

The remaining words were then grouped into the LOW, MID, HIGH ranges described above, and potential test items were further vetted with the help of two native Tagalog speakers (who would not participate in the experiment), who confirmed attested versus non-attested items. The last pass to determine eligibility as test items was based on their ability to be reliably and accurately segmented. Ideally, only test words with easily segmentable obstruent-vowel-obstruent sequences would be used. Unfortunately, this was not possible; despite the large

[8] To calculate frequency in the written corpus, words that differed in the actual spelling of the *u/o* alternation and/or contained a hyphen or non-grammatical symbols (most likely typos) were treated as an instance of the same word. For example, the root *paro* 'butterfly', appeared as *paroparo*, *paro-paro,* and '*paru-paro.* Each of these instances served as a frequency count for the item; the single quote in the last item was assumed to be a typo. Compound-reduplicants that contained particles, e.g., *ng* in *bagong-bago* 'new', and affixation, e.g., *ma-* in *mabango-bango* 'aromatic', were not counted in the frequency count of its respective compound-reduplicated form, however.

[9] Zuraw (2006) notes that web corpora data will be "messier;" therefore, contributions from non-native speakers is inevitable.

amount of written data in the corpus, words falling within the specific frequency ranges, and those which passed the other criteria, were too few, and unbalanced across the three frequency groups. Therefore, some of the less-preferred sequences remained in the test items; these included some words with weak fricatives and liquids, such as *halo-halo* “ice dessert”, and compounds with adjacent vowels straddling a morpheme boundary, such as *ubo-ubo* “slight cough”. Therefore, various aspects of the design of the study, further described below, were intended to circumvent some of these issues.

Selecting 10 words for each of the 3 frequency groups resulted in the 60 compound reduplicants: 30 unsuffixed compound reduplications, and 30 containing suffixes. The full list of the word items are shown in Table 1.

Table 1. Full compilation of stimuli for the production task, grouped by lexical frequency.

Low Frequency Range

Stem	Unsuffixed Redup	Gloss	Suffixed Redup	Gloss
bako	bako-bako	*'rough'*	baku-baku+an	*'very bumpy'*
biro	biro-biro	*'joketime'*	biru-biru+an	*'not real; jokingly'*
buhok	buhok-buhok	*'a lot of hair'*	buhuk-buhuk+an	*'play or fake hair'*
buntot	buntot-buntot	*'following around'*	buntut-buntut+an	*'someone who closely follows another'*
gusot	gusot-gusot	*'crumpled'*	gusut-gusut+an	*'very crumpled'*
lukot	lukot-lukot	*'creased'*	lukut-lukut+in	*'to make very creased'*
luto	luto-luto	*'cooked'*	lutu-lutu+in	*'overcooked; play food'*
paltos	paltos-paltos	*'blisters'*	paltus-paltus+an	*'very blistery'*
turok	turok-turok	*'prick in successive order'*	turuk-turuk+in	*'to prick in successive order'*
ubo	ubo-ubo	*'slight cough'*	ubu-ubu+hin	*'to cough'*

Mid Frequency Range

Stem	Unsuffixed Redup	Gloss	Suffixed Redup	Gloss
abo	abo-abo	*'dust, ashes'*	abu-abuh+in	*'to be covered with ashes'*
bago	bago-bago	*'new, more recent'*	bagu-baguh+in	*'to renew'*
baho	baho-baho	*'stinky''*	bahu-bahu+an	*'very smelly'*
buko	buko-buko	*'node'*	buku-bukuh+in	*'a lot of nodes'*
bungkos	bungkos-bungkos	*'bunch, wad'*	bungkus-bungkus+in	*'to bunch something together'*
durog	durog-durog	*'crushed into many pieces'*	durug-durug+in	*'to crush'*
lasog	lasog-lasog	*'broken into pieces'*	lasug-lasug+in	*'to break into many pieces'*
sulok	sulok-sulok	*'corners of a room or place'*	suluk-suluk+an	*'corners of a room or place'*
tuhog	tuhog-tuhog	*'Filipino street food'*	tuhug-tuhug+in	*'to eat street food'*
yapos	yapos-yapos	*'act of hugging tightly'*	yapus-yapus+in	*'to hug very tightly'*

High Frequency Range

Stem	Unsuffixed Redup	Gloss	Suffixed Redup	Gloss
bundok	bundok-bundok	*'mountainous'*	bunduk-bunduk+in	*'mountainous'*
buto	buto-buto	*'bones'*	butu-butuh+an	*'a lot of bones'*
dugo	dugo-dugo	*'bloody'*	dugu-dugu+an	*'very bloody'*
laro	laro-laro	*'game playing'*	laru-laru+an	*'pretend play'*
liko	liko-liko	*'twisted, bent'*	liku-liku+in	*'to twist something'*
paro	paro-paro	*'butterfly'*	paru-paru+an	*'butterflies'*
puno	puno-puno	*'overflowing'*	punu-punu+in	*'to be overfilled'*
sabog	sabog-sabog	*'blast, exploded'*	sabug-sabug+an	*'something that has exploded'*
sinto	sinto-sinto	*'gullible'*	sintu-sintu+in	*'very gullible'*
tatlo	tatlo-tatlo	*'in threes'*	tatlu-tatluh+in	*'to bundle in threes'*

2.1.1.2.Carrier frames for elicitation

The production task, in which the test items just described were elicited, was designed so that participants were designed to produce multiple tokens of each test word. Another goal was to minimize the effect of orthography, since the target vowel (the second vowel in the first copy) was always spelled with an "o". This was accomplished as follows:

First, base forms were presented in an initial carrier sentence, for which participants were instructed to reduplicate whenever a blank line was encountered on the slide:

(12) **Carrier Sentence 1:**
Ang unang salita ay [tatlo], at ang pangalawang salita ay [_______].
(The first word is [three], and the second word is [_______].)

