The differential development of vowel context effects on sibilant fricatives

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Purpose

- ▷ When measured at a discrete point near the fricative-vowel boundary, the magnitude of anticipatory vowel-context effects on the spectral properties of English /s/ and /ʃ/ have been found to be greater in children's than in adults' productions (Nittrouer *et al.*, 1989, 1996).
- ▷ Greater vowel-context effects on sibilants have been argued to indicate that children's productions are more syllabic, as opposed to segmental, than are those of adults.
- ▷ The spectral properties of adults' productions of /s/ and /ʃ/ vary temporally, and these temporal variations are affected by the rounding and height of a following vowel (Iskarous *et al.*, 2011; Reidy & Beckman, 2015). But vowel-context effects on the spectral dynamics of sibilants have not been investigated in children's productions.
- ▶ **Hypothesis:** If children's sibilant-vowel productions are more syllabic than segmental, then the magnitude of anticipatory effects of vowel rounding and height on both the static and dynamic spectral properties of the fricative will decrease with age.

Background

Figure 1: Discretization of phonetic feature continua of English vowel categories.

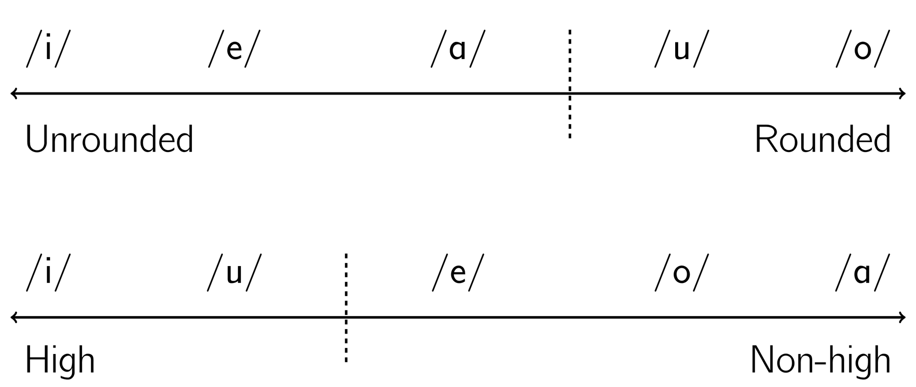
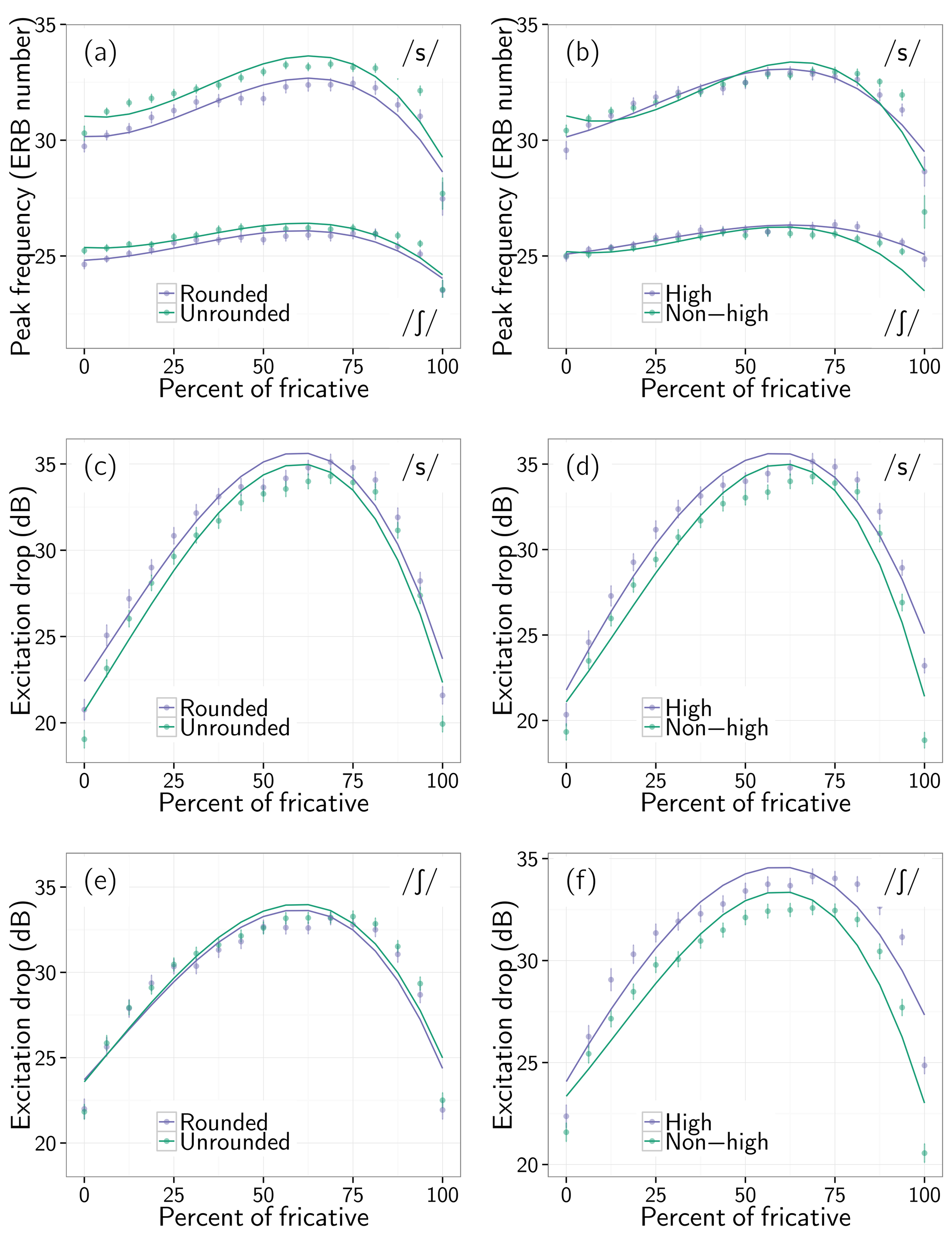


