Phonological development: The acquisition of a (really) complex system

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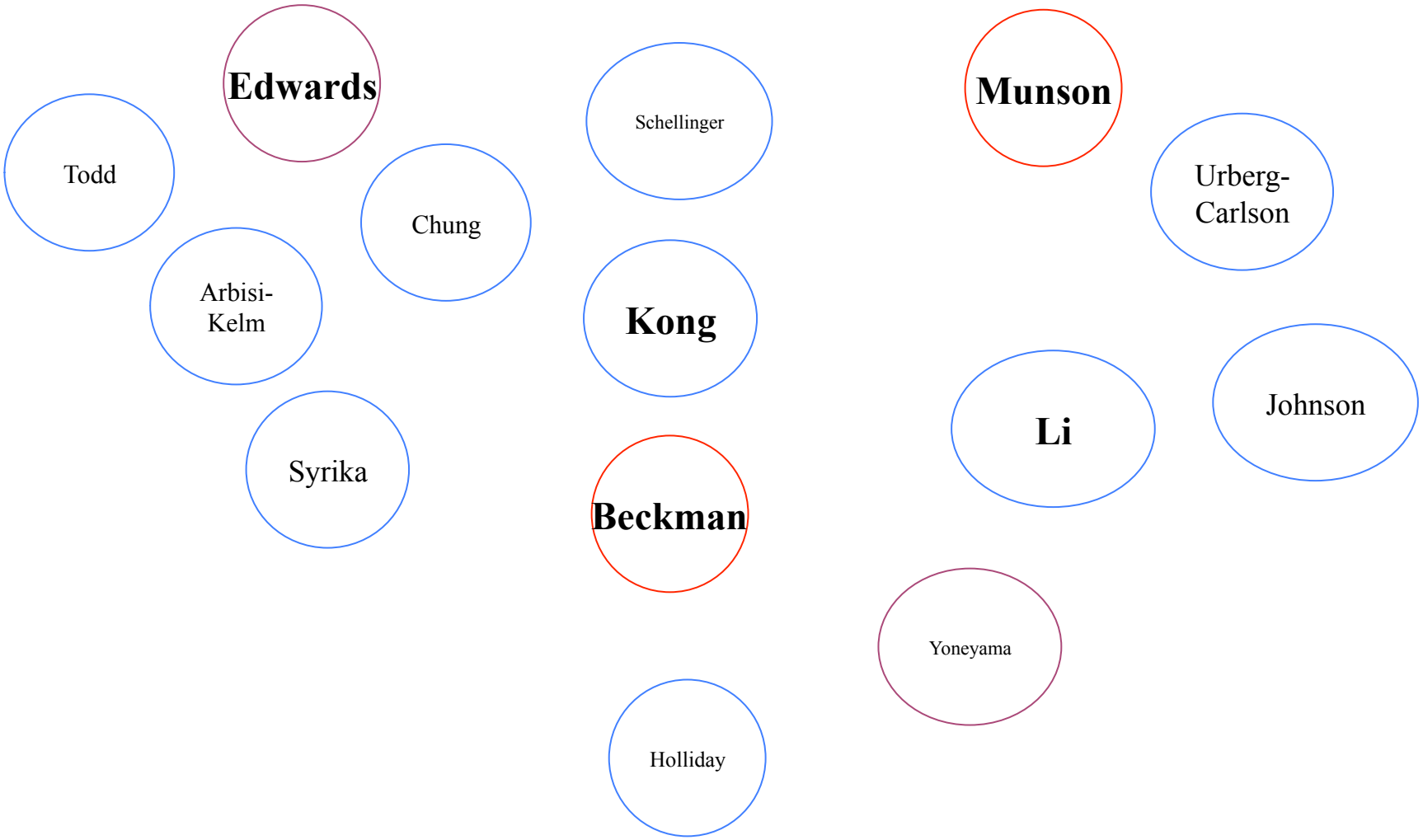
A complex web of collaborators



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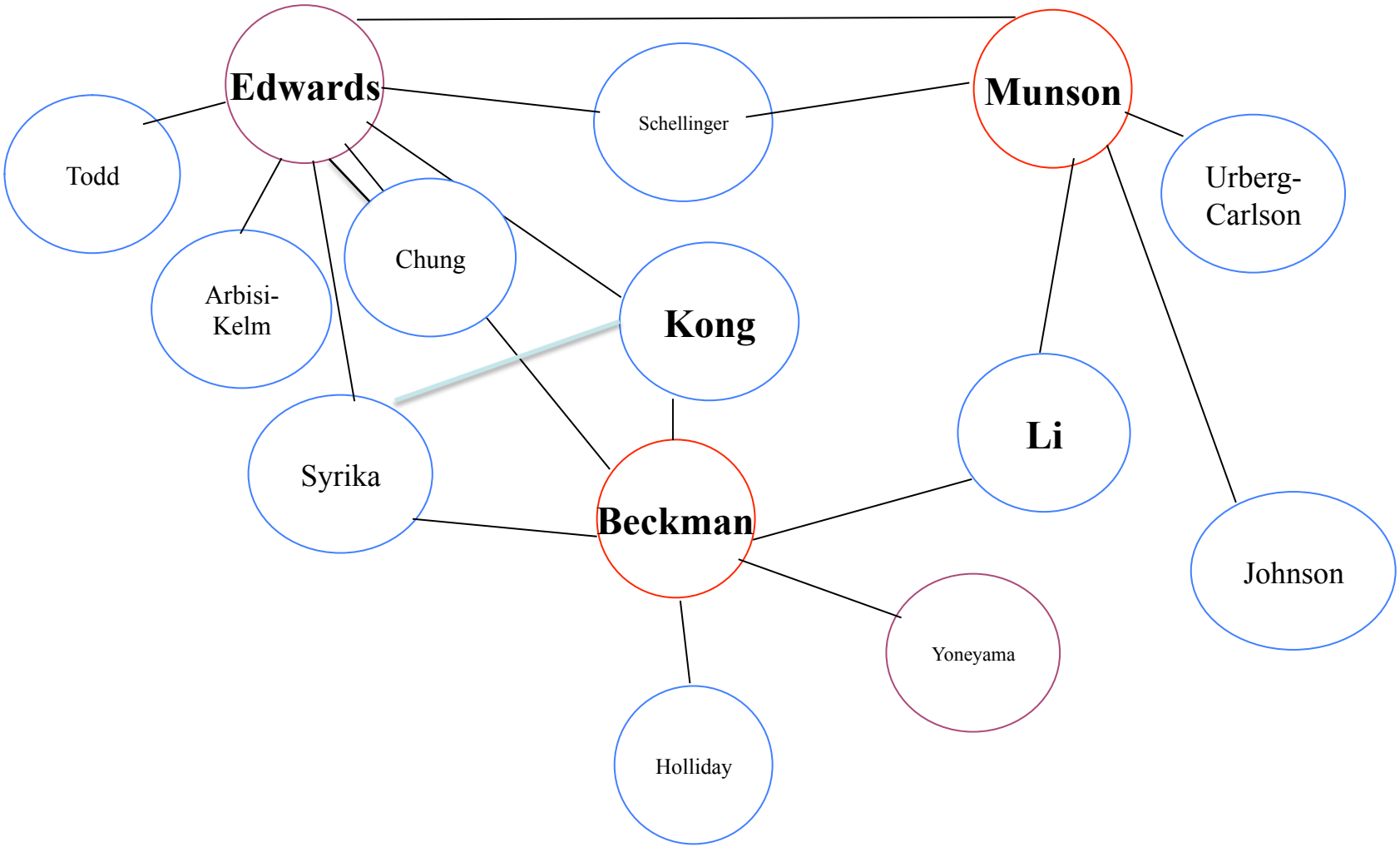

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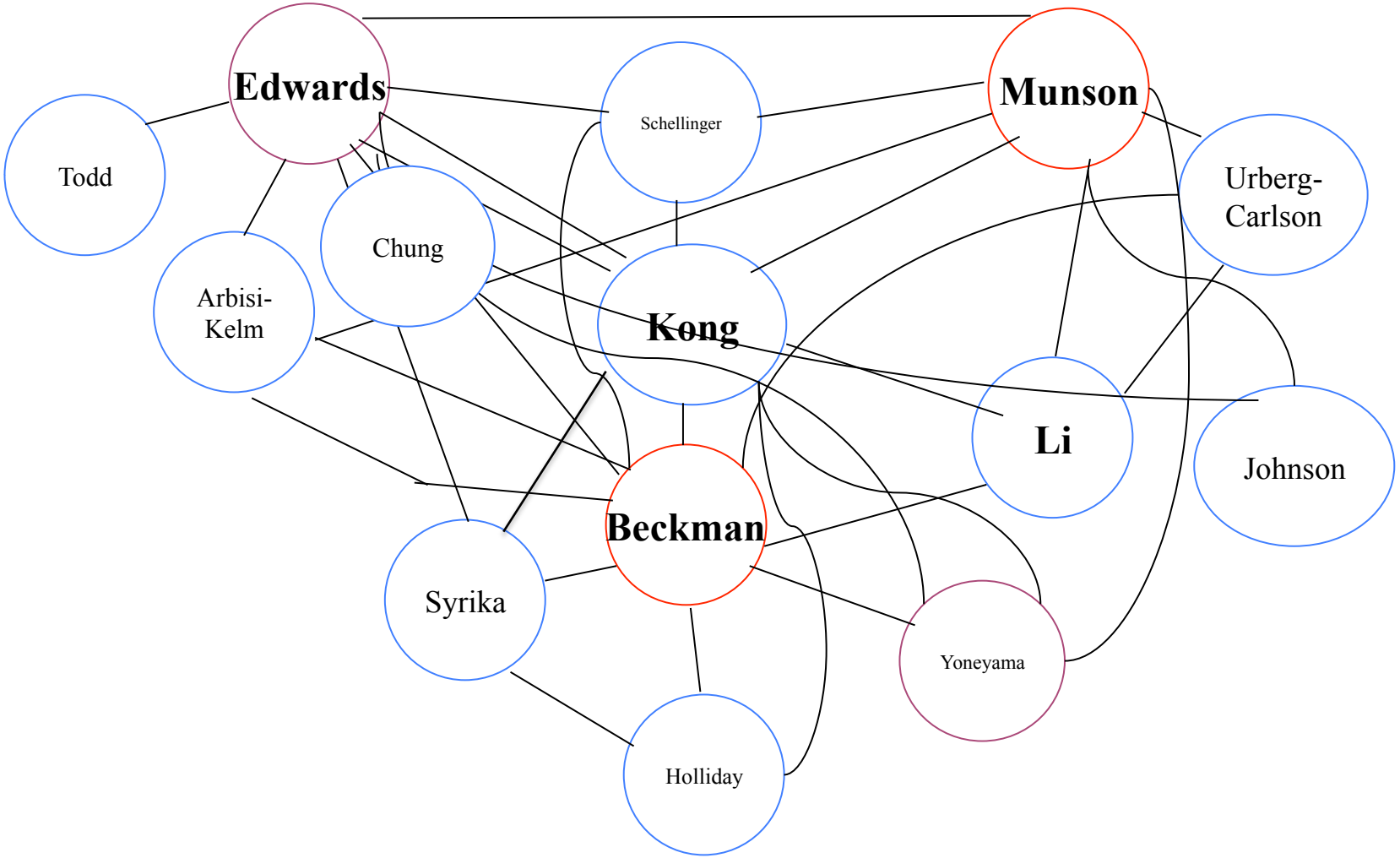


Is phonological learning trivial?

