

# Articulatory correlates of morphologically conditioned assimilation:

## Evidence from ultrasound imaging

Bartłomiej Czaplicki<sup>1</sup> Małgorzata E. Cavar<sup>2</sup>, Paula Orzechowska<sup>3</sup>  
<sup>1</sup>University of Warsaw (Poland) <sup>2</sup>Indiana University, Bloomington (USA), <sup>3</sup>Adam Mickiewicz University (Poland)

### Introduction

- Impact of morphology on phonology:**
  - casual speech processes (Shockey 2003)
  - allophonic variation of /l/ (Sproat & Fujimura 1993)
  - palatalization (Zsiga 2000)
- Articulatory studies**
  - intergestural timing (Cho 2001, Gafos et al. 2010)
  - coarticulation in coda clusters (Song et al. 2013)
  - l-darkening (Strycharczuk & Scobbie 2016)
- Articulatory correlates of palatalization:**
  - raising and/or fronting of tongue front towards the hard palate (Ladefoged & Maddieson 1996)
  - Tongue root and dorsum advancement (Bennett et al. 2018, Cavar & Lulich 2021)
- Impact of lexical frequency on articulation**
  - more frequent words have more coarticulation/gestural overlap than less frequent words (Bybee 2000, Bush 2001)

### Instrumental Study: Method

- Tongue articulatory data was collected via real-time 3D ultrasonography, using the Philips EpiQ-7G machine and a Philips xMatrix x6-1 digital 3D/4D transducer. The ultrasound probe was stabilized under the jaw with an Articulate Instruments Ltd headset (Scobbie et al. 2008).
- Audio signals—recorded at a sampling rate of 48 kHz with a SHURE KSM32 directional dynamic microphone—were captured simultaneously with the ultrasound recordings.
- 8 native speakers of Polish, aged 23–60;
- Ultrasound files were analyzed using custom MATLAB toolbox, called “WASL”.

### Assimilation in clusters

fricative + fricative/affricate

dental /s z/ + pre-palatal /c z tʃ dʒ/

- Assimilation possibilities:
  - > two gestures = no assimilation /s z/ /tʃ dʒ/
  - > one gesture = assimilation /c z/ /tʃ dʒ/
  - > or possibly an intermediate category

### References

- Bennett, R., Ni Chiosáin, M., Padgett, J., & McGuire, G. (2018). An ultrasound study of Connemara Irish palatalization and velarization. *JIPA*, 48(3), 261–304.
- Cavar, M. E. & Lulich, S. M. (2021). Variation in the articulation of Russian stressed vowels and the mechanics of palatalization in consonants. *Phonological Data and Analysis* 3, 1–44.
- Cho, T. (2001). Effects of morpheme boundaries on intergestural timing: Evidence from Korean. *Phonetica*, 58, 129–162.
- Gafos, A. I., Hoole, P., Roon, K., & Zeroual, C. (2010). Variation in overlap and phonological grammar in Moroccan Arabic clusters. *Laboratory Phonology* X, 657–698. Berlin, Germany: Mouton de Gruyter.
- Song, J. Y., Demuth, K., Shattuck-Hufnagel, S., & Ménard, L. (2013). The effects of coarticulation and morphological complexity on the production of English coda clusters: Acoustic and articulatory evidence from 2-year-olds and adults using ultrasound. *Journal of Phonetics*, 41, 281–295.
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### Design of the study

Predictions:

- Assimilation depends on the **morphological composition** of the clusters and the **strength/transparency** of the boundary:
- the stronger the boundary, the more assimilated the C1.
- the faster the **tempo**, the more assimilated the C1.
- more **frequent** words – more assimilation than less frequent words

