How to provide exactly one interpretation for every sentence, or what eye movements reveal about quantifier scope

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Theoretical considerations:

- What are the available readings?
- What are the relevant representations?
- How are these representations constructed?
Methodological considerations:

- Offline preferences: first interpretation or reinterpretation?
- Online results:
  - disambiguation often insufficient
  - disambiguation may distort preferences on ambiguous parts of the sentence
Bringing it all together...
Experiment

- written instructions: “Name an animal...”
- computer displays
definite NP + ’each’/’all’

(c) Das Tier auf jedem Bild sollst du nennen!
   “Name the animal in each field!”

(d) Das Tier auf allen Bildern sollst du nennen!
   “Name the animal in all fields!”
Materials: Control A
Materials: Control A

- one picture appeared in all three fields
- all other pictures represented a different category
Experimental items: inverse linking constructions

(a) Genau ein Tier auf jedem Bild sollst du nennen! “Name exactly one animal in each field!”

(b) Genau ein Tier auf allen Bildern sollst du nennen! “Name exactly one animal in all fields!”

- the inverse scope reading is favored
- ’each’ demands wide scope more strongly than ’all’
Experimental items: inverse linking constructions

(a) Genau ein Tier auf jedem Bild sollst du nennen!  
   “Name exactly one animal in each field!”

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   “Name exactly one animal in all fields!”

- the inverse scope reading is favored
- ’each’ demands wide scope more strongly than ’all’
Materials: Items/Control B
Materials: Items/Control B

- all pictures belonged to the same category (e.g. animal)
- two pictures appeared in all three fields
- other pictures appeared only once in the display
two quantifiers, disambiguated

(e) Von jedem Bild sollst du irgendein Tier nennen!
   “From each field, name some animal!” $\forall \exists$ only

(f) Ein Tier, das sich auf allen Bildern befindet, sollst du nennen!
   “Name an animal which can be found in all fields!” $\exists \forall$ only
Sentence materials

Summary of conditions:

(a) two quantifiers, 'each', ambiguous
(b) two quantifiers, 'all', ambiguous
(c) definite NP, 'each'
(d) definite NP, 'all'
(e) two quantifiers, 'each', $\forall \exists$ only
(f) two quantifiers, 'all', $\exists \forall$ only
An experimental trial

Genau ein Tier auf jedes Bild/auf allen Bildern sollst du nennen!
An experimental trial
An experimental trial

“Monkey”
Measures:

- eye movements during reading
- eye movements during inspecting displays
- responses

30 subjects, 72 items in 6 conditions, 70 fillers
Predictions

Cond. (a)  • inverse scope preferred, plus
   • ’each’ wants wide scope
   → second quantifier integrated easily
   → $\forall \exists$ response

Cond. (b)  • inverse scope preferred, but
   • ’all’ does not want wide scope
   → difficulty integrating second quantifier
   → larger proportion of $\exists \forall$ responses

Do reading times differ depending on the answer?
Inspecting pictures
Responses

Coding the responses:

∃∀ reading: subject inspected all three fields, and provided a single answer

∀∃ reading: subject responded field-by-field
Results: Responses

- 'each' received more $\forall \exists$ responses than 'all'
- Cond. (b) ('all') fully ambiguous (60% $\forall \exists$ readings)
Results: Responses

- control B (unambiguous): 99% expected answers
Genau ein Bauwerk auf jeder Tafel sollst Du nennen!
Reading instructions

Genau ein Bauwerk auf jeder Tafel sollst du nennen!

region 1          region 2          region 3
Results: Reading times

[Graph showing reading times across different regions and conditions for ambiguous and control groups.]
Results: Reading times

![Graph showing reading times for different conditions (ambig. - all, ambig. - each, Control A - all, Control A - each) across three regions (1. region, 2. region, 3. region). The x-axis represents the regions, and the y-axis represents the total reading times (± 95% confidence intervals) in milliseconds (ms). The graph illustrates the differences in reading times between the conditions and regions.](image-url)
Results: Contingent reading times

[Graph showing reading times for different quantifiers across three regions.]
Results: Summary

- overwhelming preference for inverse scope
- modulated by quantifier type
- scope relations computed immediately
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An additional contrast

Control A: definite NP + ‘each’/”all’

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Conclusions

- What are the available readings?
  - depends on the quantifiers:
    - distributivity influences scope preferences

- What are the relevant representations?
  - not always clear, cf. definite NPs

- How are these representations constructed?
  - immediately
  - more balanced preferences → greater interpretation difficulty
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