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

Khia A. Johnson

University of British Columbia, Linguistics
Final Oral Defense | December 10, 2021

Slides ↴
git.io/JMb8q

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

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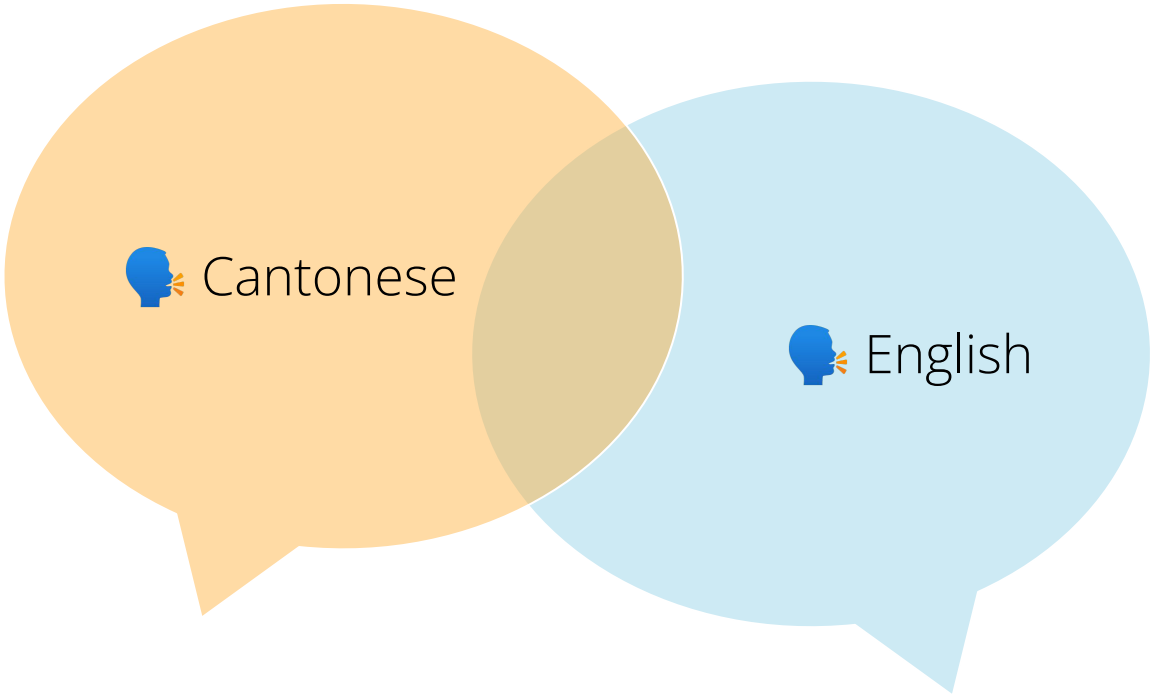
Bilingual sound systems overlap