The second condition was created to encourage more naturalistic speech production and to draw attention away from structure. Although data from this part of the elicitation is not analyzed for the purposes of this paper, it is described here as it was part of the elicitation procedure. This part of the task required speakers to describe, in their own words, what the target word in question meant or referred to. Speakers were also instructed to speak in the manner that was most natural and familiar to them, including using English if the meaning was hard to describe in Tagalog. This part of the task was elicited in the following carrier frame:

(13) **Carrier Sentence 2:**
Ang ibig sabihin nang [_____] ay…
(The meaning of [_____] is…)

A final carrier frame elicited an additional production of the test word in a more neutral sentence. This was added due to a concern that the first frame used might elicit a contrastive focus, possibly altering the prosodic realization in the word in crucial ways. This final elicitation was also added in case the speaker's first production was disfluent.

(14) **Carrier Sentence 3:**

Ang paborito kong salita ay [_____].

(My favorite word is [_____].)

The corresponding suffixed σσ-reduplicated words served as a baseline condition, based on the fact that Zuraw (2009) found suffixed forms to be spelled with "*u*" nearly 100% of the time (recall the reduplicative identity effect described in §1.2). An example of the three carrier sentences for unsuffixed forms is as follows:

(15) **Carrier Sentence 1:**

Ang unang salita ay [tatlo], at ang pangalawang salita ay [tatlu-tatluhin].

'The first word is [three], and the second word is [_______])

(16) **Carrier Sentence 2:**

Ang ibig sabihin nang [_____] ay…

(The meaning of [_____] is…)

(17) **Carrier Sentence 3:**

Ang paborito kong salita ay [_____].

('My favorite word is [_____].)

The participants were thus given the opportunity to produce each (test or control) item at least 3 times per slide. The three carrier sentences were presented on a single PowerPoint slide, which speakers read from; all speakers read the entire PowerPoint list twice (in the opposite order) resulting in two repetitions of the target word in each carrier sentence. As there were a total of 30 test items and 30 control items, there was the potential for each participant to provide a combined total of 360 items (possibly more, since speakers could, in principle, produce the word more in the less-constrained Carrier Sentence 2). Thus, there was a potential grand total of 4,680 test and control items available for measurement and analysis. An additional 24 compound-reduplicated items and 24 suffixed compound-reduplicated items served as fillers. These words generally lacked the possibility of *u~o* alternation, and are not discussed further.

2.1.2 Participants

Nineteen native speakers of Tagalog, 14 female and 5 male, were recruited via posters on the campuses of the College of Staten Island (CSI) and LaGuardia Community College (LaGCC), as well as the author's webpage. Because there were far less male participants than female ones, data from the former group were excluded from analysis. Additionally, one female participant's recording was excluded, since only one of the two repetitions was performed. Thus, data from 13 female speakers were ultimately measured and analyzed for the current paper. Their mean age was 36 years old; ages ranged from 20 to 80 years old. Two participants reported English, and not Tagalog, as their primary home language. The longest length of residence in the U.S. was 25 years, and two had been visiting U.S.-residing relatives for 2 months or less. 11 reported the use of a second language at home; 1 reported 2 additional home languages. See Appendix I for details of the background information. All participants received monetary compensation.

2.1.3 Procedure

Each testing session consisted of a background questionnaire and the production task including a practice session, followed by a short debriefing. English was used to communicate with the participants during the information and instruction stages. Recordings were carried out in the CSI-CUNY Speech Lab at the College of Staten Island or the Audiology Lab at the Graduate Center. The stimuli were presented to the participants in PowerPoint slides. At CSI, the stimuli were read from a computer monitor; elsewhere, stimuli were presented on an iPad. Three different pseudo-randomized versions of the PowerPoint lists were evenly distributed across all original 19 participants; of the 13 whose data was used for analysis, 5 read from the first list, 5 from the second list, and 3 from the third. Each slide, containing a test or control item, was ordered such that test items did not appear next to each other, always separated by at least one filler item. Additionally, each unsuffixed form and its corresponding suffixed form were separated by at least 4 different items. For the second repetition, participants were instructed to go through the slides in the reverse order.

Participants proceeded through the slides at their own pace while being recorded; recordings were made digitally using a Shure SM10A head-mounted microphone and a computer running Audacity (in mono). At the CUNY GC, a Shure X2U XLR-to-USB Signal Adapter was used with the microphone to record at a 16-bit resolution with a sampling rate of 22,050Hz. At CSI, an ART USB Dual pre-amp was used with the SM10A to record at a 32-bit resolution with a sampling rate of 44,100Hz. Participants were permitted to take a short break if they desired, between repetitions of the PowerPoint slides. The entire experimental task lasted approximately 75 minutes.

2.1.4 Analysis

Praat (Boersma & Weenink, 2012) was used to analyze the audio files recorded from participants in the production task just described. Two types of analyses were to be carried out, which are here referred to as Analysis 1 and Analysis 2. Before submitting the production data to the analyses (described in more detail below), it was necessary to exclude a portion of the data, which would be unusable either because they were disfluent, mispronounced, or would be difficult to accurately measure for various reasons.

To this end, carrier sentences on all trials produced by participants were examined and excluded is they were found to contain: (1) disfluencies during or near the experimental token, e.g., prolongations, hesitations, re-starts, substitutions, omissions or unplanned pauses[10]; (2) tokens whose target vowels had an unidentifiable beginning and/or end. For example, as described above, some of the test words contained adjacent vowels, such as *ubo-ubo*, *'slight cough'*. In the vast majority of cases, the copy-final vowel and copy-initial vowel were separated by a glottal stop or strong glottalization that resulted in a clear trough between the amplitude peaks corresponding to the two vowels. When this was not the case, however, and when the vowels were separated by only smooth-transitioning amplitude and, the token was dropped from the analysis.

