

## THE ROLE OF DURATION IN JAPANESE SPEAKERS' PRODUCTIONS OF ENGLISH VOWELS

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Japanese uses length as a primary acoustic cue to distinguish some pairs of vowels, whereas North American English varieties rely mainly on spectral differences. While many studies investigating Japanese learners' acquisition of English vowels have examined acoustic features, only a handful have focused in detail on durational patterns. This study adds to the latter body of research by investigating the carry-over of Japanese durational features into English. To this end, native Japanese and Canadian English speakers' productions of CVC words were elicited using a picture-naming task. A comparison of duration data for /i/, /ɪ/, /u/, /ʊ/ in three pre-consonantal contexts (/k/, /t/, /d/) revealed that the Japanese speakers' tense vowels were significantly longer than their lax counterparts regardless of the following consonant, while the native English speakers generally did not show such a pattern. The Japanese speakers furthermore displayed native-like lengthening of vowels before a voiced stop. Nonetheless, contrary to hypothesis, an assessment by native English listeners yielded no evidence that the exaggeration of durational differences for tense/lax contrasts adversely affected vowel intelligibility.

### INTRODUCTION

Various studies have examined the effect of first language (L1) on Japanese learners' acquisition of English vowels (Ingram & Park, 1997; Lee, Guion, & Harada, 2006; Oh et al., 2011; Tsukada, 1999). While acoustic features have been addressed in this work, only a handful of investigations (e.g., Liu, Jin & Chen, 2014; Tsukada, 2009) have focused specifically on durational patterns. This is surprising, considering that the two languages differ in their use of duration in a number of respects. For example, while Japanese employs duration as a primary acoustic cue to differentiate certain pairs of vowels and consonants, North American varieties of English make vowel distinctions mainly at the spectral level, with duration playing a relatively minor role in tense-lax pairs (Flege, Bohn, & Jang, 1997; Hillenbrand, Clark, & Houde, 2000). Production data show that English tense vowels are, on average, longer than lax vowels. However, perceptual research indicates that native English speakers distinguish such tense-lax pairs as /i/-/ɪ/ and /u/-/ʊ/ at high rates of accuracy when duration differences are neutralized (Hillenbrand et al., 2000). Moreover, duration differences alone do not cue perceptual distinctions. It follows that L2 users of English must learn to perceive and produce the spectral differences in these distinctions in order to successfully acquire the English vowel inventory.

In Japanese, length is phonemic, and, in contrast to English, five vowel pairs are distinguished primarily on the basis of duration, including /i:/ - /ɪ/ and /u:/ - /ʊ/. Given the phonemic status of duration in their L1, coupled with the fact that English does, to some degree, exhibit length differences in such pairs, speakers of Japanese may be prone to misinterpret English tense-lax

distinctions as duration-based contrasts. In fact, a number of L2 speech studies have pointed to learners' difficulties with English lax vowel accuracy. In Munro (1993), for instance, Arabic speakers exaggerated tense-lax duration differences and were rated as producing lax /ɛ/ much less well than other English front vowels. Munro and Derwing (2008) observed that lax /ɪ/ was by far the least intelligible vowel produced by English speakers from Mandarin and Slavic backgrounds. And in a study of Italian immigrants in Canada, Munro, Flege and MacKay (1996) observed poor performance on the same vowel, as well as on /ʊ/. Finally, both Bohn (1995) and Wang and Munro (2004) observed that Mandarin speakers had difficulty perceiving the difference between English /i/ and /ɪ/, in part because they relied inappropriately on length differences.

A production study that investigated the transfer of Japanese duration phenomena into learners' English tense-lax vowel pairs was Tsukada (2009), who found that the Japanese speakers tended to exaggerate the duration distinction between English tense /i/ and lax /ɪ/ in comparison to Australian English speakers. In particular, her native English groups produced /i/-/ɪ/ duration ratios of 0.69 and 0.67 in a /p/ context, while the Japanese group exhibited a considerably larger duration difference with a ratio of only 0.55. Such exaggeration may reflect incomplete acquisition of the distinction, though Tsukada recommended that future work should establish the perceptual relevance of their production patterns through evaluation by native listeners.

