Incomplete neutralization of a vocalic length contrast in Japanese*

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Abstract

There has been a large body of the literature on incomplete neutralization, patterns where phonologically "neutralized" segments show subtle phonetic differences. The current experiment adds a new case of incomplete neutralization to this growing body of literature. Following Mori (2002), the experiment shows that the vowels of monomoraic nouns in Japanese are lengthened when they appear in isolation within a Prosodic Word, in order to satisfy a bimoraic minimality requirement (Poser, 1990). However, going beyond the scope of Mori's (2002) study, the experiment also shows that the lengthened nouns' vowels are not as long as underlyingly long vowels. These results expand the typology of incomplete neutralization by showing that incomplete neutralization happens for duration-based length contrasts. This result also provides evidence against the claim that patterns that show incomplete neutralization are actually phonetic (c.f. Barnes 2006; Davidson 2006; Fourakis and Port 1986; Ohala 1974). The Japanese lengthening pattern is clearly phonological in that it is motivated by a morphophonological word minimality requirement.

*Acknowledgments: We presented a previous version of this experiment to the Tokyo Circle of Phonologists (TCP) in May 2012, where we also discussed the current stimulus sets with Prof. Shosuke Haraguchi, who offered much needed help at that time. Prof. Haraguchi passed away shortly after the meeting, and therefore we would like to dedicate this article to him. We are also grateful to the audience at TCP and Seoul National University for comments on this project. Remaining errors are ours. A previous version of the experiment, which used a smaller number of stimuli and speakers, is reported in Braver and Kawahara (2014).

1 Introduction

The current experiment offers a new case study on incomplete neutralization from Japanese. Incomplete neutralization refers to cases in which two segments that are apparently neutralized phonologically are realized with subtle phonetic differences on the surface. A classic case of incomplete neutralization is coda devoicing, which has been found in many different languages: Afrikaans (van Rooy et al., 2003), Catalan (Dinnsen and Charles-Luce, 1984), Dutch (Warner et al., 2004, 2006; Ernestus and Baayen, 2007), German (Dinnsen and Garcia-Zamor, 1971; Taylor, 1975; Mitleb, 1981b,a; Port and O'Dell, 1985; Kleber et al., 2010; Röttger et al., 2012), Polish (Slowiaczek and Dinnsen, 1985; Slowiaczek and Szymanska, 1989), and Russian (Dmitrieva et al., 2010; Kharlamov, 2012). In these languages, devoiced consonants, which are underlyingly voiced, result in a different surface realization than underlyingly voiceless segments. For example, Port and O'Dell (1985) found that in German, vowels before devoiced stops are approximately 15 ms longer than those before underlyingly voiceless stops. They also found differences in aspiration duration, voicing duration, and closure duration—each of which was consistent (to a reduced degree) with the differences found between voiced and voiceless consonants in non-devoicing contexts in German and other languages.

Since Port and O'Dell's classic finding on German coda devoicing, incomplete neutralization has been found in a number of other cases, including epenthesis in Levantine Arabic (Gouskova and Hall, 2009), flapping in American English (Braver, under review; Herd et al., 2010), insertion of intrusive stops in English (Fourakis and Port, 1986), tonal neutralization in Cantonese (Yu, 2007), voicing assimilation in Russian (Burton and Robblee, 1997), [ə]-insertion in English speakers' pronunciation of non-native clusters (Davidson, 2006), and coda aspiration in Eastern Andalusian Spanish (Gerfen, 2002).

While the vast majority of previously described cases of incomplete neutralization center on feature- and segment-level contrasts, our aim is to provide evidence of a novel case of incomplete neutralization in the domain of duration-based length contrasts. A few durational phenomena have been alleged to be cases of incomplete neutralization; however such examples tend to be related to

stress-based lengthening or phrase-final lengthening. This seems to be the case in Chickasaw (Gordon and Munro, 2007), in which both underlyingly short and underlyingly long vowels lengthen in final position. Similarly, in St. Lawrence Island Yupik (Krauss 1975; Leer 1985; Hayes 1995, p. 241), Chickasaw (Gordon et al., 2000), Swedish (Hayes 1995, p. 84; Bruce 1984), Tongan (Hayes, 1995, p. 84), Wargamay (Hayes, 1995, p. 84), there is a reported durational distinction between lengthened short vowels and underlyingly long vowels. However these cases seem to be stress-based lengthening, which is likely to be phonetic, as they are correlated with other phonetic manifestations of stress. Due to these prosodic influences—which can affect even languages without a phonological short/long vowel length contrast—the cases cited above cannot serve as strong evidence for a true incomplete neutralization of a duration-based length contrast.

Another alleged case of durational incomplete neutralization is found in Kinyarwanda, where a short/long vowel length contrast surfaces as three different durations: short vowels, lengthened short vowels before NC sequences, and long vowels (Myers, 2005). As Myers himself argues, however, the distinction between lengthened and long vowels is best described as phonetic shortening of vowels in closed syllables (Fowler, 1983; Maddieson, 1985). Since this case is explained by factors of phonetic implementation, it does not constitute evidence of true incomplete neutralization of a duration-based length contrast either.

Given these phonetically-driven cases of subphonemic distinctions, one can ask whether incomplete neutralization has a truly phonological basis at all. One implementation of the pure *phonetic* view of subphonemic distinctions comes in the form of historical change or drift: two originally distinct phonological categories succumb to phonetic pressures such as coarticulation, causing the distributions of the two categories to, over time, overlap (Pierrehumbert, 2001; Barnes, 2006). Barnes (2006), in fact, argues that *all* cases of incomplete neutralization are implemented in the phonetic component; we intend to show that this is not the case.