- Speech sounds are often thought of as the mere 'front end' of higher-level language.

- Pinker: " [Learning of] words and grammar are different. The sequence of sounds making up a word is not capturable by rules (*monkey* cannot be understood as a combination of *mon* and *key*), but must be memorized. And because there are a finite number of words, they all can be recorded." (*Science*, 1997)

Assumptions underlying a traditional "phonology as mere front end" view

1. Children are acquiring abstract phonological categories when they are learning to produce sounds correctly.

2. There are more-or-less universal patterns of development.

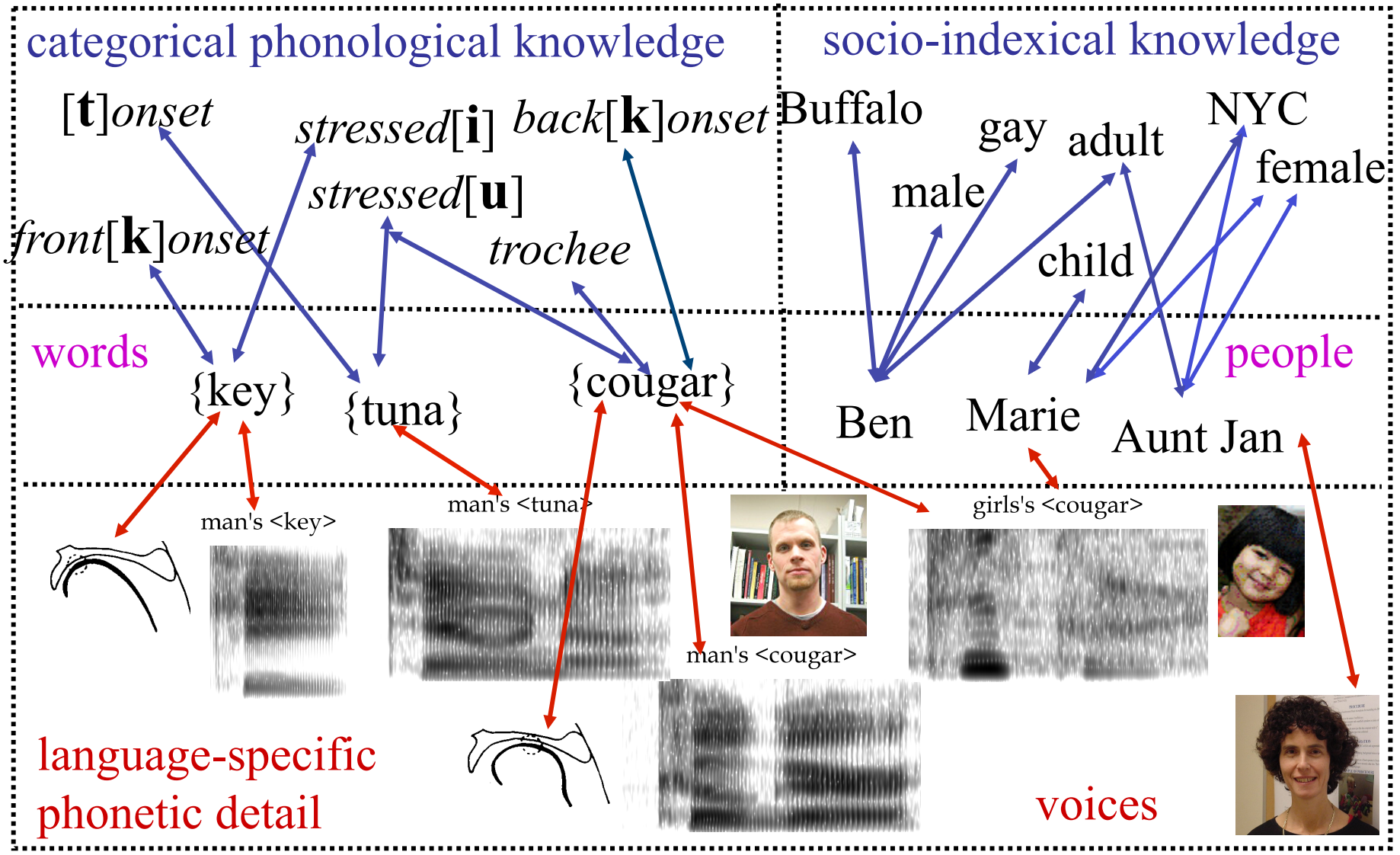
3. Acquisition can be studied through alphabetic phonemic transcriptions alone.

4. Acquisition after about age 5-6 is primarily related to fine-tuning of motor skills.

Organization of talk

1. Model of phonological knowledge.
2. Do children acquire abstract phonological categories such as the phonemes /s/ vs. /ʃ/ (“sh”) directly?
3. Do children acquire the same sounds, such as /s/ and /ʃ/, in the same way across languages?
4. Is alphabetic transcription of sounds like /s/ and /ʃ/ adequate to capture phonological development?
5. Is acquiring categories like the phonemes /s/ and /ʃ/ all there is to phonological development?
6. Clinical implications.

