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Competition, Variation, and Language Learning

Elizabeth Bates
University of California, San Diego

Brian MacWhinney
Carnegie-Mellon University
The child language data exchange system*

BRIAN MacWHINNEY
Carnegie-Mellon University

AND CATHERINE SNOW
Harvard University

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Outline

• The Now-or-Never bottleneck
• Chunk-Based Learner
The Now-or-Never bottleneck
The Challenge from Linguistic Input

- Linguistic input is highly transient
  - Auditory: 50-100 ms (Elliott, 1962; Remez et al., 2010)

- Linguistic input is fast
  - 10-15 phonemes/sec (Studdert-Kennedy, 1986)
  - Auditory resolution: 10 sounds/sec (Miller & Taylor, 1948)

- Memory for sound sequences is limited
  - Less than 4 non-speech sounds (Warren et al., 1969)
  - Linguistic items: 4±1 (Cowan, 2000) 7±2 (Miller, 1956)
Immediacy of Language Processing

- **Chunk-and-Pass Processing**
  - Chunk language input and “pass” it to a higher level of linguistic representation

- **Incremental Processing**
  - Representational locality

- **Multiple Levels of Linguistic Structure**
  - Increasingly more compressed representations

- **Predictive Processing**
  - Prediction using multiple cues is key to being right first time
Processing Bottleneck

Comprehension | Production

Discourse

Words/Chunks

Phonology

Acoustics

Time

Source: Christiansen & Chater, BBS, 2016
Language Acquisition as Learning to Chunk

• Language acquisition as skill learning
  • The child must learn how to create and integrate the right chunks rapidly, before the input is gone

• Eager Learning
  • Online learning from multiple cues

• Local Learning
  • Learning is piecemeal, limited by memory

• Predictive Learning
  • Children gradually learn to apply top-down knowledge to facilitate processing via prediction
Recap:

Language Acquisition: Learning to Process

- Language acquisition involves learning to do Chunk-and-Pass processing

- Highlights multiword chunks as building blocks of language:
  - Children and adults sensitive to multi-word chunks (e.g., Arnon & Snider, 2010; Bannard & Matthews, 2008)
  - Multiword chunks facilitate learning (e.g., Arnon & Christiansen, 2017; Arnon & Clark, 2011; Tomasello, 2003)
Can we provide a computational account of acquisition as learning to process?
Chunk-Based Learner (CBL)
Key Psychological and Computational Features

- On-line processing
- Incremental learning
- Local dependencies
- Statistical learning
- Item-based
- Prediction

- Chunkatory
- Comprehension
- Production
- Naturalistic input (CHILDES)
- Cross-linguistic coverage
Learning to Comprehend

\[
BTP = \frac{\text{Freq}(\text{the cat})}{\text{Freq}(\text{cat})}
\]

<table>
<thead>
<tr>
<th>Chunkatory</th>
<th>Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>\ldots</td>
<td>\ldots</td>
</tr>
<tr>
<td>the cat</td>
<td>1</td>
</tr>
<tr>
<td>chased</td>
<td>1</td>
</tr>
<tr>
<td>the dog</td>
<td>2</td>
</tr>
<tr>
<td>\ldots</td>
<td>\ldots</td>
</tr>
</tbody>
</table>
Gold Standard

Not full trees

Shallow parsing

I think John stole the cookies
Cross-Linguistic Comprehension

Source: McCauley & Christiansen, Psych Review, 2019
Language Production

the cat chased the dog

Gold Standard: What the child actually said
Learning Lexical Frames

... *in the air* ...

<table>
<thead>
<tr>
<th>Chunkatory</th>
<th>Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td><em>in the box</em></td>
<td>32</td>
</tr>
<tr>
<td><em>in the morning</em></td>
<td>27</td>
</tr>
<tr>
<td><em>in the back</em></td>
<td>23</td>
</tr>
<tr>
<td><em>in the garden</em></td>
<td>19</td>
</tr>
<tr>
<td><em>in the air</em></td>
<td>1</td>
</tr>
<tr>
<td><em>in the ____</em></td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Examples Frames

- Top-5 frames
  - the ___ (56117)
  - a ___ (42937)
  - your ___ (8366)
  - in the ___ (7718)
  - on the ___ (6950)

- Interesting frames
  - what’s ___ (2122)
  - a big ___ (1401)
  - more ___ (837)
  - I want to ___ (427)
  - on ___ own (228)

Cross-Linguistic Production

Recap:
Language Acquisition as Learning to Chunk

- Language acquisition captured by a chunk-based model using incremental, on-line learning
- Can model data from developmental experiments (McCauley & Christiansen, *Psych Review*, 2019)
- Shows comprehension/production asymmetry (Chater, McCauley & Christiansen, *JML*, 2016)
- Captures differences in chunk use by L1 and L2 speakers (McCauley & Christiansen, *TopiCS*, 2017)
Conclusion

• Chunk-and-Pass processing is key to overcoming the Now-or-Never bottleneck.
• Multiword chunks form key building blocks of language processing and acquisition.
• No separation of grammar and lexicon.
• Language acquisition is learning to process.
Acknowledgments

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