Children’s language comprehension: incremental, interactive and abstract

Michigan State University
March 2014

Jesse Snedeker
Harvard University
How does language comprehension develop?
Adult language comprehension

1. Builds a series of linked representations
2. Interpretation is incremental
   – cascaded processing
3. Processes at each level are interactive
   – influenced by multiple other levels
   – both linguistic and nonlinguistic
Adult language comprehension

1. Builds a series of linked representations

2. Interpretation is incremental
   – cascaded processing

3. Processes at each level are interactive
   – influenced by multiple other levels
   – both linguistic and nonlinguistic
Comprehension builds series representations

- Phonology
- Lexicon
- Syntax
- Semantics
- Pragmatics
Adult language comprehension

1. Builds a series of linked representations
2. Interpretation is incremental
   – cascaded processing
3. Processes at each level are interactive
   – influenced by multiple other levels
   – both linguistic and nonlinguistic
Incremental Cascaded Processing

phonology

- lexicon

- syntax

- semantics

- pragmatics
Incremental Cascaded Processing

- Phonology
- Lexicon
- Syntax
- Semantics
- Pragmatics
Incremental Cascaded Processing

- Phonology
- Lexicon
- Syntax
- Semantics
- Pragmatics
Adult language comprehension

1. Builds a series of linked representations
2. Interpretation is incremental
   – cascaded processing
3. Processes at each level are interactive
   – influenced by multiple other levels
   – both linguistic and nonlinguistic
Interactive Processing

- pragmatics
- semantics
- syntax
- lexicon
- phonology
- acoustic
- prosody
Language interacts with other cognitive systems.
How does this system develop?
Preschooler’s online comprehension is

1. Incremental
   - Phono-semantic priming, negation
2. Interactive
   - Syntactic ambiguity resolution
3. Builds abstract representations
   - Structural Priming
1. Incremental Processing

Yi Ting Huang
University of Maryland

Miseon Lee
Hanyang University

Tracy Brookheyser
Harvard

phonology

lexicon

syntax

semantics

pragmatics
Phono-semantic priming

"Pick up the logs"

Semantic priming via phonological cohort member

Marslen-Wilson & Zwisterlood, 1989; Yee & Sedivy, 2006
Phono-semantic priming in young children

“Pick up the logs”

<table>
<thead>
<tr>
<th>Key</th>
<th>Ladybug</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pillow</td>
<td>Logs</td>
</tr>
</tbody>
</table>
Phono-semantic priming in young children

“Pick up the logs”

Phono-semantic prime

Target

Huang & Snedeker, 2011
Phono-semantic priming in young children

“Pick up the logs”

Huang & Snedeker, 2011
Phono-semantic priming in young children

“Pick up the logs”

Looks to phono-semantic prime

Huang & Snedeker, 2011
Phono-semantic priming in young children

“Pick up the logs”

Control Trial

Prime replaced with unrelated item

Huang & Snedeker, 2011
Phono-semantic priming in 5 year olds

Proportion of looks to picture

Unrelated

Prime

p < .05

Huang & Snedeker, 2011
Children make incorrect actions as well

Huang & Snedeker, 2011
Incrementality at higher level....

• Lexical storage could support stable associations
  – Facilitating incremental processing
• Are higher-level semantic representations constructed incrementally?
• Negation as test case
  – Reverses the usual pattern of association
• Adult negation processing
  – Negatives often initially treated as affirmatives in weak contexts\(^1\)
  – But not in rich discourse contexts\(^2\)

1. Kaup et al., 2007; Fischler et al., 1983; Kunios & Holcomb, 1992; Ludke et al., 2008.
Negative

Affirmative
Prediction: associative processing

Prediction: associative processing

Proportion of Looking to Affirmative Objects

Time in milliseconds relative to noun onset

-800 -700 -600 -500 -400 -300 -200 -100 0 100 200 300 400 500 600 700 800 900 1000

broke/
didn't break

one of the plates

Affirmative condition

Negative condition
Prediction: incremental semantics

Proportion of Looking to Affirmative Objects

Time in milliseconds relative to noun onset

Affirmative condition
Negative condition

one of the plates

broke/ didn't break
Adults are incremental

\[ \text{One of the plates broke/didn't break} \]
4 year olds are incremental but slower  M=4;7

broke/
didn't break

one of the plates
3 year olds are incremental but noisier

M=3;5

Affirmative condition

Negative condition

broke/
didn't break

one of the plates

*
Incrementality

• Lexical processing is cascaded in children
• By 3 children do incremental semantic interpretation
• Eye-movements reflect processing at several levels (lexical and combinatorial)
Interactive Processing