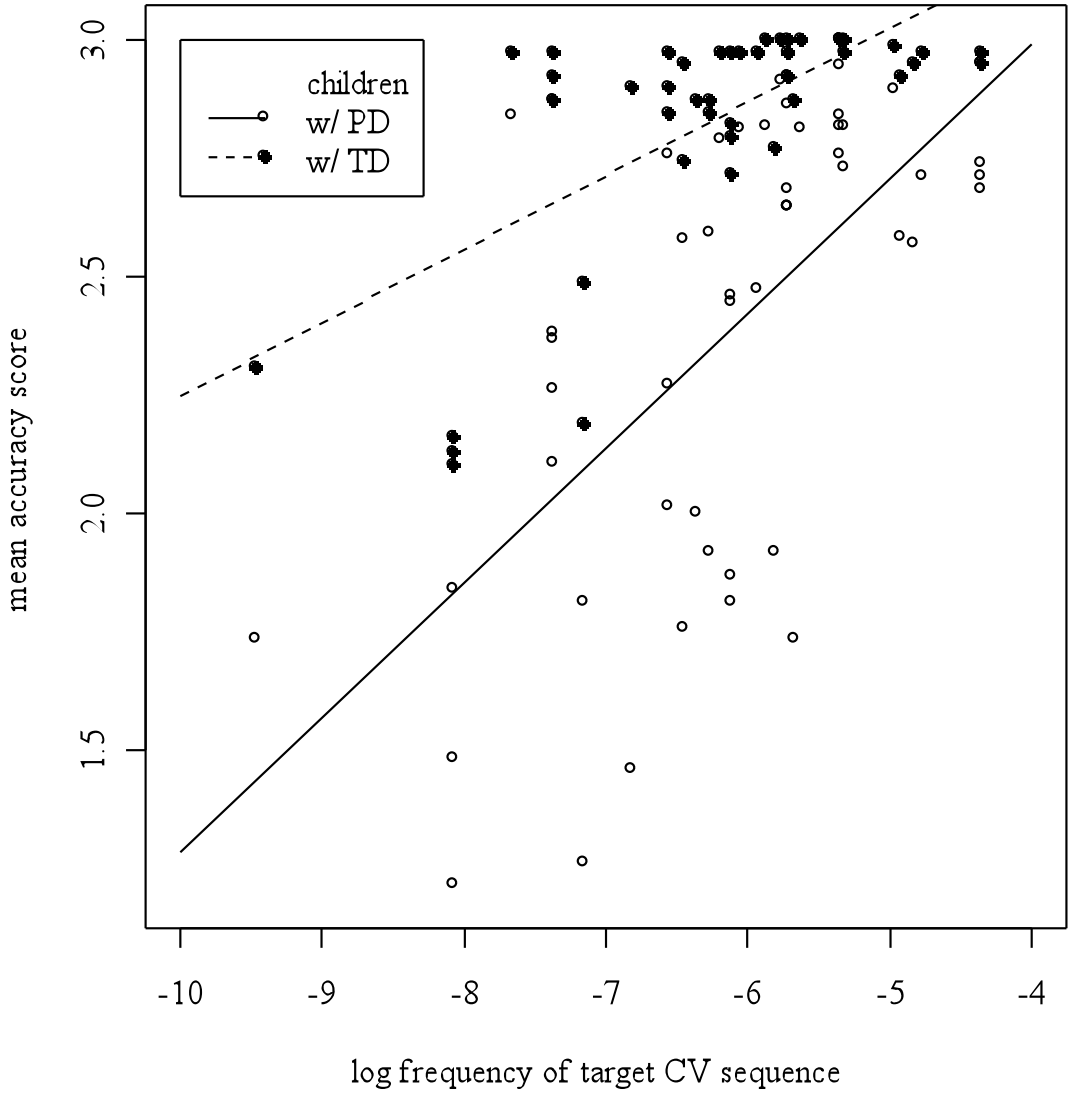
Levels of knowledge about speech sounds



1. Children learn sounds in words

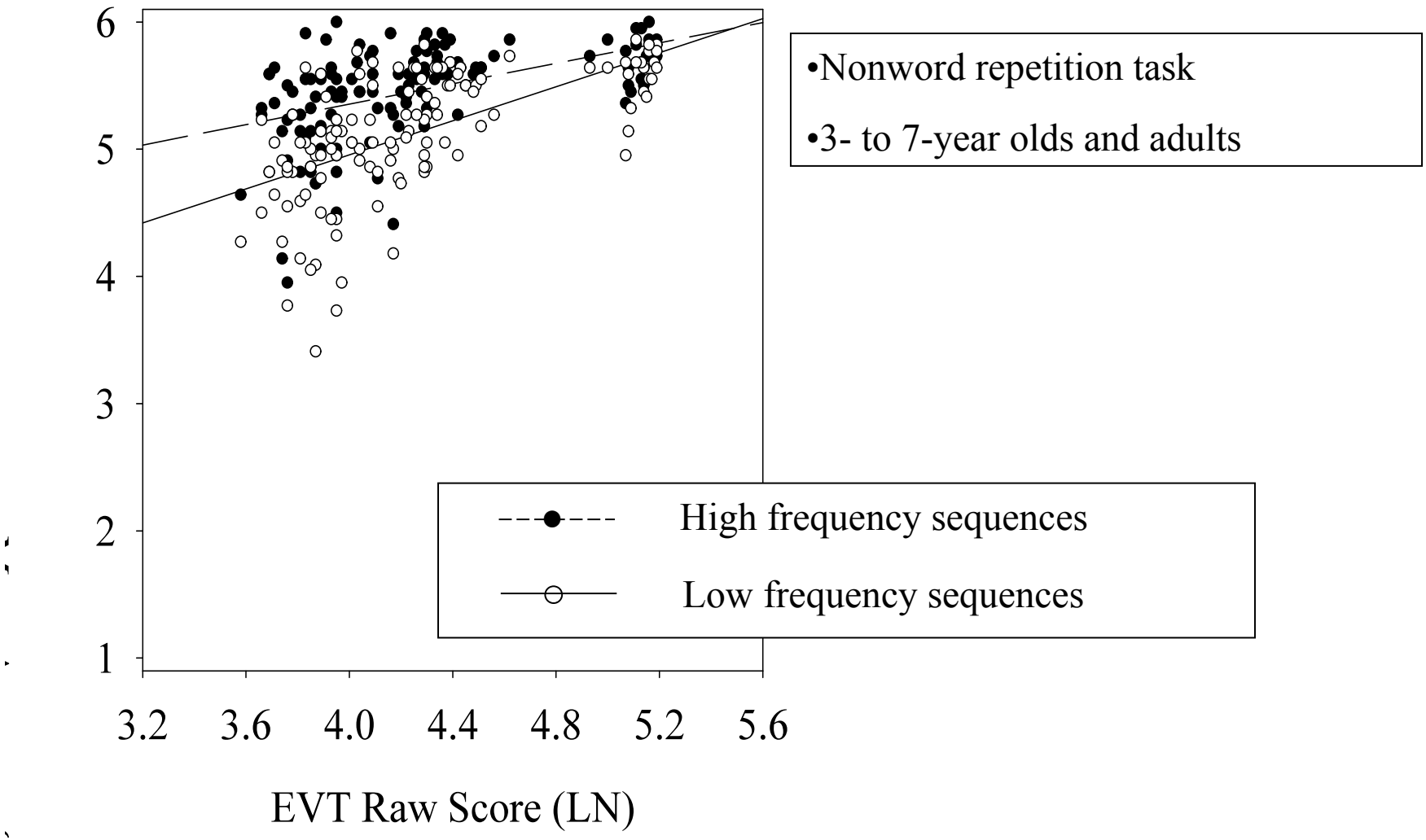
- Claim: Abstract phonological categories develop gradually.
  - Relationships between phoneme frequency and production accuracy across languages.
  - Relationships among phoneme frequency, production accuracy, and vocabulary size in English.

Phoneme frequency and accuracy: English (Vodopivec, 2004)



- Picture naming task
- 3- to 5-year-olds with phonological disorders and typically developing age controls.

Consonant accuracy, frequency, and vocabulary size: English (Edwards et al, 2004)



Lexical generalization hypothesis

- Edwards et al., 2004 interpretation: Children make phonological generalizations over their lexicon.
  - The larger the lexicon, the more robust and context-independent these phonological generalizations are.
  - This is why children with larger lexicons are more accurate at producing familiar sounds in novel contexts.

- Alternative interpretation:
  - Perhaps some sounds and sound sequences are low in frequency *because* they are more difficult to produce or perceive.

Why we need to examine phonological development cross-linguistically

- The frequency of sounds and sound sequences differs across languages.
  - /tʃ/ (“ch”)
    - high-frequency in Japanese
    - low-frequency in English
    - non-existent in Greek
  - /si/ (“see”)
    - high-frequency in Greek
    - non-existent in Japanese
  - /kʲo/ (“kyo”)
    - non-existent in English
    - mid-frequency in Japanese
  - /tu/ (“too”)
    - high-frequency in English
    - non-existent in Cantonese

The παιδολογος database

- Targets: word-initial lingual obstruents in 5 vowel contexts in:
  - Cantonese, English, Greek, Japanese
  - Also, Korean, Mandarin, Taiwanese, French, ….
- Participants:
  - About 20 2-, 3-, 4-, 5-year-olds and adults / language
- Procedure:
  - Elicit single word repetitions of target CVs in familiar words and nonwords.
  - Data collected in Hong Kong, Tokyo, etc.
- Measures:
  - Native-speaker transcriptions of target word-initial consonants
  - Acoustic measures
  - Naïve listeners' perceptions

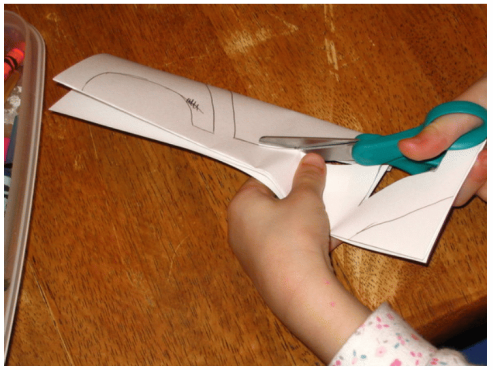
Example stimuli for /k/ in English

kaytush

key

coffee

cube



cutting

cougar

coat

quick

Example stimuli for /k/ in Japanese

[kʲimono]

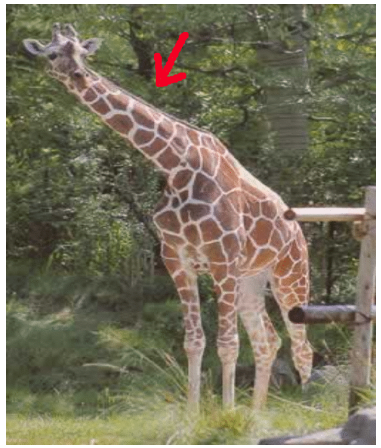
[kʲe:ki]

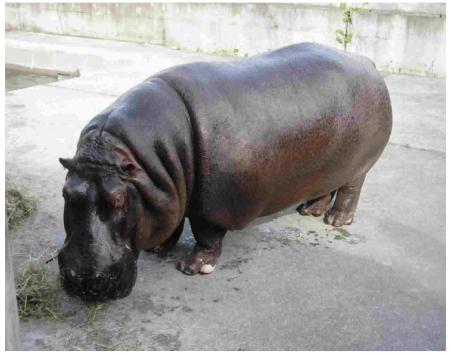
[kʲu:ri]

[kuma]

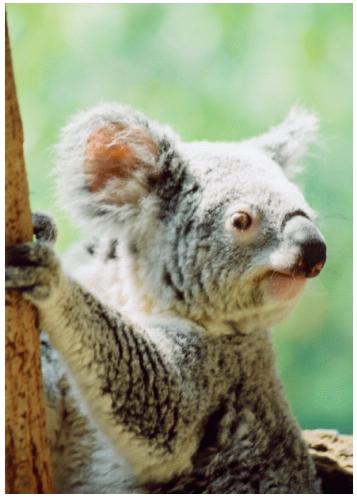
[kuruma]

[kubi]



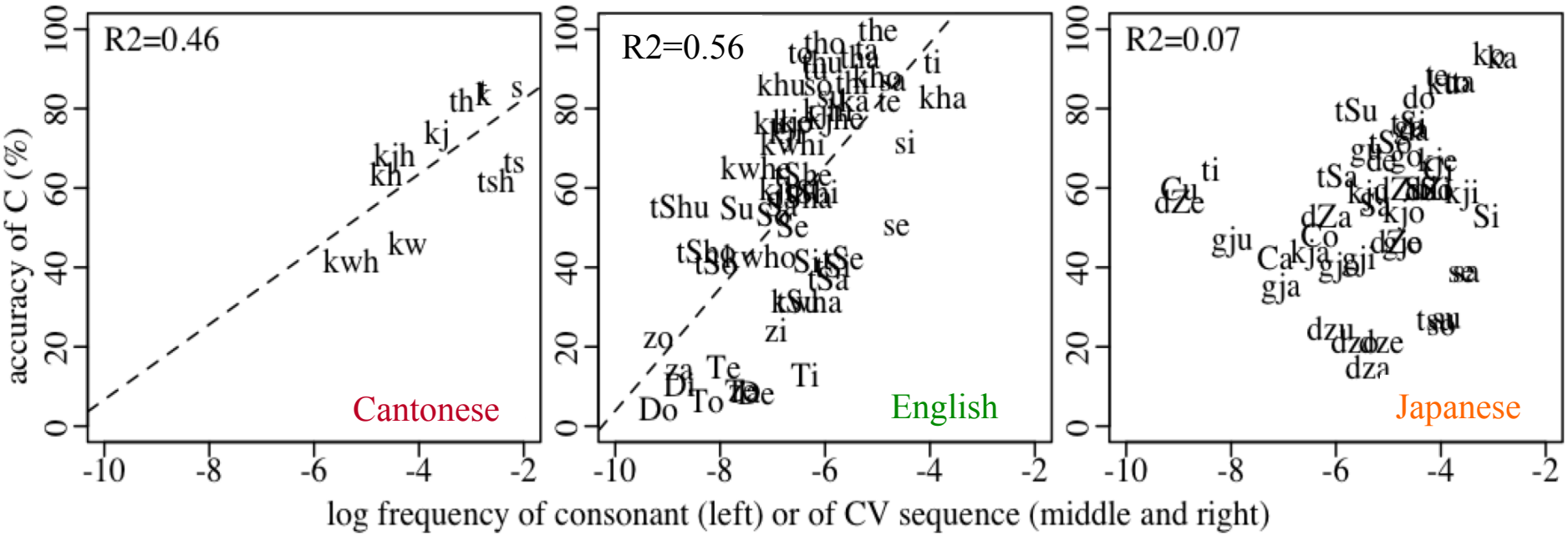


[kaba]

