

**Prosodically-induced Acoustic  
Variation**

**in**

**English and Korean:  
Adult-directed speech vs.  
Child directed speech**

**Hansook Choi**

**Michigan State University**

# **Acoustic Variation**

- ✓ **Characteristics of Sounds**
- ✓ **Prosodic factors**
- ✓ **Contextual factors**
- ✓ **Language inventory systems**

# Prosodic Effects

- **Accent**

- Accent has a lengthening effect in a broad domain that exceeds the accented syllable nuclei (Turk & Sawusch, 1997; White, 2002).
- Vowels show greater opening of the vocal tract under stress: “**Sonority Expansion**” - Beckman *et al.* ('92)
- Accented segments are produced with more extreme articulatory movement: “**Local Hyperarticulation**” - De Jong ('95)

- **Domain-Final Lengthening**

- Longer acoustic or articulatory duration in the final position of some domains – final rhymes ( Klatt, 1976; Wightman *et al.*, 1992; Turk and White, 1999; etc).
- Greater articulatory movement which is more extreme domain-finally (Edwards *et al.*, 1991; Fougeron & Keating, 1997; Cho, D., 2001). Still, in controversy (Beckman *et al.*, 1992)

# Prosodic Effects

- **Domain Initial Strengthening**

- Greater linguopalatal contact for the segments in domain-initial position (Fougeron & Keating, 1997; Cho, T. 2001).
- VOTs in domain-initial positions are greater than in domain-medial position, and the increase is proportional to the level in a prosodic hierarchy. (e.g., Jun, S. 1993; Pierrehumbert and Talkin, 1992)
- Larger glottal opening gesture (Pierrehumbert and Talkin, 1992) and greater airflow in the domain-initial position (Cho & Jun, 2000).

- **Accent vs. Boundary (not identical in the effects)**

- Accents induce durational increase, faster and larger movement and consistent expansion of displacement of accented C & V.
- Segments at boundary are produced not necessarily faster or larger movement and show more localized expansion of displacements (Domain-initial Cs and domain-final Vs)

# Effects of Contrast system

- Variation due to language specific phonological sound inventories  
:Correlation between the phonological inventories and the corresponding phonetic variations (Magen, 1984; Manuel, 1990; Manuel & Krakow, 1984)
- Prosodically conditioned strengthening => enhancement of linguistic contrast
  - Syntagmatic contrast (C vs. V)
    - Sonority expansion.
    - Strengthening at edges of domains.
  - Paradigmatic contrast ( $C_1$  vs.  $C_2$ ,  $V_1$  vs.  $V_2$ )
    - Hyperarticulation.
    - VOT patterns in Korean & Taiwanese.

# Child-directed speech (CDS)

- Marked prosodic patterns in CDS
  - higher pitch, more variable pitch change, and exaggerated stress
  - A tendency to pronounce labels for objects more distinctly
  - General agreement on the pattern that CDS provides enhanced distinctiveness:
    - Segmental contrast
    - Difference in prosodic structures

# Research Question I

- How are the prosodically prominent contexts different from one another acoustically?  
(Domain-initial vs. Domain-final vs. Accented position)
- How does articulatory strengthening affect the acoustic features that mark linguistic contrasts?
- What is the variation conditioned by different inventory systems in diverse languages?
- What is the variation in different speech styles, particularly adult-directed-speech vs. child-directed-speech?
- In CDS, Is the different prosodic prominences marked even further distinctively or does it become neutralized to enhance the contrast at the segmental level?

# Hypotheses

- Prosodically induced articulatory strengthening will result in acoustic strengthening.
- Accentual effects will be more dominant than boundary effects in acoustic patterns of CVs.
- Domain-initial consonants will show more acoustic strengthening than domain-medial and final consonants, based on findings of articulatory strengthening at domain edges (Fougeron & Keating, 1997). In the same way, domain-final vowels will show more acoustic strengthening.
- Patterns of acoustic variation due to prosodic factors are under influence of systemic factors.
  - languages with less crowded inventories are more tolerant to acoustic variation.
- CDS may mark difference in prosody and segments more distinctively compared to Adult-directed speech.

# Research Focus

- Laryngeal contrast in American English stop consonants/p,b/, and vowel contrast of /i, , /.
- Laryngeal contrast in Korean stops /p, p<sup>h</sup>, p'/ and vowel contrast of /i, ,u/ in Korean.
- Prosodic conditions of
  - Focal accent (global and local focus)
  - position in Utterance/Intonational Phrase.
- Different speech styles of Adult-directed speech (ADS) and Child-directed speech (CDS)

# Experimental Design

## – English ADS condition

- ***Subjects***

6 American English male speakers  
(AL, BD, HE, JH, MC, & RF)

- ***Materials***

- English words with /p/,/b/ + V sequence.  
(‘pottery’, ‘botany’, ‘Peter’, ‘beater’, ‘petter’, ‘bettor’, ‘Pah’, ‘Bah’)
- CV in Utterance (IP)-Initial/medial/**final**
- Focused / Nonfocused (contrastive focus)
- 5 repetitions
- 840 tokens in total = 6 speakers x 5 repetitions x 2 focal conditions x 2 voicing contrast x ((initial+medial) x 3 words + final)

# Experimental Design

## – Korean ADS condition

- **Subjects**

5 Seoul Korean male speakers (CS, HK, KS, PS, YI)

- **Materials**

- Korean words with /p/,/p<sup>h</sup>/, /p'/ + V sequence.

(p t 'the sea', p<sup>h</sup> t 'to dig', p' t 'butter',

p it 'to be empty', p<sup>h</sup> it 'to bloom', p' it 'to sprain'

p, p<sup>h</sup>, p' (exclamation); pul 'fire', p<sup>h</sup>ul 'grass', p'ul 'horn').

- CV in Utterance (IP)-Initial/medial/final

- Focused / Nonfocused (contrastive focus)

- 6 repetitions

- 1064 tokens in total = 1080 -16

- 1080= 5 speakers x 6 repetitions x 2 focal conditions x 3 positions x 3 stops x 2 vowels.

- 16= Devoiced tokens: PS (11) + YI (3) + KS (2).

# Samples of the speech corpus

- **English (Contrastive focus with bold characters)**

- **Initial-Focused**

A: Pottery is the main subject of his book?

B: **Botany** is the main subject of his book.

- **Medial-Focused**

A: A yellow pottery book was on the desk?

B: A yellow **botany** book was on the desk.

- **Initial-Nonfocused**

A: Pottery is the title of your book?

B: Pottery is the **main subject** of my book.

- **Korean (Contrastive focus with bold characters)**

- **Initial-Focused**

A: 가 ? /p'ata-ka ki jeki-ii hekʃim-i-ni/  
'Is butter the point of the story?'

B: 가 /**pata**-ka ki jeki-ii hekʃim-i-ja/  
'The sea is the point of the story.'

- **Medial-Focused**

A: 가 가 ? /kim-cak'a-ii p'ata-ka ki jeki-ii hekʃim-i-ni/  
'Is Writer Kim's Butter the point of the story?'

B: 가 가 / kim-cak'a-ii **pata**-ka ki jeki-ii hekʃim-i-ja/  
'Writer Kim's The Sea is the point of the story.'

- **Final-Nonfocused**

A: 가 ? /pita-ka ki munceii cə tap-i-ni/  
'Is emptiness the answer for the question?'

B: /pita-nin **ki ta**im munce-ii cə tap-i-ja/  
'Emptiness is the answer for the next question.'