Another pertinent difference between Japanese and English concerns the lengthening of vowels before tautosyllabic voiced obstruents. While this phenomenon is pervasive in English and serves as an important perceptual cue to obstruent voicing in syllable codas (Raphael, 1972), Japanese allows very few coda consonants, none of which are voiceless (Vance, 1987). Consequently, Japanese has no phonemic distinction between voiced and voiceless consonants in syllable-final position. On the basis of production data showing relatively small differences in vowel duration in V+t and V+d syllables, Tsukada (2009) concluded that her Japanese speakers had not acquired this duration cue.

## THE PRESENT STUDY

This study will add to the body of research on English L2 vowel acquisition by further investigating the carryover of Japanese length phenomena into English. We extended Tsukada's original analysis by (1) adding the two high back vowels /u/ and /ʊ/ to determine whether her findings would be paralleled in another tense-lax distinction, (2) including one additional consonantal context (/k/), and (3) focusing on a different English variety, Canadian English. To probe the potential effect of exaggerated duration contrasts on intelligibility (as suggested by Tsukada), we also added a vowel identification assessment by native English listeners.

### Expectations and Hypothesis

On the basis of the previous findings on Japanese acquisition of English vowels, we undertook this study with two expectations: (E1) that Japanese speakers would tend to exaggerate the duration differences between the English tense/lax vowel pairs /i/-/ɪ/ and /u/-/ʊ/, and (E2) that Japanese speakers would not produce a native-like duration difference in vowels preceding tautosyllabic voiced vs. voiceless consonants.

We also tested one specific new hypothesis: (H1) that exaggeration of the durational contrast in tense-lax pairs would occur at the expense of accurate vowel quality. In particular, such exaggeration might indicate a general lack of success in acquiring the vowel distinctions. Learners

might, for instance, have inadequate articulatory control of the sounds because they have focused too much on the duration differences. Furthermore, it is possible that the more a learner of English uses duration to distinguish tense and lax vowels, the less the speaker accurately produces the necessary spectral differences. Since some degree of spectral accuracy is essential for listeners to perceive tense/lax distinctions, the less intelligible these individuals' vowel productions will be.

## METHODS

### Stimuli and speakers

The speakers were 24 (6 male, 18 female) Japanese speakers of English who had been living in Western Canada for a mean of 2.4 years ( $SD = 1.97$ ). All had come to Canada as young adults, and all had high oral English proficiency as evidenced by the fact that they were enrolled in or had recently been enrolled in English-speaking post-secondary institutions in Canada. In addition, they had all studied English in the Japanese school system, typically beginning at age 12 or 13.

### Procedures

Recordings of 26 CVC words (see Table 1) were made in a sound-treated room via a picture naming task. No spoken model was provided. On the basis of randomized presentations of the pictures, each speaker uttered the target items within the sentence frame "Now I say \_\_\_." Three productions of each item were digitally recorded. For baseline data, the same words were also elicited, using an identical procedure, from six male and three female native Canadian English speakers who had all grown up in Western Canada.

Table 1

*Rhymes and target words used to elicit the four high vowels*

Rhyme	Target Words	Rhyme	Target Words
/i/	heat, seat, feet	/u/	boot, suit
/ik/	cheek, speak	/uk/	Luke, toque <sup>1</sup>
/id/	read, feed	/ud/	food
/it/	hit, sit	/ʊt/	put, foot
/ik/	chick, kick, sick	/ʊk/	book, cook, look
/id/	kid, lid	/ʊd/	good, wood

<sup>1</sup> Pronounced /tuk/ and sometimes spelled "tuque." Widely used in Canada to refer to a close-fitting winter hat.

The four high vowels under consideration were the front vowels /i/ and /ɪ/ and the back vowels /u/ and /ʊ/, produced in the pre-consonantal voiceless contexts /k/ and /t/, and the voiced context /d/. We opted not to include final-/g/ items because of the rarity of high-frequency English words with /ig/ rhymes. In anticipation of future analyses of word-based effects on duration (not to be reported here), we included more than one word for most of the rhymes. Although we attempted to identify multiple common target words that would be familiar to the talkers and that would have similar consonants for each rhyme, in some instances this proved impractical, either because the rhyme

type was rare, or because the possible targets could not be easily depicted with pictures. In the case of /ud/, for instance, we identified only one suitable target word ('food').