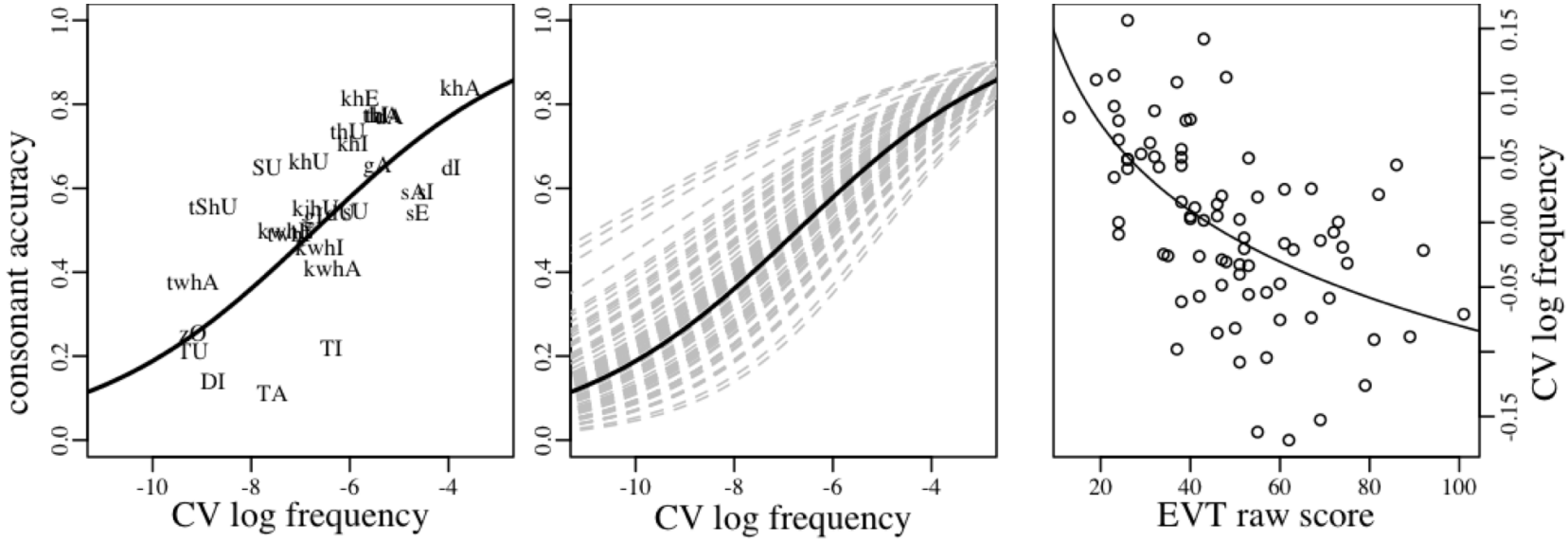


[koara]

Relating accuracy to frequency: Cantonese, English, and Japanese



Consonant accuracy, frequency, and vocabulary size (again): English



- Significant relationship between accuracy and frequency.
- The slope of this function differs across participants.
- Slope = *frequency effect.*

1. Conclusion: Children learn sounds in words

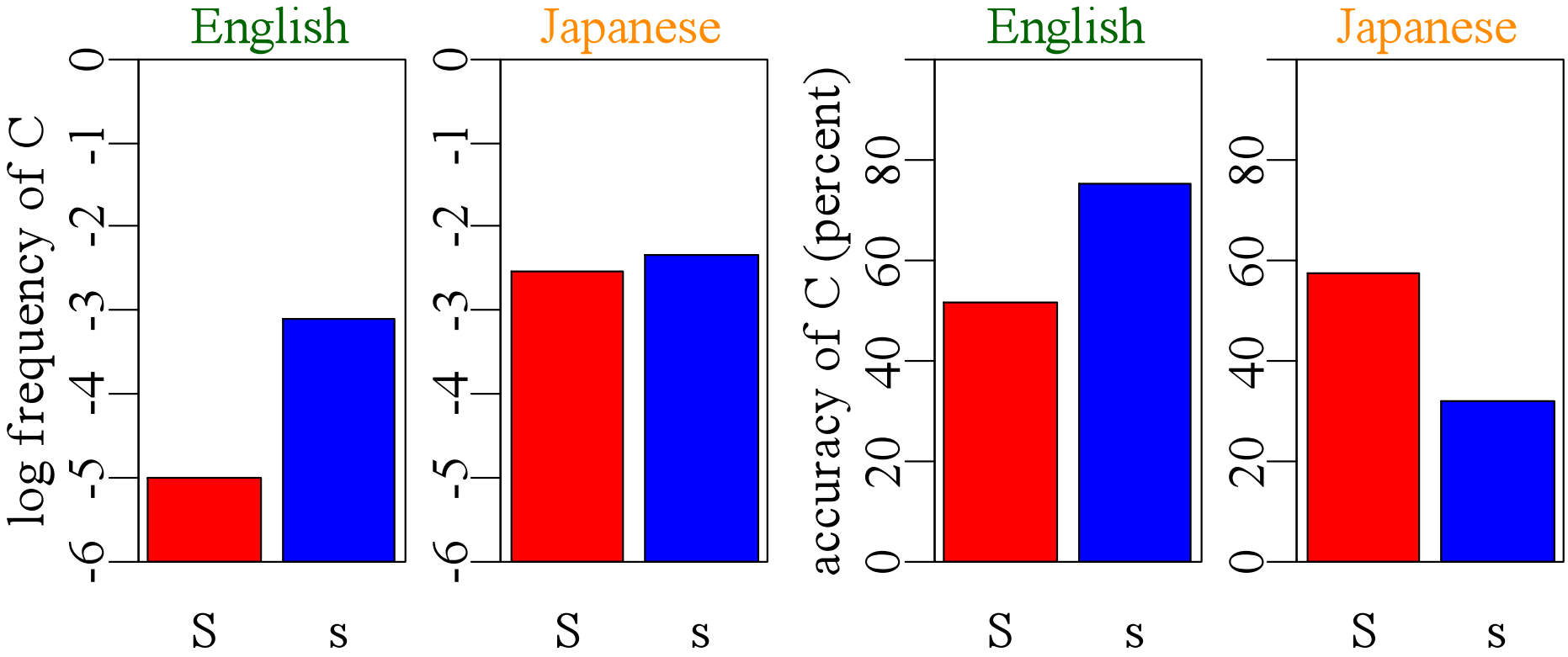
- CV frequency is correlated with consonant accuracy across languages.
- This influence of CV frequency on accuracy decreases as vocabulary size increases.
- Supports Edwards et al. (2004) interpretation of the relationship between vocabulary size and the influence of frequency in English.
  - It's not simply the case that low-frequency sounds and sequences are more difficult to produce/perceive.
  - Low-frequency sounds and sequences are less accurate because children have less practice hearing and producing them.

2. Phonological learning is language-specific

- Cross-linguistic differences in phoneme frequency do not explain all language-specific patterns.
  - For example:

    Sibilant fricative contrast in Japanese acquired later than similar contrast in English, although phoneme frequencies are similar.
- At least some of these cross-linguistic differences seem to be related to differences in fine phonetic detail across languages.

Cross-linguistic differences in fine phonetic detail: Fricatives and fricative development



Questions to address

- Why is /s/ produced with such low accuracy by Japanese-speaking 2- and 3- year olds?

- Why is /s/ produced with such high accuracy by English-speaking 2- and 3- year olds?

Cross-linguistic differences in fine phonetic detail: Fricatives and fricative development (from Li et al., in press)

- Both English and Japanese have a contrast between /s/ and /ʃ/.
- Large-scale studies show opposite patterns of acquisition and different error patterns.
  - English:
    - /s/ is mastered earlier than /ʃ/ and [s] is commonly substituted for /ʃ/ (Smit et al. 1991).