To be clear, we do not claim that every subphonemic distinction is purely phonological, but rather that the term 'incomplete neutralization' is best used to describe those cases where two phonological categories are *phonologically* merged, yet result in a subphonemic distinction. In

order to establish the phonological nature of an instance of incomplete neutralization, it would have to be shown that a phonological process treats the (phonological) output of the incomplete neutralization as a categorical merger (i.e., the phonology 'sees' the two categories as merged), while at the same time we observe a subphonemic, phonetic distinction (Barnes, 2006, p. 229). We argue that the case of Japanese monomoraic noun lengthening fits this description, and therefore serves as evidence for the phonological nature of at least a subset of the subphonemic distinctions reported in the literature.

Our study centers on a prosodic constraint in Japanese which requires every Prosodic Word to be minimally bimoraic. When monomoraic nouns appear in isolation, they must lengthen to meet this prosodic minimality requirement (Mori, 2002). The current experiment shows that these lengthened nouns are not as long as underlyingly long nouns—a case of subphonemic distinction. Further, foot-based phenomena such as pitch accent are evidenced in both underlyingly monomoraic and underlying bimoraic nouns, suggesting that the lengthening is morphophonological in nature. Because lengthened monomoraic nouns are identical (mora-wise) to underlyingly bimoraic nouns, a difference in duration is not expected. This pattern—phonological identity, but phonetic distinction—is the hallmark of incomplete neutralization. This study expands the typology of incomplete neutralization by showing that duration-based length contrasts can be incompletely neutralized.

2 Background

Japanese contrasts short vowels vs. long vowels (e.g. [obasan] 'aunt' vs. [obaasan] 'old lady'). Aspects of this vocalic length contrast have been much studied in the past: For general durational properties of long vowels in Japanese, see Han (1962); Hirata (2004); Kawahara and Braver (2013); Mori (2002); Port et al. (1987); for secondary, non-durational acoustic correlates, see Behne et al. (1999); Hirata and Tsukada (2009); Kinoshita et al. (2002). These studies show that this contrast is primarily a matter of phonetic duration, with other acoustic cues being only secondary.

There is a large body of evidence showing that Japanese has a bimoraic minimality requirement

on Prosodic Words (Itô, 1990; Poser, 1990; Mester, 1990; Itô and Mester, 1992; Mori, 2002). This bimoraicity requirement is observed in many word formation patterns, all of which are based on a bimoraic template, including nickname formation, *geisha* client name formation, loanword abbreviation, verbal root reduplication, scheduling compounds, and telephone number recitation.

For instance, in the nickname formation pattern, a full name must be truncated to two moras before suffix *-chan*[1] can be applied. For example, the five-mora name *Wasaburoo* can be truncated to two moras as in (1b), but not one, as in (1c). Similarly, the three-mora name *Kotomi* can be truncated to either two monomoraic syllables, as in (2b), or a single bimoraic syllable, as in (2c). *Kotomi* cannot, however, be shortened to a single mora, as in (2d).

(1)	(a)	wasaburoo	(full name)
	(b)	wasa(-chan)	(2 moras)
	(c)	*wa(-chan)	(1 mora)

(2)	(a)	kotomi	(full name)
	(b)	koto(-chan)	(2 moras)
	(c)	koc(-chan)	(geminate; 2 moras)
	(d)	*ko(-chan)	(1 mora)

The bimoraicity requirement is evident, too, in telephone number recitation patterns (Itô, 1990). In the recitation of telephone numbers, monomoraic digits (e.g. *ni* 'two') are lengthened, as in (3a). Additionally, those digits which have both a monomoraic and a bimoraic allomorph (e.g., *shi*∼*yon* 'four') always surface as the bimoraic allomorph, as in (3b).

(3) (a)

6	5	1	-	3	2	8	6
roku	**goo** / *go	ichi	(no)	san	**nii** / *ni	hachi	roku

(b)

4	6	1	-	3	8	9	6
yon / *shi	roku	ichi	(no)	san	hachi	**kyuu** / *ku	roku

[1]Here and throughout, Japanese morphemes are given in the standard Romaji romanization, except when enclosed in [square brackets], in which case, they are given in IPA.

What nickname formation and telephone number recitation—as well as numerous other morphophonological processes in Japanese (Itô, 1990; Poser, 1990; Mester, 1990; Itô and Mester, 1992; Mori, 2002)—have in common is that they are all based on the requirement that a Prosodic Word must be binary at the moraic level. More specifically, A Prosodic Word must contain at least one foot, and the foot must be binary (McCarthy and Prince, 1986, 1993) (at the moraic level in Japanese), as in (4).

(4) (a) 

(b) 

In spite of this bimoraicity requirement, there are monomoraic nouns in the Japanese lexicon; e.g., [ki] 'tree', [i] 'stomach', and [e] 'picture'. Itô (1990) argues that the bimoraic minimality requirement holds only for morphologically derived words. However, Mori (2002) shows that when these monomoraic nouns appear in isolation within a prosodic word (e.g., without case particles and in a non-derived environment), lengthening occurs. She found that monomoraic nouns lengthen in this context by 40–50%, while underlyingly bimoraic nouns do not show such lengthening in the same environment.[2] Therefore, Mori concludes that the lengthening of monomoraic nouns is caused by a phonological bimoraic minimality requirement: monomoraic nouns with a case particle in the same Prosodic Word satisfy the bimoraicity requirement (by virtue of the particle's mora), as in (5a), while monomoraic nouns must gain an additional mora to satisfy this requirement, as in (5b).

[2]Kubozono and Ota (1998) note that in the Kinki dialect of Japanese, this lengthening occurs in monomoraic nouns even when not in isolation (i.e., when they are immediately followed by a case particle). See also Haraguchi (1977); Higuchi and Haraguchi (2006) for a similar observation.

(5) (a) No lengthening with a particle (b) Lengthening without a particle

Although Mori does not include underlyingly long vowels in her stimulus set, she does refer to previous studies (Beckman, 1982; Hoequist, 1983) which have shown that Japanese heavy syllables are are generally 66–80% longer than light syllables. A more recent phonetic study by Hirata (2004) shows that long vowels in Japanese can be up to 150% longer than short vowels. This difference between Mori's results (40-50% longer) and other studies on Japanese length distinctions implies, as Mori herself suggests, that we may be observing a case of incomplete neutralization. The experiment reported below sets out to directly test this hypothesis by comparing the vowel duration of lengthened nouns to that of underlyingly long nouns.