# Measurement of Acoustic Cues

- Laryngeal contrast in stops
  - VOT (Lisker & Abramson, '64)  
: Measured as duration from the stop release to the voice onset of the 2<sup>nd</sup> formant
  - F0 at the following vowel onset (Whalen *et al.*, '93)  
: Manually calculated at the voice onset after the stop release.  
( Mean over 3 glottal cycles) =>  $3/\text{duration for the 3 cycles} = F0$
- Vowels
  - Vowel Duration: duration from the voice onset of the 2<sup>nd</sup> formant to the disappearance of 2<sup>nd</sup> and higher formants.
  - F1 & F2: automatically measured (manually corrected) by Praat at the midpoint of the Vowel.

# Results – English ADS

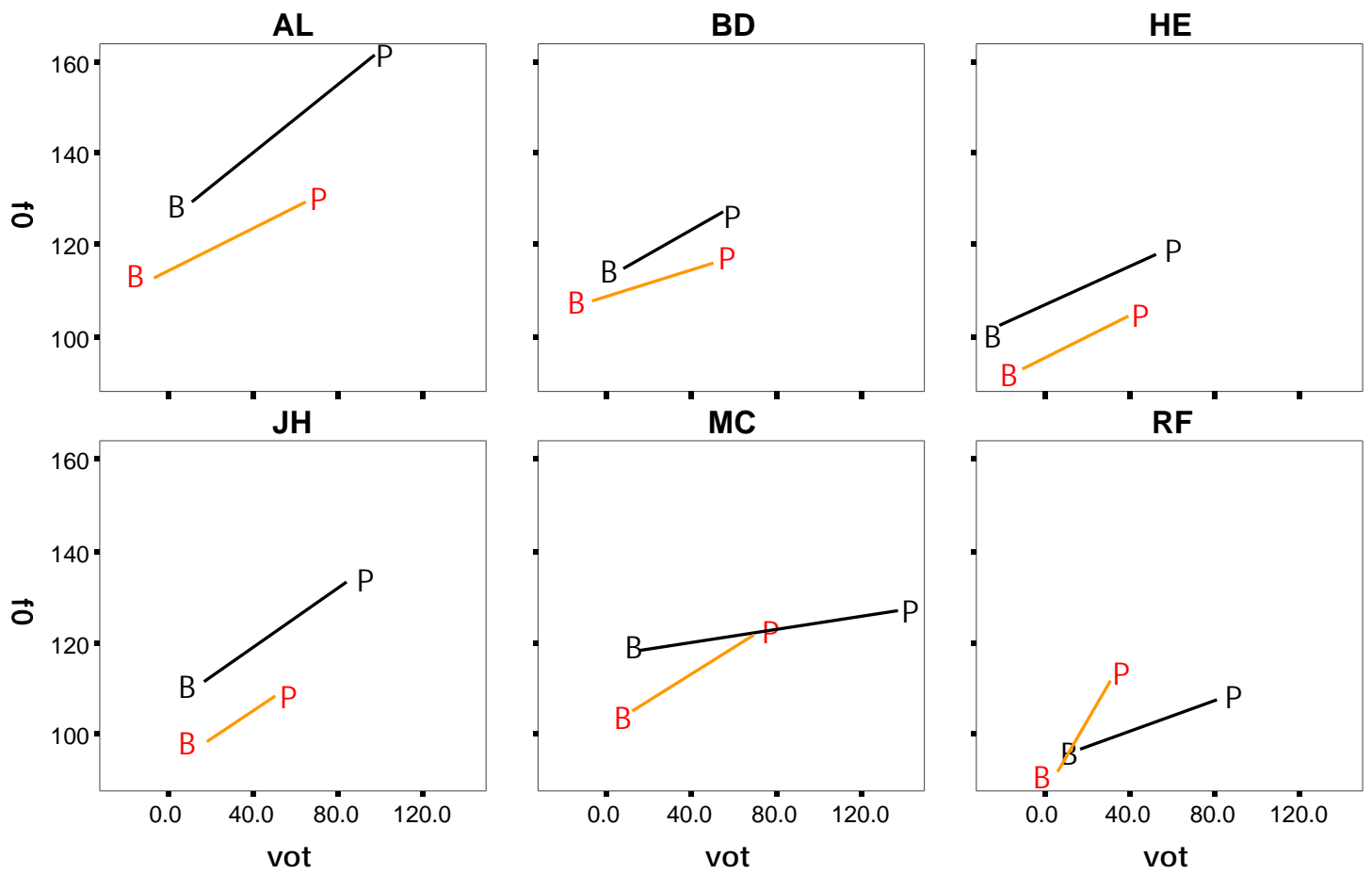
- Consonants

- In general, accentual effects are more obvious and consistent across all the speakers compared with positional effects: 3-way ANOVA ( Focal accent x Position x CV syllable) reveals that Focal Accent is a significant factor for more cases than Position ( 10 vs. 4 cases)
- VOT shows a clear increase under focus especially for voiceless stops.
- F0: higher under focus for most of subjects.
- Domain-initial position does not show a very different pattern from other positions ( No enhancement of acoustic values but some diminished VOT values in initial Cs ).

# Results – English ADS

- Laryngeal contrast in consonants
  - Focus does enhance the contrast between voiced and voiceless stops in English.
  - The voicing contrast in the relatively prominent position, U/IP-initial, is never better marked – always worse marked.
  - The contrast in the final position is as well marked as in initial.

