Resolving Quantificational Ambiguities

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The target sentences from Brasoveanu & Dotlačil

A caregiver comforted a child every night.

Subject and Verb
The {caregivers, caregiver} wanted

Object
the {child, children} to get

Spillover
Wrap-up
some rest.
Brasoveanu & Dotlačil

Target sentences

Context:

A caregiver comforted a child every night.

a. The caregivers[pl] wanted the children[pl] to get some rest.
   (subject: NS, object: NS)

b. The caregivers[pl] wanted the child[sg] to get some rest.
   (subject: NS, object: AMB)

c. The caregiver[sg] wanted the children[pl] to get some rest.
   (subject: AMB, object: NS)

d. The caregiver[sg] wanted the child[sg] to get some rest.
   (subject: AMB, object: AMB)
Figure 1: Acceptability task: Means & SEs
Brasoveanu & Dotlačil

- AMB
- NS
Brasoveanu & Dotlačil

Wrap-up, probability of re-reading

Probability of re-reading

Wrap-up Prob. of regression

Probability of regression

Object scope
AMB
NS
Scope of subject
AMB
NS
Target sentences: early- and late-disambiguation

Early scope disambiguation towards narrow scope caused by different led to faster RT

**Late:**

a. **Subject:**SG, **Object:**PL:

A caregiver comforted a child every night.

The caregiver wanted the **children** **to get** some rest.

**Early:**

b. **Object:**different:

A caregiver comforted a **different** child every night.

The caregiver wanted the **children** **to get** some rest.
Brasoveanu & Dotlačil

Key findings:

The plural subject facilitates the processing of the plural object when plural arguments are used to disambiguate scope.

The inverse-scope interpretation of the subject creates the inverse-scope interpretation of the object as a by-product.
Is the observed effect due to quantifier scope?

It looks like it, but we need probably need more controls, other than ‘different’ (which has its own issues).
Evidence for scope

- If we want to determine whether wide scope of the ‘every’ in adjunct position leads to narrow scope of both subject and object (plurals), look at frozen scope:

- **Double object construction**

- **A judge awarded an athlete every medal.**

  *every>*α

  **The judges hoped the athletes were proud.**

Bruening 2001; Larson 1990
Evidence for scope

- If we want to determine whether wide scope of the ‘every’ in adjunct position leads to narrow scope of both subject and object (plurals), look at frozen scope:

  - **Spray-load construction**

  - A worker loaded a truck with every box.

    *every>a

    The workers hoped the trucks were not too heavy.

  

Bruening 2001
Evidence for scope

- If we want to determine whether wide scope of the ‘every’ in adjunct position leads to narrow scope of both subject and object (plurals), look at frozen scope:

- **Antecedent-contained deletion**

- A teacher gave a student [everything Bill did].

- *every>a

- Because ‘a student’ and ‘everything...’ both move, and the second ‘tucks in’ beneath the first. Moreover, QR in ACD is said to target a position below the subject.

Bruening 2001; Fox, 2002
How does this research relate to other experimental work on the resolution of quantificational ambiguities?

Their findings are consistent with:
- Case 1: Online processing of quantifiers
- Case 2: Offline preferences for surface scope/specific interpretation
- Case 3: Specific indefinites – wide scope
Case no. 1

Plural continuation increases processing load
Kurtzman & MacDonald (1993):

a/b. A kid climbed every tree.  c/d. Every kid climbed a tree.

a. The kid was full of energy.  c. The tree was full of apples.

b. The kids were full of energy.  d. The trees were full of apples.
Online Processing

Tunstall (1998):

Kelly showed a photo to every critic last month.

a. The photo was of a run-down building.  
   forward scope: a > every

b. The photos were of a run-down building.  
   inverse scope: every > a

Kelly showed every photo to a critic last month.

c. The critic was from a major gallery.  
   inverse scope: a > every

d. The critics were from a major gallery.  
   forward scope: every > a
Online Processing

Tunstall (1998):
Tunstall (1998):

**Principle of Scope Interpretation (PSI)**

The default relative scoping in a multiply quantified sentence is computed from the required LF-structure of that sentence, where the required LF is determined by required grammatical operations acting on the S-structure. The default scoping is the preferred scoping unless there is evidence to go beyond it.
Anderson (2004):

**Surface-scope context, singular disambiguating sentence**

With the increased popularity of adventure sports, the cliffs outside Campbellton were becoming a popular destination.

One weekend, the climbing equipment shop sponsored a show to demonstrate the sport.

While an announcer described the techniques, an experienced climber scaled every cliff.