3 Experiment

In this experiment, native speakers of Japanese were asked to read sets of sentences. Each set was constructed with a minimal triplet: (a) an underlyingly monomoraic, short noun with a particle, (b) an underlyingly monomoraic noun without a particle, and (c) an underlyingly bimoraic, long noun. From the previous studies discussed above, we expect (i) that monomoraic nouns are lengthened without case particles, as Mori (2002) found, but (ii) that the lengthened nouns are not as long as underlyingly long vowels.

3.1 Method

3.1.1 Stimuli

15 sets of minimal triplet sentences were constructed, each containing: (a) a monomoraic noun followed by the particle *mo* ('short/prt' condition), (b) a monomoraic noun without a particle ('short/Ø' condition), and (c) an underlyingly long noun without a particle ('long' condition). A sample set is given in Table 1.

	Condition	Japanese orthography	Transcription	Gloss
(a)	short/prt	木もなくしたよ。	ki mo nakushita yo	tree ALSO lost DISC
(b)	short/Ø	木なくしたよ。	ki nakushita yo	tree lost DISC
(c)	long	キーなくしたよ。	kii nakushita yo	key lost DISC

Table 1: Sample stimulus set from the experiment.

Within each set, the nouns' segmental content was identical, with the exception of vowel length in the long condition and the presence of a case particle in the short/prt condition. We used non-approximant consonants as onsets (if present) in the target nouns to facilitate clear segmentation. Our previous study (Braver and Kawahara, 2014) used the nominative particle *ga*, since it is arguably the default case marker in Japanese subjects (Fukui, 1986; Inoue, 1997). In that study, however, we found that [g] sometimes spirantized, which made the segmentation more difficult. Therefore, in this study, we chose to use the commitative particle *mo* in the short/prt condition in order to facilitate segmentation. We did not include a particle in the long vowel condition, because our main target comparison was between the short/Ø condition and the long condition, and because Mori (2002) had already shown that long nouns are barely affected in duration by the presence/absence of case particles.[3] All three items within a given set had the same predicate to control for any sentence-level duration compensation effects. The predicate always started with a non-approximant consonant to make the segmentation more straightforward. A sentence-final discourse particle [yo] was attached at the end of each sentence to make the stimulus sentences

[3]Due to an error, one stimulus set contained the particle *mo* in the long condition. Even with this set excluded from the data, the results described below still hold. See footnote 4 for further discussion.

more colloquial, thereby further making the absence of case particles more natural. The list of all the stimuli used in this experiment is provided in the appendix.

3.1.2 Participants

Twelve native speakers of Japanese participated in the experiment. They were all undergraduate students at International Christian University (Tokyo, Japan) and were paid ¥500 for their time. Each speaker signed a consent form before participating in the experiment.

3.1.3 Procedure

The recording session took place in a sound-attenuated room at International Christian University. We used Superlab version 4.0 (Cedrus Corporation, 2010) to present the stimuli. The stimuli were written in the standard Japanese orthography, with a mixture of kanji, katakana, and hiragana (see the appendix).

In each block, every stimulus was presented once, and speakers were asked to read the stimuli as they were presented on the screen. The speakers were allowed to take a short break after each block. The order of the stimuli within each block was randomized by Superlab. Each speaker read each sentence a total of 7 times. 30 minutes was allotted for each speaker to complete the experiment.

Before the main session, as practice, each speaker read all the stimuli once to familiarize themselves with the stimuli and the task. After the practice phase, the experimenter (the second author) answered any questions that they had. Their speech was directly recorded onto a portable recorder (TASCAM DR-40) with a 44k sampling rate and a 16 bit quantization level. The second author sat with each speaker throughout the experiment to monitor the progress of the recording.

The duration of each vowel was measured, starting at the offset of the preceding consonant and ending at the end of visible F2/F3, using Praat (Boersma and Weenink, 2009). The offset of a preceding consonant was marked at the onset of periodic energy and visible formant structure. A representative spectrogram is given in Figure 1 to illustrate our segmentation procedure.

