Pragmatic interpretation and use of numerically-quantified expressions

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Overview

- Numerical expressions in language
  - Semantic/pragmatic analyses of number
  - Comparative and superlative quantifiers
- Constraints on (numerical) quantifier use?
  - Implementing a constraint-based model
  - Testing and refining it

Number and linguistics

- Semantic and pragmatic treatment of
  - the meaning of numerals
    - e.g. Barwise and Cooper (1981), Carston (1998), Geurts (2006), Krifka (2007), etc. etc.
  - the meaning of expressions containing numerals
    - e.g. Geurts and Nouwen (2007), Geurts et al. (in press), Breheny (2008), etc. etc.

Core meaning of numerals

- Intuitively, this ‘obvious’ abstract property
- However, multiple meanings of numerals:

  “John has two children” [Exact]

  “People with two cars should pay extra taxes” [Lower bounding]

  “You can have 2000 calories without putting on weight” [Upper bounding]

- Which is the core meaning? Or are they all?

Comparative and superlative quantifiers

- Comparative quantifiers:
  “more than”, “fewer/less than”
- Superlative quantifiers:
  “at least”, “at most”

- Both take numerals as arguments:
  “more than two”, “at least three”, etc.

Semantics of comparative and superlative quantifiers

- “More than” $>$
- “Fewer than” $<$
- “At least” $\geq$
- “At most” $\leq$
- “There are more than five people” $\Leftrightarrow$ $|People| > 5$

- Could there be more to it than that?

Redundancy of comparative and superlative quantifiers?

- “There are more than five people” ⇔ $|\text{People}| > 5$
- “There are at least six people” ⇔ $|\text{People}| \geq 6$
- But $|\text{People}| > 5$ ⇔ $|\text{People}| \geq 6$ …assuming that people are indivisible…

Redundancy of comparative and superlative quantifiers?

- On the classical view
  - “more than n” means the same as “at least n+1”
  - “fewer than n” means the same as “at most n-1”

- So why have both types of quantifier in the system?

Other motivations for Geurts and Nouwen's modal account

- Comparative and superlative quantifiers differ:
  - In the inferences they admit
  - In distribution
  - In whether they allow a specific construal

    "There were at least three people, namely Tom, Dick and Harry"

    *"There were more than two people, namely Tom, Dick and Harry"
  - In whether they give rise to an ambiguity

    "You may have at most three/fewer than four drinks"
  - And more…

The modal account

- Comparative quantifiers are purely >, <
- Superlative quantifiers:
  - "at most *n*" grants the possibility of *n*, and excludes the possibility of "more than *n*"
  - "at least *n*" grants the possibility of *n*, and excludes the possibility of "fewer than *n*"
- Differences ensue
  - more so for "at most" than "at least"

What the modal account does

- Comparative and superlative quantifiers differ:
  - In the inferences they admit
  - In distribution
  - In whether they allow a specific construal

Does “at most two” imply “at most three”?

NO (c. 90% of participants)

What the modal account does

- Comparative and superlative quantifiers differ:
  - **In the inferences they admit**
  - In distribution
  - In whether they allow a specific construal

Extra contexts for superlatives make some kind of sense with modality

What the modal account does

- Comparative and superlative quantifiers differ:
  - In the inferences they admit
  - In distribution
  - **In whether they allow a specific construal**

Modal possibility specifies referent for following clause ("at most two people" = "it is possible that two people…")

What else the modal account does

- Additional prediction #1:
  - Superlative quantifiers will be acquired later than comparative quantifiers

- A good prediction, because
  - (i) it's readily testable
  - (ii) it's already been shown to be correct (Musolino 2004)

Testing the order of acquisition

“Please make the toys and boxes match my sentence…”
“At least three of the boxes have a ball”

What else the modal account does

- Additional prediction #2:
  - Superlative quantifiers will be processed more slowly than comparative quantifiers

