

***4pSC17:  
Influence of prosodic factors  
on segment articulations and  
acoustics in English***

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# Introduction

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- Two kinds of prosodic effects:  
Boundary-marking vs. Prominence-marking
  - **Boundaries (edges)**: beginnings and ends of prosodic domains, e.g. final lengthening, initial strengthening (Fougeron & Keating 1997)
  - **Prominences**: stresses and accents, e.g. stress lengthening, local hyperarticulation
- **Issue**: Cho (2002, in press) claims that edges and prominences are marked differently, are not the same strengthening/ hyperarticulation (**Question A**)

# Two ways that prominence and edge effects could be different

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## 1. Opposite (conflicting) effects

Prominences and boundaries could be marked on the **same** phonetic dimensions, but in **opposite** ways, e.g. prominence marked by higher values but boundaries marked by lower values

## 2. Independent effects

Prominences and boundaries could be marked completely **independently** on **different** phonetic dimensions, e.g. prominence uses one dimension while boundaries use another

# How prominence and edge effects could be the same

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## 3. Converging effects:

Prominences and boundaries could be marked on the **same** phonetic dimensions, with either

- a. Across-the-board effects of both prominences and boundaries separately, with no statistical interaction
- b. Interacting effects, e.g. a ceiling effect for total strengthening of any one syllable

## Secondary issues

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- Does the occurrence of initial strengthening depend in any way on the **location** of prominences? (Question B)
- Leaving aside edge effects and just considering two kinds of prominences, **lexical stress vs. phrasal accent**:  
When a word is accented, does the accent affect the whole word, or just the (stressed) syllable that hosts the accent? (Question C)

# Outline of current study

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Measure **initial strengthening** of C and V in CV along several phonetic dimensions while varying two prominence factors (Stress and Accent)

- Test Cho's claim that initial-edge and prominence effects are different (**Question A**)
- Test for dependencies between initial strengthening and prominences (**Question B**)
- Test for dependencies between the prominences themselves (**Question C**)

# Methods:

## Prosodic factors tested

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- Two boundary-related positions
  - Word-initial (=Utterance-medial)
  - Utterance-initial
- Two prominences
  - Lexical primary-stress (vs. secondary-stress)
  - Focal pitch accent (vs. no accent)

# Methods: Corpus

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- 3-syllable words, but we look only at the initial CV syllables
- 4 factors, fully crossed
  - Consonant (n, t): nebəben vs. tɛbəbet
  - Stress: 'ne**bə**,ben vs. ,nebə'ben
  - Accent (focused vs. unaccented)
  - Boundary in a 3-word sentence :  
nebəben fed them vs. one deaf nebəben



## Example test utterances

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- 'nɛbəβɛn fed them
- nɛbə'βɛn fed them
- tɛbə'βɛt fed them
- one deaf 'tɛbəβɛt
- one deaf nɛbə'βɛn

(where ' = stress, underline = accent)

# Methods:

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- Speakers

- four American English speakers
- one male and three female phoneticians
- the women were the 3 subjects in Fougeron & Keating (1997); one was the first author

- Recordings

- total 15 repetitions of each sentence from 3 speakers, 10 or fewer from 1 speaker
- items repeated if prosodic pattern not produced, e.g. if intermediate phrase boundary occurred mid-utterance

