A network analysis of maternal input through preschooler-oriented storytelling

Mengyao SHANG[1], Jihong ZHANG[2], Yue CAO[1], Ziyin MAI[1]

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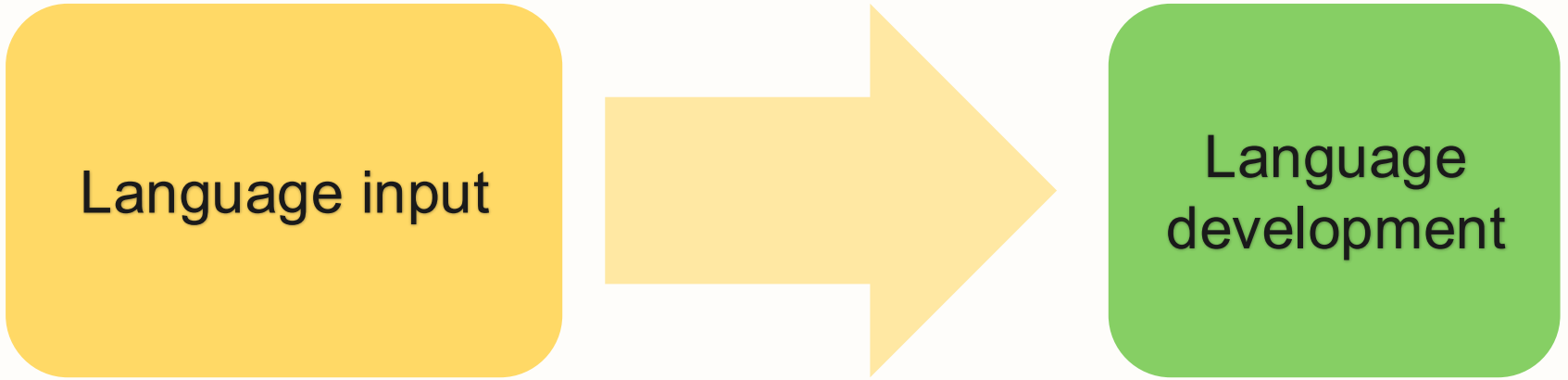
Quality of language input and child language development

Language input

Language development

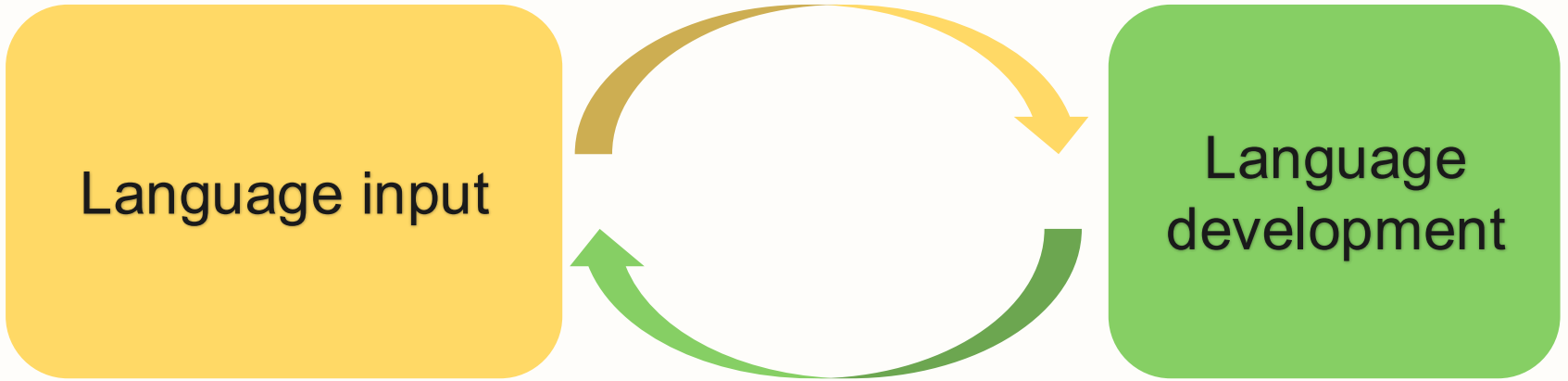
Quality of language input and child language development



Input quality (Naigles & Hoff-Ginsberg, 1998; Pan et al., 2005; Ramírez-Esparza et al., 2014; Romeo et al., 2018)

- Linguistic complexity
- Interactive strategies
- Contextual/decontextualized content

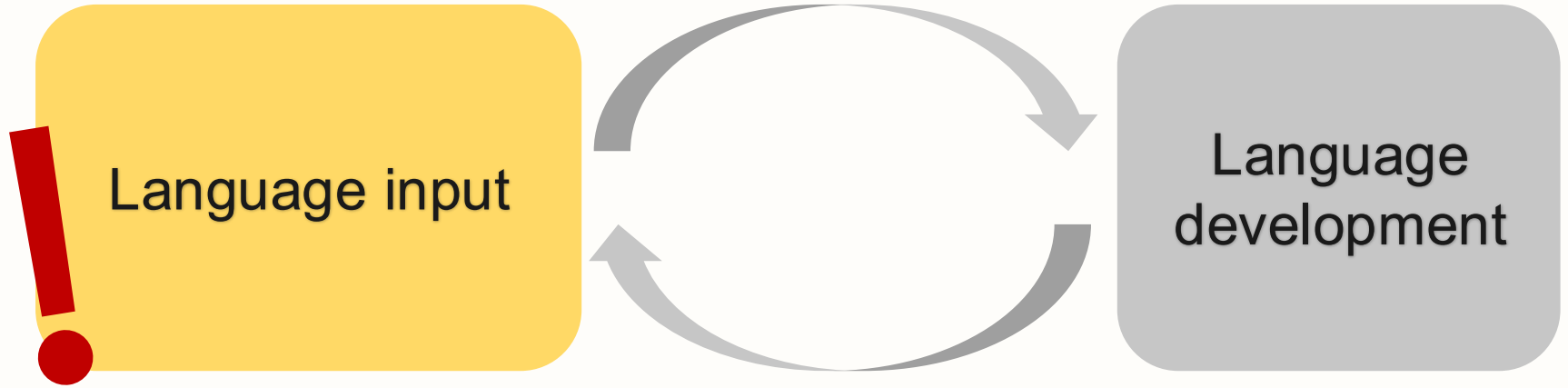
Quality of language input and child language development



Input of high quality adapts to children's developmental stage
(Rowe and Snow, 2020; ***Zone of Proximal Development***, Vygotsky's, 1978)

- Interactional support
- Linguistic complexity
- Conceptual challenge

Quality of language input



Quality of language input

- 3 Dimensions of input quality (Rowe and Snow, 2020)

Interaction

(Rowe et al., 2017; Masataka, 1992; Spinelli et al., 2017; Han et al., 2022)

- attention getters

Language

(Quigley & Nixon, 2020; Genovese et al., 2020; Rowe, 2012; Hadley et al., 2017)

- diverse vocabulary
- complex sentence

Content/Concept

(Rowe, 2012; Demir et al., 2015; Grimminger et al., 2020)

