

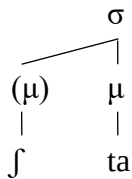
## Consequences of high vowel deletion for syllabification in Japanese

Jason A. Shaw (Yale) & Shigeto Kawahara (Keio)

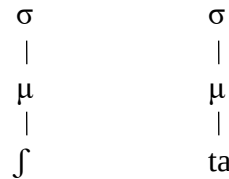
**SYNOPSIS:** Japanese high vowels devoice between two voiceless consonants (e.g. [ʃʊtaisei] ‘subject’); recent work has shown that devoiced [ʊ] is also variably deleted. A question that arises is how the resulting cluster (e.g. [ʃt]) is syllabified in Japanese. This paper reports converging evidence from phonology and phonetics that the resulting clusters are syllabified heterosyllabically. The phonetic evidence comes from articulatory stability patterns in EMA data; the phonological evidence comes from two patterns sensitive to syllabic structure. We take this convergence as further evidence for the relation between syllabification and temporal organization in speech production (Browman & Goldstein 1988; Shaw et al. 2009; Shaw & Gafos 2015).

**PHONOLOGICAL EVIDENCE:** Currently, there are two proposals for how consonant clusters are syllabified after high vowel deletion. Take a schematic sequence like /ʃʊta/, in which the first vowel is devoiced and deleted, yielding [ʃta]. One proposal posits that the first consonant is resyllabified into the following syllable, forming a complex onset, (1a) (Kondo 1997). The other posits that the first consonant remains a syllable of its own (Matsui 2017), forming a “consonantal” syllable, (1b).

(1) a. Complex onset cluster



b. Consonantal syllable



There is phonological evidence that supports the representation in (1b). First, Ito (1990) describes the truncation template in (2a) as a bimoraic syllable followed by an additional light syllable (syllable boundaries are shown with “.”). Ito (1990) argues that the appendical light syllable is attached to satisfy the requirement that a Prosodic Word in Japanese must branch at the syllabic level (i.e. a single syllable is too small). The data in (2b) show that a syllable with a devoiced vowel (which may also be deleted) satisfies the prosodic branching requirement.

(2) a. A heavy syllable plus an appendical light syllable (Ito 1990)

[dai.ja] < [dai.ja.mon.do] “diamond”  
[paa.ma] < [paa.ma.nen.to] “permanent”

b. Devoiced syllables count as a light syllable

[mai.ku] < [mai.ku.ro.foon] “microphone”  
[am.pu] < [am.pu.ri.ɸai.aa] “amplifier”  
[paŋ.ku] < [paŋ.ku.tɕaa] “punctuation, a blowout”

Evidence from accentuation also supports the hypothesis in (1b). The default accentuation in Japanese loanwords is generally the Latin Stress Rule (Kubozono 2011): place accent on the penultimate syllable if it is heavy, otherwise place accent on the antepenultimate syllable. Examples such as [ra.hu.ra’n.su] ‘pear’ and [ku.ri’.su.ta] ‘Christa’ show that devoiced syllables still count as syllables for the purpose of accent assignment.

**PHONETIC EVIDENCE:** The phonetic evidence comes from articulatory trajectories of words containing devoiced vowels (the middle column in Table 1) recorded using Electromagnetic Articulography (EMA). Six native speakers of Tokyo Japanese produced 10-15 repetitions of the

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items in Table 1, which included target words containing a devoiced vowel (middle column), items that are similar to the target words but do not contain devoiced vowels (left column) and control words with no high vowels (right column). We first determined whether the vowel was present or deleted through a Bayesian classification of tongue dorsum (TD) trajectories. The classifier was trained on voiced vowel TD trajectories (vowel present scenario) and a linear interpolation between flanking segments (vowel deletion). Tokens classified as vowel deletion were included in a second analysis, in which we assessed the articulatory stability of syllable-referential intervals (Figure 1) across CCV sequences, e.g., [ʃtai] in [ʃtasei], and CV sequences, e.g., [tai] in [tasei].

| Voiced V   | Deleted V  | Control     |
|------------|------------|-------------|
| [masuda]   | [maʃtaa]   | [baʃaa]     |
| [yakuzai]  | [haʃsai]   | [daʃai]     |
| [ʃudaika]  | [ʃtasei]   | [tasei]     |
| [ʃuzoku]   | [ʃsoku]    | [kaʃoku]    |
| [katsudoo] | [katʃtoki] | [miruʃtoki] |

Table 2: experimental stimuli

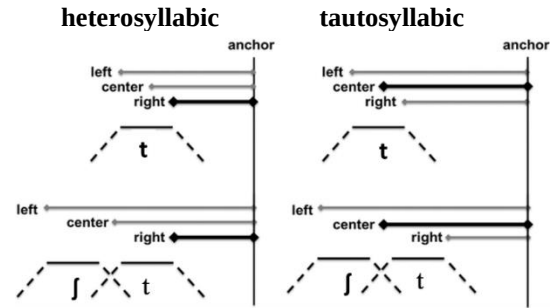


Figure 1: Pattern of syllable-referential intervals, left edge to anchor (LE-A), center to anchor (CC-A), right edge to anchor (RE-A), corresponding to a tautosyllabic (right) and heterosyllabic (left) parse of consonant clusters. The anchor point for the analysis was the end of the vowel in each syllable.

**RESULTS:** The number of tokens without lingual articulatory movements for /u/ (classified as deletion) varied across speakers and across items. Across speakers /u/ was deleted 138 times in /ʃtasei/ (5 speakers), 129 times in /katsutoki/ (4 speakers), and 78 times in /ʃsoku/ (2

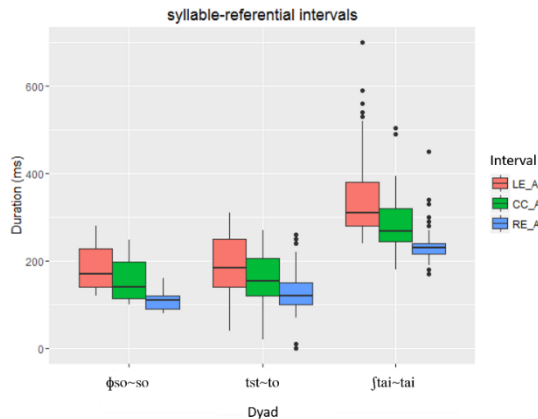


Figure 2: interval duration

| target dyad  | LE-A | CC-A | RE-A        |
|--------------|------|------|-------------|
| [ʃso]~[so]   | 0.32 | 0.34 | <b>0.24</b> |
| [tʃt]~[to]   | 0.25 | 0.23 | <b>0.20</b> |
| [ʃtai]~[tai] | 0.23 | 0.18 | <b>0.11</b> |

Table 2: Coefficient of variance. Lower values indicate higher articulatory stability for the RE-A interval, the heterosyllabic pattern.

speakers). Figure 2 shows box plots of these intervals. The other items did not contain enough deletions to support the stability analysis. Table 2 shows the coefficient of variance for each interval; lower variance indicates higher articulatory stability. When /u/ was deleted, the right edge to anchor interval (RE-A) remained more stable than the center to anchor interval (CC-A) or the left edge to anchor (LE-A) interval, a stability pattern characteristic of a heterosyllabic parse of consonants (Hermes et al., 2013).

**CONCLUSIONS:** Japanese high vowels sometimes delete in devoicing environments. Both evidence from phonological patterns as well as evidence from articulatory stability show that the resulting consonant clusters form separate syllables, indicating that Japanese has syllables with fricative nuclei. We also take the convergence of phonological and phonetic evidence as further support for the view that syllabification conditions articulatory dynamics.