Vowel quality and voice quality of vowels in infant-directed speech: Hyperarticulated but soft voices of IDS vowels

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Introduction

We talk about:

- An acoustic analysis of the vowels in *infant-directed speech* (*IDS*) compared to those in *adult-directed speech* (*ADS*):
  - RIKEN Japanese Mother-Infant Conversation Corpus (R-JMICC) was used.
  - All 5 vowels were analyzed.
  - Prosodic environment was taken into account.
- A comparison of the data with that of Corpus of Spontaneous Japanese (CSJ).

Introduction

We look at:

- Vowel quality
  - Vowel space based on F1 & F2.
- Voice quality
  - H1-H2 (amplitude difference between 1st and 2nd harmonics) as the measure that represents spectral tilt.

Introduction

Findings in short:

- Vowel space is larger in IDS than in ADS in Japanese in two different prosodic environments.
- The voice quality of IDS tends to be more breathy than that of ADS.
- CSJ, assumed as representative “clear speech,” is similar to IDS with respect to vowel space but different in prosodic properties.

Background

- IDS is widely seen across many languages.
- General question:

  Is there any reason that this unique speech style is used as the carrier of the first linguistic input to infants?
- More specific question:

  Could IDS facilitate language acquisition, especially phonological acquisition?

Background

- IDS shows acoustic properties that are very much different from ADS (Fernald & Simon 1984, Grieser & Kuhl 1988, Fernald et al. 1989, Igarashi & Mazuka, 2008, Stern et al. 1982).
  - Shorter utterance length
  - High average F0
  - Expanded pitch range
  - Increased number of pauses

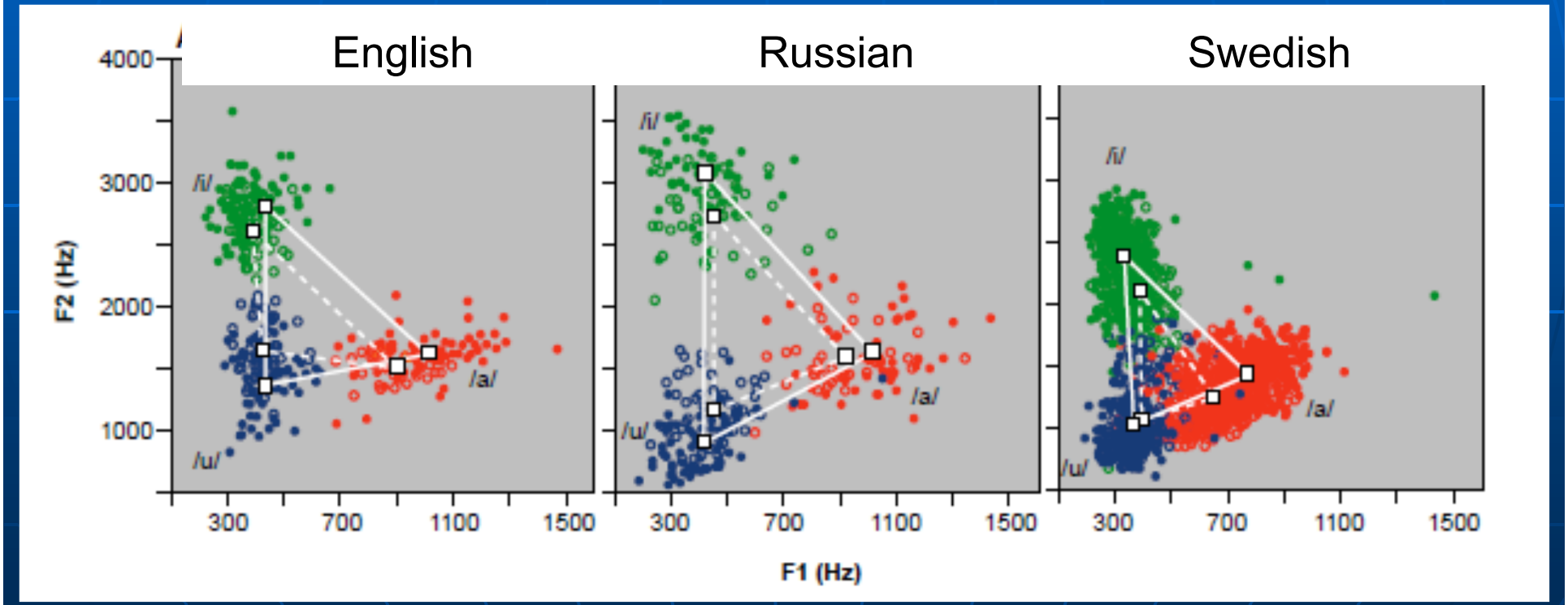
Background

- Differences are also seen at segmental level:
  - Expansion of vowel space (Kuhl et al. 1997, Liu et al. 2003)
    - Observed in many languages:

      English, Russian, Swedish (Kuhl et al. 1997), French (Dodane & Al-Tamimi 2007), Chinese (Liu et al. 2003).
  - Result of shifted but not expanded vowel space has also been reported (Englund & Behne 2005).