### **Vowel duration measurements**

With the help of spectral and waveform displays in *Praat* (Boersma & Weenink, 2017), the onsets and endpoints of the vowels were located and demarcated with cursors by a research assistant. The chief criteria for identifying vocalic stretches were the presence of quasi-periodicity in the signal, along with energy in the lower formants (F1 and F2). Cursor locations were visually inspected by the authors, and tokens were re-measured when inaccuracies were noted. A *Praat* script was then used to extract the vowel durations to the nearest 1 ms.

### **Intelligibility assessments**

The intelligibility evaluations were provided by two phonetically-trained native-speaking Canadian judges who each completed a forced-choice identification task. The CVCs from each production were digitally excised from their sentence context and presented randomly via headphones in a quiet lab. The listeners identified the vowel in each production by matching it to a labelled button on a custom *Praat* screen. Up to three replays were permitted. Although we attempted to elicit only 4 phonemic vowel targets from the speakers during the recording sessions, pre-screening of the productions indicated that several of them did not match any of the intended categories. To allow the judges as much flexibility as possible in identifying the productions, we therefore provided them with 10 vowel choices. In addition, an "other" category was available when no satisfactory match could be made. The judgment task was thus comparable in some respects to transcribing vowels by hand, except that the *Praat* presentation allowed automatic tallying of responses.

## **RESULTS**

A variety of analyses were carried out to evaluate the effects of vowel category and consonantal context on vowel durations, and to pinpoint differences in patterning between the Japanese and Native English speakers. We focused on whether the Japanese speakers produced exaggerated duration differences between vowels, whether they used vowel duration to distinguish final voiced from voiceless consonants, and whether the intelligibility of their vowels was related to length. Where ANOVA and correlational analyses are reported, we used  $p < .05$  as the criterion for significance. For all pairwise post hoc comparisons ( $t$ -tests), we used a Bonferroni adjustment to maintain an overall  $\alpha$  of .05.

### **Vowel durations**

We reduced the measurement data to obtain each speakers' mean duration for each rhyme by pooling over all the representations of that particular rhyme. Visual inspection of the data suggested a trend in both groups for tense vowels to be longer than lax vowels and for vowels to be longer before /d/ than before the voiceless consonants. However, statistical analyses were required to establish any between- and within-group differences in patterning.

For each L1 group, a two-factor repeated measures ANOVA was computed to probe the effects of vowel category (V, 4 levels) and coda consonant (CC, 3 levels) on duration. A significant two-way interaction between V and CC emerged for both the English speakers, [ $F(6, 48) = 9.390, p <$

.0005], and the Japanese speakers, [ $F(3.099, 71.268) = 4.470, p = .006$ , Greenhouse Geisser adjustment due to violation of the sphericity assumption]. Follow-up single-factor ANOVAs yielded a significant effect of V for both speaker groups in all coda conditions; i.e., the Japanese and the English speakers both showed duration differences across vowels in all three consonant contexts (Table 2).

Table 2

*Effects of Vowel identity on durations*

Coda	L1 English	L1 Japanese
/t/	$F(3, 24) = 6.259, p = .003$	$F(3, 69) = 69.777, p < .0005$
/k/	$F(3, 24) = 3.805, p = .023$	$F(3, 69) = 58.344, p < .0005$
/d/	$F(3, 24) = 26.904, p < .0005$	$F(3, 69) = 52.029, p < .0005$

***Tense-lax pairs***

Differences in tense-lax vowel durations were examined through pairwise within-group comparisons in the three coda conditions. As illustrated in Figures 1, 2, and 3, the Japanese speakers produced tense vowels with significantly longer durations than their lax counterparts regardless of coda. Effect sizes (Cohen's *d*) for the Vt and Vk pairs were large, ranging from 1.03 to 2.07 (Larson-Hall, 2015).

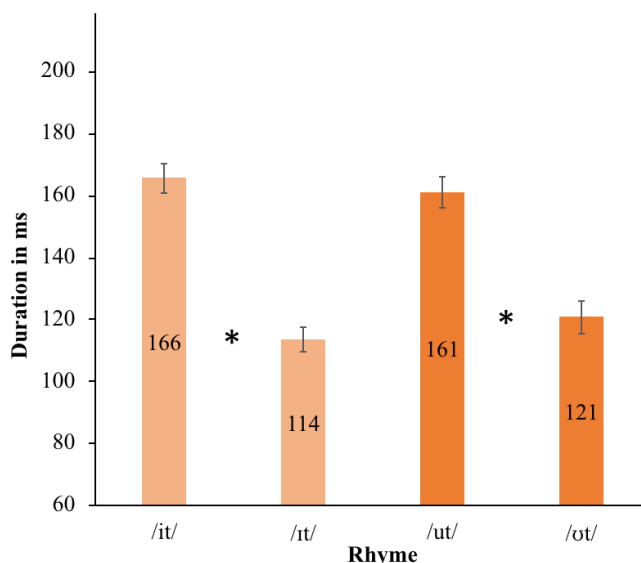


Figure 1: Japanese speakers' mean durations (with standard error) for the four vowels in /t/ context. (\*  $p < .05$ )