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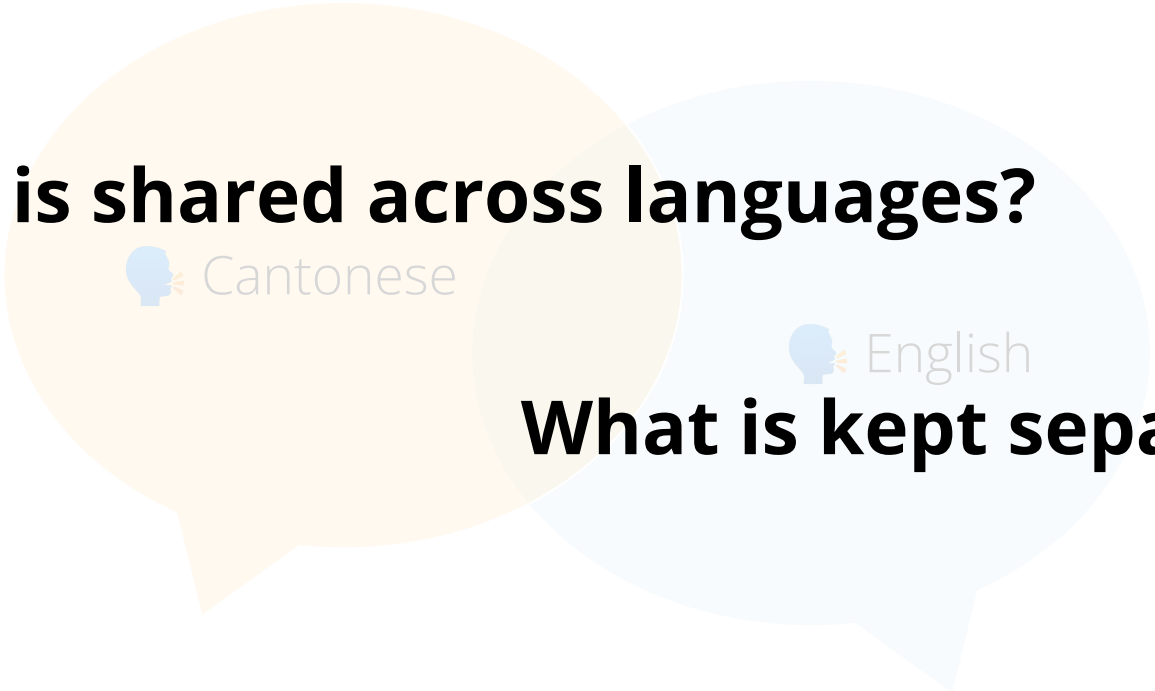


What is shared across languages?

