A rate-independent acoustic attribute of gemination: A cross-linguistic perspective

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This study addresses three related questions: How do singleton and geminate consonants as well as adjacent vowels scale with speech rate across different languages? What do these scaling relations tell us about the control of duration? Is it possible to provide an invariant acoustic attribute of gemination contrast that transcends languages and speaking rates?

In this study, we present preliminary acoustic results from four typologically unrelated languages where consonant gemination is phonemic (Finnish, Italian, Japanese, and Tashlhiyt). We used the same target words (/ima/ and /imma/) and embedded these in language-specific carrier sentences (1):

(1) Finnish: Ottakaa ___ mukaan! *'Take ___ with you.'*
Italian: Parli con ___ fuori. *'Talk to ___ outside.'*
Japanese: Kore wa ___ nano. *'This is ___.'*
Tashlhiyt: Innajam ___ bahra. *'He told you (f.) ___ a lot.'*

To elicit variation in speaking rate, we designed a rate manipulation task, using a visual motion analogue before each trial at various speeds. Each speaker produced 640 repetitions of /ima/ and /imma/.

Durations of geminate [mm] and singleton [m] change approximately linearly with rate in all languages, with geminate consonants increasing more as rate slows (Fig. 1). These scaling factors differed across languages. Adjacent vowels also scaled differently across languages, indicating differences in V-C interaction. In Tashlhiyt, Japanese, and Italian, rate effects on the preceding vowel [i] were smaller before [mm] than [m], while the interaction with the following vowel [a] was similar between singletons and geminates. This supports the claim that gemination affects the preceding vowel duration more strongly than the following vowel duration (Payne 2005, Ridouane 2007, Engstrand & Krull 1994). While showing that singleton and geminate durations cannot be controlled with only a global speech rate mechanism, these results point towards the existence of a rate-normalized acoustic measure for distinguishing singletons and geminates across typologically unrelated languages. Despite overlap of singleton/geminate durations at fast rates, a relational measure such as singleton/geminate duration as a proportion of word duration (Fig. 2) reliably distinguishes between the two categories (in line with Pickett et al., 1999 for Italian, and Hirata & Whiton 2005 for Japanese), and thus could form the basis for a language-independent acoustic attribute of gemination.

The results provide important constraints on how singleton and geminate durations are controlled: (1) Although consonant and vowel durations scaled differently across languages, proportional durations may allow for a rate-invariant perceptual boundary for discriminating between singletons and geminates; (2) Large differences in rate-scaling of singletons and geminates demonstrate that consonant durations cannot be modelled as an intrinsic duration plus a global speech rate adjustment: some additional mechanism is needed to account for the scaling differences; (3) Cross-linguistic variation, both in singleton/geminate duration and its interactions with adjacent vowels, suggests that language-specific differences are related to differences in the way length is controlled. We discuss whether these findings can be understood in relation to phonological differences underlying the prosodic organization of syllables and words in the four languages.

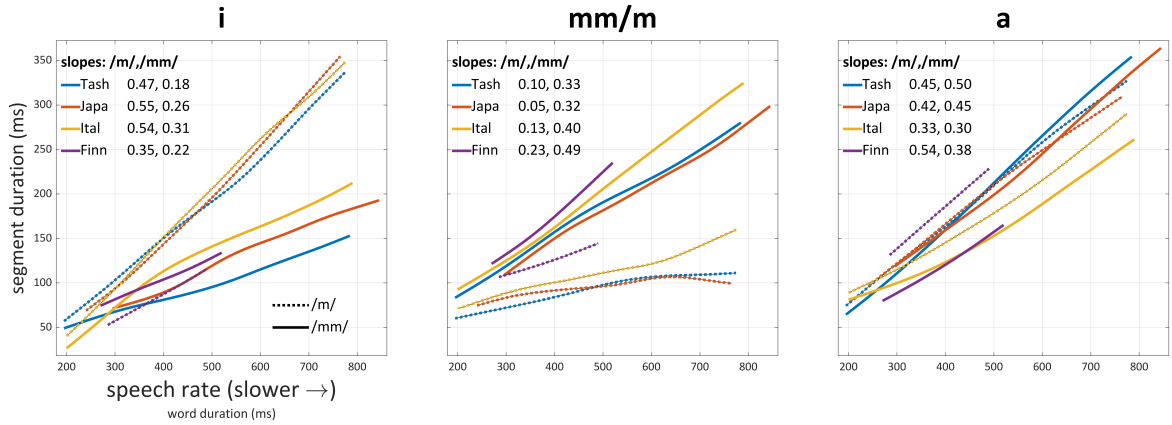

Figure 1: Spline fits of segment durations as a function of speech rate, plotted for Tashlhiyt, Japanese, Italian and Finnish. The slopes of best fitting linear regressions are included in the legends.

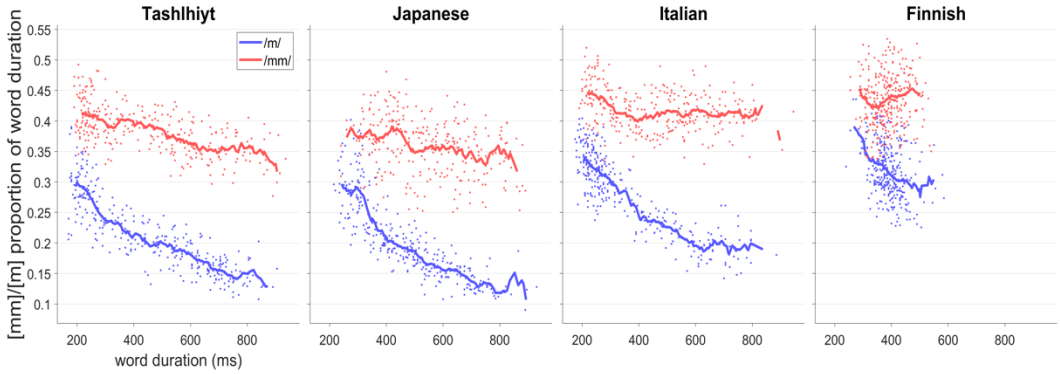

Figure 2: Proportional /m/ and /mm/ duration (i.e. proportion of word duration), as function of speech rate, plotted for Tashlhiyt, Japanese, Italian and Finnish.

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