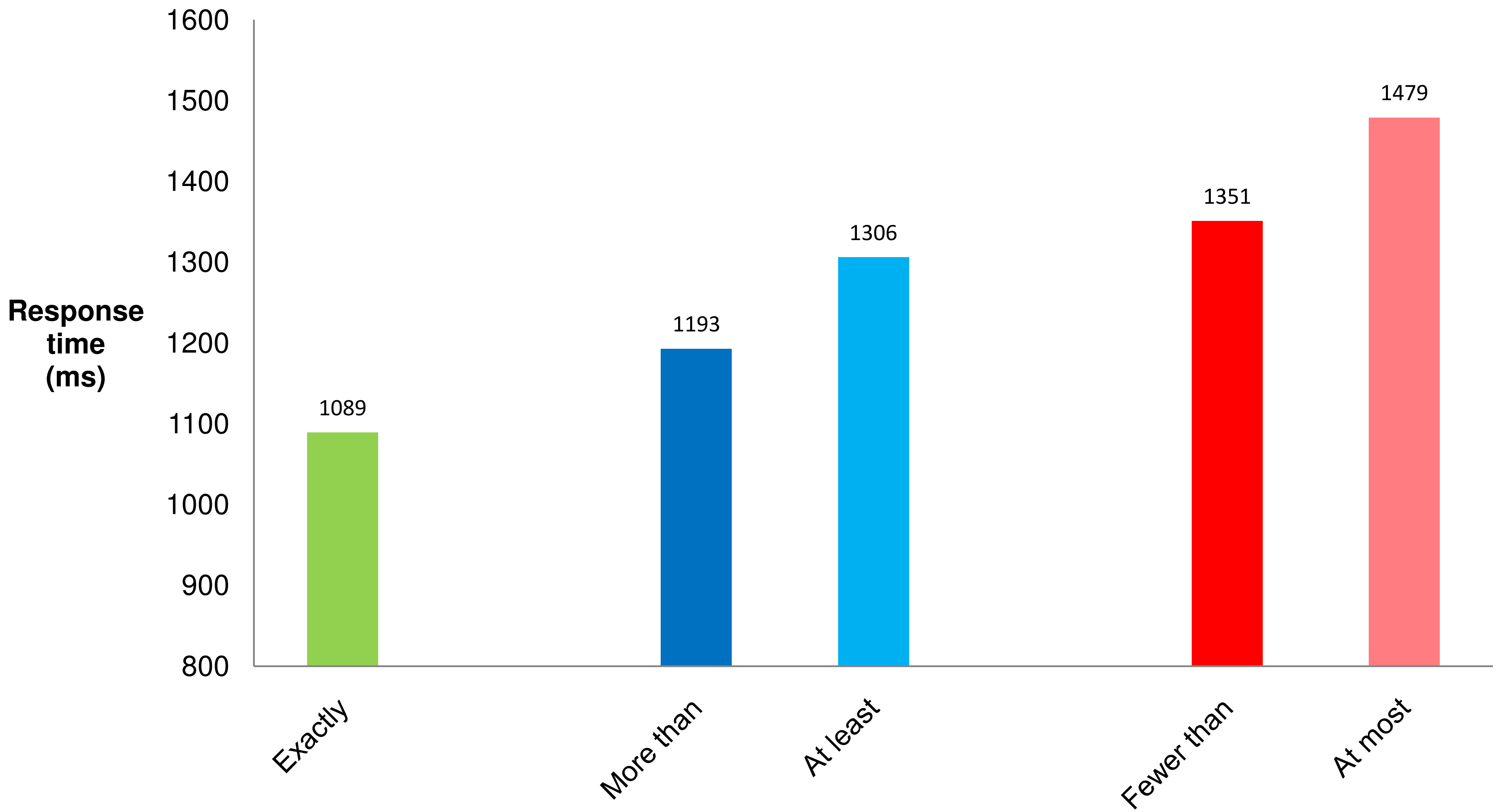
Testing the ease of processing

There are [ ] Bs

Testing the ease of processing

BBB

Testing the ease of processing



Interim summary

- Modal account explains
  - different inference patterns
  - differences in distribution
  - specific construal of superlative quantifier
  - order of acquisition
  - difference in processing difficulty

  better than the existing ‘classical’ account

Specific construal, revisited

- "At most two people have that authority, namely the Queen and the Prime Minister" vs.
  * "Fewer than three people have that authority, namely the Queen and the Prime Minister"

- What about
  "No(t) more than two people have that authority, namely the Queen and the Prime Minister"?

- Does it work just because we *mentioned* "two"?