The climber was very skilled.

The shop's sales increased substantially the next weekend.

**Surface-scope context, plural disambiguating sentence**

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Online Processing

Anderson (2004):

*Inverse-scope context, singular disambiguating sentence*
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The shop's sales increased substantially the next weekend.
Online Processing

Anderson (2004):

- Surface scope
- Inverse scope

Bar graph showing mean residual reading time (ms) for singular and plural conditions.
Online Processing

Anderson (2004):

\[ a, \text{ every} \]

\[
\begin{align*}
\text{mean residual reading time (ms)} \\
\text{the climber(s)} & \quad \text{were} & \quad \text{very skilled}
\end{align*}
\]

\[ \text{singular} - \text{plural} \]
Online Processing

- Anderson (2004):

**Processing Scope Economy**
The human sentence processing mechanism prefers to compute a scope configuration with the simplest syntactic representation (or derivation). Computing a more complex configuration is possible but incurs a processing cost.
The singular indefinite is in the scope of the distributive quantifier, so one might expect that the plural continuation the documents should not cause processing difficulties compared to the document, since narrow scope would be favored.

But even here...

- Anderson (2004): singular continuation is more easily processed.
- Filik et al. (2004), Paterson et al. (2008): with either a>every or every>a, the plural continuation causes processing difficulties.
Case no. 2

Offline preferences
Offline preferences

- Anderson (2004):

  A cashier greeted every customer.

  81%

  a. One cashier greeted customers.

  b. Several cashiers greeted customers.
Once a month, the city tested its emergency alert systems. The regular schedule for the air-raid sirens was to test them on the first of the month. At exactly ten in the morning on that day, an employee sounded every siren.

How many employees sounded sirens?

A. One.  
B. Several.
## Offline preferences

- Anderson (2004):

<table>
<thead>
<tr>
<th>Condition</th>
<th>Surface-scope response One</th>
<th>Inverse-scope response Several</th>
</tr>
</thead>
<tbody>
<tr>
<td>ambiguous surface-biased</td>
<td>0.81</td>
<td>0.19</td>
</tr>
<tr>
<td>unambiguous inverse scope</td>
<td>0.04</td>
<td>0.96</td>
</tr>
<tr>
<td>ambiguous inverse-biased</td>
<td>0.47</td>
<td>0.53</td>
</tr>
</tbody>
</table>
Offline preferences

Conroy (2008):

*Every dog isn’t wearing a hat.*
Case no. 3

‘specific’ indefinites take wide(st) scope
Specific Indefinites – wide scope


U1: context matches widest scope reading of indefinite
Roger is a terrible student, the worst in this department. All of the professors in this department are sure that Roger will fail the difficult qualifying exam.

a. Every professor thinks that a student will fail the exam. YES
b. Every professor thinks that a certain student will fail the exam. YES

**U2: context matches intermediate scope reading of indefinite**

Every professor has one student in his or her class who is a really terrible student, a student that the professor is sure will fail the qualifying exam that all students in this department have to pass. For instance, Dr. Smith thinks that Sarah will fail the exam, Dr. Johnson expects Roger to fail, and Dr. Chung is sure that Chris will fail. Interestingly, all of the professors expect different students to fail.

a. Every professor thinks that a student will fail the exam. YES
b. Every professor thinks that a certain student will fail the exam. YES
Specific Indefinites – wide scope


U3: context matches narrow scope reading of indefinite
The professors in this department make the qualifying exam a very difficult one. Every professor is sure that at least one student will fail this exam, although none of them know exactly which students will pass and which students will fail.

a. Every professor thinks that a student will fail the exam. YES
b. Every professor thinks that a certain student will fail the exam. NO
Specific Indefinites – wide scope

  - ‘a’ indefinites can have wide and narrow scope
  - ‘a certain’ indefinites cannot have narrow scope.

Table 1. Mean results for type U categories (% corresponds to %YES)

<table>
<thead>
<tr>
<th>Context</th>
<th>U1 (wide scope indefinite)</th>
<th>U2 (intermediate scope indefinite)</th>
<th>U3 (narrow scope indefinite)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a</strong>-indefinite</td>
<td>(12a): YES result: 93%</td>
<td>(13a): YES result: 96%</td>
<td>(14a): YES result: 99%</td>
</tr>
<tr>
<td><strong>a certain</strong>-indefinite</td>
<td>(12b): YES result: 98%</td>
<td>(13b): YES result: 74%</td>
<td>(14b): NO result: 31%</td>
</tr>
</tbody>
</table>
Resolving ambiguities
The goal of the parser/interpreter (step 1): search through the space of syntactic structures and meaning representations quickly (the end state is reached fast) and accurately (the end state is the interpretation intended by the speaker).
Resolving ambiguities

- When a hearer encounters an indefinite, he must determine the interpretation intended by the speaker – quickly, economically, and accurately.

