Incomplete Vowel Lengthening in Japanese: A First Study

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1. Introduction

1.1. Synopsis

Many phonetic studies have investigated cases of incomplete neutralization, where contrasts that are seemingly neutralized phonologically nevertheless leave some phonetic distinctions. The majority of this previous work, however, focuses on the case of final devoicing in different languages. Building on this body of the literature (see Braver 2013 for an overview), this paper offers a new case study of incomplete neutralization: the phenomenon of monomoraic vowel lengthening in Japanese. Japanese phonology requires prosodic words to be minimally bimoraic (i.e., one foot) (e.g., Poser, 1990; Itô, 1990; Itô & Mester, 1992)—a requirement which is responsible for shaping many morphophonological patterns. Because of this prosodic restriction, Japanese monomoraic nouns, when produced in isolation, are lengthened (Mori, 2002). Our experiment shows that, despite this phonological lengthening, the contrast between lengthened monomoraic nouns and underlyingly long nouns is not completely neutralized at the surface phonetic level. This study thus contributes to expanding the typology of incomplete neutralization.

1.2. Theoretical background

Incomplete neutralization refers to cases in which two underlyingly distinct segments become nearly—but not completely—identical. In other words, even when the contrast seems neutralized phonologically, some small trace of the underlying distinction is manifested on the surface in terms of fine phonetic details, in the direction of the canonical realization of the contrast. For example, in German coda devoicing, coda voiced stops seem to neutralize to voiceless stops by way of devoicing. However, this neutralization is actually incomplete. In a classical work on incomplete neutralization, Port and O'Dell (1985) found that (i) vowels before devoiced stops are, on average, 15ms longer than those before underlyingly voiceless stops; (ii) aspiration is shorter by 15ms in devoiced stops (iii) voicing into closure is longer for devoiced stops by about 5ms; (iv) closure duration is marginally shorter in devoiced stops. In these senses, "devoiced" stops seem to inherit some acoustic correlates of voiced stops in their canonical realization (in pre-vocalic position). More plainly put, devoiced stops do not become as voiceless as underlyingly voiceless stops.

Many cases of incomplete neutralization that have been studied in the previous literature since Port and O'Dell (1985) involve final devoicing in other languages in addition to German: Catalan (Dinnsen & Charles-Luce, 1984), Polish (Slowiaczek & Dinnsen, 1985; Slowiaczek & Szymanska, 1989), Russian (Dmitrieva, 2005) and Dutch (Warner et al., 2004), among others. Although there are some other cases of incomplete neutralization that have been studied instrumentally, such as epenthesis in Levantine Arabic (Gouskova & Hall, 2009) and flapping in English (Braver, 2013), it is still unclear which phonological

*We call this version "a first study", as we report a follow-up study in Braver & Kawahara (2012). Thanks are due to the participants in our experiments, as well as the undergraduate lab assistants at the Rutgers Phonetics Laboratory who participated in this research: Christopher Kish, Sarah Korostoff, Megan Moran, and Jessica Trombetta. We also thank Professors Tomo Yoshida and Shin-ichiroo Sano for their help in making arrangements for recording at International Christian University, and the audience at the May 2012 meeting of the Tokyo Circle of Phonologists and WCCFL 31 for their helpful comments. This project was supported in part by a JICUF Visiting Scholarship fund to the second author.

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processes can result in incomplete neutralization, and which processes cannot (cf. Kim & Jongman 1996); nor, relatedly, is it clear how widespread incomplete neutralization is given a wide range of phonological processes that we observe in natural languages (see Braver 2013 for a more detailed review). The first aim of this paper is therefore to expand the typology of incomplete neutralization by studying a case of neutralization of short-long contrasts in Japanese vowels.

