The likelihood of upper-bound construals among different modified numerals

Yaron McNabb, Rick Nouwen, Stavroula Alexandropoulou, Dominique Blok and Sophia Bimpikou
Utrecht University

Universiteit Utrecht

Two kinds of modified numerals

Class A/B distinction (Nouwen, 2010): classification of modifiers into two categories: those that give rise to obligatory ignorance inferences (class B) and those that do not (class A)

(1) **Class A**
I know exactly how many books I have, and it's { more than / fewer than / under / over } 200.

(2) **Class B**
#I know exactly how many books I have, and it's { at least / at most / minimally / maximally / up to } 200.

Upper-bounded numeral modifiers

- Our focus: the bounds of numeral modifiers
- *Up to* behaves differently from other upper-bounded numeral modifiers

1. NPI licensing (Schwarz et al., 2012):

(3) a. { At most / Fewer than / *Up to } five students have ever been in this cave.
b. { At most / Fewer than / *Up to } three students give a damn about Pavarotti.

2. Cancellable upper bound (Blok, 2015):

(4) a. #At most ten people died in the crash, perhaps even more.
b. #Fewer than ten people died in the crash, perhaps even more.
c. Up to ten people died in the crash, perhaps even more.

3. Non-cancellable lower bound (Blok, 2015):

(5) a. At most three students will show up to the lecture, if any.
b. ?Fewer than three students will show up to the lecture, if any.
c. #Up to three students will show up to the lecture, if any.

Entailed and implicated upper bounds (Blok, 2015)

- *Up to* asserts a lower bound; *at most* and *fewer than* do not
- *Up to* implicates an upper bound; *at most* and *fewer than* assert an upper bound

	Lower bound	Upper bound
at most 10	—	semantic
fewer than 10	—	semantic
up to 10	semantic	pragmatic

Table 1: The bounds of *at most*, *fewer than*, and *up to*

(6) Up to ten people died in the crash.

- Semantics of (6): for every number on a scale [1...10], the speaker considers it possible that that many people died in the crash
- Implicature for (6): for every number in [11...∞), the speaker does not consider it possible that that many people died in the crash

(7) { At most ten / Fewer than eleven } people died in the crash.

- Semantics of (7): $\text{MAX}_{\boldsymbol{n}}$ [(the speaker considers it possible that) ***n*** people died in the crash] = 10

Additional evidence: interaction with evaluative predicates

- Evaluative adverbs target the assertion of an utterance rather than its implicature (Nouwen, 2006):

(8) a. Fortunately, some students attended the wedding.
b. Fortunately, the soup is warm.

- This also holds for *up to* , *at most*, and *fewer than*:

(9) a. Fortunately, up to 100 people will attend my wedding.
b. Fortunately, { at most / fewer than } 100 people will attend my wedding.

- Related notion: *directivity* (Nouwen, 2010b): certain quantifiers (such as *up to* n) highlight the elements for which the predicate holds, while others (such as *at most* / *fewer than* n) highlight the elements for which the predicate does not hold

(10) a. In the airplane crash, {few / not quite all / at most ten / fewer than ten} passengers were killed, which is a good thing.
b. ?In the airplane crash, {a few / almost all / up to ten} passengers were killed, which is a good thing.

The role of distance in implicature calculation

- Another factor: granularity/distance (Cummins, Sauerland, and Solt 2012):

(11) John's birthplace has more than 1000 inhabitants.
$\not\rightarrow$ John's birthplace doesn't have more than 1001 inhabitants.
$\rightarrow$ John's birthplace doesn't have more than a million inhabitants.

Research questions

- Is it the case that the upper bound of *up to* is cancellable (which would support an implicature-based account)?
- If so, to what extent?
(experiment 1 & 2)
- Does distance play a role?
(experiment 2)

Experiments

Experiment I

- In Greek
- Numeral modifiers:
  - *lighoteros/-i/-o' apo* (adj.) 'fewer than' / *lighotero apo* (adv.) 'less than'
  - *to poli*, *lit.* the much, 'at most'
  - *mehri* 'up to'/'until'

Methods (a)

- Coherence judgement task

Interns in advertisement companies get { ***fewer than*** / ***less than*** / ***at most*** / ***up to*** } ***n*** dollars per month; the interns in some of them are paid ***m*** dollars per month.