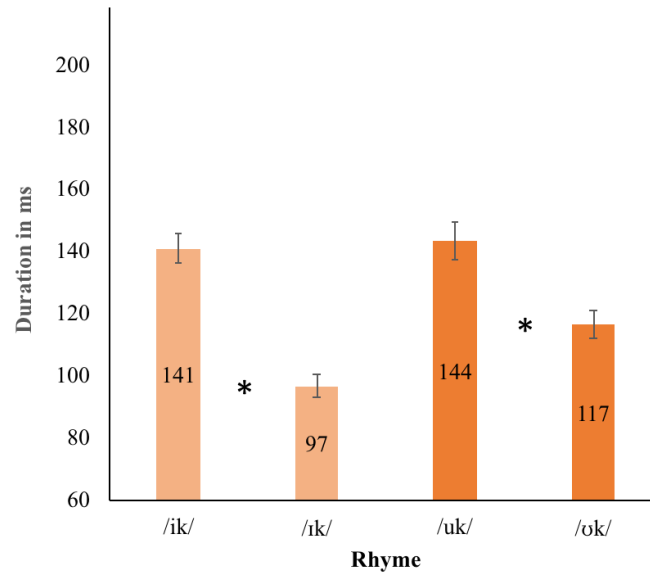


Figure 2: Japanese speakers' mean durations (with standard error) for the four vowels in /k/ context. (\*  $p < .05$ )

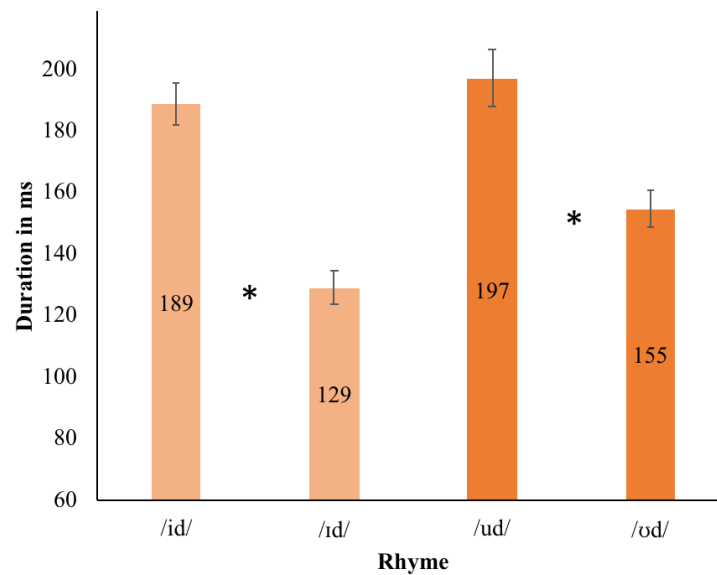


Figure 3: Japanese speakers' mean durations (with standard error) for the four vowels in /d/ context. (\*  $p < .05$ )

The native English speakers, however, produced fewer significant differences. They produced /u/ significantly longer than /ʊ/ when followed by /t/ (Figure 4) and /i/ was longer than /ɪ/ when

followed by /d/. (Figure 5). None of the other differences, including those for vowels before /k/, reached significance. Effect sizes for Vt and Vk were noticeably smaller than for the Japanese group, with Cohen's *d* ranging from .41 to .91.