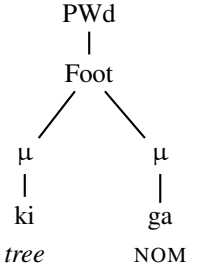
Another point that we would like to make in this study is that although some cases of incomplete neutralization can be relegated to the phonetic component, our current case cannot be. Some contrasts that are purportedly incompletely neutralized may not actually be neutralized in phonology, but are instead neutralized in phonetics, and hence incomplete because of the gradient nature of the phonetic component. English nasal-fricative intrusive stop (as in, e.g., *prin[t]ce* 'prince'), for example, may be an example of this kind (Fourakis & Port, 1986; Ohala, 1974). Schwa deletion in English and French, which are arguably incomplete, may be treated the same way (Davidson, 2006; Fougeron & Steriade, 1997). We argue in this paper that the lengthening in Japanese that we study is phonological in nature, and thus cannot be relegated as a matter of phonetic implementation.

1.3. The bimoraicity requirement and lengthening in Japanese phonology

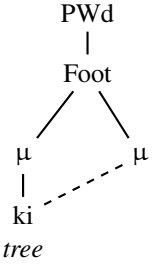
The empirical focus of this study is lengthening of vowels in monomoraic nouns in Japanese. First, it should be noted that Japanese shows a number of morphophonological alternations that are based on bimoraic feet (Poser, 1990; Itô, 1990) (where vowels and coda consonants count as one mora each). For example, many truncation patterns result in bimoraic forms; the English borrowing [demonsutoreeshon] 'demonstration' and [rihaasaru] 'rehearsal' get shortened to [demo] and [riha], respectively, but not any shorter. This bimoraicity requirement has been taken as evidence that Japanese has a word minimality requirement, which requires that a prosodic word should contain a bimoraic foot (Itô, 1990; Itô & Mester, 1992). In fact, there is evidence for the bimoraicity requirement from lengthening too—monomoraic "day" nouns (e.g. [ka] in [kayoobi] 'Tuesday' and [do] in [doyoobi] 'Saturday') become long and bimoraic when used in compounding (e.g. [kaa-doo] 'Tuesday and Saturday') (Itô, 1990).

In spite of the preference for bimoraicity, some Japanese lexical nouns are monomoraic (e.g., [me] 'eye' and [ki] 'tree') (Itô, 1990). These short nouns usually do not violate the bimoraicity requirement in actual utterances, because a case particle provides the second mora necessary to form a bimoraic foot, as in illustrated in (1-a).

(1) a.



b.



In colloquial speech, however, these case particles can sometimes be dropped; e.g. [me-Ø akai-yo] from [me-ga akai-yo] '(Your) eyes are red' (the example is from Mori 2002). Mori (2002) shows that monomoraic nouns without particles undergo lengthening: monomoraic nouns not followed by a case particle or a pause are 40–50% longer than monomoraic nouns that are followed by a case particle. This lengthening occurs in order to satisfy the bimoraic minimality requirement, as in (1-b).

However, previous phonetic studies show that bimoraic syllables in Japanese are generally 66–80% longer than monomoraic syllables (Beckman, 1982; Hoequist, 1983). Given that lengthened monomoraic nouns are only 40–50% longer in Mori's (2002) study, this case of lengthening may instantiate a case of incomplete neutralization. Mori (2002) makes this point explicitly (pp. 704–705), but her experiment does not include underlyingly long nouns to directly test this incompletely neutralizing aspect of lengthening—our experiment thus sets out to do so.

2. Method

2.1. Stimuli

The stimuli consisted of eleven sets of three sentences containing either: (i) a monomoraic noun with a particle ('short/prt'); (ii) a monomoraic noun without a particle ('short/Ø'); (iii) an underlyingly long noun ('long'), as exemplified in (2). The hypothesis was that monomoraic nouns without a particle undergo lengthening, but that they do not become as long as underlyingly long nouns. Nouns within each set had the same segmental content. We did not include sentences with long nouns without particles (with the exception of the first set in Table 1), because Mori (2002) did not find lengthening in long nouns. Table 1 shows the list of whole stimuli.

