Logical language and the development of reasoning by the disjunctive syllogism

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Background

- Whether abstract, combinatorial thought can exist in the absence of language is highly debated. [1-4]
  - The **disjunctive syllogism** is a logical reasoning process that requires combinatorial thought.

- **Evidence** on whether young children can use the disjunctive syllogism appears **mixed.** [5-7]
  - In a **non-linguistic task,** where children searched for a reward across 4 possible locations after seeing that one location was empty, 3- to 5-year-olds succeeded but 2.5-year-olds failed. [5]
    - Such failures may suggest that very young (i.e., "pre-linguistic") children do not yet have the logical concepts of disjunction (OR) and negation (NOT).
  - However, in a **linguistic version of the same task,** where cues to "emptiness" were conveyed with a negative statement (e.g., X is not in A), even 2.5-year-olds succeeded. [6]
    - Such successes may suggest that language (linguistic negation) facilitates the construction of the logical (negative) premise.

Current Study

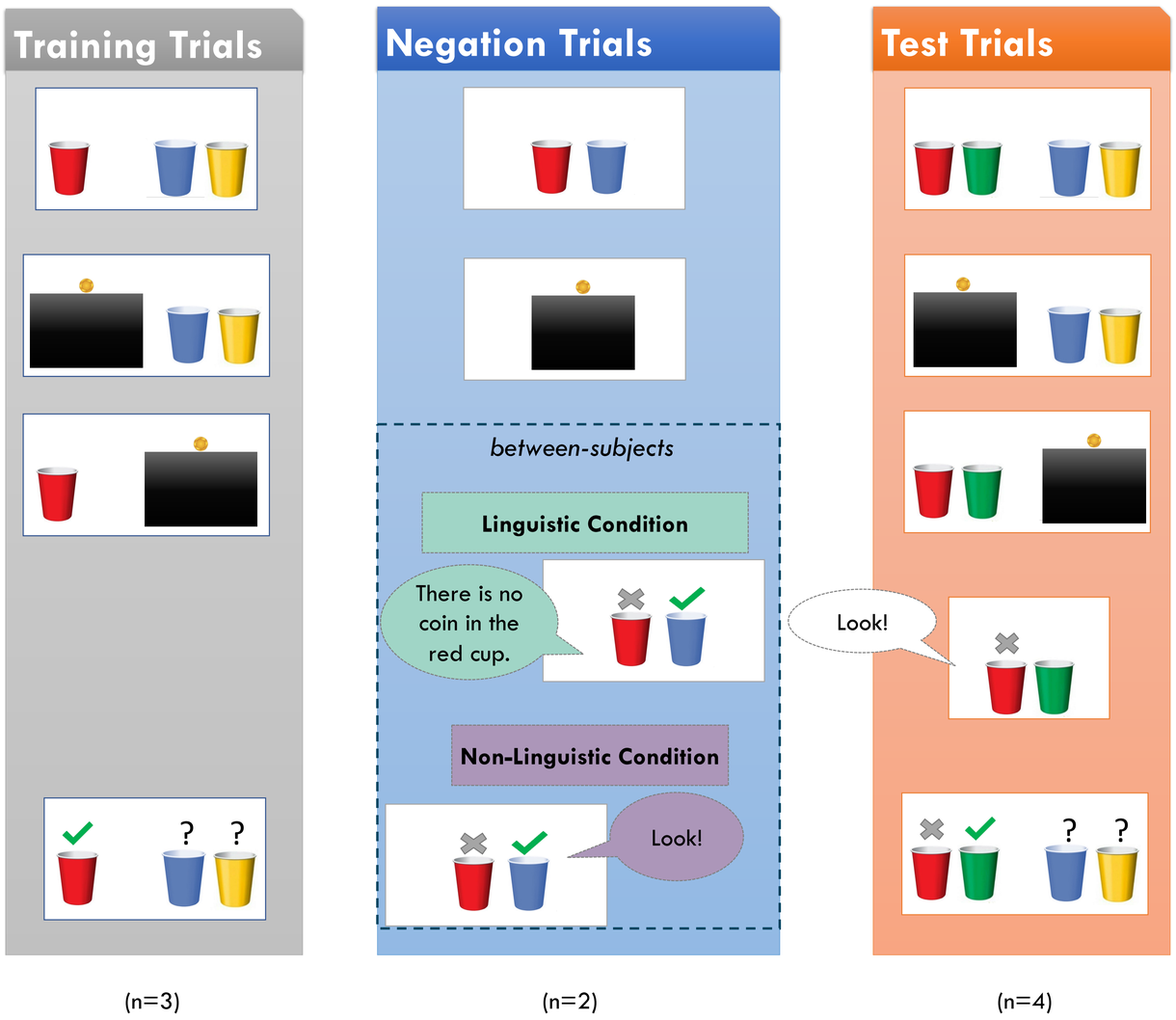
- Does the modality of cues to "emptiness" (verbal vs. visual) affects children's ability to reason with the disjunctive syllogism?
  - Systematic manipulation of the differences between the two prior studies.