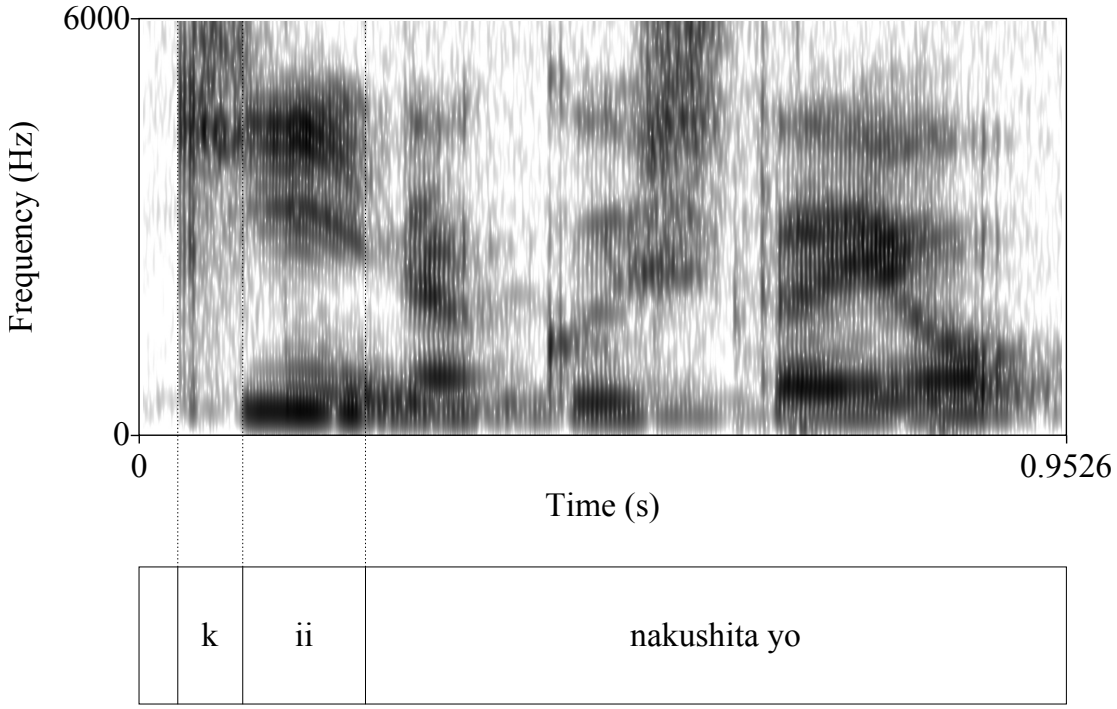


Figure 1: A representative segmented spectrogram. Speaker 43, *kii nakushita yo* (long), repetition 7.

3.1.4 Statistical analysis

Statistical significance was assessed with a linear mixed model (Baayen, 2008) in which vowel duration was regressed against condition (short/prt, short/Ø, long) as a fixed factor and with speaker and item as random factors. Condition was treatment coded to produce comparisons between short/prt vs. short/Ø (to assess whether lengthening occurs) and short/Ø vs. long (to assess whether lengthened nouns are as long as underlyingly long nouns). Since the way to calculate degrees of freedom for these analyses are not yet known (Baayen, 2008), the significance values are calculated by the Markov Chain Monte Carlo method using the `pvals.fnc()` function of the `languageR` package (Baayen, 2009). Of a possible 3,780 tokens (45 stimuli $\times$ 7 repetitions $\times$ 12 speakers), 3,668 tokens were included in the analysis—tokens were excluded if the vocalic boundary was unclear enough to judge duration or if speakers accidentally skipped an item.

3.2 Results

Figure 2 shows the overall results, averaging over all speakers and all items. Comparison between the first two conditions shows that short nouns are lengthened when they appear without case particles and hence are longer than short nouns that appear with particles (mean difference: 69.98 ms, $t = 15.692, p < 0.001$), replicating Mori's (2002) result. Comparison between the last two conditions, however, shows that the lengthened nouns are not as long as underlyingly long nouns (mean difference: 32.47 ms, $t = 7.047, p < 0.001$)[4]. Therefore, the Japanese lengthening pattern instantiates a case of incomplete neutralization.

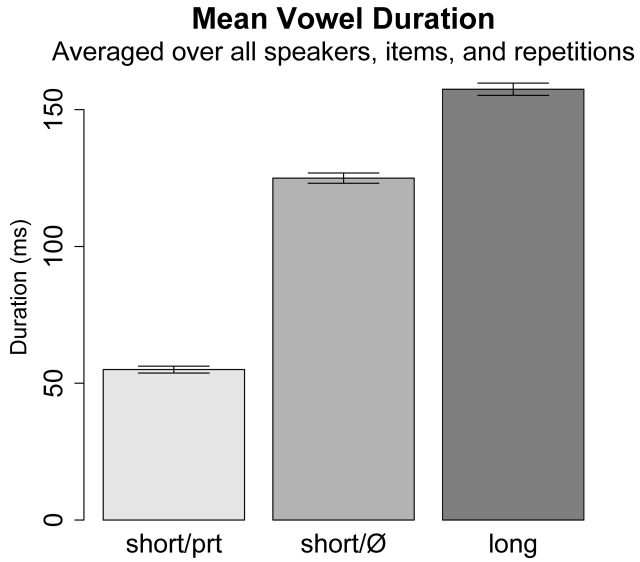


Figure 2: Vowel duration over all speakers and all items.

To investigate whether this tripartite distinction holds across speakers, Figure 3 shows the patterns of all 12 speakers analyzed. We observe that all speakers show incomplete neutralization: lengthened nouns are not as long as underlyingly long nouns for any speaker.

Finally, to investigate the possibility of an item effect, Figure 4 shows a by-item analysis, with results for each of the 15 lexical sets. We again observe that within each set, all short nouns are lengthened without particles, but they are not as long as underlyingly long nouns.

[4]As per footnote 3, one set contained the particle 'mo' in the long condition. While long tokens in this set were on average 16.21 ms longer than in other sets (158.58 ms vs. 142.37 ms), this difference did not affect the overall results. A post-hoc analysis shows that the model remains significant even with the exclusion of this set—short/prt vs. short/Ø: $t = -15.192, p < 0.001$; short/Ø vs. long: $t = -6.847, p < 0.001$.

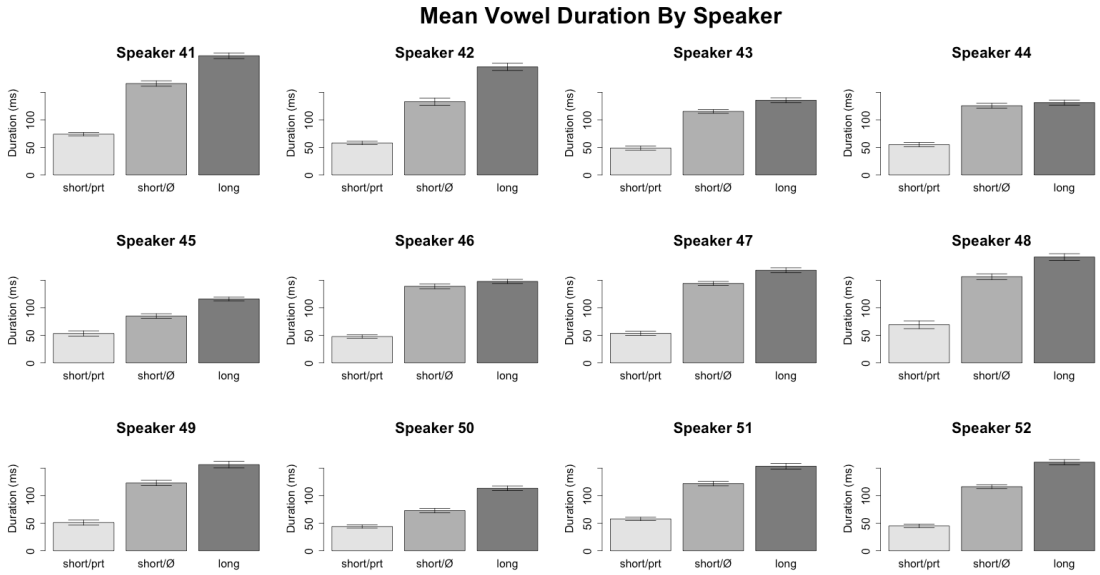


Figure 3: Vowel duration by speaker, averaged across items.

