What do German quantifiers tell us about semantic theories?

Janina Radó & Oliver Bott

Goethe-Universität Frankfurt & Universität Tübingen

Quantifier Scope: Syntactic, Semantic, and Experimental Approaches
Aim of the talk: theoretical issues

which readings are available? which readings are preferred?
  • configurational vs. multi-factor theories

when does scope interpretation take place?
  • underspecification vs. automatic scope interpretation
Aim of the talk: methodological issues

- which readings are available? which readings are preferred?
  - unbiasing method to measure scope preferences
  - distinguishing dispreferred from unavailable readings

- when does scope interpretation take place?
  - method to provide delayed disambiguation
Three factors that may affect quantifier scope

(a) Jeder Student las genau einen Aufsatz.  
   Each student\textsubscript{NOM} read exactly one paper\textsubscript{ACC}.
(b) Genau einen Aufsatz las jeder Student.  
   Exactly one paper\textsubscript{ACC} read each student\textsubscript{NOM}.
(c) Alle Studenten lasen genau einen Aufsatz.  
   All students\textsubscript{NOM} read exactly one paper\textsubscript{ACC}.
(d) Genau einen Aufsatz las jeder der Studenten.  
   Exactly one paper\textsubscript{ACC} read each of the students\textsubscript{NOM}.

1 (a) vs. (b): **linear order** of quantifiers
2 (a) vs. (c): **distributivity** (each vs. all)
3 (b) vs. (d): “**discourse binding**” (partitive construction, quantifier with anaphoric restriction)
Configurational accounts

- scope ambiguity is treated as a kind of syntactic ambiguity (e.g. May 1977)
- scope bearing elements are moved (raised, reconstructed) to a covert position where they take scope
- German: reconstruction is the only possible option (e.g. Frey 1993)
- some versions also take into account non-syntactic factors (e.g. Beghelli & Stowell 1997)
(a) Every boy read some book.

(b) QQ interaction in German
Predictions of configurational accounts

purely configurational accounts (e.g. Frey 1993)
- QQ sentences with subject before object word order: only linear scope is possible
- QQ sentences with object before subject word order: scope ambiguous; object quantifier can be reconstructed

feature checking accounts (e.g. Beghelli & Stowell 1997)
- lexical properties of quantifiers matter, for instance distributivity
- ‘scope factors’ are incorporated into hierarchical structure
  ▶ asymmetrical dependencies
- scope factors interact: a factor realized higher in the tree rules out effects of factors lower in the tree
Multi-factor theories (e.g. Pafel 2005)

several scope factors are expected to contribute their influence independently of the others:

1. linear order: the first quantifier tends to scope over the second
2. distributivity: distributive quantifiers tend to take wide scope
3. discourse binding: d-bound quantifiers tend to take wide scope
Multi-factor theories (e.g. Pafel 2005)

several scope factors are expected to contribute their influence independently of the others:

1. linear order: the first quantifier tends to scope over the second
2. distributivity: distributive quantifiers tend to take wide scope
3. discourse binding: d-bound quantifiers tend to take wide scope

additive model with weighted $w_1, \ldots, w_n$ scope factors $F_1, \ldots, F_n$:

$$Preference_{Q1 > Q2} = w_1 \ast F_1 + \ldots + w_n \ast F_n$$

- factors should show purely additive effects, no interaction

in models with thresholds, some QQ sentences may be unambiguous
we need a method that allows us to measure quantifier scope in naive subjects without introducing a bias, therefore . . .

- we chose quantifiers for which neither scope reading entails the other
  - sentences with universal quantifier (\(\forall: \text{jed- vs. all-}\)) and non-monotonic exactly one (\(\exists!\))
- we pretested the applied method with unambiguous materials to make sure that it yields unbiased results
Für genau einen Aufsatz gilt, dass jeder Student ihn gelesen hat. Exactly one paper is such that each student read it.

Für jeden Student gilt, dass er genau einen Aufsatz gelesen hat. Each student is such that he read exactly one paper.

