# Modeling individual and item differences in atypicality inferences with ACT-R

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## Background

Atypicality inferences: Some events are implied by the context and thereby redundant if uttered:

*(1) Mary went to a restaurant. She ate there!*

To repair this redundancy, comprehenders infer that event to be *atypical* and accommodate with explanations.

*(2) Mary doesn't usually eat at a restaurant because she only orders beer.*

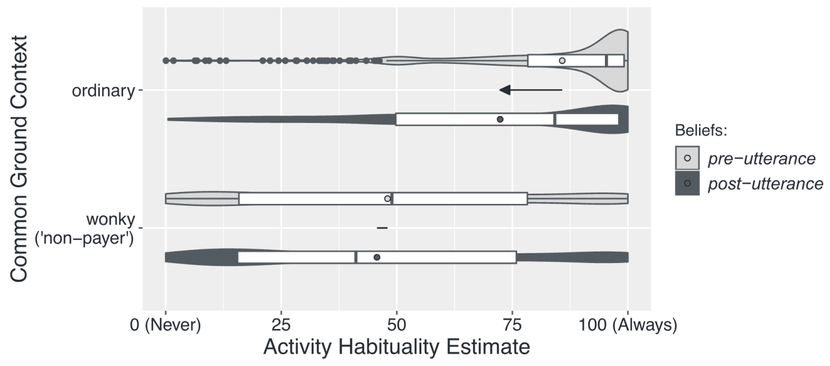



*Figure 1. How often do you think Mary usually eats at a restaurant?*

Individual differences: Not everyone draws such inference all the same.

- ↑ reasoning abilities measured by *Raven's Matrix* (Ryzhova et al., 2023), ↑ inference rate

Item differences: Inferences drawn from different contexts and events aren't all the same.

- Items have different priors for how habitual an event is (Kravtchenko and Demberg, 2022). *Picking topping when ordering pizza < Eating when going to a restaurant*

## Takeaway

How to model *individual* and *item* differences in atypicality inferences?

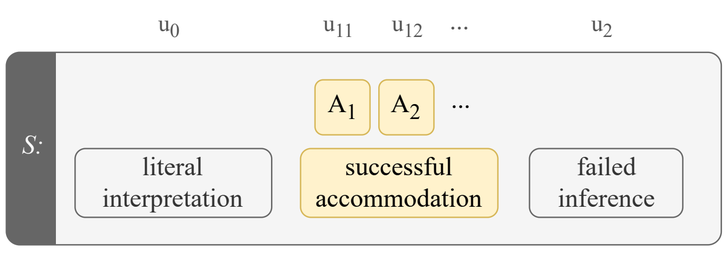
Hybrid model (*cognitive modeling + event plausibility*) can help explain pragmatic inference variance among humans.

## ACT-R Cognitive Model

A comprehender model (Fig. 4) that can be **parameterized individually** (shown to correlate with Raven's) and **implements several interpretation strategies**.

1. **Persistence** ($\tau$) and **Negative Feedback** ($F_{\text{neg}}$): *Individual* exploration tendencies to persist and disengaged in failed inference .
2. **Initial utility** $u$: *Item* predispositions to interpret literally or accommodate with explanations.

**Strategy** $S$: A comprehender can interpret literally, accommodate with valid or invalid explanations, or fail to make inference. Encodes the success likelihood and the strategy cost.




## Finding 1: ACT-R Model parameters can simulate human variance

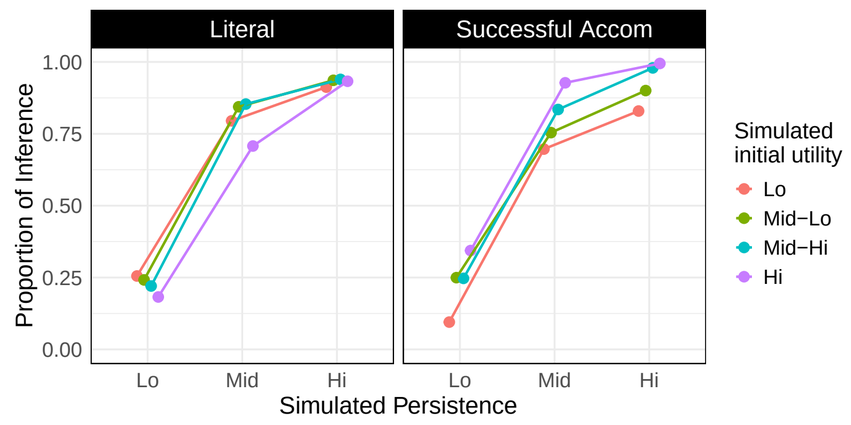



*Figure 2. Higher persistence and higher initial utilities for accommodations (Right) ∼ Higher inference*