(2) A sample triplet

a.	short/Ø			b.	short/prt			c.	long		
	麸	が	すばらしい。		麸	Ø	すばらしい。		封	が	とれた。
	fu	ga	subarashii		fu	Ø	subarashii		fuu	ga	toreta
	gluten	NOM	excellent		gluten	Ø	excellent		seal	NOM	came

A few remarks are in order about our stimuli, which we will come back to in more detail in section 4.2. Japanese accents are lexically contrastive (Kawahara, to appear), but accent was controlled in 9 of the 11 sets. In the long condition, long vowels were orthographically indicated by either (a) kanji alone, or (b) kana with a length mark (ー). Some morphemes written with kanji, had they been written in hiragana, would have been written as diphthongs. They are generally pronounced as long monophthongs (see Vance, 2008:63-68, for discussion).

2.2. Participants

Participants were seven female native speakers of Japanese. They were undergraduate and graduate students at Japanese universities. One speaker was excluded from analyses since she explicitly informed us that she noticed the lengthening phenomenon during the recording. The remaining six speakers were all from the Kanto area (near Tokyo).

2.3. Recording

The recording took place in a sound-attenuated room at International Christian University (Tokyo, Japan), using a TASCAM DR-40 recorder, with a 44.1kHz sampling rate. SuperLab (ver. 4, Cedrus Corporation, 2010) was used to present the stimuli. Speakers practiced all items once to ensure that they read kanji as intended. Each speaker read all thirty-three sentences in random order. The sentences were re-randomized, and the speaker re-read the sentences. Each speaker read each sentence a total of ten times. Speakers were instructed not to pause mid-sentence, in order to prevent them from inserting a pause or glottal stop rather than lengthening for the short/Ø condition.

2.4. Acoustic measurements

For each token, vowel duration of the target noun was measured. Segmental boundaries were placed where F2 and/or F3 disappear or significantly weaken. A sample spectrogram in Figure 1 illustrates the segmentation procedure.

2.5. Statistical analysis

A linear mixed model was run using the `lme4` package (Bates & Maechler, 2009) in R (R Development Core Team, 2009). Vowel duration was regressed against phonological length (short/lengthened/underlyingly long) as a fixed factor, and speaker and item as random factors. Phonological length was treatment coded, to produce comparisons between short vs. lengthened nouns, and lengthened vs. underlyingly long nouns.

Japanese orthography	Transcription	Gloss
木が倒れた。	*ki'* ga taoreta	tree NOM fell
木倒れた。	*ki'* taoreta	tree fell
キー見つかった?	*ki'i* mitsukatta	key found
菜が煮えた。	*na'* ga nieta	vegetable NOM cooked
菜煮えた。	*na'* nieta	vegetable cooked
「なー」と言われた。	*na'a* to iwareta	DISC COMP was.said
火が消えた。	*hi'* ga kieta	fire NOM went.out
火消えた。	*hi'* kieta	fire went.out
「ひー」と叫んだ。	*hi'i* to sakenda	INTERJ COMP shouted
酢がない。	*su'* ga nai	vinegar NOM NEG
酢ない。	*su'* nai	vinegar NEG
スーが見つからない。	*su'u* ga mitsukara nai	Sue NOM found NEG
背がのびた。	*se'* ga nobita	spine NOM stretched
背のびた。	*se'* nobita	spine stretched
正の整数。	*se'i* no seisuu	positive MOD integer
血がでた。	*chi* ga deta	blood NOM went.out
血でた。	*chi* deta	blood went.out
地位がある。	*chi'i* ga aru	social.status NOM have
手がしびれた。	*te'* ga shibireta	hand NOM became.numb
手しびれた。	*te'* shibireta	hand became.numb
低の長さ。	*te'i* no nagasa	base.of.shape MOD length
戸が壊れた。	*to* ga kowareta	door NOM broke
戸壊れた。	*to* kowareta	door broke
「とー」と叫んだ。	*to'o* to sakenda	INTERJ COMP shouted
根がぬけた。	*ne'* ga nuketa	root NOM pulled.out
根ぬけた。	*ne'* nuketa	root pulled.out
「ねー」と言われた。	*ne'e* to iwareta	DISC COMP was.said
麩がすばらしい。	*fu'* ga subarashii	gluten NOM excellent
麩すばらしい。	*fu'* subarashii	gluten excellent
封がとれた。	*fu'u* ga toreta	seal NOM came.off
目が腫れた。	*me'* ga hareta	eye NOM swelled
目腫れた。	*me'* hareta	eye swelled
「メー」と鳴いた	*me'e* to naita	"baa (sheep sound)" COMP made.animal.sound

Table 1: Full stimulus list. Apostrophes represent lexical HL pitch accent.