shoe *safe*

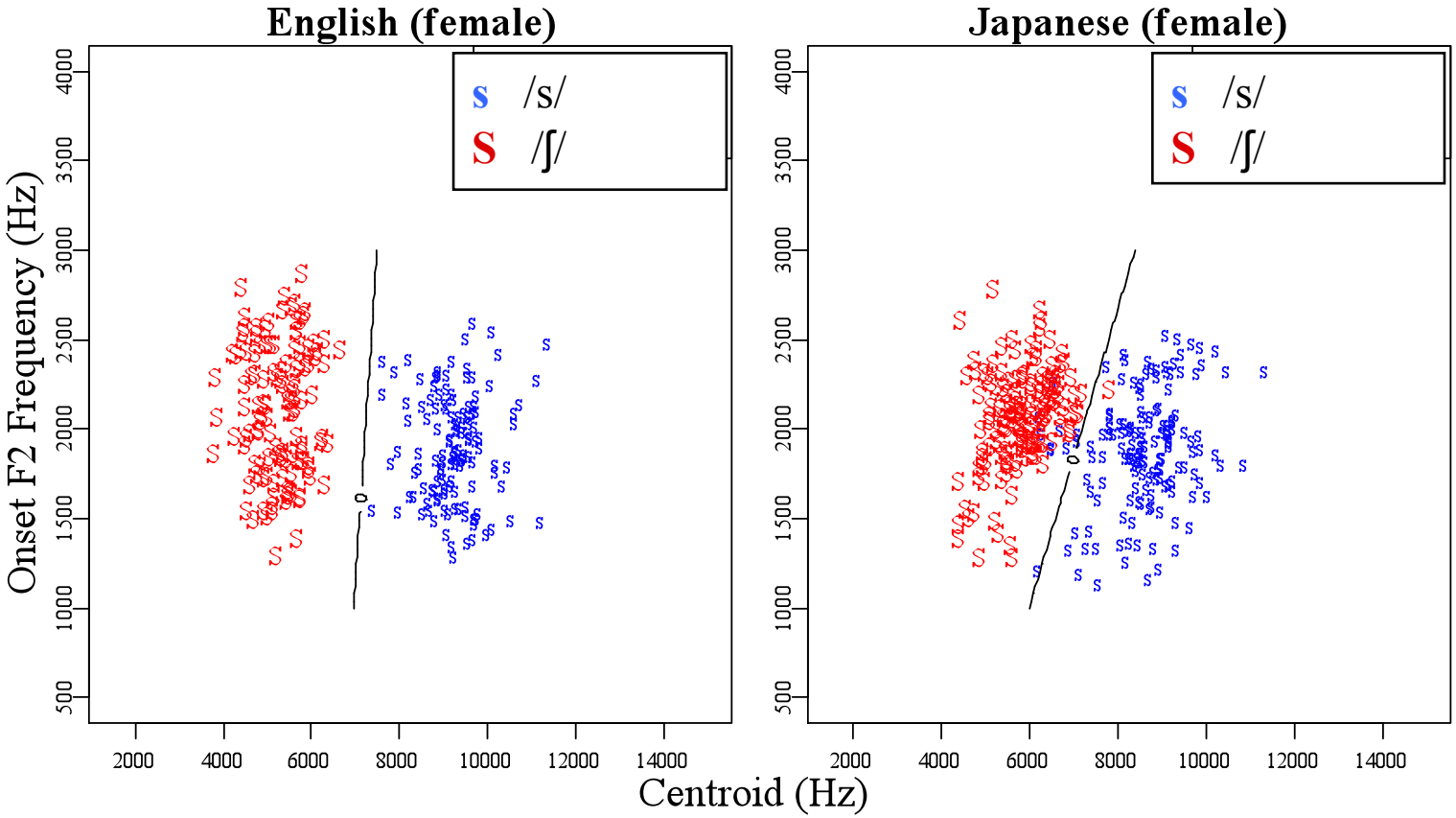

English: Fronting error

  - Japanese:
    - /ʃ/ is mastered earlier than /s/ and [ʃ] is often substituted for /s/ (Nakanishi et al., 1972).

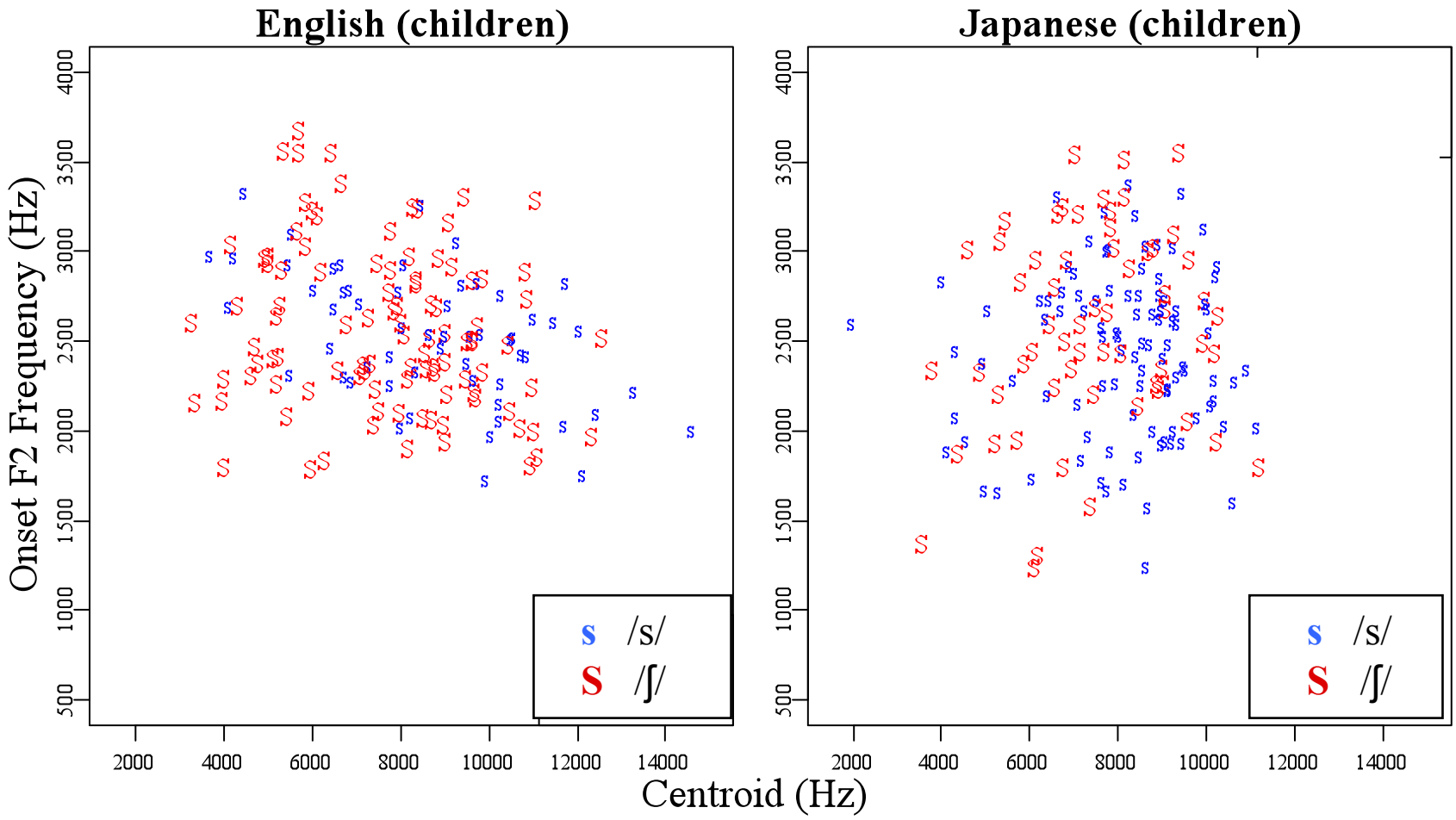
Shukurimu "cream puff" *semi* "cicada"


Japanese: Backing error

Acoustic analysis of adults' productions: English vs. Japanese



Acoustic analysis of children's productions: English vs. Japanese



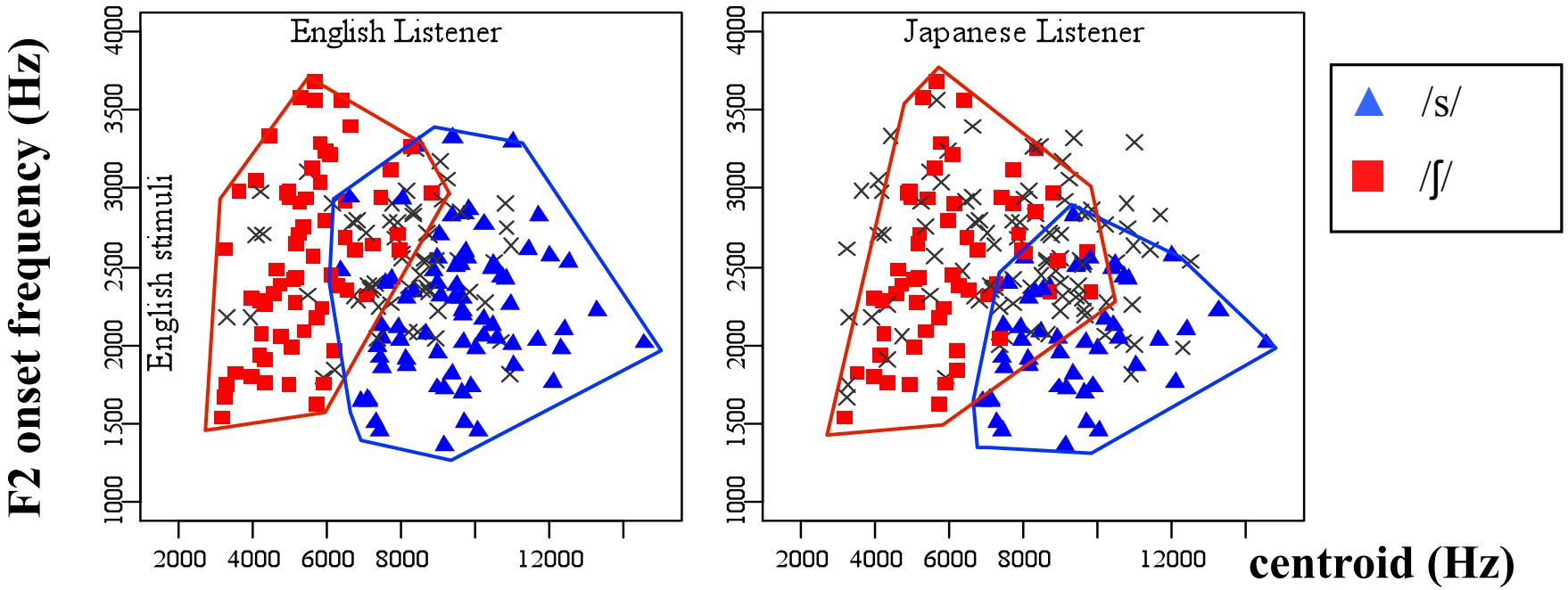
Cross-linguistic perception experiment: Rationale and methods (from Li et al., in press)

- Research questions:
  - To what extent is the apparent cross-linguistic asymmetry due to differences in perceptual norms?
- Prediction:
  - Given the production differences, we might expect that adult native speakers of English and Japanese would parse the multidimensional acoustic space differently.
- Participants:
  - 20 naïve adult native English speakers (Minneapolis, MN)
  - 20 naïve adult native Japanese speakers (Tokyo, Japan)

Cross-linguistic perception experiment: Methods

- Stimuli:
  - Initial CV in words produced by English- and Japanese-speaking children and adults.
  - Correct productions of **/s/** and **/ʃ/** by children and adults, prototypical substitutions of children in each language.
- Task:
  - Each listener heard two blocks of the same 400 tokens.
  - In one block: "Is it an **"s"**? In other block: "Is it an **"sh"**?
  - Responded by pressing "Yes" or "No" button as quickly as possible.
  - Naïve listeners didn't know they were listening to multiple languages.
- Analysis:
  - Determine the 'community consensus' for each token by examining whether it received a 'yes' response by 70% or more listeners.