Resolution of structural ambiguity in children

John Trueswell  Sylvia Yuan  Carissa Shafto  Amanda Worek
Interactive Processing

- pragmatics
- semantics
- syntax
- lexicon
- phonology
- prosody
- acoustic

Diagram showing the relationships between these components in interactive processing.
Alice attacked the paper with the flawed data
Alice attacked the paper with the flawed data
Information for ambiguity resolution

• Adults use:
  – Lexical: verb information
  – Pragmatic: need to resolve referential ambiguity
  – Prosodic: phrase boundaries
  – Conceptual: plausibility of interpretation

• What cues do preschoolers use (4;0-6;0)?
Paradigm

“Feel the frog with the feather”
What information do children use? (Snedeker & Trueswell, 2004)

• Different verbs → different interpretations
  – Choose the pig with the fan (modifier)
  – Hit the pig with the fan (instrument)

• Referential ambiguity does not affect parsing
  – Two pigs vs. one pig
Do children use prosody in parsing?  
(Snedeker & Yuan, 2008)

- **Instrument Prosody**
  
  *You can feel the frawwg.... ....with the feather*

- **Modifier Prosody**
  
  *You can feeel.... ....the frog-with-the-feather*

- **Blocked Design**
children’s actions affected by prosody but only for the first block of trials

Snedeker & Yuan, 2008
a. Block 1 Modifier Prosody

b. Block 1 Instrument Prosody

*Snedeker & Yuan, 2008*
Conclusion: Children’s parsing is interactive

- Use verb information
- Use prosodic cues

Why do children fail to use referential ambiguity?

Perhaps they are poor at rapid use of top-down information....
Top down vs. Bottom up
Constraints

/kæt/: noun, singular, animate
/sæt/: verb, past, intransitive
/mæt/: noun, singular, inanimate

Reference

Syntax

Lexical

Acoustic

Prosodic
Plausibility, another top-down constraint

• Plausibility: how likely is a given interpretation given the affordances of the objects?

• Low instrument plausibility:
  Tickle the bear with the mirror

• High instrument plausibility:
  Tickle the bear with the paintbrush

Snedeker, Shafto & Worek, in prep
Eye movement data

In adults, plausibility effects emerge early and dominate parsing

Snedeker, Shafto & Worek, in prep
Eye movement data

In children, lexical effects emerge early and dominate parsing

Snedeker, Shafto & Worek, in prep
Early in life, bottom-up constraints prevail.
Preschooler’s online comprehension is

1. Incremental
   - Phono-semantic priming, negation
2. Interactive
   - Syntactic ambiguity resolution
3. Builds abstract representations
   - Structural Priming
What representations guide children’s comprehension?

Structural Priming

Malathi Thothathiri
George Washington University
Adults: broad, syntactic and semantic abstractions

Pass me the paper

Pass me the paper

Pass me the paper

Pass me the paper
What representations lurk behind children’s utterances?

Adult-like abstract structures?
What representations lurk behind children’s utterances?

Give (me) (a cookie)

Item-Based Frames? (Tomasello, 1992)
How do we tell the difference?

• Do children generalize knowledge to novel verbs?
  – Production: 3 yo often don’t
  – Comprehension: 2 yo clearly do

• Issues of interpretation
  – Does the child treat novel verbs as novel (vs. translation)?
  – Are these representations invoked for known verbs?
Structural Priming

• Datives: Verbs of transfer *(give, show).*

• Dative alternation
  – Double-Object Dative (DO)
    *Give the boy the truck*: **Recipient-First**
  – Prepositional Dative (PO)
    *Give the truck to the boy*: **Theme-First**
The mother is giving her son an apple.
The mother is giving an apple to her son.
The woman is giving the man a book.
The woman is giving a book to the man.
The mother is giving her son an apple.
The mother is giving an apple to her son.
The woman is giving the man a book.
The woman is giving a book to the man.
The mother is **singing** the baby a song.
The mother is **singing** a song to the baby.

