**Cross-linguistic timing contrast in geminates: A rate-independent perspective**

Anne Hermes[1], Sam Tilsen[2], Rachid Ridouane[1]
[1]*Laboratoire de Phonétique et Phonologie, UMR 7018, CNRS/Sorbonne-Nouvelle, Paris*
[2]*Department of Linguistics, Cornell University, Ithaca*

In addition to durational differences between singletons and geminates, the phonetic implementation of gemination may have implications for most, if not all of a form's phonetic shape, including temporal differences in adjacent vowels (Engstrand & Krull 1994, Payne 2005, Ridouane 2007). Variation in speech rate may have dramatic influence on these temporal characteristics. A consequence of this is that a singleton in slow rate may display longer duration than a geminate in fast rate, thus resulting in a non-contrastive overlap (e.g. Pind 1995, Picket et al. 1999, Hirata & Whiton 2005). In this study, we provide evidence that (i) singletons and geminates duration scale almost linearly with speech rate, with geminates being more affected by speech rate; and (ii) that scaling as well as the vowel-consonant-vowel relations differ across languages. While we assume that there is no global speech rate mechanism, however, our results indicate that rate-normalized measures could transcend the languages under investigation.

**Method:** We collected /ima/ and /imma/ productions from four typologically unrelated languages where consonant length is phonemic (Tashlhiyt, Japanese, Italian and Finnish). Target words were embedded in language-specific carrier sentences (see table). To elicit variation in speech rate, we used a visual motion analogue before each trial (a box moving across the screen at various speeds). Each speaker produced 320 repetitions of /ima/ and /imma/. In analyses, we use target word duration as a proxy for speech rate.

| Language | Carrier phrase | Gloss |
|---|---|---|
| Tashlhiyt | Innajam __ bahra. | *He told you (f.)___a lot.* |
| Japanese | Kore wa __ nano. | *This is___.* |
| Italian | Parli con __ fuori. | *Talk to ___ outside.* |
| Finnish | Ottakaa __ mukaan! | *Take ___ with you.* |

**Results:** Durations of singletons and geminates change approximately linearly with rate in all languages, with geminates increasing more as rate slows (Fig. 1, middle). These scaling factors differed across languages. Adjacent vowels also scaled differently across languages, indicating differences in vowel-consonant interaction. In Tashlhiyt, Japanese, and Italian, rate effects on the preceding vowel were smaller before [mm] than [m] (Fig. 1, left), while the interaction with the following vowel was similar between singletons and geminates (Fig. 1, right). This shows that gemination affects the preceding vowel duration more strongly than the following vowel duration. 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 (Fig. 2) reliably distinguishes between the two categories (in line with Hirata & Whiton 2005 for Japanese), and thus could form the basis for a language-independent attribute of gemination.

**Discussion/Conclusion:** The results provide important constraints on how singleton and geminate durations are controlled. First, 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. Second, 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. Third, cross-linguistic variation, both in singleton/geminate duration and in the interactions with adjacent vowels, suggests that language-specific differences are related to differences in the way length is controlled.