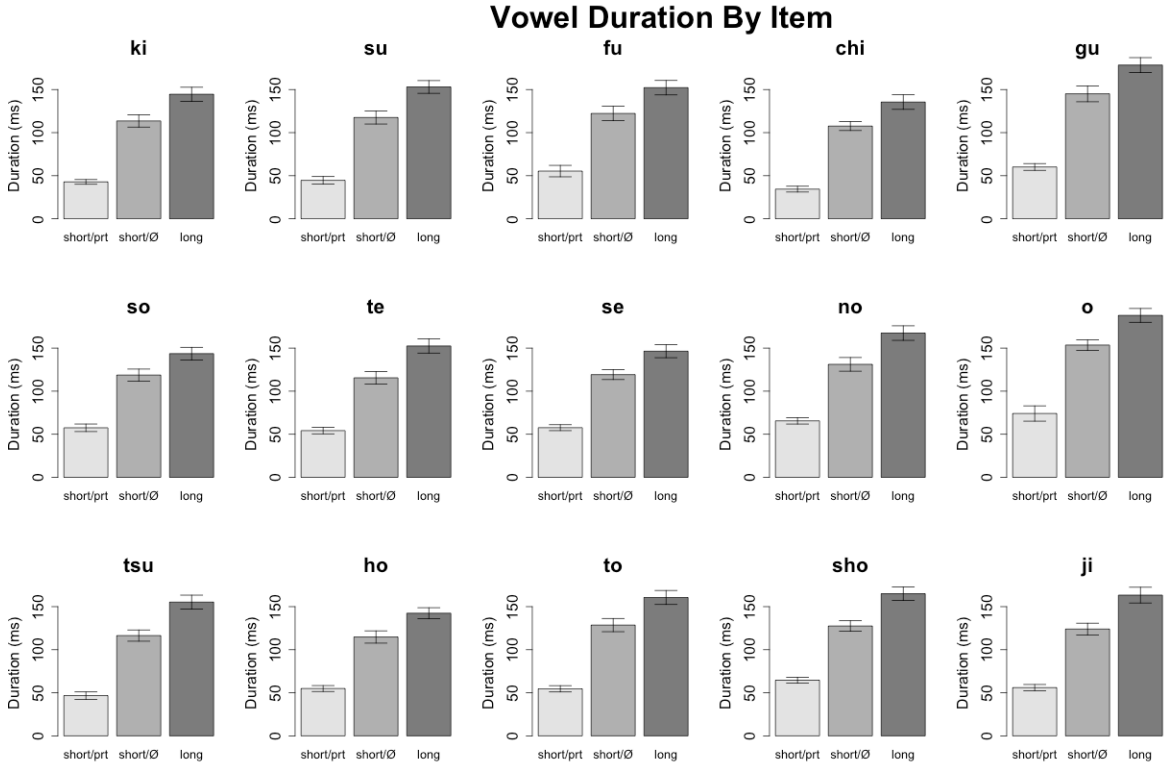


Figure 4: Vowel duration by item, averaged across speakers.

3.3 Discussion

3.3.1 The phonological nature of monomoraic lengthening

In order to establish that a given case of subphonemic distinction is also an instance of phonologically-motivated incomplete neutralization, it must be shown that the phonology treats the two neutralized categories identically, in spite of a phonetic distinction. In the case of monomoraic lengthening, the phonology of Japanese treats both lengthened monomoraic noun and underlyingly bimoraic nouns as both having two moras. This is evident from the fact that lengthened monomoraic nouns can carry a pitch accent within them. In other words, the 'lengthened portion' can carry the L tone of the accentual H*L. The tone bearing unit in Japanese is the mora (Haraguchi, 1977; McCawley, 1977) and thus the lengthened vowels must have two moras.

Figure 5 shows pitch tracks for *ki nakushita yo* (underlyingly monomoraic, but lengthened) and *kii nakushita yo* (underlyingly bimoraic), both from speaker 41; the two figures look almost identical in terms of the shape of the pitch drop. The pitch tracks both demonstrate the H*L tonal pattern associated with Japanese pitch accent on their first syllable. In particular, the L tone of the accentual H*L complex lands on the second mora; in lengthened monomoraic nouns this means that the 'lengthened portion' bears the L tone. Additionally, the fact that the bimoraicity requirement can effect even allomorph selection (a clearly morphological process), as in (3), further suggests that monomoraic lengthening has a phonological basis.

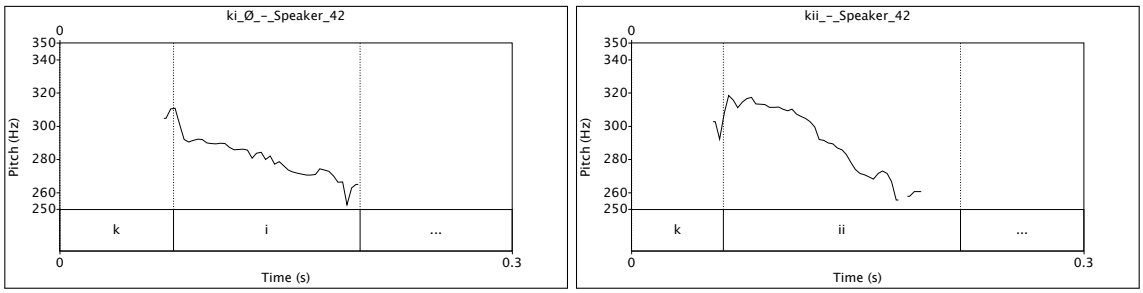


Figure 5: Pitch tracks for stimuli *ki*∼*kii* from speaker 42. Both lengthened *ki* (left) and underlyingly long *kii* (right) bear an L tone.