The woman is **giving** the man a book.
The woman is **giving** a book to the man.

**Structural Priming**

**Across-Verb Priming**
Priming and Representation

• Item-Based Frames →
  Within-verb priming only

• Abstract Generalizations →
  Within-verb + Across-verb priming

Comparison: 4 year olds and 3 year olds
(M=4;0, M=3;1)
Design

Prime: *Pass the lion the ball* or *Pass the ball to the lion*

Target: *Pass the cow the book* or *Pass the couch to the dog*
Double Object Primes
4 year olds
Prepositional Object Primes (4 year olds)

![Graph showing proportion of looks over time from noun onset for different categories (Animal (Recipient), Object (Theme), Other Animal, Other Object). The analysis window is highlighted, showing changes in proportion of looks across different time points.](image-url)
Structural priming present at 4 and 3

Thothathiri & Snedeker, 2008a
Children construct abstract representations during comprehension....

For parallel production findings: Bencini & Valian 2008; Rowland et al., 2012

But what are the primed representations?

1. Surface syntax?
2. Syntax-semantics mappings?

Adults: Bock & Loebell, 1990; Bock et al., 1992; Chang, Bock, & Goldberg, 2003; Griffin & Weinstein-Tull, 2003
Confounded in dative alternation

– different semantic mappings
  • Pass  the cup  to the lion  → theme + recipient
  • Pass  the lion  the cup  → recipient + theme

– different syntactic forms
  • Pass  the cup  to the lion  → V + NP + PP
  • Pass  the lion  the cup  → V + NP+ NP
But not in locative alternation

- different semantic mappings
  - Load the hay onto the truck → theme + location
  - Load the truck with the hay → location + theme

- single syntactic form
  - Load the hay onto the truck → V + NP + PP
  - Load the truck with the hay → V + NP + PP
Locative-to-Dative Predictions

If surface syntax is primed

- Both locatives should prime PO datives (both have NP+PP structure)

If semantic mappings are primed

- Theme-first locative will prime PO dative (theme first)
- Location-first locative will prime DO dative (recipients and locations are both goals)
Dative priming in 4 yr olds
Comprehension priming depends on thematic mappings
Young children have abstract structural representations

Paradigm primes syntax-semantics mappings

Give me a break!

Priming persists across different tasks
The critical features of adult language processing are in place by 3 years of age

1. Incremental
   - Phono-semantic priming, negation

2. Interactive
   - Syntactic ambiguity resolution

3. Builds abstract representations
   - Structural Priming
But young children differ from adults...

• Poor use of top-down cues
  – Referential context, plausibility
  – Due to slower processing speed? (ala Dell, 1986)
  – Less predictive and more reactive processing?

• Failure to override incorrect analyses
  – Phonosemantic errors, perseveration prosody
  – Immature executive functions? (Novick, Kan, Trueswell, Thompson-Schill, 2009; January et al., 2009; Mazuka, et al., 2009)
  – Limited experience?
New Questions

• Using the tools to study disorders
  – Prosody in autism
  – Top-down cues schizophrenia

• Different languages, different cues
  – Comprehension of case marking in Turkish
How do children with autism interpret prosodic accents?

Tracy Brookhyser

Eun Kyung Lee

Becky Nappa
Communicative deficits in autism

- Pragmatics Impaired
- Syntax Impaired
- Vocabulary Impaired
Autism with, and without, language impairment

Kjelgaard & Tager-Flusberg (2001)
Communicative deficits in autism

- Vocabulary Impaired
- Syntax Impaired
- Pragmatics Impaired
What does prosody do?

