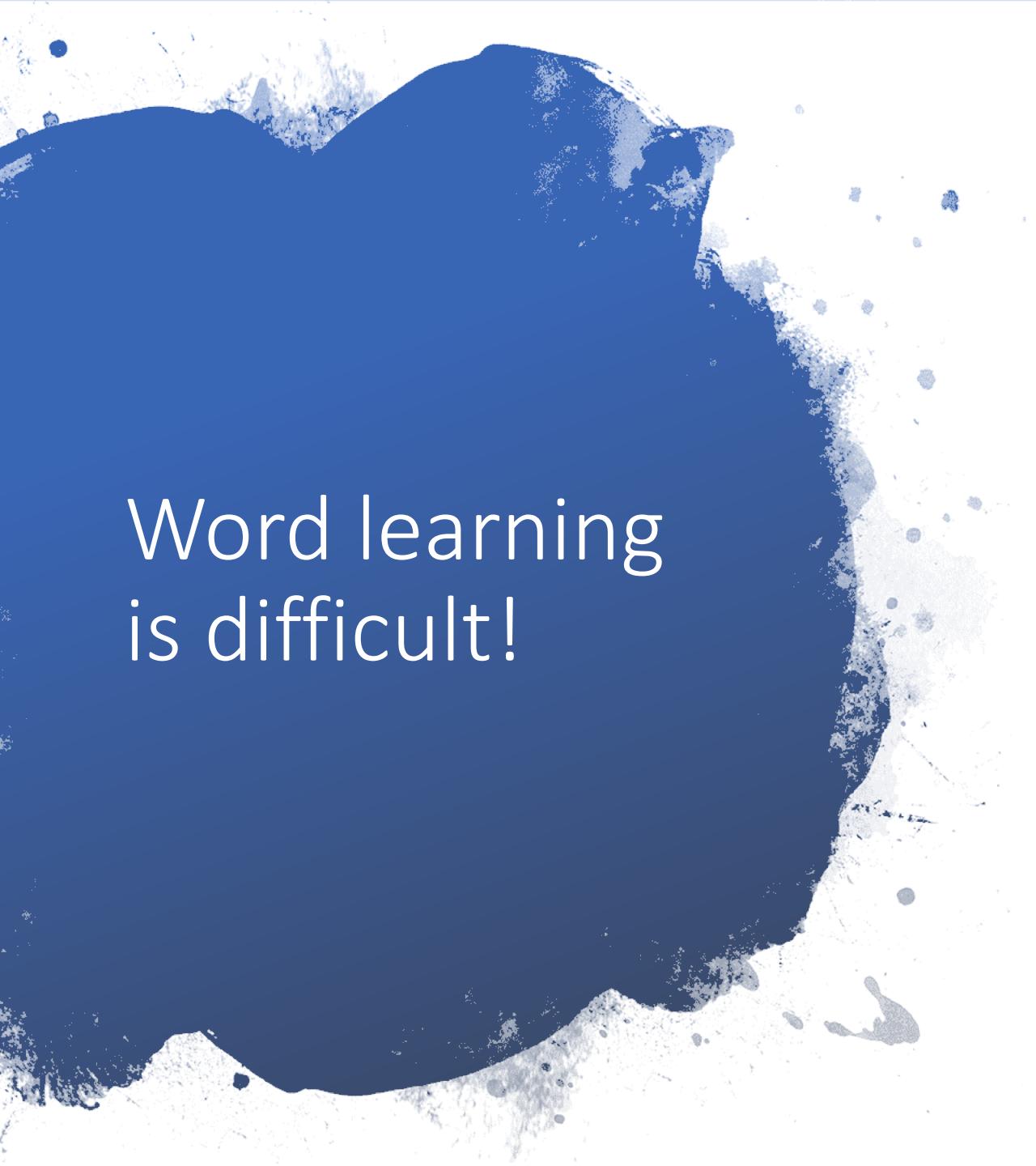


Who says it and what does it sound like? Quantifying within- and between-talker variability in infants' naturalistic input