- 2 x 2 design: within factors scope, disambiguation
- 24 items (+36 fillers)
- 24 participants
- picture verification task: “yes, fits” vs. “no, doesn’t fit” judgments
∀∃! disambiguation:

∀∃! Für genau einen Aufsatz gilt, dass jeder Student ihn gelesen hat. 
Each student is such that he read exactly one paper.

∃∀! disambiguation:

∃∀! Für jeden Student gilt, dass er genau einen Aufsatz gelesen hat. 
Exactly one paper is such that each student read it.
results:

<table>
<thead>
<tr>
<th></th>
<th>$\forall\exists!$-sentence</th>
<th>$\exists!\forall$-sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\forall\exists!$-sentence</td>
<td>95.1%</td>
<td>6.3%</td>
</tr>
<tr>
<td>$\exists!\forall$-sentence</td>
<td>14.6%</td>
<td>88.9%</td>
</tr>
</tbody>
</table>

- highly significant interaction
- main effects not significant
- picture materials do not have a bias
Scope preferences

Outline

Radó & Bott (Goethe-Universität Frankfurt & Universität Tübingen)

QQ interaction in German

Quantifier Scope
A test case with diverging predictions

(a) Genau ein Student las jeden dieser Aufsätze.
Exactly one student\textsubscript{NOM} read each of these papers\textsubscript{ACC}

(b) Jeden dieser Aufsätze las genau ein Student.
Each of these papers\textsubscript{ACC} read exactly one student\textsubscript{NOM}

(c) Genau einen Aufsatz las jeder Student.
Exactly one paper\textsubscript{ACC} read each student\textsubscript{NOM}

Frey’s configurational account:
- (a) unambiguous: only surface scope
- (b) and (c) are fully ambiguous
A test case with diverging predictions

(a) Genau ein Student las jeden dieser Aufsätze.
Exactly one student\text{NOM} read each of these papers\text{ACC}

(b) Jeden dieser Aufsätze las genau ein Student.
Each of these papers\text{ACC} read exactly one student\text{NOM}

(c) Genau einen Aufsatz las jeder Student.
Exactly one paper\text{ACC} read each student\text{NOM}

Frey’s \textit{configurational account}:
- (a) unambiguous: only surface scope
- (b) and (c) are fully ambiguous

Pafel’s \textit{multi-factor account}:
- graded preferences
- strong preference for linear reading in (b)
A test case with diverging predictions

(a) Genau ein Student las jeden dieser Aufsätze.
Exactly one student\textsubscript{NOM} read each of these papers\textsubscript{ACC}

(b) Jeden dieser Aufsätze las genau ein Student.
Each of these papers\textsubscript{ACC} read exactly one student\textsubscript{NOM}

(c) Genau einen Aufsatz las jeder Student.
Exactly one paper\textsubscript{ACC} read each student\textsubscript{NOM}

Frey’s \textit{configurational account}:
- (a) unambiguous: only surface scope
- (b) and (c) are fully ambiguous

Pafel’s \textit{multi-factor account}:
- graded preferences
- strong preference for linear reading in (b)

▷ comparison with unambiguous controls
Experiment 1: disambiguation and controls

∀∃! disambiguation:

jeden dieser Aufsätze las genau ein Student.
Each of these papers read exactly one student.

Für jeden dieser Aufsätze gilt: ihn las genau ein Student.
For each of these papers holds: it read exactly one student.
3 x 2 x 2 design: within factors construction, ambiguity, disambiguation

- 36 items
- 48 participants
- rating the appropriateness of a sentence wrt. a disambiguating picture on a 7-point Likert scale
- 3 judgments per item and condition
Scope preferences

Experiment 1: Frey’s predictions, schematic view

Radó & Bott (Goethe-Universität Frankfurt & Universität Tübingen)

QQ interaction in German

Quantifier Scope
Scope preferences

Experiment 1: Frey’s predictions, schematic view

Radó & Bott (Goethe-Universität Frankfurt & U)  QQ interaction in German
Quantifier Scope  19 / 1
if reconstruction is cost-free:
Scope preferences