- **Semantics**
  - $\exists x [\text{cat}(x) \land \text{on mat}(x)]$
  - $\land \forall y [\text{cat}(y) \land \text{on mat}(y)] \land x = y$

- **Lexicon**
  - /sæt/: noun, singular, animate
  - /sæt/: verb, past, intransitive
  - /mæt/: noun, singular, inanimate

- **Phonology**
  - әкәтсәтмәт

- **Prosody**
  - $\exists x [\text{cat}(x) \land \text{on mat}(x)]$
  - $\land \forall y [\text{cat}(y) \land \text{on mat}(y)] \land x = y$

- **Syntax**
  - $S \rightarrow \text{Det the N sat on P the N mat}$

- **Acoustic Processing**
  - Waveform

- **Pragmatic Interpretation**
semantics

\[ \exists x \left[ \text{cat} (x) \land \text{on mat} (x) \right] \land \forall y \left[ \text{cat} (y) \land \text{on mat} (y) \right] \ x = y \]

lexicon

/kæt/: noun, singular, animate
/sæt/: verb, past, intransitive
/mæt/: noun, singular, inanimate

phonology

 prókætsætmæt

acoustic processing

pragmatic interpretation

syntax
Joshua Diehl
Notre Dame

Diehl, Friedberg, Paul & Snedeker
(under review)
Typically-developing children do not perseverate but children with ASD do (until 13)

Typically-developing Children

8-17 years (block 2)

Proportion of Instrument Actions

Typically Developing

Children with Autism

8-17 years (block 2)

Proportion of Instrument Actions

Children

Adolescents
semantics

\[ \exists x \left[ \text{cat}(x) \land \text{on mat}(x) \right] \land \forall y \left[ \text{cat}(y) \land \text{on mat}(y) \right] x = y \]

lexicon

/\text{kæt}/: noun, singular, animate
/\text{sæt}/: verb, past, intransitive
/\text{mæt}/: noun, singular, inanimate

phonology

\text{ðkætsætmæt}

acoustic processing

\text{pragmatic interpretation}

syntax

\[ \exists x \left[ \text{cat}(x) \land \text{on mat}(x) \right] \land \forall y \left[ \text{cat}(y) \land \text{on mat}(y) \right] x = y \]
A: How was your parents’ visit?

B: OK.

My dad bought a BB gun for Oscar.

What should A say next?
A: How was your parents’ visit?
B: OK.
   My dad bought a BB gun for *Oscar*.
   But he’s only six!
   Was his brother jealous?
A: How was your parents’ visit?
B: OK.

    My dad bought a *BB gun* for Oscar.

Why did he buy that?
What are you going to do with it?
A: How was your parents’ visit?
B: OK.

My *dad* bought a BB gun for Oscar.

How is he doing?
What did your mom say?
• Hypothesis 1: accent signal new referent
  – Explains some cases
    “Put the candle on the square. Put the CANDY/candle....”
  – But not others
    “Click on the orange house. Now click on the RED house”

• Hypothesis 2: accent invokes a contrast set (Rooth, 1992)
  – Accent marks a variable
  – Replace variable with alternate values
  – To get set of alternatives under consideration
“Put the candle on the square. Now...”
Typical kids use accent as cue to novelty

Nappa & Snedeker (in prep); see also Arnold (2008)
Kids with ASD do too

accent hinders same referent

accent helps novel referent

Nappa & Snedeker (in prep)
“Click on the yellow house. Now...”
Typical kids use accent to identify contrast

Nappa & Snedeker (in prep); see also Ito et al. (2011)
Kids with ASD have the opposite response!

Nappa & Snedeker (in prep)
• Hypothesis 1: accent signal new referent
  – Put the candle on the square. Put the CANDY/candle....
  – **Click on the orange house. Now click on the RED ___

• Hypothesis 2: accent invokes contrast set (Rooth, 1992)
  – Accent marks a variable
  – Replace variable with alternate values
  – To get set of alternatives under consideration
Thank you!

- National Science Foundation (0623945 & 0921012), Simons Foundation SFARI, Ellison Foundation
- Marvelous Lab Techs: Sylvia Yuan, Carissa Shafto, Amanda Worek, Beth Casserly, Carlyn Friedberg, Kate McCurdy, Noemi Hahn & Tracy Brookhyser