Distribution, revisited

– "Wilma danced with Fred and Barney, at least"
  vs.
  *"Wilma danced with Fred and Barney, more than"

"More than" … so something else is relevant…

…but we didn't mention it in the first clause…

…so it can't be relevant, or we're inconsistent…

…so the utterance is infelicitous

Interim summary, revisited

- Modal account explains
  - different inference patterns
  - order of acquisition
  - difference in processing difficulty

  better than the existing 'classical' account

Alternative proposal

- Superlative quantifiers are not semantically modal, but they are **marked**

- Matters arising:
  - Why?
  - Does it work?
  - Is it better?

Complexity of non-strict comparison

- Idea: non-strict comparison (≥, ≤) more complex than strict comparison (>, <)

- True if
  - "bigger than" and "same as" are the simplex operators
  - the expressions with disjunction reflect the way we think about these structures
  - it's actually the case that non-strict comparison is harder to work with

Testing the ease of processing, again

There are [ ] Bs

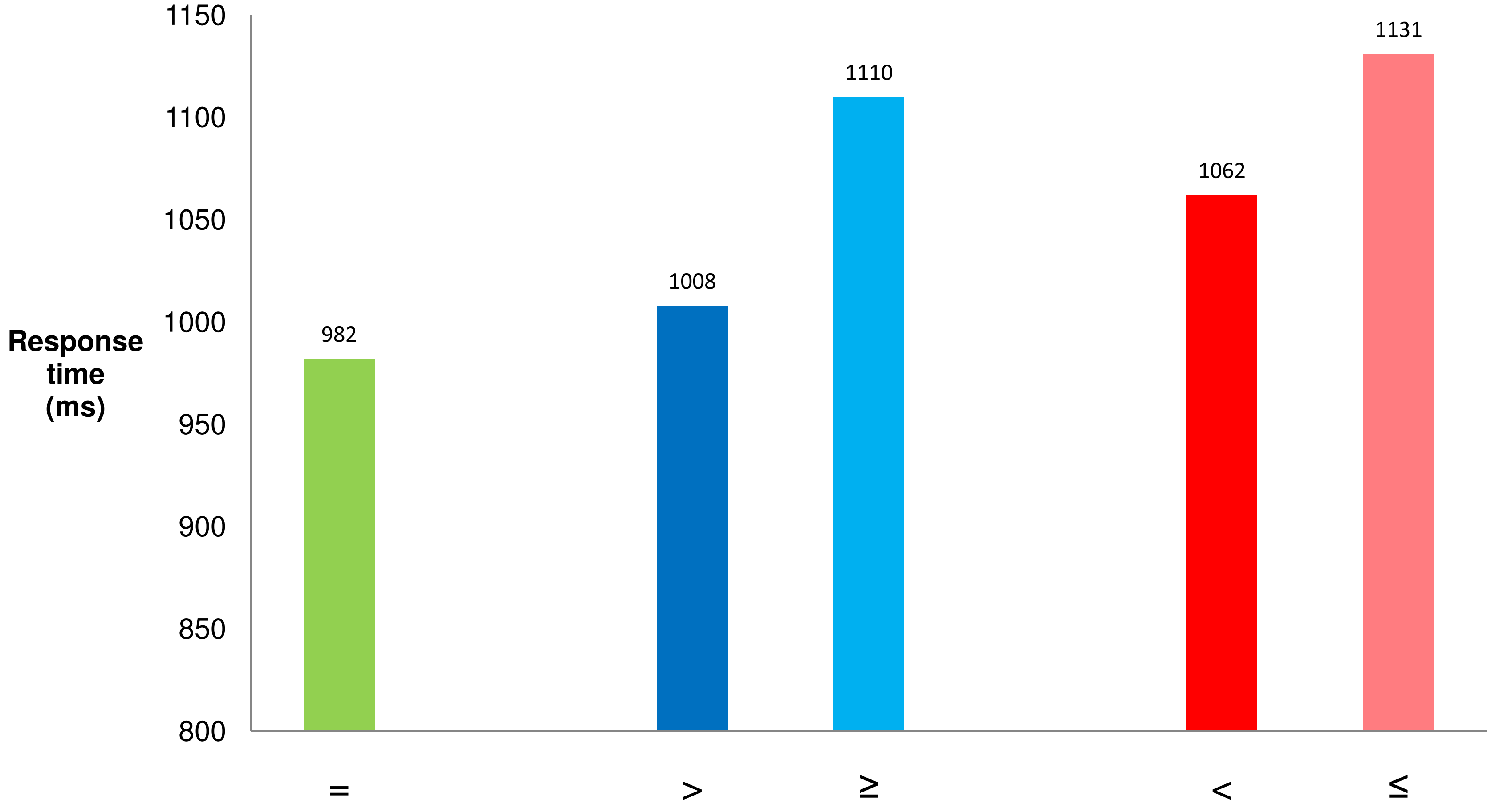
Testing the ease of processing, again

$B \geq 2$

Testing the ease of processing, again

BBB

Testing the ease of processing, again



Acquisition, complexity, etc.

- Assuming that non-strict comparison is more complex than strict, it's reasonable to suppose that the corresponding linguistic forms are marked
- This also predicts
  - Lower frequency
  - Later acquisition
  - Processing delays

Reasoning patterns, revisited

- "at most two" does not imply "at most three"
