Parsing for Principle C at 30 months

MEGAN SUTTON
MICHAEL FETTERS
JEFFREY LIDZ
Questions

- Behavior = underlying knowledge \textit{and} deployment
- Principle C: test to separate knowledge vs. deployment
- Principle C: a pronoun cannot c-command a name to which it refers
- Anna\textsubscript{i} and Katie\textsubscript{j} are friends
  1. She\textsubscript{i/j} likes candy
  2. She\textsubscript{i/*j} likes Katie\textsubscript{j}
Principle C

- Principle C in acquisition research
  - Stable cross-linguistically
  - Robust knowledge in older children

Baker (1991); Crain & McKee (1985)
Principle C

- Principle C in acquisition research
  - Stable cross-linguistically
  - Robust knowledge in older children
- Principle C in young children
  - Variability at 30 months
  - Vocabulary size predicts adult-like behavior

Baker (1991); Crain & McKee (1985); Lukyanenko, Conroy & Lidz (in review)
Principle C

- **Principle C in acquisition research**
  - Stable cross-linguistically
  - Robust knowledge in older children

- **Principle C in young children**
  - Variability at 30 months
  - Vocabulary size predicts adult-like behavior

- **Question: Is vocabulary effect indicative of:**
  - Having vs. lacking knowledge?
    - (No, all children show adult-like behavior)
  - Grammatical development or deployment processes?
    - (Grammatical development)

Baker (1991); Crain & McKee (1985); Lukyanenko, Conroy & Lidz (in review)
Questions

Do children at 30 months have adult-like *knowledge* of Principle C?

<table>
<thead>
<tr>
<th></th>
<th><strong>Adult-like grammar</strong></th>
<th><strong>Non-adult-like grammar</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deployment of knowledge</td>
<td>Dependent on structure-building</td>
<td>Independent of structure-building</td>
</tr>
<tr>
<td>Observed behavior</td>
<td>Variability predicted by dependent on speed of structure-building</td>
<td>Variability predicted by independent of speed of structure-building</td>
</tr>
</tbody>
</table>
Questions

- Do children at 30 months have adult-like knowledge of Principle C?

<table>
<thead>
<tr>
<th></th>
<th>Adult-like grammar</th>
<th>Non-adult-like grammar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deployment of knowledge</td>
<td>Dependent on structure-building</td>
<td>Independent of structure-building</td>
</tr>
<tr>
<td>Observed behavior</td>
<td>Variability predicted by dependent on speed of structure-building</td>
<td>Variability predicted by independent of speed of structure-building</td>
</tr>
</tbody>
</table>

- Efficiency of syntactic processing $\rightarrow$ efficiency of parsing sentences in Principle C contexts
Outline

- Background
- Previous Research
- Experimental design/ method
- Results and Conclusions
Previous Research

How early do children show knowledge of Principle C?

She’s patting Katie!

Lukyanenko, Conroy & Lidz (in review)
Previous Research

- Children begin to show adult-like behavior in Principle C contexts by at 28-32 months
- Vocabulary size predicts adult-like behavior

Lukyanenko, Conroy & Lidz (in review)
Behavior ≠ Knowledge

- Data reflects behavior, not knowledge
- Indicates *preferred* interpretation
- Alternative hypotheses yielding identical results:
  - Linear order
  - Transitivity bias
  - Clause-mate condition
  - Pragmatic effect of possibility of reflexive
- Question nature of children’s knowledge by exploring vocabulary effect
The Vocabulary Effect

- No explanatory link to knowledge of Principle C
- Vocabulary size as an index of:
  - Syntactic development
  - Processing efficiency
The Vocabulary Effect

- No explanatory link to knowledge of Principle C
- Vocabulary size as an index of:
  - Syntactic development
    - Vocabulary size correlates with measures of syntactic complexity:
      - MLU
      - Proportion function words in vocabulary
  - Processing efficiency

Devescovi et al. (2005)
The Vocabulary Effect

- No explanatory link to knowledge of Principle C
- Vocabulary size as an index of:
  - Syntactic development
    Vocabulary size correlates with measures of syntactic complexity:
    - MLU
    - Proportion function words in vocabulary
  - Processing efficiency
    - Vocabulary size and processing speed correlated at 25 months
    - Processing speed at 25 months predicts vocabulary growth by 36 months

Devescovi et al. (2005); Fernald et al. (2006)
Vocabulary Size Indexing Lexical Access Speed?

- Processing efficiency as previously measured = lexical access speed
  - no correlation with vocabulary size
  - not predictive of success on Principle C task
- Question: could vocabulary size index processing at the syntactic level?

Sutton, Lukyanenko & Lidz (2011)
Outline

• Background
• Previous Research

• Experimental design/ method
  • Experiment 1: Lexical Access task
  • Experiment 2: Phrase Structure Integration task
  • Experiment 3: Principle C task

• Results and Conclusions
Participants

- 32 children
  - 28;3 – 31;25 (mean 30;8, median 30;7)
  - CDI Vocabulary: 99-689 (mean 515, median 570)
- Experiment 1: Lexical Access Task
- Experiment 2: Phrase Structure Integration Task
- Experiment 3: Principle C task
Experiment 1: Lexical Access Task

- Goal: obtain measure of lexical access speed
- Word-object mapping task (8 trials)
- Where’s the train?