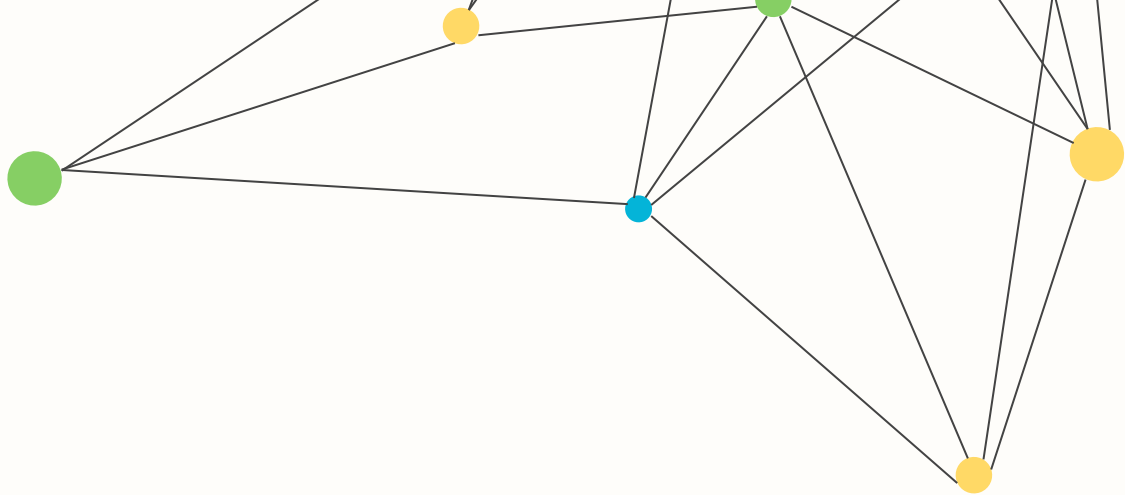
- abstract notions
- inferences, deductions, imaginations

Child-oriented storytelling as a sample of input quality

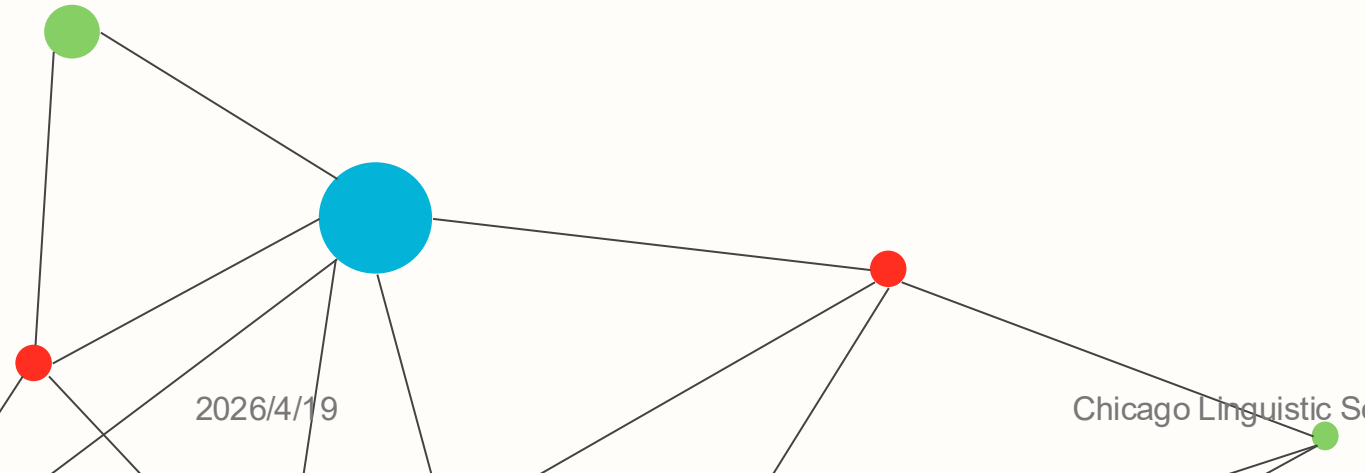
Storytelling > toy-play

(Hoff, 2010; Salo et al., 2016; Rowland et al., 2003; Ornstein et al., 2004; Rohlfing, 2011; Han et al., 2020)

- Diverse vocabularies
- Frequent questions
- Abstract concepts (e.g., internal states)
- Decontextualized content (e.g., children's previous experiences)
- Prosodic variation (e.g., pitch shifts for unfamiliar concepts)



What explains input features in storytelling?



Storytelling input features

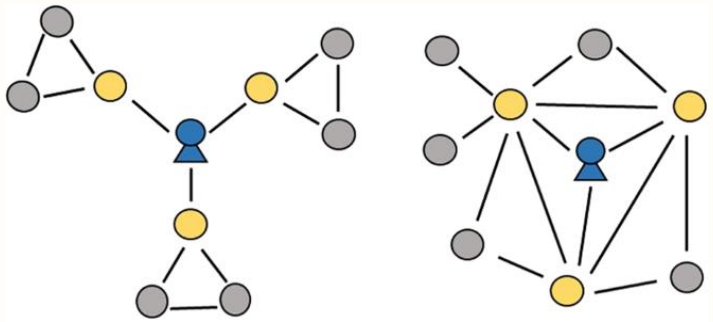
“External” factors

Child characteristics

Mother characteristics

“Internal” dynamics

Input features (across dimensions) interact with each other



This study

“External” factors

- What child and mother characteristics predict mothers’ storytelling features?

“Internal” dynamics

- What are the interrelationships among mothers’ storytelling features?

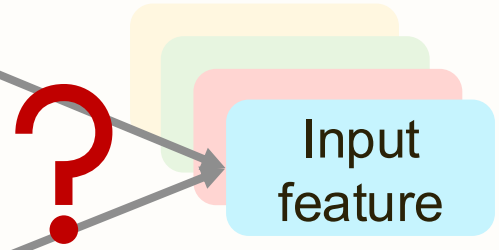
Statistical methods

Multiple factors as predictors
➔ Ridge regression (Hoerl & Kennard, 1970)

“External” factors

Child characteristics
- gender
- age/developmental stage
- language proficiency

Mother characteristics
- education background



“Internal” dynamics

Interaction

Language

Content

Prosody

Statistical methods

Network analysis
➔ Gaussian Graphical Model (Epskamp et al., 2018)

“External” factors

Child characteristics
- gender
- age/developmental stage
- language proficiency

Mother characteristics
- education background

Input feature

“Internal” dynamics

Interaction
- attention getters

Language
- vocab
- sentence

Content
- contextual
- decontextualized

Prosody
- pitch
- intensity

Methods

Participant

- 42 Mandarin-speaking mother-child dyads (mid-high SES, 22 girls, $M_{\text{age in months}}$ = 59, 3;0-7;5)

Data collection

	Task	Measures
Child	**30min free play** - without the mother's presence - transcribed in CHAT format (*The CHILDES Project*, MacWhinney, 2000)	**Productive vocabulary diversity** - Vocabulary diversity (VOCD) by CLAN **Productive sentence complexity** - Mean length of utterances (MLUw) by CLAN
	Receptive vocabulary test (WPPSI-MRVT, Wechsler, 2012)	**Receptive vocabulary**

