Position Statement

- Systematicity in speech timing is to be found
  - in the relationship between cognitive aspects of language and speech
  - in timing consequences of spatial requirements of speech segments
  - other general physical and cognitive factors

- Systematicity will be **difficult to find in surface timing patterns,** unless we have models of
  - the relationship between language and timing aspects of speech
  - the effects of physical and general cognitive factors on timing properties

- Developing the models requires controlled experiments which
  - manipulate cognitive aspects of language and other factors
  - allow observation of their effects on surface timing patterns.

- These experiments will give us
  - an understanding of factors and structures relevant for speech timing
  - an understanding of controlled variables (what is timed?)
  - an understanding of how these variables are controlled

From last time

- Showed the systematic effects of a series of factors on duration
- Showed preliminary evidence for what is timed:
  - "motor equivalence" of different types of duration implementation (e.g. steady state vs. closing movement speeds) (Edwards, Beckman & Fletcher 1991)
- Today—continue with one more prosodic factor
- Discuss how speakers distinguish the many uses of duration

Prosodic prominence structure

```
        X
X       X
X   X   X   X
```

Condensation

- Lexical stress on 1st and 3rd syllables of *condensation*
- Primary phrasal prominence associated with the syllable bearing primary lexical stress, optional "pre-nuclear" prominence on 1st syllable.

- *Did you say MORE condensation or LESS condensation*?
  - Lexical stress on 1st and 3rd syllables of *condensation;* distinction between stressed vs. unstressed is signaled phonetically via full vs. reduced vowel distinction
  - No phrasal prominence on *condensation*.

Phonetic correlates of prominence structure include

- Word-level stress:
  - **Duration**
  - Full vs. reduced vowels (in some languages)
  - Spectral tilt (understudied but cf. Sluijter & van Heuven 1996)
  - F0 (in some languages, e.g. Tunisian Arabic (Bouchhioua 2009)
  - Greater number of segmental contrasts (cf. Kingston, today)
- Phrasal prominence:
  - **Duration**
  - Phrasal pitch accents can be associated with stressed syllables (in some languages)
  - Spectral tilt
  - F0

Prominence: Articulatory strategies

- Reduced vs. full vowels: Differences in
  - Distance
  - Peak Velocity/Distance relationship

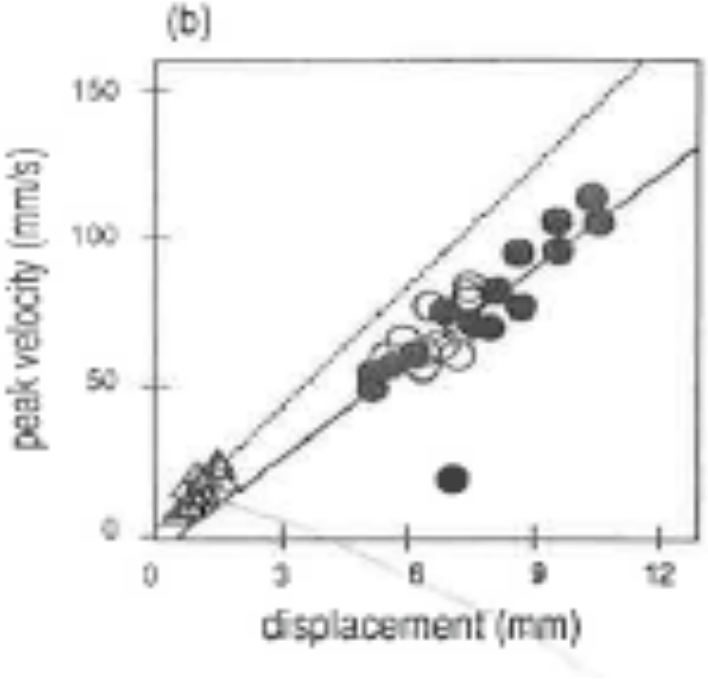


Figure from Edwards, Beckman & Fletcher 1991

Phrasal prominence

- Summers 1987
- CVC; C = /b,p,f,v/
- Steady state duration
- Distance (all speakers but 1)
- Pvelocity/Distance relationship of closing movements (speaker-specific)

Summers 1987

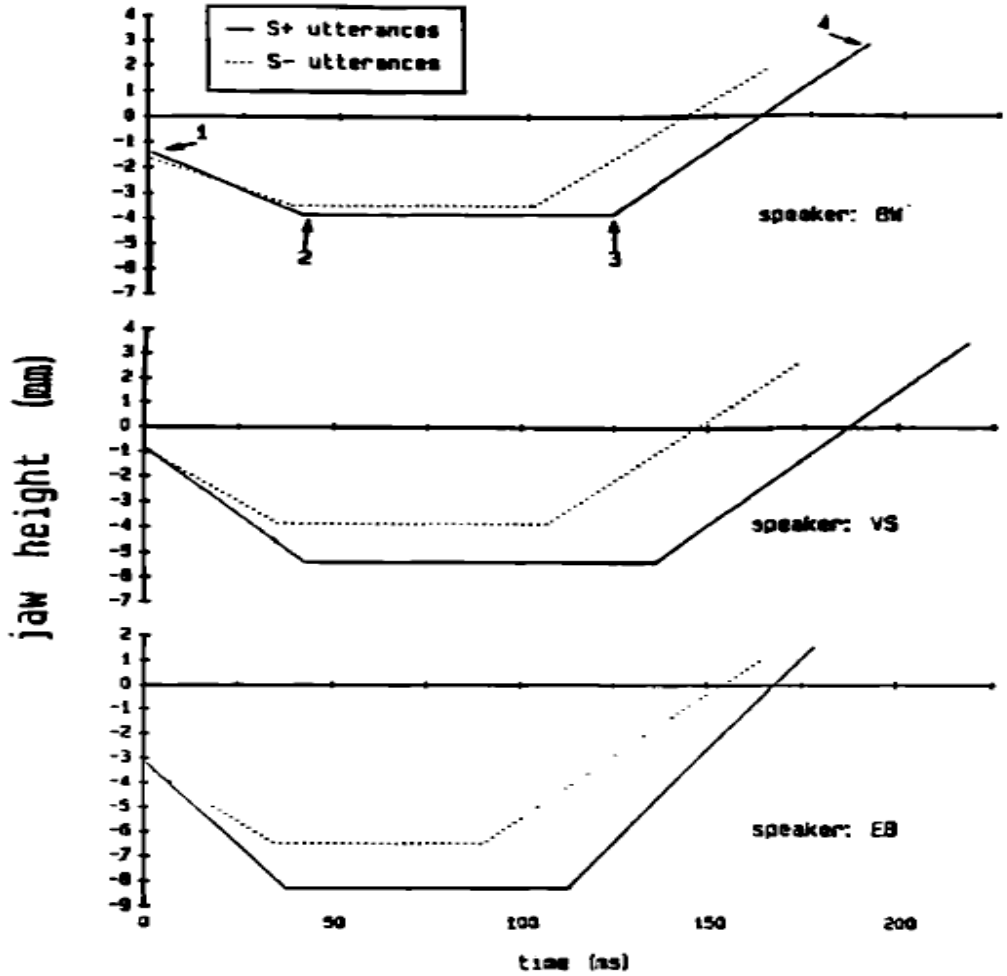


FIG. 5. Jaw position plots for stressed ($S+$) versus unstressed ($S-$) utterances, based on mean positions and mean durations listed in Table I.

Conclusion from Day 2

- Speech shows systematic relationships between
  - Phonological representations and surface timing patterns
  - At multiple levels
    - Segmental
    - Prosodic

  Also Global effects of rate
  - Hints of motor equivalence between duration implementation strategies (steady state, opening & closing mvt adjustment)—Beckman, Edwards,
  - consistent with interval timing, but studies and numbers of speakers are few.

Distinguishing the many uses of duration

And

Theories of affected stretches of speech

How do speakers differentiate the different functions of duration?

