4pSC3
Modeling prosodic rhythm: Evidence from L2 speech

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Cross-linguistic rhythmic classification

- ‘Stress-timed’ vs. ‘syllable-timed’ languages (Pike 1945, Abercrombie 1967)
  - Original distinction cast in terms of ‘isochrony’; no evidence found for this basis
- Dauer 1983: Continuum of +/- ‘syllable’ or ‘stress’ timed
  - Vowel reduction: English √ , Spanish ∅
  - Syllable structure inventory:
    - Open syllables: English 44%, Spanish 70%;
    - CV syllables: English 34%, Spanish 60%
  - Correlates of word-level stress:
    - Vowels in stressed syllables 50% longer than unstressed in English, Spanish only 10%

Measurement techniques

- Measurement techniques for rhythmic classification:
  - ∆ V, ∆ C: standard deviation of vocalic, consonantal intervals (Ramus et al. 1999)
  - nPVI-V, rPVI-C: pairwise variability index is a measure of unit-to-unit variation in speech (Low & Grabe 2002)
  - Rhythm Ratio: average of the ratio of adjacent syllables (Gibbon and Gut 2001)

Measurement techniques

- Voicing ratio (VR) (Dellwo et al. 2007)

$$VR = \frac{\text{voiceless intervals}}{\text{voiced sequences}}$$

- V%: total percentage of speech that is voiced
- VCL: standard deviation of voiceless intervals
- Advantage: values generated automatically over large data set

Rhythm in L2 Speech

- L1 rhythmic influence on L2 rhythm: values between L1 and L2 (White 2007)
  - L1 Chinese, L2 English
    - nPVI-V (Low et al. 2000)
    - Δ C, %V (Lin & Wang 2005)
  - L1 Mexican Spanish, L2 English bilinguals:
    - nPVI-V values between L1 and L2 related to much lower incidence of vowel reduction in their L2English (Carter 2005)

Rhythm in L2 Speech

- English: reduced, deletes vowel more common than German
  - Reduced vowels in German occur in final syllables, inflectional morphemes
  - Results: L1English reduced/deleted vowels in L2 German at a higher rate than L1 German controls, L1Italian/Romanian at a lower rate

    (Gut 2003)
- Acquisition cue: function words generally unstressed in English; unstressed vowel as underlying property of English “stress-timed” rhythm

Rhythm and L2 acquisition

- Current study: Acquisition of prosodic proficiency in English: the rhythm connection

  – Difference between stressed and unstressed syllables is greater in English than in Spanish

  (Archibald 1993, Hayes 1989, 1995, Roca 1988, 1997)

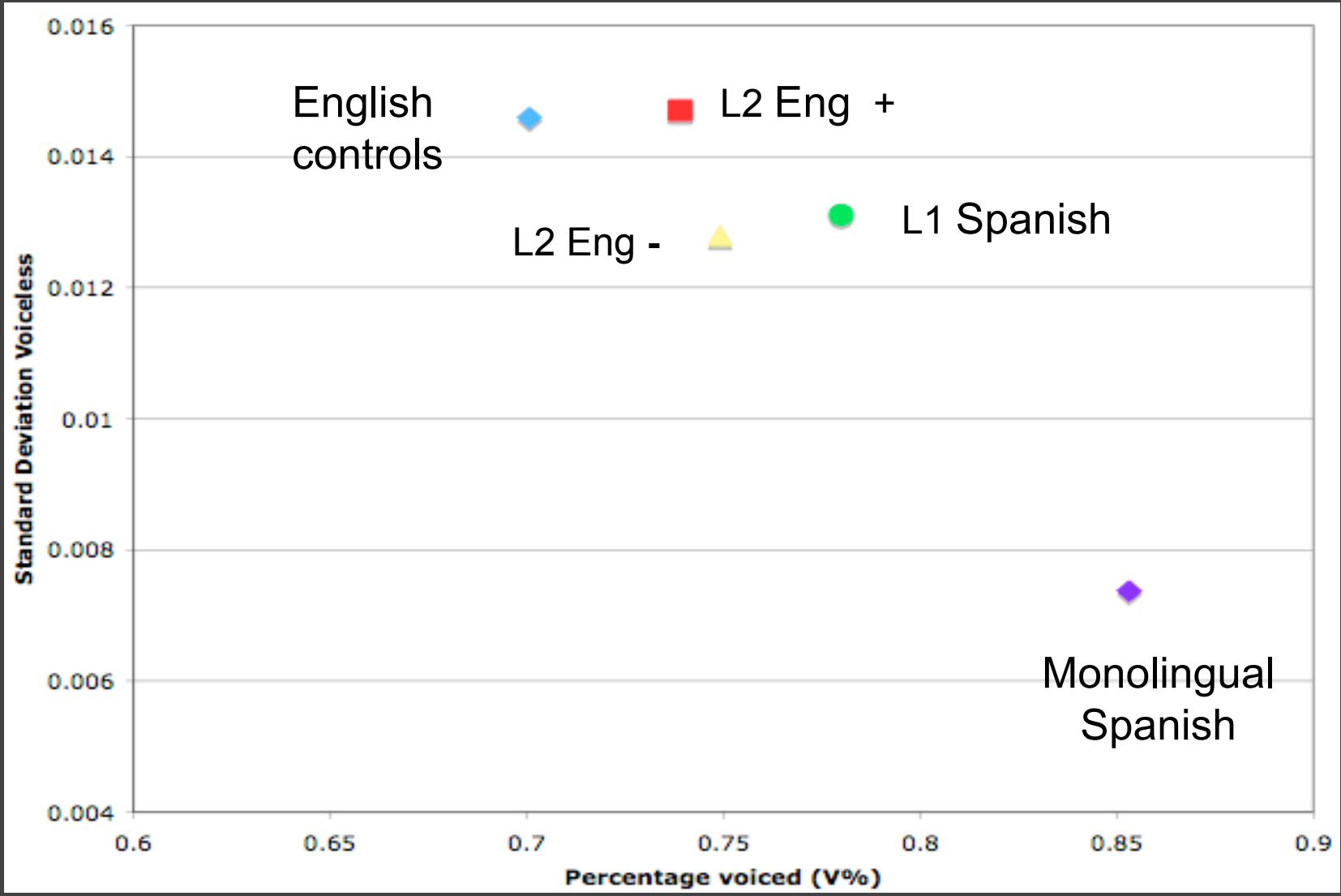
- L1Spanish/L2English speakers:

