The inquisitive semantics and pragmatics of modified numerals
Matthijs Westera
Santa Cruz, February 4th, 2013

• Example (1) seems to show that superlatively modified numerals implicate/entail ignorance, while comparatively modified numerals don't (Nouwen, 2007, 2010).

(1) a. # A hexagon has at least five sides.
b. A hexagon has more than four sides.
c. # A hexagon has at most seven sides.
d. A hexagon has fewer than eight sides.

• In the literature:
  ◦ No explanation of (1) exists that does not stipulate a semantic difference between the two kinds of modifiers.
  ◦ Actual patterns in natural language, to be discussed, are more subtle (Coppock and Brochhagen (ms.)).

Claim of this talk:
The finer grain of unrestricted inquisitive semantics provides sufficient foothold for a Gricean pragmatics to derive the relevant patterns (and more).

• Outline: First the framework, then the data.

1. Unrestricted inquisitive semantics (Ciardelli, 2009; Westera, 2012)

  • A possibility is a set of worlds. A proposition is a set of possibilities.
  • I assume the following FO formulae and meanings for the expressions in (2) and (3):

(2) a. John came or Bob came \( C_j \lor C_b \)
b. n people came \( \exists \ x . |x| = n \land C_x \)
   (depicted for \( n=1 \))

(3) a. John came or Bob came or both \( C_j \lor C_b \lor (C_j \land C_b) \)
b. at least \( n \) people came \( \exists \ x . |x| \geq n \land C_x \)
   (depicted for \( n=1 \))
c. more than \( n \) people came \( \exists \ x . |x| > n \land C_x \)
   (depicted for \( n=0 \))

• We can easily distinguish “\( n \)” from “at least \( n \)” even on a one-sided account of numerals.

• Indifference assumption: (mainly for easier drawing; perhaps linguistically interesting)
The individuals in the domain are not/cannot be distinguished.

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1 Financial support from the Netherlands Organisation for Scientific Research is gratefully acknowledged. Many thanks to Elizabeth Coppock and Thomas Brochhagen for intense discussions on the topic.
(4a) 2 people came  
(Here 0 people came)  
(Here 4 people came)  

b. At least 2 people came  
c. More than 1 person came

- On top of inquisitive semantics, I assume:

**Semantic domain restriction**  
Natural language quantifiers are semantically incomplete without a domain restriction. One might add the restriction to the formulae in (2) and (3), but I will leave it implicit.

(5) At least 2 people came (with implicit domain restriction: it was an even number of people)

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2. **Inquisitive pragmatics** (Westera, 2012+)

- A straightforward (…) application of Gricean pragmatics to inquisitive semantics.
- Most implicatures are computed only relative to an (explicit or implicit) QUD.

<table>
<thead>
<tr>
<th>QUD</th>
<th>Response</th>
<th>Implicatures</th>
</tr>
</thead>
</table>
| a. John came or Bob came. | Possibly John, poss. Bob (*possibility*)  
I'm not sure who (*ignorance*)  
Only one person came (*exhaustivity*) |
| (6) Who came?  
∃x. Cx | + | = |

<table>
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<tr>
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<th>Implicatures</th>
</tr>
</thead>
</table>
| b. John came or Bob came or both | Possibly John, poss. Bob, poss. both  
I'm not sure who  
Only one person came |

- The ignorance and exhaustivity implicatures, being quantity implicatures, occur only if a complete answer to the QUD is asked for (see granularity, below).
• On top of a Gricean backbone, I assume:

**Privacy Principle** (Schwarzschild, 2002)
The domain restriction of a quantifier may be known to only the speaker.

• As a consequence, the hearer may not be sure which possibilities are actually in the proposition conveyed. We can depict this as follows:
  ○ Solid ——— if the possibility is in the proposition for sure.
  ○ Dashed ------ if the possibility may not be in the proposition.
• Only the solid lines may yield possibility implicatures.

<table>
<thead>
<tr>
<th>QUD</th>
<th>Response</th>
<th>Implicatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(7) Who came? 1 person came</td>
<td>Possibly John, possibly Bob  Possibly (and certainly) one person I'm not sure who Only 1 person came</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QUD</th>
<th>Response</th>
<th>Implicatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(8) How many people came? 2 people came</td>
<td>Possibly John, possibly Bob  Possibly (and certainly) 2 people I'm not sure who Only 2 people came</td>
<td></td>
</tr>
</tbody>
</table>

**Beware:** Solid vs. dashed is not conceptually analogous to highlighted versus non-highlighted (Farkas and Roelofsen); though it may play the same role technically. Rather, the pictures give a hearer's perspective on what is communicated.

• I need one more assumption, that helps predict when quantity implicatures arise:

**Granularity assumption**
Mentioning a (witness for a) possibility (typically) commits one to a fine grain, and to seeking the *strongest answer* at that level of granularity.
• Superlative modifiers, but not comparatives, mention a possibility, and hence:
  ◦ reveal part of their domain restriction; and
  ◦ typically commit the speaker to a fine grain.

(9)a. At least 2 people came
b. More than 1 person came

\[ \begin{array}{c}
\bullet \bullet \bullet \\
\text{typical goal (fine grain)} \\
\end{array} \quad \begin{array}{c}
\bullet \bullet \bullet \\
\text{typical goal (coarse grain)} \\
\end{array} \]

**Prediction:** Comparative modifiers are more typically used with round numbers, or with contextually already salient numbers.