Background

- Substantial vowel space expansion in English, Russian and Swedish (Kuhl et al. 1997)



Solid line = IDS Dotted line = ADS

Background

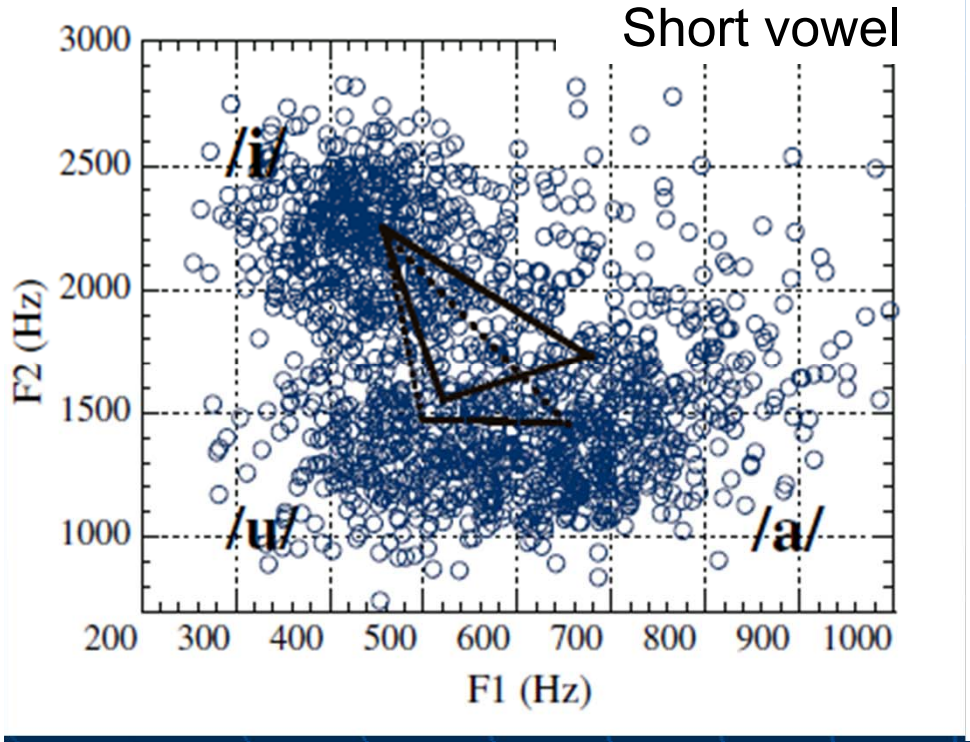
- Kuhl et al. (1997) suggest that vowel space expansion:
  - indicates extreme vowel articulation.
  - increases acoustic distances among vowels.
  - makes each vowel perceptually more distinctive from other vowels.
  - may contribute to infants' acquisition of vowel categories.

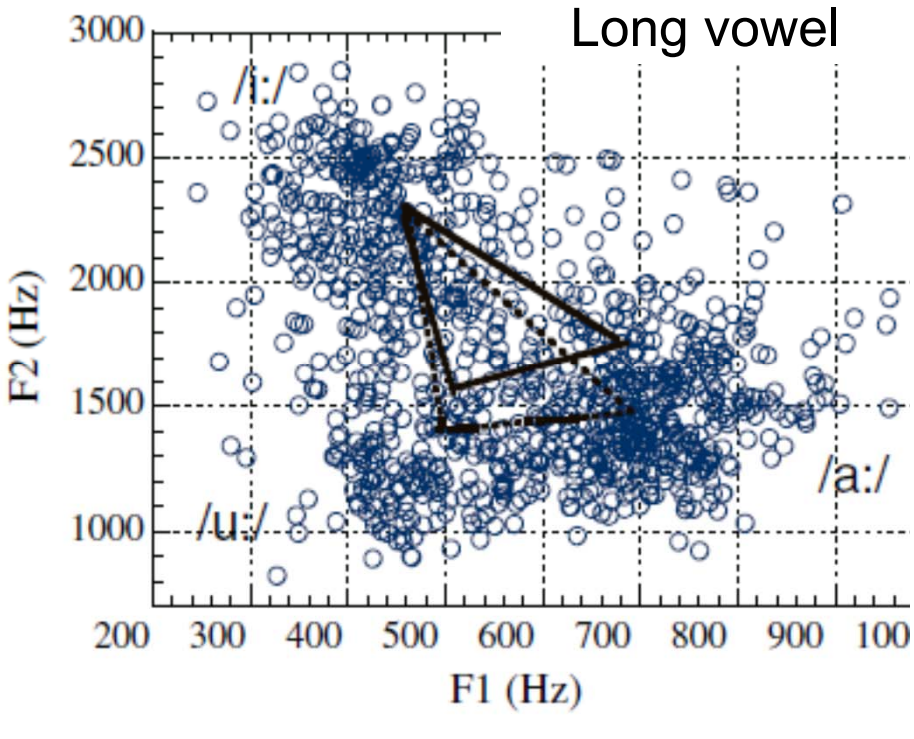
Background

- Liu et al. (2003) found a positive correlation between mothers' vowel space and their infants' (6-12 mo) vowel discrimination ability.
- Infants whose mothers use extreme vowel articulation obtained better scores.
- However, we cannot build cause-effect relationship based on correlation…

Background

- Only shift of vowel space, and no expansion in Norwegian: (Englund & Behne, 2005)