# **Methods:**

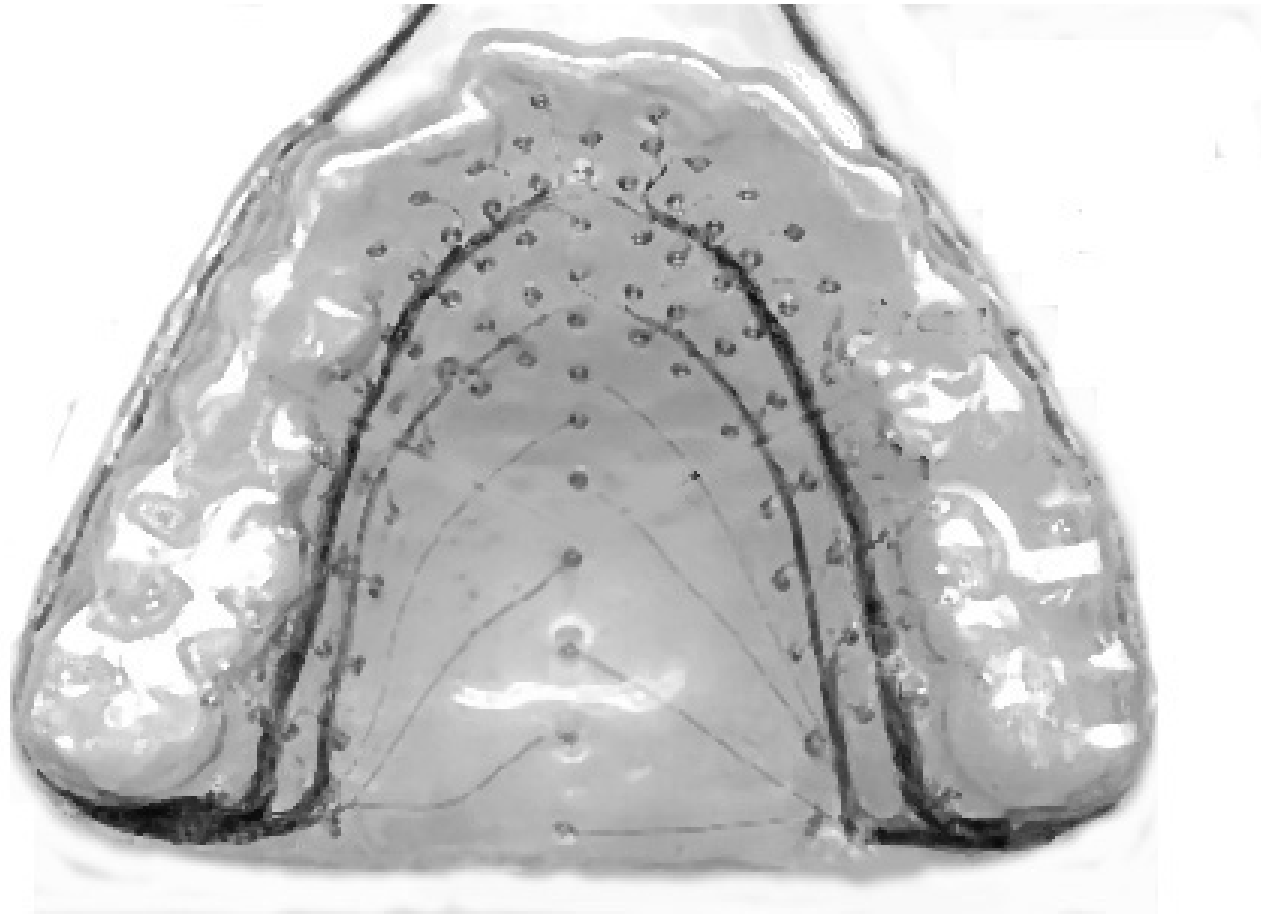
## **Electropalatography (EPG)**

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- Speaker wears a false palate embedded with 96 contact electrodes
- When tongue touches electrodes, a circuit is completed and contact is registered
- Computer samples contact over entire palate every 10 msec
- A single frame of data shows how many electrodes contacted, and where