  What do native Spanish speakers learn about the foot when they acquire native-like competence in English?

Experiment 1: Rhythmic proficiency

- Stimuli: “The North Wind and the Sun” (English, Spanish)
- Participants:
  - 30 English Controls
  - 45 L1Spanish/L2 English
  - 20 monolingual Spanish
- Voicing ratio (VR = voiceless/voiced)
  - value automatically detected for each separate sentence of recorded passage
- Percentage voiced, SD of voiceless
  - V%: total percentage voiced speech
  - SD VCL: standard deviation of voiceless intervals

Experiment 1: Results V%, SD VCL



- +/- phrasal prosody: Separate experiment determined degree of English native-like prosodic proficiency

Experiment 1: Results discussion

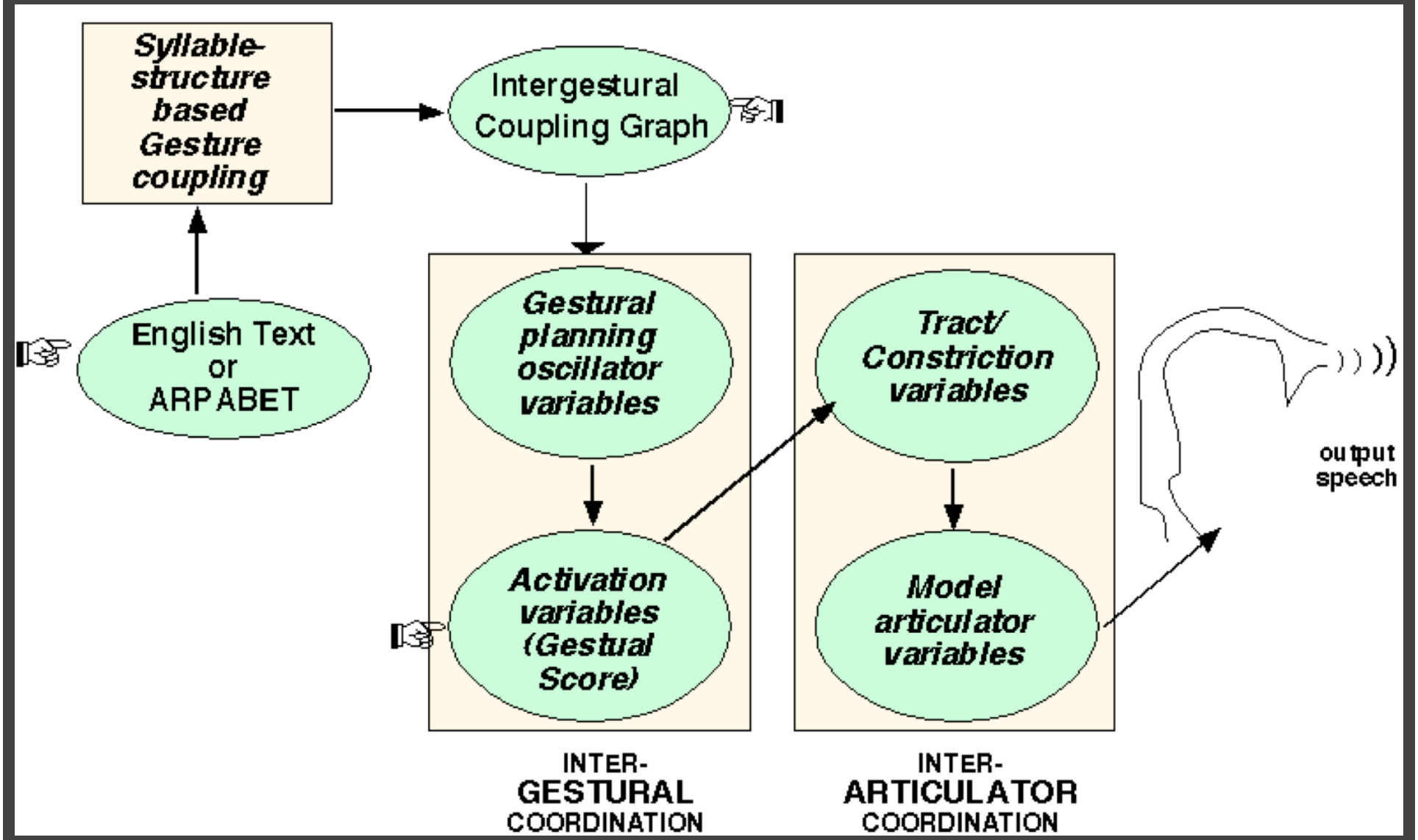
- English: lower V%,higher SD VCL
- Spanish: higher V%, lower SD VCL
- L2 results: grant insight into acquisition process, don't reveal whether acquisition of syllable level of foot level in English