Cross-linguistic perception experiment: Results



English listeners:

- acceptable range for /s/ is larger than acceptable range for /ʃ/

Japanese listeners:

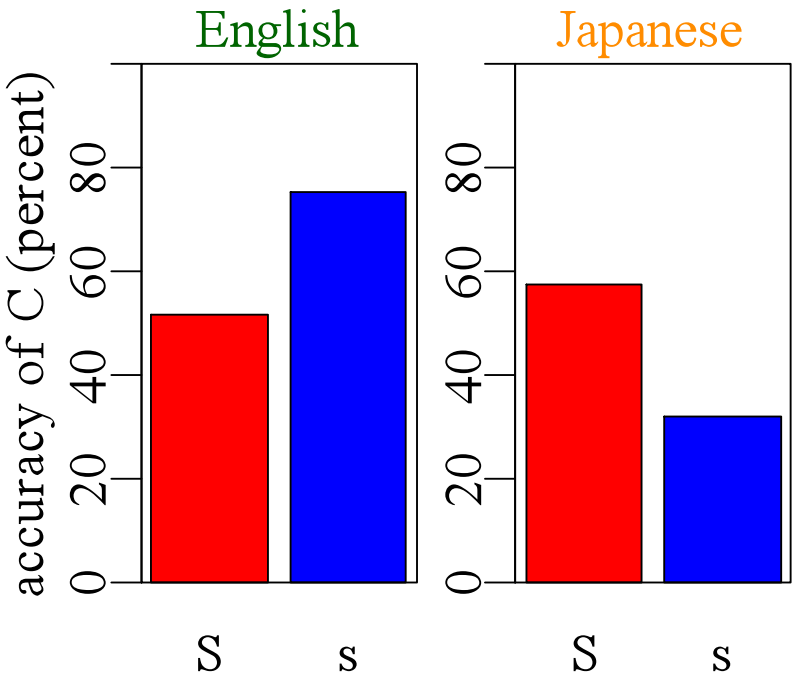
- acceptable range for /ʃ/ is larger than acceptable range for /s/

Phonological learning is language-specific: Conclusion

Questions:

•Why is accuracy of /s/ so high in English?

•Why is accuracy of /s/ so low in Japanese?



• Production: The contrast between /s/ and /ʃ/ is more robust in English than in Japanese.

•Perception: English listeners accept a wider range of productions as correct for /s/; Japanese listeners accept a narrower range of productions as correct for /s/.

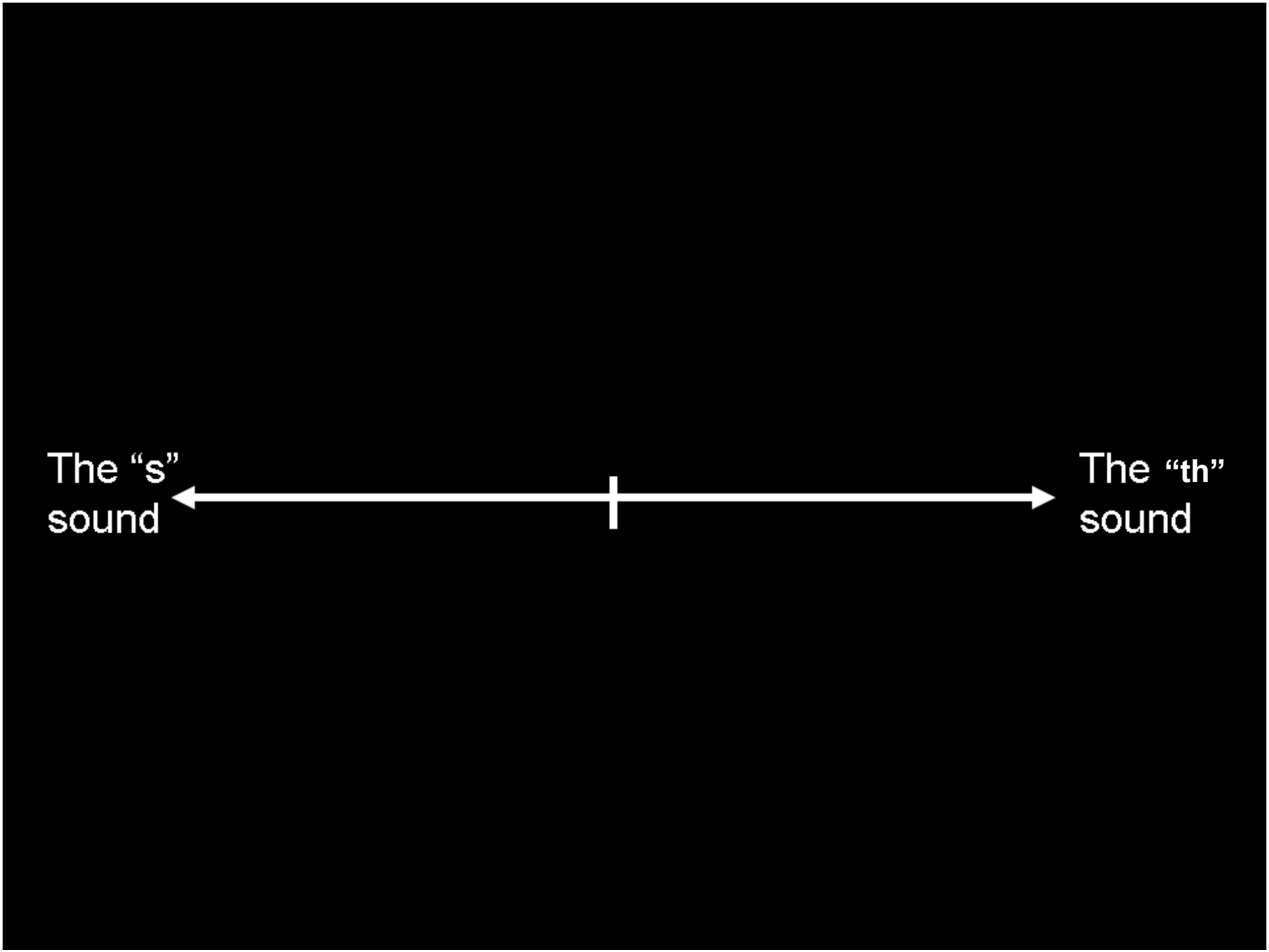
Conclusion: At least some cross-linguistic differences in acquisition related to language-specific fine phonetic detail in perception and production.

3. How informative is alphabetic transcription?

- Assumption: acquisition can be studied through alphabetic phonemic transcriptions.
- However, accuracy judgments depend on listeners' experience.
- Also, children do not always progress directly and categorically from incorrect to correct productions.
  - Covert contrast: systematic acoustic difference that is not perceptible (Macken, 1980)
  - Other intermediate productions
  - English: [k] or [ɡ] 
    [f] or [θ] 
  - Greek: [k] or [t] 
    [s] or [θ] 
- Clinical importance of intermediate productions (Tyler, 1995)

Perception experiment: Intermediate productions and visual analog scaling (Schellinger et al., 2008)

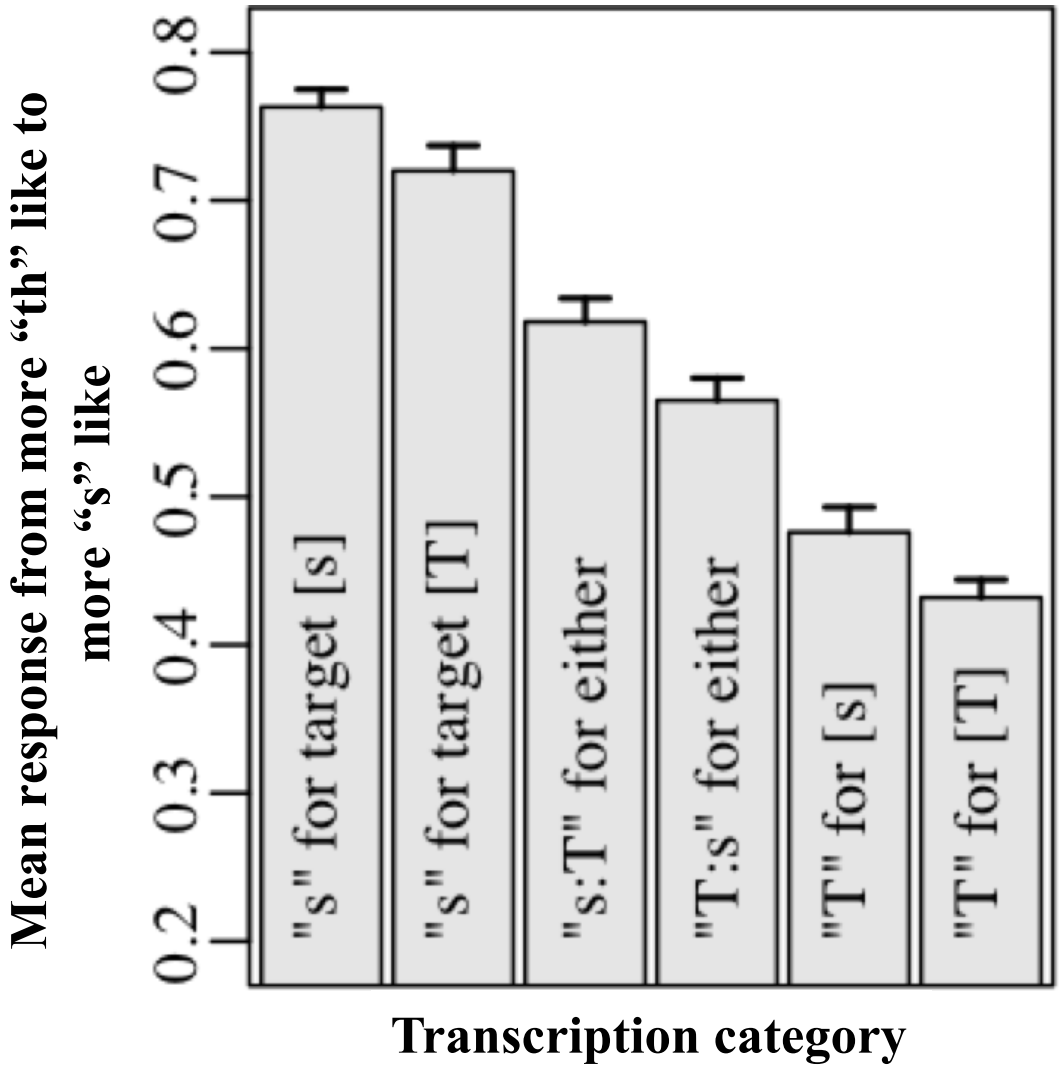
- Research questions:
  - Can naïve listeners reliably categorize productions as intermediate between /s/ and /θ/ (“th”)?
- Prediction:
  - Naïve listeners would be able to do so, given the right task.
- Participants:
  - 20 naïve adult listeners in Minneapolis, MN
- Method: Visual analog scaling
  - Allows people to scale where a token falls relative to fixed endpoints.
  - The visual space is made essentially analogous to the perceptual space.