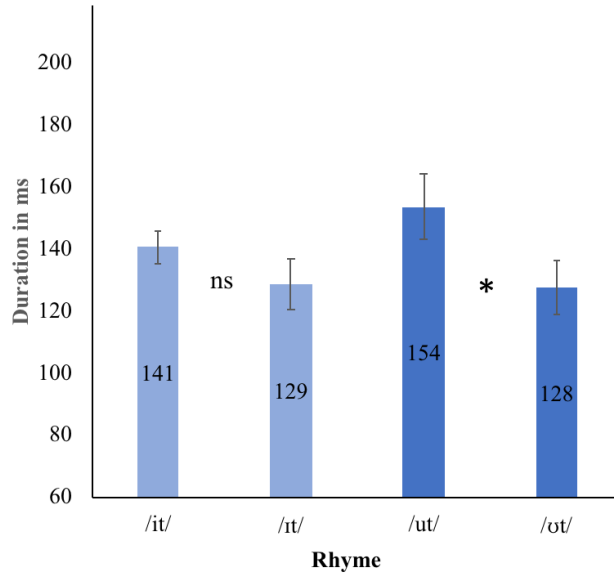


Figure 4: English speakers' mean durations (with standard error) for the four vowels in /t/ context. (\*  $p < .05$ )

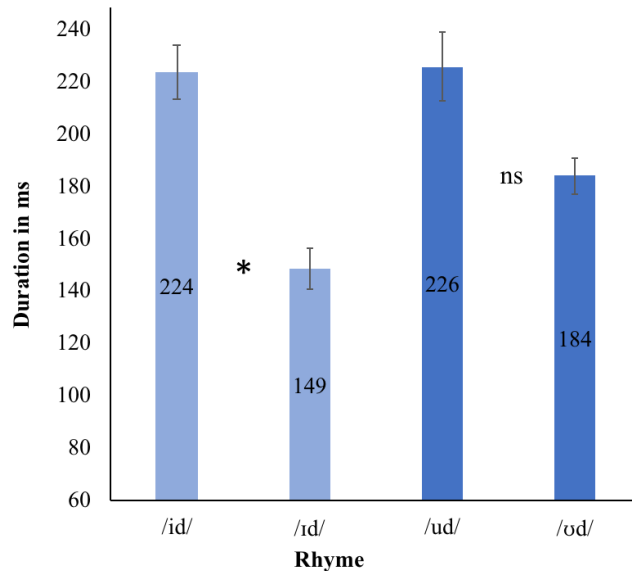


Figure 5: English speakers' mean durations (with standard error) for the four vowels in /d/ context. (\*  $p < .05$ )

To further assess the degree to which the Japanese speakers exaggerated the tense/lax duration differences we computed mean lax/tense duration ratios for both speaker groups for the four sets of rhymes shown in Table 3. In all cases, the English speakers' ratios were comparatively closer to 1, indicating smaller duration differences between tense vowels and their lax counterparts than for the Japanese group. Pairwise independent samples *t*-tests confirmed that for all except the /ut-ʊt/ contrast, the Japanese speakers' ratios were significantly smaller than those of the native English speakers. To sum up, the Japanese group produced larger duration discrepancies in three of the pairs than did the English group, and there was a non-significant trend in the same direction for the fourth pair.

Table 3

*Vowel duration ratios by rhyme for the two speaker groups*

Rhymes	Mean Lax/Tense Ratios	
	Native English	Japanese
it, ɪt*	.92 (.161)	.69 (.103)
ik, ɪk*	.92 (.078)	.69 (.112)
ut, ʊt	.84 (.114)	.76 (.202)
uk, ʊk*	.96 (.067)	.83 (.133)

\*  $p < .05$

### *Effects of coda*

Besides the effect of V, there were also significant effects of CC on the vowel durations of all four vowels for both the Japanese and English speakers, as shown in Table 3.

Table 3

*Effects of coda on vowel durations*

Vowel	L1 English	L1 Japanese
/i/	$F(1.23, 9.85)^\dagger = 69.452, p < .0005$	$F(1.45, 33.39)^\dagger = 51.590, p < .0005$
/ɪ/	$F(2, 16) = 6.970, p = .007$	$F(1.51, 34.65)^\dagger = 34.110, p < .0005$
/u/	$F(2, 16) = 33.923, p < .0005$	$F(1.29, 46) = 26.469, p < .0005$
/ʊ/	$F(2, 16) = 32.481, p < .0005$	$F(2, 46) = 44.440, p < .0005$

<sup>†</sup>Because of violations of the sphericity assumption, the Greenhouse-Geisser adjustment was applied.



For the sake of brevity, this portion of the paper focuses only on the effect of coda voicing on vowel durations; i.e., it compares only the V+/t/ durations with the V+/d/ durations. Pairwise within-group comparisons were run for both the Japanese and English speakers. As shown in Figures 6 and 7, the vowels before /d/ were generally longer than the matching vowels before /t/. In fact, almost all pairwise differences in both groups were significant, except for the lax vowel /ɪ/ as produced by the native English speakers.