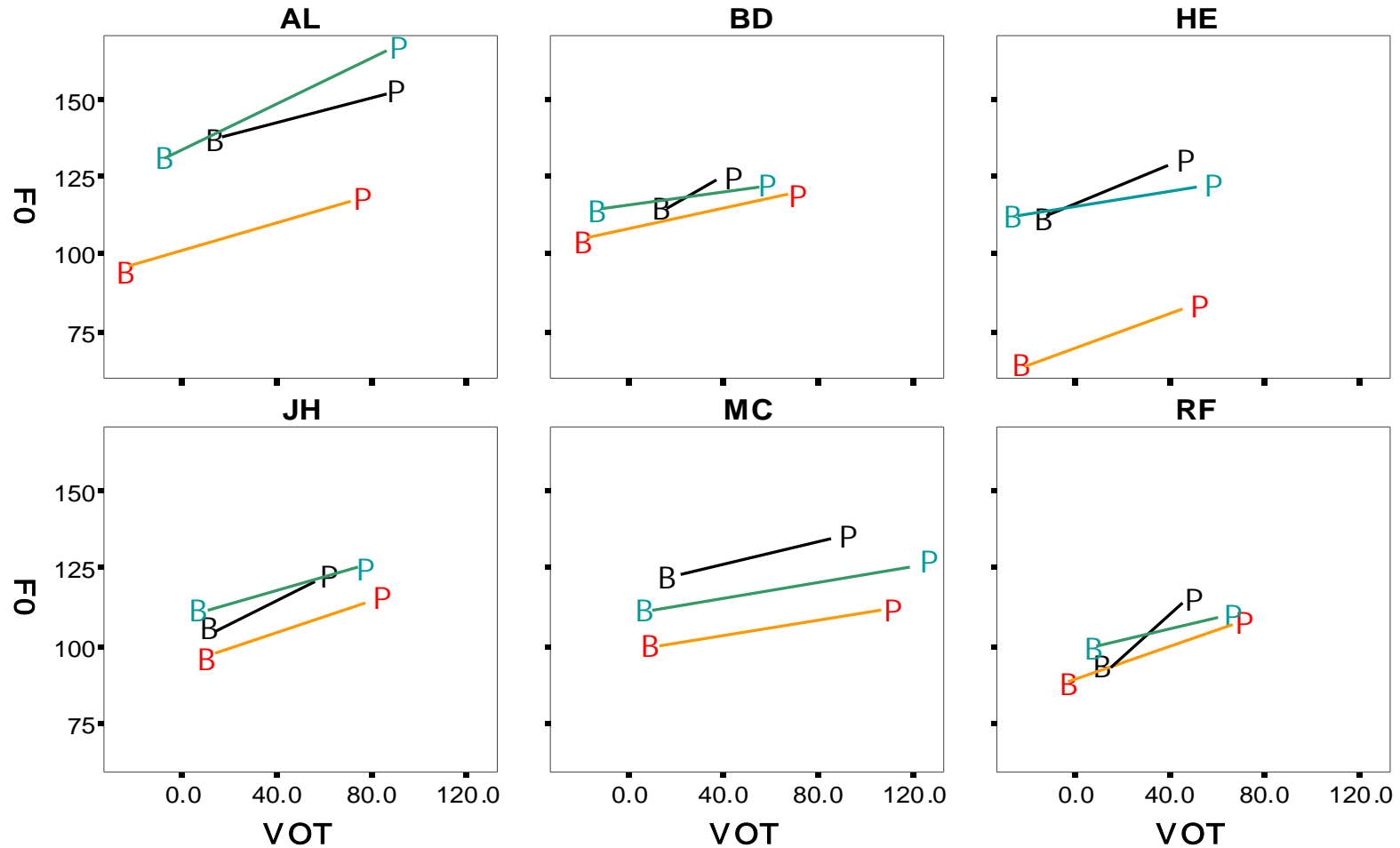
# English Stop Contrast by Focus



**focus**  
■ focused  
■ nonfocused

**voicing**  
B voiced  
P voiceless

# English Stop Contrast by Position



## position

■ final

■ initial

■ medial

## voicing

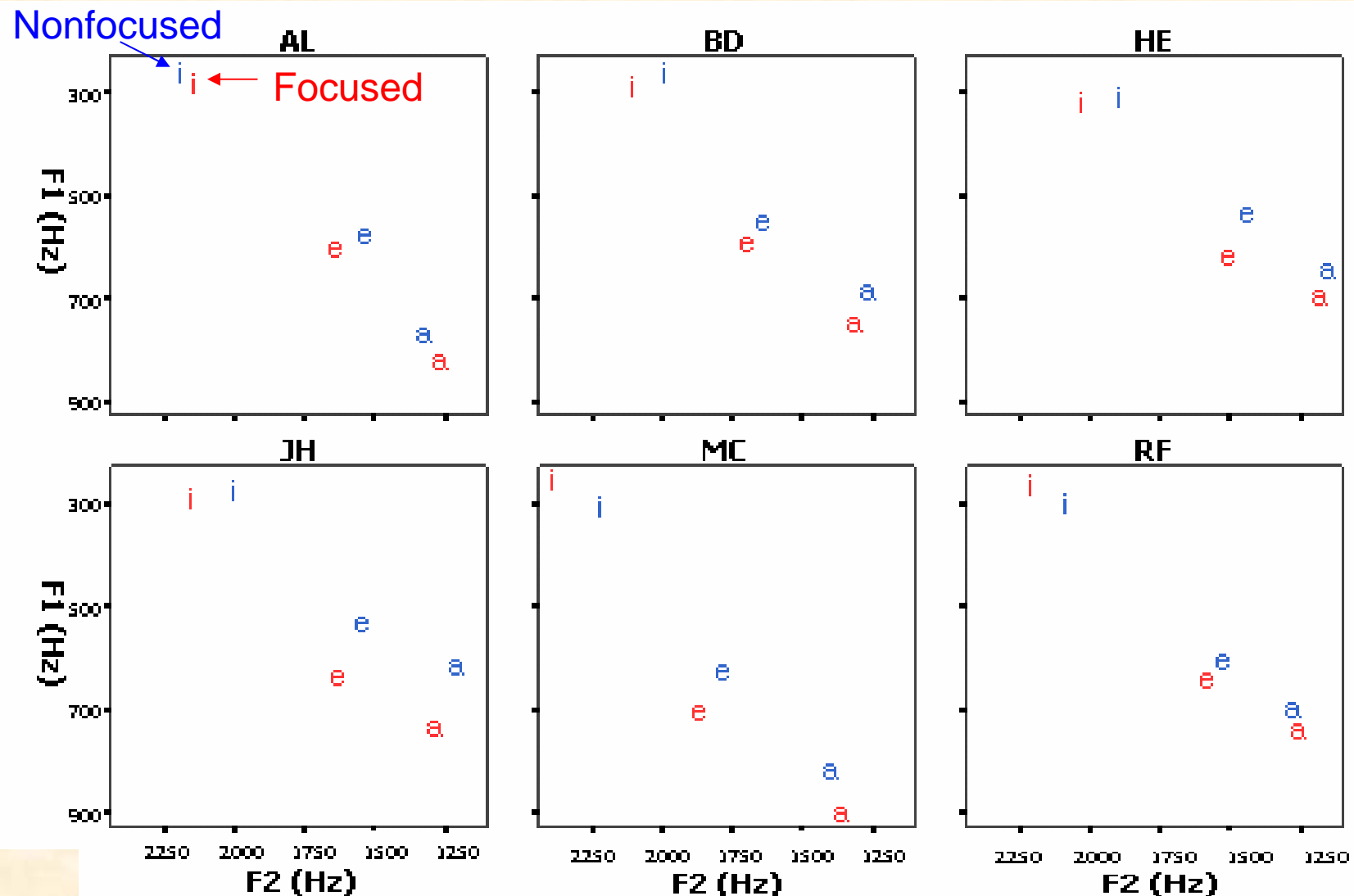
B voiced

P voiceless

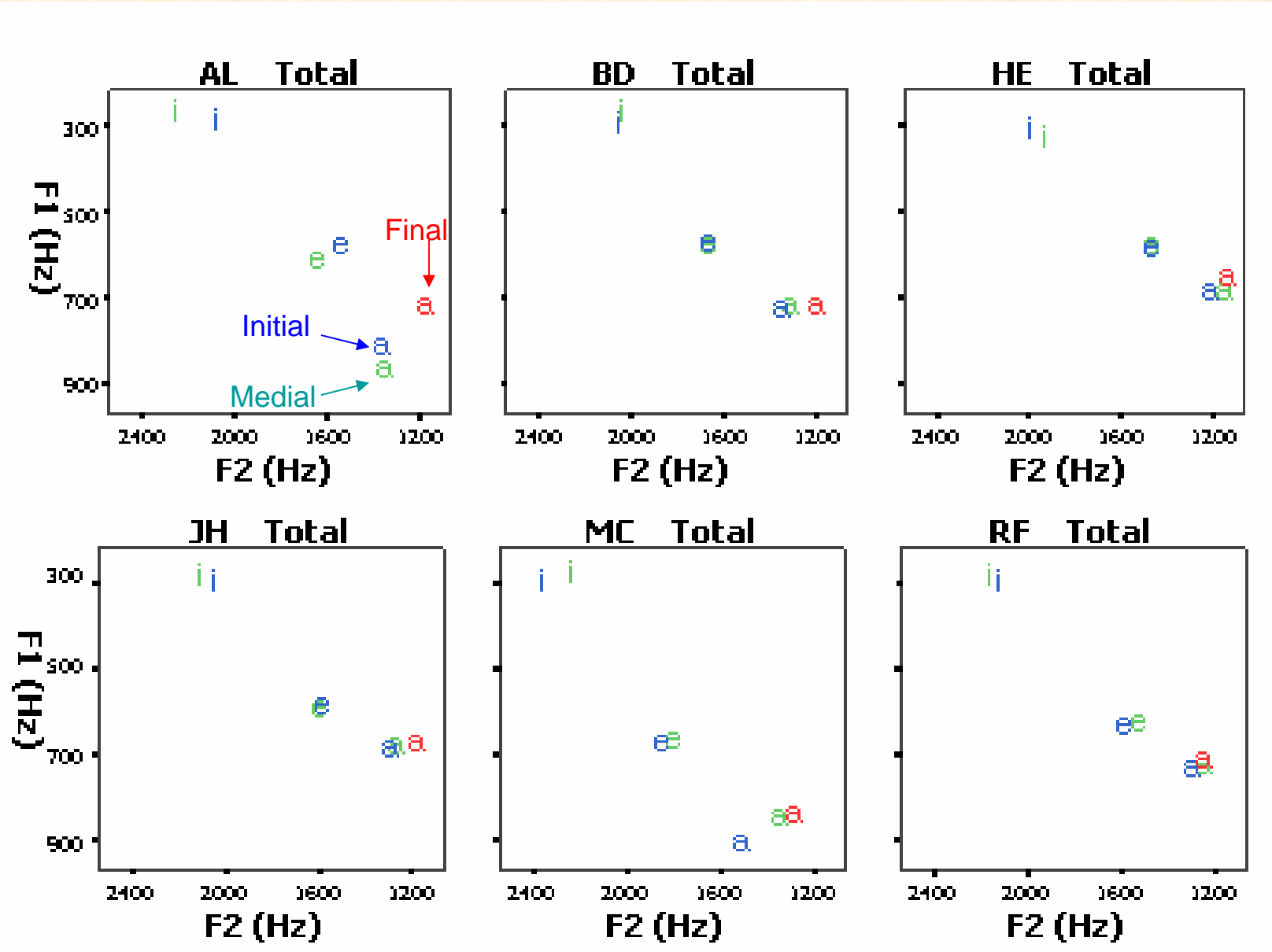
# Results – English ADS

- Vowels
  - In general, accentual effects are consistent across all the conditions: vowels are longer under focus in all 3 positions and vowels.
  - Final vowels are significantly longer than the vowels in other positions.
  - Initial and medial do not show significant difference in vowel duration ( no strengthening in initial Vs).
  - Vowels are more peripheral when focused. => Paradigmatic enhancement of vowel contrast.
  - Positional variation is not very consistent across speakers.
  - Final / / does not show higher F1 though vowel duration is significantly greater in the final position => No change in sonority profile.
  - Accented / / shows higher F1 and longer vowel duration. => supporting the findings from articulatory studies.

# English Vowel Contrast by Focus



# English Vowel Contrast by Position



# Results of Korean ADS

- Consonant
  - General increase for acoustic cues under focus except tense stops (in VOT) and plain stops (in F0).