- Which aspects of English-like rhythm have been acquired by L2 speakers?
- Possible answer: If learning is primarily at the syllable level, TaDA would reproduce those results

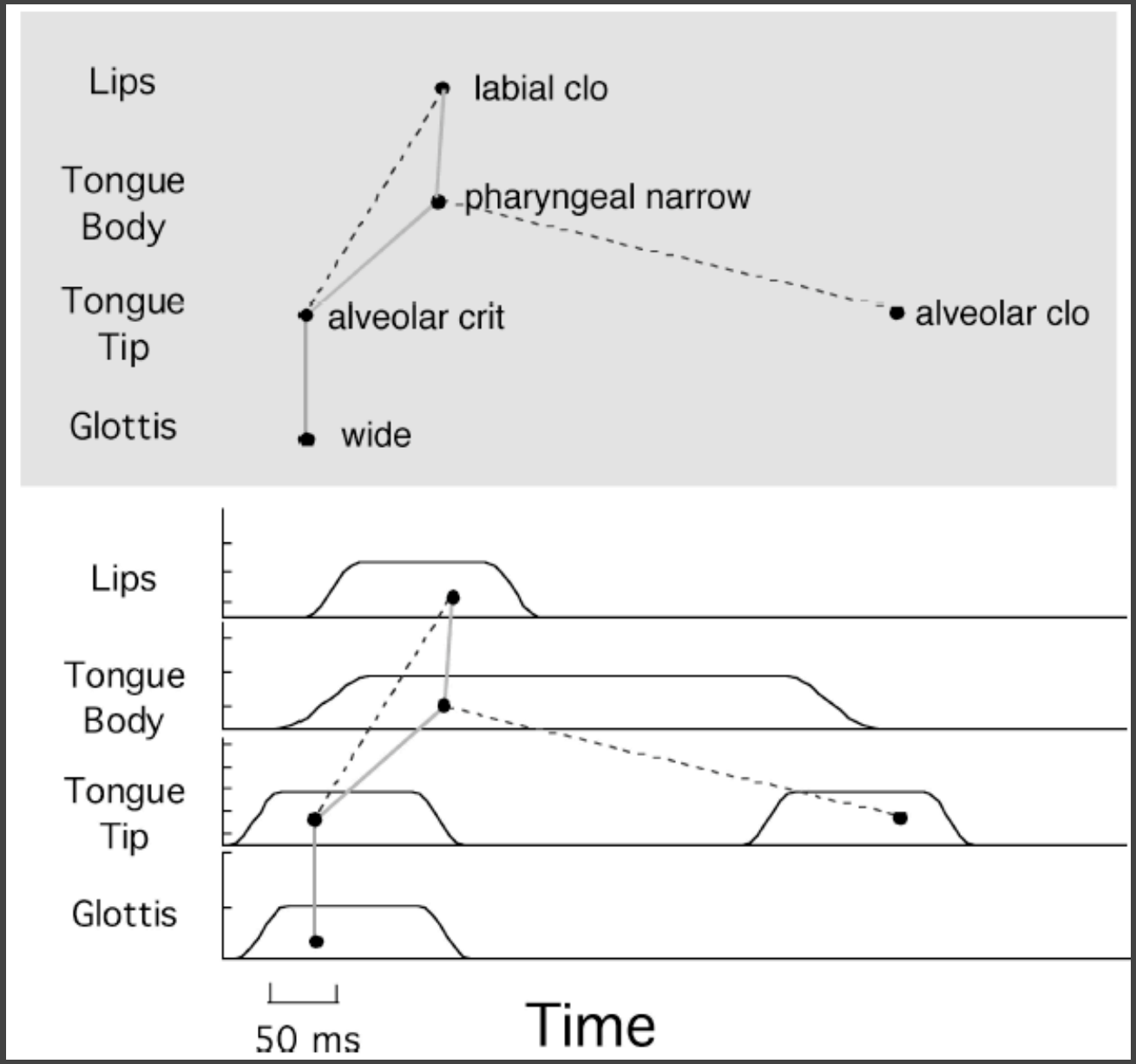
Modeling prosodic rhythm: TaDA

- TaDA: Task-dynamics model of speech production generates gestural patterning in time and the resulting acoustic output (Nam et al, 2005).
  - Current model: Incorporates knowledge about coordination for English at the syllable level (including effects of complex onsets and coda)
  - BUT aprosodic: does not incorporate temporal effects due to foot structure, so …
  - Model behaves like L2 speaker who has acquired the temporal structure of English at the syllable level but not the foot level

Information flow through TaDA



Coupling graph & gestural score: “spot”



In-phase

Anti-phase

TaDA English:

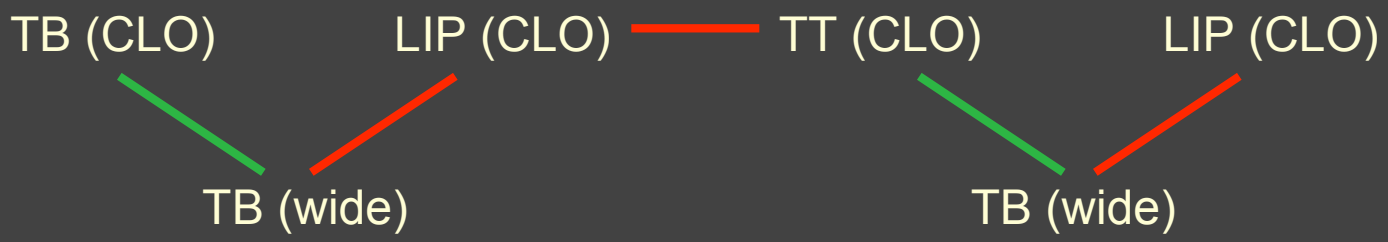
- Given English text input ⟶
  gestures taken from dictionary ⟶
  coupling graph generated

- Resulting construction has knowledge of English syllable structure, but not prosody
  - No vowel reduction in unstressed syllables

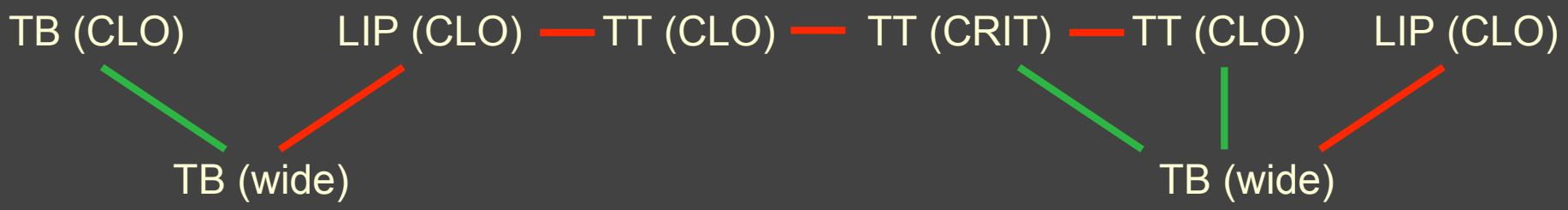
- Example: “cop top” vs. “copped stop”
  - TaDA appropriately accommodates English syllable structure: increased voiceless interval

Coupling graphs

“cop top”

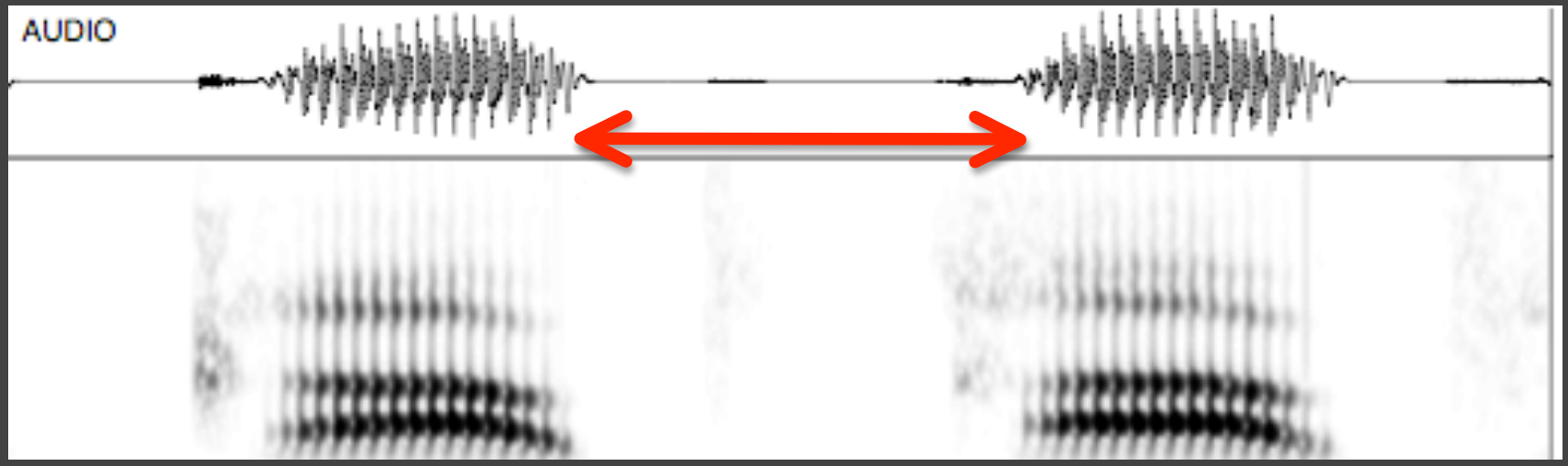


“copped stop”