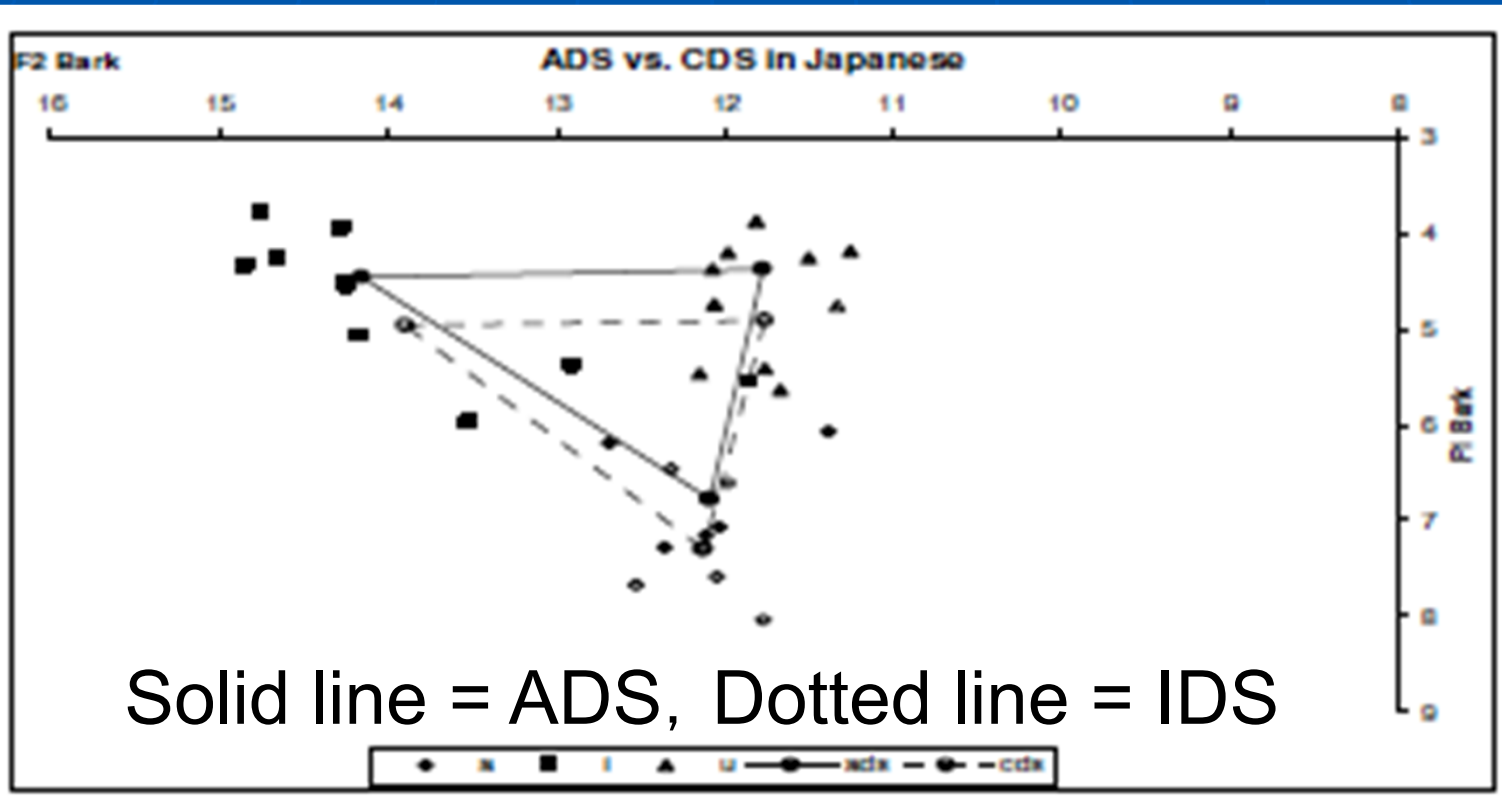
Solid line = IDS Dotted line = ADS

Background

- Japanese? Mixed.
  - Dramatically reduced vowel space expansion in Japanese IDS compared to the data in Kuhl et al. (1997) (Andruski et al. 1999).
  - Vowel space is shifted but not expanded. (Dodane & Al-Tamimi 2007)

Background

- Only shift of vowel space; no expansion in Japanese (Dodane & Al-Tamimi, 2007)



Issues

- Results on Japanese are mixed.
- Amount of data is not enough:
  - e.g. Dodane & Al-Tamimi (2007): 5 speakers, # of vowels: 177 (IDS) and 159 (ADS)
- Only [i, a, u] are analyzed.
- Prosodic environment is not considered.
  - e.g. influence of accentual-phrase-final boundary pitch movements (BPM).
- Only vowel space is considered.
  - Other measures ? Voice quality, for example?

In This Study…

- Large amount of vowel data were obtained from R-JMICC.
- All 5 Japanese vowels were analyzed.
- Different prosodic environments were taken into account:
  - Within accentual phrase（AP-）
  - At the end of AP or higher prosodic levels (AP+)

Methods：Vowel Space

- Vowels of equal or more than 40 ms were measured for their F1, F2 and F0 at their mid points.
- Values were transformed into the ERB scale
- Vowels with extremely high or low F0 (SD ±2.5) were removed.
- Vowels were classified based on their prosodic environment: AP- and AP+
- Short vowels only.

Methods : Vowel Space

- CSJ:
  - 662 hours of recording, 7.5 million words.
  - Consists of ‘academic presentation speech (APS)’ and ‘stimulated public speech (SPS)’.
- Current data:
  - SPS by 13 female speakers in their 30’s were used (about 3 hours of recording).