Methods

Participants

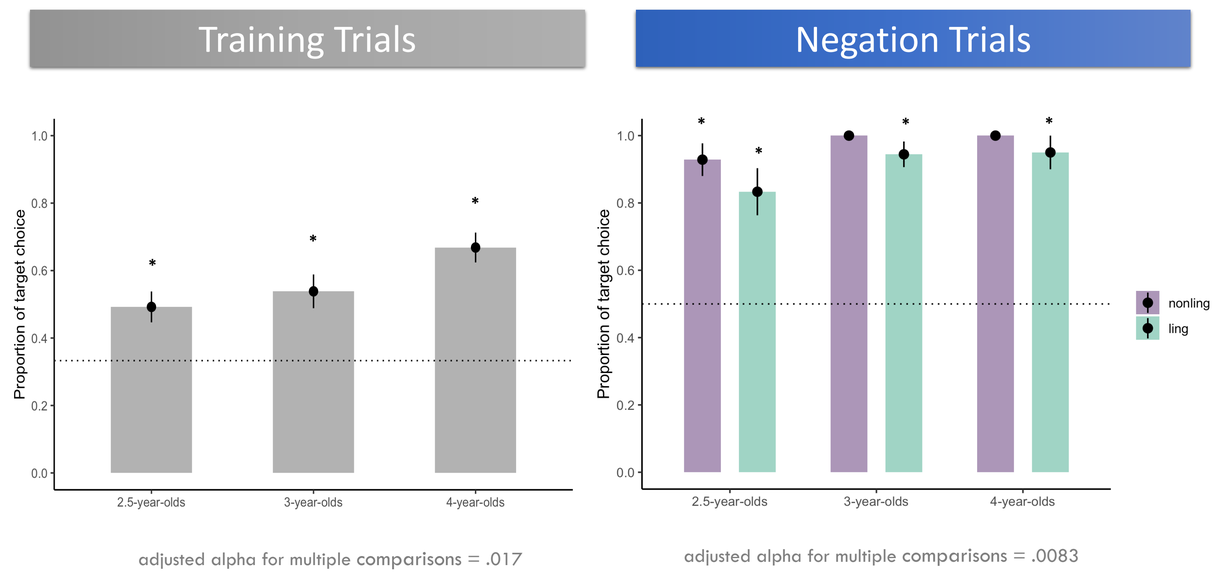
40 **2.5-year-olds** (M = 2.8 years, range = 2.4 – 3.0);
40 **3-year-olds** (M = 3.4 years, range = 3.0 – 4.0);
40 **4-year-olds** (M = 4.4 years, range = 4.0 – 4.9)