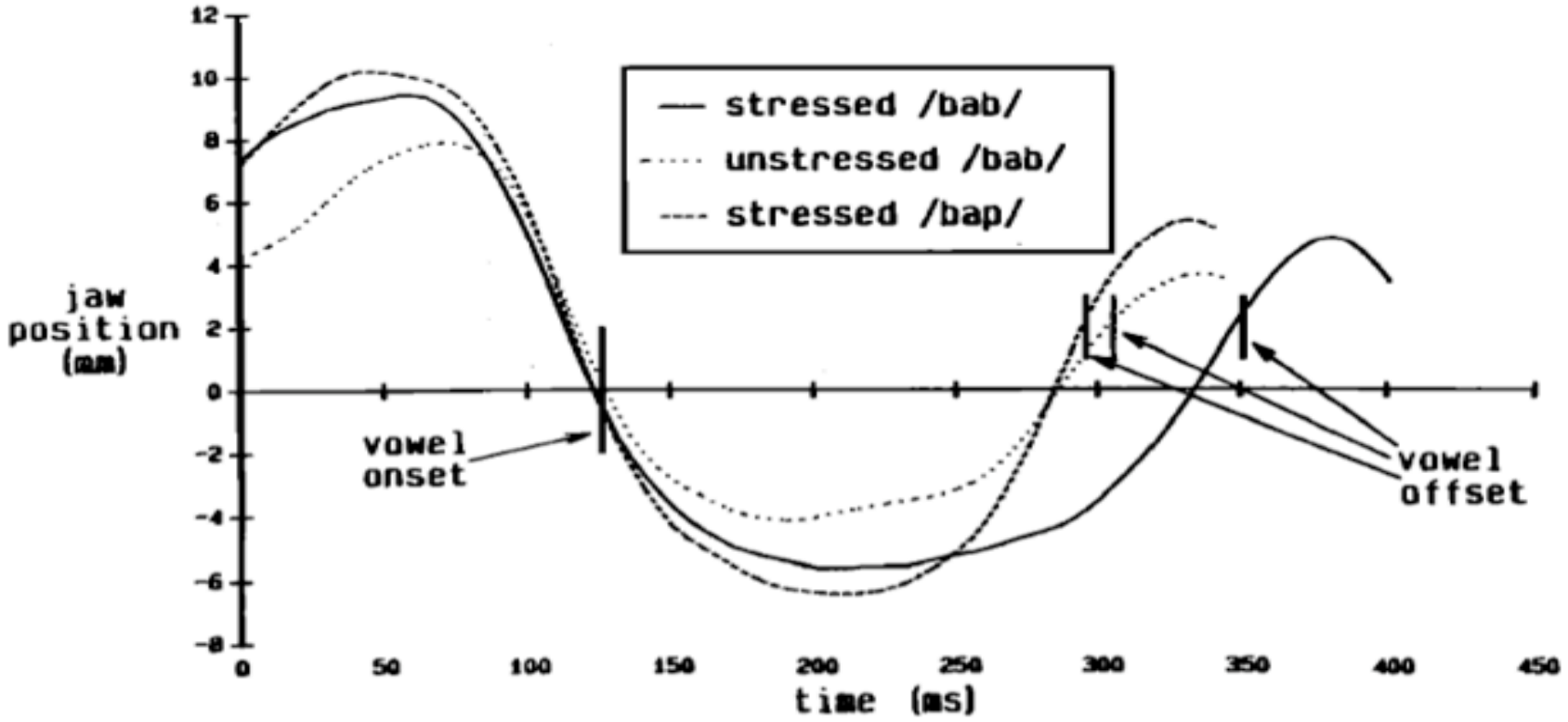
- Articulatory strategies
- Co-occurrence with other cues
- Magnitudes of effects
- Affected stretches of speech
  - Discussion of theories

Articulatory strategies

- Intrinsic segmental differences often co-occur with perceptible spatial differences, e.g.
  - Intrinsic vowel duration & vowel quality differences
  - Some exceptions in quantity languages, e.g. Japanese and Finnish short and long vowels are similar in quality.

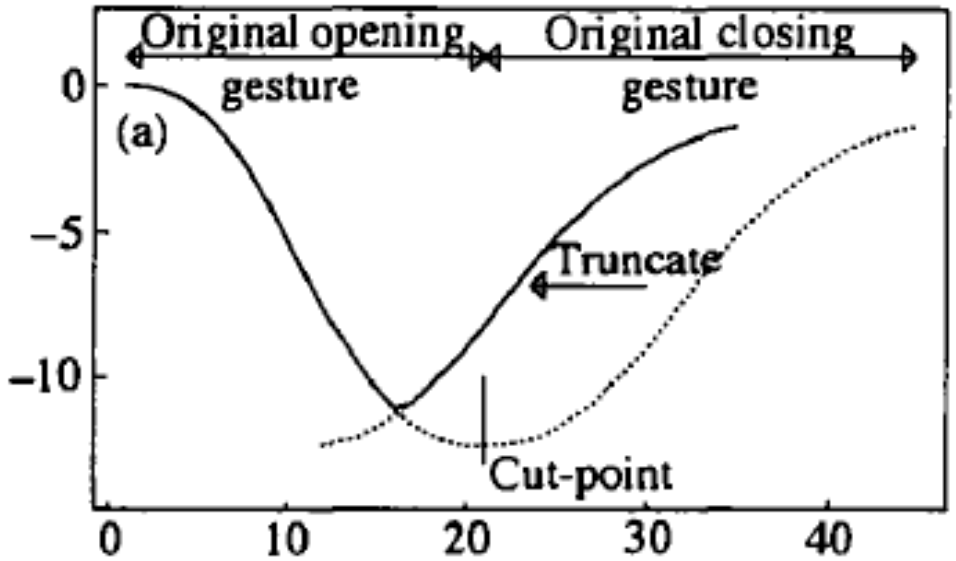
Articulatory strategies

- Prominence-related effects also co-occur with spatial differences: Summers 1987,cf. also Cho 2005 sonority expansion and localized hyperarticulation.



Truncation: A possible mechanism for spatial + durational differences

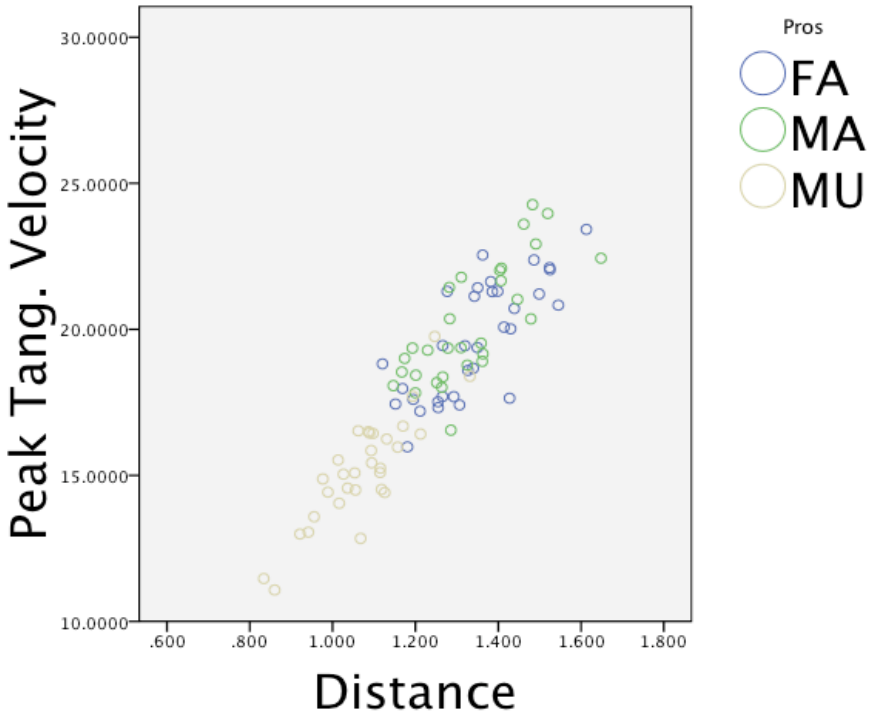
- Beckman & Edwards 1992, Figure from Harrington, Fletcher, Roberts 1995

