Children’s comprehension of negation: When can you say “no” to a toddler?

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Negation

• Abstract
  – Picks out the complement set
• A conceptual and linguistic universal
• Challenging to process
• Strange pattern of acquisition
Developmental mystery

• Production
  – 1-year-olds produce negation, but in limited ways (Bloom, 1970; Pea, 1980; McNeill & McNeill, 1968; Drozd, 1995)

• Online Comprehension
  – 2- to 4-year-olds have surprising difficulty understanding negative utterances
  – Nordmeyer & Frank, 2014
“See these boys?”

Look at the boy who has apples.
Look at the boy who has no apples.
Children’s online comprehension

Nordmeyer & Frank (2014) 4 year olds

Proportion Affirmative Looks

Time (ms)

has (no) apples.
Children’s online comprehension

Nordmeyer & Frank (2014) 2 year olds (24-35m)

Proportion Affirmative Looks

\[ \text{has (no) apples.} \]

Time (ms)
Hypotheses

Children’s poor comprehension could be due to:

• **H1: Inhibitory demands**
  – Construct negative via affirmative, then inhibit
  => processing of negation necessarily difficult

• **H2: Inability to fill in weak pragmatic contexts**
  – Negation implies consideration of polar question
  – If QUD is clearly established then rapid processing of negation
Evidence for inhibitory account: negation involves construction of affirmative

• Simplest interpretation of Nordmeyer & Frank (2014)
• Adults slower to interpret negated utterances (Clark & Carpenter, 1974)
• Adults seem to initially construct affirmative counterpart of negated utterance
  (Kaup, Yaxley, Madden, Zwaan & Ludtke, 2007; Ludtke, Friedrich, De Filippis & Kaup, 2008; Fischler et al., 1983; Kunios & Holcomb, 1992; Staab, 2007)
Evidence for inhibitory account

Fig. 1. Sample materials.

Early (750 ms)

Reaction Time

Affirmatives

Negatives

Consistent

Inconsistent

Late (1500 ms)

Reaction Time

Affirmatives

Negatives

Consistent

Inconsistent
Evidence for pragmatic hypothesis

Tian, Breheny & Ferguson (2010)

Non cleft
Jane didn’t cook the spaghetti

QUD:
Did (or didn’t) she cook it?

Cleft
It was Jane who didn’t cook the spaghetti

QUD:
Who didn’t cook the spaghetti?

<table>
<thead>
<tr>
<th>Match</th>
<th>Mismatch</th>
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Tian, Breheny & Ferguson (2010)

![Bar graph showing reaction times for different conditions](image-url)
Goals of Study 1

• Use a method with finer temporal resolution
  – Picture response data ambiguous

• Provide supportive discourse context look at processing pattern in
  – Adults
  – 4 & 5 year olds
  – 3 year olds
Incremental prediction

Subject Verb Pre-noun Noun Post

Prop of Looking to Affirmative Items

Affirmative

Negative

D.W. didn't break/broke one of the plates
Inhibitory prediction

D.W. didn't break/broke one of the plates
Results

Adults (n = 16) vs. Affirmative vs. Negative
Results

- **Adults (n = 16)**
- **4- and 5-year-olds (n = 40)**

Affirmative vs. Negative

Proportion Affirmative Looks

-100 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500
Results

- **Adults (n = 16)**
- **4- and 5-year-olds (n = 40)**
- **3-year-olds (n = 40)**

Proportion Affirmative Looks vs. Negative

- Affirmative vs. Negative
OK. How about two year olds?

Need to simplify task...
Study 2

3-year-olds
• 36-48 mos (n = 16)
  $M = 42$ mos

• PPVT (vocabulary)
  $M = 113$, $SD = 12.6$

2-year-olds
• 28-33 mos (n = 28)
  $M = 31$ mos

• PPVT (vocabulary)
  $M = 101$, $SD = 22.6$
Study 2

DW likes to eat fruits and vegetables.
Study 2

Look! She ate the little apple.
Study 2

She was going to eat the other apple too, but she had a banana instead.
Study 2

• Oh, I know what happened!
• *DW ate/didn’t eat one of the apples.*
• Which one was it? Can you show me?
Study 2

3-year-olds

• 36-48 mos (n = 16)
  \( M = 42 \text{ mos} \)

• PPVT (vocabulary)
  \( M = 113, SD = 12.6 \)

2-year-olds

• 28-33 mos (n = 28)
  \( M = 31 \text{ mos} \)

• PPVT (vocabulary)
  \( M = 101, SD = 22.6 \)
Study 2: 3-year-olds

Proportion Affirmative Looks

ate/didn’t eat

one of the apples.