Federica Bulgarelli & Elika Bergelson

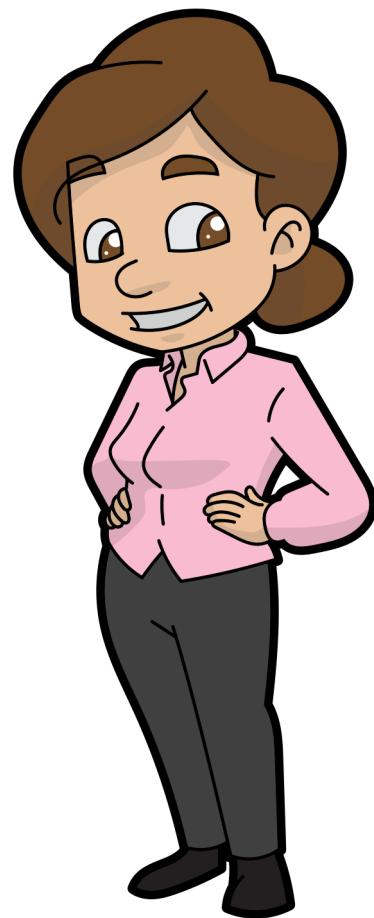
Duke University

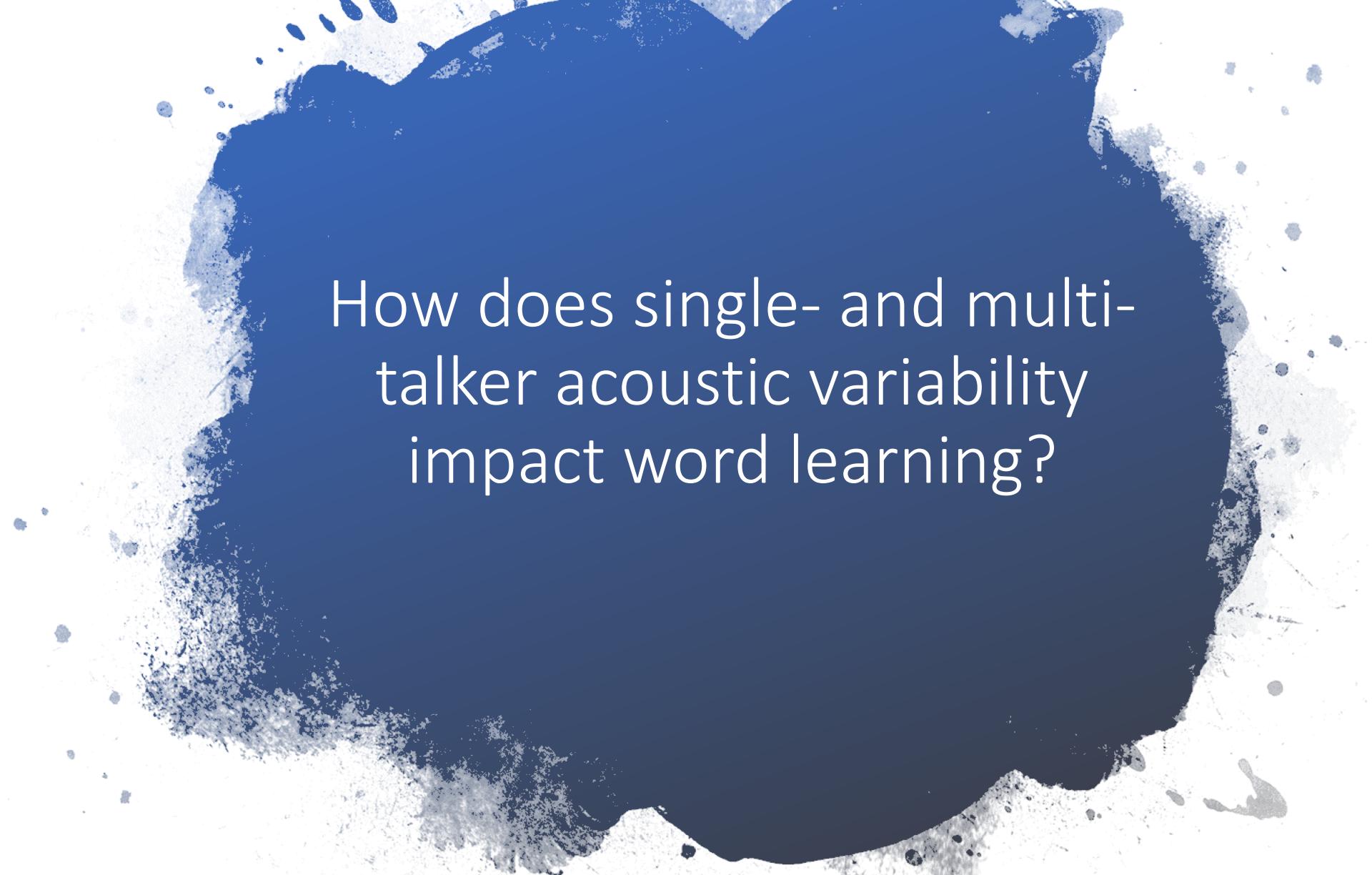
- Please note that this is work in progress, stay tuned for the paper!



Word learning
is difficult!

One component of word learning is forming appropriately specific representations of what words sound like