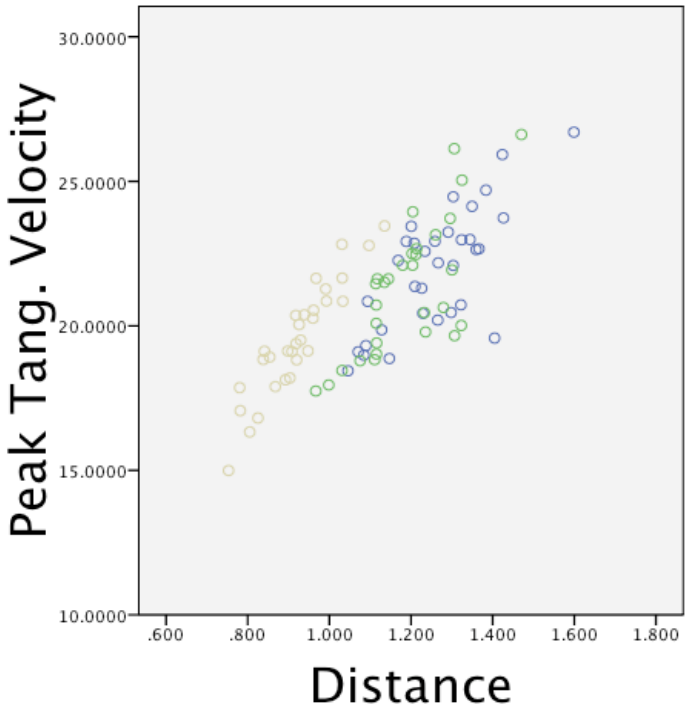


But: Predicts differences in Peak Velocity/Distance relationship for both opening and closing gestures (don't always occur)

Fewer spatial differences for constituency effects

- Tongue Tip example from 1 speaker
  - *dad* Utterance-final Accented (FA), Phrase-medial Accented (MA), Phrase-medial Unaccented (MU)





Co-occurrence with other correlates

- Prominence-related lengthening co-occurs with, e.g.
  - Local hyperarticulation (Cho 2005)
  - Phrasal pitch accents (e.g. English)
  - Less spectral tilt (Sluijter & van Heuven 1996)
  - Greater overall amplitude
- Pre-boundary lengthening co-occurs with
  - Phrase-final laryngeal phenomena, e.g. glottalization, breathy voice (language-specific)
  - Lower amplitude
  - Intonational boundary tones
  - Etc.

Effect Magnitudes—rough guide

- Phonological Vowel length—2 length systems
  - Approx. 100% (Lehiste 1973)
- Phrase-initial lengthening (Keating 2006)
  - Dependent on level in hierarchy; effects for strongest boundaries: 50-100%+
- Phrase-final lengthening (Turk & Shattuck-Hufnagel 2007)
  - Dependent on level in hierarchy; effects for strongest boundaries: 50-100%
- Intrinsic vowel duration differences (non-contrastive)
  - 10-50% (Peterson & Lehiste 1960)
- Phrasal prominence (Turk & White 1999)—size in English can depend on number of syls. In a word
  - 15-35%
- Contextual voicing effects (Summers 1987)
  - 25-30%

  - Note: Difficult to compare magnitudes across studies, most studies on English and other Germanic langauges

Effect magnitudes

- Berinstein's Functional Load Hypothesis
  - Assumes that the phonemic use of duration carries a higher functional load than the prosodic use of duration.
  - Would the prosodic use of duration be absent in languages with phonemic vowel length distinctions?
- Not absent, but may be constrained to some extent.

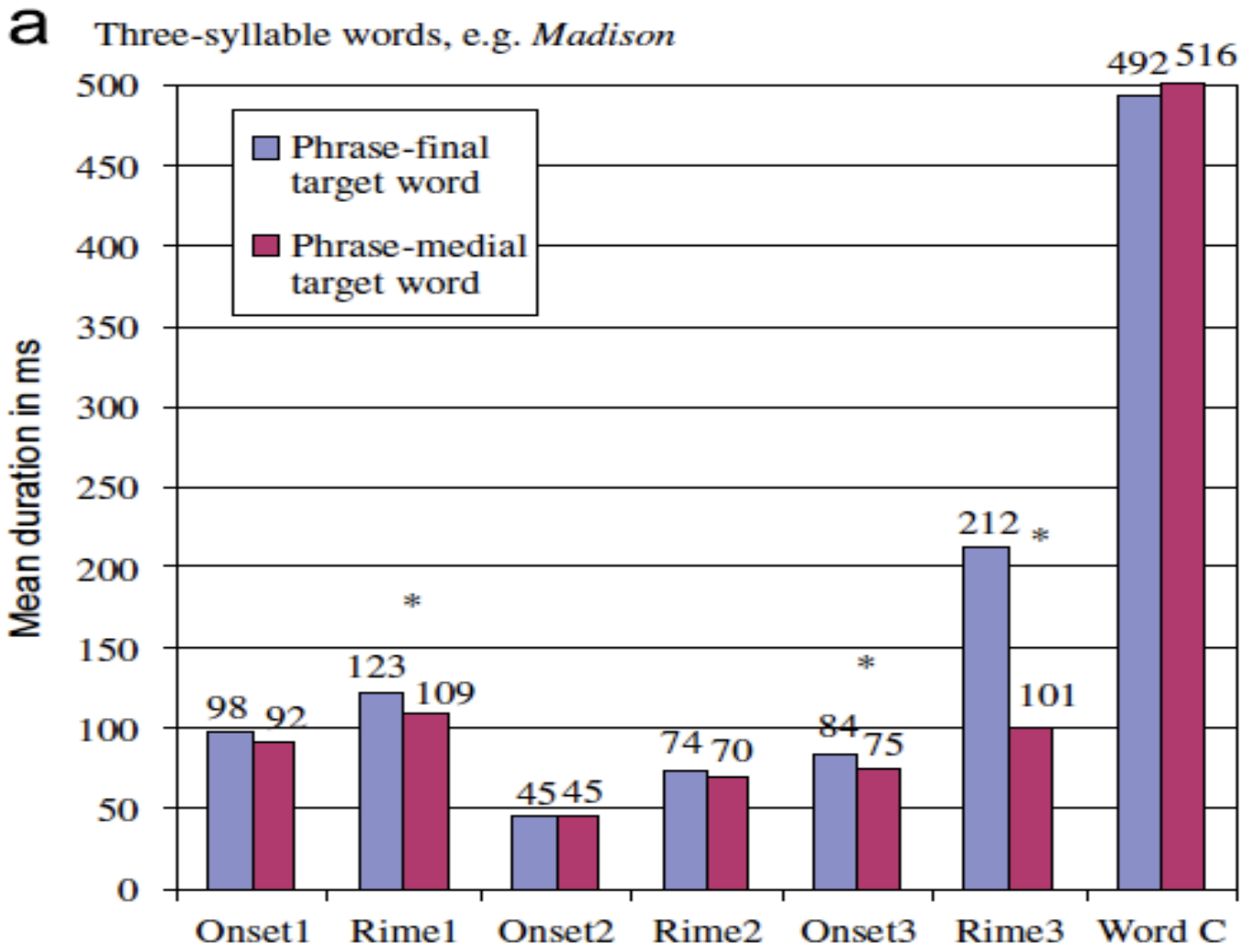
Effect magnitudes

- Dinka—3 levels of length; Remijsen & Gilley 2008
  - V, VV, VVV
  - Final lengthening on
    - Short vowels: V: 9%
    - Medium vowels VV: 16%
    - Long vowels VVV: 35%
- Final lengthening in this study is much smaller than in other studies of languages without 3 length distinctions.
-
- Final lengthening appears to be constrained by the number of phonological length distinctions

