Crosslinguistic Similarity and Structured Variation in Cantonese-English Bilingual Speech Production

Khia A. Johnson

University of British Columbia, Linguistics
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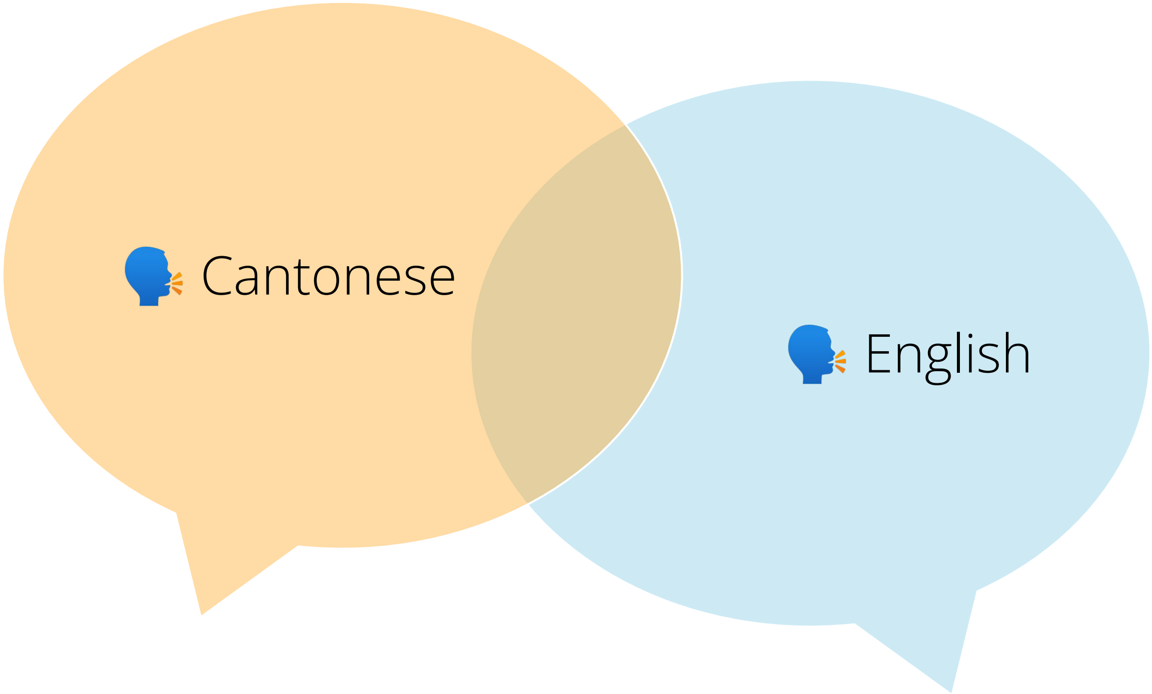
A "bilingual is NOT the sum of two complete or incomplete monolinguals; rather, [they have] a unique and specific linguistic configuration…a different but complete linguistic entity"