• We can now compare the implicatures of superlative vs. comparative modifiers:

<table>
<thead>
<tr>
<th>QUD</th>
<th>Response</th>
<th>Implicatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>(11) How many people came?</td>
<td>a. At least 2 people came</td>
<td>Possibly John, possibly Bob</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possibly 2 people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I'm not sure how many</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only 2 people came</td>
</tr>
<tr>
<td>b. More than 1 person came</td>
<td></td>
<td>Possibly John, possibly Bob</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Possibly 2 people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I'm not sure how many</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only 2 people came</td>
</tr>
</tbody>
</table>

• This yields two predictions that would seem incompatible with a semantic approach.

**Prediction:** Although a comparative modifier does not typically commit one to a fine granularity, the context may do so, in which case an ignorance implicature arises.

**Prediction:** Although a comparative modifier does not reveal its domain restriction, the context may strongly suggest one, in which case a possibility implicature arises.

• These predictions seem borne out in (12).

(12) A: Did 11, 12 or 13 people come to the party?
B: More than 11 people came. \( \rightarrow \) possibly 12, possibly 13, and I'm not sure how many.
3. Data

(1) a. # A hexagon has at least five sides.
   b. A hexagon has more than four sides.
   c. # A hexagon has at most seven sides.
   d. A hexagon has fewer than eight sides.

• Explanation: a and c are bad for two reasons:
  ◦ Superlative modifiers implicate ignorance, which is unjustified in all cases.
  ◦ Superlative modifiers implicate possibility, which is unjustified in c.

  Prediction: Because of the latter, c must be even worse than a.

• The same explanation works for Geurts et al.'s (2010) data on inference patterns (appendix).
• The prediction seems borne out in new data from Coppock and Brochhagen (submitted):

(13) a. At least three apples are on the table. (100%)
   b. More than two apples are on the table. (100%)
   c. # At most five apples are on the table. (76%)
   d. Fewer than six apples are on the table. (100%)

• Explanation: Truth judgement enforces a coarse granularity, hence the ignorance implicatures occur nowhere. Nevertheless, possibility implicatures still arise for a and c. For c, the possibility implicature happens to be false.

  Prediction: “at most four” should yield 100% acceptance in a truth-jugement task.

4. Conclusion

• Inquisitive semantics and pragmatics are a powerful tool (and there's more!).
• We don't need a semantic difference between superlative and comparative modifiers.
• We have a lot of interesting new predictions that seem intuitively right.

5. Bonus: QUD and negativity

• Brasoveanu, Farkas and Roelofsen's experiment 1 reveals that negated sentences:
  ◦ with referential DPs elicit an agreeing response with “no”.
  ◦ with modified numerals elicit an agreeing response with “yes”.
  ◦ with “some” is in between.

  Polar QUD origin of negativity: A sentence allows agreement with “no” iff it selects the negative possibility of a polar QUD.

• Explanation: the constructions differ regarding the QUDs they typically answer:
  ◦ Modified numerals typically answer a “how many”-question.
  ◦ Referential DPs typically answer a polar question.
  ◦ “some” can answer either kind of question.
• In the absence of an explicit QUD, participants invent one according to these expectations.
**Prediction:** By making the QUD explicit in the experiment, we can force participants in the case of “some” to give either agreeing responses with “no”, or agreeing responses with “yes”.

**Prediction:** Like “some”, unmodified numerals can answer both kinds of questions. We expect them to pattern alike (though, I expect, biased towards a “how many”-question).

- Answering a polar question rather than a “how many”-question may be easier for comparative modifiers, who enjoy coarse granularity.

**Prediction:** Comparative modifiers are more likely to elicit agreeing responses with “no” than superlative modifiers.

6. **Other ideas**

**Discourse exhaustivity of modifiers:**
Although upper-bound modifiers do not implicate truth-conditional exhaustivity, they do implicate *discourse exhaustivity*. E.g., in response to 'at least 5 people came', anaphor 'they' picks up the maximal set of people who came. This is so because all *continuations* of the dialogue in which the contents of the referent become known, exhaustivity will be implicated.

**Exhaustivity of downward-entailing modifiers:**
Downward-entailing modifiers have an upper bound because (i) like unmodified numerals, they implicate exhaustivity in response to a 'how many'-question, (ii) like all modifiers, they presuppose a 'how many'-question, (iii) without the upper bound, they are tautological. One might consider it a *lexicalized implicature*.

**Narrower distribution of comparative modifiers:** Superlative modifiers can modify bigger things, besides numbers and gradeable properties. Comparatives don't like that, because in their case processing the bigger thing, the bound, is a waste of effort – it is false, anyway. Is this also why superlative modifiers do not like being negated?

7. **Appendix: Geurts et al.'s (2010) inference patterns**

<table>
<thead>
<tr>
<th>Premiss</th>
<th>Conclusion</th>
<th>Acceptability rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Berta had 3 beers</td>
<td>Berta had at least 3 beers</td>
<td>50</td>
</tr>
<tr>
<td>b. Berta had 3 beers</td>
<td>Berta had more than 2 beers</td>
<td>100</td>
</tr>
<tr>
<td>c. Berta had 3 beers</td>
<td>Berta had at most 3 beers</td>
<td>61</td>
</tr>
<tr>
<td>d. Berta had 3 beers</td>
<td>Berta had fewer than 4 beers</td>
<td>93</td>
</tr>
<tr>
<td>e. Berta had at most 2 beers</td>
<td>Berta had at most 3 beers</td>
<td>14</td>
</tr>
<tr>
<td>f. Berta had fewer than 3 beers</td>
<td>Berta had fewer than 4 beers</td>
<td>71</td>
</tr>
</tbody>
</table>