EXPERIMENTAL EVIDENCE FOR IMPLICATURES WITH MODIFIED NUMERALS

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Motivation

Between 91 and 93
Between 90 and 100
...  
More than 91
More than 90
More than 80
More than 50
...  
Fewer than 93
Fewer than 94
Fewer than 100
Fewer than 1000
...  
92
About 90
About 100
The Bigger Question

- What factors govern speakers’ choice between (infinitely) many truth-conditionally adequate alternatives?
  - Today: A particular consequence of competition between alternatives

Scalar Implicature

The use a weaker term on an implicational scale implies that, as far as the speaker knows, stronger terms on the scale do not hold (Horn 1972)

- *Sue has read some of Jane Austen’s novels* <some,all>
  - ‘she hasn’t read all of them’
- *Sue has 3 children* <3,4,5,...>
  - ‘not 4, 5, etc.’, i.e. exactly 3

- Has been observed that modified numerals do not give rise to scalar implicatures (Krifka 2002, Fox & Hackl 2006)
  - *Sue has more than 3 children*
    - ‘not more than 4’, i.e. exactly 4
Main Claims

- Modified numerals of the form *more than n* and *at least n* do trigger scalar implicatures
- Such implicatures are constrained by (at least) two factors:
  - The granularity level of the numeral scale
  - The discourse salience of the numeral *n*

Pragmatic Strengthening

*London has more than 1000 residents*

*London has more than 7000 residents*
Granularity

*The distance between Amsterdam and Vienna is one thousand kilometers*

*The distance between Amsterdam and Vienna is nine hundred sixty-five kilometers*

- Krifka (2009): Granularity modelled via scales that differ in density of scale points:

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Granularity and modified numerals

- Granularity level contextually determined – bias towards coarse-grained representation (Krifka 2007) or contextual parameter of interpretation (Sauerland & Stateva 2007)

- Modified numerals should compete with alternatives matched in granularity
Prediction #1

- Expressions with modified numerals should give rise to Scalar Implicatures at the appropriate granularity level

  E.g. ‘more than $n$’ should implicate ‘not more than $m$’, where $m$ is a higher value on a scale of the same granularity as $n$

Experiment 1

Stimuli

A newspaper reported the following:

More than 100 people attended the public meeting about the new highway construction project

Based on reading this, how many people do you think attended the meeting?

A) Between _____ and _____ people attended.
B) ______ people attended.

More than 100  At least 100
More than 110  At least 110
More than 93  At least 93

- Online survey via Amazon MTurk
- n= 100/condition
Experiment 1
Results

Median Estimates

<table>
<thead>
<tr>
<th>n = 100</th>
<th>More than n</th>
<th>At least n</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper bound</td>
<td>Most Likely</td>
</tr>
<tr>
<td>150</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>94</td>
<td></td>
</tr>
</tbody>
</table>

ANOVA High Estimate Most Likely
More than n F=5.45, p<.01 F=5.81, p<.01
At least n F=2.34, p=.099 F=3.99, p<.05
Experiment 1

Subject Comments

- 'More than 100' condition:
  I feel that if there was more than 150, the newspaper would say more than 150.
  I chose the above number because I felt had the numbers been higher the paper would have said more than 200.
  I think 125 would be the next increment worthy of mentioning.

- 'More than 110' condition:
  I chose 135 because I felt that a number higher than that would have been described as, "Close to 150 people attended...".
  If it had been >120 it would have described them as such.
  If it was more than 115 the writer would have probably said "Almost 120 people attended the meeting".

Prediction #1

- Expressions with modified numerals should give rise to Scalar Implicatures at the appropriate granularity level

  - Though assumed granularity level not consistent
However...

- Non-round numbers (e.g. 93) occur only on scale of granularity 1
  - Prediction: ‘more than 93’ should implicate ‘not more than 94’, i.e. ‘exactly 94’ ✗

- Use of modified numeral (e.g. ‘more than n’) for non-round n is odd in out-of-the-blue context
  - But felicitous when number is salient:
    U.S. coach Bob Bradley will call in more than 23 players when the Americans start their final training camp ahead of the World Cup.

Prediction #2

- Contextual activation of the numeral will weaken granularity-based scalar inference
  - Gives speaker a potential additional reason to (re-) use numeral, independent of granularity considerations
  - Hearer is aware of this, and moderates strength of inference from this numeral accordingly
Experiment 2

Stimuli

**Primed:**
- A: We need to sell 60 tickets to cover our costs. How are the ticket sales going?
- B: So far we’ve sold fewer than 60 tickets

**Unprimed:**
- A: We need to sell tickets to cover our costs. How are the ticket sales going?
- B: So far we’ve sold fewer than 60 tickets

How many tickets have been sold?
From _____ to _____, most likely _____.

- Paper and pencil questionnaire
- n=45

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3 levels of granularity
- Coarse: Multiple of 100
- Medium: Multiple of 10
- Fine: non-round

2 numerical expressions:
- *more than* \( n \)
- *fewer than* \( n \)

2 levels of priming:
- Unprimed
- Primed
Experiment 2

Results

Most Likely Estimate (vs. n)

3 x 2 x 2 ANOVA – most likely estimate (relative to n)

Main effect of granularity:
F=47.4, p<.0001

Main effect of priming:
F=8.1, p<.01

Main effect of quantifier:
F=8.9, p<.01

Experiment 3

Stimuli

**Primed:**
Salesperson: This shelf unit is designed to hold 60 CDs. How many CDs do you own?
Customer: I have more than 60 CDs

**Unprimed:**
Salesperson: This shelf unit is designed to hold CDs. How many CDs do you own?
Customer: I have more than 60 CDs

How many CDs do you think the customer owns?
Between ____ and _____; most likely number _____

- More than 60
- Fewer than 60

-1-question MTurk survey
- n=100/condition
Experiment 3
Results

Median Estimates

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<td></td>
<td>Upper Bound</td>
<td>Most Likely</td>
</tr>
<tr>
<td>Unprimed</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Primed</td>
<td>100</td>
<td>80</td>
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</table>

2 x 2 ANOVA – most likely estimate (vs. n)
Main effect of priming: \( F = 39.2, \ p < .001 \)
Main effect of quantifier: \( F = 33.9, \ p < .001 \)
Interaction of quantifier and priming: \( F = 8.5, \ p < .01 \)

Experiment 3
Results

More than 60 – upper bound
Prediction #2

- Contextual activation of the numeral will weaken granularity-based scalar inference

Conclusions

- Contrary to prior claims, modified numerals do trigger scalar implicatures
  - No need to account for gap in otherwise general pattern
- The implicatures in question are dependent on...
  - ...the granularity of the numeral scale
  - ...the discourse salience of the numeral
  hence the difficulty in detecting them without controlled experiments
Outlook

- Constraint Based Model of quantifier usage – choice among quantified expressions as output of multiple constraint satisfaction problem (Cummins ms.)
- Potential constraints:
  - Informativeness
  - Granularity
  - Contextual activation
  - Quantifier simplicity
  - Etc.
  - Potential to explain observed lack of implicatures with small numerals (e.g. *more than 3*)

Thank you!