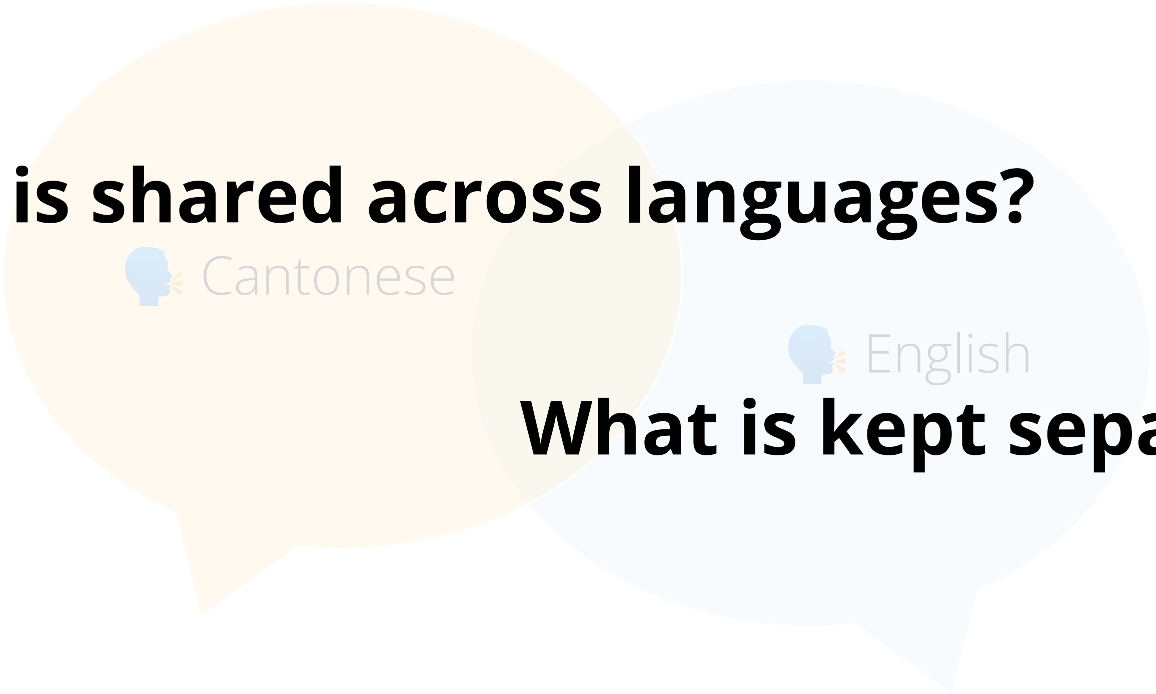
Grosjean, 1989: p. 6

Bilingual sound systems overlap



Bilingual sound systems overlap

What is shared across languages?



What is kept separate?

The SpiCE Corpus

(**Sp**eech **i**n **C**antonese and **E**nglish)

What is SpiCE?

UBC Research Data Collection (University of British Columbia)

Scholars Portal Dataverse > University of British Columbia >
UBC Research Data Collection >

SpiCE: Speech in Cantonese and English

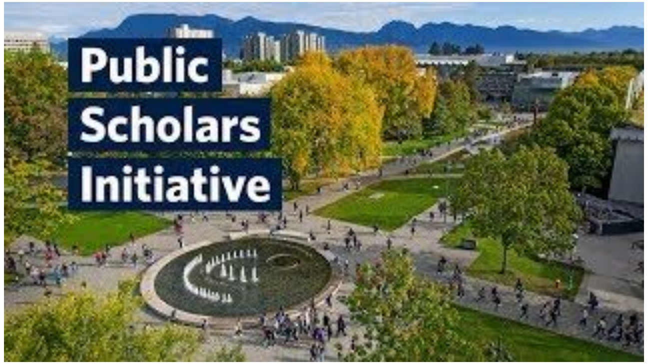
Version 1.0

Johnson, Khia A., 2021, "SpiCE: Speech in Cantonese and English", https://doi.org/10.5683/SP2/MJOXP3, Scholars Portal Dataverse, V1, UNF:6:c6HNIwwpBuQOA349cyCu7w== [fileUNF]

Cite Dataset

Learn about Data Citation Standards.