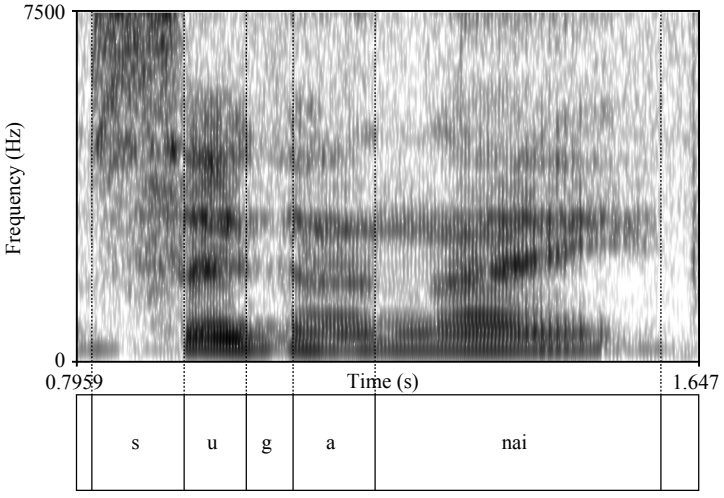


Figure 1: Sample spectrogram, Speaker 14, 酢がない (su ga nai), repetition 9

3. Results

Figure 2 illustrates the general results.

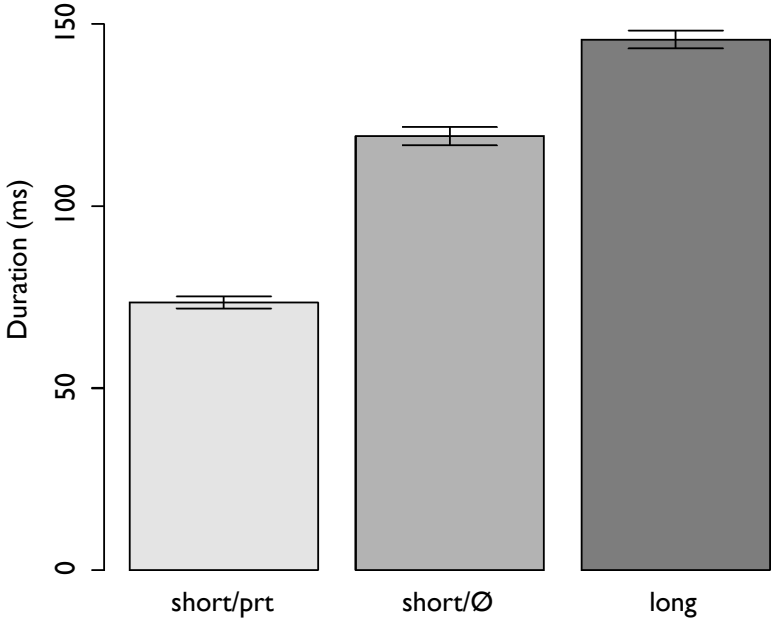


Figure 2: Mean vowel duration by condition, for all speakers and all items.

On average, short nouns with a particle were 73.5ms, short nouns without a particle were 119.2ms, and underlyingly long nouns were 145.7ms. These results show that short nouns lengthen without case particles ($t = -8.018, p < 0.001$), but they do not become as long as underlyingly long nouns ($t = 1.369, p < 0.05$).[1] Figures 3 and 4 show that this tripartite distinction among the short, lengthened and long conditions holds across all the stimulus sets and all speakers we studied in this experiment.