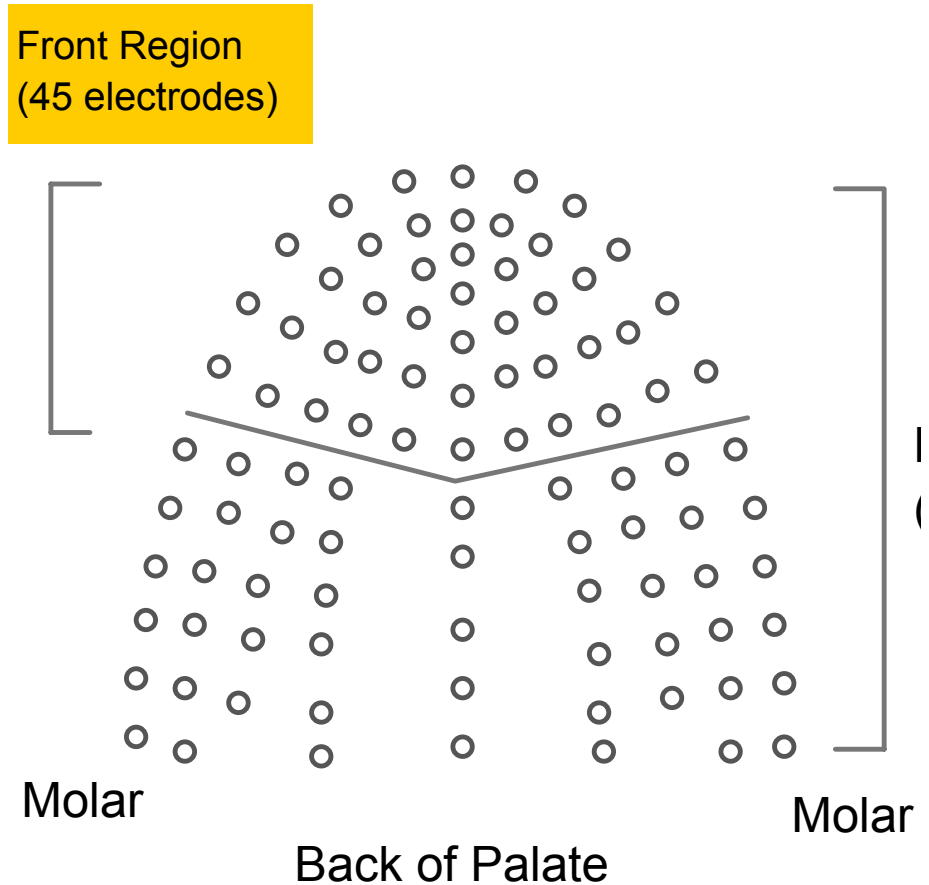
# Pseudo-palate for EPG

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# Analysis: Regions of linguopalatal contact

- For consonants, analysis region of 45 electrodes in the front region of the palate →
- For vowels, entire palate



# Analysis: Linguopalatal contact measures

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- C seal duration (as in our earlier studies)
- C peak contact (as in our earlier studies)
- C contact at acoustic release (perhaps more relevant perceptually than peak contact)
- Vowel contact at peak amplitude
- C-to-V maximum contact difference

# Acoustic measures for:

## C

## and

## V

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### ● For /n/:

- Nasal duration
- Nasal energy

### ● For /t/:

- VOT
- RMS burst energy
- Center Of Gravity (COG) of burst spectrum

### ● For /ε/:

- Duration
- Peak Amplitude
- F1 at peak amplitude

## Statistical analysis

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- Basic analysis was RM ANOVA, averaging repetitions within speakers, trend  $p < .08$
- Posthocs based on repetitions,  $p < .01$
- Error bars in graphs are standard error



# Overview of main effects:

## Position vs. Prominence

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- |   |   |                                 |
|---|---|---------------------------------|
| • More C contact                              | ↔ | • Same C contact                |
| • Same V contact                              | ↔ | • Less V contact                |
| • Greater CV contact difference               | ↔ | • Greater CV contact difference |
| • More V amplitude                            | ↔ | • More V amplitude              |
| • Same V F1                                   | ↔ | • Greater V F1                  |
| • Longer /t/ VOT                              | ↔ | • Same /t/ VOT                  |
| • Same /n/, V duration                        | ↔ | • Longer /n/, V duration        |
| • Longer C contact (trend)                    | ↔ | • Longer C contact              |
| • Less /t/ energy,<br>less /n/ energy (trend) | ↔ | • More /n/ and /t/ energy       |
- effects: opposite independent converging

# Main effects and interactions: do entries line up in same rows?

MEASURE	Main effects	Main effects	Main effects	Interactions
C peak contact	BOUNDARY			
C release contact	BOUNDARY			Bound x Str
C seal duration	BOUNDARY trend	STRESS		Bound x Str x Acc
/n/ nasal duration		STRESS	ACCENT	Bound x Acc x Speak
/n/ nasal energy			ACCENT	Bound x Str x Acc
/t/ VOT	BOUNDARY			Bound x Acc
/t/ burst energy	BOUNDARY		ACCENT	
/t/ burst COG		STRESS	ACCENT	
V min contact		STRESS		Bound x Str x Acc x Cons
V peak F1		STRESS	ACCENT	Bound x Str x Cons trend
V duration		STRESS		
V energy	BOUNDARY	STRESS trend	ACCENT	Bound x Str
CV contact difference	BOUNDARY	STRESS		Bound x Str x Acc

effects: **opposite** **independent** **converging** **mixed**

# Boundary and prominence effects are different

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1. When they affect the same dimension in opposite ways (**conflicting**)
2. When they affect different dimensions (**independent**)