OPEN ACCESS



SpiCE by the numbers

🗣 **Cantonese**
🗣 **English**

34 early bilinguals × **2** languages × **3** tasks

18-34 years old
50% female
50% male

📕 sentence reading
🖼 storyboard narration
👥 conversational interview

SpiCE by the numbers

32.8 total hours

219,000 words

Cantonese
English

34 early bilinguals × **2** languages × **3** tasks

18-34 years old
50% female
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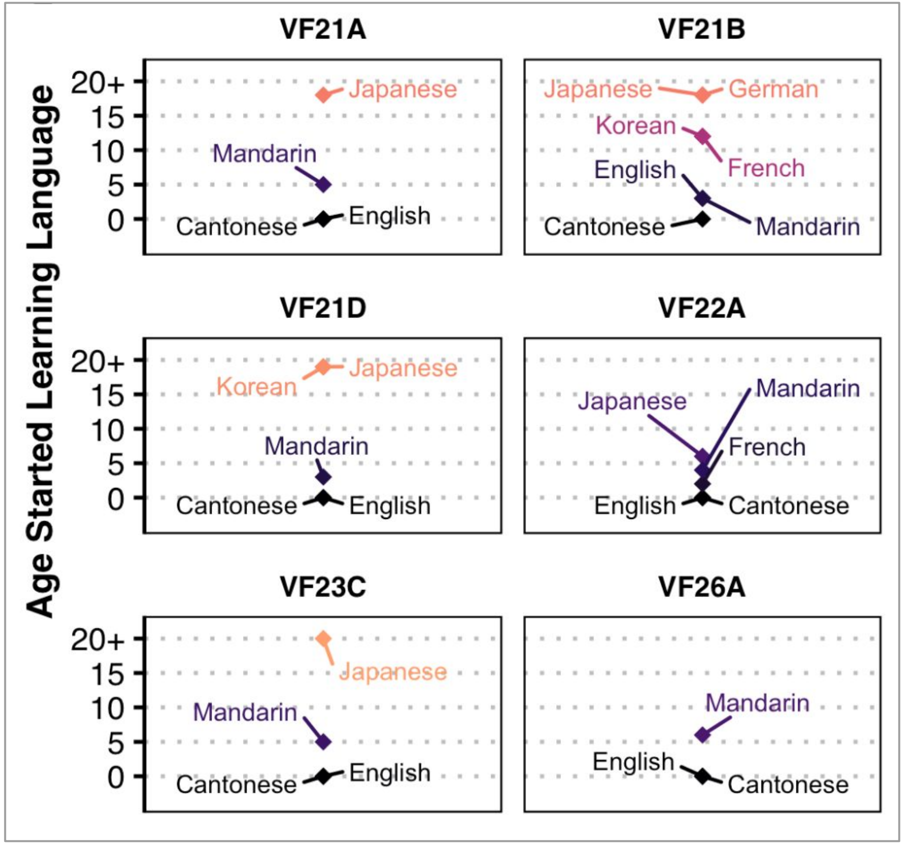
sentence reading
storyboard narration
conversational interview

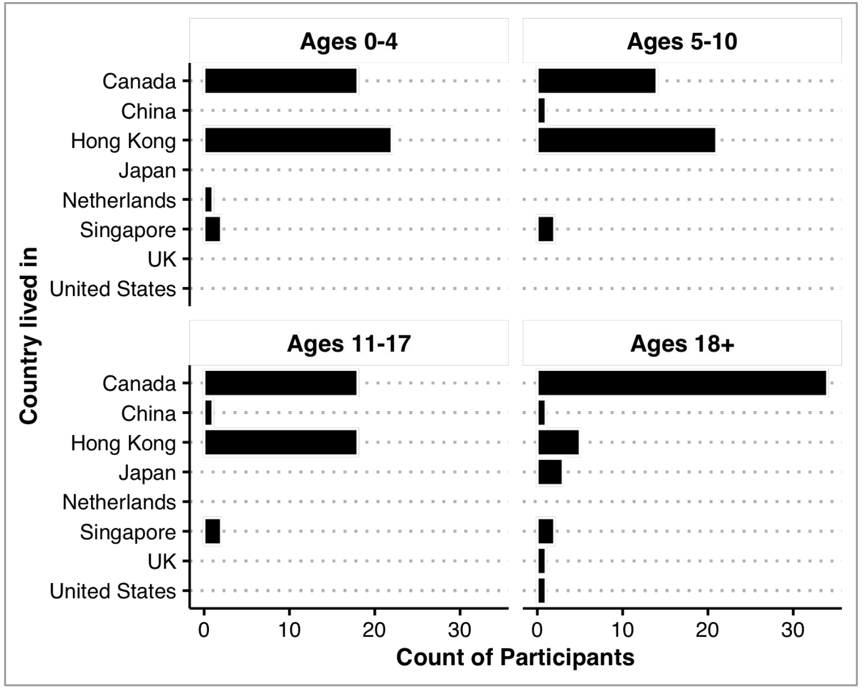
The SpiCE bilinguals

- English and Cantonese learned very early
- **Multi**lingualism is widespread
- For example, 6 talkers →



The SpiCE bilinguals

- Have roots from all over the diaspora
- Don't necessarily speak the same varieties



SpiCE is well-suited for...

- Corpus phonetics
- Within-talker designs
- Studying variation

Study 1
Shared structure in voices

Voices are highly variable

- Voice variability is largely idiosyncratic (Lee, Keating, & Kreiman, 2019)
- To know a voice is to know how it varies across environments, physical states, and emotions
- Is this variation influenced by **language**?