  - Focal effect involves a stable and consistent effect regardless of data setting, while Positional effect is more dependant on data setting- little discrepancy between Initial and medial tokens.
  - Paradigmatic effect – Increase by focus interacts with stop categories:
    - Aspirated stops that involve greatest VOT and F0 values show biggest variation due to focus.
    - Tense stops' VOT and plain stops' F0 do not depict any marked increase under focus.

# Results of Korean ADS

- Vowels
  - General increase in vowel duration under focus particularly in final position – still, overall changes are very small.
  - Durational lengthening in final position is very distinctive, to even greater amount than lengthening by focal accent
  - Focal effect is stable and consistent regardless of data setting, whereas Positional effect is very marked in final position.
  - Paradigmatic effect in formant frequencies– Increase by focus interacts with vowel qualities:
    - In F1, / / shows greatest increase – focus conditions greater opening; no decrease in close vowels.
    - In F2, /i/ increases whereas /u/ decreases – Both front and back features increased.
  - Final / / reveals enhancement in vowel qualities:
    - F1: increases in final => greater opening
    - F2: decreases in final => further retraction

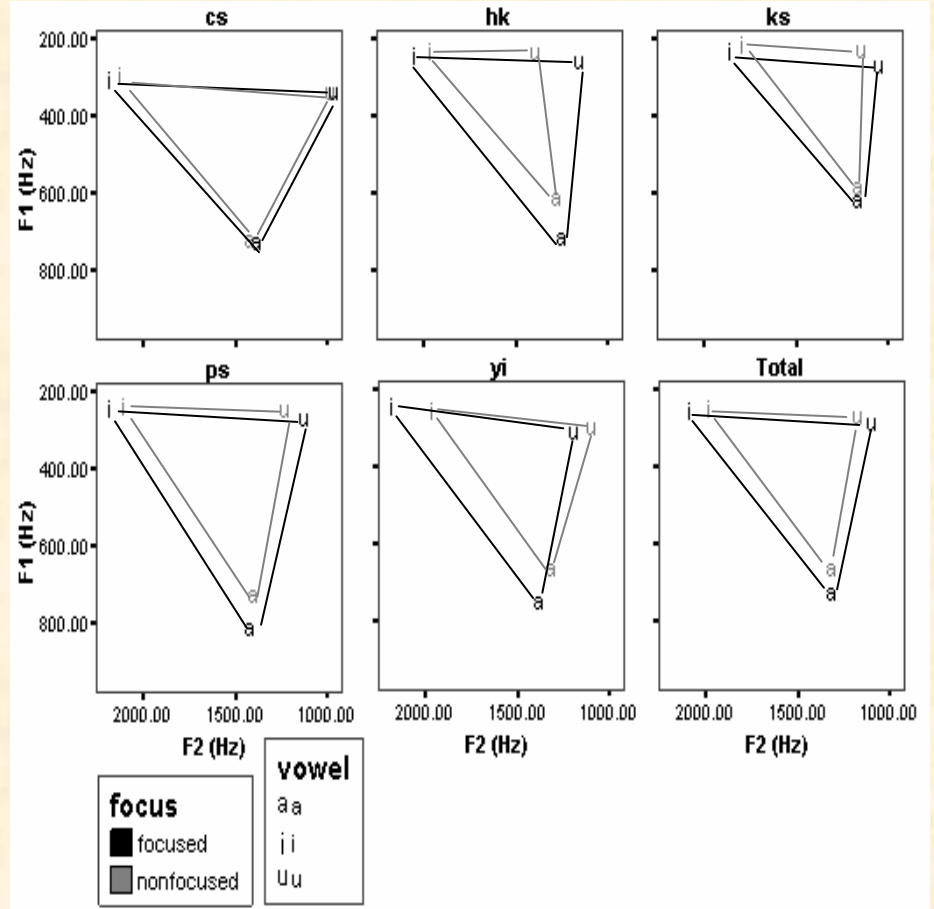
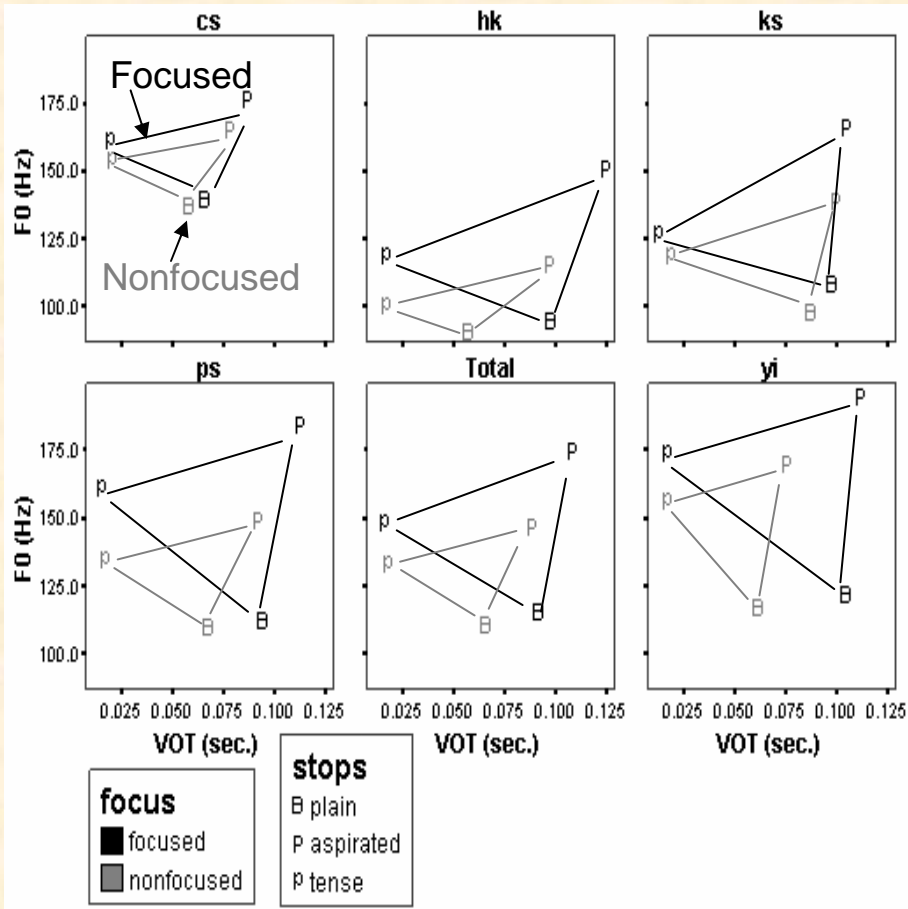
# Results – Korean ADS