Procedure



Results

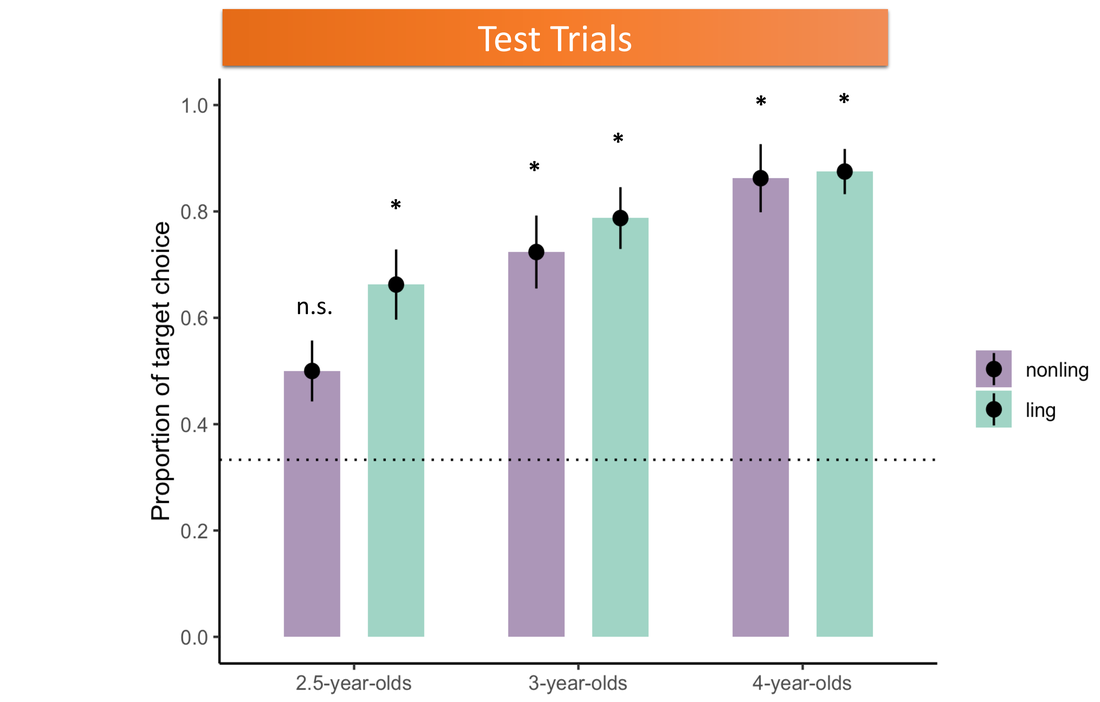
Significance levels: * $p < .001$.



adjusted alpha for multiple comparisons = .017

adjusted alpha for multiple comparisons = .0083

Age (4s vs. 2.5s & 3s): $\beta = .72$, $SE = .25$, $z = 2.92$, $p = .004$



adjusted alpha for multiple comparisons = .0083

Age (4s vs. 3s & 2.5s): $\beta = 1.44$, $SE = 0.38$, $z = 3.78$, $p < 0.001$
Age (2.5s vs. 3s): $\beta = 1.09$, $SE = 0.38$, $z = 2.87$, $p = 0.004$

Conclusion

- Children showed **successful but not perfect performance in reasoning over certainty,** with the ability developing over preschool years.
  - In training trials, 2.5-, 3- and 4-year-olds chose the target cup significantly above chance (.33).
  - 4-year-olds performed significantly better than 3- and 2.5-year-olds.

- The **modality of cues** to "emptiness" (verbal vs. visual) **affected younger (but not older) children's reasoning** with the disjunctive syllogism.
  - 2.5-year-olds chose the target cup significantly above change when presented with a linguistic cue (i.e., a negative statement), but at chance when presented with a visual cue (i.e., an empty cup).
  - Older children showed above chance performance in both conditions.

- Providing children with a negative proposition **verbally** rather than visually gave them more direct access to the relevant premise "NOT A", thus jumpstarting the syllogistic process.
  - Similarly to evidence from other domains,[8] hearing logical language (negation) may have facilitated the construction of the negative logical premise, through the activation of the relevant semantic structure.

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