[1]The effect size may seem small, despite the fact that the mean difference in raw duration is 26.6ms. A post-hoc t-test confirms the significance of the lengthened vs. long vowel length distinction ($t(1278.99) = -14.90, p < 0.001$).

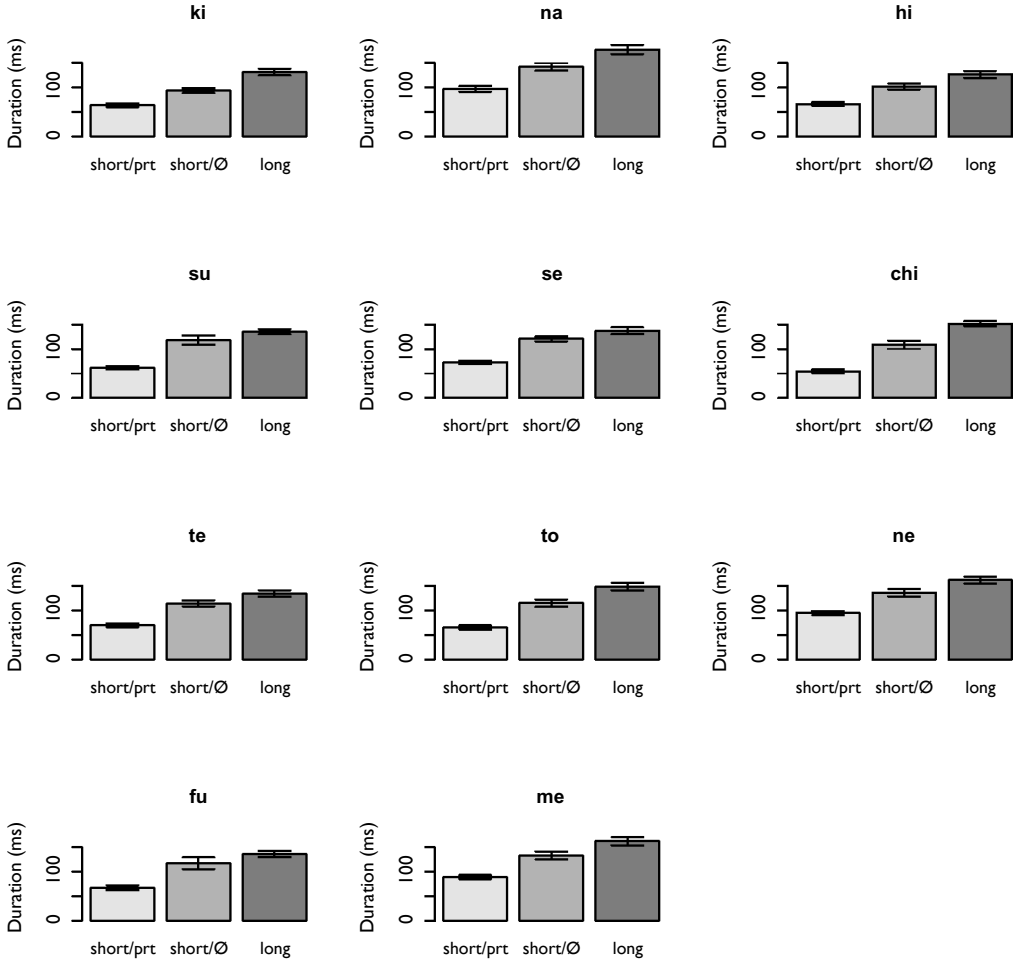


Figure 3: Mean vowel duration by condition, for each stimulus set.

Before we conclude that the Japanese monomoraic lengthening pattern instantiates a novel type of incomplete neutralization, we consider one alternative possibility. That is, if in the short/Ø condition, our current participants did not lengthen some short nouns at all and also *completely* neutralized some short nouns, we might have obtained the above results, even if they did not incompletely neutralize: we can get intermediate values by averaging short and long values. If that were the case, the vowel durations in the short/Ø condition would show a bimodal distribution, one peak overlapping with the short condition and the other peak overlapping with the long condition. Figure 5 presents histograms to address this possibility.