Experiment 1: Pafel’s predictions, schematic view

![Graph showing judgment preferences for experiment 1](image-url)
Scope preferences

Experiment 1: results

![Graph showing QQ interaction in German](image-url)
Experiment 1: results

OVS conditions
- **each of these > exactly**: strong linear preference
- **exactly > each**: fully ambiguous
Experiment 1: results

OVS conditions
- *each of these* > *exactly*: strong linear preference
- *exactly* > *each*: fully ambiguous

SVO condition
- strong linear preference
all construction types are ambiguous

OVS conditions
- *each of these* > *exactly*: strong linear preference
- *exactly* > *each* fully ambiguous
  ▶ evidence for additive factors, unexpected in configurational accounts

SVO condition
- strong linear preference
  ▶ largely consistent with Frey (1993), but not with Pafel (2005)
systematically testing how scope factors influence scope preferences

- Experiment 2: manipulating *linear order* and *distributivity*
- Experiment 3: manipulating *discourse binding* and *distributivity*
Experiment 2: “linear order” and “distributivity”

(a) Genau einen dieser Aufsätze hat jeder Student gelesen.
Exactly one of these papers has each student read.

(b) Genau einen dieser Aufsätze haben alle Studenten gelesen.
Exactly one of these papers have all students read.

(c) Jeder Student hat genau einen dieser Aufsätze gelesen.
Each student has exactly one of these papers read.

(d) Alle Studenten haben genau einen dieser Aufsätze gelesen.
All students have exactly one of these papers read.

- $\exists!$: always discourse bound/anaphoric
- $\forall$: distributive in (a)/(c) and non-distributive in (b)/(d)
Frey’s configurational theory
(no reconstruction costs)

Pafel’s multi-factor theory
(without thresholds)

▷ only effect of order

▷ effects of order and distributivity
Experiment 2: methods

- $2 \times 2 \times 2$ design: within factors order, distributivity, disambiguation
- 24 items (+ 36 fillers)
- 56 participants
- offline Magnitude Estimation task (Bard et al 1996)
- latin square design (▷ eight lists)
linear order matters: sig. interaction order $\times$ disambiguation

distributivity matters: sig. interaction distributivity $\times$ disambiguation

additive effect
Experiment 2: discussion

- linear order and distributivity both affect scope
- the effects are additive
- expected in multi-factor theories, but not in configurational accounts
- pattern of results doesn’t fully match Pafel’s predictions
Experiment 3: “discourse binding” and “distributivity”

(a) Genau einen dieser Aufsätze hat jeder Student gelesen. 
Exactly one of these papers_{ACC} has each student_{NOM} read.

(b) Genau einen dieser Aufsätze haben alle Studenten gelesen. 
Exactly one of these papers_{ACC} have all students_{NOM} read.

(c) Genau einen Aufsatz hat jeder dieser Studenten gelesen. 
Exactly one paper_{ACC} has each of these students_{NOM} read.

(d) Genau einen Aufsatz haben alle diese Studenten gelesen. 
Exactly one paper_{ACC} have all of these students_{NOM} read.

- only OS sentences
- discourse binding: partitive quantifiers
- distributivity: jed- vs. all-
Pafel’s multi-factor theory (without thresholds)

- additive effects of *discourse binding* and *distributivity*
- inverse scope should be easily available in (c) and (d)
Experiment 3: methods

- $2 \times 2 \times 2$ design: within factors *discourse binding*, *distributivity*, *disambiguation*
- 24 items (+ 36 fillers)
- 24 participants
- offline Magnitude Estimation task (Bard et al 1996)
- latin square design (> eight lists)
Experiment 3: results

- discourse binding matters: sig. interaction
  *discourse binding $\times$ disambiguation*
- distributivity matters: sig. interaction *distributivity $\times$ disambiguation*
- additive effects
distributivity and discourse binding both effect scope
the effects are additive
consistent with multi-factor account
unexpected under configurational accounts
but: observed distribution of readings different from Pafel’s predictions
Interim summary