- Contrast marking conditioned by prosody
  - In general, focal accent facilitates an improved distinctiveness between the contrastive stops and vowels.
  - Paradigmatic enhancement in the competing segments leads to an enhanced contrast marking.
  - Enhanced laryngeal contrast in initial is not supported. Final stops show different distribution from others because of the marked F0 distribution in U/IP-final.
  - Final / / seems more peripheral: final lengthening is revealed along with greater opening and slight retraction. – Sonority is enhanced in final.
  - ↳ should we consider this as evidence of a paradigmatic strengthening in final position?  
:The present setting dose not give an answer for this...

# Korean contrast as a function of Focus

## Laryngeal Contrast

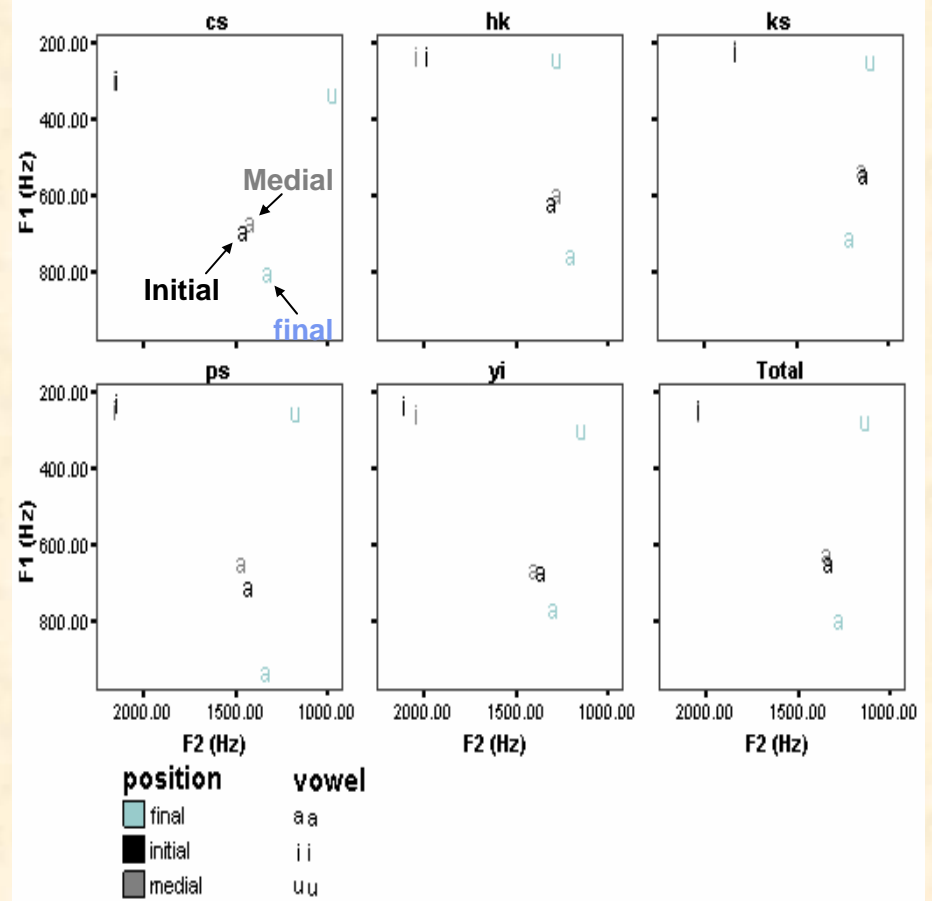
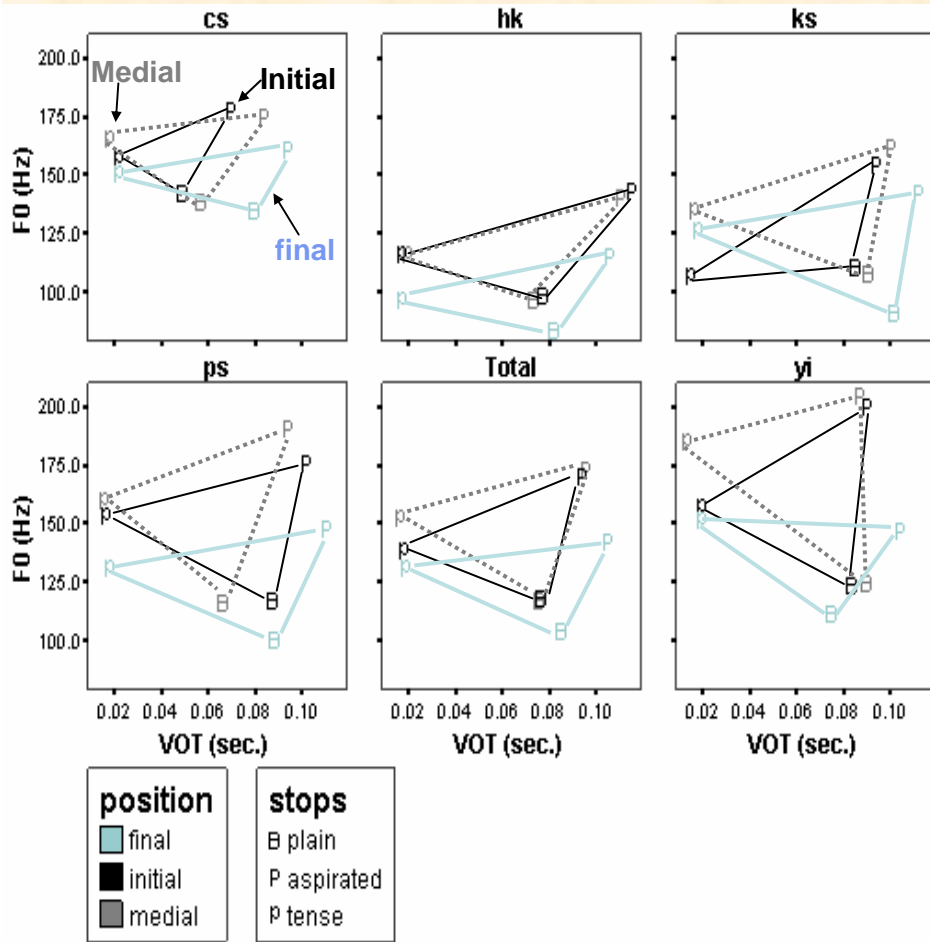
## Vowel Contrast



# Korean contrast as a function of Position

Laryngeal Contrast

Vowel Contrast



# Experimental Design

## – English and Korean CDS condition

- **Subjects**

2 American English speaking mothers (E1, E2) and 2 Korean speaking mothers (K1, K2) as their native tongues, who have infants in the one word stage. (The original study have 10 subjects, but only 4 subjects' patterns are reported here)

- **Materials**

- The words used in the ADS experiment were selected as target words and provided as names of similar types of toys.