All other tokens were included in the analyses, which I now turn to. The purpose of the two types of analyses were to address the different research questions, (Q1) - (Q4), described in §1.4.

2.2 Analysis I

2.2.1 Motivation

The first type of analysis carried out made use of phonetic transcriptions of the vowels of interest, namely the second vowels in the first copy of σσ-compounds. There were two primary reasons for this, both having to do with the kind of variation possible in the [u]~[o] alternation under study. First, consider the consequence of perfectly categorical optionality of vowel selection in speakers' productions of reduplicants. If speakers probabilistically chose prototypical token vowels, it would be possible that one out of four productions (by the same speaker) of, for

[10] It is important to note, however, that a large pause sometimes occurred between the two reduplicants, which I return to later. For those cases, if it sounded normal, fluent, and lacked hesitation, the vowel was included for analysis.

example, *halohalo* "ice dessert", could be produced with an [u], and the other three with an [o]. Averaged across the four tokens, the [u] token would be an outlier, affecting the average F1 value only slightly. That is, a meaningful kind of variation (probabilistic production of a clear [o] production rather than a clear [u] production) could be difficult to detect in raw acoustic data. This issue is complicated further when we consider the additional variation introduced across test items due to different adjacent consonants affecting formant values differently. This was one reason for choosing phonetic transcriptions for the measure of analysis.

The second reason was to address what is essentially the opposite problem: the possibility that clear [u] and clear [o] variants are never or only very rarely produced, and rather, the vowel tends to be something in between. As mentioned in §1.1, in Zuraw's (2009) analysis of corpus data, she found that the vast majority of reduplicants showed variable spelling, with "u" being possible anywhere from 10% and 90% of the time. That is, very few reduplicants were always spelled with "o" or always spelled with "u" in the first copy. While it is possible that this variation in spelling behavior reflects the kind of probabilistic selection of either [o] or [u] that was just described, it is also possible that it reflects phonetic gradience. That is, it may be that, in many cases, the corpus data indicate that the representation of the vowel lies phonetically in-between /o/ and /u/, leading to uncertainty on the part of the writers of the corpus, who had to choose one of only two orthographic symbols (i.e., either "*o*" or "*u*") available to them.

2.2.2 Labeling of Vowels in Reduplicants

The analysis presented here was based on phonetic transcriptions carried out by a linguistically-trained transcriber, namely the present author. The methodology made use of an essentially forced-choice decision about the identity of the vowels in the reduplicants, using the following categories:

- a rounded high (perceived as either IPA [u] or [ʊ][11]), henceforth simply "[u]"
- a rounded low vowel, henceforth "[o]"
- a vowel in-between (i.e., a rounded back vowel that could not be clearly identified as either high or low), henceforth simply "?"
- any other vowel other vowel category (a non-back or non-rounded vowel)

For each production of a target word, the present author listened to the reduplicant in isolation (i.e., isolated from the rest of the carrier sentence) a maximum of five times, sometimes listening to the whole reduplicant, sometimes listening to the copy containing the vowel only. This was done for the second vowel in both copies for all reduplicants, although the present study focuses on only the first-copy final vowels (for unsuffixed and suffixed compounds). For the purposes of this analysis, productions of reduplicants from the scripted carrier phrases (carriers 1 and 3; see §2.1.1.1) were combined and analyzed together; the less restricted productions recorded from the Carrier Sentence 2 frame are not analyzed as part of this study.

2.2.3 Acoustic Analysis

It was also of interest to know what acoustic properties of the vowels correlated with their assignment to these categories [u], [o] and "?" categories. The parameter of primary interest was that which correlates most reliably with vowel height, namely the frequency of the first formant (F1). Thus for each vowel token labeled, the F1 was measured, taking the value from a stable region at the midpoint of the vowel. This was accomplished by identifying the beginning and ends of the vowel (defined by the onset and offset, respectively) of a strong F2. This interval also defined, for the purposes of Analysis 1 (but not Analysis 2), the vowel's duration. The center of the vowel was then defined as the midpoint of this interval, and F1 values were extracted

[11] See Schachter and Otanes (1972) for some description of variation involving the realization of back vowels in Tagalog.

automatically using a Praat script from this midpoint. Subsequent to this automatic extraction, all tokens with a recorded F1 value more than two standard deviations above or below the speaker's own mean were rechecked and (if necessary) corrected manually.

2.3 Analysis 2

Whereas the goals of the first analysis were to provide data on the kind of variation present in compound reduplication (relevant to Q1 and Q2) and any correlation with lexical frequency (relevant to Q3), Analysis 2 was intended to address the issue of prosody's role (relevant to Q4). In particular, since the question was whether [o] vowels tend to precede a prosodic boundary and [u] vowels do not, evidence for such phrasal differences was sought in segmental durations. As noted in §1.4.4, this may come in the form of final lengthening of first-copy [o], but not first-copy [u] (Wightman, et al, 1992); it could conceivably also come in the form of (duration) initial strengthening of the consonant in the second copy's initial consonant.