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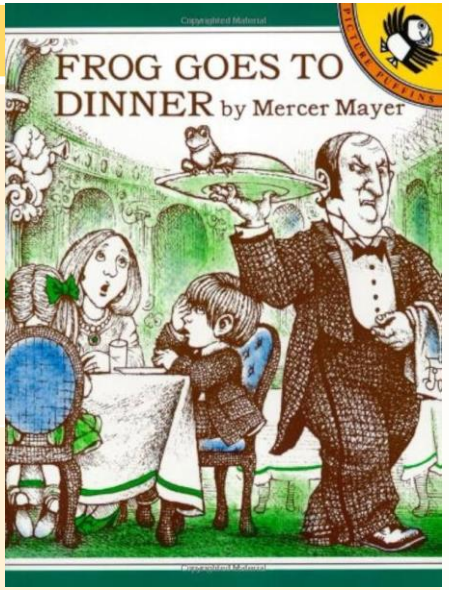
	Receptive vocabulary test (WPPSI-MRVT, Wechsler, 2012)	Receptive vocabulary
Mother	**Child-oriented storytelling** (*Frog goes to dinner*, Mayer, 1974) - without the child's presence - transcribed in CHAT format	(12 input features, see next page ->)



Methods

Input features	Measures	Dimensions
Vocabulary diversity	VOCD by CLAN	Linguistic complexity
Mean length of utterances	MLUw by CLAN	

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Decontextualized -	Frequency -	
Role-play speech	Frequency -	

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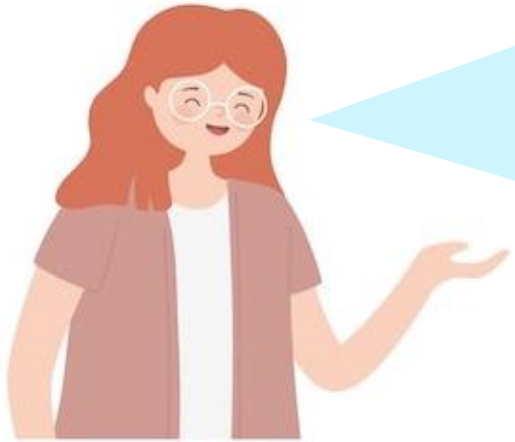
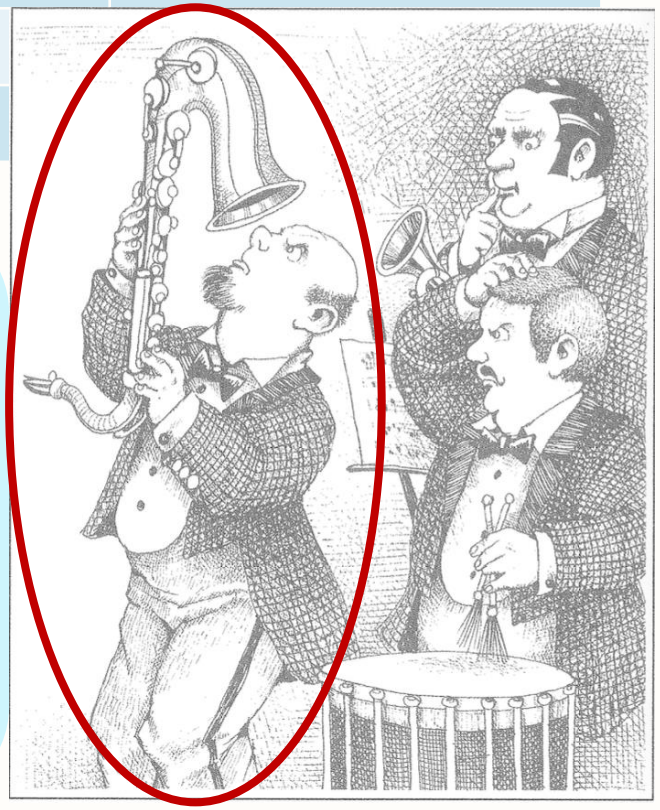


[A man is looking into his saxophone]

Contextualized expansion:
- The man WONDERS what's wrong.
- The man is TRYING to fix his saxophone.

Decontextualized expansion:
- Your grandpa also plays saxophone.
- Such musicians usually appear at concerts.

Role play speech:
- "What's wrong with my saxophone?"
- "Why can't I make any sound?"



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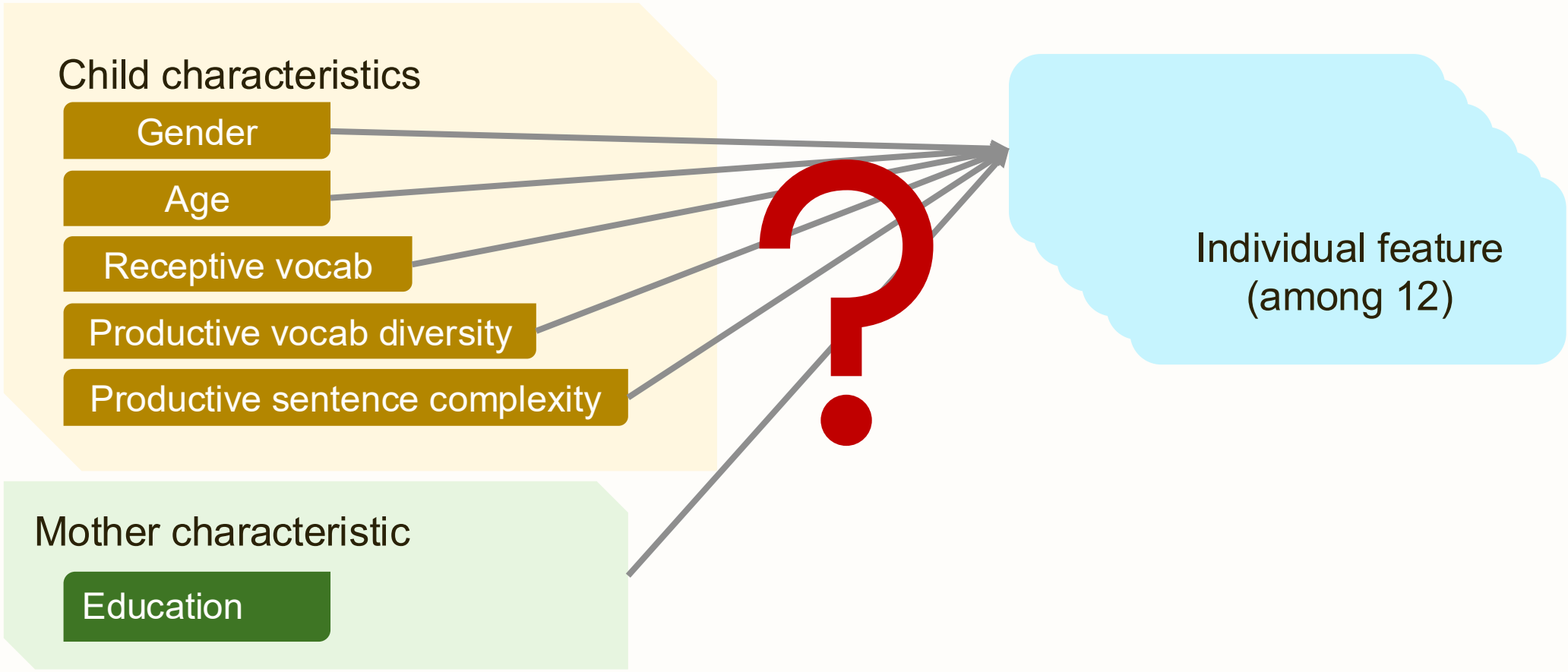
Direct address	Frequency -	
Special sounds	Frequency -	
Pitch SD	SD (sentence level mean pitch)	Prosodic variability
Pitch Range	Average (sentence level pitch range)	
Intensity SD	SD (sentence level mean intensity)	
Intensity Range	Average (sentence level intensity range)	