- English: 'pottery', 'botany', 'Peter', 'beater', 'petter', 'bettor', 'Pah', 'Bah', 'booh', 'pooh'
- Korean: 'pita' 'phita' 'p'ita' 'pata' 'p'hata' 'p'ata'

- The mother's casual speech with the infant using the given toys were recorded at a sound-attenuated booth at the Haskins Laboratory.

- 321 English and 352 Korean tokens were selected from Utterance-initial, -medial, -final positions and accented or non-accented contexts: focal accent is still used though it can be either global or local in this setting.

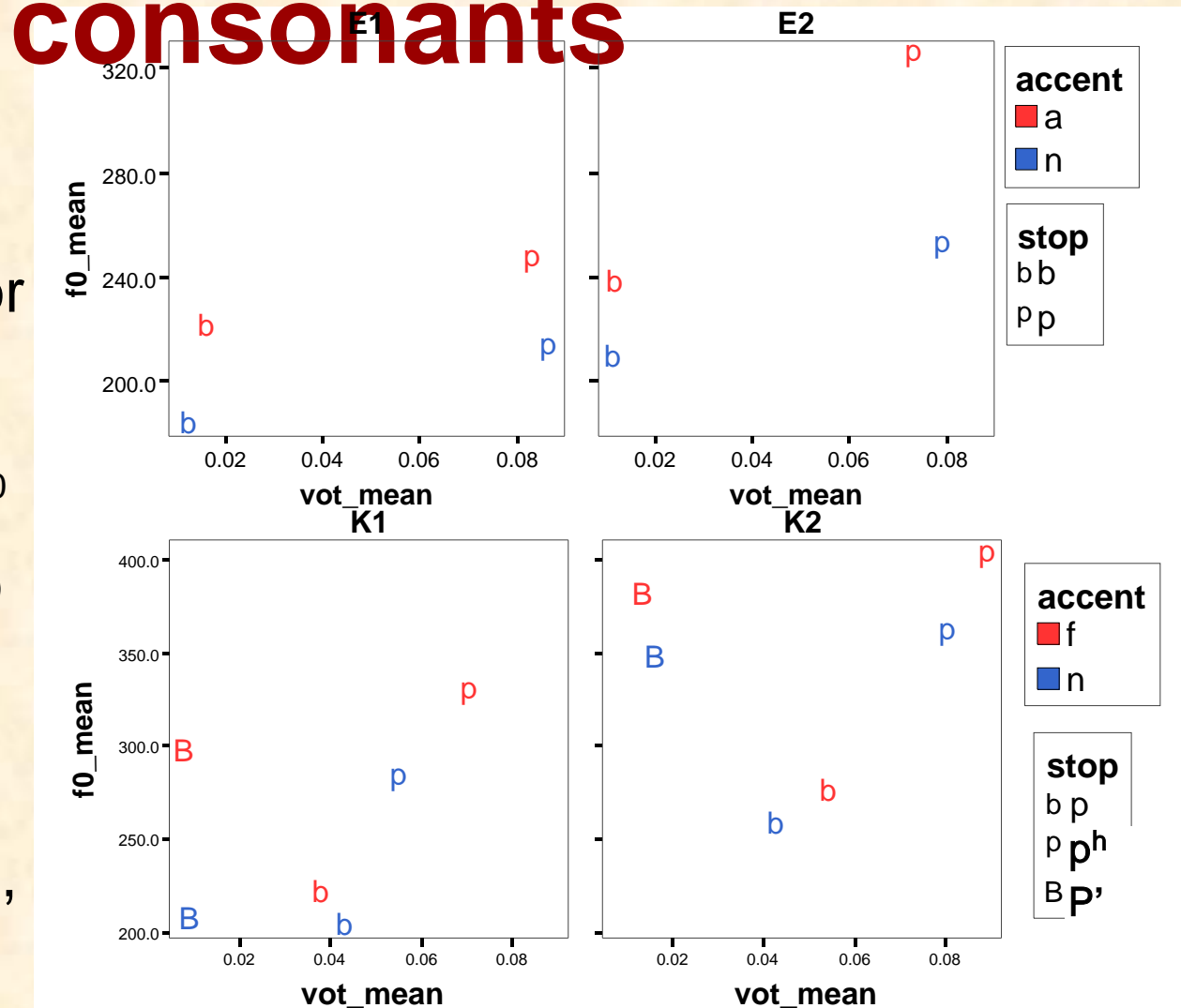
- **Measurement**

- Identical to the way in the ADS experiments

# Results – CDS

## Effects of accent on consonants

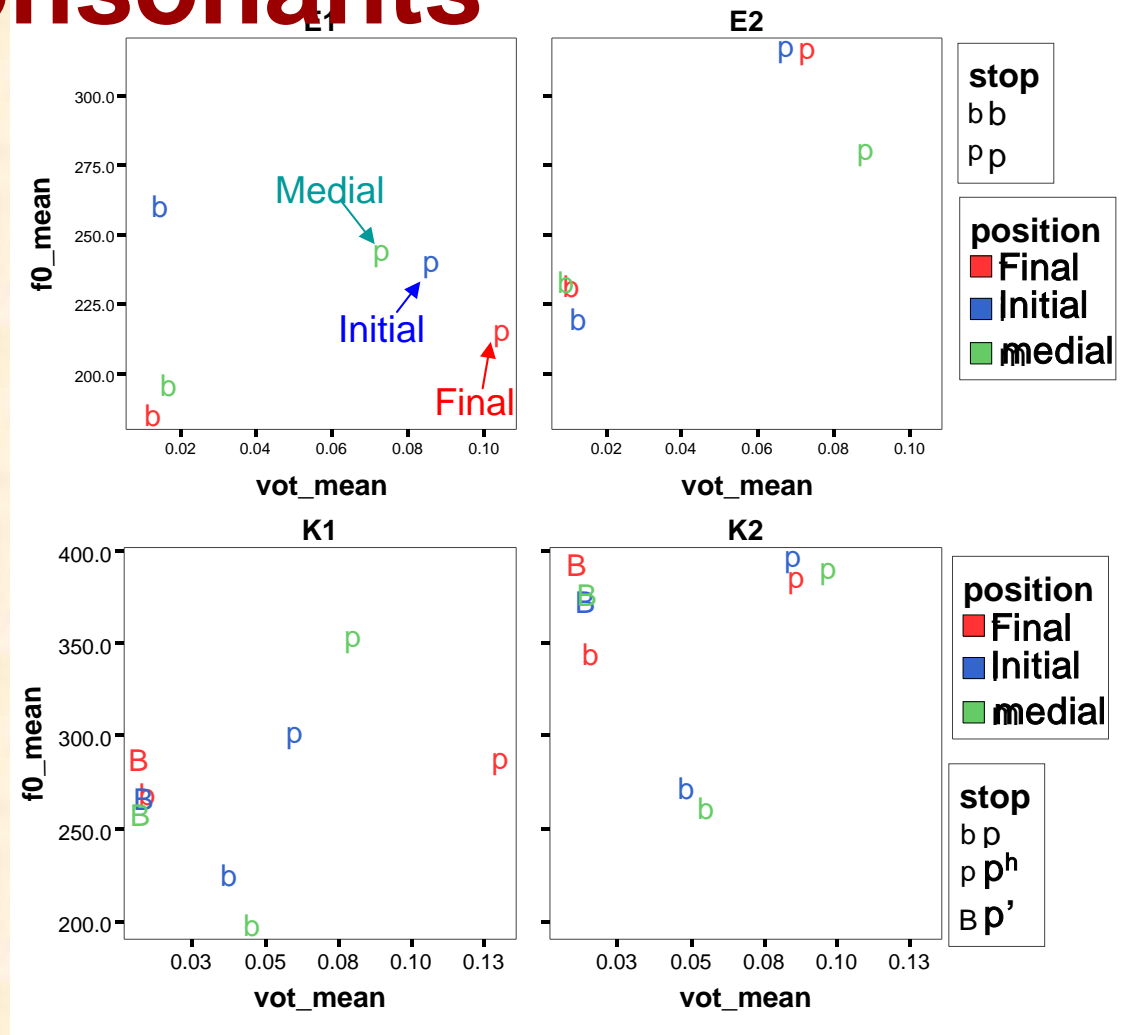
- 3-way ANOVA analysis on each individual reveals that Accent is a significant factor for most VOT and F0 measurements (E1's VOT ( $F=28.163$ ,  $p<.0001$ ); E2's VOT ( $F=3.088$ ,  $p<.05$ ) & F0 ( $F=24.88$ ,  $p<.0001$ ); K1's VOT ( $F=4.077$ ,  $p<.05$ ) & F0 ( $F=9.24$ ,  $p<.01$ ); K2's F0 ( $F=9.03$ ,  $p<.01$ ))
- Significant accentual effects are revealed as enhanced stop contrast for E2, K1, and K2.