The role of language in voice variability

- Segmental, suprasegmental, & prosodic aspects of languages vary
- Few Cantonese-English voice quality comparisons (Ng et al., 2012)
    - English tends to be creakier (or less breathy)
    - Cantonese tends to have lower, more variable pitch
- Perceptual evidence that bilingual talkers can be identified after a language switch, especially by other bilinguals (Orena, Polka, & Theodore, 2019)

Methods overview

- Identify all voiced speech with Praat algorithm (Boersma & Weenink, 2020)
  - Vowels
  - Voiced consonants
- Make acoustic measurements every 5 ms in VoiceSauce (Shue et al., 2011)

Acoustic measures

Pitch F0	**Source spectral shape** H1*-H2* H2*-H4* H4*-H2kHz* H2kHz*-H5kHz
Formants F1 F2 F3 F4	**Source spectral noise** CPP Energy SHR

(Kreiman et al. 2014)

Acoustic measures

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(Kreiman et al. 2014)

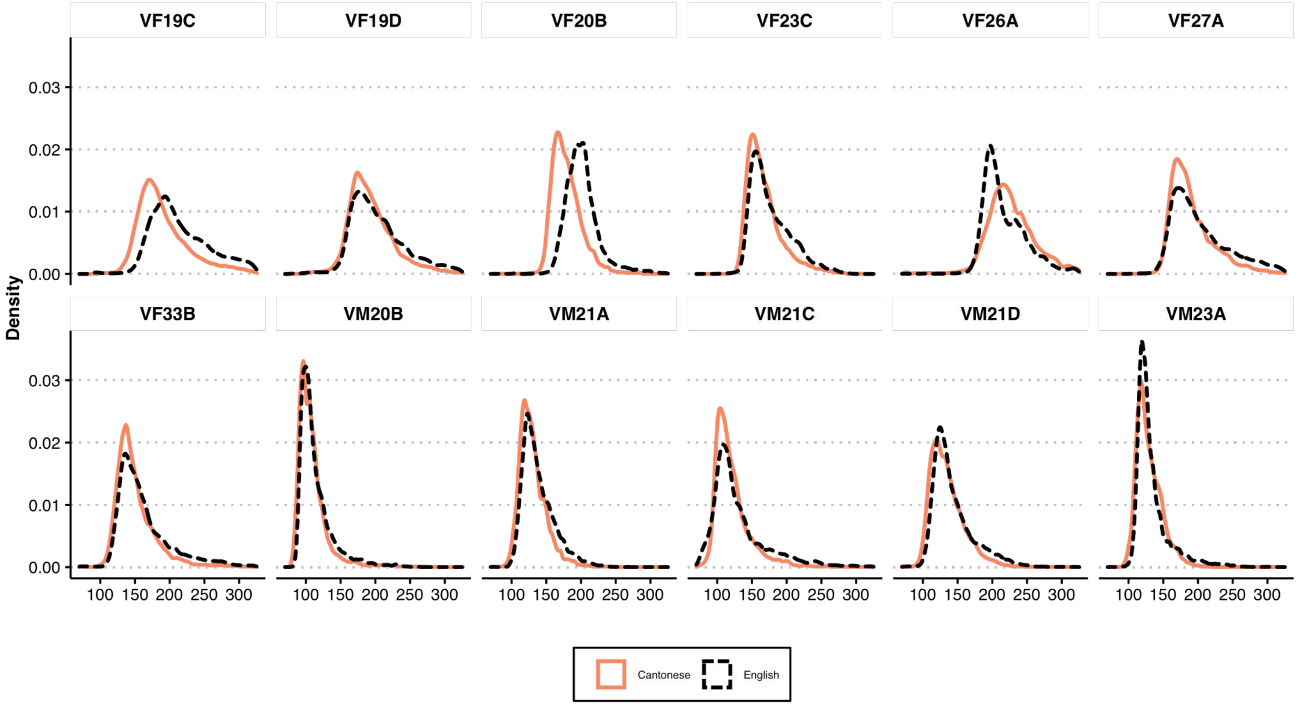
Methods overview, continued

- Remove impossible values
- Calculate rolling standard deviations
- 3-part analysis