To explore these possibilities, a subset of the unsuffixed CVCV-CVCV compounds recorded from speakers (i.e., a subset of tokens analyzed in Analysis 1) were chosen, namely those with obstruent consonants that could be segmented with maximal accuracy. These included productions of the following six compounds:

(18) a. bago-bago *'new; more recent'*
b. bako-bako *'rough'*
c. buko-buko *'node'*
d. buto-buto *'bones'*
e. dugo-dugo *'bloody'*
f. puno-puno *'overflowing'*

The boundaries of the consonants (and thus the intervening vowels) were identified according to the recommendations in Turk, Nakai, & Sugahara (2006); generally, the onsets of obstruents were marked by the onsets of constriction following a previous vowel, visible by a sharp and abrupt decrease in the amplitude of the waveform. Offsets (and therefore vowel onsets) were marked by the release of the constriction. An example of a segmentation of *puno-puno* ‘overflowing’ is shown in Figure 2.

One thing that this did not allow for accurate measurement of was stop consonants in absolute initial position (and, unfortunately, all 6 of the compounds began with stops). The only acoustic evidence of the stop’s onsets following silence would, in the case of voiced stops, be the onset of voicing during closure. For voiceless stops (like the initial stop in *puno-puno*) even this evidence would be absent. Note that the same problem arises in cases where the two copies are separated by a sufficiently long pause; in this case, the second copy’s initial consonant is effectively in initial absolute initial position, being offset from the previous vowel.

To address the first issue, stops in absolute initial position were not included in the statistical analysis (e.g., the first [p] in *puno-puno* “overflowing”); this does not pose a problem, since these consonants do not factor into any predictions about the presence versus absence of a boundary between the two copies. To address the second issue, the entire compound token was excluded from the analysis if a large pause (more than 2.5 times the stop’s average duration in the data collected) was intervening between the two copies. However, it should be noted that the presence of a long pause between the two copies in in fact a kind of evidence in and of itself; such pauses suggest the presence of a large prosodic boundary, and so the number of such exclusions is potentially informative as to (Q4). It is therefore predicted that the number of exclusions based on inter-copy pausing should be very few in the case of compounds with first-copy [u], and more likely for those produced with first-copy [o].

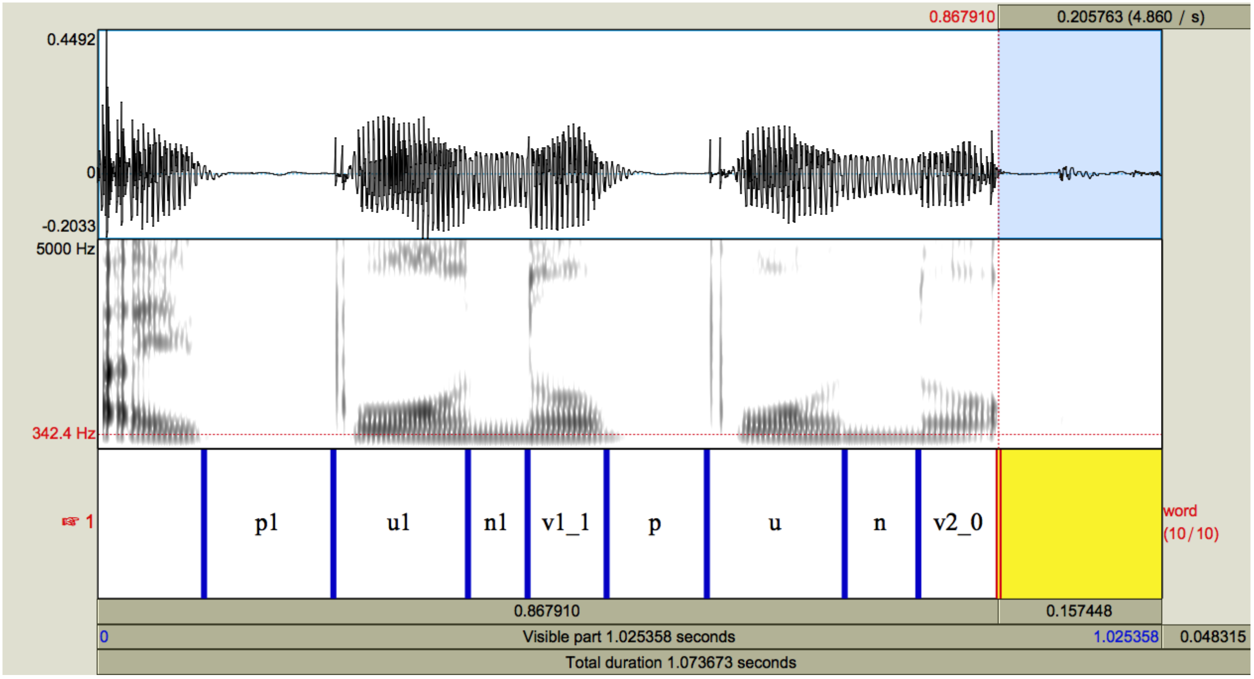


Figure 2. The σσ-reduplicated form of /*puno-puno*/ 'overflowing' produced by Speaker 8 in sentence 1 of the second repetition.

2.4 Results: Analysis 1

2.4.1 Assignment of Vowel Variants

Table 2, below, provides a summary of the overall patterns for Analysis 1. As can be seen, numerically, [u] is less common in first-copy final vowels in unsuffixed (*halo-halo*) forms than in suffixed forms (*halo-haloan*). Note, however, that there was some variation in this vowel even in suffixed forms, since [u] rates, although very high, were not at 100% even in the suffixed condition. Note also that frequency was not an obvious predictor of [u] rate for the unsuffixed condition; although HIGH had the highest rates of [u], LOW had the second highest rates, and MID the lowest. The relation between lexical frequency and likelihood of [u] for both unsuffixed and suffixed forms is illustrated graphically in Figure 3.