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

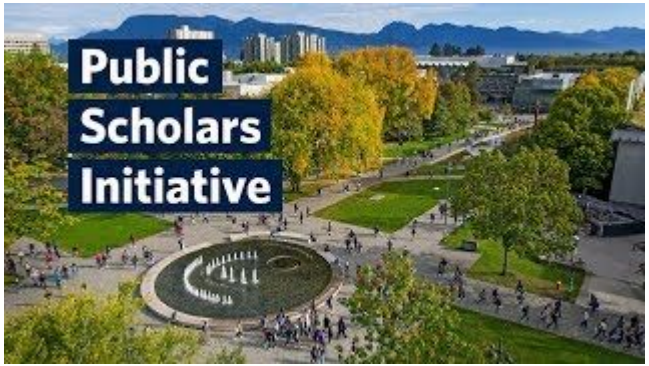
Version 1.0

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

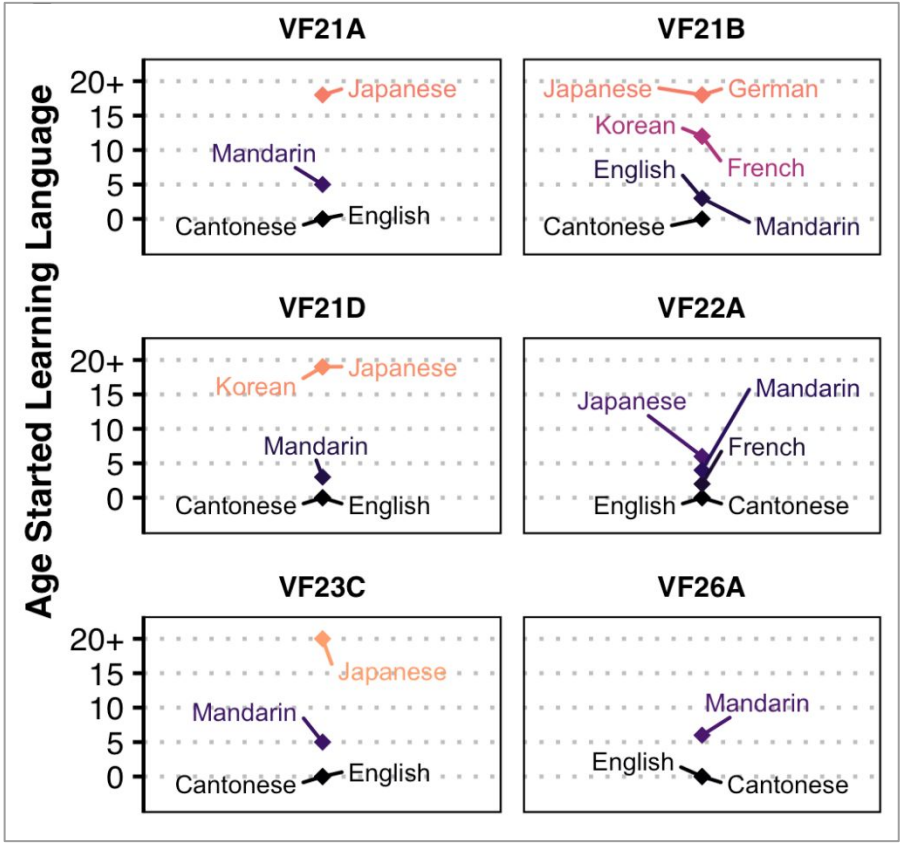
SpiCE by the numbers

32.8 total hours

219,000 words

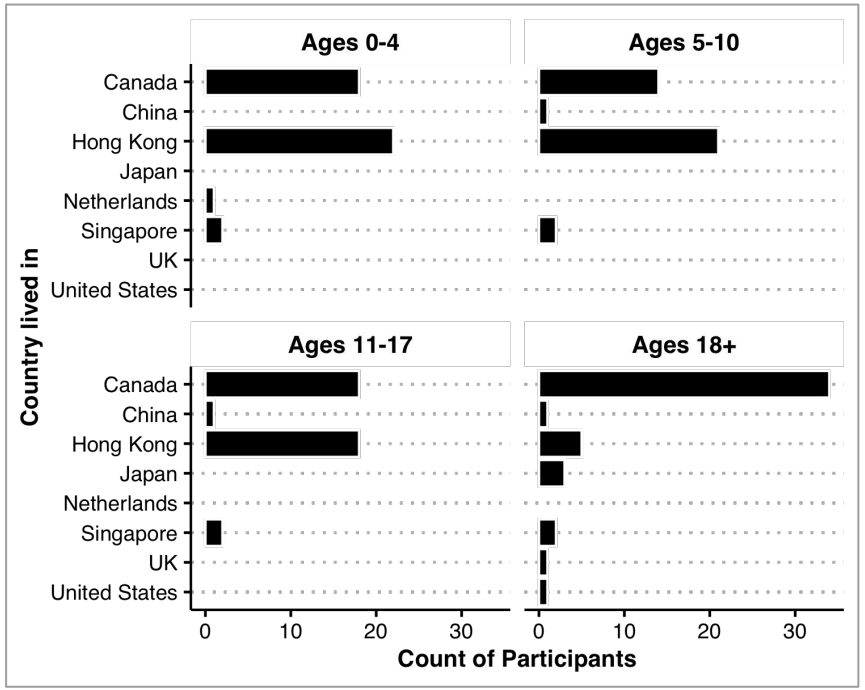
The SpiCE bilinguals

- 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 voice

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
- Some Cantonese-English voice quality comparisons (Ng et al., 2012)
- Perceptual evidence that bilinguals can identify voices after a language change (Orena, Polka, & Theodore, 2019)

Methods overview

- Identify all voiced speech with Praat algorithm (Boersma & Weenink, 2020)
  - Vowels
  - Voiced consonants
  - Other vocalizations
- 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)

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(Kreiman et al. 2014)

