Age-related changes in implicit causality and consequentiality pronoun biases

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Background

Protracted development of discourse-level learning remains largely unexplored.

Pronouns offer a window into discourse-level processes.
- Interpretation involves high-level inferences from:
  - syntactic,
  - semantic, and
  - pragmatic discourse factors.

RQ: How does sensitivity to discourse-level pronoun biases develop across the lifespan?

Focus on two pronoun biases (IC biases):
In causally-dependent clauses [1-5]:

***Implicit Causality*: pronouns tend to refer to the cause**
1. Josh feared Paul because he…[he=Paul]
2. Josh frightened Paul because he…[he=Josh]

***Implicit Consequentiality*: pronouns tend to refer to the affected entity**
3. Because Josh feared Paul, he…[he=Josh]
4. Because Josh frightened Paul, he…[he=Paul]

Method

Re-analysis of 2 large-scale datasets
- Off-line pronoun interpretation in IC-biased sentences

Dataset 1: Hartshorne & Snedeker (2013)

ICaus A

> Sally VERBed Mary because she is a dax.
> Who is a dax?
> Sally Mary

Dataset 2: Hartshorne, O'Donnell, & Tenenbaum (2015)

ICaus B

> Sally VERBed Mary because she daxed.

ICons

> Because Sally VERBed Mary, she daxed.

Outcome measure:
- convergence with young adult (YA) interpretation
- 1 = matches modal YA response, otherwise 0

Method Continued

Participants

Dataset 1:

ICaus A
N participants = 978
Age range = 9-81 years
N verbs = 265

Dataset 2:
Age range = 8-81 years
N verbs = 502

ICaus B
N participants = 2,616

ICons
N participants = 2,621

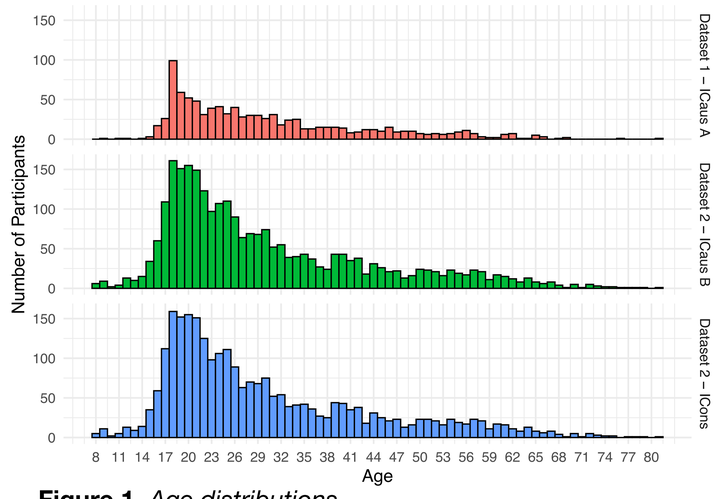

Figure 1. *Age distributions.*

Analysis Plan

***Step 1*: fit 2-parameter IRT model**
(adjusts for participants seeing different sets of items, see [6,7])

***Step 2*: fit Bayesian regression with spline smoothing term on age**
(models nonlinear effects of age)
latent_ability ~ s(age)

***Step 3*: calculate slope of curve for each 1/100th year for each sample, providing 95% credible interval (CI)**
(Each age interval CI doesn't overlap with 0 = significant change)

Results

Implicit Causality and Consequentiality show protracted learning trajectories, extending into early adulthood.

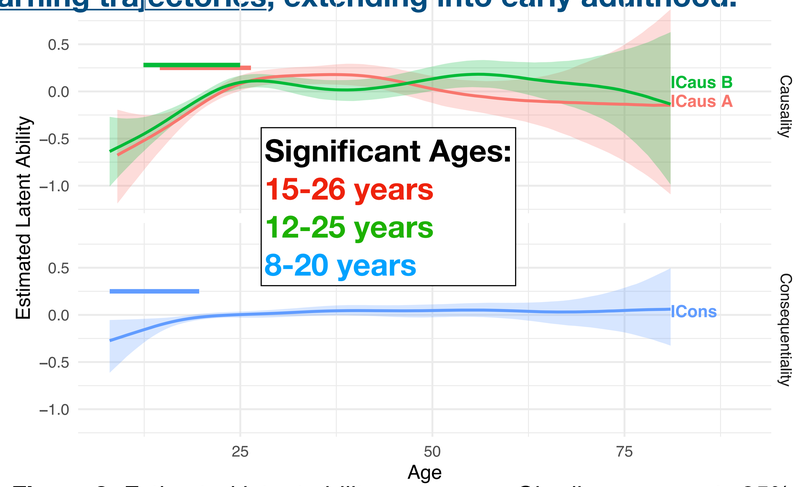

Figure 2. *Estimated latent ability across age. Shading represents 95% credible intervals Horizontal bars show age ranges where the estimated change in ability was significant.*

References:
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Discussion

Key pattern: extended development
- Implicit Causality → improves until mid-20s
- Implicit Consequentiality → improves until ~20

Different accounts predict different learning mechanisms, both compatible with our findings:

- Hartshorne and colleagues [1,2]: biases **emerge "for free"** from reps of verbs and/or event structure
  - protracted development reflects **change in verb and/or event knowledge**

- Arnold and colleagues [8]: biases reflect **discourse-level statistical learning**
  - protracted development reflects **increasing exposure** to relevant verbs and discourse structures
  - **plateaus** in development reflect **underlying estimates approach population distribution**

Future Directions

Learn more about:
- Acquisition of verbs and their argument structure
- Acquisition of discourse structure
- Viable statistical learning algorithms

(to generate more precise developmental predictions)