- diagrams provide good method for obtaining judgments
Interim summary

- diagrams provide good method for obtaining judgments
- all three factors affect scope preferences
- results partially support multi-factor and configurational theories
- but: neither predicts the full range of data
Interim summary

- diagrams provide good method for obtaining judgments
- all three factors affect scope preferences
- results partially support multi-factor and configurational theories
- but: neither predicts the full range of data

▷ large-scale testing necessary to obtain valid generalizations
Underspecified scope representations?
(a) Genau ein Tier auf jeder Karte ist ein Affe.
   Exactly one animal on each card is a monkey

   • inverse linking construction: wide scope for second quantifier
     (e.g. Kurtzman & MacDonald 1993)
   • each takes wide scope easily
     ▶ interpretation easy

(b) Genau ein Tier auf allen Karten ist ein Affe.
   Exactly one animal on all cards is a monkey

   • inverse linking construction: wide scope for second quantifier
   • all prefers narrow scope
     ▶ scope conflict
Scope conflict

(a) Genau ein Affe ist auf jeder Karte zu finden.
Exactly one monkey is on each card to find.

(b) Genau ein Affe ist auf allen Karten zu finden.
Exactly one monkey is on all cards to find.

- construction with “light verb”: wide scope for second quantifier
  - *all* in (b) prefers narrow scope
    - scope conflict
underspecification

- single compact representation of all interpretation possibilities
- economical
- full specification only at disambiguation
When is scope conflict “noticed”?

**automatic scope interpretation**

- scope computation even without disambiguation
- at the earliest possible point
  - at the second quantifier *immediate full interpretation*
  - at complete *minimal domain*: complete proposition
The celebrity gave an in depth interview to every reporter from the newspaper, but the interview(s) ...

- indication of scope conflict at second quantifier
- interpreted as evidence for automatic scope interpretation
- but: late effect, readers already saw the disambiguation
  ▶ results do not distinguish between underspecification and automatic scope interpretation
crucial: disambiguation should follow long after sentence boundary

- two-stage experimental procedure
  - stage 1: self-paced reading
  - stage 2: picture verification
Experiment 4: predictions

(a) Genau ein Affe ist auf allen/jeder Karte(n) zu finden. ‘Exactly one monkey is depicted on all/each card(s).’

- automatic scope interpretation: scope conflict at second DP
- underspecification: no scope conflict during reading
Experiment 4: predictions

(a) Genau ein Affe ist auf allen/jeder Karte(n) zu finden.
‘Exactly one monkey is depicted on all/each card(s).’

- automatic scope interpretation: scope conflict at second DP
- underspecification: no scope conflict during reading

(b) Genau ein Tier auf allen/jeder Karte(n) ist ein Affe.
‘Exactly one animal on all/each card(s) is a monkey.’

- immediate full interpretation: scope conflict at second quantifier
- minimal domain: scope conflict at sentence boundary
- underspecification: no scope conflict during reading
sentence conditions:

Genau ein | Affe | ist | auf | allen/jeder | Karte(n) | zu | finden.
’Exactly one monkey is depicted on all/each card(s).’
sentence conditions:

Genau ein | Affe | ist | auf | allen/jeder | Karte(n) | zu | finden.
’Exactly one monkey is depicted on all/each card(s).’

DP conditions:

Genau ein | Tier | auf | allen/jeder | Karte(n) | ist | ein | Affe.
’Exactly one animal on all/each card(s) is a monkey.’
Experiment 4: materials

sentence conditions:

Genau ein | Affe | ist | auf | allen/jeder | Karte(n) | zu | finden.
’Exactly one monkey is depicted on all/each card(s).’