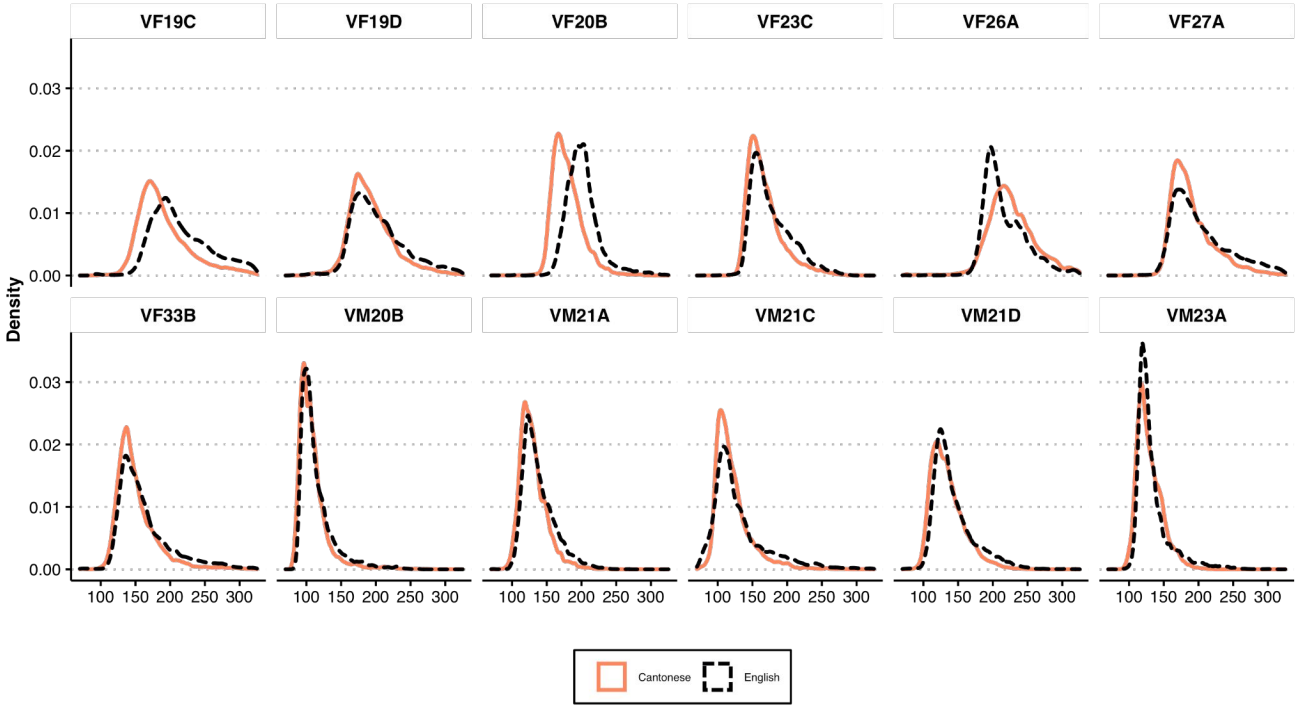
Methods overview, continued

- Remove impossible values (measurement error)
- Calculate rolling standard deviations → 24 total measures
- 3-part analysis