Table 2. Summary of results for Analysis 1: % Tokens assigned [u], [o], and in-between labels for reduplicants of different lexical frequencies, with the corresponding average F1 and duration values for vowel tokens with each label.

	unsuffixed			suffixed		
Low Frequency	**[u]**	**?**	**[o]**	**[u]**	**?**	**[o]**
% Tokens	36.7	12.3	51.0	77.6	10.3	12.1
Mean F1 (Hz)	472	496	538	453	490	537
Mean Duration (ms)	61	51	75	69	39	56
Mid Frequency	**[u]**	**?**	**[o]**	**[u]**	**?**	**[o]**
% Tokens	32.5	13.3	54.2	83.2	7.2	9.6
Mean F1 (Hz)	453	465	506	435	475	501
Mean Duration (ms)	60	49	69	64	41	64
High Frequency	**[u]**	**?**	**[o]**	**[u]**	**?**	**[o]**
% Tokens	40.9	10.2	48.9	82.0	6.7	11.3
Mean F1 (Hz)	433	486	528	430	471	522
Mean Duration (ms)	72	64	85	76	51	67

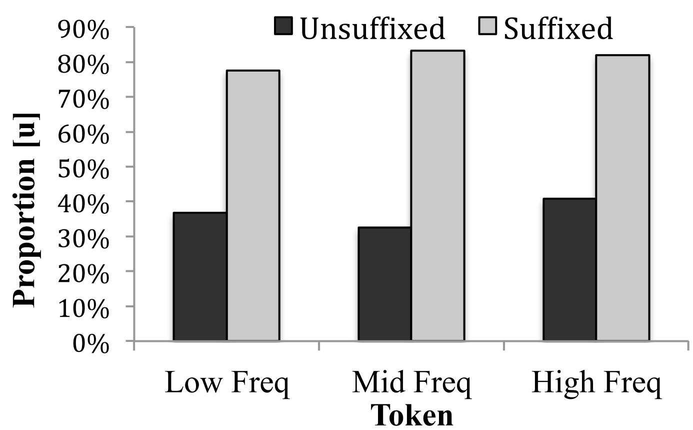


Figure 3. Overall proportion of compound reduplicants with [u] for V_1 and V_{1s}, grouped by the lexical frequency of the compound. Dark bars show proportion for unsuffixed compounds (e.g., *halo-halo* 'ice dessert'), light bars show [u] proportions for suffixed compounds (e.g., *halo-halo+an* 'something mixed').

To test the statistical significance of these numerical patterns, the production data, in particular the labels assigned to the second vowel in the first reduplicant, were explored using mixed-effects logistic regression. The outcome variable to be predicted by the model was an "[u]" production of that vowel. This was predicted based on the random effects factors (both intercepts) “speaker” and “item”, and the following fixed-effects factors: suffixation of the reduplicant (+/- suffix), the lexical frequency of the reduplicant form (LOW, MID, HIGH), which instance of the reduplicant it occurred in the trial (first or second), and whether this was a repetition of the whole trial (first or second repetition). Two-way interactions between all factors were tested, as well as three-way interactions between suffixation and frequency and each of the other factors. In a step-wise fashion, each effect in this initial model was dropped if its p-value was above 0.1, as long as this did not result in a decrease in the fit of the model relative to the model that contained the factor; this model comparison was carried out using the *anova* function in the *lmer* package (Bates, Maechler, Bolker, & Walker, 2013) of R (R Development Core Team, 2014). After all non-contributing factors were removed, the model was refitted, and is the basis for the analysis below.

Table 3 displays the output of the final model. As can be seen, the asymmetry in the distribution of high vowels was, in fact, highly significant, with the unsuffixed reduplicants showing far fewer /u/ vowels than the suffixed forms. That is, a high vowel was less likely in the first copy of /halo-halo/ than in the first copy of /halo-halo+an/ ‘something mixed’. This is in line with Zuraw’s written corpus findings. Also in line with Zuraw’s findings is that there was no main effect of lexical frequency on vowel raising. That is, frequency did not predict high vowel variants in general. However, a significant interaction between lexical frequency and suffixation indicated that the three frequency groups were not all statistically equivalent. While the unsuffixed reduplicants (relative to the suffixed reduplicants) in HIGH contained the most tokens with [u], this difference was significant only when compared with MID tokens, and not with tokens in LOW. Thus, these results showed a suggestive trend, but it was not a reliable one.

Table 3. Output of the linear mixed-effects model used to test the differences among the labels assigned to the second vowel in the first reduplicant.

Fixed effects:

	β	SE	z	p	
(Intercept)	2.834	0.454	6.24	< .001	*
Suffix (– suffix)	-3.503	0.241	-14.50	< .001	*
Freq (Low vs. Mid)	-0.378	0.468	-0.80	> .1	n.s.
Freq (High vs. Mid)	-0.193	0.471	-0.41	> .1	n.s.
Freq (High vs. Low)	-0.185	0.465	-0.39	> .1	n.s.
Trial-Rep (2^{nd})	-0.312	0.118	-2.64	< .01	*
Suffix (–suffix) * Freq (Low vs. Mid)	0.663	0.311	2.13	< .05	*
Suffix (–suffix) * Freq (High vs. Mid)	0.633	0.313	2.01	< .05	*
Suffix (–suffix) * Freq (High vs. Low)	0.030	0.301	0.10	> .1	n.s.

Finally, Table 3 also shows that there was also a significant main effect of number-in-trial, such that reduplicants, regardless of their suffixation status, were more likely to be pronounced with an [u] in their first, rather than in their second, production in a trial. There was no similar effect for repetition, however (as repetition did not contribute significantly to the model).

