Quantifier Processing: Theories of Semantic Interpretation

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Lecture 3 topics:

1. Processing accounts and semantic interpretation
2. Theories of semantic interpretation
   a. Optimality theoretic semantics
   b. Identifying restrictor clauses
3. Empirical studies of quantifier processing
Processing Accounts

- Formal accounts of syntax describe structural relations between words in a sentence in a language.
- Processing accounts are concerned with how structures are computed during comprehension and production.
- A fundamental aim is to explain how the language processor resolves structural ambiguity.
  - These can be global ambiguities, or local (often temporary) ambiguities.
Processing Accounts

- Examples of syntactic ambiguity:
  
  Visiting relatives can be boring.
  The horse raced past the barn fell.
  The old man the ships.

- A syntactic processing account must explain the difficulty experienced in reading these sentences in terms of the real-time computation of syntactic structure.
Processing Accounts

- Formal semantics provides framework for understanding how “meaning” of a sentence is computed.

- Processing accounts must explain how these meanings are arrived at during comprehension (and how they inform production).

- Much less attention to semantic interpretation than to syntactic processing in psycholinguistic research. However, several recent accounts have been proposed.
An ambiguity

“There were six ships on the horizon. Three ships sank.”

- Is “three ships” interpreted with respect to context?

- Two possibilities:
  - Presuppositional / subset reading: 3 of the 6 ships.
  - Existential / new set reading: 3 other ships.

- Same ambiguity found with bare quantifiers:
  “There were six ships on the horizon. Three sank.”
Optimality Theoretic Semantics

- Theory strongly influenced by connectionist approaches.
- Assumes that semantic interpretation involves the optimal satisfaction of set of multiple, ranked, “soft” constraints.
- Constraints take form of general rules, ranked in terms of importance, and said to be “soft” because constraint that is more highly ranked can override one that is lower ranking.
- Possible interpretations are considered in parallel and the interpretation ultimately selected is one that optimally satisfies the constraints.
Optimality Theoretic Semantics

- Hendriks & de Hoop (2001) outline several possible constraints on the interpretation of anaphora that are relevant to our example problem:
  - DOAP (“don’t overlook anaphoric possibilities.”)
  - Topicality: reference to the current discourse topic is preferred.
  - Forward-directionality
  - Parallelism: anaphor preferentially refers to element in a parallel syntactic position.
  - Ten students attended the meeting. Three didn’t.
  - (Requires that three refers to students not profs)
  - Emptiness: antecedent should refer to non-empty set.
Optimality Theoretic Semantics

- Forward-directionality

“Topic range induced by the domain of quantification of a determiner (set A) is reduced to the topic range induced by the intersection of the two argument sets of this determiner (A \ B)” (Hendriks & de Hoop, 2001: p19).
Ten students attended the meeting. Three spoke.
- First argument of the quantifier is the set of students.
- Second argument is the set of persons who attended the meeting.
- Intersection of the two argument sets corresponds to the set of ten students who attended the meeting.

- Accordingly, preference for interpreting “three” as referring to ‘three of the ten students’.
- Forward-directionality predicts preference for subset reading of ambiguity.
Identifying the Restrictor Clause

- Diesing (1990): Mapping Hypothesis

- Proposed tripartite structure for quantification.
  
  Quantifier
  Restrictor
  Nuclear Scope

- Material in VP maps onto Nuclear Scope
All men laugh.

- Quantifier: All(x)
- Restrictor: Men (x)
- Nuclear Scope: laugh
Identifying the Restrictor Clause

- Frazier’s (1999) proposal:
  - Except possibly for indefinites every overt NP in subject position immediately initiates a search for a restrictor clause as does a definite NP in any position.
  - Modified this account to state that any “strong” determiner phrase initiates search for restrictor clause.
Strong & Weak Quantifiers.

- Milsark (1977) argued for broad distinction between determiners that encompasses well-known distinction between definite and indefinite expressions.

- “Strong” determiners are inherently relational but “weak” determiners aren’t.

- “Most X are Y” means that most individuals in given set of X’s are Ys.

- This presupposes set of X's in discourse context.
Strong & Weak Quantifiers.

Milsark used existential there-sentences as test of this distinction, based on the argument that because strong determiners already presuppose existence, this will create a tautology that renders sentences unacceptable.

1. There is a boy in the garden.
2. There are some boys in the garden.
3. There are many boys in the garden.
4. #There is the boy in the garden.
5. #There is every boy in the garden.
6. #There are most boys in the garden.
Identifying the Restrictor Clause

- So, following Frazier's approach, strong determiners will initiate search for restricting information.

- Restricting information may:
  a) Be overtly supplied in the sentence.
  b) Extracted from prior discourse context.
  c) Have consequences for structural processing decisions.
Identifying the Restrictor Clause

There were six ships on the horizon.

1. Three ships sank.
2. A fisherman said that every ship sank.
3. A fisherman said that some ships sank.

- In (1), “three ships” initiates search for restrictor clause, which is provided by context.
- In (2), “every ship” is “strong” so initiates search for restrictor clause.
- In (3), “some ships” is “weak”, so doesn’t initiate search for restrictor clause.
Empirical Research

- Is there evidence of a preference for the subset reading of a referential ambiguity?

- Is this preference observed during on-line sentence processing?