# Re #1: Boundary and prominences can conflict

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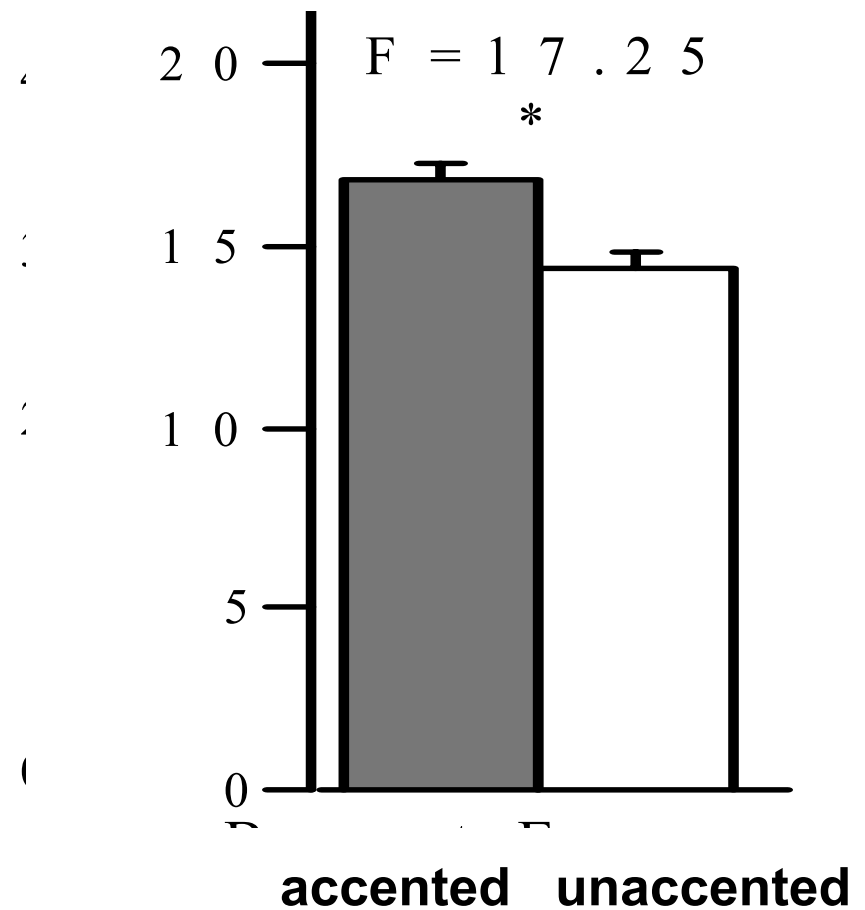
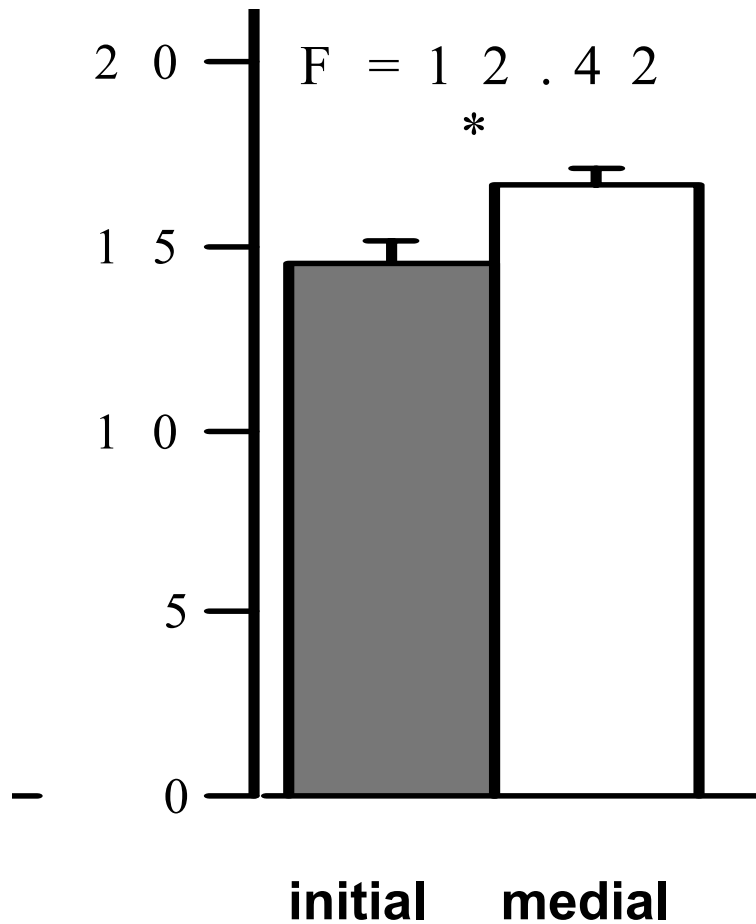
- /t/ burst energy