2.4.2 Acoustic properties of ambiguous vowels

Apparent from Table 3, above, is the fact that, although a minority, a non-trivial portion of target vowels in the compound reduplicants could not be categorized as a high vowel or a low vowel. It is of interest to know whether these vowels, which were perceived as "in-between" [u] and [o] were also acoustically between [u] and [o]. That is, what measurable properties of these vowels might have influenced their categorization as "in-between"?

The two acoustic measures collected here were F1 and duration. A mixed-effects linear regression model was constructed to test differences between vowel categories first in terms of F1 and then in terms of duration. The outcome variable for the first model was therefore F1, with "vowel label" ([u], [o], or "?") and "suffixation status" (+/–suffix), and their interaction, as predictors. The same random effects structure was used as in the previous logistic regression model above, and the removal of non-contributing factors was carried out in the same way. A second model followed this same procedure, but “duration” replaced “F1” as the outcome variable.

The resulting model for F1 is shown in Table 4. As can be seen, vowels assigned an ambiguous label (which serve as the comparison group in the model) had F1 values that were significantly bigger than vowels assigned a [u] label, and significantly smaller than vowels assigned an [o] label. An interaction between vowel label and suffixation did not contribute to the model, indicating the lack of an interaction. There was, however, a main effect for suffixation, such that target vowels in suffixed compound reduplicants had significantly lower F1.

Table 4. Output of the linear mixed-effects model used to test differences in F1 for vowels assigned to different height categories.

Fixed effects:

	β	SE	t	p	
(Intercept)	459.851	11.813	38.93	< .001	*
[u] vs. ?	-12.068	2.474	-4.88	< .001	*
[o] vs. ?	24.079	2.624	9.17	< .001	*
Suffix (– suffix)	23.735	1.618	14.67	< .001	*

The resulting model for duration, shown in Table 5, indicated that vowels assigned to the ambiguous category were also categorized by short duration, as they were significantly shorter than both the [u] and [o] vowels. An interaction between vowel label and suffixation did not contribute to the model, indicating the lack of an interaction. No other factors (namely suffixation) contributed significantly to the model.

Table 5. Output of the linear mixed-effects model used to test differences in duration for vowels assigned to different height categories.

Fixed effects:

	β	SE	t	p	
(Intercept)	55.157	6.223	8.86	< .001	*
[u] vs. ?	11.523	1.561	7.38	< .001	*
[o] vs. ?	17.941	1.672	10.73	< .001	*

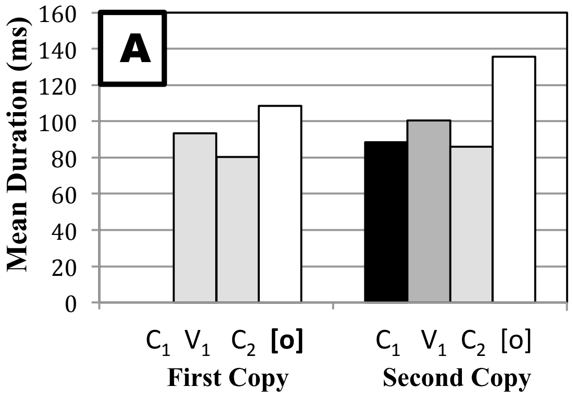
2.5 Results: Segment Durations (Analysis 2)

The last set of data was intended to test primarily (Q4), regarding the correlation between first-copy vowel variants, and phonetic evidence for prosodic phrasing. I will now consider how segmental durations bear on this question.

Figure 4 displays average segmental durations, separately for compounds containing — according to the transcriptions in Analysis 1— first-copy [o]s (Figure 4A) and first-copy [u]s (Figure 4B). Although the absolute differences were small, first-copy [o]s were numerically longer than first-copy [u]s, the basic pattern expected if there were final lengthening on [o]s but not [u]s. This difference is more striking when considered relatively; first-copy [u]s in Figure 4B are strikingly short compared with their second-copy (and thus word-final) vowel counterparts.

Looking next at second-copy initial consonants, these were also longer in compounds with first-copy [o]s than compounds with first-copy [u]s. The direction of this numerical difference is consistent with initial strengthening—which would also serve as evidence for an inter-copy prosodic boundary in compounds with first-copy [o]s, but not those with first-copy [u]s.

To determine whether these numerical differences were statistically confirmed, a mixed-effects linear regression model was constructed to test the difference between first-copy [o]s versus first-copy [u]s. The modeling was carried out as before with the following crucial fixed-effects factors: “Copy” (first-copy final vowel vs. second copy final vowel) and “vowel label” (assigned an [u] or an [o] transcription), and, crucially their interaction.



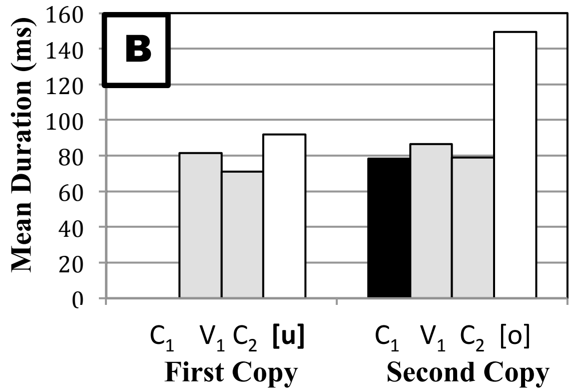


Figure 4. Mean segmental durations of σσ-reduplicants containing first-copy [o]s, on the left in (A), and first-copy [u]s, on the right in)B), based on transcriptions in Analysis 1.

In fact, as shown in Table 6, the interaction was significant, such that the difference between first-copy final [u]s were significantly shorter (relative to their second-copy counterparts) than first-copy [o]s (relative to *their* second-copy counterparts). Important to emphasize is the importance of the relative effect; this was presumably due to the fact that first-copy [u] was not only shorter (in absolute terms) than first-copy [o], but also because word-final vowels were longer in compounds with a first-copy [u]. This is the sort of relative lengthening effect we would expect to see if there were a difference in the overall prosodic structure of the compound.

