Quantifier Processing: Quantifier Scope Ambiguity

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Lecture 4 topics:

- Formal accounts
- Processing accounts
- Empirical findings
- Under-specification
Quantifier Scope Ambiguity

“A boy kissed every girl.”

- Sentences containing 2 quantified expressions are often ambiguous.
- There is one individual boy who kissed each girl (in a particular domain).
  \[ \exists x \left[ \text{boy} (x) \& \forall y \left[ \text{girl} (y) \rightarrow \text{kissed} (x, y) \right] \right] \]
- On this analysis, the existential phrase (a boy) takes score over the universal quantifier (every girl).
- Often called the surface-scope interpretation.
Quantifier Scope Ambiguity

“A boy kissed every girl.”

- In another possible interpretation, there are as many boys as there are girls.
  \[ \forall x \ [ \text{girl}(x) \ & \ \exists y \ [ \text{boy}(y) \ & \ \text{kissed}(x,y) ] ] \]
- On this analysis, the universal quantifier (every girl) takes score over the existential (a boy).
- Often called the **inverse-scope interpretation**.
- Combinatorial explosion in possible readings with 3 or more quantifiers.
- How are multiple scope dependencies processed?
Quantifier Scope Ambiguity
Quantifier Raising

“Everyone loves someone.”

- Widely argued that such sentences are not syntactically ambiguous, but map onto different Logical Form representations.
- LF is a covert structural representation that follows the syntactic structure and is level of representation that determines the semantics of a sentence.
- Scope ambiguous sentences undergo QR transformation to produce distinct LF representations that differ in terms of the order of quantifiers.
Quantifier Raising

“Everyone loves someone.”

- Although this sentence is unambiguous at level of syntactic structure it can map onto LF representations that differ in the order of quantifiers.
How are the alternative analyses processed during normal comprehension?

Models of sentence processing tend to divide between serial processing models and parallel processing models.

Approaches based on these principles make different predictions concerning the processing of quantifier scope ambiguities.
Processing Accounts

1. Garden-Path theory (e.g., Frazier, 1987; Frazier & Clifton, 1996).
   - Structural principles guide selection of single parse for an ambiguity.
   - Preferred analysis is structurally simpler.
   - Extra-syntactic information (e.g., plausibility, context) used to evaluate parse and to trigger reanalysis if necessary.
   - Recent approaches (Frazier, 1999; Tunstall, 1998) propose that LF parsing follows same principles.
Processing Accounts

2. Constraint-based accounts (e.g., MacDonald, 1994; Trueswell & Tanenhaus, 1994).
   - Alternative possible analyses are constructed in parallel and compete for selection.
   - Multiple sources of information (syntax, context, lexical biases) contribute to process.
   - Easier processing of ambiguity when several sources of information support one analysis.
   - Difficulty when alternative analyses are equally supported, as this results in greater competition.
   - Alternative possible analyses are constructed in parallel and evaluated in terms of plausibility with respect to the discourse context.
   - “Principle of Parsimony” - A reading which carries fewer unsupported presuppositions will be favoured over one that carries more.
   - In absence of context, favours referentially simpler analysis.
Processing Accounts

- Several accounts propose that quantifier scope is processed in order quantifiers are encountered, i.e., the first quantifier takes wide scope. (e.g., Fodor, 1982; Johnson-Laird, Byrne, & Tabossi, 1989, 1992).
- Fodor (1982) proposed an account based on the Mental Models approach to cognition (e.g., Johnson-Laird, 1983).
- Fodor’s account emphasises the influence of incremental interpretation on the computation of relative quantifier scope.
Processing Accounts

Every boy kissed a girl.

Equally easy to process under Fodor’s incremental processing account.
Processing Accounts

A boy kissed every girl.

Easy to process incrementally.

Hard to process incrementally.
Processing Accounts

- Several accounts propose that interactions between hierarchical principles determine quantifier scope.
- Ioup (1974): Two hierarchies interact to determine scope preference
  - Hierarchy of Quantifiers
    Each > every > a > all > most > many > several > some > a few.
  - Hierarchy of Grammatical Categories
    Topic > deep & surface subject > indirect object > prepositional object > direct object
Examples

- Each girl carried a box.
- Several girls carried a box.
- A box was carried by each girl.
- A box was carried by several girls.
Examples

- The girl showed a photo to every critic.
- The girl showed every critic a photo.
- The girl showed every photo to a critic.
- The girl showed a critic every photo.
Processing Accounts

- Thematic Hierarchy (Grimshaw, 1990; Jackendoff, 1972).
- Kurtzman & MacDonald (1993) speculated that a thematic hierarchy may be implicated in the processing of relative quantifier scope.
  
  Agent > Experiencer > Theme

- According to this account, phrases that express an agent preferably take wide scope and this preference may be stronger in relation to a phrase expressing an experiencer than one expressing a theme.
Kurtzman & MacDonald (1993)

- Acceptability judgements for continuations.

  A kid climbed every tree.
  The kid(s) was / were full of energy.
  A fox saw every chicken.
  The chicken(s) was / were in the henhouse.

- Varied order of quantifiers - “a” or “every” first.
- Varied sentence construction so that verb was either:
  - Action verb: subject NP is agent, object NP is theme;
  - Perception verb, subject NP is experiencer, object NP is theme.
- Compared these with unambiguous constructions.
Kurtzman & MacDonald (1993)

Wide scope preference for first NP, but stronger for sentences with action than perception verbs.
Kurtzman & MacDonald (1993)

- Experiment 1 findings:
  - Consistent with the Thematic Hierarchy.
  - Also evidence that indefinites will be taken to refer to singular referents if encountered first in sentence.