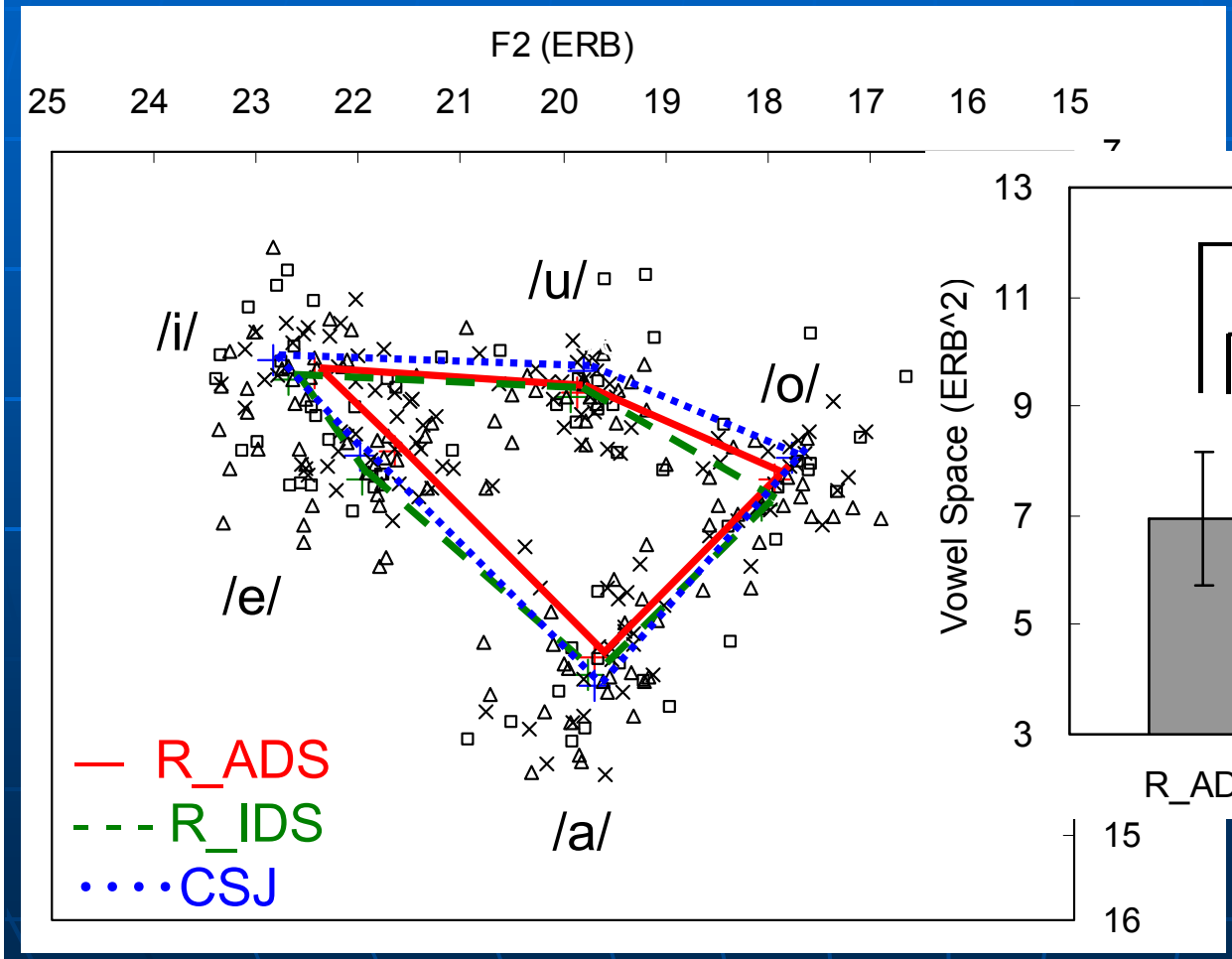
Number of Vowels

	ADS		IDS		CSJ	
	AP-	AP+	AP-	AP+	AP-	AP+
/a/	5843	1283	14088	3375	12075	3986
/e/	2567	1632	3819	2644	4350	2864
/i/	2274	646	4974	1309	5264	1929
/o/	3600	1298	8213	2645	7256	3959
/u/	1568	212	3193	778	2619	844

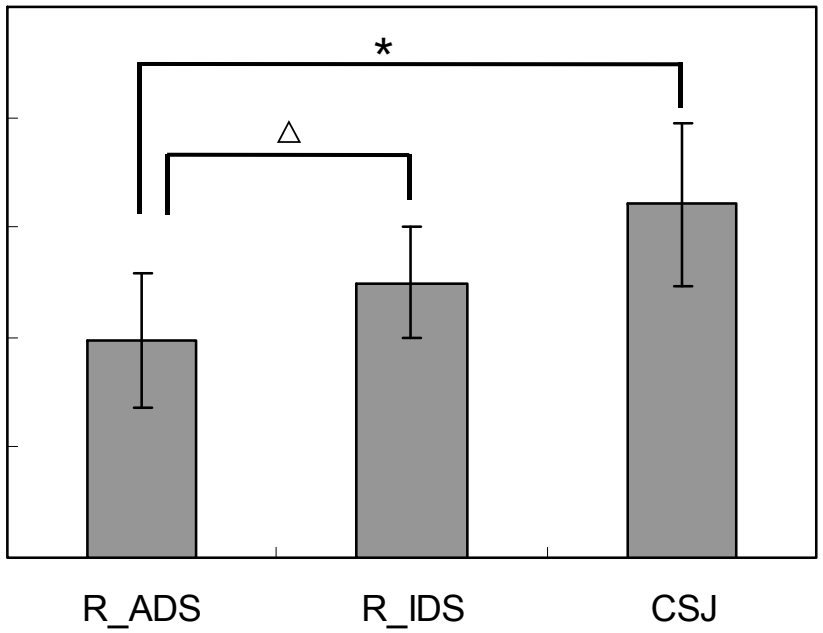
Results : AP-

ADS → R_ADS　　IDS → R_IDS

* Sig.
△ marginally sig.