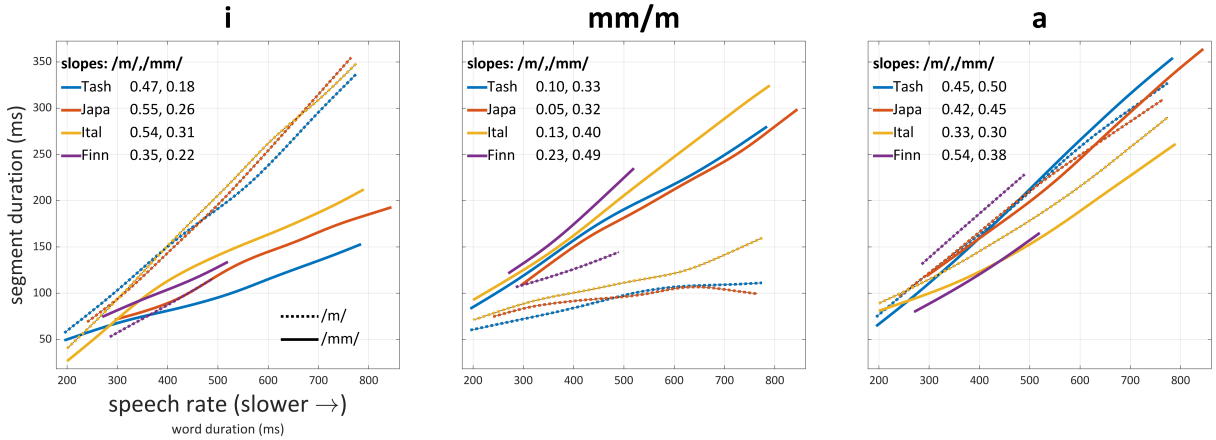


*Figure 1: Spline fits of segment durations as a function of speech rate, plotted for Tashlhiyt, Japanese, Italian and Finnish. The slopes of best fitting linear regressions are included in the legends.*

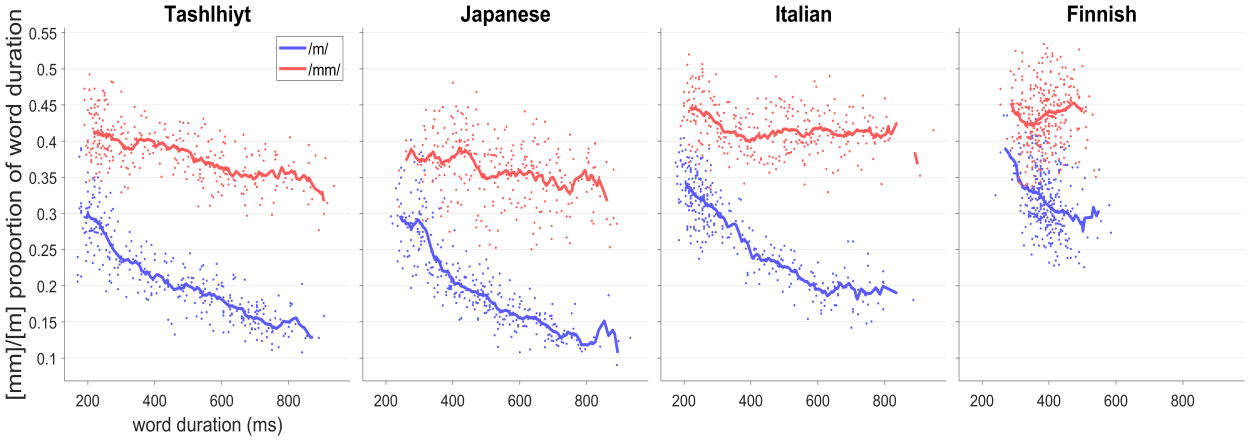


*Figure 2: Proportional /m/ and /mm/ duration (i.e. proportion of word duration), as function of speech rate, plotted for Tashlhiyt, Japanese, Italian and Finnish.*

## References


Engstrand, O., & Krull, D. (1994). Durational correlates of quantity in Swedish, Finnish and Estonian: Cross-language evidence for a theory of adaptive dispersion. *Phonetica*, 51(1-3), 80-91.

Hirata, Y., & Whiton, J. (2005). Relational acoustic invariance in the single/geminate stop distinction in Japanese. The *Journal of the Acoustical Society of America*, 117(4), 2569-2569.

Payne, E. M. (2006). Non-durational indices in Italian geminate consonants. *Journal of the International Phonetic Association*, 36(1), 83-95.

Pickett, E. R., Blumstein, S. E., & Burton, M. W. (1999). Effects of speaking rate on the singleton/geminate consonant contrast in Italian. *Phonetica*, 56(3-4), 135-157.

Pind, J. (1995). Speaking rate, voice-onset time, and quantity: The search for higher-order invariants for two Icelandic speech cues. *Perception & Psychophysics, 57*(3), 291-304.

Ridouane, R. (2007). Gemination in Tashlhiyt Berber: an acoustic and articulatory study. *Journal of the International Phonetic Association*, 37(2), 119-142.