- Experiment 2 on passives showed no strong scope preferences.
Kurtzman & MacDonald (1993)

Figure 2. Compatibility judgments for continuation sentences in Experiment 2.
Kurtzman & MacDonald (1993)

- When factors collectively favour one representation then that representation is constructed, but if the factors are in conflict then competition between the alternative representations occurs before one finally is selected, with competition incurring a processing cost.
Filik et al. (2004)

- Measured eye movements while reading for dative and double object sentences in which the direct and indirect objects were indefinites or quantified expressions.

- Examined influence of:
  - Quantifier Hierarchy: “every / each” > “a”.
  - Grammatical Hierarchy: indirect object > direct object
Filik et al. (2004) / Paterson et al. (2008)

- **Dative sentences**
  
  Kelly showed a photo to every critic.
  
  Direct object is followed by indirect object

- **Direct objects**

  Kelly showed a photo to every critic.
  
  Indirect object is followed by direct object
Table 2. Predictions concerning reading-time effects for plural and singular noun phrases at the continuation region

<table>
<thead>
<tr>
<th>Condition</th>
<th>Surface order</th>
<th>Grammatical hierarchy</th>
<th>Quantifier Hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Double object/“a–each”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The celebrity gave1</td>
<td>a reporter from the newspaper each in-depth interview, but2</td>
<td>S &lt; Pl</td>
<td>S &lt; Pl</td>
</tr>
<tr>
<td>the reporter(s) was/were3</td>
<td>not very4</td>
<td>interested5</td>
<td></td>
</tr>
<tr>
<td>B. Double object/“each–a”</td>
<td></td>
<td></td>
<td></td>
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Note: S = singular. Pl = plural. Includes examples of dative and double-object sentences. Vertical lines delimit analysis regions, and slashes denote alternatives.
Datives: “a-each” harder than “each-a” order.

Double Objects: “each-a” harder than “each-a” order.

Evidence for processing difficulty when Quantifier and Grammatical Hierarchies are in conflict?

Also “a-each” overall much harder than “each-a”.

Evidence for linear order constraint?
A Role for Context?

- Key question concerns the role of prior discourse context in resolving quantifier scope ambiguity.
- Can context eliminate ambiguity (e.g., in line with Referential theory)?
- Anderson (2004) conducted only study to date to examine effects of context.
  - Ambiguous sentences embedded in contexts that supported either a single-referent or a many-referent reading of an indefinite phrase.
  - Preference for first quantifier to take wide scope.
  - No indication of context effect.
Anderson (2004)

One-referent context: One weekend, the climbing equipment shop sponsored a show to demonstrate the sport.

Many-referent context: One weekend, the climbing equipment shop sponsored a race between climbing enthusiasts.

While an announcer described the techniques, *an experienced climber scaled every cliff.*
Under-specification

- An alternative approach to quantifier scope ambiguity has been proposed in the computational (e.g., Hobbs & Shieber, 1987; Poesio, 1996; Reyle, 1993) and processing literature (e.g., Sanford & Sturt, 2002).

- These approaches assume that an underspecified representation is initially computed (that encompasses alternative readings of ambiguity).

- From this representation, more restricted readings can be obtained, for example, by application of syntactic preferences, world-knowledge, or topic/focus distinction.
Under-specification: Shallow Processing

- Provided levels of processing account of interpretation, and argued that many aspect of sentence may be subject to shallow processing.
- Standard assumption is that words undergo full lexical, syntactic, and semantic processing during comprehension.
- According to shall processing account, this may not be the case, and some aspects of sentence may be processed to a greater degree than others.
- Argue that in many cases, quantifier scope is not processed.

Sanford & Sturt (2002), Sanford & Graesser (2006)
Under-specification: Shallow Processing

- Also point to important of message level influences on interpretation.
- Imagine, on booking a hotel room, that you are told: “Every room has a bath.” Would it be acceptable if there was a single bath at the end of the corridor?
- Similar, if told “every student has a tutor”, does it matter if there is a 1-to-1 pairing, or just that each student has a particular person they can meet?

Sanford & Sturt (2002), Sanford & Graesser (2006)
Quiz questions

- World religions
- What is the name of the holy book in Islam?
- Where was the Buddha born?
- How many disciples did Jesus have?
- How many animals of each sort did Moses put on the Ark?
- How many brothers did Joseph have?
Quiz questions

- Legal matters
- What is the legal age for alcohol consumption in Denmark?
- What is a legal age for marriage in England?
- Can a woman marry her male cousin?
- Can a man marry his widow's sister?
- Can a divorced woman keep her married surname?
A brief note on shallow processing

Commonly assumed that linguistic information is fully processed.
However, evidence to suggest that this is not always the case, and that there partial or shallow processing.

Can a man marry his widow's sister? No, he's dead!

How many animals of each sort did Moses put on the Ark?
None. It was Noah.

Perhaps complex scope dependencies are frequently shallow processed.
Conclusions

- Quantifier scope is potentially an important topic for revealing processes underlying semantic interpretation.
- Data on quantifier scope processing is mixed, and clearly many issues remain to be addressed, including the role of context and knowledge in determining scope.
- The topic also has the potential to reveal processing mechanisms underlying computation of sentence meaning, and to reveal the depth that linguistic information is processed during comprehension.
References

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