Results

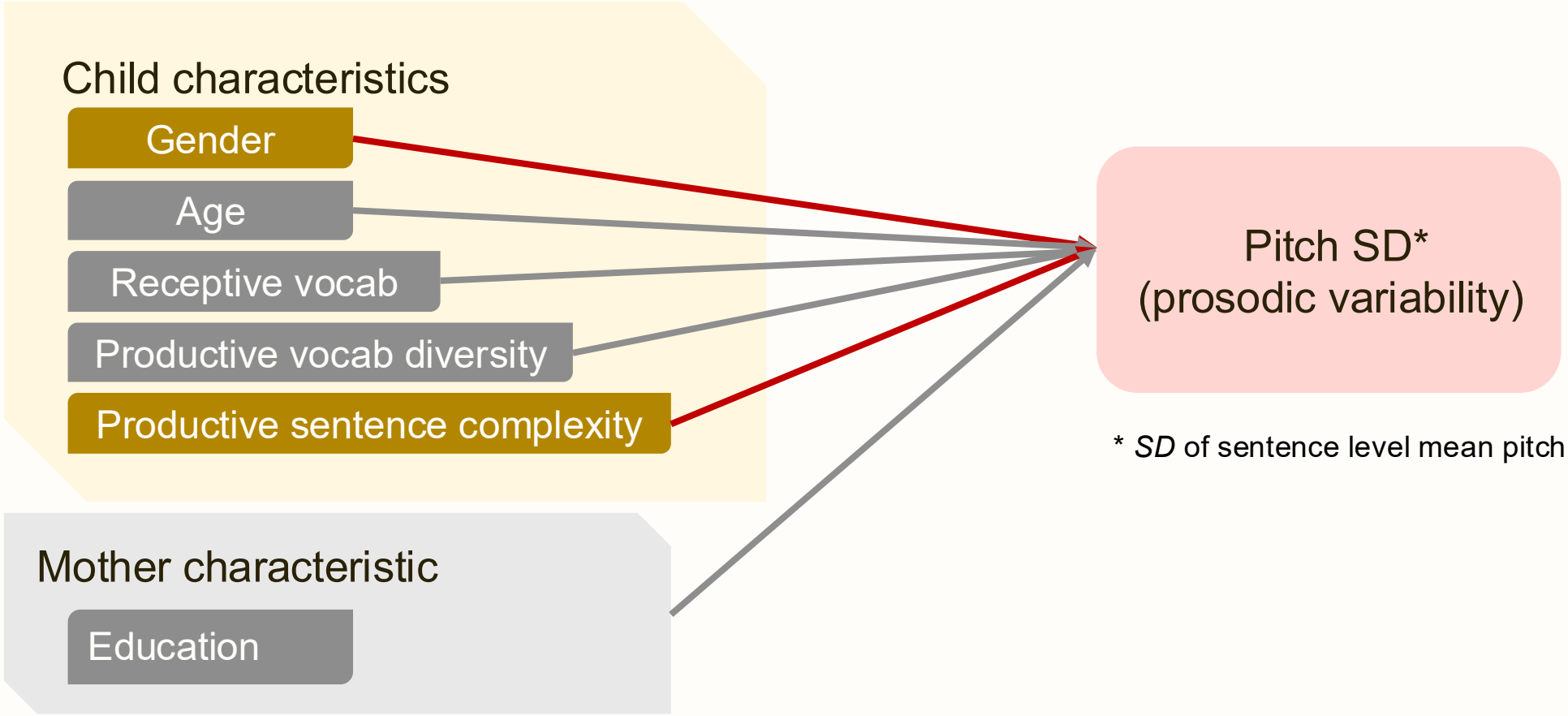
Results – “External” factors?

- Ridge Regressions: predictors of storytelling features



Results – “External” factors

- Ridge Regressions: predictors of each storytelling feature



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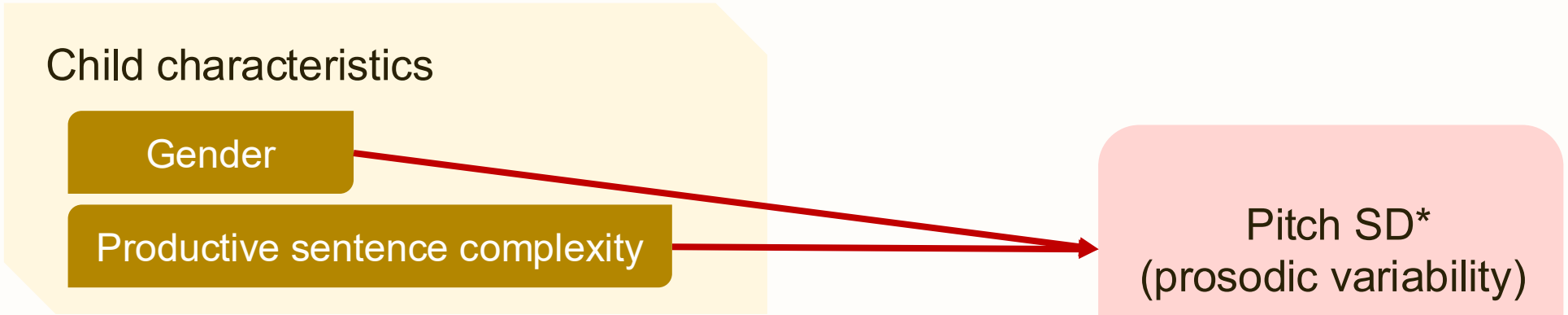


- Mothers of GIRLS
- Mothers of children who produce LONGER sentences

~ tell stories with reliably higher prosodic variability in sentence-level pitch values

* *SD* of sentence level mean pitch

Results – “Internal” dynamics?