Table 6. Output of the linear mixed-effects model used to test differences between vowel variants in the first copy of compound reduplicants.

Fixed effects:

	β	SE	t	p
(Intercept)	144.4	7.169	20.14	< .001
First-Copy Vowel vs. Second Copy Vowel	-26.671	3.876	-6.88	< .001
Vowel Label (u vs. o)	10.417	4.137	2.51	< .05
First-Copy Vowel * Vowel Label (u)	**-30.792**	**5.192**	**-5.93**	**< .001**

Unlike lengthening due to prosodic phrase boundaries, the effect of initial strengthening of the second-copy initial segments is less likely to be a relative effect, and in most studies testing articulatory strengthening of consonants at the onsets of prosodic phrases, a comparison of absolute measures is the standard type (Fougeron & Keating, 1997). This was tested using a very simple model (with the same random-effects structure), comparing second-copy initial consonants following [u] versus [o]. Although post-[o] initial consonants were slightly longer, this was not found to be significant (β = -1.069, t = -0.589, p > .1). Thus, there was not statistically significant evidence for any initial strengthening effects that correlated with vowel production in the compounds.

Finally, as mentioned above, it was of interest to know if there were any differences in the number of tokens discarded due to large pauses between copies. The number of tokens discarded for compounds with second-copy [o] vowels was 26, and only 2 for compounds with second-copy [u] vowels. A mixed-effects logistic regression model found this difference to be only marginally significant (pauses following [u] vs. [o]: β = -1.555, t = -1.769, p = .07), likely due to the small number of discarded tokens overall.

3 General Discussion and Conclusion

3.1 Is there evidence for variation? (Q1)

An important goal of the study was to address the general issue of phonetic evidence for the completeness of /o/-raising, since it is a process frequently cited in the phonological and descriptive literature, yet instrumental phonetic evidence is lacking. Zuraw's (2009) analysis of the web corpus suggested that there is variation in V_1 – sometimes "u" surfaces, and other times "o" surfaces; her analysis of V_{1s}, the corresponding vowel in the suffixed form, in contrast, revealed that "u" almost always surfaces, and rarely does "o". The asymmetry in the distribution of high vowels in Analysis 1 of the current study provided evidence to support the written corpus pattern: there was a statistically significantly lower rate of [u] in V_1 position compared to V_{1s}, both for individual frequency ranges, or when frequencies are collapsed. It is important to note that variation was also found for V_{1s}, with a rate of 81% of [u] tokens (the corpus predicted the rate of [u] to be nearly 100%). However, this result provided support for the corpus's pattern since it was trending in the right direction. Therefore, the results of the current study corroborate Zuraw's (2009) findings, and the descriptive literature, in general.

3.2 Is there gradience? (Q2)

Closely related to the issue of quantitative evidence for the attested variation (explored in Q1), is how the variation is manifested, i.e., whether gradience is present. Unlike the written corpus, where the authors of the data had a binary choice of "u" or "o", the vowels produced in the current experiment could not be transcribed as either the high or low variant; there seemed to be a middle representation. Analysis 1 showed that the acoustic properties of these ambiguous vowel tokens, F1 and duration, provide support for this middle realization. Collapsing for frequency, vowels that were assigned as [u] had mean F1 values that were significantly less than the ambiguous (in-between) vowel, which in turn were significantly lower than vowels labeled as [o]. Thus, the perceptual assignment of vowel tokens into categories, which corroborated with gradient variation, lined up with the acoustic data. However, further work may be needed to further support this finding, since only mean F1 values were examined. Distribution of the tokens were not explored here, thus it is unknown how much overlap exists among the three vowel categories. The second acoustic measure, duration, showed that vowels labeled as ambiguous were shorter in duration compared to both [u] and [o].

3.3 Are there frequency influences related to variation? (Q3)

Another important goal of the present study was to investigate whether lexical frequency predicts the quality of the realized vowel. Based on Zuraw's (2009) written corpus, probabilistically, V_1 in higher frequency items would exhibit more [u] realizations, but in V_{1s}, [u] was expected to occur nearly 100% of the time regardless of frequency range. This latter corpus pattern was not entirely supported in the current study: lexical frequency did not play a role on the outcome of the rate of [u]-use in V_{1s}, but, unexpectedly, it also did not for V_1. However, there were suggestive trends: [u] tokens for V_1 in HIGH were significantly greater than in MID, but not significantly greater than [u] tokens in LOW. This indicated that the three frequency groups were not all statistically significant. Thus, while the pattern was trending in the right direction, i.e., more [u]'s in high frequency items, this was not a reliable trend and it did not carry over cleanly across the frequency ranges. The data bearing on this question suggest that there is not a strong relationship between variation and frequency. However, that does not necessarily imply that the prosodic analysis laid out by Zuraw (2009) does not follow; this will be described next.