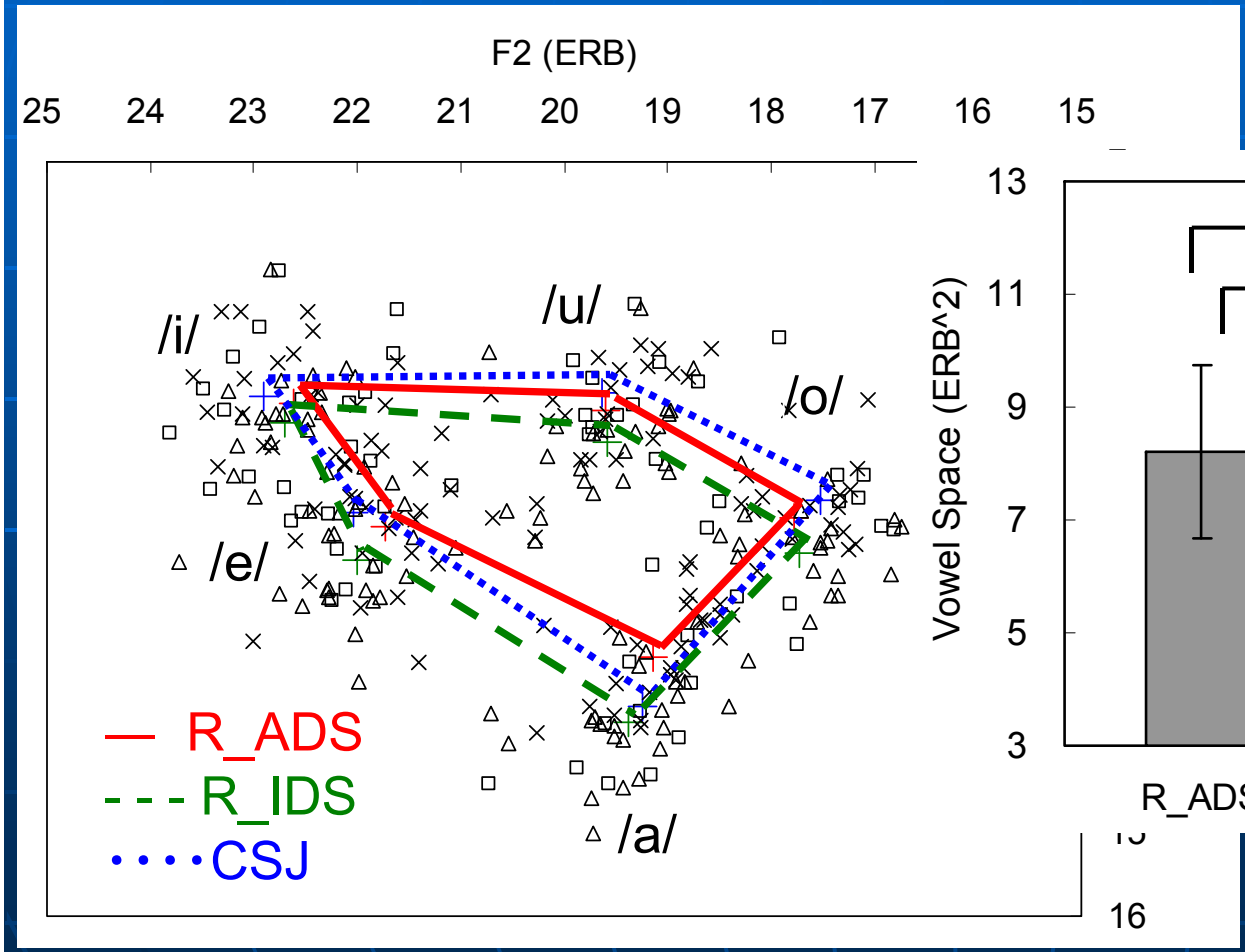


Vowel space area

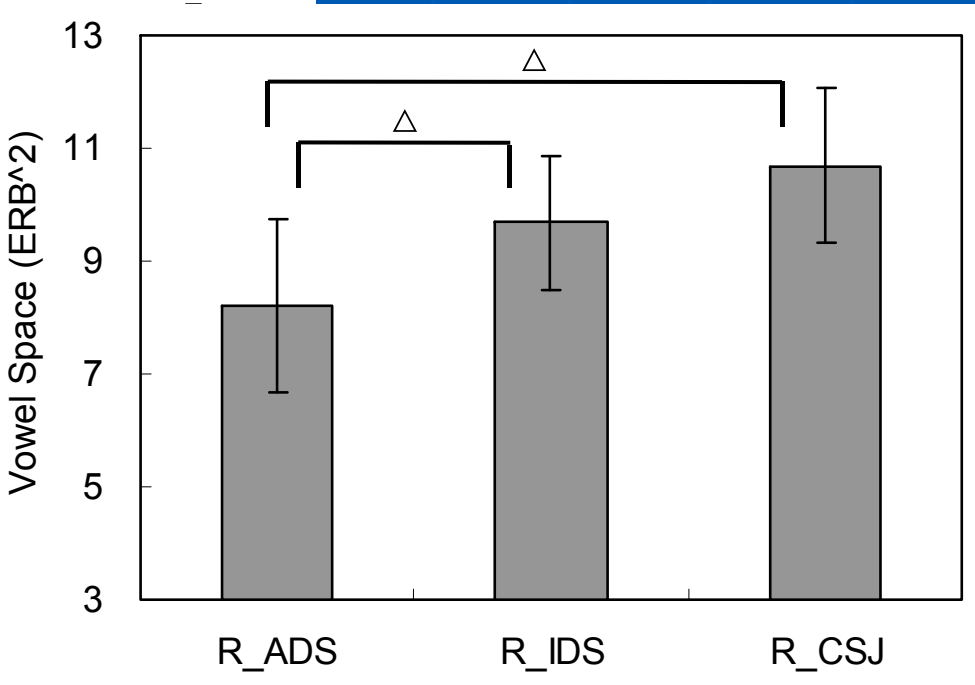


Error bars: 95% CI

Results : AP+



Vowel space area



Results: Vowel Space

- R_ADS < R_IDS, CSJ
- AP- < AP+
  ($t(110)=-2.675$, $p=.009$)