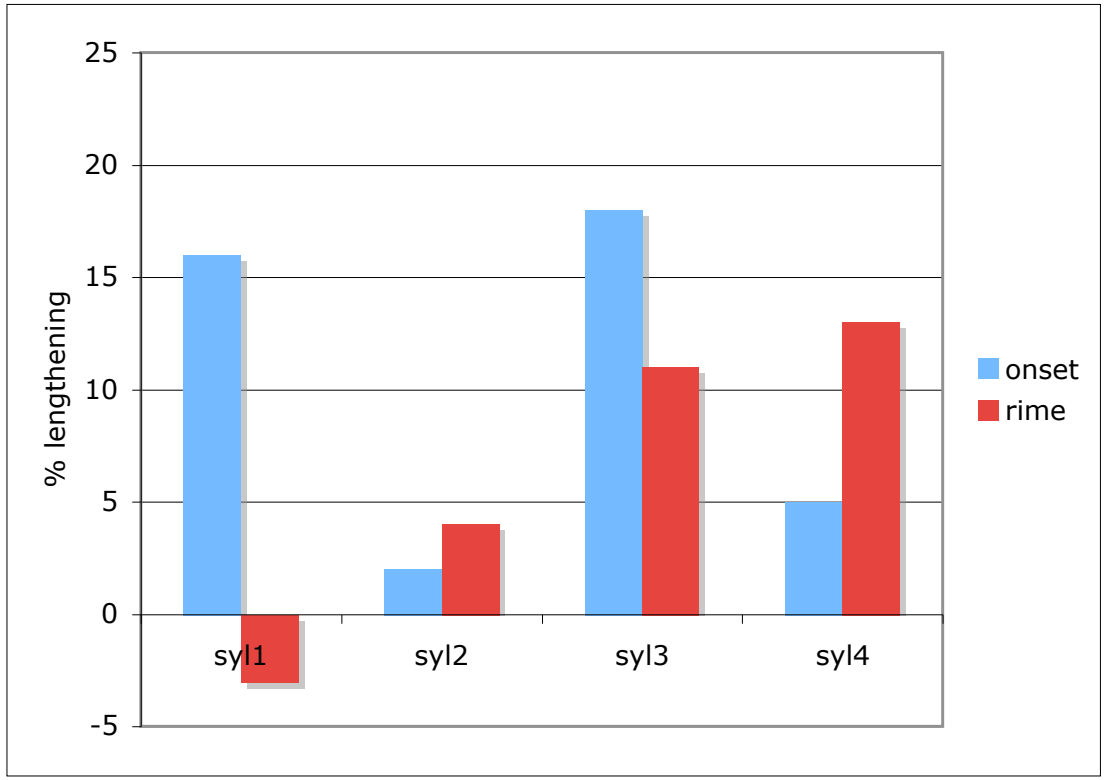
Affected stretches of speech

- Initial lengthening
  - Constituent-initial C constriction (sometimes VOT)
- Final lengthening
  - Later segments tend to show more final lengthening than earlier segments
  - Greatest effects appear on the rime (and often the coda) of the final syllable.
  - Can also affect earlier stressed syllable rimes
  - Sporadic effects elsewhere
- Prominence-related lengthening
  - Stressed CV
  - Can also affect syllable coda, often to a lesser extent
  - Phrasal prominence can also affect final syllables and initial C constrictions of prominent words
  - Spillover effects onto following syllables

Final lengthening—e.g. *Madison* in phrase-final vs. phrase-medial position (Turk & Shattuck-Hufnagel 2007)



Phrasal stress-related lengthening on e.g. *condensation*



Initial and final lengthening in addition to lengthening on the primary stressed, 3rd syllable - from Dimitrova & Turk 2007.

Theories of affected stretches of speech

(At least) 3 theories with different predictions for lengthening patterns

- Structural
- Expandability
- Pi-gesture

Structural Theory

(e.g. Klatt 1976, Wightman et al. 1992, Turk & Sawusch 1997, White 2002, Turk & Shattuck-Hufnagel 2007)

Affected segments are predicted by their structure, e.g. membership in a constituent, position with respect to stress, etc.

Final lengthening affects rimes of final syllables as well as those of primary stressed syllables in English (lengthened segments are in red)

'Kenneth , Madison vs. *Bang'kok, Ti'bet*

(Turk & Shattuck-Hufnagel 2007.)

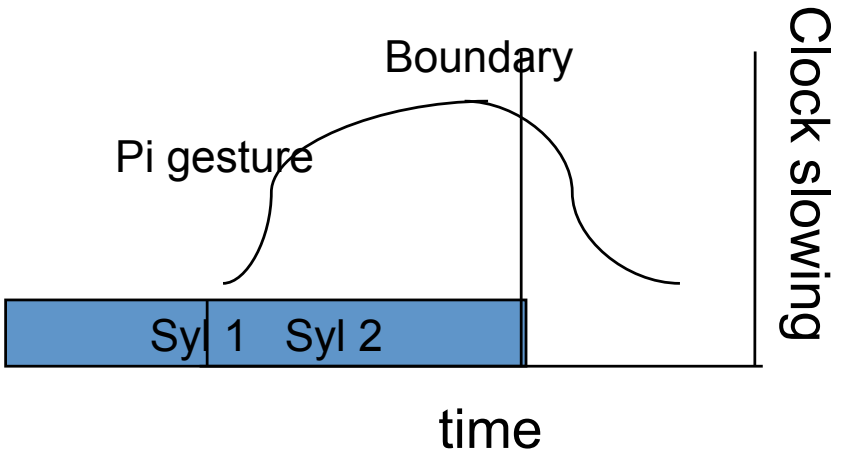
Expandability theory (Cambier-Langeveld 2000)

If a final syllable contains a segment with constraints on its expandability, then segment(s) in a pre-final syllable will be affected

Earlier onset of final lengthening in Dutch words with final schwa:

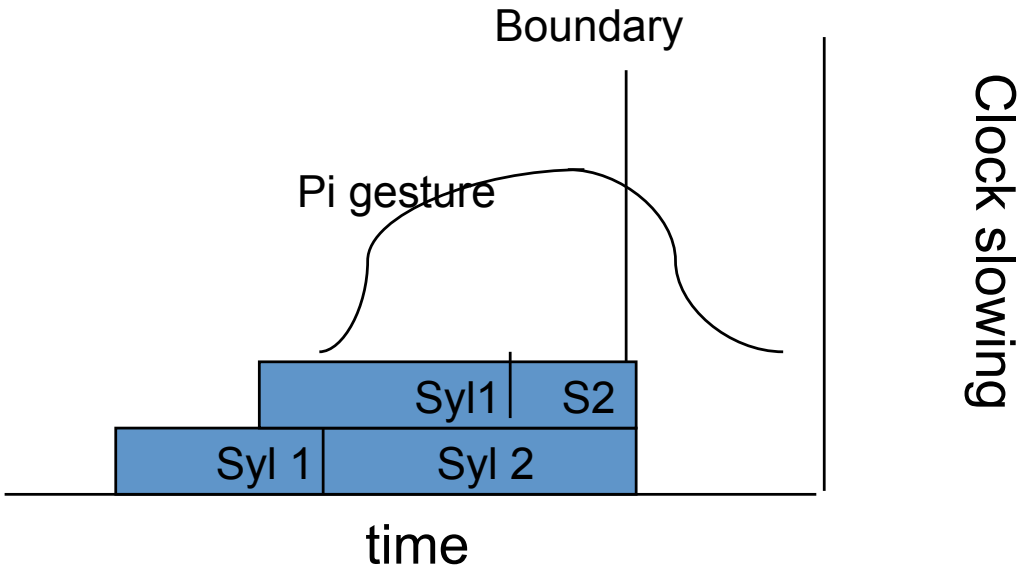
‘mode, ‘tandem vs. ‘yucca, ‘marathon

Pi-gesture theory (Byrd & Saltzman 2003); Articulatory phonology framework



- The extent of boundary-related lengthening is determined by a Pi-gesture “anchored in some sense to the boundary”
- The Pi gesture lengthens overlapped boundary-adjacent articulatory gestures by “slowing the internal clock” during the overlapped period.
- The degree of clock slowing is determined by the height of the Pi-gesture.

Pi-gesture theory (cont.)



- If the final syllable is composed of gestures that are intrinsically short, lengthening on an earlier syllable will be more likely/greater.

Content-based vs. Structural theories

- Expandability and Pi-gesture theories both suggest that the likelihood of final lengthening affecting a pre-final syllable depends on the content of the following, final syllable:
  - Its expandability
  - Its complexity, duration

- Structural theory suggests that the likelihood of final lengthening on a pre-final syllable depends on its structural properties, not on properties of a following syllable.

Finnish and Japanese—Turk & Nakai (AMLAP2006, in prep.; Nakai et al. 2009)

- Are ideal test languages for content-based theories since both have phonological contrasts between short and long vowels (V *vs* VV)

  - Expandability: Short vowels may be less expandable than long vowels (final lengthening on VV1 in CVVCV more likely than in CVVCVV).

  - Pi gesture: Earlier syllable Pi-gesture overlap more likely when a final syllable contains a short vowel.

Materials

- Disyllabic nonsense words with lexical prominence on the first syllable
  - CVCV(n) ‘sasa ‘sasan
  - CVVCV(n) ‘saasa ‘saasan
  - CVCVV (n) ‘sasaa ‘sasaan (Finnish only)
  - CVVCVV(n) ‘saasaa ‘saasaan (Finnish only)

  - 7 Speakers, 2 repetitions of each

  - Lexical prominence = stress in Finnish; pitch accent in Japanese

  - Real words were also recorded; results were similar to those reported for nonce words.

Materials (cont.)

- Recorded in frame sentences designed to elicit target words
  - In phrase-medial and utterance-final contexts
  - Without phrasal stress

- Phrase-medial and utterance-final frame sentences had comparable syllable/mora counts.

- Phrase-final measurements included non-modal voice quality typical of both languages (breathy voice for Finnish, creaky voice for Japanese).