Possibilities for interpretation of indefinites:
- The singular indefinite takes wide scope relative to the quantifier.
- A choice function returns an individual for which the predicate holds true (while interpreting the indefinite in situ).
- The domain of the singular indefinite is implicitly restricted (by the speaker) and interpreted as a ‘singleton indefinite’.
The quickest and most economical thing for a hearer to do might be to assume that the speaker

Intends the most likely/most frequent interpretation (unless there is reason to do otherwise).

Is being consistent in the interpretation of all indefinites within a sentence (for the benefit of the speaker and/or the hearer)

Would signal to the hearer that a change in interpretive strategies was called for with explicit surface-level cues.
Resolving ambiguities

- Assume surface scope (or specific indefinite)
- Assume this throughout, unless the speaker provides explicit information for you to do otherwise.
- Once the distributive quantifier is encountered, revise your interpretation, and do so for all indefinites.
Resolving ambiguities

- One can manipulate these expectations about scopal relations and interpretations of quantifiers.
- We have evidence that manipulating pragmatic information facilitates accessing of non-default interpretations, and interpretations that are otherwise deemed hard to access, or even ungrammatical.
  - Case 1: Numeral indefinites
  - Case 2: Specific singular indefinites
  - Case 3: Comparative quantifier phrases
  - Case 4: Embedded ACD readings
Case no. 1

Numeral indefinites
Numeral indefinites


The detective didn’t find two guys.

Children: 81% yes

Reading 1: It is not the case that Donald found two guys (not > two) = TRUE
two>neg FALSE, neg>two TRUE

Reading 2: There are two guys that Donald didn’t find (two > not) = FALSE
Numeral indefinites


The detective didn’t find two guys.

Children: 33% yes

Reading 1: It is not the case that Donald found two guys (not > two) = FALSE
two>neg TRUE, neg>two FALSE

Reading 2: There are two guys that Donald didn’t find (two > not) = TRUE

Every horse didn’t jump over the fence.
Numeral indefinites


Naanu eraDu pustaka ood-al-illa
I-nom two book read-inf-neg
"I didn’t read two books."

Kannada

English

I

IP

I'

NP

VP

NP

V

Neg

NP

read

2 book

Neg

V

NP

read

2 book
Numeral indefinites

- Children in both languages prefer **narrow scope**, despite word order differences, implicating c-command, not linear order.
Gualmini (2004), Gualmini et al. (2008):

**Question:** Did the Troll deliver all the pizzas?

(16) The Troll didn’t deliver some pizzas.

(17)a. It is not the case that the Troll delivered some pizzas.
   = The Troll didn’t deliver any pizzas.
   b. There are some pizzas that the Troll didn’t deliver.

That was a story about the Troll who was delivering pizzas. And I know what happened. **The Troll didn’t deliver two pizzas.**

Am I right or wrong?

Children: 75% yes
Same for every, negation

- Gualmini et al. (2008):
- **Every** letter wasn't delivered.

Children: 80% yes
Case no. 2

Specific indefinites
Specific indefinites

- The indefinite can be interpreted specifically even without an explicit marker of specificity (*a certain, a particular*, etc.).

- An indefinite in object position can more easily be interpreted as specific when linked to the discourse or backgrounded.

Enç 1991, Geurts 2002
Specific indefinites

- Miller & Schmitt (2004):

  Today’s a good day for feeding animals.
Specific indefinites

Miller & Schmitt (2004):

<table>
<thead>
<tr>
<th>Target Sentence</th>
<th>Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Angie didn’t ride a dog</td>
<td>65.5% (19/29)</td>
</tr>
<tr>
<td>2. Denny didn’t eat a cookie</td>
<td>86.2% (25/29)</td>
</tr>
<tr>
<td>3. Troy didn’t buy a hat</td>
<td>34.5% (10/29)</td>
</tr>
<tr>
<td>4. Julie didn’t feed a cat</td>
<td>75.9% (22/29)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>65.5% (76/116)</strong></td>
</tr>
</tbody>
</table>
Miller & Schmitt (2004):
- 20 4-5-year-olds, 10 undergraduates

**Researcher:** “This is Peter and these are drawers that are all in his dresser and he’s closing them. Peter’s dad told him to close all of the drawers before going outside to play. Let’s see what happens.”