3.3.2 Looking deeper into the data

We first take a deeper look at the data, discussing some aspects of our stimulus sets and our results.

3.3.2.1 Distribution of conditions within each speaker One might argue that this case of incomplete neutralization derives from optional application of vowel lengthening. If speakers apply lengthening of short/Ø nouns optionally, they would produce both short and long nouns in the short/Ø condition—averaging over these tokens would result in an intermediate duration between the short/prt and long conditions, thus creating the illusion of incomplete neutralization. To address this possibility, Figure 6 provides histograms of each condition for each speaker. This alternative hypothesis predicts that lengthened nouns should show a bimodal distribution—one portion of the short/Ø tokens overlapping with the short/prt condition and the other portion overlapping with the long condition.

We observe that, contrary to the hypothesis entertained above, lengthened nouns have a unimodal distribution which is intermediate between the short condition distribution and the long condition distribution.

3.3.2.2 Orthographic diphthongs According to Japanese writing convention, some long vowels are represented as 'orthographic diphthongs' when spelled out in the hiragana syllabary. For example, *nou* [noo] 'brain' would be written in hiragana as 'のう' (no + u). Some long vowels in our experiment, had they been written in hiragana, would have been rendered this way (e.g., *nou* as above, and *tei* [tee] 'base' as 'ていい' (te + i)); none of the long target stimuli were written in this manner in the current experiment. These orthographic diphthongs are generally pronounced as long vowels (Labrune 2012; see Vance 2008, pp. 63–68 for discussion), and thus were not expected to be a confound. Moreover, recall from Figure 4 that the tripartite incomplete neutralization holds for all lexical sets—only some of which would have had orthographic diphthongs had they been written in hiragana. Incomplete neutralization holds in both the 7 sets where orthographic diphthongs would have been present had we used hiragana for the long nouns, as well as in the 8 remaining sets where the writing system did not call for orthographic diphthongs (see Table

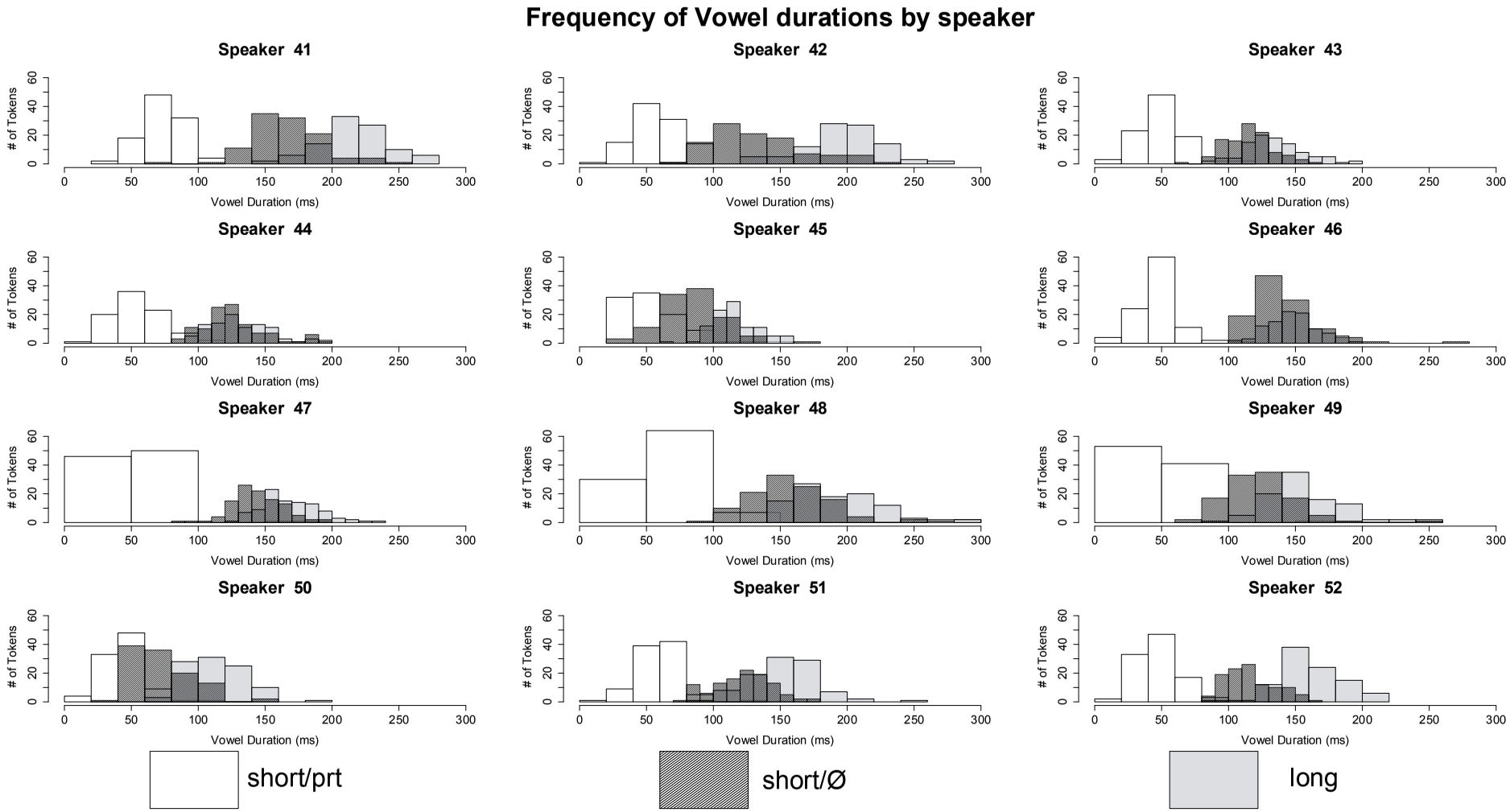


Figure 6: Distribution of vowel duration by condition, for each speaker.