Part 1: 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**

Part 1: Non-trivial F0 differences



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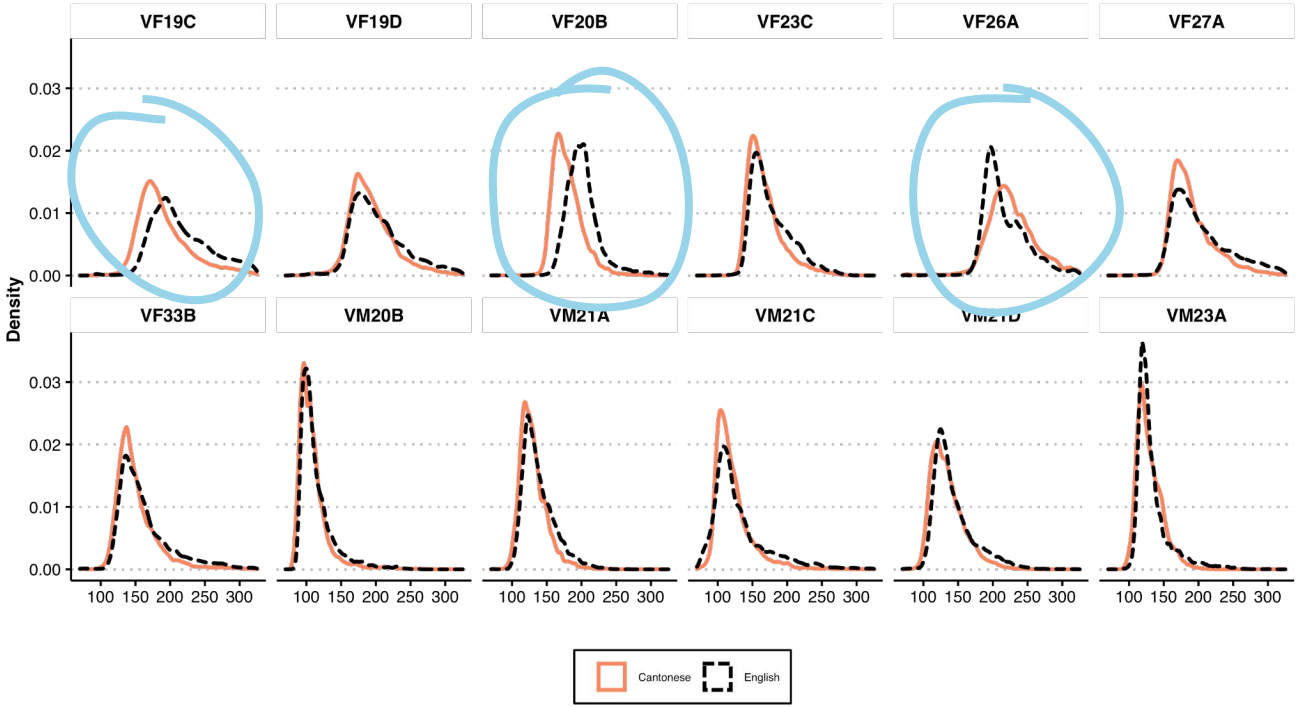
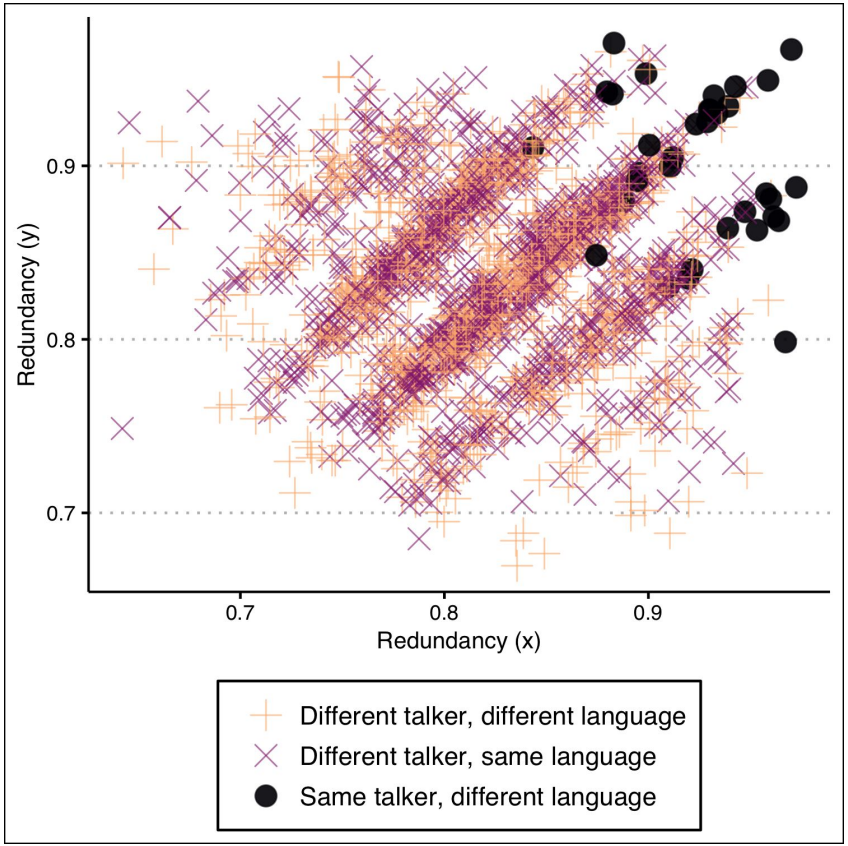


Part 2: Principal Components Analyses

- Dimensionality reduction
  - Many measured dimensions → Fewer important groups
  - Example: number of layers + daylight hours + temperature → “coldness” component
- 1 PCA each talker+language → 68 PCAs
- Main takeaways?
  - Lots of shared components across PCAs
  - Examples: Brightness/breathiness component

Part 3: 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 a lot of basic 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 (“VOT”)
  - Cantonese: ~91 ms (Clumeck et al., 1981)
  - English: ~80 ms (Lisker & Abhramson, 1964)
- Anecdotally very similar

More than just similar?