DP conditions:

Genau ein | Tier | auf | allen/jeder | Karte(n) | ist | ein | Affe.
’Exactly one animal on all/each card(s) is a monkey.’

control conditions:

Auf | allen/jeder | Karte(n) | ist | ein | Schimpanse.
’On all/each card(s) is a chimpanzee.’
Experiment 4: reading stage

a sample trial

+
Experiment 4: reading stage

a sample trial

Exactly one
Experiment 4: reading stage

a sample trial

animal
a sample trial

on
Experiment 4: reading stage

a sample trial

all
a sample trial

cards
Experiment 4: reading stage

a sample trial

is
Experiment 4: reading stage

a sample trial

a monkey.
task: read sentence and then uncover a display
on each card decide whether
  - the sentence is true or false (pressing either button ends the trial)
  - more information is needed (move on to the next card)
only press “false” if the sentence doesn’t allow this interpretation
  ▶ all possible interpretations have to be considered
  ▶ best strategy: underspecification

40 participants
60 items + 80 fillers (40 false)
a participant saw each sentence in only one condition
Experiment 4: verification stage

(a) Exactly one monkey is depicted on all cards.
(b) Exactly one animal on all cards is a monkey.
Experiment 4: verification stage
Experiment 4: the disambiguations

linear

inverse
Underspecified scope representations?

Experiment 4: fully uncovered displays

linear

inverse
scope ambiguous QQ sentences:

- 2 x 2 x 2 design:
  - construction: \textit{Sentence} vs. \textit{DP} (= inverse linking)
  - universal quantifier: \textit{all} vs. \textit{each}
  - disambiguation: $\exists!\forall$- vs. $\forall\exists!$-\textit{displays}
Experiment 4: design

scope ambiguous QQ sentences:
- 2 x 2 x 2 design:
  - construction: *Sentence* vs. *DP* (= inverse linking)
  - universal quantifier: *all* vs. *each*
  - disambiguation: \( \exists ! \forall \) vs. \( \forall \exists ! \)-displays

control conditions:
- quantifier: *all* vs. *each*
- one relevant object (e.g., the chimpanzee) on each card, first card identical to QQ-conditions

▷ 10 conditions (six data points per participant and condition)
linear scope dispreferred, but still possible (cf. false fillers)
Experiment 4: judgment results

- Linear scope dispreferred, but still possible (cf. false fillers)
- Inverse scope more often rejected after *all* than after *each*
  - Scope conflict in the *all* conditions
QQ:

- All slower than each in QQ-conditions
- No all/each contrast in the controls

▶ Scope conflict already observed during reading

Controls:

Radó & Bott (Goethe-Universität Frankfurt & Universität Tübingen)

QQ interaction in German

Quantifier Scope
no *all/each* contrast at second quantifier

▷ evidence for the minimal domain account
Underspecified scope representations?

Experiment 4: reading times, DP conditions

- no *all/each* contrast at second quantifier
- evidence for the minimal domain account
- delayed effect covered by sentence wrap-up?
evidence against underspecification

- comprehenders resolve quantifier scope before the disambiguation
- additional support from Dotlačil & Brasoveanu (2014): hierarchical scope representation

evidence for minimal domain account

- scope is computed when a complete proposition is available
- additional support from Bott & Schlotterbeck (2013): scope computation at sentence boundary
Conclusions

Outline

Radó & Bott (Goethe-Universität Frankfurt & Universität Tübingen)

Quantifier Scope 65 / 1

QQ interaction in German
which readings are available? which readings are preferred?

when does scope interpretation take place?
which readings are available? which readings are preferred?
  - unbiased method for measuring offline scope preferences

when does scope interpretation take place?
  - method for providing delayed disambiguation in online experiments
Summary: theoretical results

which readings are available? which readings are preferred?

- unbiased method for measuring offline scope preferences
- neither configurational nor multi-factor theory predicts the full set of preferences

when does scope interpretation take place?

- method to provide delayed disambiguation in online experiments
- evidence for automatic scope interpretation
Conclusions

experimental results are important for refining semantic theories

- offline results provide rich data set that constrain semantic theories
- online data can help evaluate predictions that are not accessible to intuitions

question to semanticists:
- why do some factors influence scope (more than others)?
Thank you for your attention!
Many thanks to
Fabian Schlotterbeck
Wolfgang Sternefeld
for discussion
Amelie Brinkmann
Andreas Konietzko
Katrin Petodnig
Tanja Werner
for help with the experiments