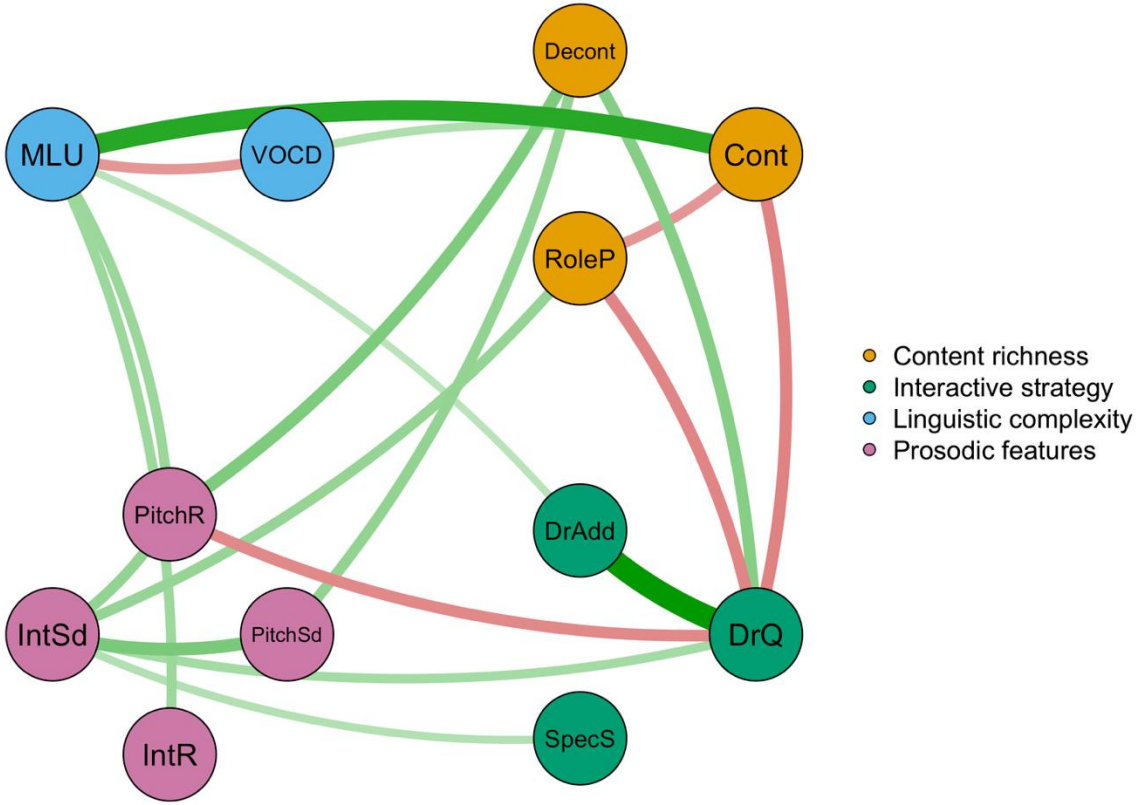
- Gaussian Graphical Model: Network Analysis of multi-dimensional storytelling features

Mutual reinforcement

- **Content – Language**
  - Contextual expansion – MLUw/VOCD
- **Content – Prosody**
  - Decontextualized content/role-play speech – prosodic variation

Trade-off

- **Interaction – content**
  - Direct question – contextual/role-play
- **Within language**
  - MLUw - VOCD



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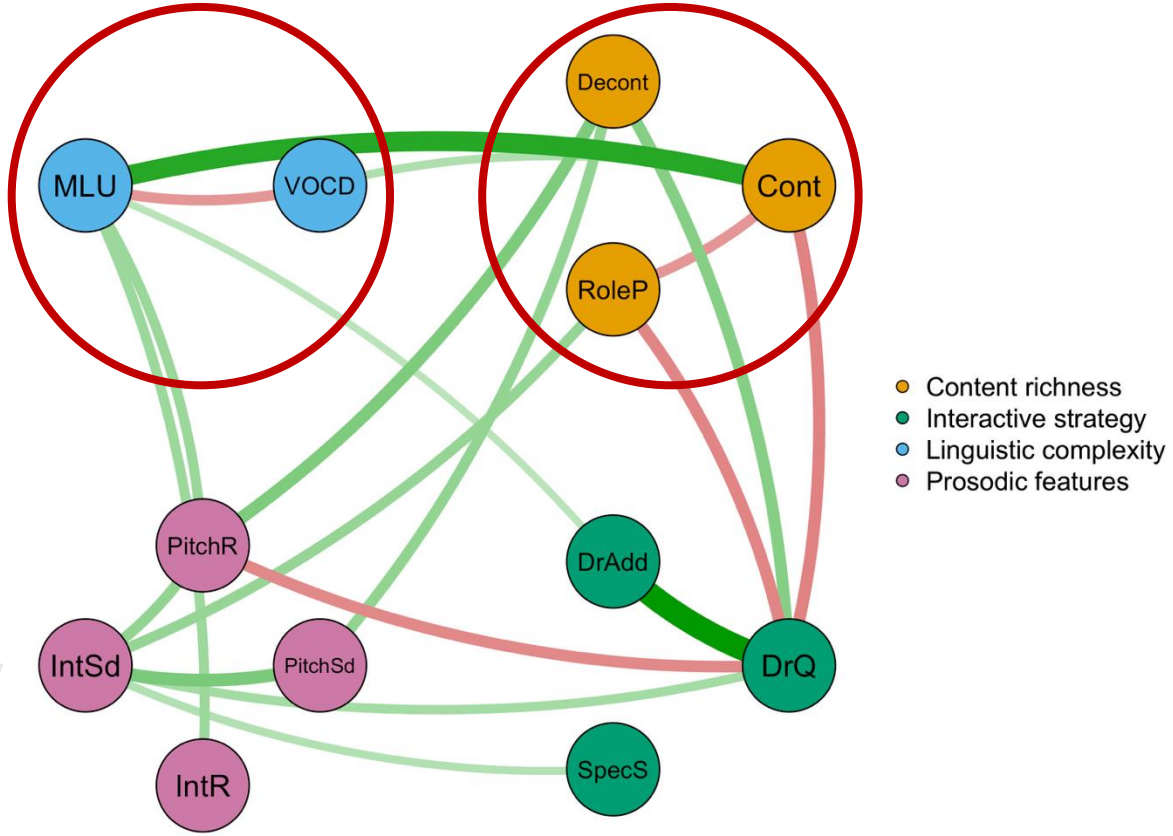

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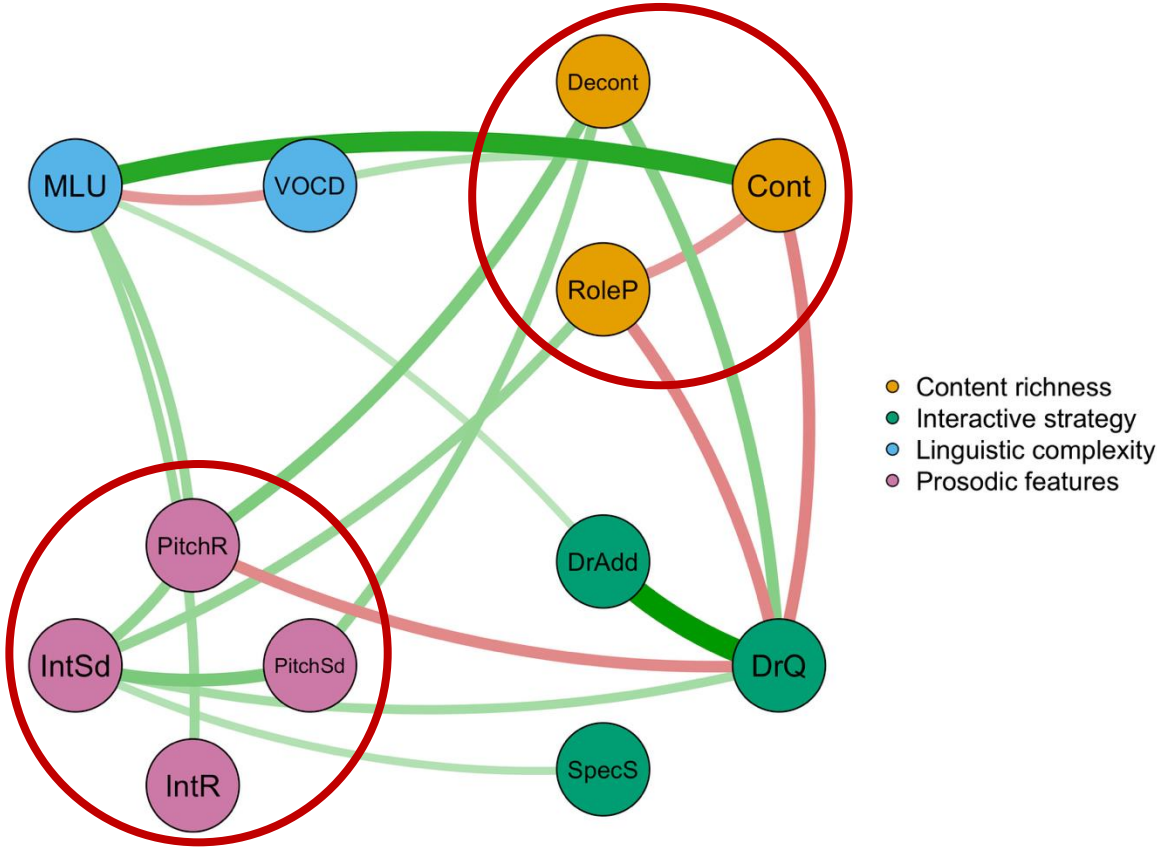