**Researcher:** “Look. Now Peter is going outside to play. But wait! What about this one? He didn’t close this one. Let’s see if the monster can say what happened.”
Specific indefinites

Miller & Schmitt (2004):

% 'wide scope' readings

<table>
<thead>
<tr>
<th>Target Sentence</th>
<th>Adults</th>
<th>Children</th>
<th>Adults</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mary didn’t paint an egg</td>
<td>100% (10/10)</td>
<td>90% (18/20)</td>
<td>85% (17/20)</td>
<td>73% (8/11)</td>
</tr>
<tr>
<td>2. Susan didn’t erase a letter</td>
<td>100% (10/10)</td>
<td>95% (19/20)</td>
<td>90% (18/20)</td>
<td>73% (8/11)</td>
</tr>
<tr>
<td>3. Peter didn’t close a drawer</td>
<td>100% (10/10)</td>
<td>85% (17/20)</td>
<td>90% (18/20)</td>
<td>81% (9/11)</td>
</tr>
<tr>
<td>4. Timothy didn’t blow out a candle</td>
<td>100% (10/10)</td>
<td>95% (19/20)</td>
<td>90% (18/20)</td>
<td>73% (8/11)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100%</td>
<td>91%</td>
<td>89%</td>
<td>77%</td>
</tr>
</tbody>
</table>
Becoming adult-like

Conroy et al. (2009)

- Adult-like performance
- inverse
- - adult parser
- - revision
- surface
- + adult parser
- + revision
- faster processors build structure from beginning
- slower processors wait until end of sentence

4 years
5 years
Case no. 3

Comparative quantifier phrases
Comparative quantifier phrases

- Comparative Quantifiers: “more than # NPs”
  - Unlike other numeral expressions: their scope appears to be frozen
  - Unable to scope over indefinite subject
    
    One student read more than three books.

Comparative quantifier phrases

However, CQPs may be able to take wide scope when surface scope is implausible and false, and inverse reading is true and preferred.

More than two students read more than two books.
A guard is standing on more than three buildings.

Comparative quantifier phrases

- Experiment controlling for
  - CQP or indefinite
  - Partitivity
  - Speaker expectations (minimal amount met by numeral)
  - False surface scope (and in some cases implausible), true inverse scope

- Work with graduate student Atsushi Oho
Comparative quantifier phrases

A middle school teacher wanted to pick a book for summer reading, but he couldn’t decide which one he should choose. So he picked five books and asked ten of his current students to choose a book among these. **They could only select one book.**
Based on their selections, he would choose the book for summer reading for the incoming class. The five book choices were *Holes, Fantastic Mr. Fox, Little Women, The Golden Compass,* and *A Wrinkle in Time.* The teacher worried that the selections would be evenly distributed among the books. But that's not what happened.
After the students made their selections, he found out that four chose *Fantastic Mr. Fox*, three chose *Holes*, and three chose *Little Women*. Surprisingly, no one chose *The Golden Compass* or *A Wrinkle in Time*.

More than two students selected more than two books.
Comparative quantifier phrases

A guard was posted in front of more than two hotels.
A vase of roses graced more than two tables.
Comparative quantifier phrases

- **Target sentences**
  - Negation, CQP
  - Indefinite (a, one), CQP
  - CQP, CQP
  - Indefinite (a, one), CQP surface implausible+false

- **+/− CQP, +/− partitive**
  - A guard was posted in front of **more than two hotels**.
  - A guard was posted in front of **more than two of the hotels**.
  - A guard was posted in front of **three hotels**.
  - A guard was posted in front of **three of the hotels**.
Comparative quantifier phrases

Average Responses: Test Items

16 participants per condition x 4 = 64 participants
Case no. 4
Embedded ACD readings
Embedded ACD readings

- **Antecedent-Contained Deletion**

  Woody jumped over every frog, and Jessie *did*, too.

  Woody jumped over every frog that Jessie *did*.

- **Problem:** infinite regress, lack of parallelism

- **Solution:** QR QNP out of VP (landing site: adjunction to VP or IP)

Woody \([_{VP} jumped over}_{QNP} every frog that Jessie \textbf{did}]\).
Embedded ACD readings

Woody $[\text{VP} \text{wanted to} \ [\text{VP} \text{jump over} \ \text{QNP} \text{every frog that Jessie}} \text{did}]]$.

a. **Embedded VP:** $\langle \text{jumped over} \rangle$

   “Woody wanted to jump over every frog that Jessie *jumped over.*”

b. **Matrix VP:** $\langle \text{wanted to jump over} \rangle$

   “Woody wanted to jump over every frog that Jessie *wanted to jump over.*”
Embedded ACD readings

Wh-Movement

a. You say that you wanted to eat what for dinner
b. What did you say [that you wanted to eat t for dinner]]?