We observe that lengthened nouns are uni-modal, distributing between the short condition and the long condition. We thus conclude that the Japanese lengthening is a genuine case of incomplete neutralization.

4. Discussion

4.1. A new case for phonological incomplete neutralization

Monomoraic nouns in Japanese become longer when they appear in isolation, in order to satisfy the bimoraicity requirement. However, the lengthened nouns do not become as long as underlying long

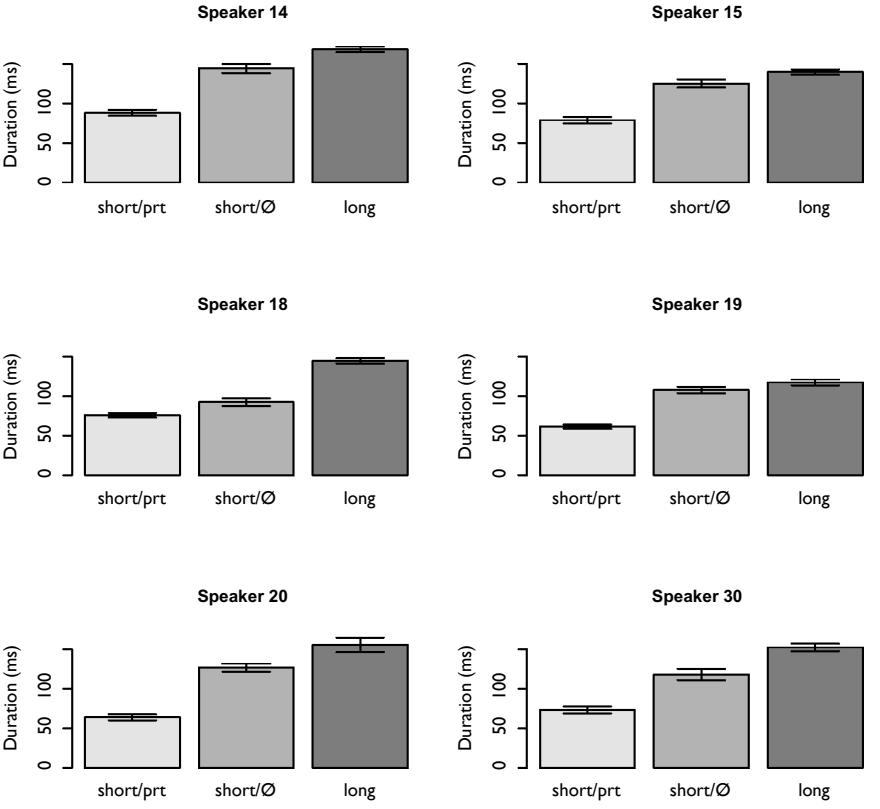


Figure 4: Mean vowel duration by condition, for each speaker.