- Is **lower** in initial position than in medial
- Is **higher** when accented

- /n/ nasal energy

- Is sometimes **lower** in initial position than in medial
- Is **higher** when accented, primary-stressed

# **/t/ burst energy conflict:** **Boundary vs. Accent**



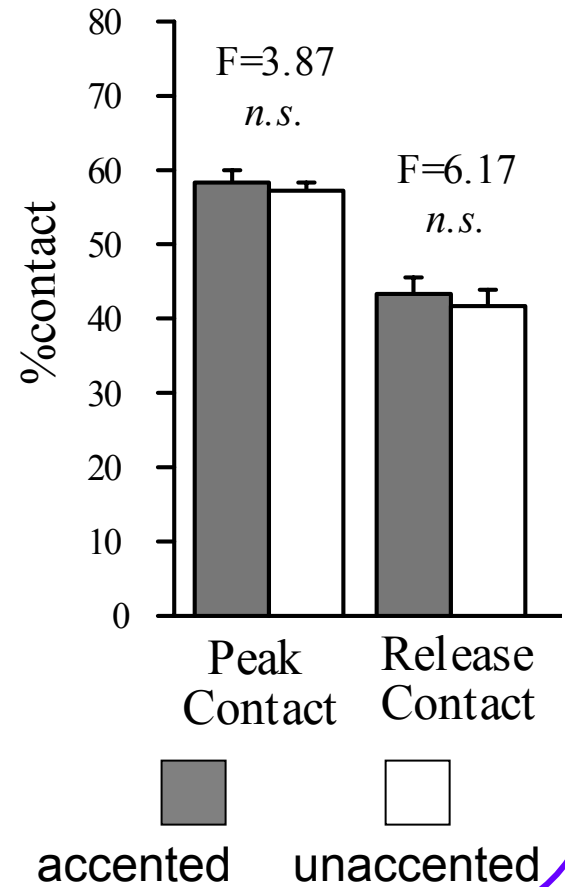
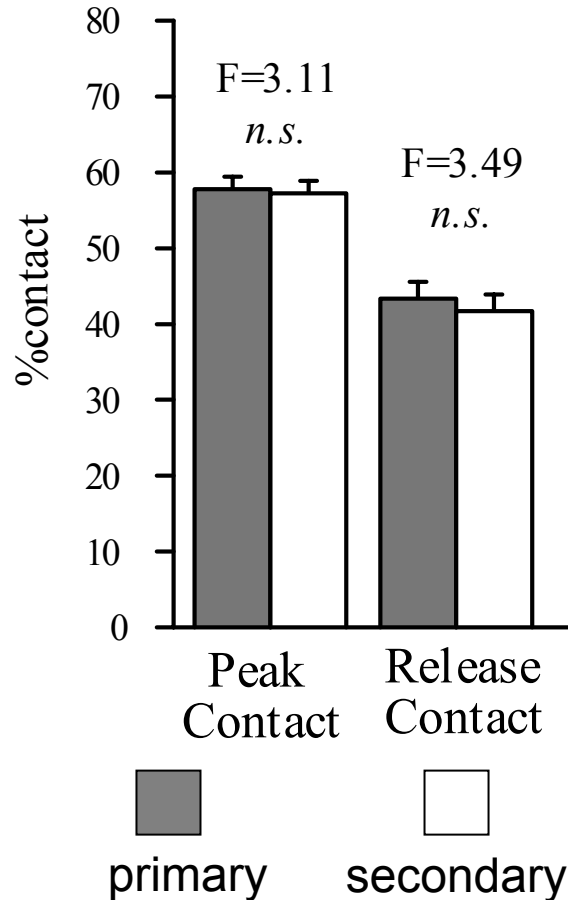
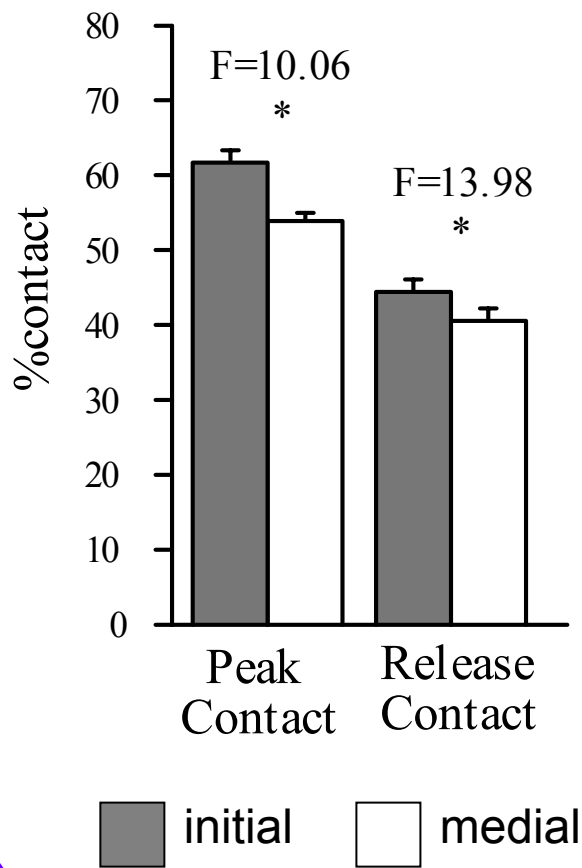
## Re #2: Boundary and prominences can be independent