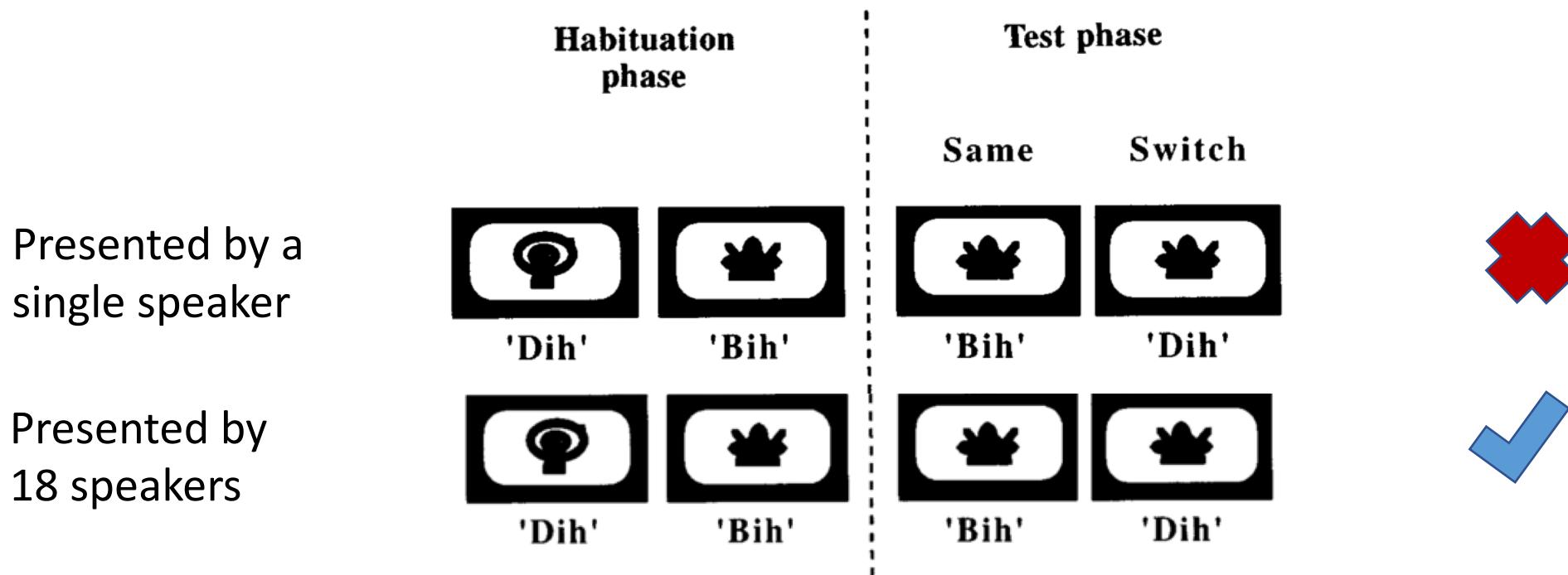


How does single- and multi-talker acoustic variability impact word learning?



- Contending with talker variability can be difficult (e.g. Jusczyk et al., 1992; Ryalls & Pisoni, 1997)
- Something learners need to overcome or ignore
 - Invariance detection (Gogate & Hollich, 2010)
 - But, can also be helpful in the lab
 - phonotactic patterns (Seidl et al., 2014), integrating input (Graf-Estes & Lew-Williams, 2015) and production (Richtsmeier et al., 2009)

Talker variability and word learning



Talker variability and word learning

	Habituation phase		Test phase		
	'Dih'	'Bih'	Same	Switch	
Presented by a single speaker					
Presented by 18 speakers					
Presented by 1 highly variable speaker					



Why?

- Talker variability should not be necessary for learning new words
- “**IRRELEVANT**” **VARIABILITY** draws attention to how words remain consistent ACROSS instances spoken WITHIN or BETWEEN talkers

Galle et al., 2015

Galle et al., 2015		
Measurement	Single talker SD	Multi talker SD
Mean pitch (Hz)	37.73	77.54
Pitch Excursion (Hz)	64.48	137.22
Pitch direction (Hz/ms)	6.67	9.57
Duration (ms)	203.65	112.03
Harmonic-to-noise (dB)	3.95	3.07
Spectral mean	198.13	151.19
Spectral variance	90.54	59.64
Spectral skew	251.34	153.91
Spectral kurtosis	88.50	44.10
Spectral tilt	.002	.008

- Talker variability has an effect on word learning in the lab
 - In-lab variability has been quantified



- What about in the real world?
 - We know very little!
 - Variability == number of talkers
(Bergmann & Tsuji, 2017; Bergmann & Cristia, 2018)
 - How much variability do infants receive in their daily input? And what does it sound like?



Quantify single- and multi- talker variability in naturalistic input

Descriptives

How many talkers do infants hear?

How many tokens do infants hear?

Acoustic variability

How much acoustic variability do infants hear?

How does it compare to in-lab variability?

Is it related to other properties of the input?