The “s” sound
The “th” sound

Perception experiment: Intermediate productions and visual analog scaling (Schellinger et al., 2008)

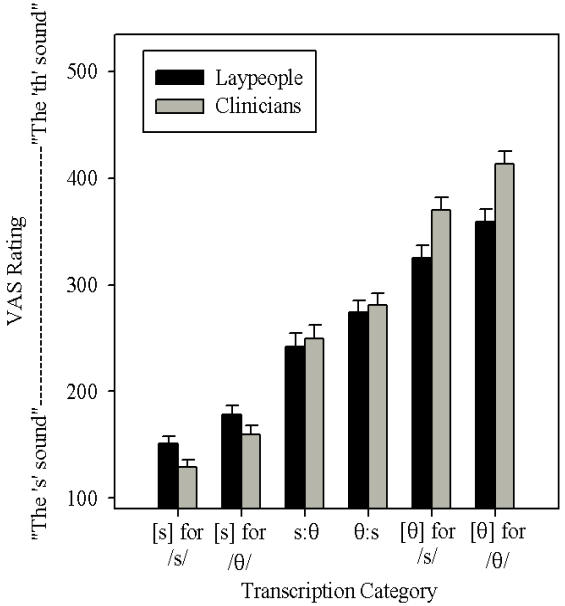
- Stimuli:
  - 200 CV sequences from single-word productions of English-speaking children, aged 2 through 5 years.
    - correct /s/
    - [s] for /θ/
    - intermediate: closer to [s] than [θ]
    - Intermediate: closer to [θ] than [s]
    - [θ] for /s/
    - correct /θ/

Perception experiment: Intermediate productions and visual analog scaling (Schellinger et al., 2008)

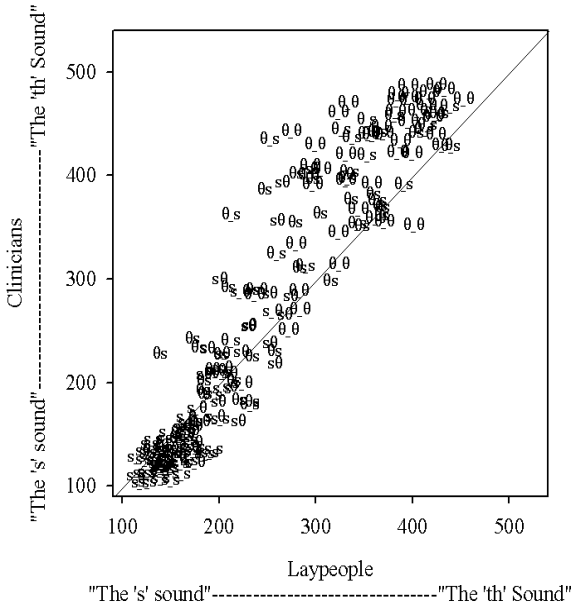


Effect of experience (Munson, Johnson, & Edwards, 2010)

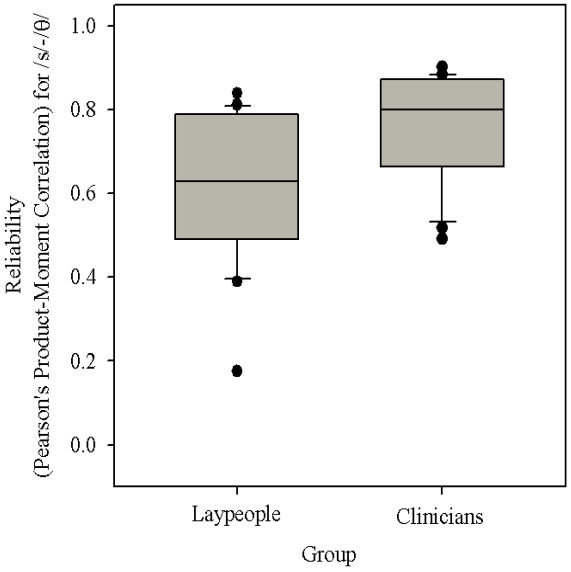
Speech-Language pathologists outperform inexperienced listeners on this task



Their responses better differentiate among transcription categories



They don't have as strong a bias to label sounds as 's'



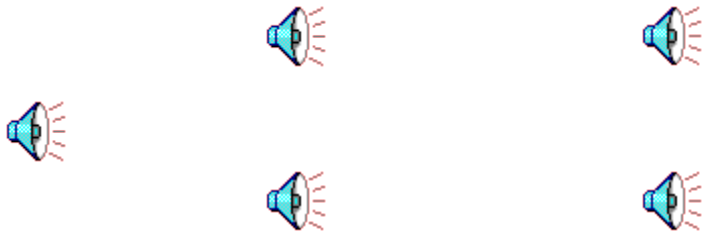
They have superior intra-rater reliability

3. How informative is alphabetic transcription: Conclusion

- Not informative enough.
- Influenced by listeners' experience.
- Children don't always proceed directly and categorically from incorrect to correct productions.
- Children produce intermediate productions that can be reliably categorized even by naïve listeners, given an appropriate task.
- Acoustic analysis and/or perception tasks are needed to describe these productions.

4. There's more to phonological development than phonemes

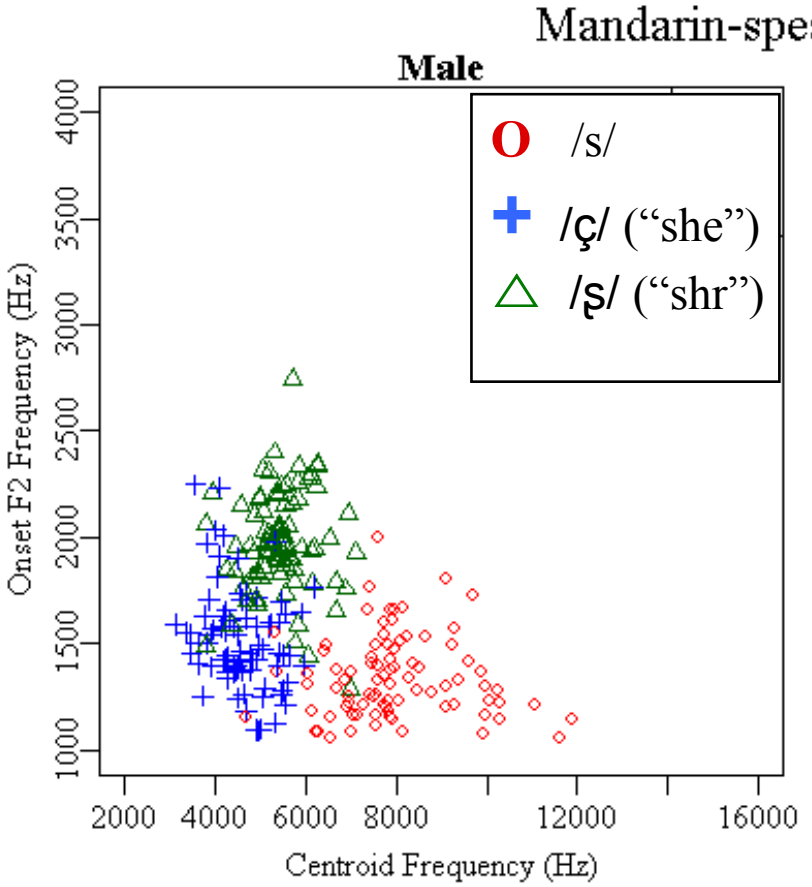
- Speech sounds encode at least two kinds of information:
  - Lexical information
  - Socio-indexical information
    - Information about social identity such as gender, age, geographic origin, ethnicity, formality, etc. (e.g., Labov 1990; Purnell et al., 1999; Clopper & Pisoni, 2004).
    - For example, what do you know about these speakers?



Speech sounds and socio-indexical categories

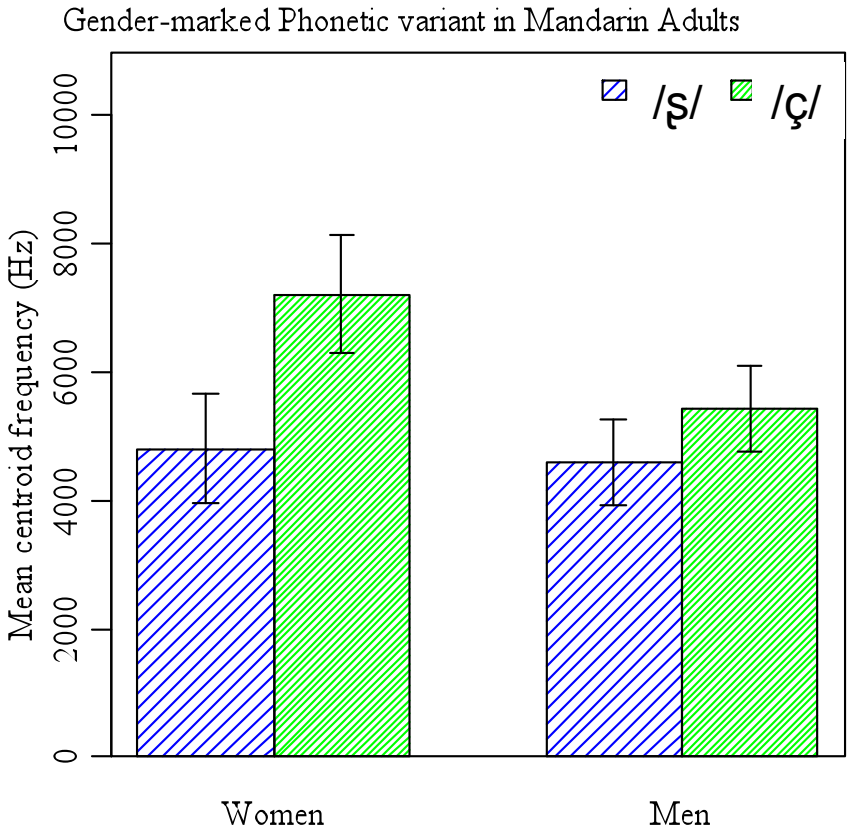
- Gender-marking: /s/
  - Glaswegian English (Stuart-Smith, 2004)
  - Systematic differences in fricative spectrum for males and females.
  - Interacts with social class and age.
- Marking of sexual orientation: /s/ and vowels
  - American English (Munson et al., 2006; Munson, 2007)
  - Listeners use different acoustic parameters to judge male sexual orientation and masculinity.
- Very little research on acquisition of socio-indexical categories