# Results – CDS

## Effects of boundary on consonants

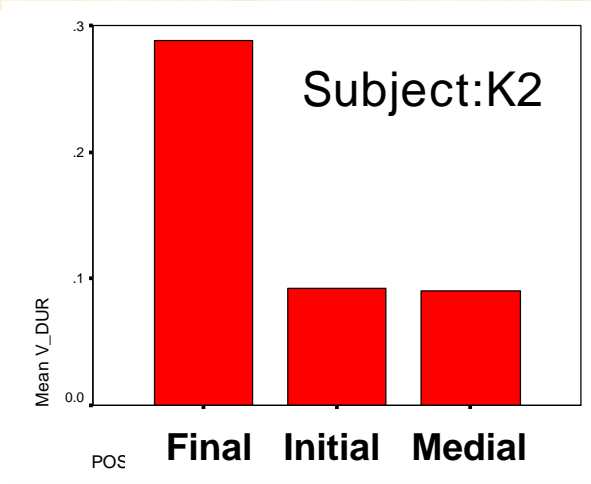
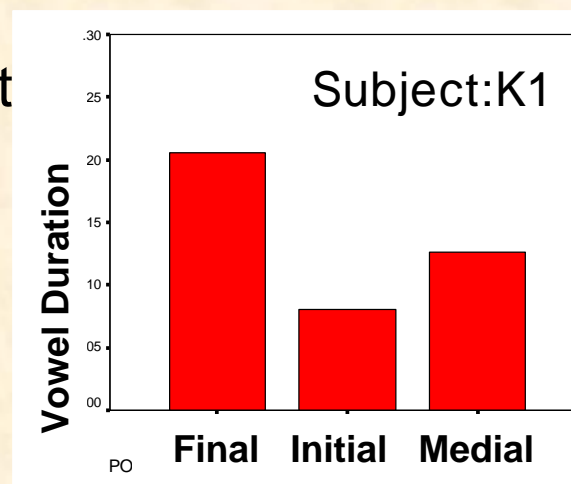
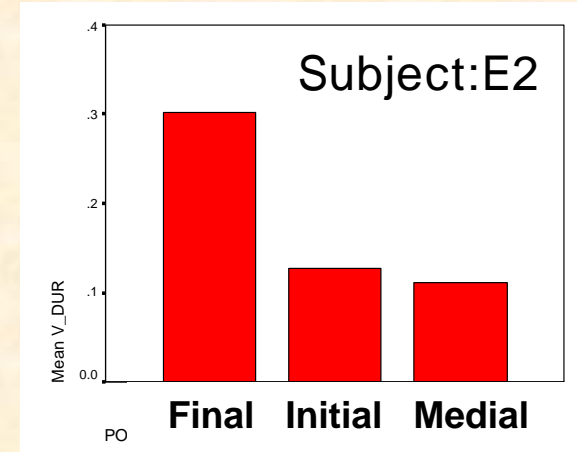
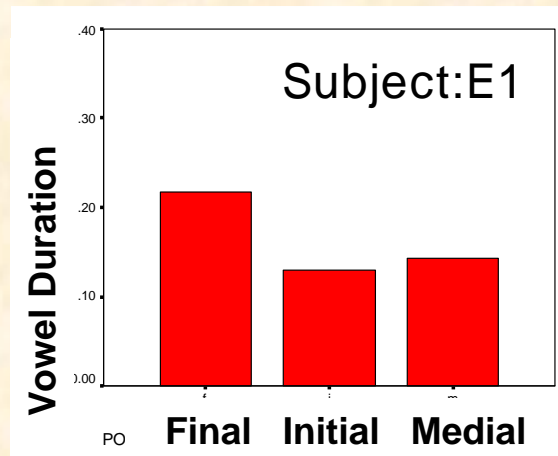
- Generally, no significant positional effect is reported from 3-way ANOVA analysis except for E2' F0 values.
- The contrasts in three different positions are not marked systematically.



# Results – CDS

## Prosodic effects on vowel duration

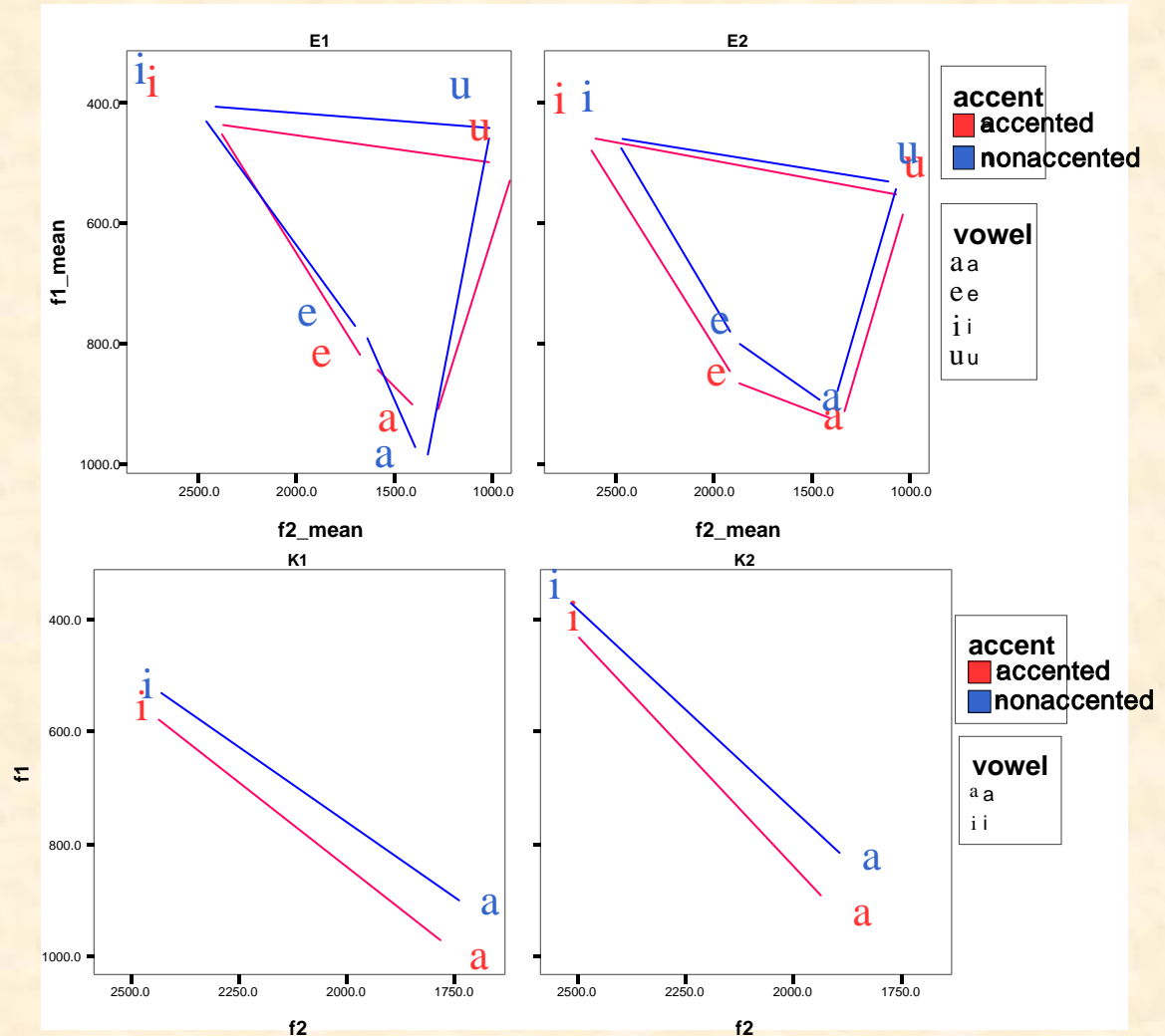
- The lengthening effect in the utterance-final position is revealed consistently across languages and subjects.
- No significant effect from Accent is reported.
- Initial and medial positions are not marked systematically in terms of duration