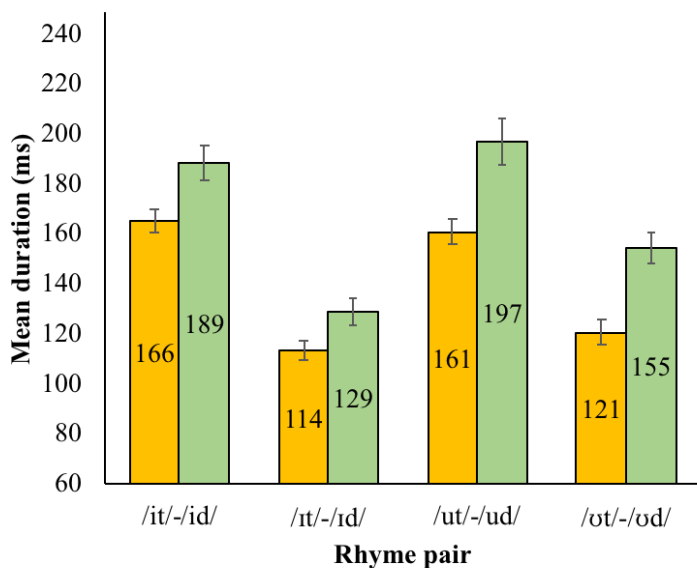


Figure 6: Effect of coda voicing on vowel durations for the Japanese speakers (standard error shown).

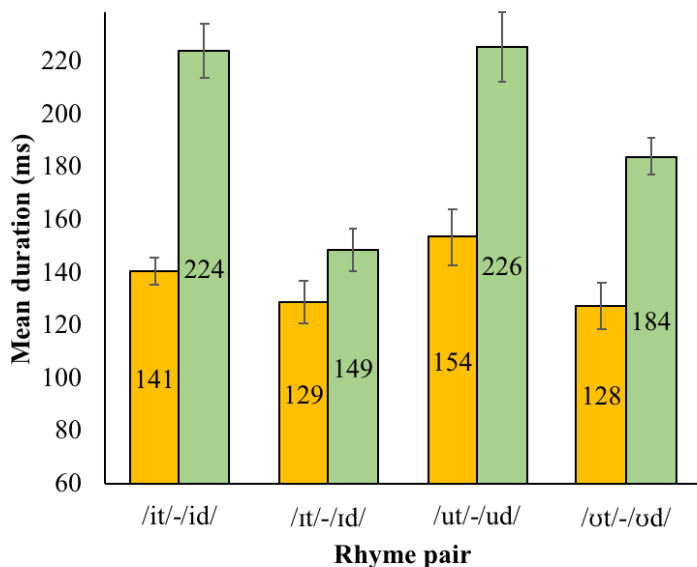


Figure 7: Effect of coda voicing on vowel durations for the Native English speakers (standard error shown).

Pairwise between-group comparisons on the duration ratios (voiceless/voiced) were computed to determine whether the Japanese speakers produced a native-like duration distinction in the vowels. The /it/-/id/ ratio proved significantly smaller for the native English group than for the Japanese group, indicating a greater discrepancy in duration on the part of the English speakers. The other between-group differences were not significant.

### **Vowel intelligibility**

Vowel intelligibility was assessed on a correct/incorrect basis by tallying the number of times each judge identified a particular production as the actual target vowel. Using this criterion, an agreement rate of 83% was observed between the two judges, an outcome that compares very favourably with the results of other vowel intelligibility studies (e.g., Munro & Derwing, 2008).

When scores were pooled for the two judges, the overall intelligibility of the Japanese speakers' target vowels was 85%. However, several qualifications must be kept in mind regarding this number. First, there was noteworthy inter-talker variability in intelligibility: individual rates varied from 69% to almost 100%. Second, variability was found across vowels as well. The lax front vowel /ɪ/ was least intelligibly-produced (76%), while its tense counterpart /i/ was the most intelligible vowel of the four (93%). The back vowels /u/ and /ʊ/ showed intermediate intelligibility rates of 87% and 82%, respectively. Third, high overall intelligibility did not guarantee equally high performance on all four vowels. Speaker JVL09, for instance, performed considerably worse on /ɪ/ (69%) than on the vowels overall (87%). The reverse pattern was observed for JVL27, who performed relatively well on /ɪ/ (79%), even though her overall identification rate (69%) was the lowest of all speakers. Finally, vowel intelligibility also depended on the following consonant, with a lack of parallelism between the front and back vowels. While tense /i/ received higher identification rates than lax /ɪ/ when followed by /k/, the opposite tense-lax ordering was found for the back vowels.