Quantifier Raising

Finite Clause

A professor expected that Mary would read every book.
(a > every, *every > a)

Non-Finite Clause

A professor expected Mary to read every book.
(a > every, every > a)
Embedded ACD readings

Clause-Boundedness of QR

- A technician said that John inspected every plane.
  (Cecchetto 2004)
- Someone believed that every politician is corrupt.
  (Reinhart 1997)
Embedded ACD readings

But maybe QR is not (always/every really) clause-bounded?

- A doctor will make sure that we give every new patient a tranquilizer. (Reinhart 1997)
- A quick test confirmed that each drug was psychoactive. VanLehn 1978 (in Tunstall 1998)
- John said that you were on every committee that Bill did. (Wilder 1997)
- John thinks that Mary is taller than Bill does. (Fiengo & May 1994, Wilder 1997)
In previous work we found that

- 4-yr-olds & adults access both the embedded and matrix reading of non-finite embedded ACD sentences.
- 4-yr-olds & some adults accepted matrix readings of sentences where ACD was embedded in a tensed clause.
- If the matrix interpretation is ungrammatical, and we assume that children are not overgenerating complicated ACD sentence interpretations, then why did some adults access the matrix interpretation?

Syrett & Lidz (2011)
Embedded ACD readings

- Follow-up experiments in my lab with undergraduates Shannon Gravatt and Siobhan McLaughlin
  - Experiments replicated and expanded on previous work
  - Contextual and linguistic manipulations gave rise to higher percentages of acceptance among adults and replicated children’s acceptances.
- Manipulations
  - No overt complementizer
  - Pronoun in embedded subject position
  - Discourse conditions highlighting matrix verb/event
Embedded VP favored “every frog that Jessie jumped over”
Matrix VP favored
“every frog that Jessie said she jumped over”
That was a great story!
And I know what happened!
Woody said he jumped over every frog that Jessie did.
Am I right?
# Embedded ACD readings

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage Acceptance/Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Children (% yes)</td>
</tr>
<tr>
<td>Embedded VP</td>
<td>39%</td>
</tr>
<tr>
<td>Matrix VP</td>
<td>35%</td>
</tr>
<tr>
<td>Matrix VP ‘that’ and full names in subject</td>
<td></td>
</tr>
</tbody>
</table>

*Adult justifications categorized by 4 independent coders*
Embedded ACD readings

- Cecchetto (2004):
  - Nothing *a priori* bars the matrix reading of sentences where ACD is embedded in a tensed clause.
  - Successive cyclic movement through the structure licensed by Scope Economy and constrained by the Phase Impenetrability Condition should allow the QNP to outscope the matrix VP.
  - Once there, the QNP could move even higher if motivated.
  - Could we get inverse scope of QNP over an indefinite subject?
I can jump over all 3 of those frogs!
I can’t believe those 3 boys said they could jump over those frogs!!
That was a great story!
And I know why Jessie was so mad!
Someone said he could jump over every frog that Jessie did.
Am I right?
Someone said he could jump over every frog that Jessie did
## Embedded ACD readings

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>VP classifiable:</td>
<td>Scope classifiable:</td>
</tr>
<tr>
<td>34% (54/160)</td>
<td>84% (135/160)</td>
</tr>
<tr>
<td>Embedded VP</td>
<td>Matrix VP</td>
</tr>
<tr>
<td>30%</td>
<td>Narrow Scope</td>
</tr>
<tr>
<td>70%</td>
<td>Inverse Scope</td>
</tr>
<tr>
<td>53%</td>
<td>47%</td>
</tr>
</tbody>
</table>

Justifications categorized by 5 independent coders
Someone didn't say they could jump over all the frogs Jessie did, each boy said they could jump over one.

All 3 boys each said that they can jump over the frogs.

Because each frog Jessie said she could jump over someone else did too.

Each boy said they can jump over a frog Jessie said she could.

The 3 boys said they could jump over the frogs too.

She thought she was the only one that was able to jump over them but then the boys said they could too.
Conclusions

- The argument that it is LF/scopal relations that facilitates processing is compelling, but we should go further to pin down scope as the source of the phenomenon.

- We might aim to find a general, unified account of these various cases across child and adult language. Do they all implicate scope at LF?

- It would be fruitful to further explore the pragmatic conditions under which non-default interpretations become more accessible (in real-time).
Thank you