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- C peak contact: affected only by Boundary
- V duration: affected only by Stress
- /t/ burst COG: affected only by Stress and Accent

(main effects, no interactions)

# C contact measures with boundary, stress, accent



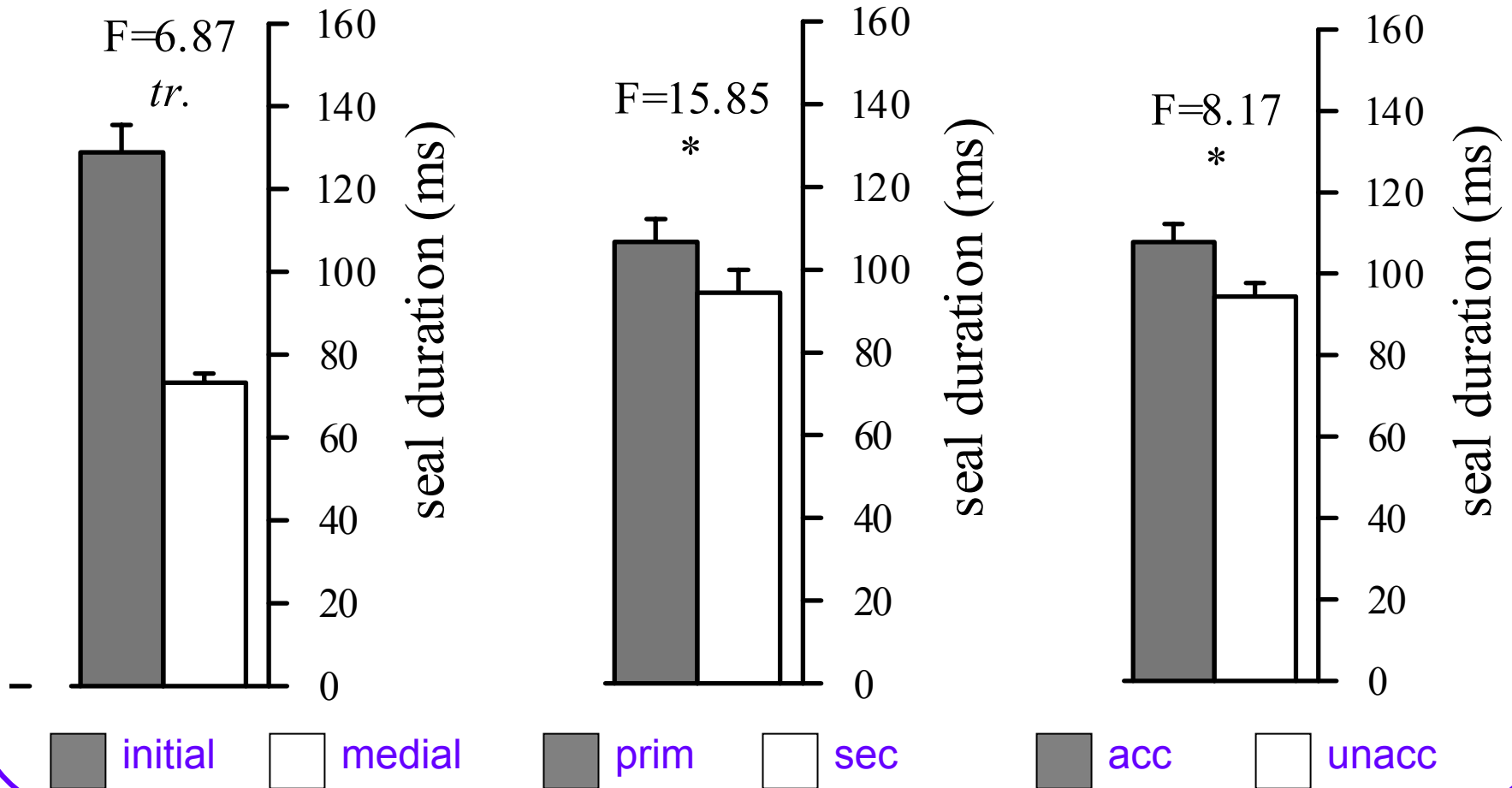
## Effects can also converge on the same dimensions