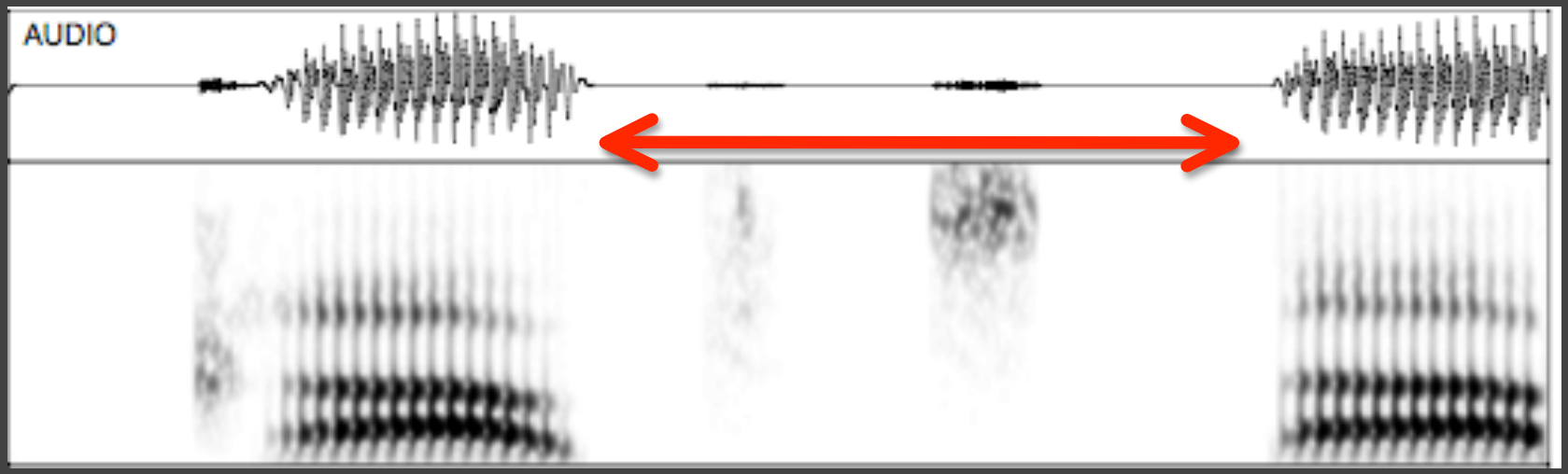


TaDA English

“cop top” VC#CV



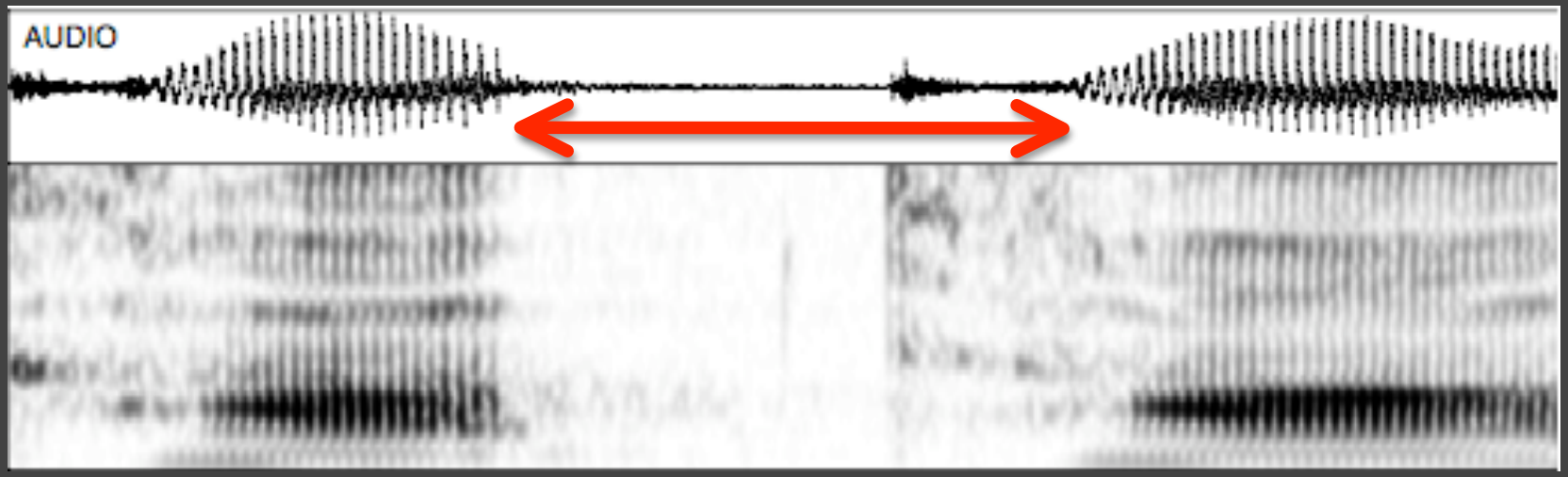
“copped stop” VCC#CCV



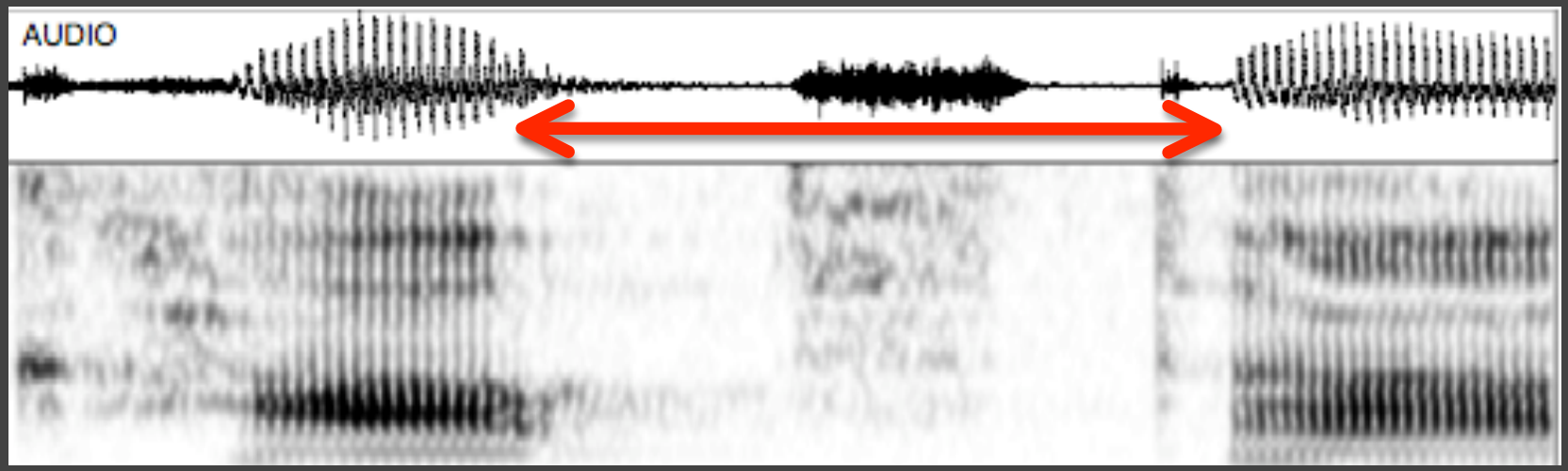
Time 680 ms

