Speaking rate and intelligibility in children's speech

Tristan Mahr, Katie Hustad
University of Wisconsin–Madison

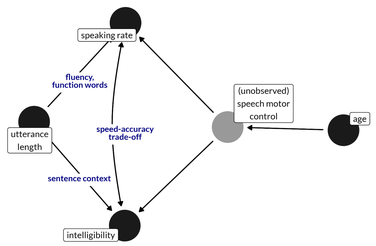
Background

- Our prior work developed percentile growth curves for articulation rate and intelligibility in typically developing children between ages 2;6 and 9;11.
- We found positive effects of age and utterance length:
  - Older children had faster, more intelligible speech productions on average.
  - Longer sentences prompted faster, more intelligible productions

Current study

- *How are rate and intelligibility related?* We examine two possible relationships:

1. **Speech-motor control as common cause.** Children with faster speaking rates have greater speech-motor control and thus higher intelligibility.
2. **Speed-accuracy tradeoff.** Increased rates are associated with reduced intelligibility.



Analysis framework. Age is a proxy for speech-motor control development.

Method

Participants

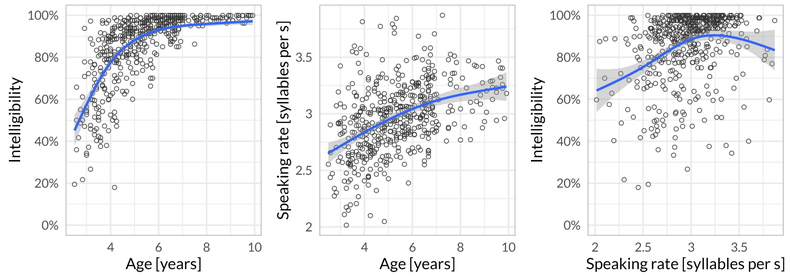
- 538 *typically developing* children between ages 2;6 and 9;11

Age Range	2;6–3;5	3;6–4;5	4;6–5;5	5;6–6;5	6;6–7;5	7;6–9;11
N	105	111	110	96	66	55

Speech measures

- Children repeated 2–7-word sentences.
- For each child, two unique untrained listeners transcribed children's utterances; they were played the productions and instructed to type out the words the child said.
- A child's **intelligibility** was the percentage of words correctly identified by listeners.
- We force-aligned utterances using the Montreal Forced Aligner to determine start and end of speech.
- **Speaking rate** was number of syllables per second.
- We computed average rate and intelligibility stratified by utterance length. We only examined 3–7-word utterances.

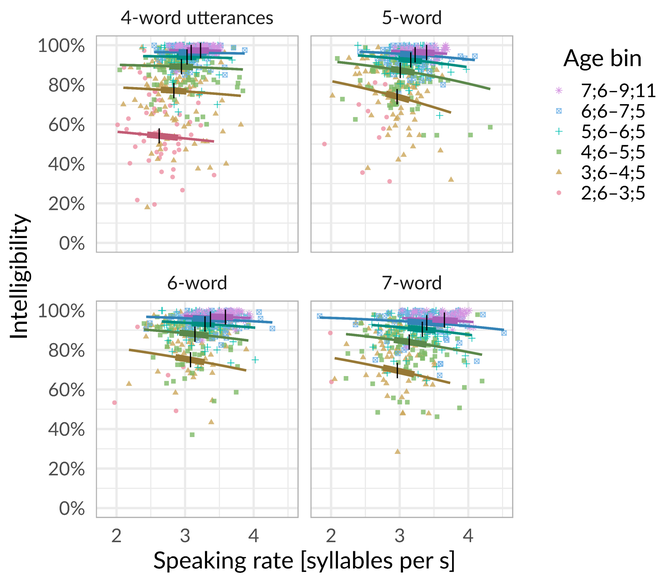
Observed relationships for 4-word-utterances



Example data. Age is related to intelligibility and speaking rate. There is a suggestive decrease in intelligibility at the highest rates, but this effect is confounded by age.

Bayesian mixed effects analysis

- We regressed intelligibility onto a 3-d.f. spline for age, utterance length, rate, and a length-by-rate interaction.
- We included by-child random intercepts and by-child length-by-rate interactions.
- On each posterior draw, we simulated one new child and computed their expected intelligibility at each rate × length × age. We averaged these simulated participants together to compute **marginal means** for intelligibility.



Marginal means of intelligibility by speaking rate, age and utterance length. Points represent observed intelligibility scores. Lines represent marginal means (population averages); these are expected intelligibility scores after averaging over between-child variability. Lines contain boxplot landmarks: Vertical marks represent the medians and thicker intervals contain the middle 50% of the observed data.

Effects of rate changes on intelligibility

- We simulated 100 participants on each posterior draw and computed the mean of the participants on each draw. We summarized these simulated sample means with the posterior median and 95% quantile interval.
- Increasing rate from 3.0 to 3.5 syllables per s for a 4-year-old:
  - 4 words: changes intelligibility by −1 [−3, 1] (76% → 75%)
  - 5 words: −5 [−7, −3] (73% → 68%)
  - 6 words: −3 [−5, −1] (75% → 72%)
  - 7 words: −4 [−6, −2] (69% → 64%)
- … for a 6-year-old
  - 4 words: changes intelligibility by 0 [−1, 0] (94% → 94%)
  - 5 words: −2 [−3, −1] (93% → 91%)
  - 6 words: −1 [−2, 0] (94% → 93%)
  - 7 words: −1 [−3, −1] (91% → 90%)
- Average observed SD of rate for each age-bin × length: .29

Discussion

- Speaking rate and intelligibility both increase with age, consistent with a shared developmental cause.
- After stratifying by utterance length and adjusting for age, there was a negative effect of speaking rate on intelligibility, suggesting a speed-accuracy trade-off.
- This effect is small and practically negligible after 5;0, but for younger children and for longer, more demanding utterances, the effect is more noticeable.

Limitations

- Speaking rates here are *habitual rates* in a sentence-repetition task meant to reduce other task demands (like sentence formulation). We might be underestimating the effect compared to spontaneous speech.
- We did not manipulate rate. A within-child design that manipulated speaking rate would more directly test for the speed-accuracy tradeoff.
- Participants were typically developing children, so the dynamic in a dysarthric population is unclear.

The authors have no financial or non-financial conflicts of interest.
Funding by NIDCD R01 DC015653 and supported in part by NICHD P50HD105353.
Conference on Motor Speech
San Diego, CA: February, 2024
Contact: Tristan Mahr (tristan.mahr@wisc.edu)