Figure 2: Effects of vowel rounding (left column) and height (right column) on the peak ERB_N number (top row) and excitation drop trajectories (middle and bottom rows) of adults' productions of English sibilant fricatives.



Methods

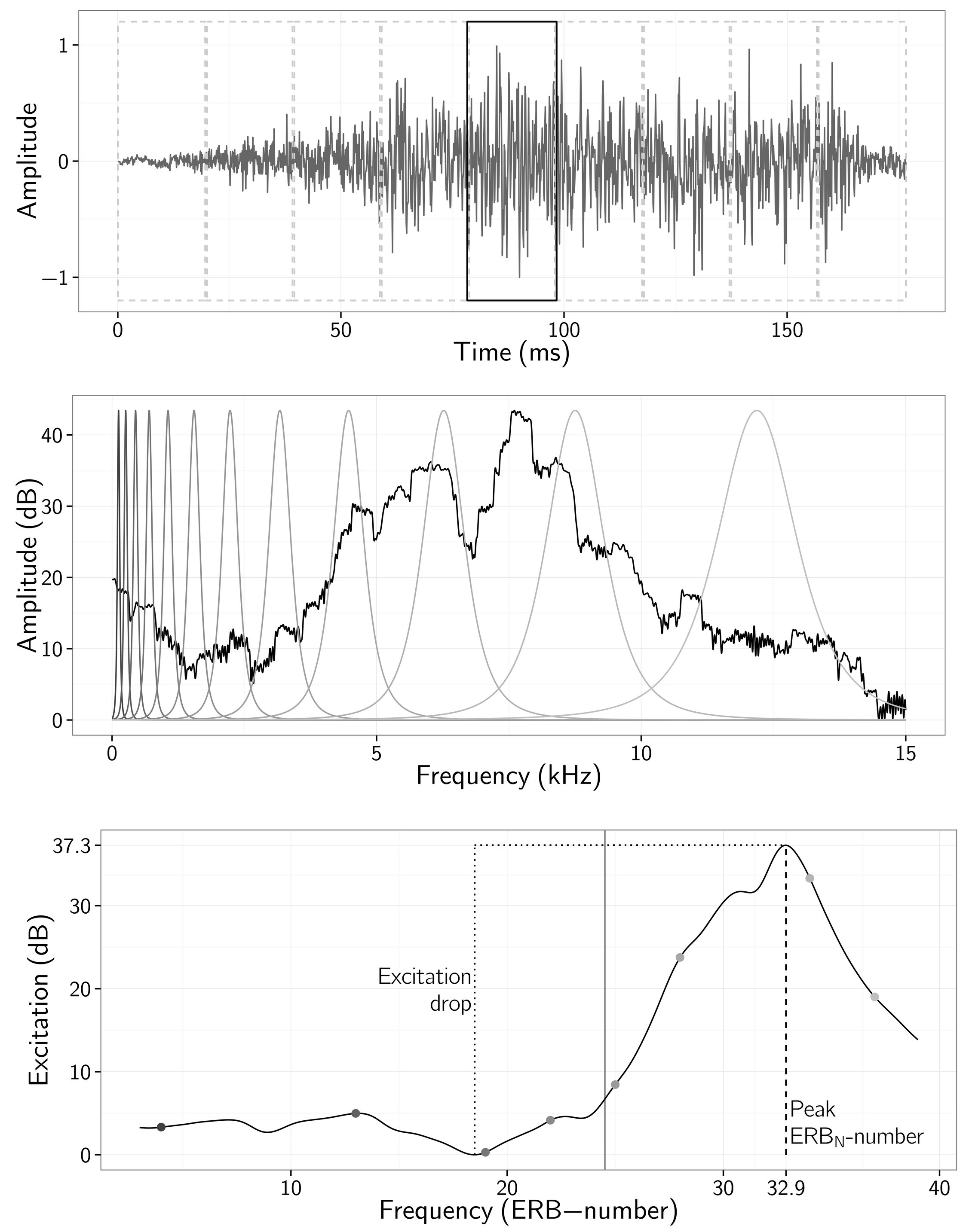
Participants & materials

- ▷ 81 typically developing, native English-acquiring children between 2 and 5 years old.
- ▷ 30 real words with /s/ or /ʃ/ in initial position, followed by a vowel.
  - – Vowels were grouped into five classes: {i}: /i, ɪ/; {u}: /u, ʊ/; {e}: /e, ɛ/; {o}: /o/; {ɑ}: /ʌ, ɑ, ɔ/.
  - – Three target words per combination of sibilant and vowel class.
- ▷ Elicited with a picture-prompted word-repetition task.

Estimation of psychoacoustic spectral properties

- ▷ From each sibilant production, 17 excitation patterns were computed from 20-ms intervals spaced evenly across the frication (cf. Fig. 3).
- ▷ Psychoacoustic properties computed from each excitation pattern:
  - ▶ *Peak ERB_N-number:* most prominent psychoacoustic frequency;
  - ▶ *Excitation drop:* difference in excitation (dB) between high-freq. peak and low-freq. trough (cutoff = 24.5 ERB_N-num. ≈ 3 kHz).
- ▷ Hence, each production represented by two 17-point trajectories.

Figure 3: Top: Waveform of /s/; odd-numbered 20-ms analysis windows overlaid. Middle: Multitaper spectrum estimated from middle window of /s/; gammatone filters overlaid. Bottom: Excitation pattern output by a 361-channel gammatone filter bank model of auditory periphery.