- **Uniformity**: a constraint on within-talker phonetic variation, in which parts of speech sounds are implemented systematically across sounds with the feature (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

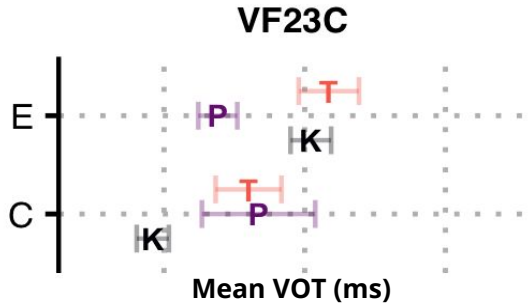
- Prevocalic word-initial / p t k / with following stress
- VOT identified, refined, and measured

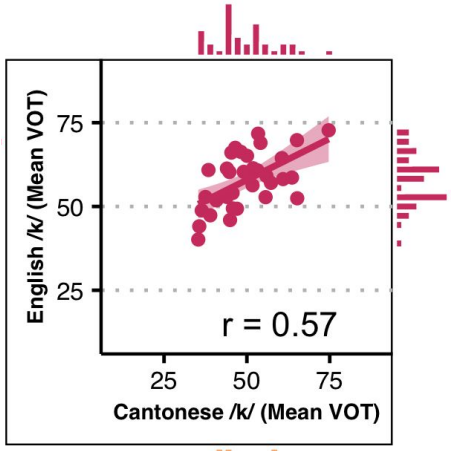
Table 4.1: The number of stop tokens (overall and range across talkers) and word types for each language and sound category.

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



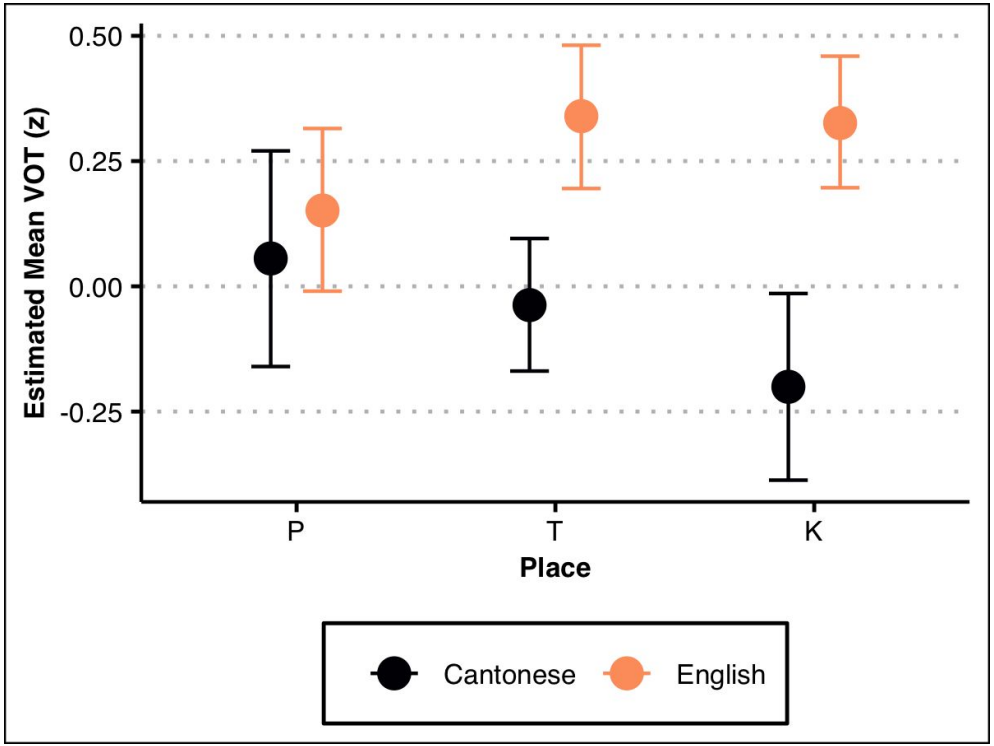


Bayesian multilevel linear model

- 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/ sounds in
- High between-talker variability, too