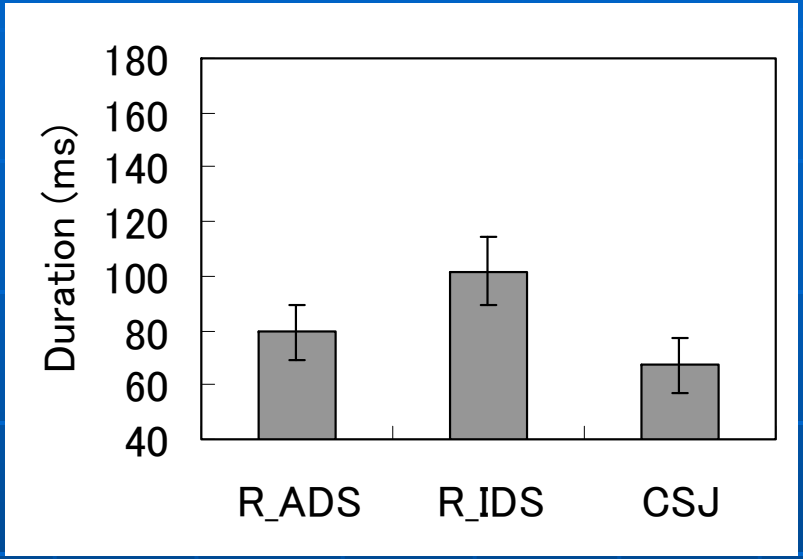
Discussion

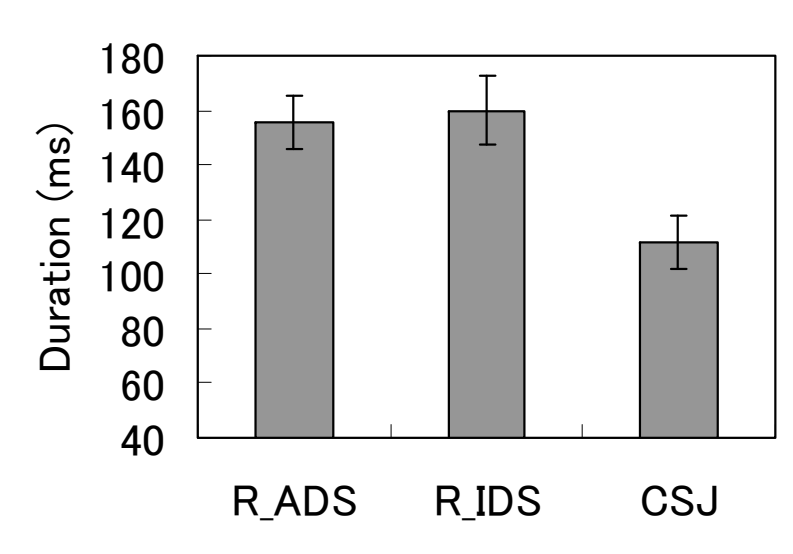
- R_IDS showed vowel space expansion (but not as dramatic as Kuhl et al.'s (1997)).
- The vowel space of CSJ is comparable with the expanded vowel space of IDS, not that of ADS.
- But the commonality between IDS and CSJ is seen in vowel space alone:

AP-

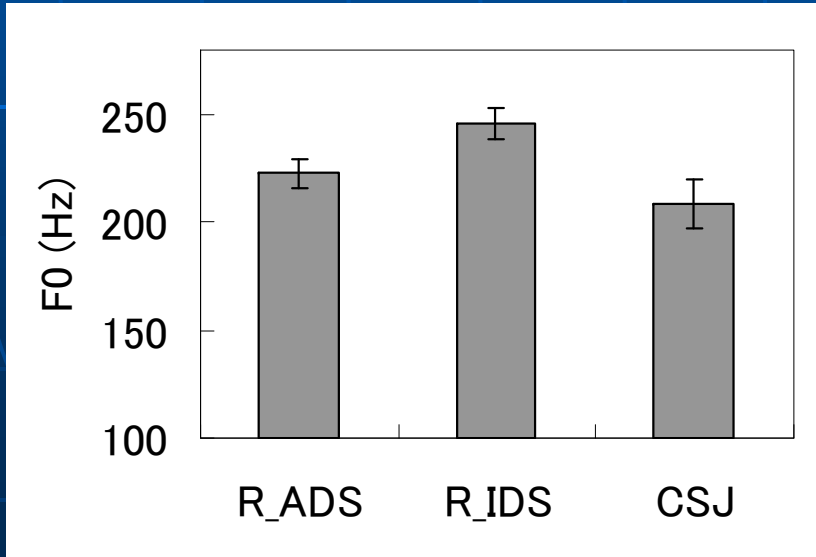
AP+

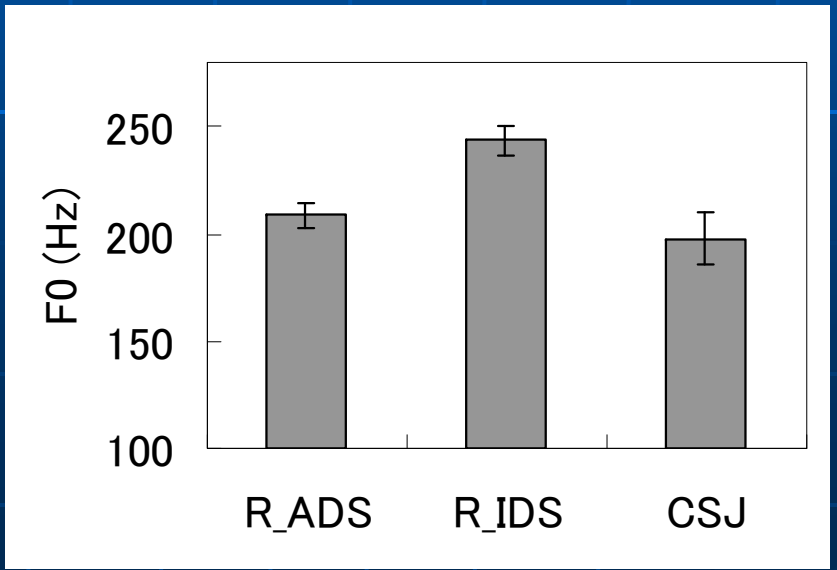
Duration





F0





Discussion: Vowel Space

- CSJ data are based on SPS, which is an instance of clear speech.
- Vowel space expansion is often seen in clear speech (Smiljanic & Bradlow 2005)
- CSJ and R_IDS are comparable with one another probably because they are both "listener-oriented."

Summary

- Vowel space is larger in R_IDS than in R_ADS in both AP- and AP+:
  - Vowel space expansion in Japanese.
- Vowel space is larger in AP+ than in AP-.
- Despite the fact that R_ADS and CSJ are both ADS, they are very much different with respect to vowel space.

Voice Quality

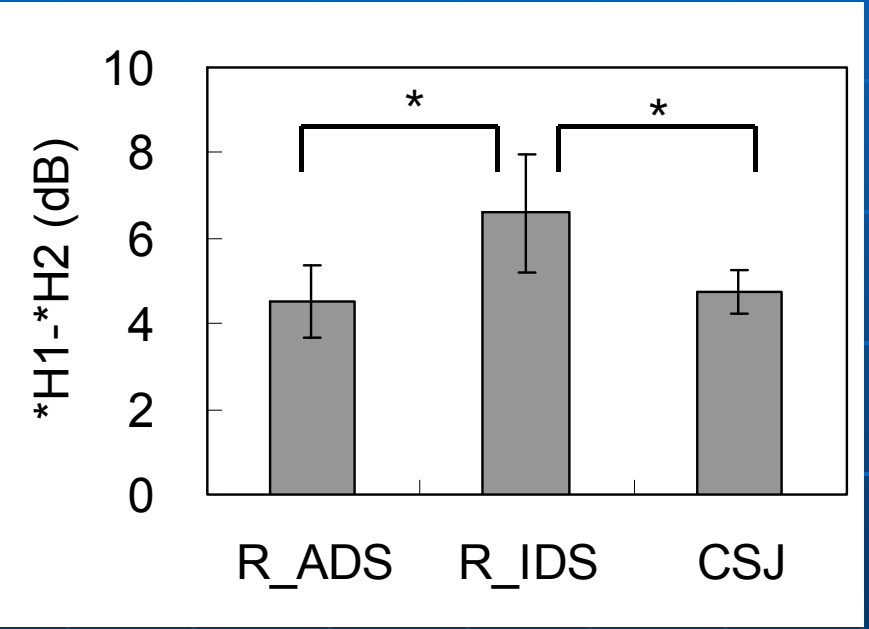
- Any other acoustic parameters that show properties characteristic of IDS?
- Does the “soft” impression of IDS have to do with voice quality?
- The softness of IDS voice could be viewed as breathiness, which is acoustically reflected on spectral tilt: the steeper it is the softer the voice sounds.

Voice Quality

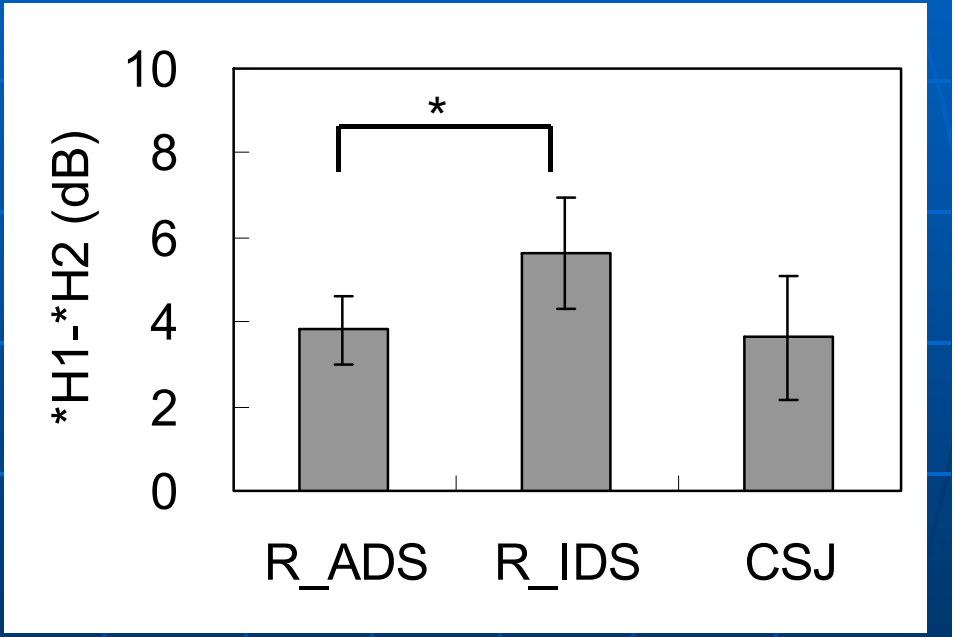
- One of the robust parameters for voice quality (Keating & Esposito, 2006)
  - H1-H2 (amplitude of 1st harmonics – amplitude of 2nd harmonics
  - The influence of F1 on H1-H2 was corrected H1-H2 (Hanson, 1996)
  - Corrected H1-H2 = *H1-*H2