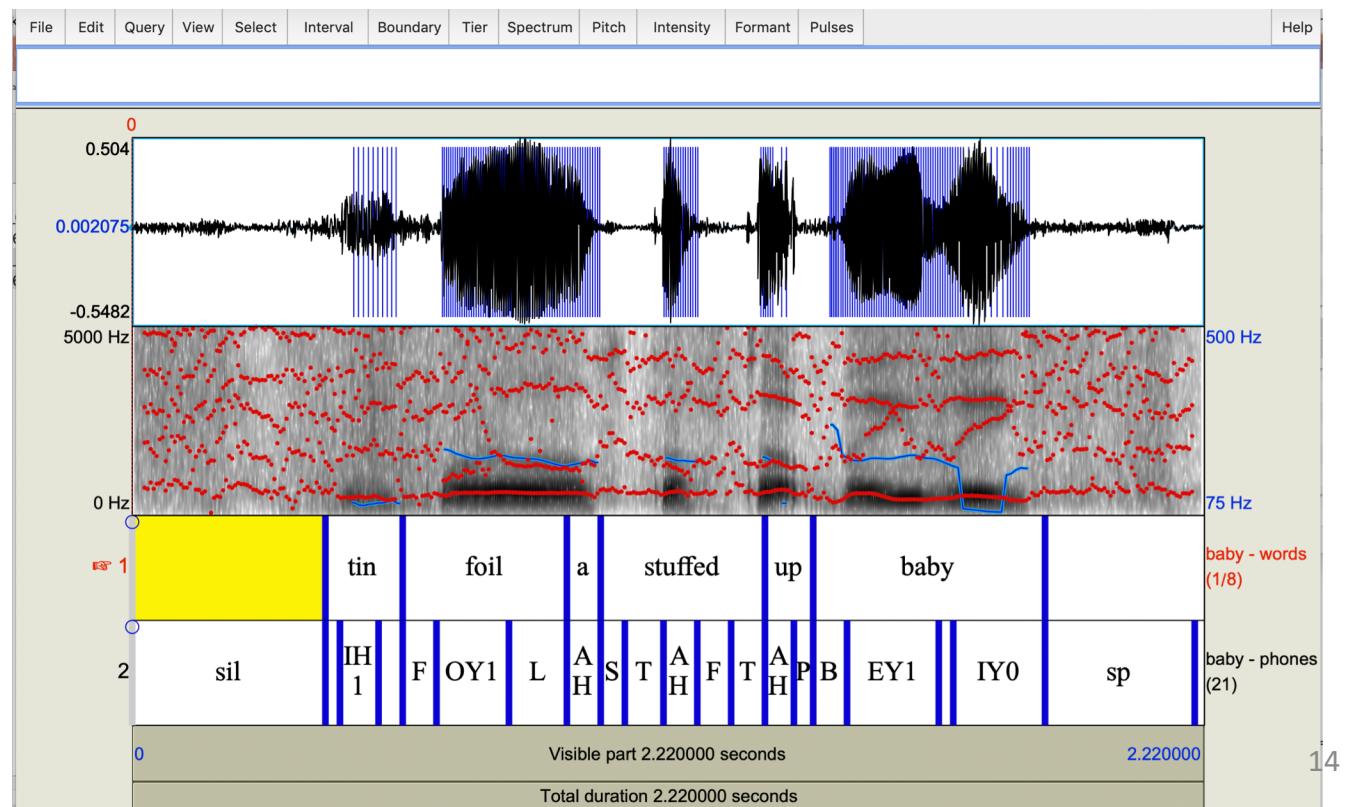
SEEDLingS corpus

- 44 infants followed longitudinally from 6-18 months
- Monthly day-long audio recordings and hour-long video recordings
- Annotated for all instances of concrete nouns
 - ~80 hours annotated per kid



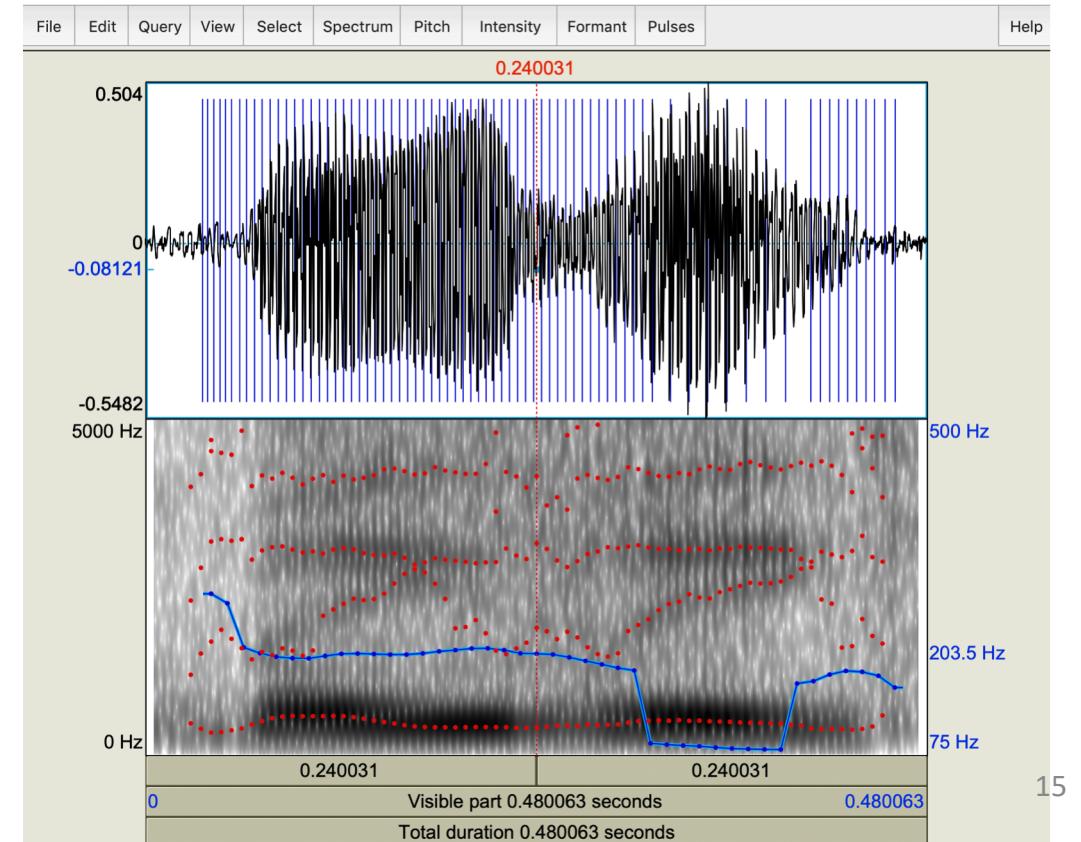
Token extraction

- Extract tokens of top 5 words in the corpus
 - Baby, ball, book, water, dog



Token extraction

- Extract tokens of top 5 words in the corpus
 - **Baby, ball, book, water, dog**