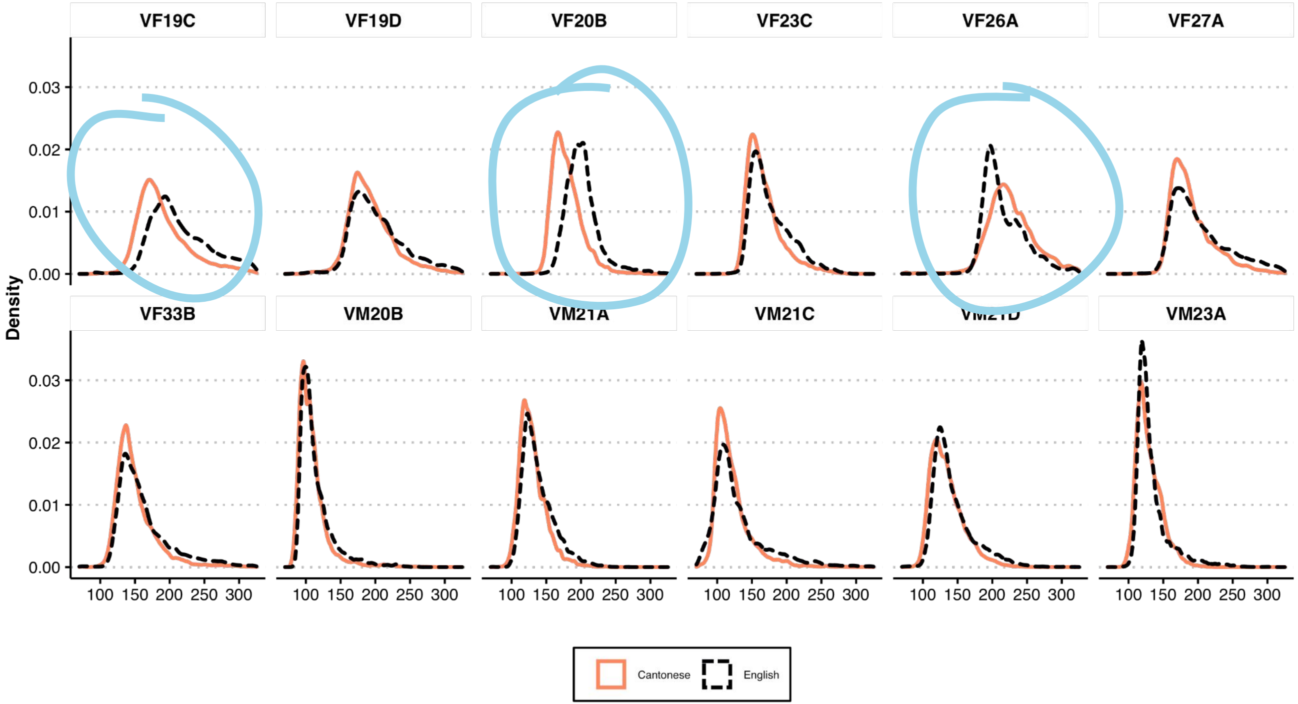
Comparing acoustic measure means

- 24 across-language comparisons per talker
- For example, do talkers differ F0 across languages?
- Cohen's *d* → is the difference...
  - Trivial
  - Small
  - **Medium**
  - **Large**