Japanese example: *‘sasan*

- Phrase-medial 

Sensei-ga 'sasan' tabun 12-ban-tte ittayo.

‘The teacher said 'sasan' is probably (the answer to question) No. 12’.

- Utterance final 

Toujou-sensei-ni kiitara 12-ban-ga 'sasan'.

‘According to Mr. Tojo, (the answer to question) No. 12 is 'sasan.’

Results

- No lengthening on C1 in the majority of cases.

- We will focus on lengthening patterns on V(V)1, where systematic lengthening is observed.

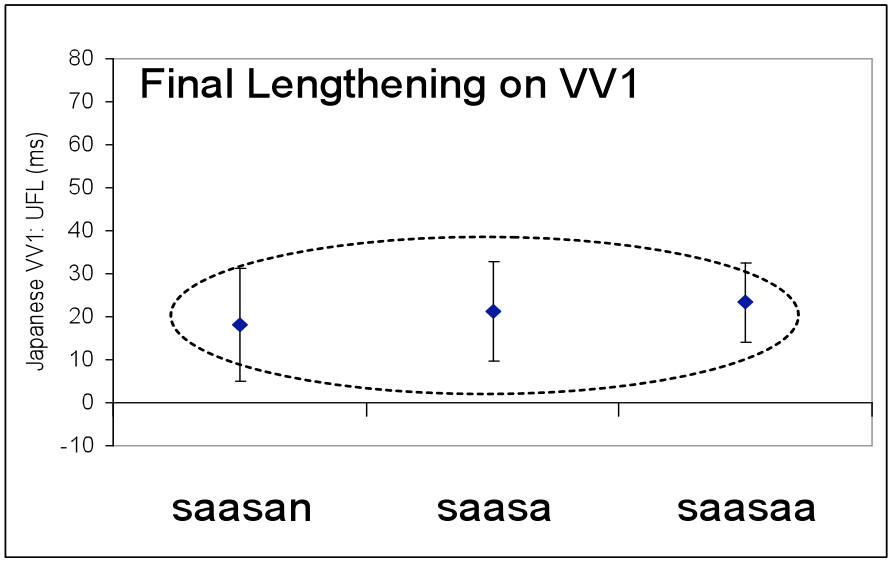
Results: Expandability

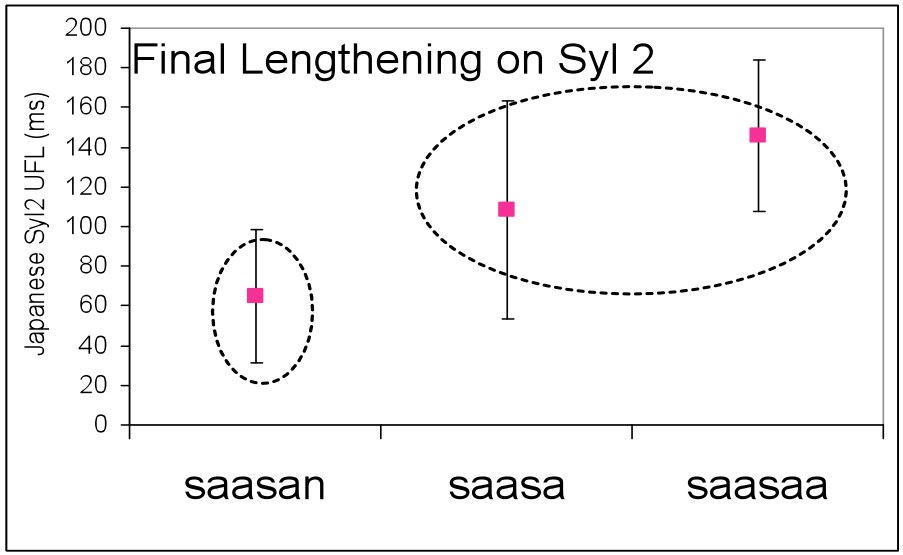
- Predicted inverse relationship between
  - amount of final lengthening on first vowel and
  - a measure of final syllable expandability: amount of final lengthening on the final syllable.

- No systematic evidence for this relationship in either language

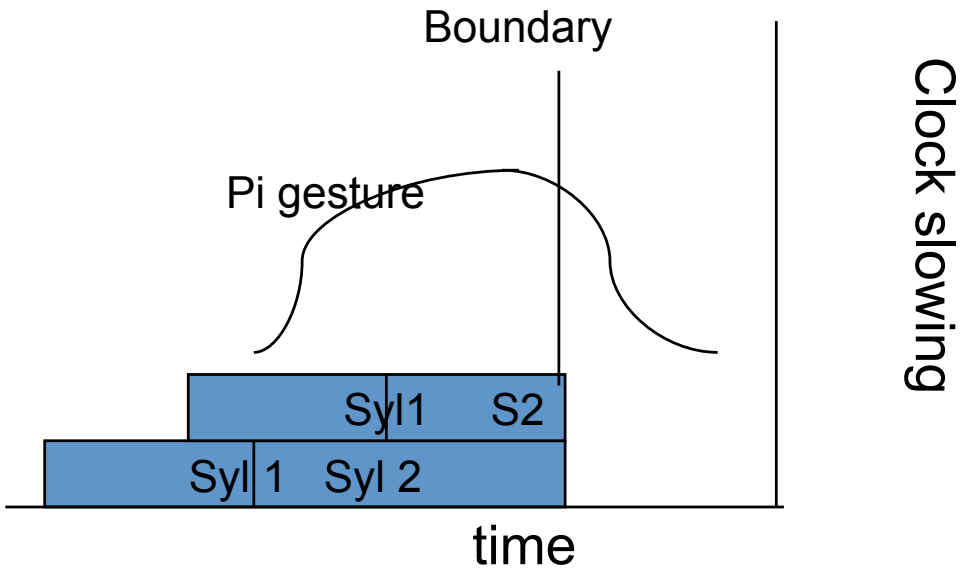
Results: Expandability (cont.), Japanese VV1

- Example from Japanese words with long first syllables (VV1)
- Typical result counter to theory: No inverse relationship between FL on Syl 2 vs. FL on vowel in Syl 1
- Short vowels are expandable (they show significant amounts of final lengthening)





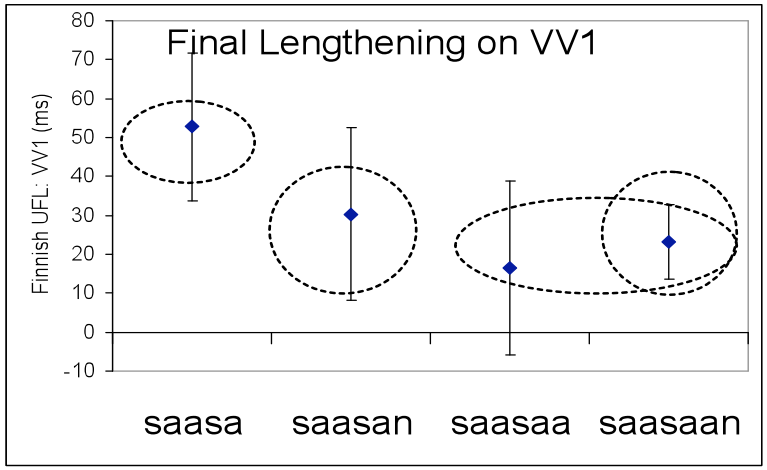
Pi-gesture

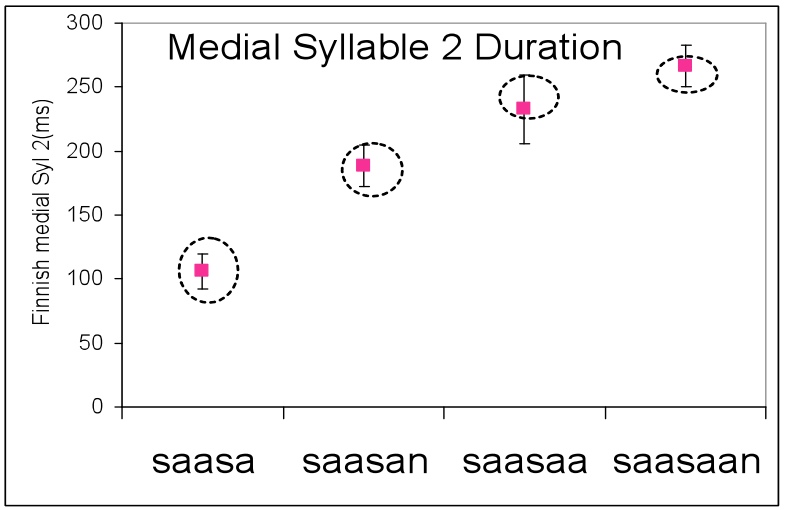


- Predicted inverse relationship between amount of final lengthening on Syl 1 and the intrinsic duration of Syl 2 (phrase-medial duration of Syl 2).