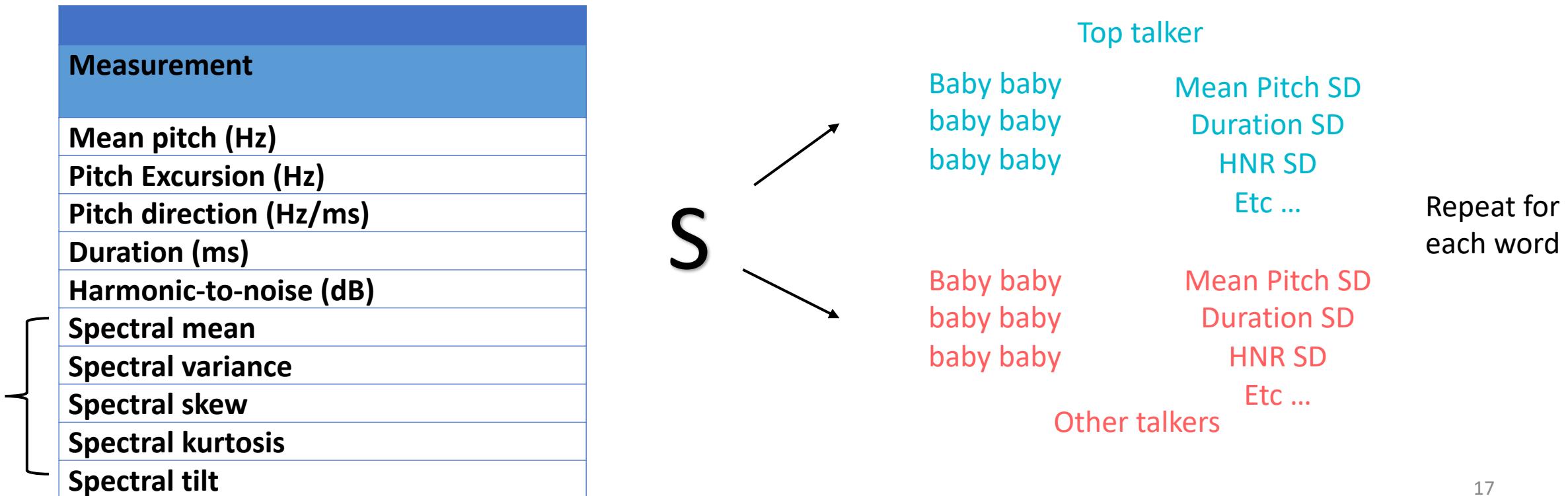
Tokens

Word	Total tokens	Usable tokens
Baby	5120	4398
Ball	3745	3157
Book	4661	3796
Water	3573	3105
Dog	2384	2078
Total	19483	16534



Token acoustic measurements

- Measured 10 acoustic properties on each token of each word
- Acoustic properties that are irrelevant to word identity



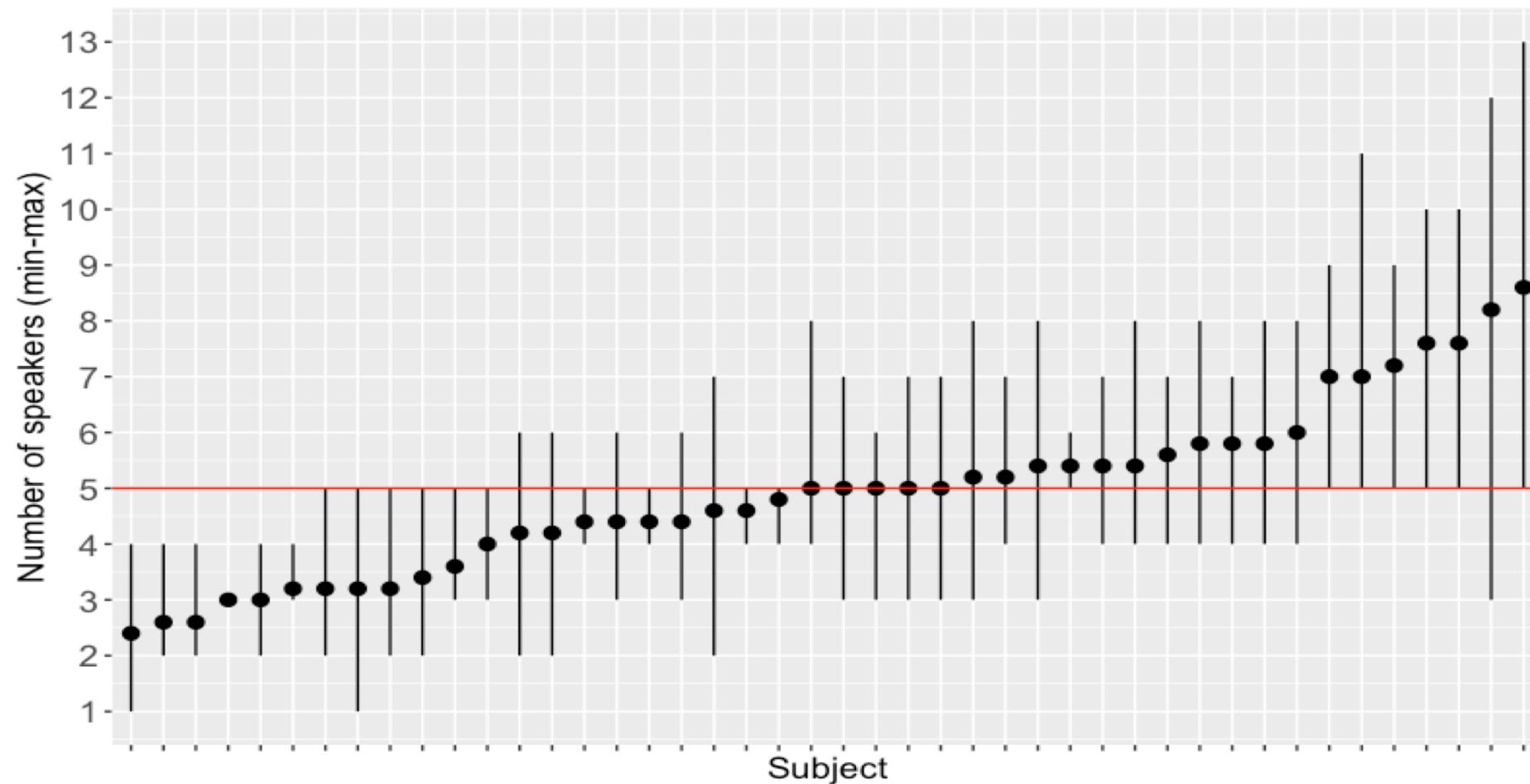
Property	Low	High
Mean pitch – average pitch	78.76 	566.30 
Duration	.169 	2.28 

Descriptives

How many different talkers do infants hear produce these 5 words?