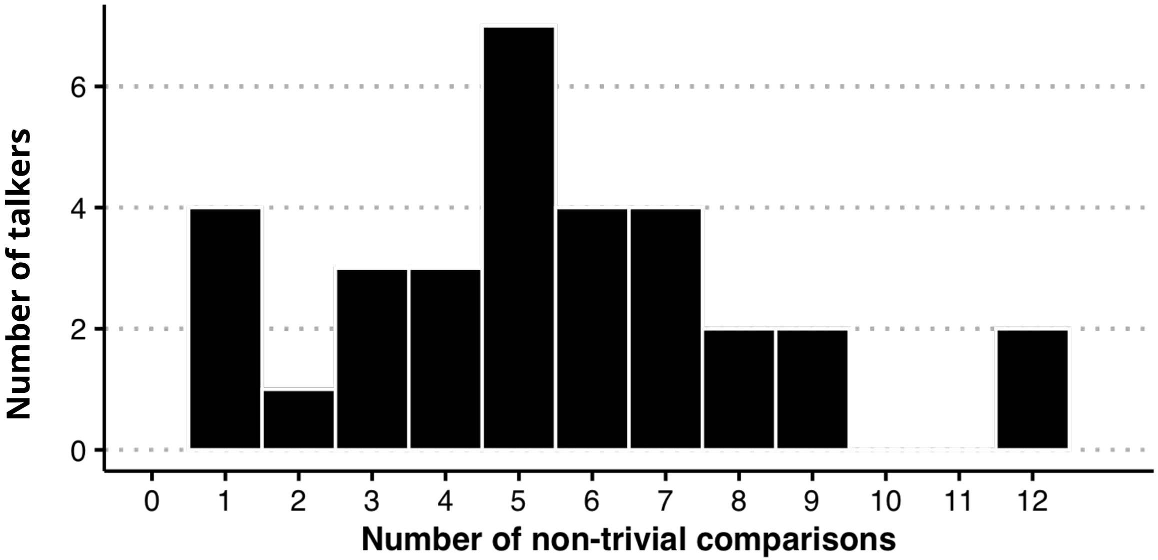
Non-trivial F0 differences



Non-trivial F0 differences



Counting non-trivial comparisons

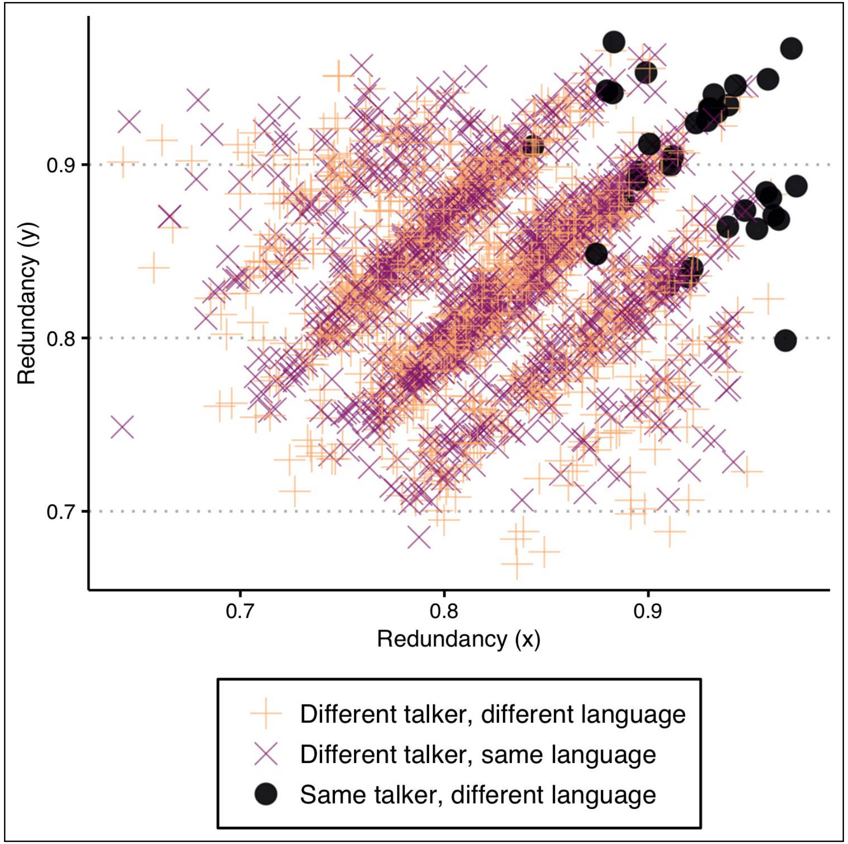


Principal Components Analyses

- Dimensionality reduction
  - Many measured dimensions → Fewer important components
  - Example: number of layers + daylight hours + temperature → “coldness” component
- 1 PCA each talker+language
- Main takeaways?
  - Lots of shared components across PCAs
  - Examples: Brightness/creakiness component, Energy component

Canonical redundancy analysis

- Or, ignoring component order, **how similar are two PCAs?**
- Asymmetrical metric → variation in PCA #1 accounted for by #2 and vice versa
- Redundancy is overall very high
- Redundancy is especially high within talker across languages



Takeaways

- Voices, broadly speaking, share lower dimensional structure (Lee et al., 2019)
- Much of idiosyncratic voice structure is retained across languages
- Voices *are* like auditory faces (Belin et al., 2004)

Study 2
Shared structure in consonants

Long-lag stops in Cantonese and English

- Both languages have long-lag /p/, /t/, and /k/ word-initially
- Typical long-lag voice-onset time in isolated speech
  - Cantonese: ~91 ms (Clumeck et al., 1981)
  - English: ~80 ms (Lisker & Abhramson, 1964)
- Often analyzed as “linked” sounds
- Classic methods in crosslinguistic depend on detecting/modulating *differences*