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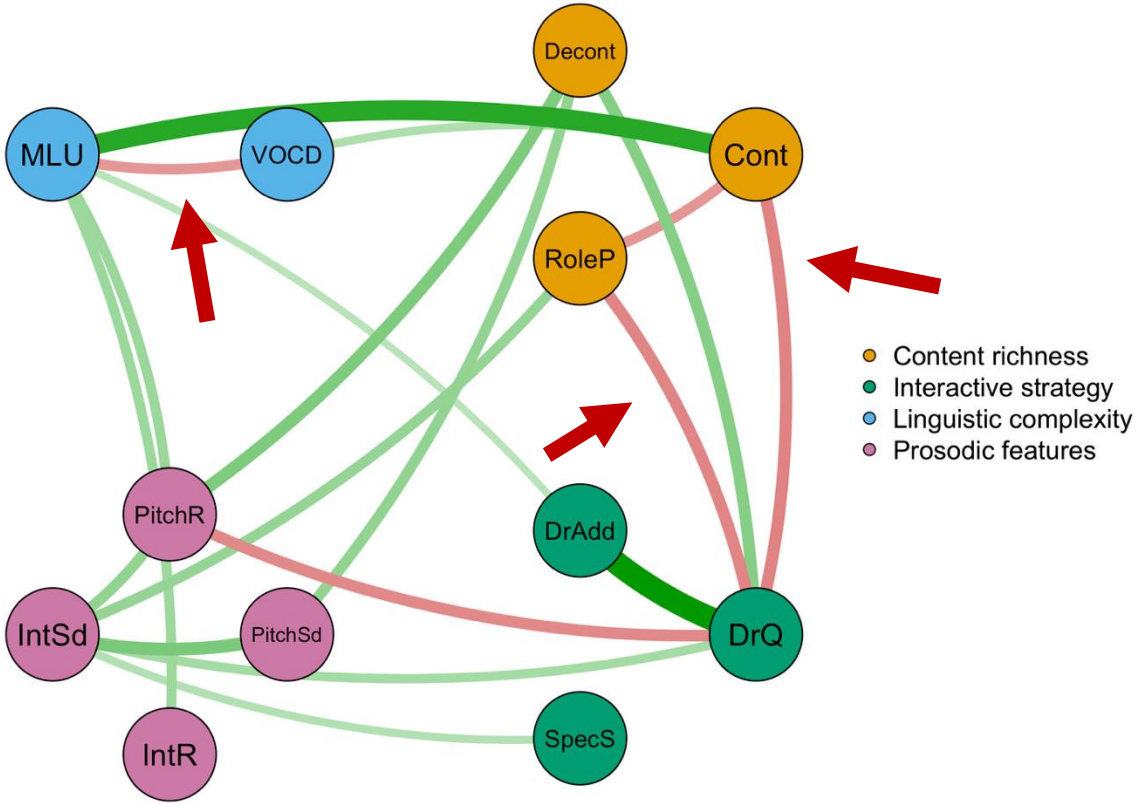

Summary and takeaways

- Limited features are driven by child or maternal background characteristics
  - Prosodic variability is most sensitive to child characteristics

- Mothers' storytelling features form a complex, internally structured system
  - Central nodes/features in mothers' storytelling:
    - Questions directed to the child – **Interaction**
    - Mean length of utterance – **Language**

  - Major associations among nodes/features
    - **Interaction ~ content**
    - **Language ~ content**