Results: Voice Quality

AP-



AP+



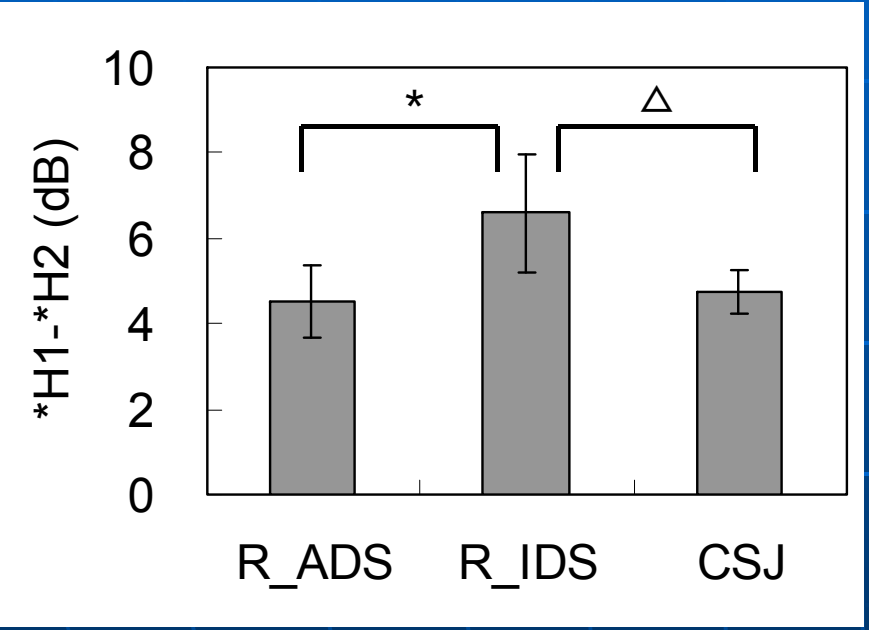
R_IDS > R_ADS, CSJ
→ R_IDS is more breathy than R_ADS and CSJ

Discussion: Voice Quality

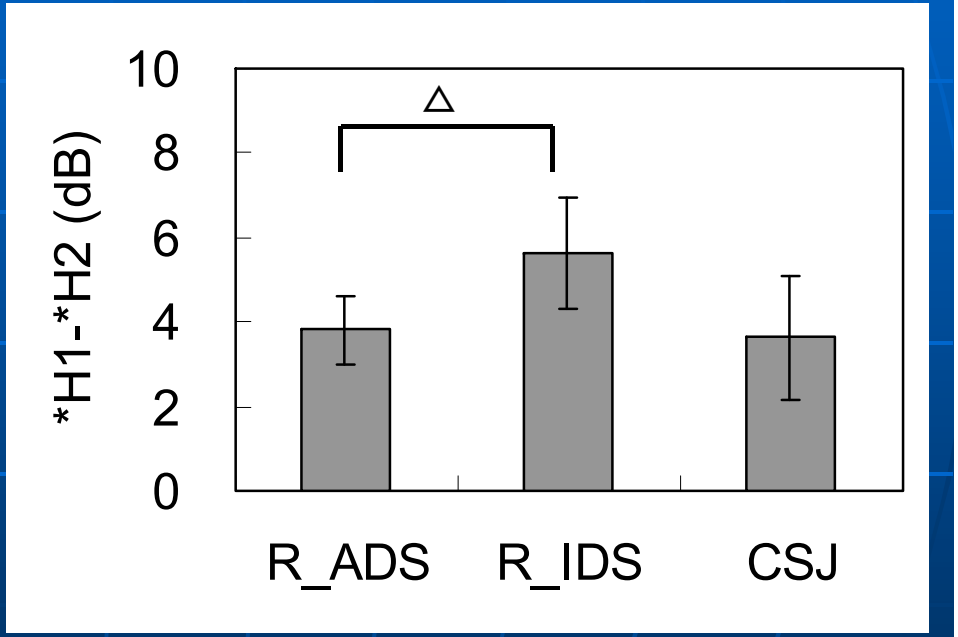
- Possible objection: *H1-*H2 is higher in IDS because IDS is high in F0.
  - High F0 means more sparse distribution of harmonics, which in turn means acoustic energy loss at high frequency range
- Analysis of covariance (ANCOVA) with F0 as the controlling factor:

Discussion: Voice Quality

AP



AP+



*H1-*H2 is still greater in R_IDS than R_ADS and CSJ even when F0 is taken into account.

Summary

- The acoustic analysis based on R-JMICC showed vowel space expansion in Japanese.
- The expansion was seen regardless of the prosodic environment.
- Clear speech in ADS (SPS in CSJ) is comparable with IDS in terms of vowel space: other acoustic properties are distinctly different.
- R_IDS showed higher *H1-*H2 values than R_ADS and CSJ, which implies that the voice quality of IDS is more breathy.

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