NYU Semantics Group, 4 May 2016

Being rational with expressions of number

Chris Cummins

University of Edinburgh

c.r.cummins@gmail.com

Overview

- Some past work with relevance to the semantic/pragmatic analysis of quantity expressions

- Some ongoing work with potential practical application to communicative purposes

- Some speculation about the relevance of all this to work on (ir)rationality in reasoning

Quantity expressions

- Numerical and non-numerical expressions ("four", "more than four", "some", "most"...)

- What do they mean, when used in normal interactions?

- Which aspects of meaning are semantic and which are pragmatic?

  - For example, what kinds of quantity implicature arise from these expressions?

  - (From a Gricean standpoint, "Quantity" is applicable to any expression, but numerical ones are particularly interesting in some respects...)

Multiple meanings of plain numerals

- *Mary has three children*

    ...in fact, she has five

    *...in fact, she has two

- Idea that exact (punctual, double-bounded, bilateral) number meaning is due to an implicature
    - "Mary has three children" has existential semantics and means that "Mary has at least three children"
    - Speaker did not say "Mary has four children"
    - Hence (assuming speaker is knowledgeable and cooperative), Mary does not have at least four children
    - Therefore Mary must have exactly three children

Multiple meanings of plain numerals

- *Mary has three children*

  …in fact, she has five

  *…in fact, she has two

- Idea that exact (punctual, double-bounded, bilateral) number meaning is due to an implicature

- Somewhat counterintuitive, e.g. in terms of the acquisition of number

- Argued against by Breheny (2008), and seemingly unpopular at present

- However, idea persists that mathematical intuitions aren't necessarily a good basis for semantic analyses…

Most

- Theoretically troublesome distributional differences between *most* and *more than half* (Solt in press)
    - *More than 50% of /??Most Americans are female*
    - *Trump has won ?most/*more than half of the Republican delegates*

Two classes of modifier

- Nouwen (2010): *more/less than* as opposed to *at most/least, minimally/maximally, up to, no more/less than*

- For integer quantities, *more than three* traditionally held to be equivalent to *at least four*, for instance

- However, distributional differences again
  - *Squares/pentagons have more than three sides*
  - *??Squares/pentagons have at least four sides*

- Most approaches posit differences in the semantics, but I'm keen to explore pragmatic factors in the mix too

Implicatures from "more than *n*"?

- With particular reference to cardinal contexts, e.g. "there are more than *n* people in the room"

- Argument in literature that "more than *n*" does not give rise to scalar implicatures
  - "*Mary has more than three children*" does not implicate "*It is not the case that Mary has more than four children*"

- However
  - this only seems to apply to cardinal usages (cf. "*The average family has more than two children*")
  - this only seems to apply to certain numbers (cf. ?"*More than 1000/7000 people live in NYC*")

Role of numeral 'roundness'

- Conjecture: there are implicatures, but they depend on the roundness of alternative numerals
  - e.g. *more than 70* implicates *not more than 80*, but does not implicate *not more than 71*
  - Argued on the basis of the additional cognitive costs associated with using non-round numbers
    - The speaker may choose to say "*more than 70*", even if they know that "*more than 71*" is true
    - Correspondingly, the hearer cannot infer that "*more than 71*" is not true from hearing "*more than 70*"
    - However, a speaker who knows that "*more than 80*" is true should say this rather than "*more than 70*"

Role of numeral 'roundness'

- Conjecture: there are implicatures, but they depend on the roundness of alternative numerals
  - e.g. *more than 70* implicates *not more than 80*, but does not implicate *not more than 71*
  - Supported by data from Cummins, Sauerland and Solt (2012)
    - For instance, *more than 100* compatible with higher values than *more than 110*
    - *More than 100* attracts various different pragmatic upper-bounds (110, 125, 150, 200…)
- So "more than n" can give rise to implicatures (or similar) but these don't necessarily involve the number $n+1$

Problem of alternatives

- Special case of a very general problem: which alternatives are pragmatically active, as a source of implicature?

  - Quantity implicatures classically about some stronger (entailing) alternative, but not all stronger alternatives give rise to implicature, and some other alternatives seem to do so…

  - Horn scales are a partial answer to this for one class of expression, but don't exhaust the issue

Practical issue: resulting meaning

- Alongside the theoretical questions about how the meaning comes about, interested in the practical question of what it is

- Quantity expressions, especially of number, often used in reporting high-stakes information, e.g. about risk

- Widespread assumption that general audiences not good at interpreting numerical information about risk

- More qualitative information favoured, but potentially problematic in its vagueness ("some", "could", …)

Side-effect risks

- Standard descriptors used in the EU and other markets

- e.g. *common*
  - What does this mean?
  - What does this mean, given the rest of the system?
    - *Very common*
    - *Common*
    - *Uncommon*
    - *Rare*
    - *Very rare*

Issues?