English Speaker

"cop top" VC#CV

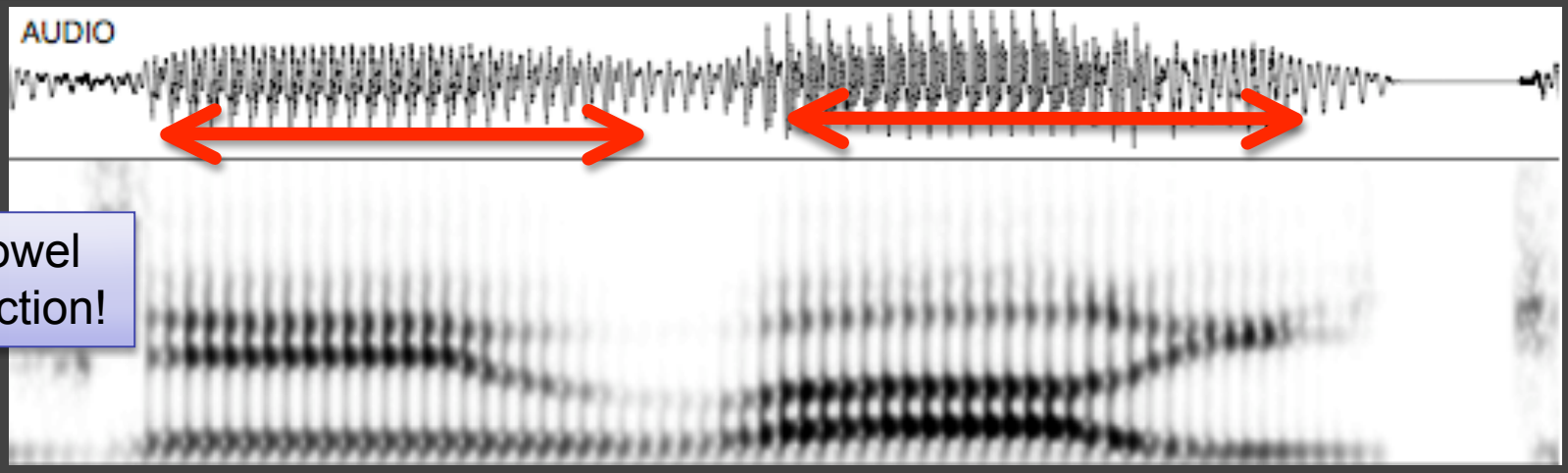


"copped stop" VCC#CCV



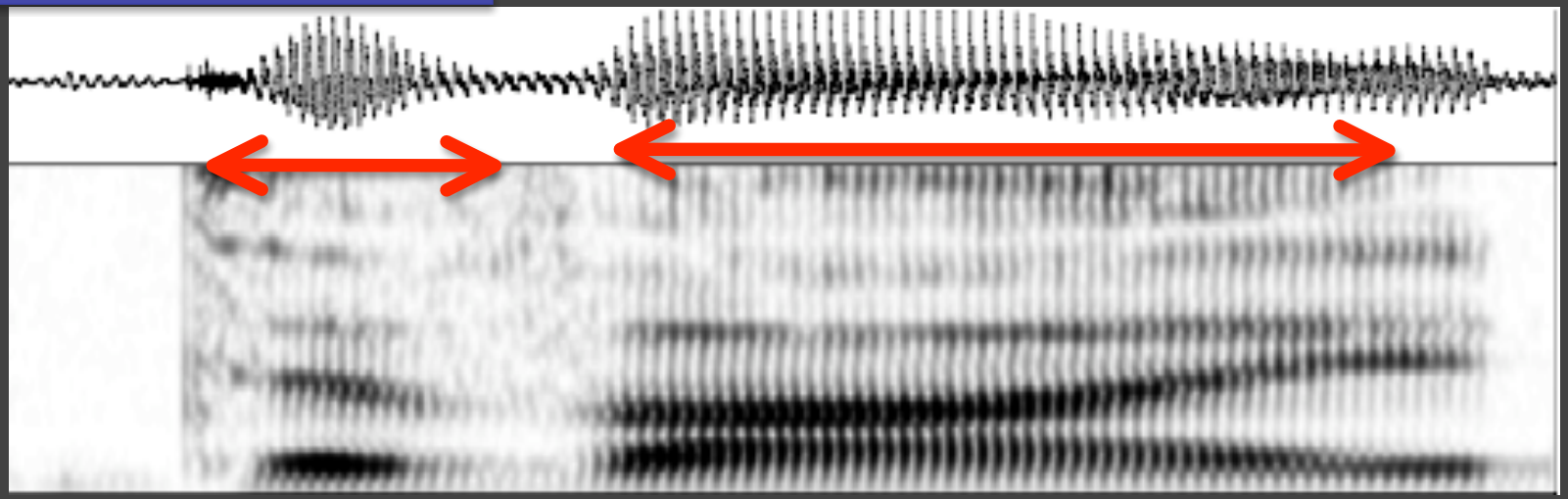
Time 680 ms

TaDA English "divide"



No vowel reduction!