Pi-gesture Results: Finnish words with long vowels in Syl 1 (VV1)

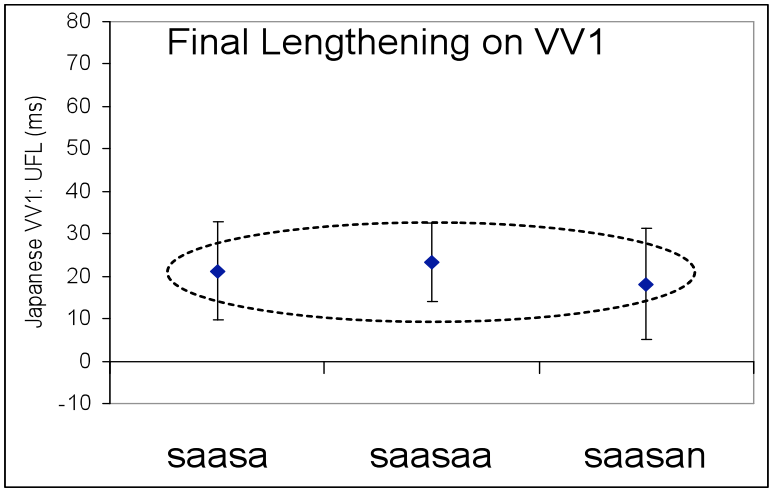
- Largely consistent with predictions of Pi-gesture theory
- Inverse relationship between amount of Final lenghtening on VV1 and medial Syl 2 duration

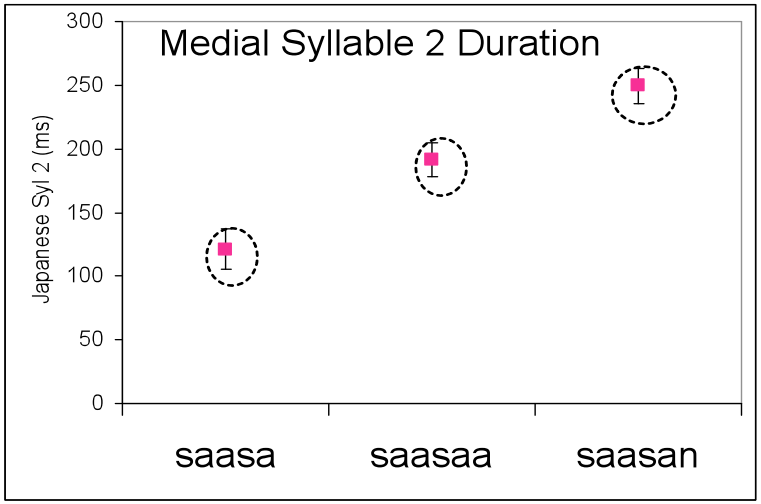




Pi-gesture Results: Japanese VV1

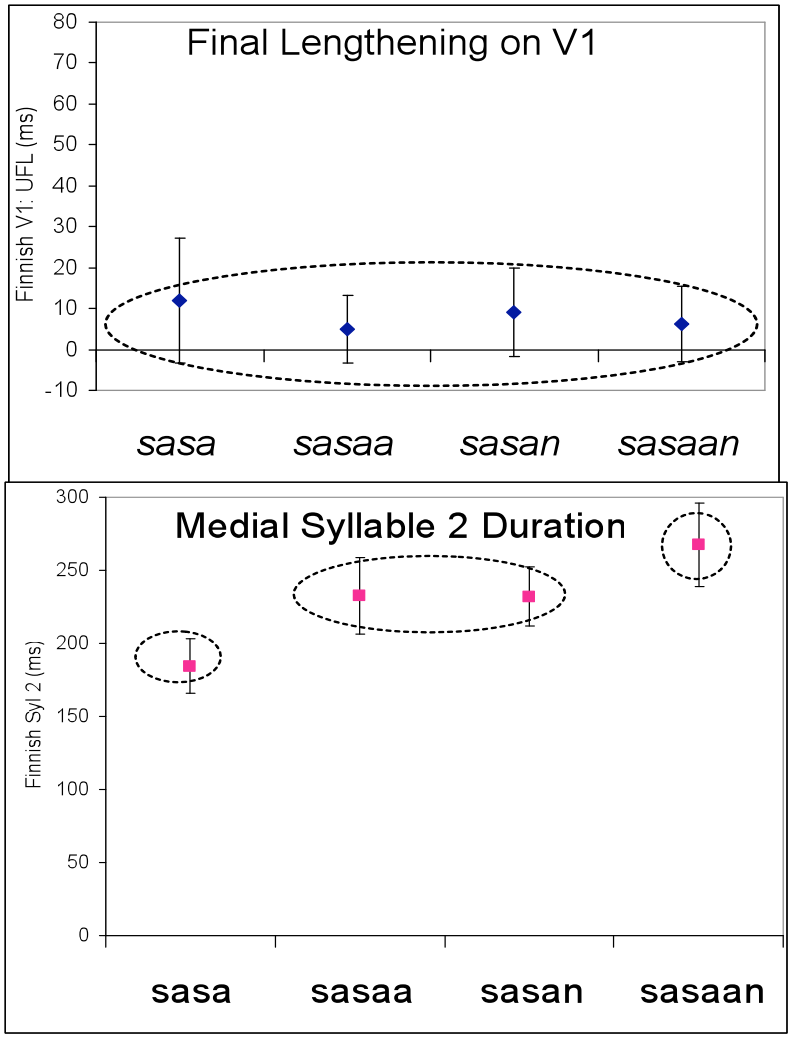
- Results do not support Pi-gesture theory
- *Saasa*, *saasaa* and *saasan* show no difference in amount of lengthening on VV1
- In spite of differences in Syl 2 duration in medial position





Pi-gesture Results: Finnish words with a short vowel in Syllable 1 (V1)

- Results do not support Pi-gesture theory
- *Sasa*, *sasaa*, *sasan* and *sasaan* show no difference in amount of lengthening on V1
- In spite of differences in Syl 2 duration in medial position



Pi-gesture Results: Japanese V1

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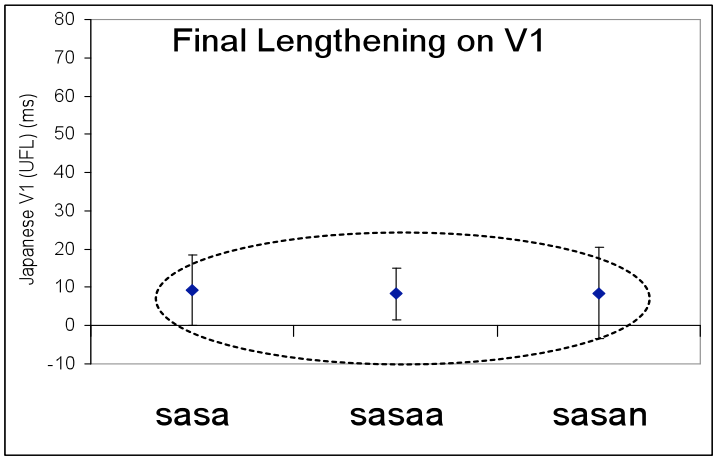
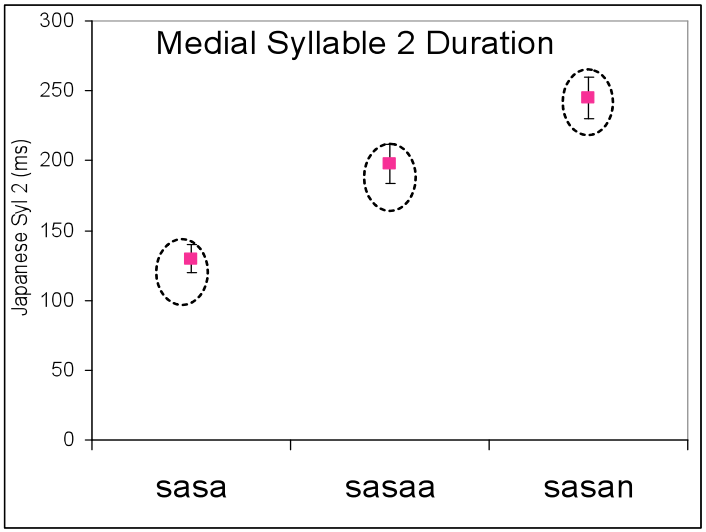