- Lexical Access Speed (LAS): mean time to re-orient to target on distractor-initial trials

Swingley & Fernald (2002)
Experiment 2: Phrase Structure Integration task

- Goal: create a measure of processing speed more closely related to processing at the syntactic level
- Three-way preferential looking task (24 trials)

Phrase Structure Integration speed: mean time to re-orient to target on distractor-initial trials
Experiment 2: Phrase Structure Integration task

- Superlative condition (12 trials): *Where’s the biggest train?*
- Superlative + adjective condition (12 trials): *Where’s the biggest red train?*
# Measures of Processing Speed

<table>
<thead>
<tr>
<th>Find the...</th>
<th>...train</th>
<th>...biggest train</th>
<th>...biggest red train</th>
</tr>
</thead>
<tbody>
<tr>
<td>lexical access</td>
<td>lexical access (x2)</td>
<td>lexical access (x3)</td>
<td></td>
</tr>
<tr>
<td>structure building</td>
<td>structure building (1 node)</td>
<td>structure building (2 nodes)</td>
<td></td>
</tr>
<tr>
<td>interpret</td>
<td>interpret (no revision)</td>
<td>interpret (revision required)</td>
<td></td>
</tr>
<tr>
<td>map to world</td>
<td>map to world</td>
<td>map to world</td>
<td></td>
</tr>
</tbody>
</table>
[Find the] *train*

- Lexical Access: *train*
- Interpret: x is a train
- Map to world:
[Find the] biggest...

- Lexical Access: 
  *biggest*
- Build structure:
- Interpret: 
  x is biggest
- Map to world:
[Find the] *biggest train*

- **Lexical Access:**
  - *biggest train*
- **Build structure:**
- **Interpret:**
  - \( x \) is biggest such that \( x \) is a train
- **Map to world:**
[Find the] *biggest*...

- Lexical Access: *biggest*
- Build structure:
- Interpret:  
x is biggest
- Map to world:
[Find the] *biggest red*...

- **Lexical Access:**
  
  *biggest*

  *red*

- **Build structure:**

- **Interpret:**
  
  x is biggest such that x is red

- **Map to world:**

  ![Diagram of a train and a steam locomotive with the red one circled and the yellow one crossed out.](image)
[Find the] *biggest red train*

- **Lexical Access:**
  - *biggest*
  - *red*
  - *train*

- **Build structure:**

- **Interpret:**
  - $x$ is biggest such that $x$ is red & $x$ is a train

- **Map to world:**
[Find the] *biggest red train*

- **Lexical Access:**
  
  *biggest*
  
  *red*
  
  *train*

- **Build structure:**

- **Interpret:**
  
  $x$ is biggest such that $x$ is red
  
  & $x$ is a train

- **Map to world:**
# Measures of Processing Speed

<table>
<thead>
<tr>
<th>Find the...</th>
<th>...train</th>
<th>...biggest train</th>
<th>...biggest red train</th>
</tr>
</thead>
<tbody>
<tr>
<td>lexical access</td>
<td>lexical access (x2)</td>
<td>lexical access (x3)</td>
<td></td>
</tr>
<tr>
<td>structure building (1 node)</td>
<td>structure building (2 nodes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>interpret (no revision)</td>
<td>interpret (revision required)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>map to world</td>
<td>map to world</td>
<td>map to world</td>
<td></td>
</tr>
</tbody>
</table>
Vocabulary size not an index of LAS

PSIS measuring syntactic processing speed, *not* compounded lexical access

PSIS (sup) measures speed of syntactic processing

PSIS (sup+adj) measures speed of syntactic processing + speed of revising interpretation

Vocabulary size not an index of syntactic processing speed
Experiment 3: Principle C task

She’s patting Katie!
Effect of Vocabulary Size on Principle C task

- Proportion looking to non-reflexive
- Time (sec)

Graph showing the effect of vocabulary size on the proportion looking to non-reflexive responses over time. The graph compares different vocabulary sizes (high, low) and includes a horizontal line representing chance level.

- 668ms
Effect of Lexical Access Speed on Principle C task
Effect of PSIS-sup (where’s the biggest train) on Principle C task
Effect of PSIS- sup+adj (where’s the biggest red train) on Principle C task

67ms
Results

- All children at 30 months succeed at Principle C task

<table>
<thead>
<tr>
<th>Covariate measure</th>
<th>Vocab size</th>
<th>LAS</th>
<th>PSIS (sup trials)</th>
<th>PSIS (sup+adj trials)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in speed on Principle C task?</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

- Efficiency of syntactic processing $\rightarrow$ response latency on a Principle C task
- Vocabulary size could be a (rough) index of this syntactic knowledge
Conclusions

- **Children** have adult-like knowledge of Principle C by 30 months
- **Differences in deployment**
  - dependent on efficiency of structure-building
  - not predicted by non-adultlike heuristics

<table>
<thead>
<tr>
<th></th>
<th>Adult-like grammar</th>
<th>Non-adult-like grammar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deployment of knowledge</td>
<td>Dependent on structure-building</td>
<td>Independent of structure-building</td>
</tr>
<tr>
<td>Observed behavior</td>
<td>Variability predicted by dependent on speed of structure-building</td>
<td>Variability predicted by independent of speed of structure-building</td>
</tr>
</tbody>
</table>
Conclusions

- Knowledge $\neq$ performance
- But, performance *indicative of* knowledge
Thank You

University of Maryland Project on Children’s Language Learning
Lab workers, parents, & participants

Annie Gagliardi, Tara Mease, Emma Nguyen

This work was supported in part by the University of Maryland’s NSF-IGERT training program in language (DGE-0801465, “Biological and Computational Foundations of Language Diversity”)