### **Effect of vowel duration on intelligibility**

The lax/tense vowel ratio data described earlier were used to assess the degree to which exaggerating the relative durational distinction between the tense and lax vowels would affect intelligibility. The Pearson  $r$  correlation between mean tense/lax ratios and overall vowel intelligibility was  $-.064$  ( $p > .1$ ), suggesting no meaningful relationship between the two. Furthermore, the three speakers who showed the most exaggerated tense/lax differences all scored above the median in terms of vowel intelligibility, one of them being the most intelligible of all. In summary, the data provided no evidence that exaggeration was predictive of reduced intelligibility.

## **DISCUSSION**

It is well known that English tense vowels tend to be inherently longer than lax vowels (Crystal & House, 1988; House, 1961; Ueyama, 2000); however, the duration difference is relatively small and might not be readily noticed by English L2 learners. Nonetheless, the Japanese speakers in this investigation not only produced a significant duration difference in tense/lax pairs, but actually did so in more rhymes and to a greater degree than did the native English speakers. In other words, our expectation of exaggerated differences in duration on the part of the Japanese group (E1) was

upheld. The precise reasons for this exaggeration cannot be ascertained. On the one hand, the speakers may have assimilated the English tense vowels to their corresponding native Japanese long vowel categories and the lax vowels to their native short categories, perhaps because they had noticed duration differences in the English input that they received. On the other hand, it is also possible that they were taught to produce tense/lax differences as length differences, as is known to occur in some English language instruction (Wang & Munro, 2004).

A second expectation of ours (E2), namely that the Japanese speakers would not produce a native-like vowel duration difference to distinguish voiced from voiceless consonant codas received little support from our data. Lengthening before voiced obstruents has long been observed in English (House, 1961, p. 1177), but the dearth of possible consonant codas in Japanese means that no such effect occurs in the speakers' L1. Moreover, Tsukada's (2009) Japanese learners of English did not produce such a distinction. The fact that the Japanese speakers tended to display native-like lengthening of vowels before voiced stops in the present study suggests that they had learned to make use of this cue in spoken English. Although we cannot be certain of the reasons for this difference in findings, it is possible that Tsukada's participants had lower overall proficiency in English and had not yet had enough opportunity to acquire this length difference.

The one hypothesis tested in this study was that exaggeration of the durational distinction between tense and lax vowels would be linked to reduced vowel intelligibility. We proposed that speakers who relied mainly on duration to distinguish /i/-/ɪ/ and /u/-/ʊ/ would do so at the expense of producing accurate spectral differences. This prediction was not confirmed in the data. Not only was there no meaningful correlation between the extent of exaggeration and listeners' intelligibility assessments, but the speaker who showed the greatest degree of exaggeration was the one who produced the most intelligible vowels overall.

## CONCLUSION

The findings reported here shed some additional light on the contributions of L1-to-L2 transfer and L2 acquisition processes to vowel production. First, the fact that the Japanese speakers exaggerated the durational differences between English tense and lax vowels suggests that they made use of their L1-based knowledge about vowel duration in their L2 implementations. Second, the data indicate that the Japanese group were successful at acquiring a new type of length distinction with no parallel in their L1.

Although this study was not designed with pronunciation teaching goals in mind, our findings are weakly suggestive of a few pedagogical consequences. In particular, the interspeaker variability that we observed in high vowel intelligibility (69% to nearly 100%) suggests that some learners may require more instruction than others in order to acquire the vowel distinctions at issue. Moreover, receiving instruction on the /i/-/ɪ/ distinction may be a worthwhile undertaking, since this contrast has a high functional load in English (see Tsukada, 2009). Yet our data showed that /ɪ/ was the least-intelligibly produced of all four vowels. We must be cautious in extrapolating from this study to classroom applications, however, since we did not look beyond vowel productions in a very limited speaking task; nor did we evaluate the benefits of any particular instructional techniques.

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