Mandarin sibilant fricatives: Lexical phonetic contrast (from Li & Kong, 2008)



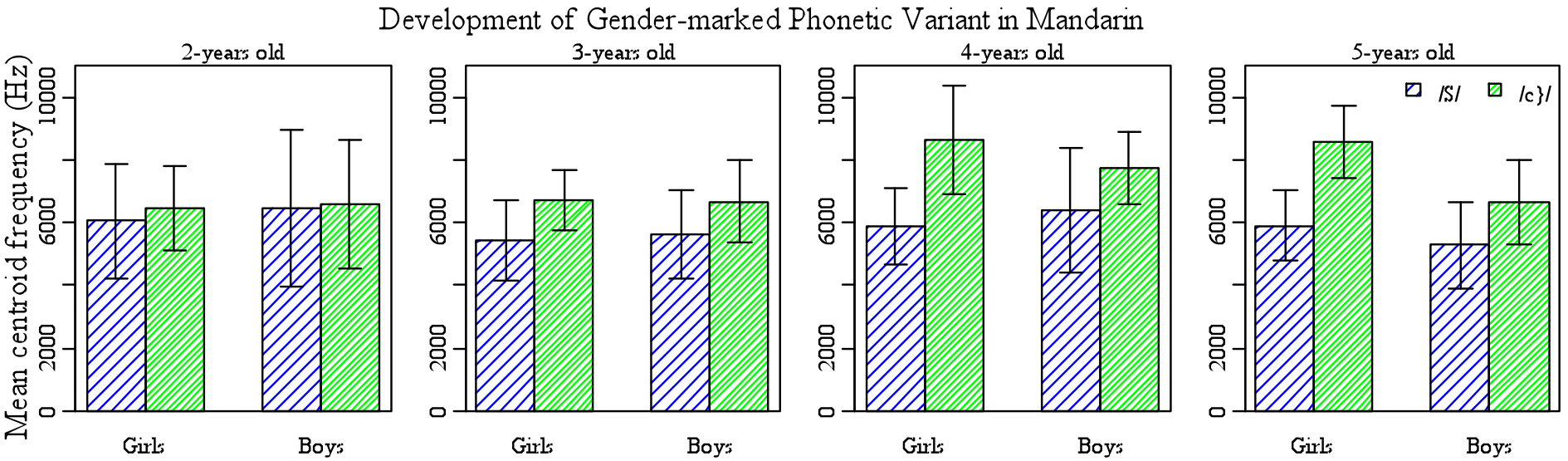
- Mandarin has two post-alveolar fricatives:
  - /ɕ/ (“she”)
  - /ʂ/ (“shr”)
- Onset F2 frequency (y-axis values) differentiates /ɕ/ (“she”) and /ʂ/ (“shr”).
- Socio-indexical coding for /ɕ/ (“she”) uses centroid frequency (x-axis).

Speech sounds and socio-indexical categories: Gender-marking by adults in Mandarin (Li & Kong, 2008)



- The difference between /ç/ (“she”) and /ʂ/(“shr”) is greater for women than for men.
- The women seem to be fronting /ç/ (“she”).
- This results in a higher centroid value and mimics the effect of having a smaller vocal tract.
  - Without fem. accent:
  - With fem. accent:

Speech sounds and socio-indexical categories: Acquisition of gender-marking in Mandarin (Li & Kong, 2008)



Boy: Girl w/o F.A. Girl w/F.A.

4. There's more to phonological development than phonemes: Conclusion

- Mandarin-speaking children can correctly produce both /ç/ ("she") and /ʂ/ ("shr") by about 3 years of age.

- However, gender-marking of /ç/ ("she")-*male* and /ç/ ("she")-*female* isn't seen until 4 or 5 years of age.

Phonological acquisition *is* complex

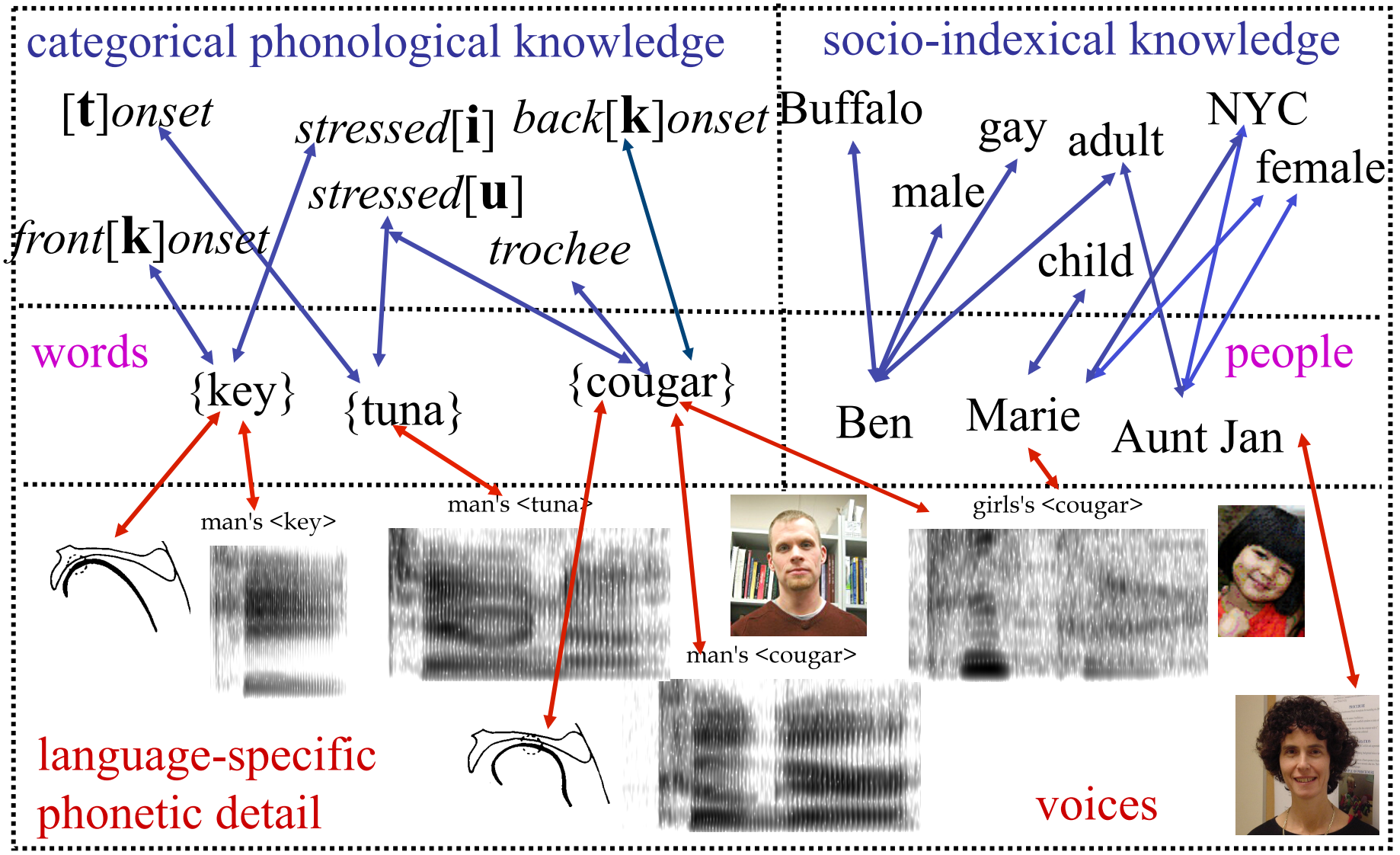
1. **Children gradually learn sounds and sound sequences in *words* of their language.**

2. **Phonological learning is highly language-dependent.**

3. **Transcription must be supplemented with other methods.**

4. **Children continue learning after they can produce speech sounds correctly.**

Levels of knowledge about speech sounds



Clinical implications: Vocabulary size and phonological acquisition

- Children with phonological disorders typically have slightly smaller vocabularies than their typically developing peers.
- What is the direction of this relationship?
  - Do children with smaller vocabularies have difficulty learning sounds because they have a smaller set of words to generalize over?
  - Do children with difficulty learning sounds have smaller vocabularies because they have difficulty parsing and remembering the sounds in words they hear?
- Clinical implications: Need to consider the words a child knows as well as the sounds he/she knows.

Clinical implications: Socio-indexical knowledge and language disorders

- Pragmatic disorders characterized by difficulties understanding social cues.
  - Autism, Asperger Syndrome, Specific Language Impairment
- Many social cues are signaled by sociophonetic features.
  - Formal vs. informal speech
  - Literal vs. figurative language
  - Use of a particular dialect
  - Sexual orientation
- Perhaps one aspect of the pragmatic disorder is difficulty in perceiving socio-phonetic cues?

Acknowledgments

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- Participation of the children and cooperation from their parents

For all of which, a heartfelt:

謝謝　　thank you　　ευχαριστώ πολύ　　ありがとう

Clinical implications: Phonological knowledge and reading

- What about children who are learning non-standard dialects of English with different phonological systems?
  - For example, African-American English (AAE).
- The phonological system of the spoken language has a tremendous impact on decoding and spelling.
  - Example from AAE:
    - "Ms. Four"
- We know very little about interactions between phonological knowledge and learning to read in non-standard dialects.

Clinical implications: Phonological knowledge of children with cochlear implants

- Children with cochlear implants have much better speech production skills relative to children with hearing aids.
- However, their speech intelligibility is reduced relative to peers with normal hearing.
- Sibilant fricative production of children with cochlear implants (Todd et al., 2010; Todd et al., in preparation).
  - Centroid frequencies for /s/ are lower relative to normal hearing peers, even for correct productions.
  - The relationship between consonant accuracy and CV frequency is weaker for children with CI's relative to either chronological-age or vocabulary-age peers.

Clinical implications

- With a more complex understanding of phonological knowledge,
  - Potentially, we can have a much finer-grained understanding of how to assess and treat phonological/language breakdowns
  - We can assess and treat breakdowns at different levels of representation.