Co-authors

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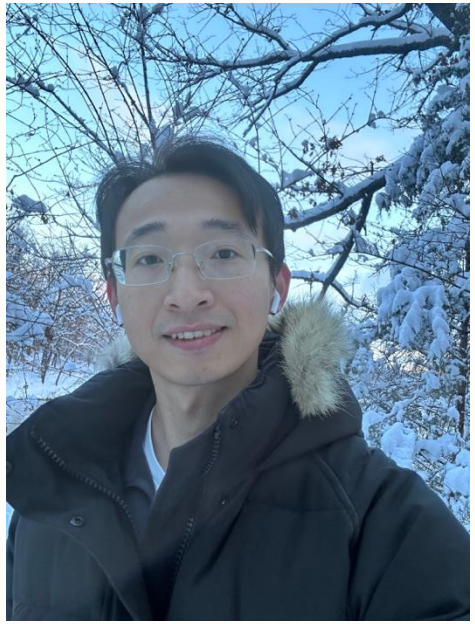
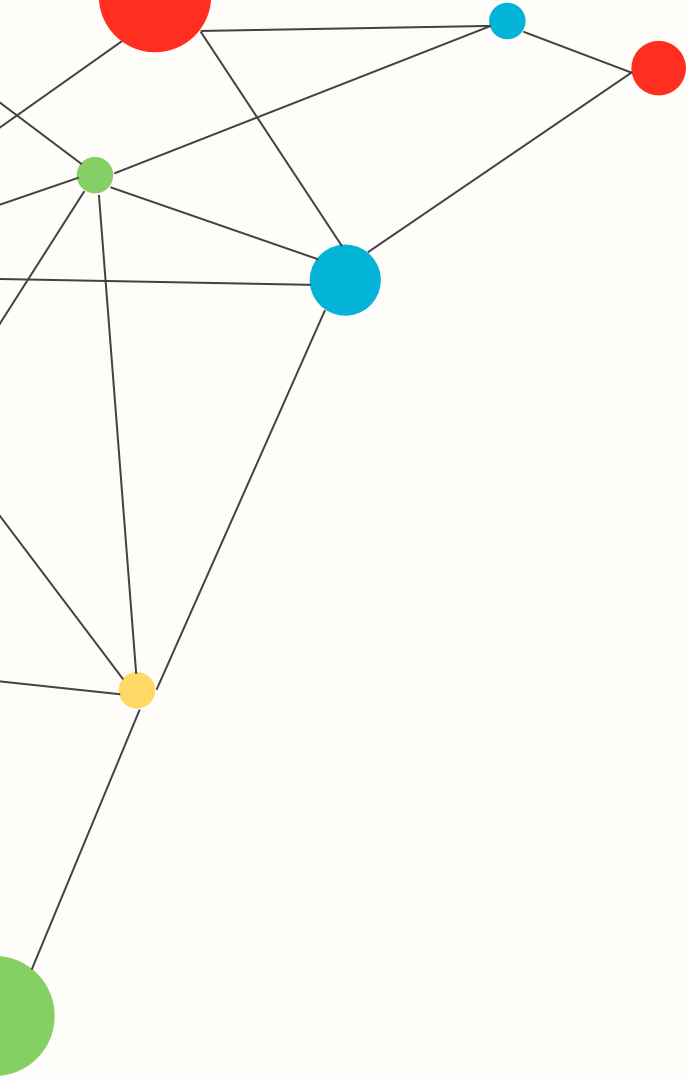
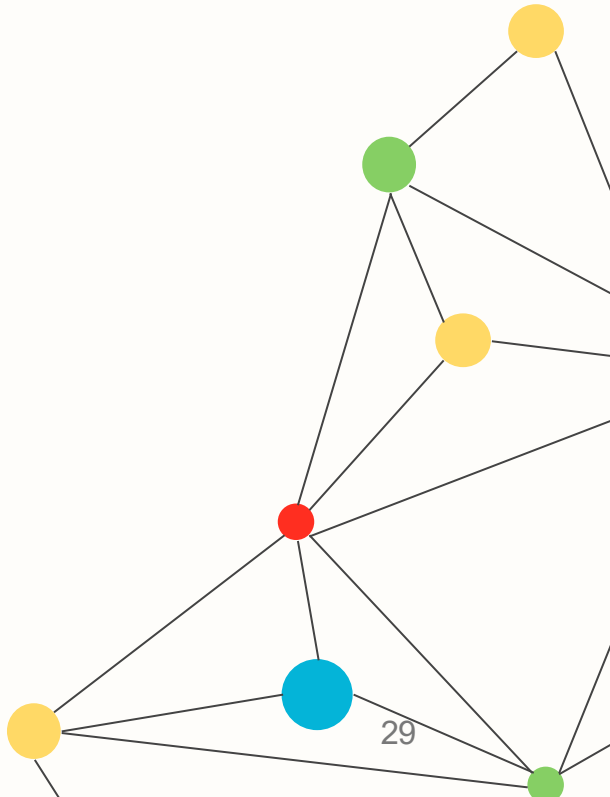
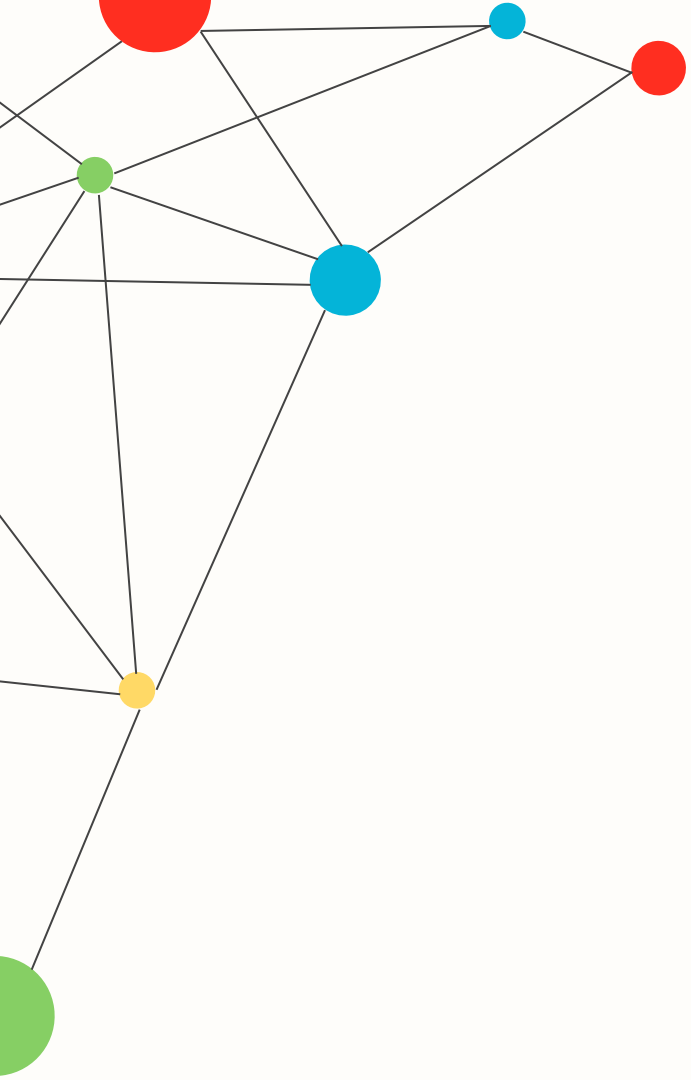


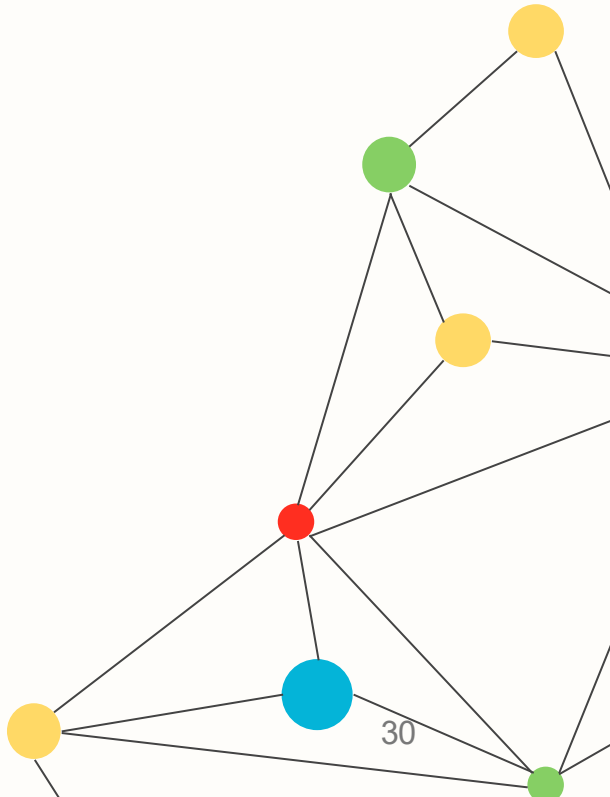


Thank you!