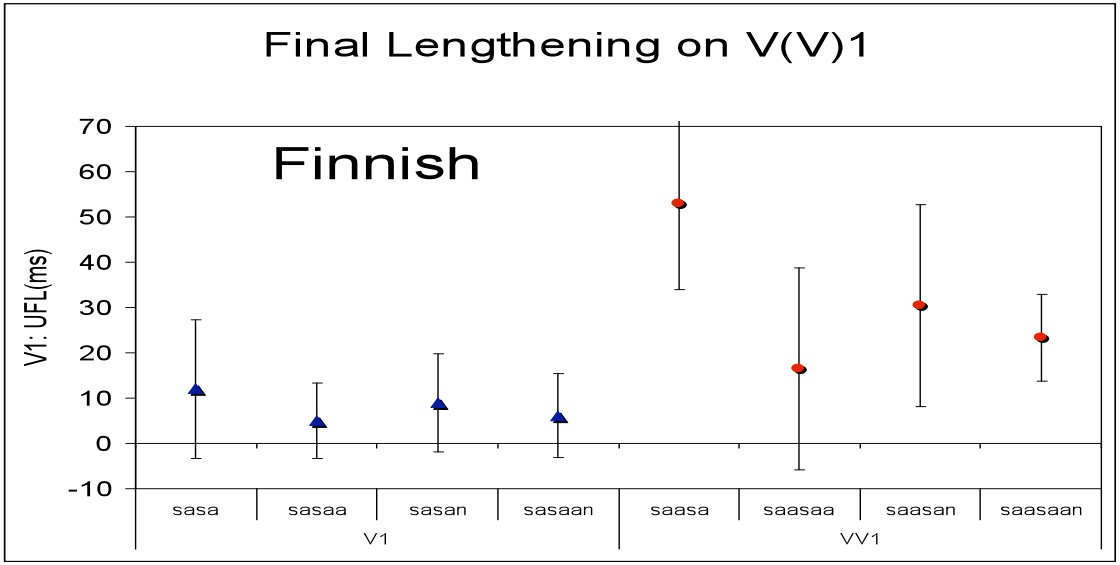
Summary: Content-based theories

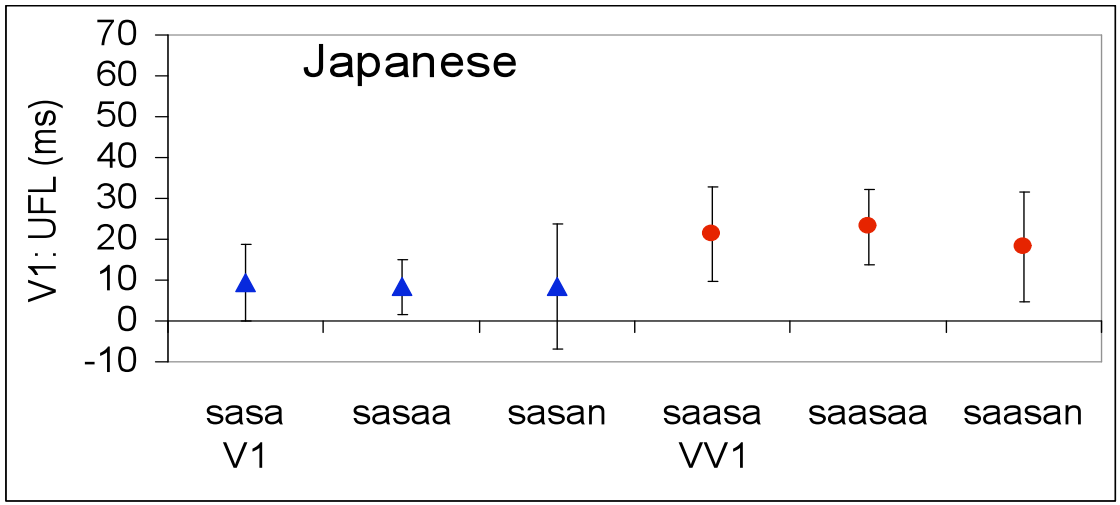
- Expandability and Pi-gesture theories are not well-supported by our Finnish and Japanese data

Alternative: Structural theory

Structural theory

- Results consistent with a structural theory that predicts final lengthening on the basis of
  - the position of lexical stress OR on word onset
  - (Significant final lengthening on lexically-prominent word-initial syllables in both languages)
  - phonological vowel length (V1 lengthened less than VV1 in absolute terms)





Details unexplained by a structural theory

- Differences in amount of final lengthening for Finnish long vowels in words of different structures
  - More lengthening of VV1 for *'saasa* than for *'saasan*, *'saasaa*, or *'saasaan*

- Subtle (10 ms) but significant lengthening on C1 in Finnish *sasa;* no lengthening on C1 for other words.

- Ideal test of a structural theory based on lexical stress position would involve words with different stress/pitch accent patterns.

Results more consistent with structural theory

- Results are more consistent with a structural theory than with content-based theories.

- Final Lengthening in Finnish and Japanese disyllabic words occurs on the nucleus of the lexically prominent syllable (also word-initial here), and on the final syllable: CV(V)CV(V)(n)
  - Similar to results for German, Am. English, Hebrew (Kohler 1983, Turk & Shattuck-Hufnagel 2007, Berkovits 1994)

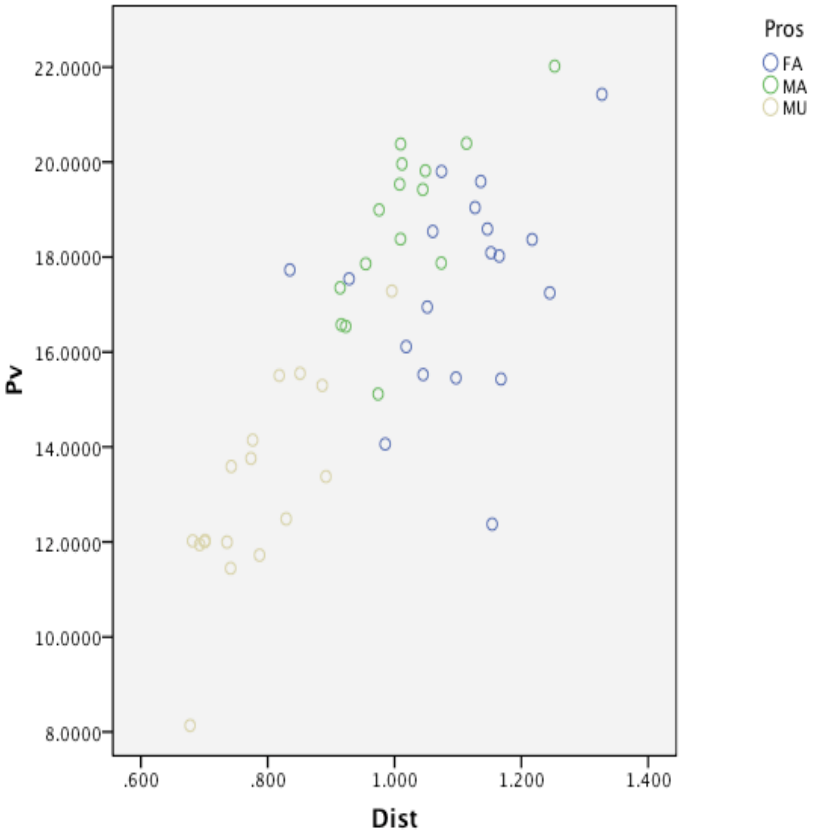
- The amount of lengthening on this syllable depends on the V vs. VV status of the syllable itself, rather than on the content of a following syllable.