  - If not a semantic contradiction, as in the modal account, why does this not go through?

- Idea: Markedness implicature
  - "at most" implicates a meaning like the modal semantic meaning, if it's not licensed for any other reason

- cf. *p* failing to imply "*p* or *q*" under similar conditions
  - Blocked by implicature of "possibly not *p*"?

Evidence for the markedness account (1)

- Experiment 1: Testing the acceptability of utterances in which the 'modality' is contradicted

- Coherence judgement on items such as

  "John has at most three cars; specifically, he has exactly two/three"

  No preference towards the items for which the modality is not contradicted

Evidence for the markedness account (2)

- Experiment 2: Testing for modality under the scope of the conditional

- Items such as

  "Anyone who has had at most three drinks is fit to drive; and Berta has had at most two drinks".

  Follow-up question: Does this speaker think that Berta is fit to drive?

  Yes – therefore modality fails to function here

Evidence for the markedness account (2)

- Can explain this under this account as follows:

  "Anyone who has had at most three drinks is fit to drive; and Berta has had at most two drinks".

  Implicature would be

  "Anyone who has had no more than three drinks, and possibly exactly three, is fit to drive"

  Not additionally informative, so no point in calculating it

Evidence for the markedness account (3)

- Can we elicit acceptance of the same inference in a declarative context?

- Implication judgement on items such as

  Jane has three cars but John has at most two cars
  Jane and John each have at most three cars