Takeaways

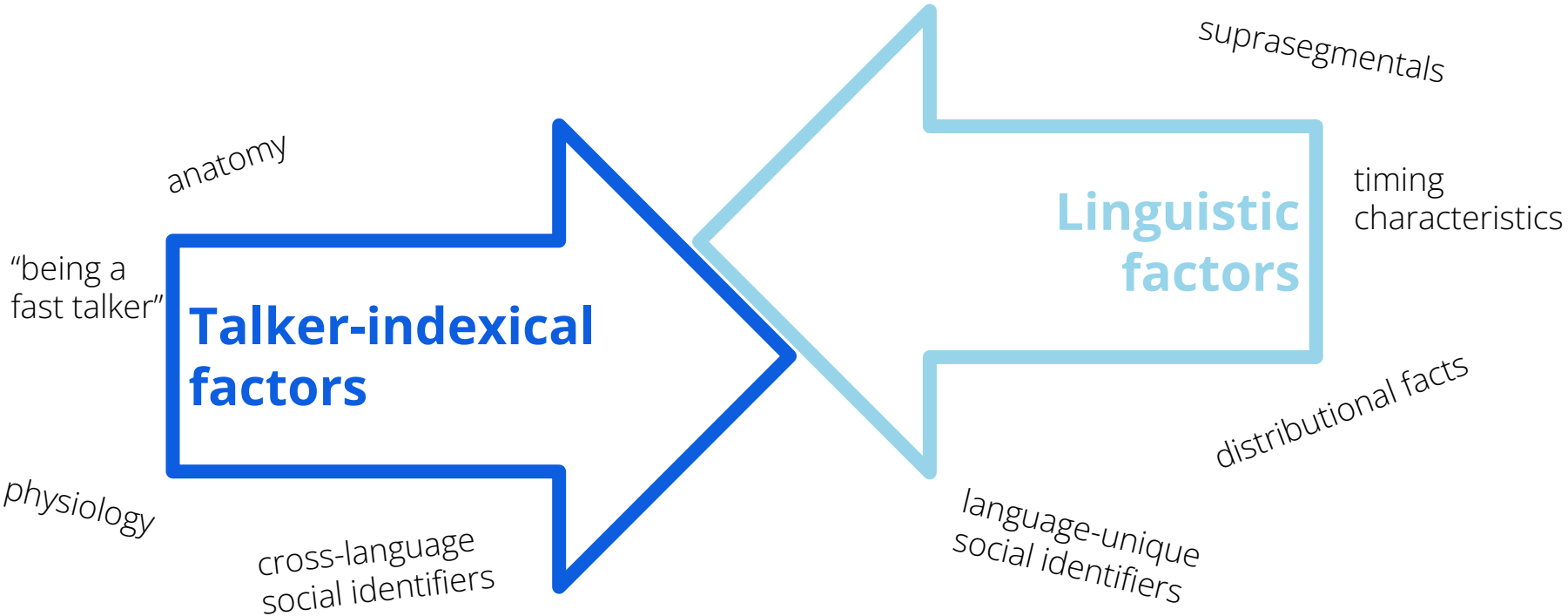
- Evidence for structure within- and across language, especially with a coarser lens
- Talkers can maintain small differences
- Spontaneous speech leads to drastically different results
  - Uncontrolled lexical content
  - Style differences

Discussion & Conclusion

What's shared?

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

Variation influencers



Key contributions

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

thank you!

Molly Babel, Kathleen Currie Hall, Márton Sóskuthy, Ivan Fong, Nancy Yiu, Katherine Lee, Kristy Chan, Natália Oliveira Ferreira, Michell To, Rachel Ching Fung Wong, Christina Sen, Ariana Zattera, Rachel Soo, Nikolai Schwarz, Robert Fuhrman, Carla Hudson Kam, Valter Ciocca, Matt Goldrick, Gloria Mellesmoen, John Alderete, Henny Yeung, everyone in the Speech in Context Lab, members of the linguistics department, my cohort, friends, family, dog!, and so many others I'm probably forgetting... the UBC Public Scholars Initiative, Molly's SSHRC grant, and my UBC fellowships. I couldn't have done this without all of you.

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