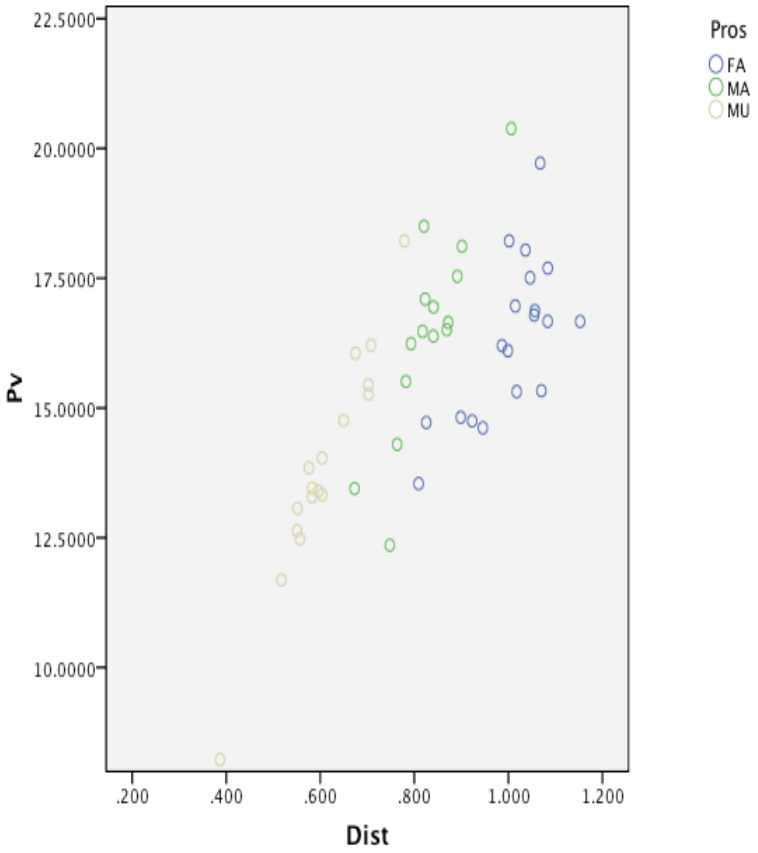
Selected References

- Byrd, D. & Saltzman, E. (2003). The elastic phrase: Modelling the dynamics of boundary-adjacent lengthening. *Journal of Phonetics* 31: 149-180.
- Cambier-Langeveld, T. (2000). Temporal marking of accents and boundaries. Doctoral dissertation, University of Amsterdam. LOT dissertation series 32.
- Peterson, G. E., & Lehiste, I. (1960). Duration of syllable nuclei in English. *Journal of the Acoustical Society of America,* 32, 693-703.

Summary

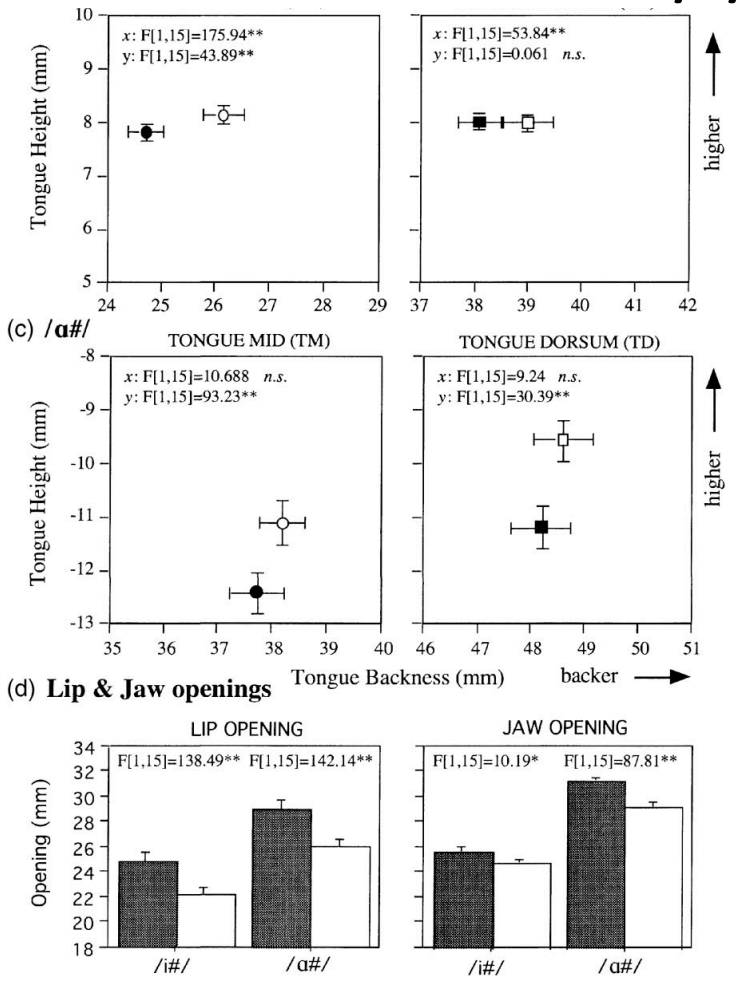
Dead same speaker





Sonority expansion and localized hyperarticulation: Cho 2005

- Accented vs. Unaccented /i/ and /a/



Cho 2005, pre-boundary vowels

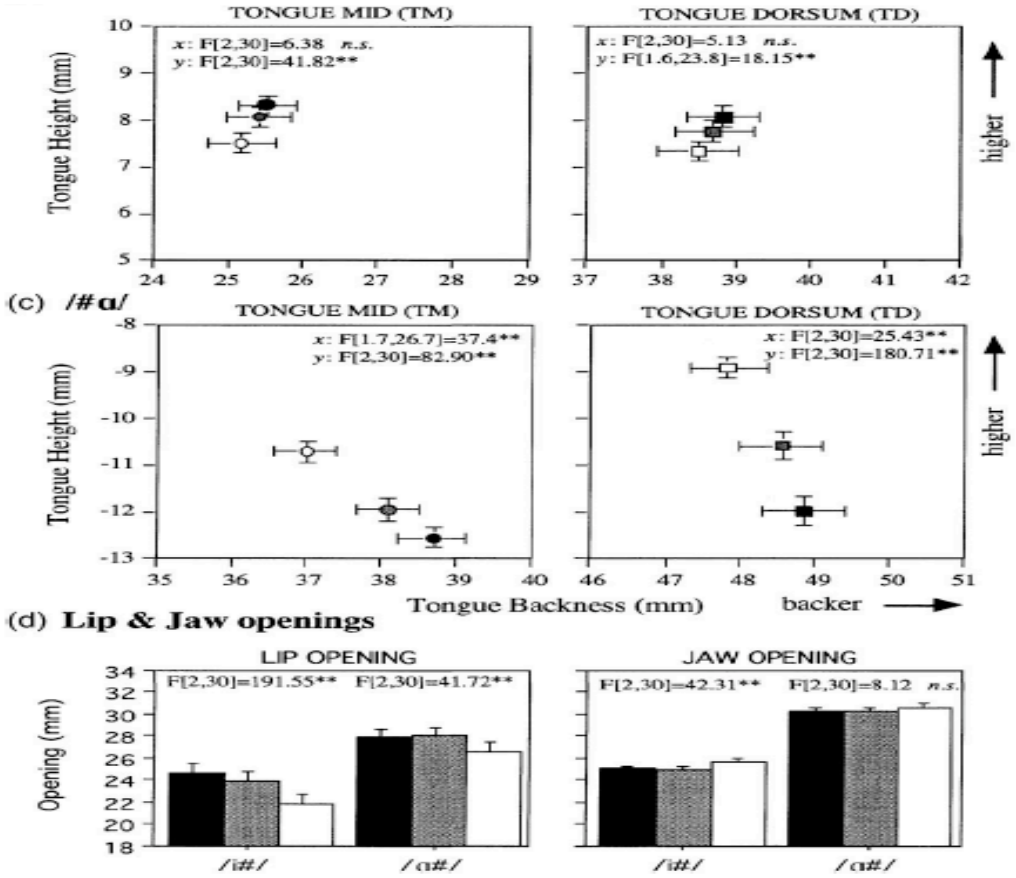


FIG. 2. Effect of Prosodic Boundary on F1 and F2 (a), the tongue maxima /i♯/ and /a♯/ (b), (c), and the lip and jaw opening maxima (d) in the domain-final position. (* refers to $p<0.01$; ** refers to $p<0.001$; $N=20$.) Note that in this case, N is 20 (5 speakers×2 accent conditions×2 accent conditions of the adjacent vowel.)

Effect magnitudes

- Example: Final lengthening in Finnish (Nakai et al. 2009):
  - Finnish Short, Long, and Half-long vowels with no difference in vowel quality
  - Comparable amounts of final lengthening on short and long vowels (computed in %), (over 50%) , depending on measurement method
  - Smaller magnitude of final lengthening on half-long vowels (to avoid confusion with long vowels?)