- Choice of terms is wrong: the meanings are systematically misunderstood, both by doctors and patients

- Premise is flawed:
  - Can't just stipulate new meanings for everyday words
  - Can't prevent pragmatic modulation of these meanings
    - *Smith is a common surname* vs.
      Difficulties with mobility are a common effect of aging

- But numerical expressions not a good solution, if we don't know what these mean either…

Pragmatics and decision-making

- These issues suggest a need for better understanding the ultimate meanings of quantity expressions (tricky)

- Would like to support better decision-making, so it's relevant to consider the interface with non-linguistic processes of this kind

- However, it's also been suggested that pragmatic factors might be relevant to the study of decision-making itself
  - Notably, work on cognitive biases

Framing effects

- Simplest case: Levin (1987) – *25% fat* vs. *75% lean*
  - Participants 'irrationally' prefer ground beef with the latter description over an identical product with the former description
  - Argued as evidence for our susceptibility to framing effects: how information is presented determines the conclusions we draw
  - However, this does require that the descriptions are equivalent:
    - *Fat* and *lean* must be complementaries – probably OK
    - Percentage values must attract punctual interpretations, rather than (for instance) existential/lower-bound ones – ?

Risky-choice framing

- Tversky and Kahneman (1981): selecting program to deal with an outbreak of disease "expected to kill 600 people"

Program A:
200 people will be saved

72 | 28

Program B:
1/3 probability that 600 will be saved; 2/3 probability none will be

Program C:
400 people will die

22 | 78

Program D:
1/3 probability that no-one will die; 2/3 probability that 600 will

Assumption of equivalence

- Again, irrational if we assume that the numbers given take exact meanings

- However, if we assume they are lower-bounded, A and C are certainly not equivalent: A is better (B vs. D less clear)
  - "Pragmatic" preference structure, coupled with decisions based naively on expected values, matches preferences in data

- Similar points made occasionally in the pragmatics literature, but first tested (AFAIK) by Mandel (2014)
  - Participants more 'rational' when the meaning of the numerical expressions is clarified with "exactly"

A note of caution, then

- Mandel: conclusions of irrationality in risky choice framing rely on extensional equivalence, which in turn relies on naïve bilateralism

- Similar arguments seem to apply to other classic demonstrations of cognitive biases, e.g. conjunction fallacy

Conjunction fallacy

- Tversky and Kahneman (1983)

- *Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.*

- Which is more probable?

  1. Linda is a bank teller.
  2. Linda is a bank teller and is active in the feminist movement.

- Irrational to prefer (2)…

- …unless you think the task should make sense…

A note of caution, then

- Mandel: conclusions of irrationality in risky choice framing rely on extensional equivalence, which in turn relies on naïve bilateralism

- Similar arguments seem to apply to other classic demonstrations of cognitive biases, e.g. conjunction fallacy
  - Even a small pragmatic effect might tip the balance
  - Perhaps the tasks promote pragmatic enrichment

- Parallel with the medical communication case: experimenters taking refuge in the semantics

Future goals

- Trying to see how much of the irrationality in reasoning is actually rationality in utterance interpretation

- Looking at the totality of interpretation of quantified expressions (Mandel simplifies somewhat)

- Trying to get at the fine detail that is pertinent for understanding what these expressions mean and how they (in some sense) ought to be used

Thank you!

References

Breheny, R. (2008). A new look at the semantics and pragmatics of numerically quantified noun phrases. *Journal of Semantics*, 25: 93–139.

Cummins, C., Sauerland, U. and Solt, S. (2012). Granularity and scalar implicature in numerical expressions. *Linguistics and Philosophy*, 35: 135–169

Levin, I. P. (1987). Associative effects of information framing. *Bulletin of the Psychonomic Society*, 25: 85-86.

Mandel, D. R. (2014). Do framing effects reveal irrational choice? *Journal of Experimental Psychology: General*, 143(3): 1185-1198.

Nouwen, R. (2010). Two kinds of modified numerals. *Semantics and Pragmatics*, 3: 1–41.

Solt, S. (in press). On quantification and measurement: the case of 'most' and 'more than half'. *Language*.

Tversky, A. and Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211, 453-458.

Tversky, A. and Kahneman D. (1983). Extension versus intuitive reasoning: the conjunction fallacy in probability judgment. *Psychological Review*, 90, 293-315.