2).

		Duration		Difference		
Orthographic diphthong sets ($n = 3$)	short/prt:	60.53ms	}	66.59ms	$t = -8.06$,	$p < 0.001$
	short/Ø:	127.13ms	}	32.66ms	$t = 3.87$,	$p < 0.01$
	long:	159.78ms				
Non-orthographic diphthong sets ($n = 12$)	short/prt:	51.12ms	}	73.91ms	$t = -13.89$,	$p < 0.001$
	short/Ø:	124.03ms	}	31.67ms	$t = 5.78$,	$p < 0.001$
	long:	155.70ms				

Table 2: Results from sets with orthographic diphthongs in the long condition, and those without.

3.3.2.3 Orthographic length marks In addition to the use of orthographic diphthongs, Japanese orthography employs a length mark (ー) in the katakana syllabary to indicate long vowels (e.g. キー (ki + length mark) *kii* 'key'). This creates a possible complication in the experiment: perhaps speakers produced long tokens with an orthographic length mark even longer than they would produce long tokens without this length mark. In this scenario, the extra lengthening of long tokens due to length marks essentially 'moves the goalposts' such that lengthened short vowels appear to miss the target for long vowels. Of the 12 stimulus sets, three employed a length mark in the long condition. The model remains significant after removing these sets, as shown in Table 3.

		Duration		Difference		
Orthographic length mark sets ($n = 3$)	short/prt:	49.19ms	}	80.96ms	$t = -7.03$,	$p < 0.001$
	short/Ø:	130.14ms	}	35.66ms	$t = 2.71$,	$p < 0.05$
	long:	165.80ms				
Non-orthographic length mark sets ($n = 12$)	short/prt:	56.45ms	}	66.77ms	$t = -13.71$,	$p < 0.001$
	short/Ø:	123.23ms	}	32.83ms	$t = 6.62$,	$p < 0.001$
	long:	156.06ms				

Table 3: Results from sets with orthographic length marks in the long condition, and those without.

3.3.2.4 Accent mismatches Finally in some sets, short nouns and long nouns differ in accent (e.g., *fu* is unaccented while *fu'u* is accented) (see the appendix). However, since the effect of

accent on Japanese vowel duration is minute (8% increase in Hoequist 1983) and 12 out 15 sets are controlled in terms of their accentuation, our finding of a durational difference between lengthened nouns and long nouns cannot be attributed to accentual differences. Recall again that the tripartite incomplete neutralization holds in all sets, regardless of whether the short nouns and long nouns agree in accent. Incomplete neutralization holds in the 3 sets with accent mismatches, as well as in the 12 sets with no such mismatch (see Table 4).

		Duration		Difference		
Accent mismatch sets ($n = 3$)	short/prt:	50.19ms	}	74.79ms	$t = 2.03$,	$p < 0.05$
	short/Ø:	124.98ms	}	30.39ms	$t = 5.08$,	$p < 0.001$
	long:	155.37ms				
Non-accent mismatch sets ($n = 12$)	short/prt:	56.12ms	}	68.86ms	$t = 6.90$,	$p < 0.001$
	short/Ø:	124.98ms	}	33.05ms	$t = 14.91$,	$p < 0.001$
	long:	158.03ms				

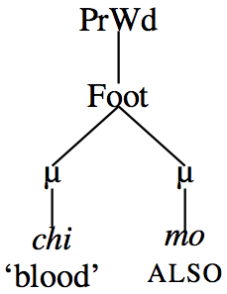
Table 4: Results from sets containing accent mismatches, and those without accent mismatches.

4 Conclusion

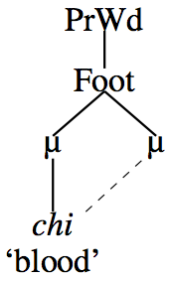
4.1 General implications

The current results suggest that the short/long vowel length distinction in Japanese is incompletely neutralized when monomoraic nouns without case particles are lengthened: these lengthened nouns must have two moras on the surface to meet the Japanese bimoraicity requirement (Itô, 1990; Poser, 1990; Mester, 1990; Itô and Mester, 1992; Mori, 2002), yet their vowel durations are intermediate between those of underlyingly short and underlyingly long vowels. As an example, take the set given in (6). Since *chi mo* (short/prt), in (6a), and *chii* (long), in (6c), both have two underlying moras within their Prosodic Word, no lengthening occurs in these conditions. In order to meet the bimoraicity requirement, *chi* (short/Ø), in (6b) must link to a second additional mora, since there is no other available underlying segmental content. This study shows, however, that lengthened vowels like those in (6b), are not as long as underlyingly long vowels, like those in (6c).

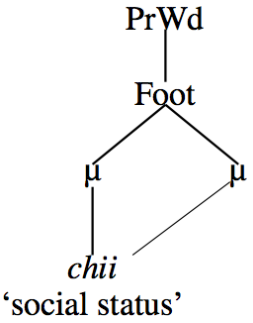
(6) (a) short/prt



(b) short/Ø



(c) long



Having established that the Japanese case is indeed a case of incomplete neutralization, some remarks on general theoretical implications are in order. First the current results expand the typology of processes that can lead to incompletely neutralized contrasts to include not just processes at the segment- and feature-level, but also processes motivated by suprasegmental structure.