Crosslinguistic *uniformity*

- **Uniformity**: a constraint on within-talker phonetic variation, in which articulatory gestures or phonological primitives are implemented systematically in speech production (Chodroff & Wilson, 2017; Faytak, 2018; Ménard et al., 2008)
- A framework for identifying overlap among segments through the structure of variation
- *Study 2 extends this set of methods to crosslinguistic comparisons*

Methods overview

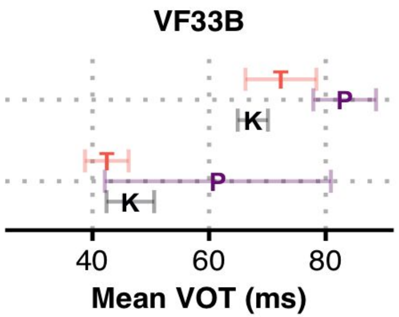
- Prevocalic word initial / p t k / with following stress
- VOT identified, refined, and measured

Table 4.1: The number of stop tokens (overall and range across talkers) and word types for each language and sound category.

Language	**Frequency**	**/p/**	**/t/**	**/k/**
Cantonese	Token (overall)	374	1373	1688
	Token (range)	0–32	17-79	19–116
	Type (overall)	60	157	68
English	Token (overall)	1035	1336	3155
	Range (tokens)	4–96	15–150	52–294
	Type (overall)	158	143	208

Mean VOT analysis

- Calculate mean VOT for each **talker × language × consonant**
- Ordinal relationships
  - Expected: /p/ < /t/ < /k/
  - Actual: Wildly inconsistent ordering across the board
- Pairwise correlations
  - Expected: Strong clear correlations
  - Actual: Moderate correlations at best, both within and across languages



Ordinal mean VOT relationships

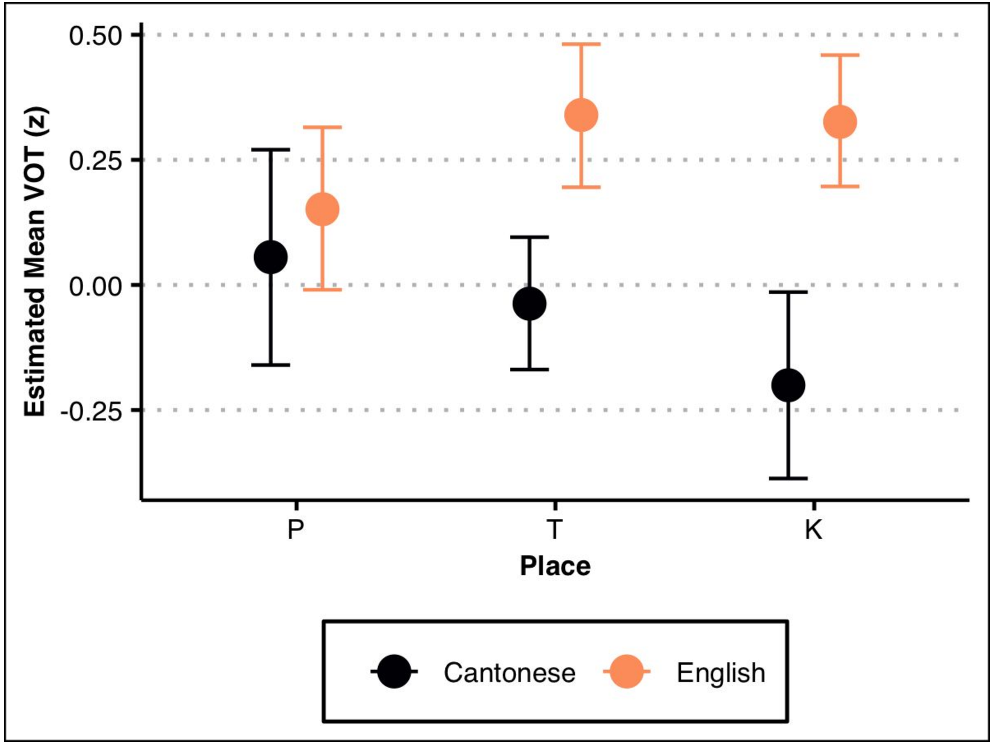
- **Expected**: p < t < k
- **Actual**: Wildly inconsistent ordering across the board
- An illustrative subset

Bayesian multilevel linear model

- Model designed to *figure out what's going on*
- Takes **speech rate**, **pauses**, and **word variability** into account
    - Note: these variables behaved *as expected*
- Code & model details → https://github.com/khiajohnson/dissertation