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- C seal duration: Lengthening of **consonants** occurs in all strong positions, especially **primary-stressed** but also to some extent **initial** or **accented**



# C seal duration with boundary, stress, accent



## Some effects that look converging, but probably aren't

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- C-V contact difference: larger both when **initial** and when **primary-stressed**, but this is because effects on C and V contact are largely **independent**
- V energy: greater especially when **initial**, but to some extent also when **accented/stressed**;

**BUT** initial V, unlike accented/stressed V, is *not* more *open*; could its greater energy come from the voice source (as in Epstein 2002)?

## Some mixed effects

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- /n/ nasal duration
- V contact
- V F1

All combine **opposite** and **converging** patterns, either across speakers or across conditions

# Discussion, Question A

## Boundaries vs. Prominence:

### Independent effects

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- **Initial strengthening** is more about having a more constricted initial **consonant** with more aspiration
- **Prominence** is more about having a more open, longer, louder **vowel**

## **Boundaries vs. Prominence: Opposite effects**

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- Initial strengthening **decreases** C energy measures
- Prominence **increases** C energy measures

## **Question B: Location of initial strengthening tied to prominences?**

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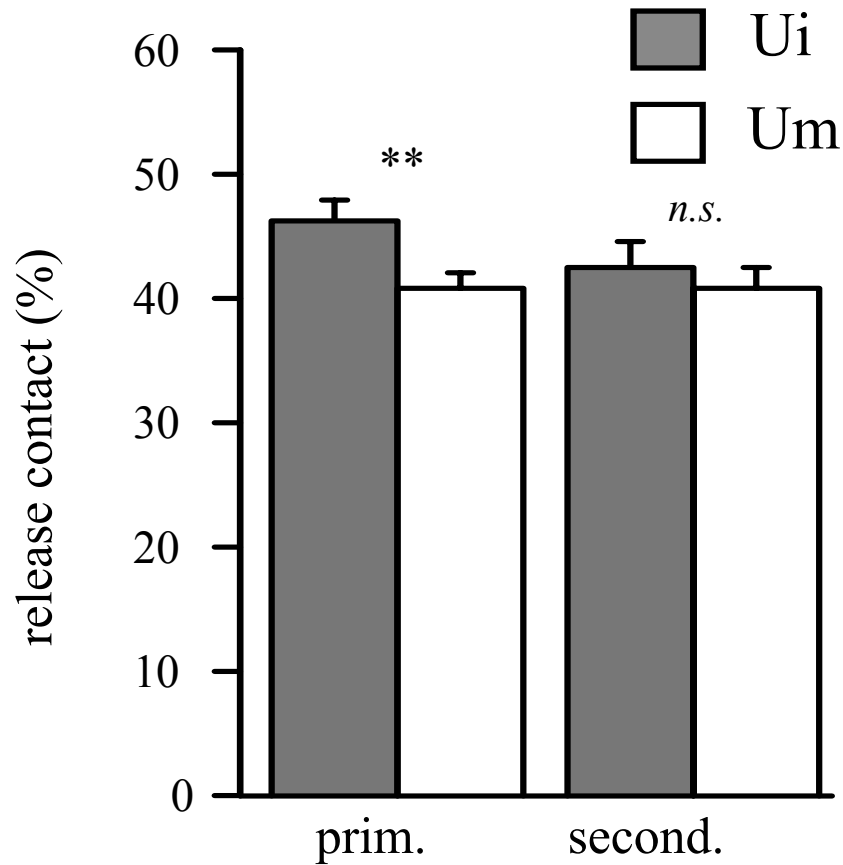
- If initial strengthening is part of a larger system of making some parts of an utterance more prominent, we might expect it to occur preferentially with already-prominent parts of an utterance: **stressed syllables and/or accented words**

## Only one clear effect like this

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- Initial strengthening of **C** release contact occurs only when *primary-stressed*
- Not a converging or ceiling effect
- ALSO **/t/ VOT** shows initial strengthening only when *unaccented* – not a ceiling effect - unexpected!