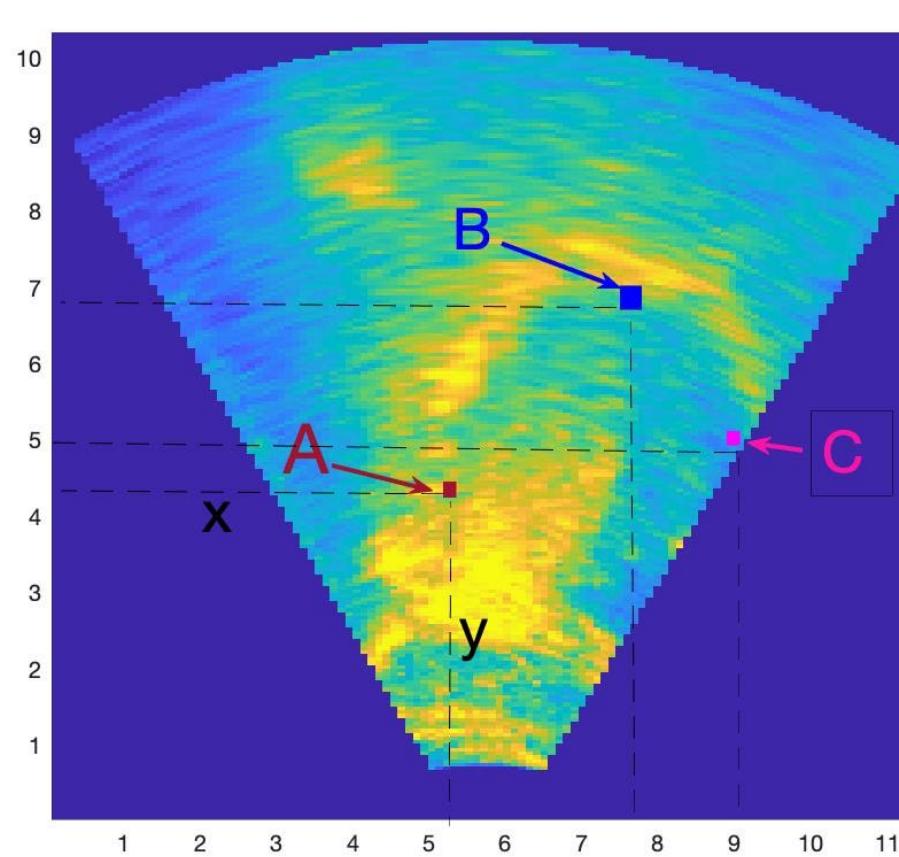
Question:

- What is the best **articulatory correlate** of palatalization for ultrasound studies?
- tongue front, tongue body, tongue root

Stimuli: 75 phrases

Procedure (1) memorize, (2) say it slowly, (3) say it fast

Carrier sentence (They said ...)

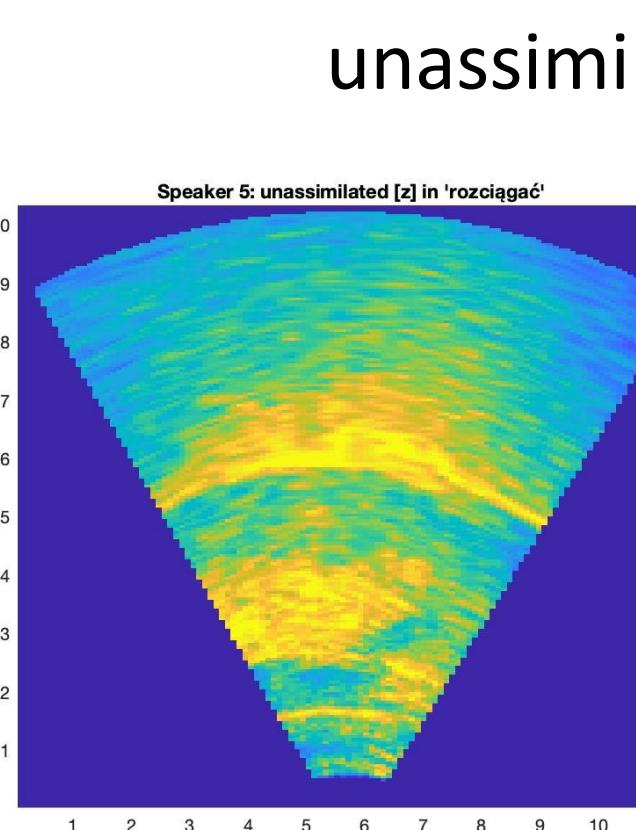


Measured points:

- the point opposite of the **tendon of the genioglossus (A)**
- the position of the **tongue body (B)**
- the frontmost position of the **tongue front (C)**.