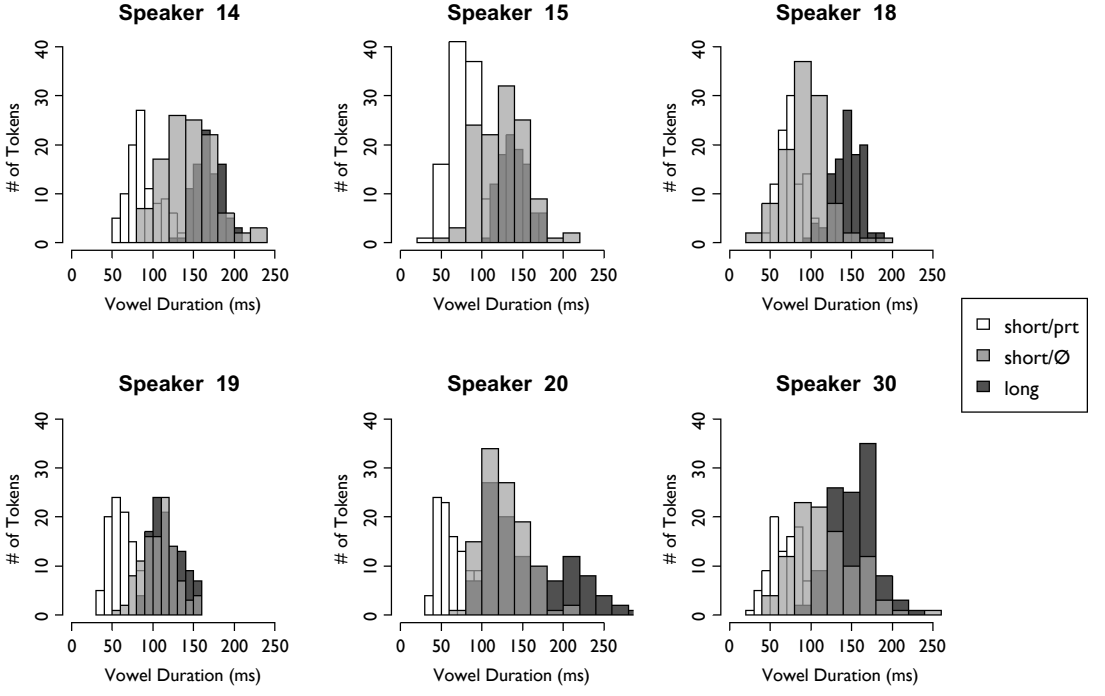


Figure 5: Histograms of vowel duration for each speaker.

nouns.[2] These results hold for all eleven triplets tested, across all six speakers. The lengthening of monomoraic nouns in Japanese is incompletely neutralizing. While we might have expected lengthened nouns to become identical to underlyingly long nouns, a trace of their underlying phonological length is apparent on the surface; i.e. lengthened nouns have a trace of their underlying phonological shortness—they are shorter than underlyingly long nouns.

The lengthening pattern cannot be relegated as a matter of phonetic implementation. The lengthening is motivated by a prosodic bimoraic word minimality requirement, which interacts with many morphophonological patterns (Poser, 1990; Itô, 1990) which yield many new morphologically derived words. In fact, Ito (1990) argues that the bimoraicity holds only in morphologically derived environments, suggesting that the prosodic bimoraicity requirement exists "deep" in Japanese phonology. We therefore maintain that this case of incomplete neutralization cannot be relegated as a matter of a phonetic implementation rule.[3]

4.2. Discussion of the current stimuli

Although we believe that the current experiment demonstrates that the Japanese monomoraic lengthening pattern is a solid case of incomplete neutralization, there are some details of the stimuli that may merit some discussion.

First, we discuss the effect of accentuation. Hoequist (1983) finds a small effect of pitch on syllable duration in Japanese (high pitch:low pitch = 1.08:1). For comparison, the results of the current experiment show that the overall long:short/Ø ratio = 1.22:1, and in the two accent mismatched sets this same ratio was 1.35:1. Given the small effect size found by Hoequist, the small difference in long vowel duration between accent matched and accent mismatched sets, and the consistent pattern across all lexical sets, we argue that the accent-mismatched sets are legitimate evidence.

Second, some stimuli in the long condition, had they been written in hiragana, would have been written as diphthongs. (Note that no stimuli were written in this way—all such stimuli were represented by kanji in the actual experiment.) For example, *sei* 'positive', was written with the kanji 「背」, however, had it been written in hiragana, it would have been rendered as 「せい」 (se+i). In any event, *sei* is pronounced [se:]. For ease of exposition, we refer to 'diphthong sets' and 'non-diphthong sets' to distinguish those sets containing long vowels that could have been written with orthographic diphthongs—even though no actual diphthongs (orthographic or pronounced) were involved in any of the sets.