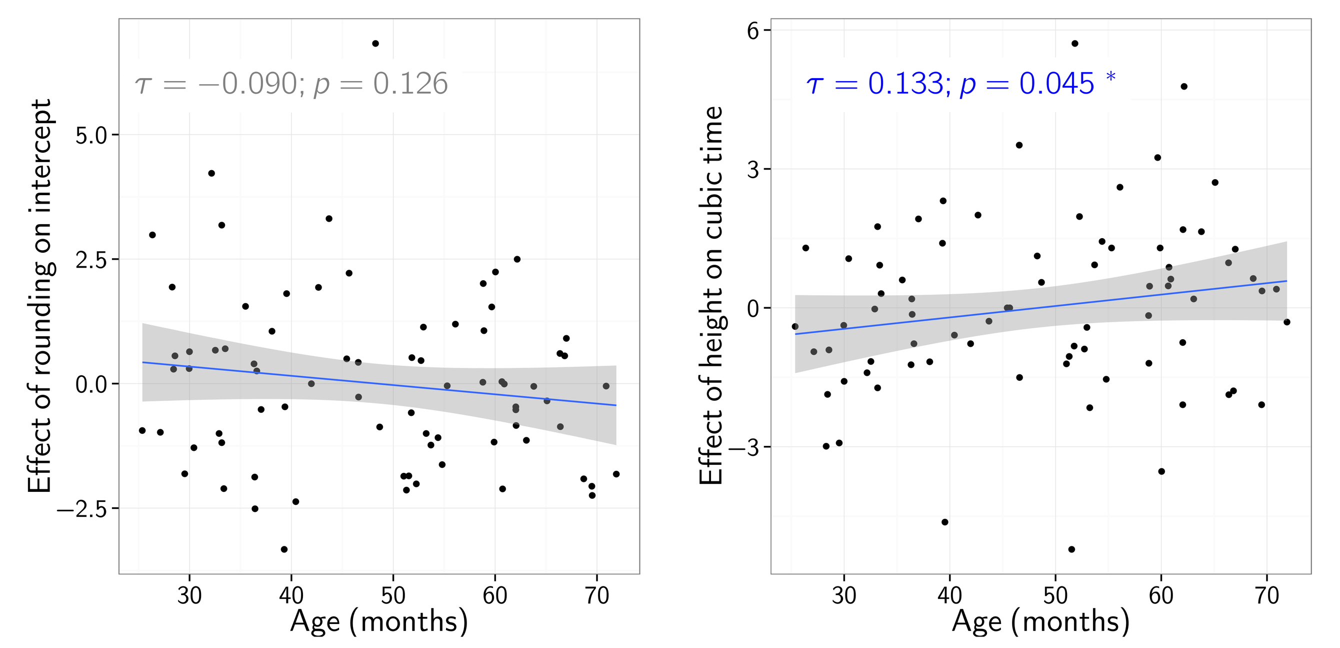


Quantifying the development of vowel-context effects

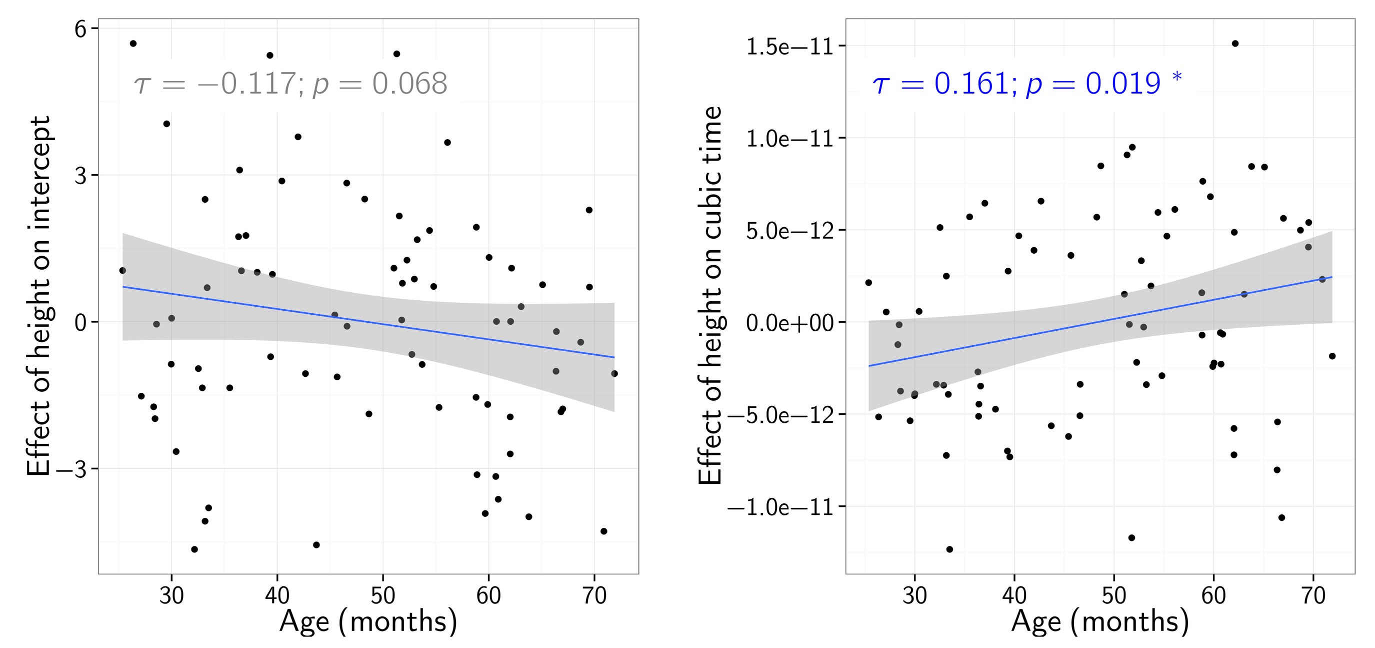
- ▷ Effects of vowel rounding and vowel height investigated independently.
- ▷ Cubic-time orthogonal polynomial growth-curve models.
  - – Random effects of vowel feature-within-participant.
- ▷ Effect of vowel feature for a participant computed by subtracting the two values of their vowel-within-participant random effects.
- ▷ Development of vowel-context effects assessed with Kendall's rank correlation coefficient (τ).