Model predictions

- Model-predicted means for Place and Language
- English has *slightly* longer VOT for /t/ and /k/



Sources of variation

- Words do the most heavy lifting
  - Example: 2 initial /k/ in →
- Removing Word from the model drastically alters the model's story
- High between-talker variability, too

Takeaways

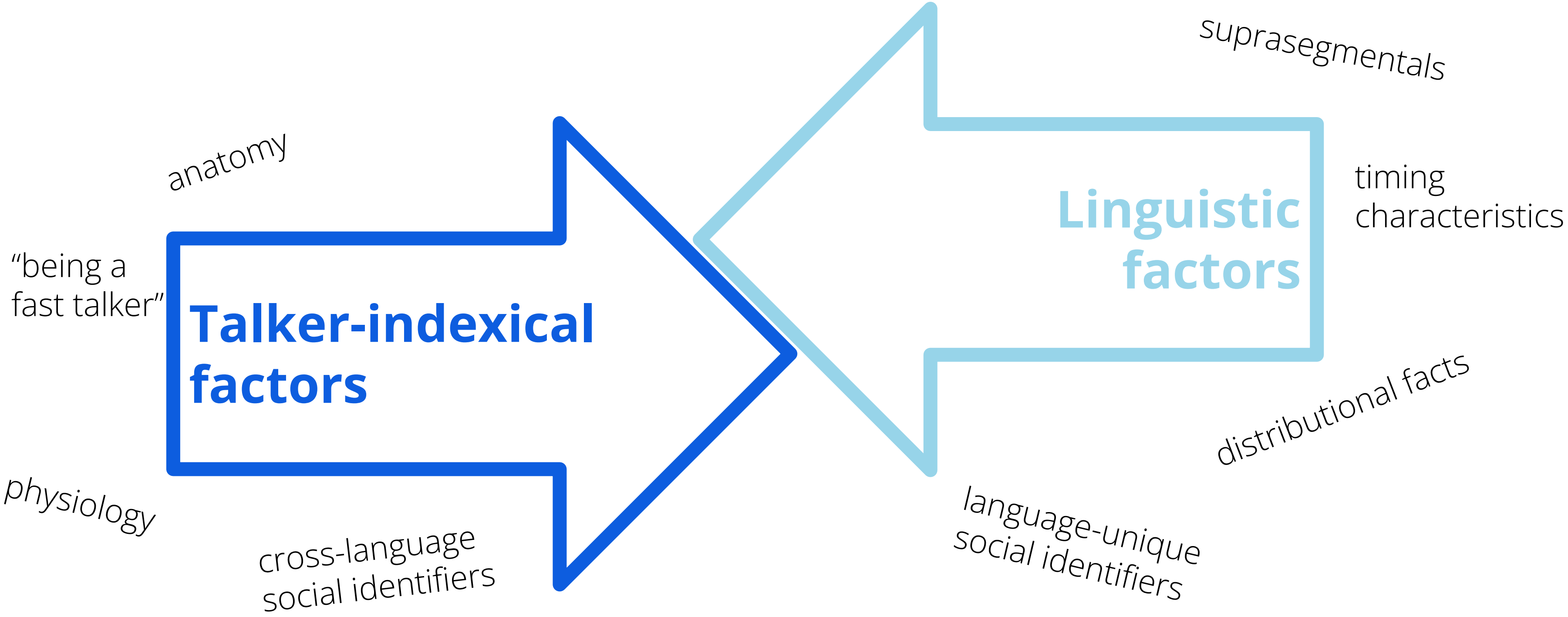
- Some evidence for within- and across-language uniformity, especially if a more “macro” approach taken
- Talkers can maintain *very* fine-grained crosslinguistic differences, though reason is unclear
- Spontaneous speech leads to drastically different results
    - Uncontrolled lexical content
    - Style differences

Discussion & Conclusion

What’s shared?

- Voices share mean values for acoustic dimensions and lower-dimensional structure
- Long-lag stops share a general target for VOT
- A lot, but not everything

Variation influencers



Key contributions

- The SpiCE corpus
- Reproducible analyses
- Improved understanding of *how* languages share sound structure
- Production-based groundwork for perception research
    - Talker identification
    - Processing uniform VOT

thank you!

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References available at:
https://github.com/khiajohnson/dissertation/blob/main/text/references.bib