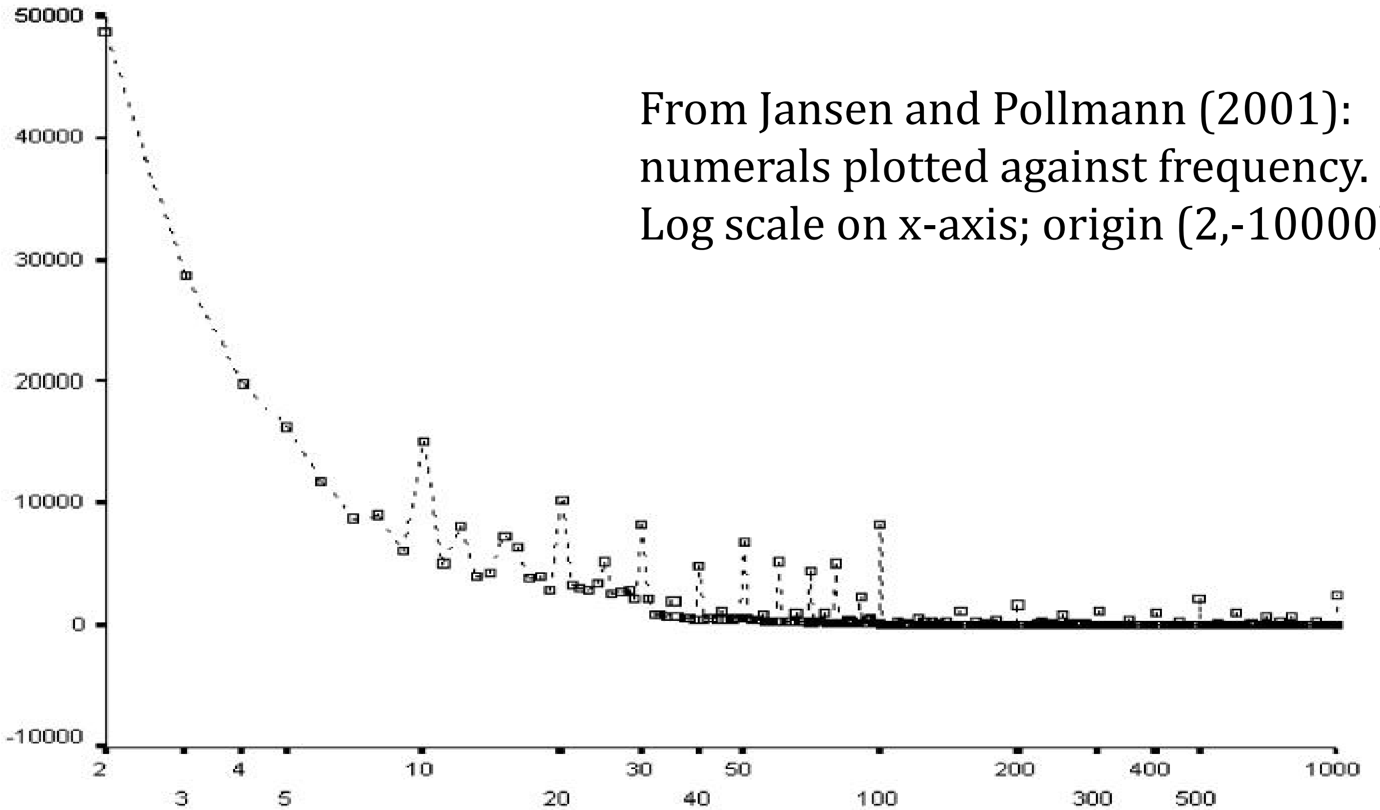
- 68% acceptance of "at most *n*" to "at most *n+1*"

Summary

- Evidence against narrow 'classical' semantics for superlative quantifiers (Geurts and Nouwen 2007, Geurts et al. in press)
- But – evidence against specific modal proposal
- Approach oriented around markedness implicature seems to reconcile both data sets

Differential salience of numbers

- ‘Round numbers’ more salient, more widely used



From Jansen and Pollmann (2001): numerals plotted against frequency. Log scale on x-axis; origin (2,-10000)

Differential interpretation of numbers

- Round numbers also liable to approximate reading

29,003 ft

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- Round numbers also liable to approximate reading

29,003 ft

Constraints on quantifier usage?

Do…	**Do not…**
…be brief	…use a complex quantifier
…be informative	…be ambiguous
…address the question under discussion	…be overinformative
…use a salient number	etc.
etc.	

Constraint-based model

- Full set of constraints
  - Also specifying how violations are to be evaluated
- Constraint ranking
- Decision procedure
  - To compare possible ‘outputs’ (choices of quantifier) and see how well they do with respect to the constraint ranking

Constraint-based model - example

- Constraints:
  (1) *COMPLEX,
  (2) SALIENTNUMBER
  (3) INFORM

- Situation: 21-24 people present
  - “at least 20” violates (1) and (3)
  - “at least 21” violates (1) and (2)
  - “ more than 20” violates no constraints

Constraint-based model - example

- Constraints:
  (1) *COMPLEX,
  (2) SALIENTNUMBER
  (3) INFORM

- Situation: 20-24 people present
  - "at least 20" violates (1)
  - "more than 19" violates (2)

Constraint-based model - example

- Constraints:
  (1) *COMPLEX,
  (2) SALIENTNUMBER
  (3) INFORM

- Situation: 22-24 people present
  – "at least 20" violates (1) and (3)
  – "at least 22" violates (1) and (2)
  – " more than 20" violates (3)

Testing and developing the model

- Establish constraint set by providing evidence for each constraint functioning independently
- Establish constraint ranking for an individual, and then determine whether this is predictively powerful

- Might need to apply alternative to classical OT…

Conclusion

- Preference for strict comparison could cause preference for comparative quantifiers, through markedness

- Nature of comparison could also explain distributional differences

- Would like to extend markedness-oriented approach to other quantifiers, possibly by invoking a constraint-based model

Thank you!

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