Which one was it?

Polarity

n.s.

Polarity

* p < .05

Time (ms) from VP onset (0)

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400

Proportion Affirmative Looks

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Study 2

2-year-olds, high vocabulary

Proportion Affirmative Looks

ate/didn’t eat  
one of the apples.  
Which one was it?

Time (ms) from VP onset (0)

Affirmative  Negative
Study 2
2-year-olds, low vocabulary

ate/didn’t eat  one of the apples.  Which one was it?

Proportion Affirmative Looks

Time (ms) from VP onset (0)

Affirmative  Negative

n.s.  n.s.  n.s.

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400
Study 3 - Design Modifications

Poor understanding of task?
More practice trials

Interference from similar referents?
apple vs. apple -> apple vs. banana

Explicit question hard to understand?

DW ate one of the apples. Which one was it?
-> Show me the one DW ate.

Difficulty switching from affirmative to negative?
Randomized → Blocked

## Study 3 - Participants

### 3-year-olds
- 36-48 mos
  - $n = 16$
  - $M = 42$ mos
- PPVT
  - $M = 123$, $SD = 14.6$

### 2-year-olds
- 28-33 mos
  - $n = 28$
  - $M = 31$ mos
- PPVT
  - $M = 112$, $SD = 12$
Blocked Design Predictions

**Perseveration Effect**
- Affirmative first => incorrect response for negative
- Negative first => incorrect response for affirmative

**Scaffold Effect**
- Affirmative first => correct response for negative
- Negative first poor but no effect on affirmative (?)
Study 3
3-year-olds

...ate/didn’t eat.  [silence until response]

**Proportion Affirmative Looks**

- **Affirmative**
- **Negative**

*\(p < .05\)*

**Time (ms) from VP onset (0)**

0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500

**Proportion Affirmative Looks**

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

*\(p < .05\)*
Study 3
2-year-olds, affirmative first

...ate/didn’t eat. [silence until response]

Proportion Affirmative Looks

Time (ms) from VP onset (0)

0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500

Affirmative  Negative

n.s. *p < .05 *p < .05
Study 3
2-year-olds, negative first

...ate/didn’t eat. [silence until response]

Proportion Affirmative Looks

Time (ms) from VP onset (0)

Affirmative  Negative
Study 3 - Picture Selection Accuracy

% Correct Responses

3-year-olds

2-year-olds, Block 1
Affirmative

2-year-olds, Block 1
Negative

Affirmative  Negative  StoryPractice  TouchPractice

* n.s. *
Conclusions

Children’s difficulties not (solely) due to failure to inhibit affirmative interpretation.

Children no worse on negatives than affirmatives.

Children don’t perseverate on the affirmative form in a blocked design (Study 3).
Conclusions

Children’s difficulties not (solely) due to insufficient pragmatic support.

We tested both age groups within the same discourse contexts.

3 year olds showed incremental symmetric interpretation

But many 2.5 year olds were unable to interpret both forms in a randomized design (Study 2)
Conclusions

At 2.5 children may have difficulty accurately building this semantic structure.

Building the affirmative representation scaffolds the negative (Study 3).

Failure to interpret negatives interferes with interpreting affirmatives (Study 2 & Study 3).
Why are they failing at affirmatives after negatives?

• Not due to inattention
• Not due to perseveration
• Children work harder on aff trials after hearing neg (greater pupil dilation)

• Does affirmation get actively represented in this context (as an operator)
• Are these representations intrinsically difficult to construct?
So when (and how) do children acquire negation?
• Does logical negation precede verbal negation?
  – Does the word label a pre-existing concept?
• Or does language build the logical operator?
  – How could word learning help fix the concept?
Do kids understand verbal negation fully when they first learn the word?

OR

Is there a gap?
Early Production of Negation

• 1-year-olds produce negation (Pea, 1980)
• Early uses more restricted (Bloom, 1970; McNeill & McNeill, 1968)
  – Rejection
    “No pajamas!” = I don’t want to put on pajamas!
  – Nonexistence
    “No apples!” = There are no more apples!
  – Denial emerges later
    “No funny!” = That’s not funny!
• Perhaps full meaning of negation emerges gradually?
Study 4

- Maximally supportive discourse
  - affirmative alternative has been introduced
- No real story to follow or question to answer
- Minimally distracting display
  - Remove affirmative action during test
“Look! They’re dancing!”
“Now it’s different! John is dancing!”