- On average, infants hear these 5 words produced from 5 different talkers
 - Range: 1-13
 - E.g.: mom, dad, grandma, sister, and toys

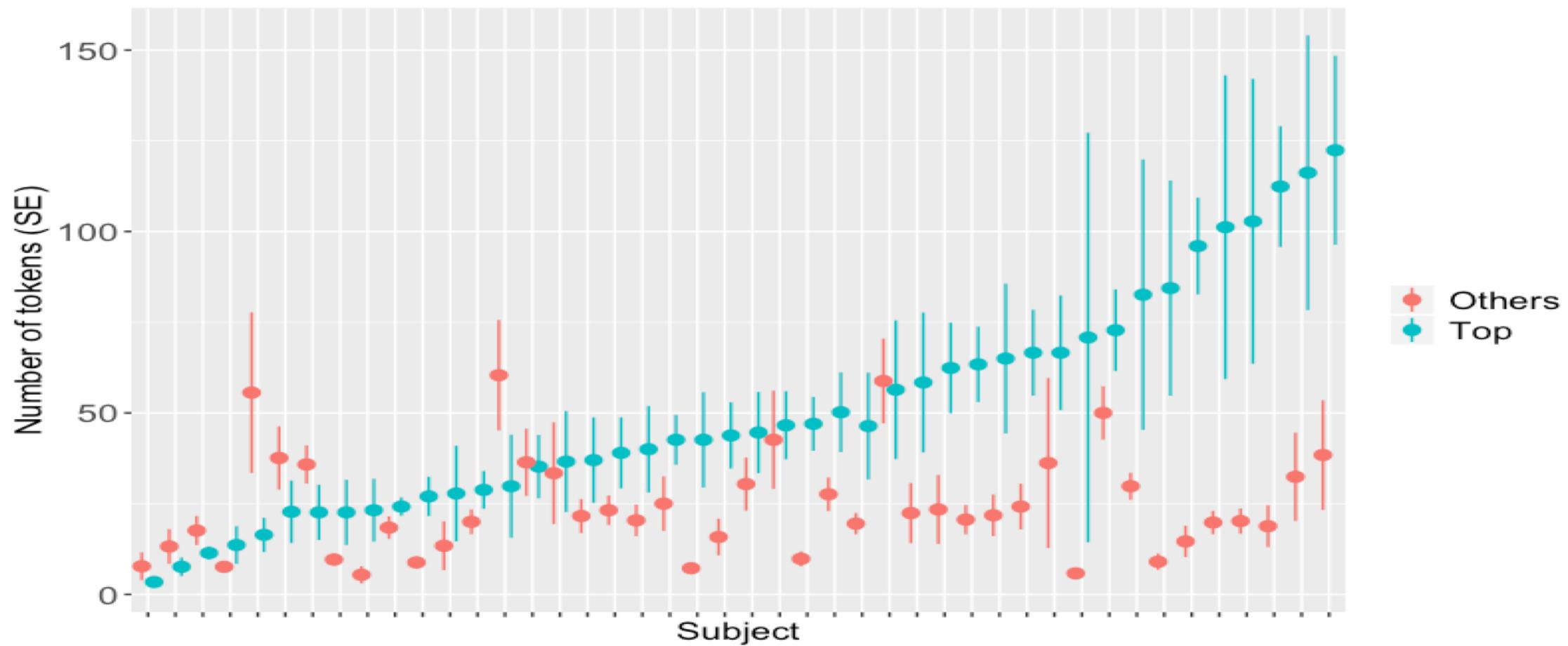
How many different talkers do infants hear produce top words?



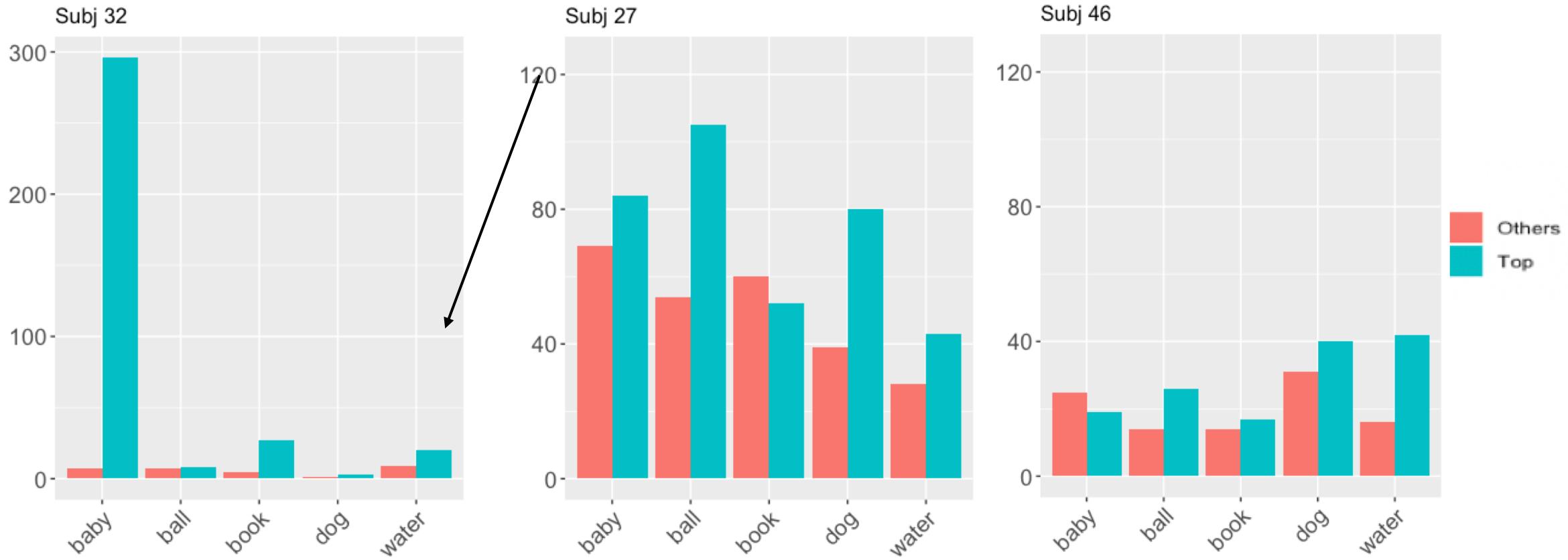
How many tokens of words do infants hear from their top talker vs. from everybody else?