Diphthong sets had long vowels, on average, 15.25 ms shorter than long vowels in non-diphthong sets (non-diphthong sets: 148.21 ms, diphthong sets: 132.87 ms, $t(154.93) = 4.42, p < 0.001$). Given that long vowels in diphthong sets were shorter, we might expect that in these sets, the short/Ø vowels (which do not have even the hypothetical potential for diphthongization, and therefore should not have depressed duration) would be as long as the depressed long vowels. In other words, in the diphthong sets, the depressed vowel duration in the long condition might lead to the appearance of complete neutralization, since the lengthening short/Ø vowels have less duration to make up to meet that of the long vowels. In spite of these facts, there is still a distinction between short/Ø vowels and long vowels in these diphthong sets (short/: 122.31 ms, long: 132.87 ms, $t(198.95) =, p < 0.01$).

As a final consideration, 5 of the 11 long nouns were quoted expressives or interjections (see Table 1). Quoted long vowels were on average 18.42 ms longer than non-quoted ones (quoted: 155.48 ms, non-quoted: 137.06 ms, $t(516.365) = -7.55, p < 0.001$). It is conceivable that the difference

[2] We note that some other languages seem to show a distinction between lengthened short vowels and long vowels (e.g., Chickasaw (Gordon et al., 2000; Gordon & Munro, 2007), St. Lawrence Island Yupik (Hayes 1995:241, Leer 1985, Krauss 1975), Swedish (Hayes 1995:84, Bruce 1984), Wargamay (Hayes, 1995::84), Tongan (Hayes, 1995::84)). Such cases, however, tend to result from stress, domain-final lengthening, or other processes that are otherwise known to have gradient implementation. As argued in this section, monomoraic noun lengthening in Japanese has its roots in a "deeply" phonological process and is therefore not susceptible to this analysis.

[3] We are making a more or less standard assumption that phonetics does not affect morphological word formation patterns (i.e., there are no morphological patterns that are sensitive to raw phonetic properties). Given this assumption, since the bimoraicity constraint governs many morphological processes, it must be phonological rather than phonetic. See also Cohn (1998) for arguments that the English minimal word requirement is based on abstract, phonological lengths rather than on raw phonetic duration.

between short/Ø and long vowel durations in the quoted sets is partly attributable to the apparent lengthening effect of quotation.

However, we argue that this is not the case. All vowels in the quoted sets—not just long vowels—are longer than vowels in the non-quoted sets. (Quoted short/prt: 83.17 ms, non-quoted short/prt: 65.26 ms, difference: 17.91 ms, $t(492.702) = -11.56, p < 0.001$). This suggests that something about the quoted sets—which pertains to both the short/prt and the long vowels—is increasing their duration for a reason that is not clear to us. Under the hypothesis that quotation itself was causing this durational difference, we would expect only long vowels to be impacted, since only long vowels were quoted in these sets.[4]

It should also be noted that the main results from this experiment still hold if the quoted sets are removed from the data. Lengthening occurs (short/Ø vowels are longer than short/prt vowels, mean difference: 48.84 ms, $t = -9.68, p < 0.001$) and neutralization is incomplete (short/Ø vowels are not as long as underlyingly long vowels, mean difference: 22.98 ms, $t = 2.50, p < 0.05$).

While we believe based on our discussion here that none of these three factors are an actual confound, we nevertheless designed a follow-up study with a larger set of better-controlled stimuli, which we report in Braver & Kawahara (2012).

4.3. Final summary

In Japanese, monomoraic nouns become longer when they appear in isolation in order to satisfy the bimoraic minimality requirement. The lengthened vowels, however, do not become as long as underlying long vowels. This tripartite distinction does not arise from averaging over the results of an optional process (Section 3; Table 5), or from some possible factors that affect duration independently (section 4.2). We thus conclude that the vowel lengthening pattern in Japanese instantiates a case of incomplete neutralization.

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[4]One possibility is that the onsets in the quoted sets allowed for greater expansion of the vowels than the non-quoted sets. This hypothesis is supported by the rather large difference in consonant duration across the two sets (quoted: 57.23 ms, not-quoted: 92.97 ms).

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