**morphology:** Strength of morphological boundaries:

1. intra-morphemic:  
w Odessie mieszkać /sç/ 'to live in Odessa'
  2. weak morpheme boundary:  
roz+ciągliwa guma /s+tç/ 'stretchy rubber'
  3. strong morpheme boundary:  
roz++siadać się wygodnie /s+cç/ 'sit comfortably'
  4. clitic boundary:  
chleb bez ziaren /s#z/ 'seedless bread'
  5. word boundary:  
włos siwy /s#ç/ 'a gray hair'
- word frequency**  
**tempo of speech**



### Statistics

#### Linear mixed-effect regression models

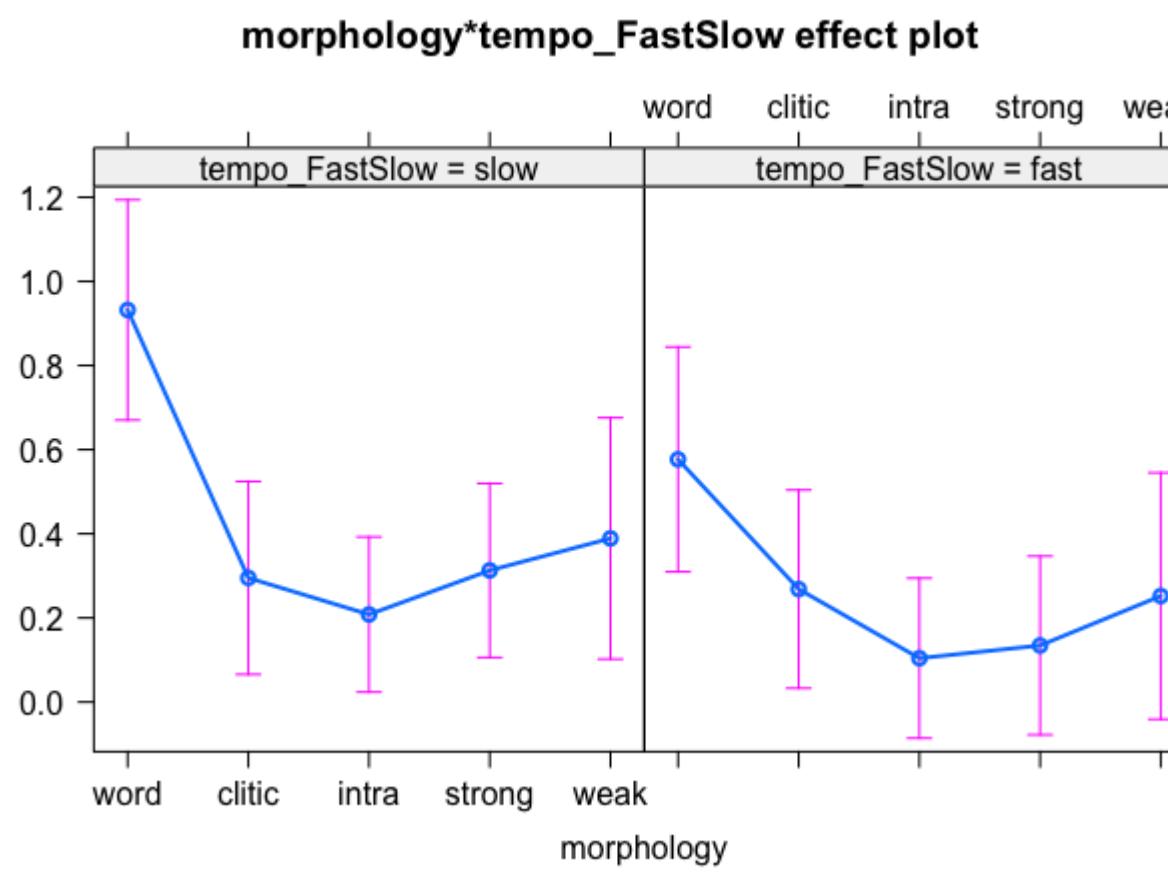
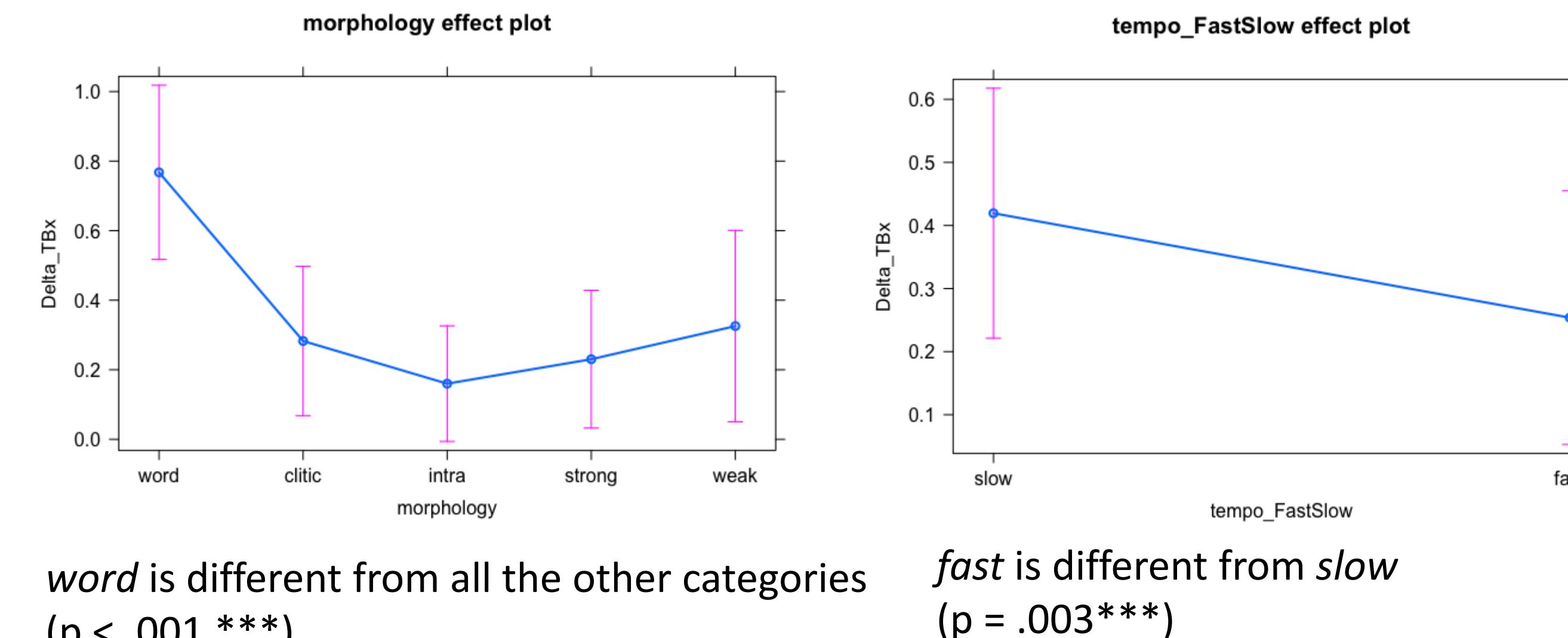
Dependent variables:  
DeltaTF, DeltaTB, DeltaTR (x and y)

Predictors:

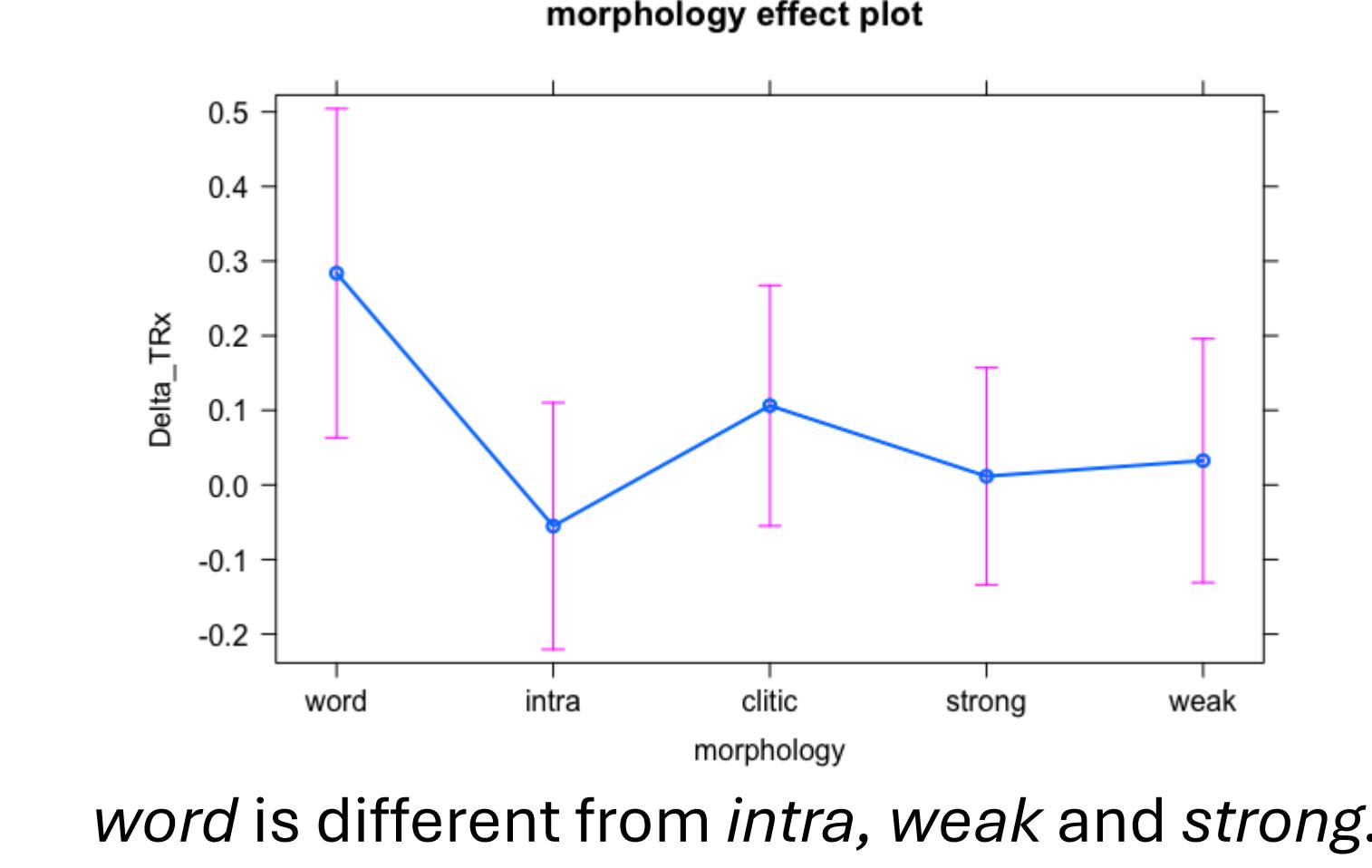
- Morphology:** word, clitic, weak, strong, intra
- Tempo (subjective):** fast/slow
- Tempo (measured):** syllables per second (target phrase)
- Frequency (categorical):** low, medium, high (corpus data)
- Frequency (continuous):** log-scaled (corpus data)
- Manner of C2
- Voicing of C2

### Results

#### Tongue Body fronting (Delta TBx)



#### Tongue Root fronting (Delta TRx)



#### The least assimilation

**Morphology:**

- Word boundaries are consistently different from all the other categories.
- Intramorphemic is different from the other categories (for tongue root fronting)

**Tempo:**

- Effects of subjective tempo (slow vs. fast)
- Effects of measured tempo (syll. per sec.) for clusters across word boundaries

**Lexical frequency:**  
no significant effects

### Conclusions

#### Articulatory correlates of palatal assimilation:

- Tongue body fronting
- Tongue root fronting

stronger and more consistent effects