# Stress-dependent C release contact



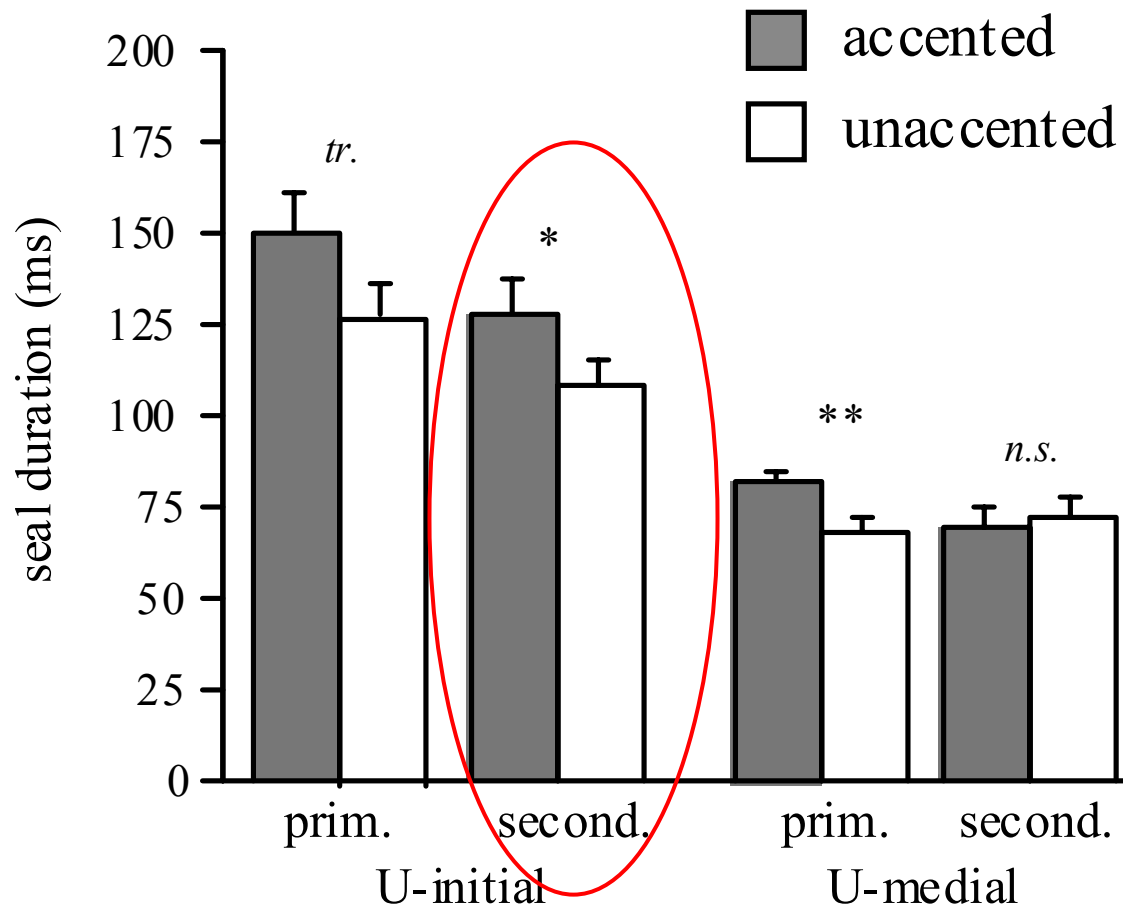


## Question C: Is the domain of accent the stressed syllable, or the word?

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- Most measures, especially **V measures**, showed accent limited to primary-stress syllables
- Some **/t/ measures** (seal duration, COG, **VOT**) show a whole-word accent effect on the initial syllable of words with final stress (i.e., the initial /t/ in ***tɛbə'bet*** reflects an accent on the word)

# Accent across stress levels



## Conclusions

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- **Question A:** Boundaries and prominences were articulated differently on several phonetic dimensions, with boundary effects seen more in consonants and prominence effects more in vowels

## Conclusions

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- **Question B:** Initial strengthening not much tied to the prominence system
- **Question C:** Accent generally limited to primary-stressed syllables, but some phonetic dimensions reflect accent through the word

## Selected references

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- Cho, T. (2002). *The Effects of Prosody on Articulation in English*. New York: Routledge.
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