- ~47 tokens from top talker and ~ 23 tokens from all other talkers
 - Top talker range: 1 – 296 tokens
 - All other talkers range: 1 – 140 tokens

How many tokens of words do infants hear from their primary caregiver vs. from everybody else?



How many tokens of words do infants hear from their primary caregiver vs. from everybody else?



Acoustic variability

S

5 Top talker SD -- baby ball book water dog -- x10 measurements

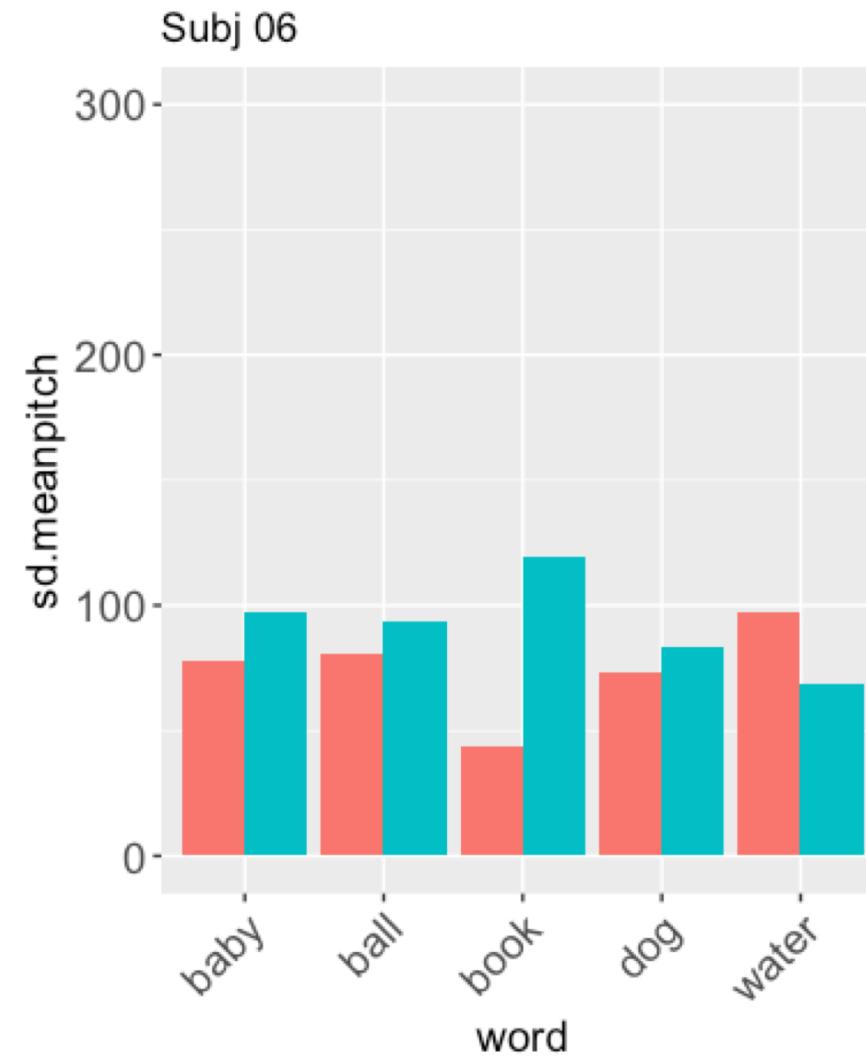
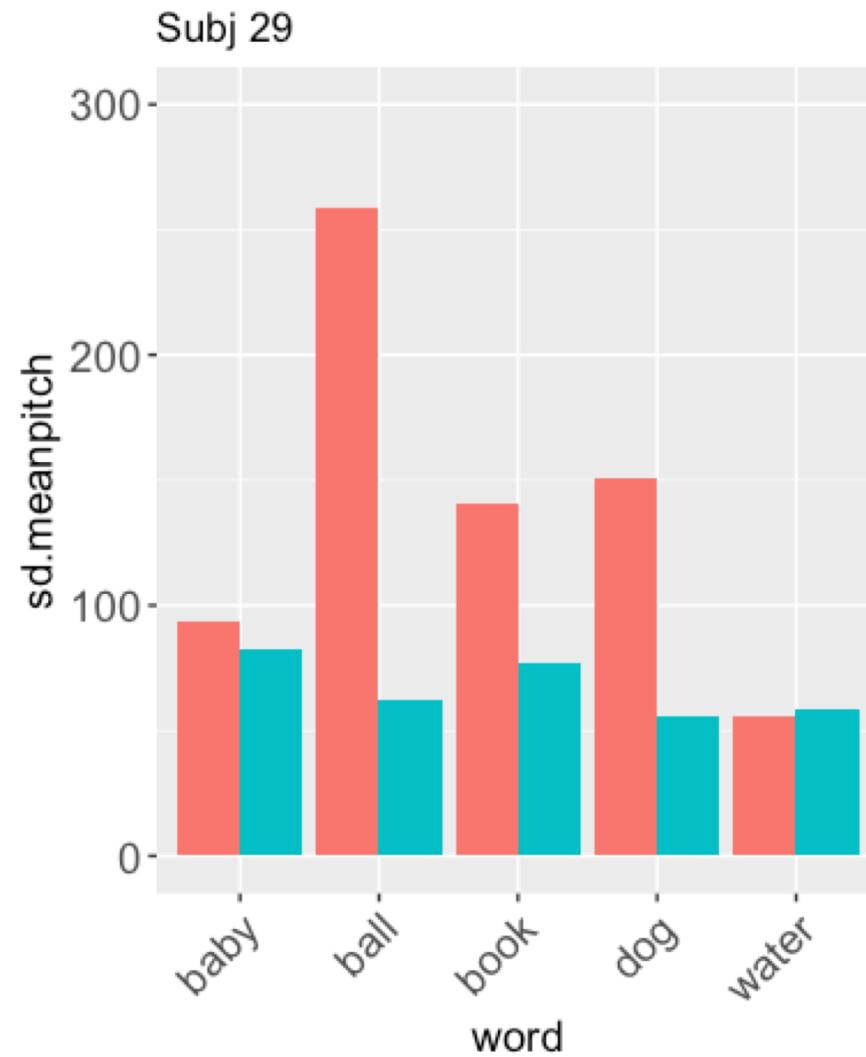
5 Other talkers SD – baby ball book water dog -- x10 measurements