## Finding 2: Estimated parameters can help predict an individual's performance

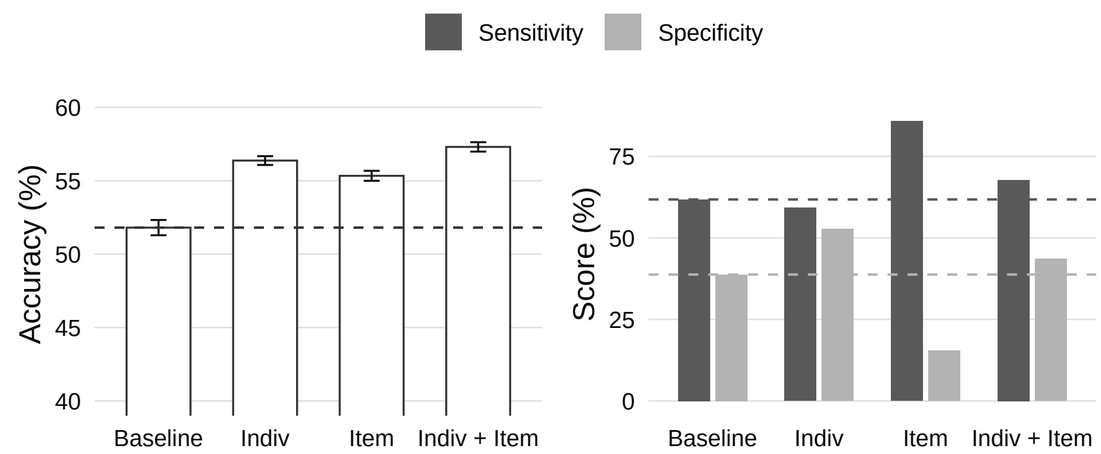



*Figure 3. Ind / Item improves accuracy. Item helps detect inferences (+8.58%) but hurts non-inferences (−9.16%)*

Comprehenders with low pragmatic profile consistently make no inference, and **item-level variation provides little help**.

## Modeling Item and Individual Differences

These model parameters are estimated and **not learned**:

- Persistence is estimated by reasoning test scores (*Raven's Matrix*).
- Initial utility is estimated by habitual ratings from humans and event plausibility from LLM surprisal.

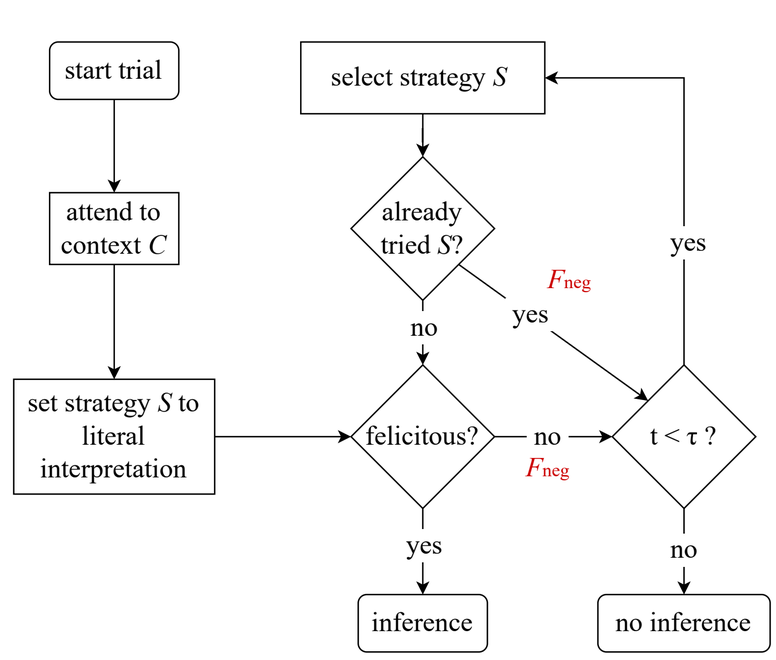



*Figure 4. ACT-R comprehender model adapted from Duff et al., 2026*

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