# Results – CDS

## Effects of accent on vowels

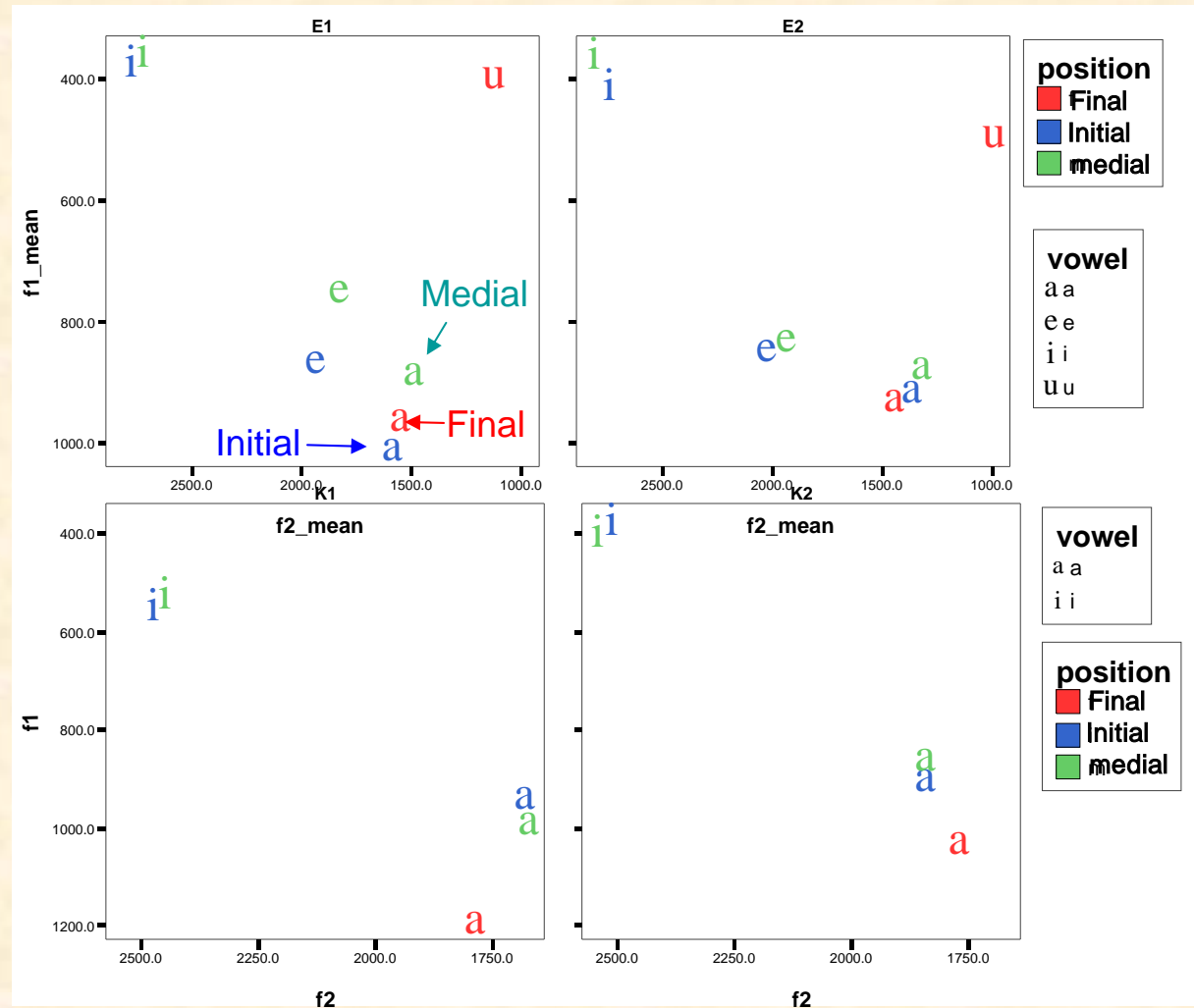
- Effects from accent are reported only for K1's F1 and E2's F2 shows a significant interaction between accent and vowels.
- No systematic enhancement of vowel contrasts conditioned by accent is found in F1 and F2 distributions.



# Results – CDS

## Effects of boundary on vowels

- Effects from different prosodic positions are reported significant for K1's F1 and E2's F1 at the very marginal level ( $p < .05$ )
- No systematic enhancement of vowel contrasts in boundary positions in terms of F1 and F2.
- CDS in Korean shows greater F1 which is similar to ADS.



# Summary I

- In ADS, accentual effects are depicted with enhanced measures and contrast in stops and vowels in English and Korean.
- Accented C and V are the unit for strengthening in both languages.
- Enhancement in domain-initial is not supported neither from consonantal features or vowel features. Instead, U-initial weakening is found (cf. White, 2002)
- Domain-final vowels show lengthening without enhancement in paradigmatic contrast. However, Korean data show more opening gesture with greater F1 values.

# Summary II

- Some cross-linguistic variation has been found. However, effects from language inventory systems are not clearly demonstrated under present study – no supportive evidence for the linear correlation between the phonological contrast system and acoustic variation.
- In CDS, similar to ADS, accentual effects are marked with enhanced acoustic measures and contrast in stops, whereas the effect in the boundary position is only marked as lengthening in vowels.
- However, unlike ADS, overall variation induced by prosody is reported less significant and moreover, CDS vowels do not reveal enhanced contrast in accented conditions.

# Discussion

- The prosodic patterns in CDS seem to follow those in ADS however not thoroughly.
- The reduced distinction of different prosodic prominences in CDS can be understood as a ceiling effect - CDS is already marked with enhanced segmental contrast.
- Difference in focal accent types (contrastive focus in ADS vs. global and local focus in CDS) may not explain the overall reduction in prosody-induced acoustic variation in CDS at least at the statistical level.
- In future research, CDS of caregivers with more syntactically advanced infants will be studied to examine whether the rather attenuated prosodic distinction of CDS in this study is related to the target infants' developmental stage (one-word stage)

# Closing remarks

- The result from the present CDS study is preliminary and the data should be treated with more caution before looking at the entire sets.
- This study is partially funded by the AAUP research grant.
- Special thanks to the colleagues at the Haskins Laboratory at Yale.