English Speaker "divide"

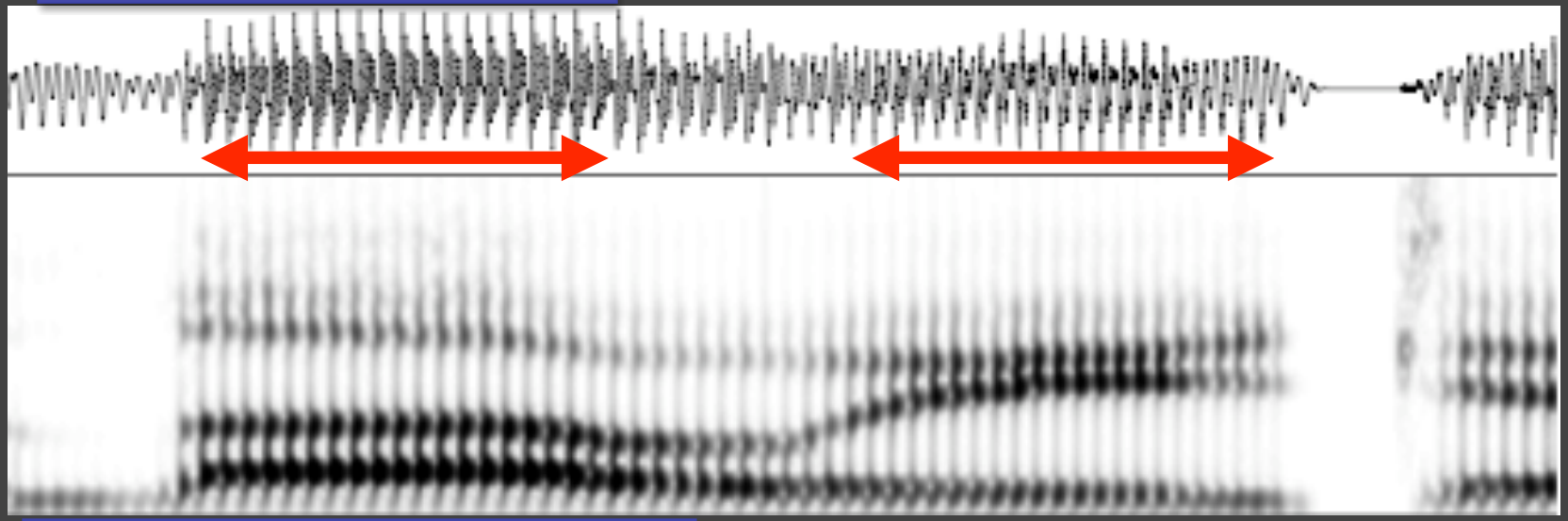


Spanish TaDA

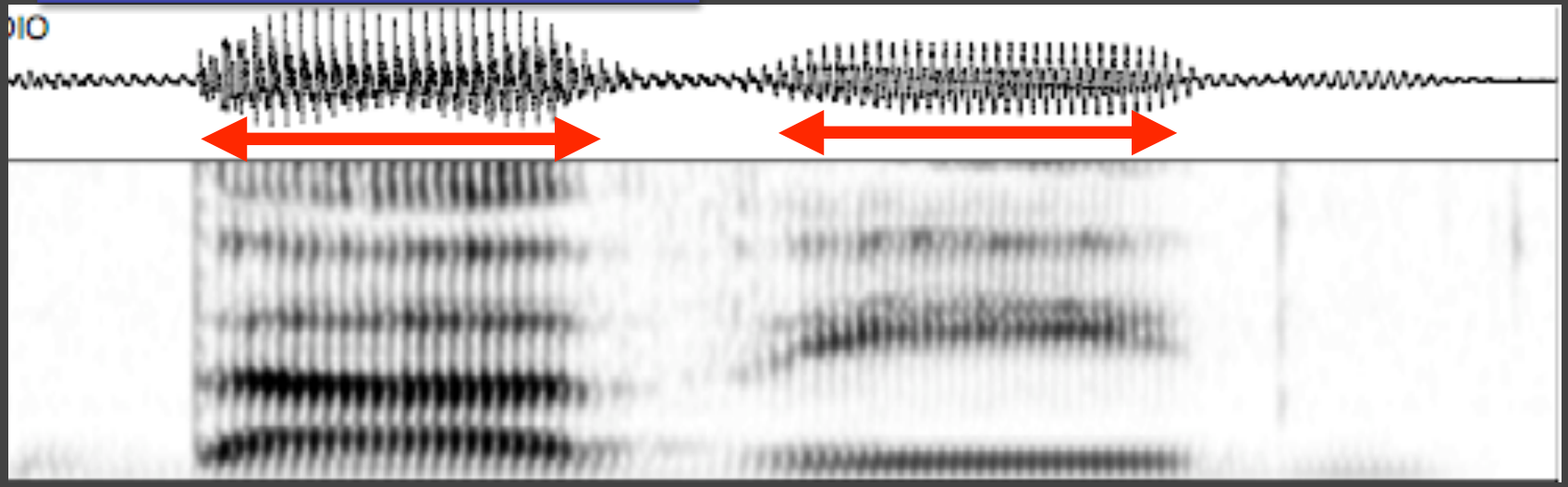
- Preliminary version of Spanish TaDA
  - Includes dictionary entries and appropriate syllable structure
- Adjustments to coupling graphs
- But NO prosody!