Supplementary

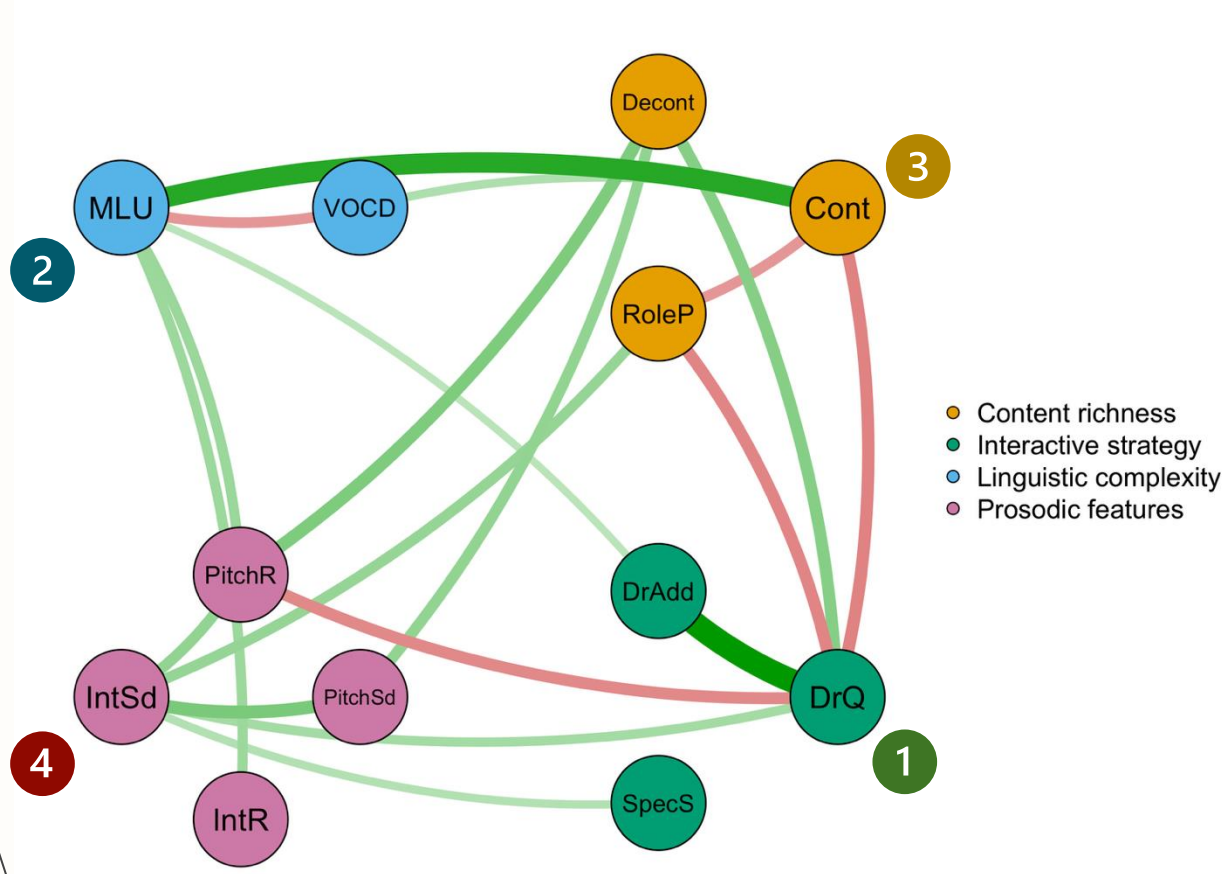


- **Table 1.** Descriptive statistics for 12 mothers' storytelling features (*N* = 42).

Feature	Dimension	*M*	*SD*
VOCD	Linguistic complexity	66.15	7.80
MLUw		8.88	1.29
Contextual expansion	Content richness	37.00	9.00
Decontextualized content		2.00	4.00
Role Play speech		16.00	7.00
Direct Question	Interactive strategy	15.00	12.00
Direct Address		11.00	9.00
Spec Sound		5.00	4.00
Pitch SD	Prosodic features	41.64	12.40
Pitch Range		319.59	49.60
Intensity SD		2.65	0.79
Intensity Range		52.23	6.94

Note. Cont, Decont, RoleP, DrQ, DrAdd, SpecS are expressed as percentages of total utterances (raw count / MLU-Utts × 100). PitchSd and IntSd are standard deviations (Hz and dB respectively). PitchR and IntR are averaged sentence-level ranges.

- Figure 2. Node strength centrality for the whole-sample network (z-scores), ordered by strength.



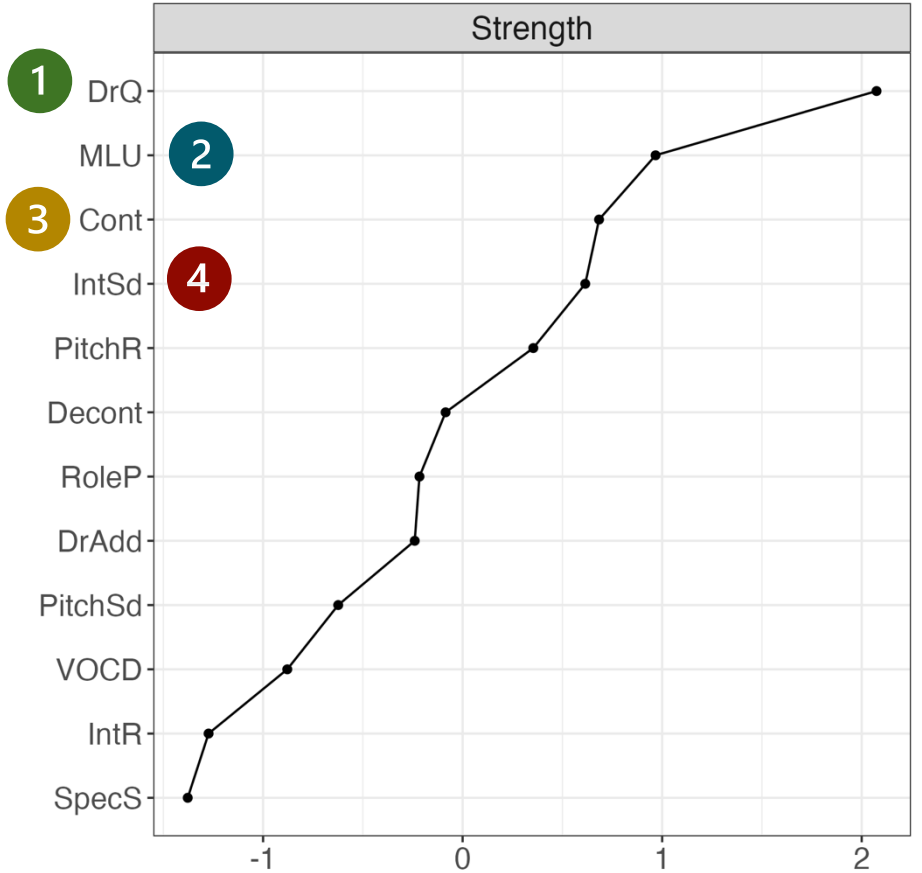


Table 4. Bootstrap 95% confidence intervals for significant ridge regression coefficients predicting PitchSd (*N* = 42, B = 1000).

Predictor	β	95% CI
ChildGender	**−0.105**	**[−0.200, −0.007]**
ChildAge	−0.019	[−0.108, 0.072]
ChildRecVoc	0.055	[−0.019, 0.138]
ChildVocDiv	0.053	[−0.030, 0.143]
ChildSenComp	**0.127**	**[0.011, 0.236]**
MotEdu	0.062	[−0.026, 0.146]

Note. α = 0 (ridge); λ selected by 10-fold cross-validation (λ_min); *standardize* = FALSE. ChildGender dummy-coded: Female = 0, Male = 1; negative coefficient indicates mothers of boys showed lower pitch SD than mothers of girls. MotEdu centered at 5 (college degree). **Bold** = 95% bootstrap CI excludes zero (significant). All other outcomes showed no significant coefficients.