Results

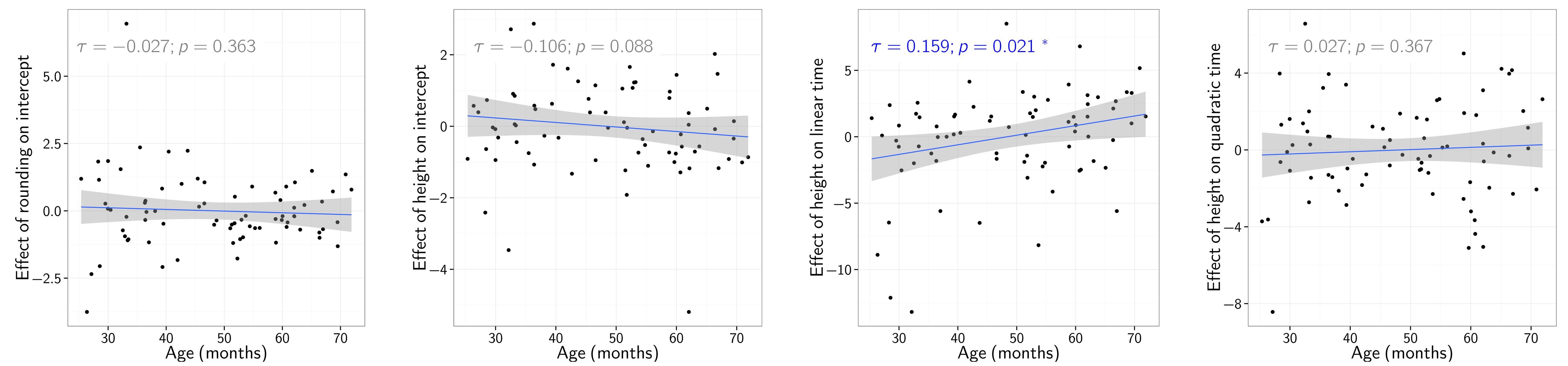
Peak ERB_N number trajectory of /s/



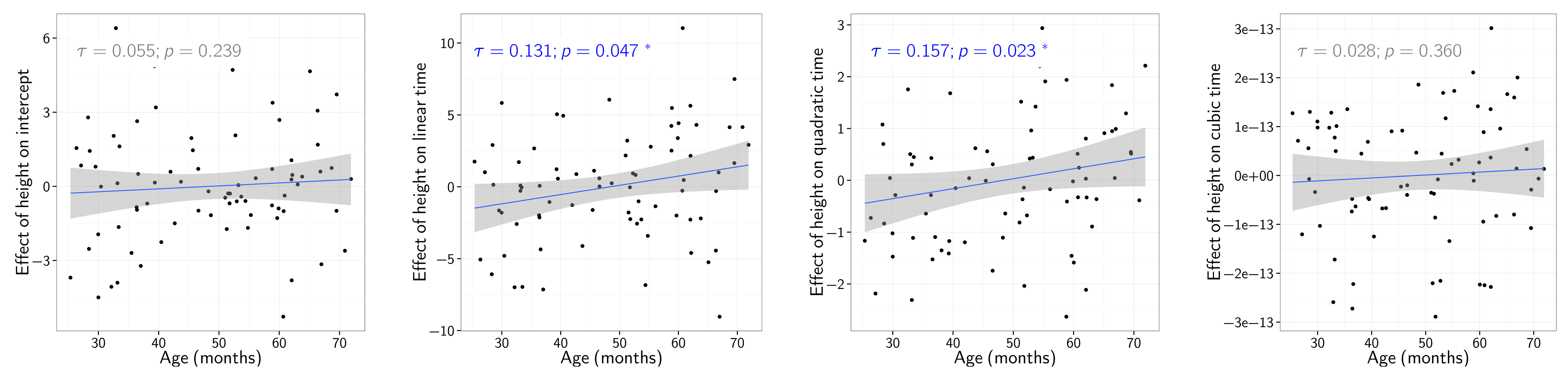
Excitation drop trajectory of /s/



Peak ERB_N number trajectory of /ʃ/



Excitation drop trajectory of /ʃ/



Discussion

- ▷ The hypothesis was not supported:
  - – Effects of rounding and height on the intercept (i.e., the level) of the peak ERB_N number and excitation drop trajectories tended to be weakly negatively correlated with age, suggesting that these effects **decrease** in magnitude as children develop.
  - – Vowel-context effects on the non-zero powers of time (i.e. the shape) of the trajectories tended to be positively correlated with age, suggesting that these effects **increase** in magnitude as children develop.
- ▷ Asymmetry between effects on trajectory intercept, which decreased in magnitude, and those on trajectory shape, which increased in magnitude, may be due to the former arising from spatial coarticulation, but the latter from temporal coordination.

Acknowledgements

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References

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