Second, since the lengthening is triggered by a clearly phonological constraint, it cannot be treated as a matter of phonetic implementation—unlike a number of proposed cases of incomplete neutralization. For example, Ohala (1974) and Fourakis and Port (1986) treat the case of intrusive stops in English as a matter of phonetic implementation. Similarly, Davidson (2006) treats [ə]-insertion in English speakers' pronunciation of non-native clusters, which results in an apparent case of incomplete neutralization, as resulting from gestural mis-coordination. If the phenomenon in question is a matter of phonetic implementation, it is not strictly speaking a case of incomplete neutralization, as two segments are not neutralized phonologically. In order to prove that a case of a subphonemic distinction is phonological, and not due purely to phonetic factors, it must be shown that phonology treats the two neutralized categories identically (Barnes, 2006, p. 229).

In the current case lengthening is motivated by a clearly phonological, rather than phonetic, bimoraic minimality constraint in Japanese. The constraint is deeply tied into the morphophonology of Japanese, as it governs many Japanese morphophonological patterns (Itô, 1990; Poser, 1990; Mester, 1990; Itô and Mester, 1992; Mori, 2002)—including allomorph selection, as in (3b). Further, the underlyingly monomoraic nouns, when lengthened, can carry a pitch accent, as discussed in §3.3.1. We thus conclude that lengthening is phonological, as it is triggered by a phonological

constraint. Since both lengthened and underlyingly bimoraic nouns are treated as bimoraic by the phonology of Japanese, the case of monomoraic noun lengthening constitutes counterevidence to the view that all incomplete neutralization patterns are phonetic in nature (Barnes, 2006, p. 229).

4.2 Final remarks

We conclude with two brief remarks. First, we note that the typology of processes susceptible to incomplete neutralization must be expanded to include processes—like monomoraic noun lengthening—that affect a contrast of length or prosodic structure. Second, incomplete neutralization—at least in this case—cannot be reduced to a question of phonetic implementation (cf. Barnes, 2006). Rather, the phonology must play a role by allowing phonetics to distinguish two phonologically neutralized segments.

Appendix: Stimuli from Experiment

Japanese orthography	Transcription	Gloss
木もなくしたよ。	**ki'** mo nakushita yo	tree ALSO lost DISC
木なくしたよ。	**ki'** nakushita yo	tree lost DISC
キーなくしたよ。	**ki'i** nakushita yo	key lost DISC
酢も見つけたよ。	**su'** mo mitsuketa yo	vinegar ALSO found DISC
酢見つけたよ。	**su'** mitsuketa yo	vinegar found DISC
スー見つけたよ。	**su'u** mitsuketa yo	Sue found DISC
麩も残したよ。	**fu** mo nokoshita yo	gluten ALSO left DISC
麩残したよ。	**fu** nokoshita yo	gluten left DISC
封残したよ。	**fu'u** nokoshita yo	seal left DISC
血も捧げたよ。	**chi** mo sasageta yo	blood ALSO dedicated DISC
血捧げたよ。	**chi** sasageta yo	blood dedicated DISC
地位捧げたよ。	**chi'i** sasageta yo	social.status dedicated DISC

(continued...)

Japanese orthography	Transcription	Gloss
具も出したよ。	**gu** mo dashita yo	ingredients ALSO gave DISC
具出したよ。	**gu** dashita yo	ingredients gave DISC
グー出したよ。	**gu'u** dashita yo	fist gave DISC
ソも確かめたよ。	**so'** mo tashikameta yo	so ALSO confirmed DISC
ソ確かめたよ。	**so'** tashikameta yo	so confirmed DISC
層確かめたよ。	**so'u** [soo] tashikameta yo	layer confirmed DISC
手も測ったよ。	**te'** mo hakatta yo	hand ALSO measured DISC
手測ったよ。	**te'** hakatta yo	hand measured DISC
低測ったよ。	**te'i** [tee] hakatta yo	base measured DISC
背も違うよ。	**se'** mo chigau yo	height ALSO is-different DISC
背違うよ。	**se'** chigau yo	height is-different DISC
性違うよ。	**se'i** [see] chigau yo	gender is-different DISC
野も持ってるよ。	**no'** mo motteru yo	field ALSO have DISC
野持ってるよ。	**no'** motteru yo	field have DISC
脳持ってるよ。	**no'u** [noo] motteru yo	brain have DISC
尾も出てきたよ。	**o'** mo detekita yo	tail ALSO appeared DISC
尾出てきたよ。	**o'** detekita yo	tail appeared DISC
王出てきたよ。	**o'u** detekita yo	king appeared DISC
津も買収したよ	**tsu'** mo baishuushita yo	Tsu ALSO bought/bought.off DISC
津買収したよ	**tsu'** baishuushita yo	Tsu bought/bought.off DISC
通買収したよ。	**tsu'u** baishuushita yo	expert bought/bought.off DISC
帆も叩いたよ。	**ho'** mo tataita yo	sail ALSO hit DISC
帆叩いたよ。	**ho'** tataita yo	sail hit DISC
ほおも叩いたよ。	**ho'o** (mo)[5] tataita yo	cheek hit DISC
都も独占したよ。	**to'** mo dokusenshita yo	city ALSO monopolized DISC
都独占したよ。	**to'** dokusenshita yo	city monopolized DISC
塔独占したよ。	**to'u** [too] dokusenshita yo	tower monopolized DISC
書も独占したよ。	**sho'** mo dokusenshita yo	book ALSO monopolized DISC
書独占したよ。	**sho'** dokusenshita yo	book monopolized DISC
章独占したよ。	**sho'u** [ʃoo] dokusenshita yo	chapter monopolized DISC

(continued...)

Japanese orthography	Transcription	Gloss
字も公開したよ。	**ji'** mo koukaishita yo	letter ALSO publicized DISC
字公開したよ。	**ji'** koukaishita yo	letter publicized DISC
爺公開したよ。	**ji'i** koukaishita yo	grandpa publicized DISC

All stimulus sets from the Experiment. Target nouns are in boldface. Accents, represented with an apostrophe following the accented syllable, are shown for target nouns only.

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[5] In the long condition of *ho'*/*ho'o*, the particle *mo* was included by mistake. See footnotes 3 and 4 for discussion.

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