- Prediction for Spanish TaDA: if foot is more 'symmetric' in Spanish than in English, then Spanish TaDA should more faithfully reproduce Spanish speech

TaDA Spanish "david"



Spanish Speaker "david"

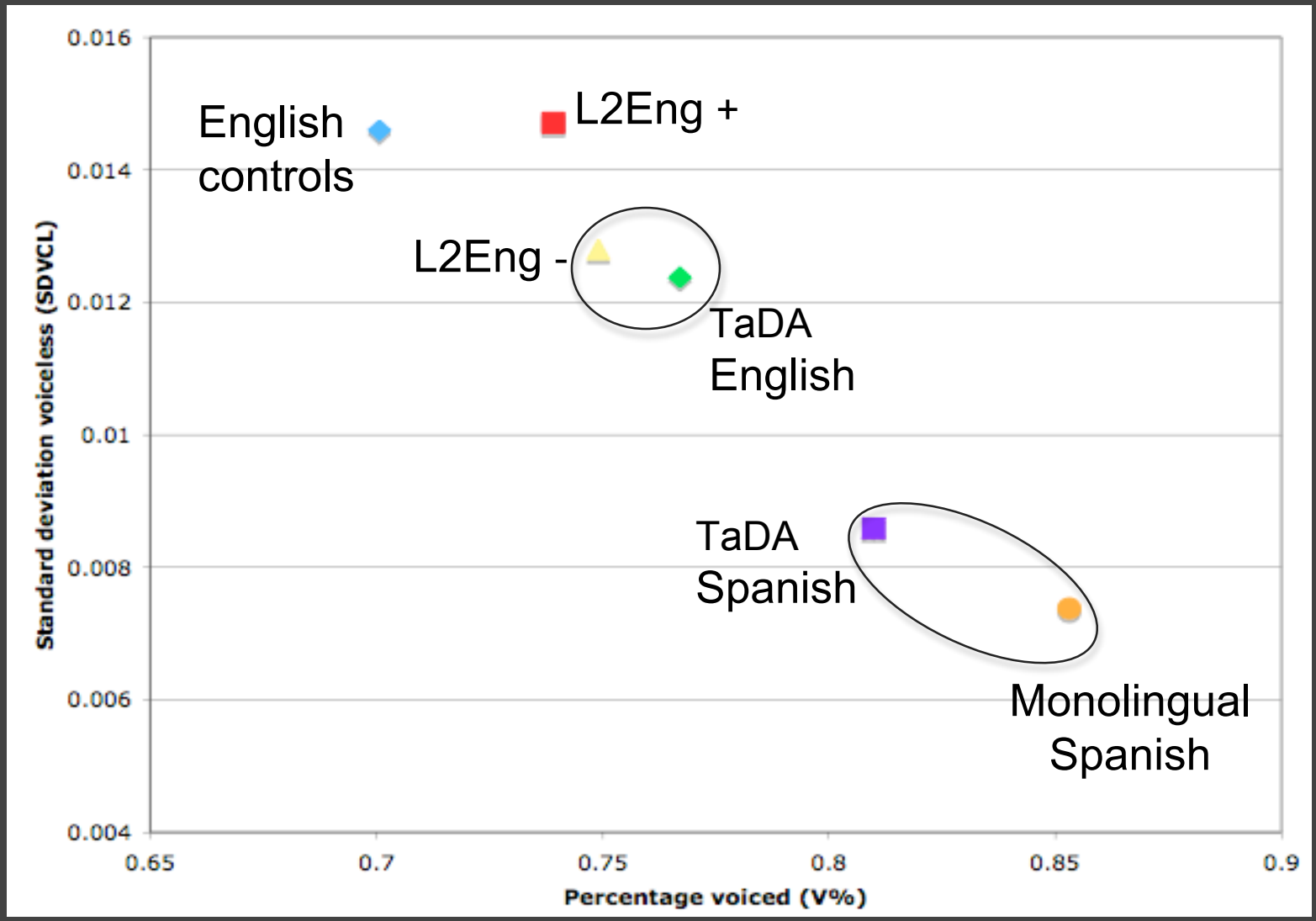


Time 600 ms

Modeling prosodic rhythm: TaDA computational experiment

- Synthesis: "The North Wind and the Sun"
  - text input to TaDA
    - English
    - Spanish
- Analysis:
  - Output acoustics analyzed using same algorithms for natural English, Spanish
    - V%: total percentage voiced speech
    - SD VCL: std dev of voiceless intervals

Modeling prosodic rhythm: Results



Results and Implications

- TaDA English and L2 English speech without native-like prosody show similar rhythm measurement
  - TaDA takes into account syllable structure but does not account for the durational differences characteristic of English foot structure
- TaDA Spanish yields results close to native Spanish
  - Appropriate syllable structure is enough; durational difference in Spanish foot not as great as in English
- Acquisition of ‘asymmetric’ foot in English essential component to native-like prosody
  - L2Eng + group has acquired foot in English, while L2Eng - has not

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