Affirmative Trial
“Now it’s different! John is not dancing!”

Negative Trial
“Where’s John? Look at John!”
“What’s John going to do next? He’s going to jump! Look at John, he’s going to jump!”
Methods

• 3 negative trials & 3 affirmative trials
  – Alternating

• Older 2 year olds (most produce “not”)
  – 30-35 months (N=27)

• Younger 2 year olds (few produce “not”)
  – 24-28 months
Older 2’s succeed

“Now it’s different! John is (not) dancing!”

“Not Dancing”
“Dancing”
Younger 2’s fail on both

“Now it’s different! John is (not) dancing!”

“Not Dancing”
“Dancing”
Maybe it’s interference?

- Switch to a blocked design
- Study 5: 24-28 m.o. (N=32)
Young 2’s

“Now it’s different! John is (not) dancing!”

“Not Dancing”
“Dancing”

Success limited to affirmatives!
So far....

- Older two’s (30-35)
  - correctly interpret negatives and affirmatives
- Younger two’s (24-28)
  - limited success with affirmatives
  - fail to incrementally interpret negation

- Why?
  - Because they can’t?
  - Because they’re not motivated by passive viewing task?
Feiman & Carey

• Use an offline measure with:
  – Strong pragmatic support
  – Clear motivation to interpret utterance
  – Finer-grained age groups
  – Test for success in identifying the referent
“It’s (not) in the truck. Can you find it?”
Methods

- 4 Negative trials
- 4 Affirmative trials
- 4 age groups
  - 20 m.o. (N=24)
  - 24 m.o. (N=24)
  - 27 m.o. (N=24)
  - 29+ (N=11)
20 month-olds | 24 month-olds | 27 month-olds | Over 28 Months
---|---|---|---
Negative | Affirmative

% Correct Choices

† * * *

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The diagram shows the percentage of correct choices for different age groups (20 month-olds, 24 month-olds, 27 month-olds, and Over 28 Months) for both negative and affirmative responses. The error bars indicate the variability in the data. Significant differences are indicated by asterisks, with † representing a trend towards significance.
Is “Not” harder than “No”? 

The graph shows the percentage of kids saying “No” and “Not” over time. The percentage of kids saying “No” remains relatively stable, while the percentage of kids saying “Not” increases over time.
Parent: (to Experimenter) “Is it in the truck?”
Experimenter “No, it’s not!/Yes, it is!”
Parent: (to Child) “Can you find the ball?”
Methods

- 4 Negative trials
- 4 Affirmative trials
- 24-26 m.o. (N=24)
- 26-28 m.o. (N=14)
No 24 month-olds

No 27 month-olds
“Look at the bucket!”
“Look at the bucket!”
Methods

- 4 Negative trials & 4 Affirmative trials
- 19-21 m.o. (N=24)
- Counterbalanced side, target container, block order
Bucket Task

• Failures on verbal negation tasks before 27 months (see also Austin et al.)
• Both with “no” and “not”
• Not due to deficits in inhibitory control
  – Success with non-verbal buckets at 17 months
• Perhaps the early meaning of “no” is rejection (not truth-functional negation)?
Acquiring Negation

• If logical negation is present before 27 months, then why is understanding of verbal negation so delayed?

• If success on the non-verbal tasks does not rely on logical negation, perhaps the logical operator only emerges around 27 months.
Developing a concept of negation

• Induced from evidence?
  – Learned through its conceptual role?
  – What hypothesis wouldn’t presuppose negation?
• Abstraction over module-internal representations?
• Innate?
  – Why so late?
Tentative evidence for developmental change

• If full negation awaits on late maturing representations or cognitive development

• Then older language learners should show precocious use of denial (truth functional negation)

• Internationally adopted children
  – 2;6-5;0 when acquire English
  – Show most of the same patterns in acquisition
  – Corpus analysis (ala Bloom)
Preliminary Findings

- Both groups more denials as MLU increases
  - Language learning
- But adoptees use denial more at earliest MLU
  - Conceptual change?
Thanks!