- When in the course of comprehension is this preference observed?
Empirical Research

Judgement task Frazier et al. (2005)
- 65% preference for presuppositional interpretation.
- (effect disappears for Q in object position)

Sentence completions Kaan et al. (2007)
- 74% preference for presuppositional interpretation.
Empirical Research

Continuous acceptability judgements Wijnen & Kaan (2006)

- Participants use button press to indicate acceptability of portions of text.

- Increased proportion of rejections following cardinality mismatch (i.e., two boys...three...).
Empirical Research

Frazier et al. (2005) examined eye movements while reading

Five ships appeared on the horizon. Three ships sank.
1. Two / Six were bombarded by enemy fire.
2. Two of them were bombarded by enemy fire.
3. Another six were bombarded by enemy fire.

- Longest reading times at cardinal (e.g., six) when this exceeded cardinality of context set.
- Evidence for on-line assessment of anaphoric relationship?
Empirical Research

Kaan et al. (2007) conducted an ERP experiment:

- Participants read short texts containing cardinals, viewing 1 or 2 of words at a time.
- Subset condition:
  Twelve flowers were put in the vase. Six had a broken stem and had to be cut very short.
- New set condition:
  Four flowers were put in the vase. Six had a broken stem and were trashed.
Empirical Research

- No effects prior to 900ms following onset of cardinal.
- Late posterior positivity effect between 900-1400ms, larger when cardinals receive new set interpretation.
Empirical Research

Paterson et al. (2009) examined eye movements while reading.
- Manipulated set size in context sentence
- Used identical critical regions across conditions.

The fishermen saw two / six ships on the horizon. Apparently, three ships had been bombarded ...
Of these, three ships had been bombarded ...
Another three ships had been bombarded ...
The fishermen saw six ships appear on the horizon. Apparently, three ships had been bombarded by enemy fire.

How many ships are there in total?
Empirical Research

- Eye movement record reveals sequence and duration of fixations during normal text comprehension.
- Can use multiple dependent variables:
  - Can partition eye movement record to analyse spatially or temporally contiguous fixations.
  - Some measures are sensitive to early processing events, others are sensitive to later stages of processing.
  - Together, they are informative about the time course of an effect.
Example Stimuli

*Ambiguous presuppositional*
The fishermen saw six ships appear on the horizon.1 |
Apparently, 2 | three ships3 | had been4 | bombarded by enemy fire.5

*Ambiguous existential*
The fishermen saw two ships appear on the horizon.1 |
Apparently, 2 | three ships3 | had been4 | bombarded by enemy fire.5

*Unambiguous presuppositional*
The fishermen saw six ships appear on the horizon.1 |
Of these, 2 | three ships3 | had been4 | bombarded by enemy fire.5

*Unambiguous existential*
The fishermen saw two ships appear on the horizon.1 |
Another 2 | three ships3 | had been4 | bombarded by enemy fire.5
Empirical Research

- Total reading times for anaphor are longer in “ambiguous existential” condition, indicating difficulty in processing.

- Evidence that number mismatch disrupts sentence processing, in line with theoretical accounts.

- This effect appears earliest in total reading times, suggesting that effects emerge relatively late in sentence processing.
What about weak vs. strong?

- Evidence that contrastive focus influences parsing decision (Liversedge et al., 2002; Ni et al., 1996; Paterson et al., 1999).

- Only motorists stopped in the car park received a warning.

- Most parsimonious to contrast 2 sets of motorists - creates expectation of modifying information that specifies nature of the contrast.
What about weak vs. strong?

- Do strong quantifiers behave similarly? (Paterson & Sauermann)

- Preliminary data indicate larger garden path effect for "many" than for "most"

  Many motorists stopped in the car park received a warning.

  Most motorists stopped in the car park received a warning.
Empirical Research

• So far considered complex examples involving focus effects and the resolution of quantificational anaphora.

• Is there evidence from simpler examples that quantifiers are fully processed as they are encountered in discourse?
Empirical Research

- Urbach & Kutas (2010) examined quantifier function & plausibility
  - Most farmers grow crops - highly plausible
  - Few farmers grow crops - less plausible
  - Most farmers grow worms - highly implausible
  - Few farmers grow worms - plausible
- If quantifier function is computed incrementally, this difference in plausibility should be evident early in processing.
- Study used EEG and specifically the N400 effect to investigate time course of quantifier processing.
Empirical Research

- Offline judgements showed expected patterns of acceptability
  
  Most farmers ... crops > Most farmers ... worms.

  Few farmers ... crops < Few farmers ... worms.

- However, EEG findings showed N400 disruption when noun was atypical, regardless of quantifier.

- Evidence that full interpretation of quantifier is not computed incrementally during comprehension? - at least, not in case of negative quantifiers (e.g., “few”)?

- Similar pattern observed for “often” vs. “rarely”.
Empirical Research

Experiment 2

(A) Off-line sentence rating

(B) Midline ERPs

(C) On-line N400 amplitude

(D) N400 and Slow Wave
Empirical Research

- Other research has examined time-course of scalar implicature.
  - “Some” logically implies “not all”, but often licenses the scalar implicature of “not all”.
  - Research has examined the timing and conditions under which the “not all” interpretation is reached.
- Evidence that scalar implicature is time-consuming, and so may not be a default interpretation (e.g., Bott & Noveck, 2004; but see Huang & Snedeker, 2008).
- Other evidence that interpretations are contextually licensed (Breheny et al., 2006).
- Others point to individual differences in response strategies (Feeney et al., 2004).
Some Conclusions


- To date, tests of the theories have focused on the interpretation of quantificational anaphora - evidence supports general claims.
References


References


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