3.4 Is prosody related to variation? (Q4)

The present study also sought to address the issue of the role of prosody, in particular whether a prosodic boundary can be identified on the basis of a vowel variant. Zuraw's (2009) corpus showed that spelled "o" vowels tend to occur before a boundary, and [u] vowels do not. Analysis 2 of the current study, which made use of segmental durations, appeared to line up with Zuraw's findings. Realizations of [o] in the first copy were significantly longer than [u] in the first copy. More importantly, there was a significant relative effect: first-copy [o]s were also longer, relative to their second copy counterparts than first-copy [u] vowels, relative to *their* second-copy counterparts]. As mentioned in §2.4.3, this is important to note, since this relative lengthening effect strongly suggests a difference in the overall prosodic structure of the compound; first-copy

[o]s surface because, like second-copy [o]s, it is final in the prosodic unit. Lastly, in support of prosodic phrasal differences, the distribution of pauses that were excluded turned out to not be random; pauses were more common following an [o] production. This, however, was not surprising since non-raising is expected in final positions. However, evidence for initial strengthening was not strong. A comparison of second-copy initial consonants showed that while the consonant following an [o] was numerically longer than C_1 following [u] productions, this difference was not significant. Overall, results from Analysis 2 provided suprasegmental support for the presence of the prosodic boundary that determines the non(application) of /o/-raising.

3.5 Summary

In sum, the current study's analyses provided some support, or suggested trends, in support of Zuraw's (2009) written corpus analysis of Tagalog /o/-raising. Analysis 1 provided acoustic data to support for Zuraw's finding that variation was found to occur in V_1 but not in V_{1s}. Analysis 1 further showed that gradience is present in the phonological process. The issue of frequency effects was the least supported by Analysis 1, for which there were suggested trends but none that turned out to be significant. Analysis 2 provided fairly good evidence in support for a prosodic structure: productions of [u] for V_1 appeared to occur in a single constituent, compared to [o] productions, which appeared to occur in two separate constituents, suggesting a prosodic boundary. Thus, the current study provided acoustic data in support for the completeness of /o/-raising and the presence of gradience in the variation, but did not fully support Zuraw's proposal that frequency determines prosodic structure: her analysis of prosodic phrasal differences is supported, but the role of frequency clearly does not fit in as neatly as it did in the written corpus.

3.6 Limitations and Future Research

In the current study, only a subset of the data elicited from the production task was analyzed, and thus much data still remain for future research. Such analyses could provide further insight into the patterns on variation just described. The following subsections contain, in part, a description of some of this future work.

3.6.1 Analysis 1

Although Analysis I showed a numerical trend that was more or less in line with Zuraw's (2009) analysis in that there was a higher rate of *u* productions in the high frequency range of unsuffixed compound reduplicants, the trend was not statistically reliable. One straightforward possibility for this outcome is that the minimum and maximum cutoffs that were chosen for the three frequency ranges were not the most favorable ones (see §2.1.1.1 for a discussion on selection of ranges). Another reason that the rate of [u] was not significant in the higher frequency range could stem from the analyzed data itself, namely the phonetic transcriptions. Only one transcriber carried out the task of perceptually assigning vowel labels (the present author), and discrepancies from a second transcriber would have exposed possible errors made by the solo transcriber. With the allowance of time, I could continue an examination of the vowel dataset (data described in Analysis 1) by looking at acoustic correlates of prosody, e.g., pitch; the issue of prosody was explored in this paper with only segment durations in a subset of the compound reduplicants, and the vowel dta could further inform the findings of the current study.

3.6.2 Analysis 2

Results from this analysis provided, generally, good support for the presence of a prosodic boundary. However, further examining the segment durations could provide additional support to the overall pattern, for example, with a comparison of the corresponding suffixed forms (only a subset of the unsuffixed conditioned was included for analysis). Recall in Figure 4 that in (A), the segment durations support the notion of separate prosodic structures, and in (B) the data supports a single prosodic structure. In other words, (B) appears to be more "group-like" than (A). To further investigate this, for example, each segment in items with first-copy [o]s could be tested for differences in duration with corresponding segments in items with first-copy [u]s. If (B) were indeed a single prosodic unit, then the prediction is that each segment in (B) would be significantly shorter than those in (A). Evidence from an analysis of pitch would also lend support for differences in prosodic structure.

3.7 Conclusion

For this paper, I analyzed productions of Tagalog σσ-reduplicated items exhibiting an alternation between [u] and [o] to investigate: (Q1) the acoustic details of this variation, (Q2) whether the variation is gradient, (Q3) frequency effects, and (Q4) differences in prosodic phrasing, based on the findings in Zuraw's (2009) study of written data. The current study provided acoustic data that supported that, indeed, *o~u* optionality in these compounds is an active phonological process, and that this variation is gradient. Unlike Zuraw's findings, the current study did not really provide data to support the notion that frequency is a predictor in determining the selection of the variant, but did support the notion that variation can be accounted for by differences in prosodic structure.

This study also allowed us to address broader issues in laboratory phonology, in particular the phonetics and phonology of Tagalog prosody. Tagalog is a major Austronesian language, and there is much ongoing work on the language in other sub-fields. However, there is little known literature, in general, providing acoustic data for Tagalog phonology, and even less acoustic data describing the language's prosodic structure. It is hoped that the observations made in this current study gives directions to future research, in addition to that described in §3.6.

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Appendices

Appendix I. Collection of background information of the 13 female participants.

#	Age (yrs)	Hometown	Length of residence in U.S. (yrs)	Primary home language	Other home languages	Stimuli List
1	36	Unknown	5	Tagalog	English	A
2	22	Pasay City	8	Tagalog	none	A
3	39	Marinduque City	15	English	Tagalog	B
4	80	Cavite City	visiting	Tagalog	English	B
5	21	La Union	4	Tagalog	Ilokano	A
6	21	Manila	4	Tagalog	English	A
7	36	Cavite City	15	Tagalog	English	C
8	37	Cavite City	15	Tagalog	English	C
9	47	Pasig City	25	English	none	C
10	27	Pampanga	9	Tagalog	English	A
11	35	Cabanatuan	19	Tagalog	English	B
12	62	Cabanatuan	visiting	Tagalog	English; Ilokano	B
13	20	Quezon City	<1	Tagalog	English	B