How much acoustic variability do infants hear from their primary caregiver vs. from everybody else?

Measurement	SEEDLingS data		
	Top-talker SD	Other talkers SD	Wilcoxon test p-value
Mean pitch (Hz)	76	87	< .001 ¹
Pitch Excursion (Hz)	115	132	< .001 ¹
Pitch direction (Hz/ms)	5.68	6.47	.041
Duration (ms)	165	163	.42
Harmonic-to-noise (dB)	4.08	3.83	< .001 ¹
Spectral mean	182	260	< .001 ¹
Spectral variance	205	260	< .001 ¹
Spectral skew	2.68	2.64	.82
Spectral kurtosis	68.3	64.8	.79
Spectral tilt	.0024	.0022	.001 ¹

¹ Would survive Bonferroni correction

Mean pitch SD



within
Others
Top

How does naturalistic acoustic variability compare to in-lab stimuli?

Measurement	Top-talker SD	SEEDlingS data Other talkers SD	Wilcoxon test p-value	Galle et al., (2015)
Mean pitch (Hz)	76	87	< .001 ¹	✓
Pitch Excursion (Hz)	115	132	< .001 ¹	✓
Pitch direction (Hz/ms)	5.68	6.47	.041	✓
Duration (ms)	165	163	.42	
Harmonic-to-noise (dB)	4.08	3.83	< .001 ¹	✓
Spectral mean	182	260	< .001 ¹	✗
Spectral variance	205	260	< .001 ¹	✗
Spectral skew	2.68	2.64	.82	
Spectral kurtosis	68.3	64.8	.79	
Spectral tilt	.0024	.0022	.001 ¹	✗

¹ Would survive Bonferroni correction

What other factors predict how much acoustic variability infants hear?

- Is acoustic variability related to other things?
 - Number of tokens (Swingley & Humphrey, 2018)
 - Number of talkers (Bergmann & Cristia, 2016; Bergmann & Tsuji, 2017)
- Short answer: NO

Descriptives summary

- Talker variability is readily available in infants' input in this corpus
 - 5 talkers on average
 - More input from their top talker than from all other talkers combined
 - Lots of variability across infants

Acoustic variability summary

- Acoustic variability in naturalistic input varies in similar ways to in lab-stimuli (in this sample)
 - This did not have to be the case!
 - Similar patterns of variability for single and multiple talkers
 - Metrics not related to other properties
- More representative samples may differ

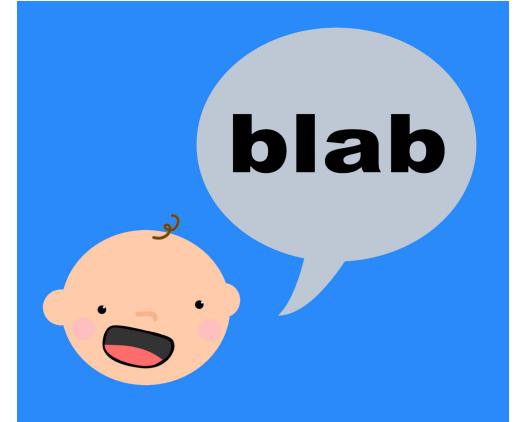
Next steps

- Helpful variability similarly present in the lab and real world
- Next steps: link naturalistic variability to word learning in the real world
 - Does the **amount or source** of variability impact word learning?
 - Before we can do this, we need even more data (top 20 words)

Stay tuned for more!

Thank you

SEEDLingS families and staff
BLAB staff and research assistants



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