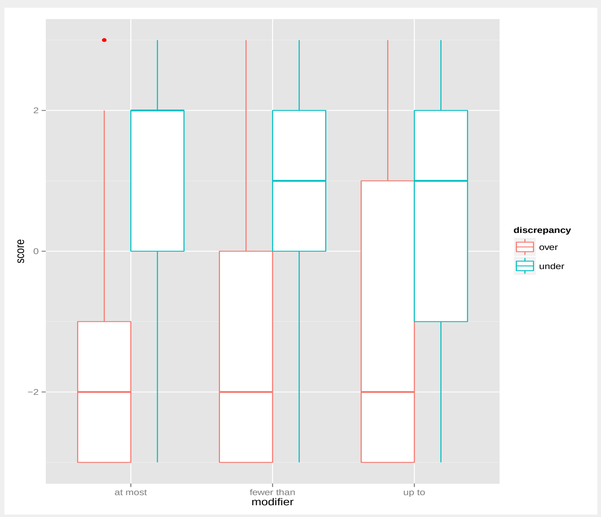
Is the underlined sentence a good continuation of the first sentence?
–3 –2 –1 0 1 2 3
very bad — very good

- 1st sentence:
  - Naturally occurring sentences adapted from HNC
  - ***n***: almost exclusively non-round numbers
- 2nd sentence:
  - Statement about a specific instance
  - ***m*** (discrepancy conditions):
    - $\boldsymbol{m < n}$ 'under'
    - $\boldsymbol{m > n}$ 'over'
  - Small distance between ***m*** and ***n***

Methods (b)

- Numeral modifier x Discrepancy
- Control: *fewer than*: asserted upper bound (Hackl, 2000; Nouwen, 2010)
- 12 items, rotated through (6) lists
- 14 fillers (7 coherent discourses & 7 contradictory discourses)
- 143 native speakers of Greek* (98 female participants, 2 no gender info; mean age: 32.8; age range: 19–67)
- Filled in on-line (created on `www.surveymonkey.com`)

Results



- 'Over' condition: Significantly higher scores for *up to* than for *fewer than* and *at most* (β = **.188**, ***SE*** = **.089**, ***p*** < **.05** and β = **.277**, ***SE*** = **.09**, ***p*** < **.01**, respectively)
- 'Under' condition: Significantly lower scores for *up to* than for *fewer than* and *at most* (β = **−.215**, ***SE*** = **.088**, ***p*** < **.05** and β = **−.266**, ***SE*** = **.088**, ***p*** < **.001**, respectively)
- No significant difference between *fewer than* and *at most* (***p*** > **.1**)

Conclusions

'Under' condition: Conclusion

- In a natural discourse setting (Exp. I)
  - Lower rates in the 'under' condition for *up to*
  - Possibly associated with directivity: quantifiers with positive directivity like *up to* trigger the expectation that higher numbers should be used in subsequent discourse

Experiment II

- Follow-up in English
- Numeral modifiers: *fewer/less than*, *at most*, *up to*
- Modifications:
  - Fine granularity: ***n***: clearly non-round number
  - Control for ***m*** vs. ***n*** distance
  - Avoid interpretation of 'over' items as exceptions → Different task

Methods (a)

- Compatibility judgement task

CLAIM: Clarendon High School used its smart classrooms 50 times last year with { ***fewer than*** / ***less than*** / ***at most*** / ***up to*** } ***n*** students participating in this classroom environment.
FACT: On one occasion the smart classroom was used at Clarendon High School last year, ***m*** students participated.

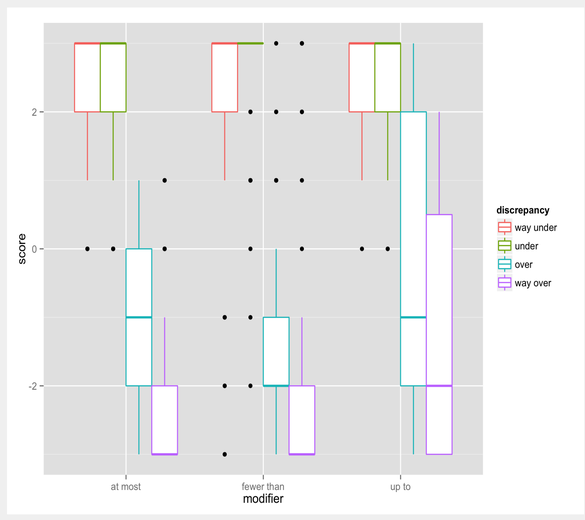
How compatible is the CLAIM with the FACT?
–3 –2 –1 0 1 2 3
completely incompatible — completely compatible

- Claim:
  - Claims with *up to* ***n*** drawn from COCA (Davies, 2008)
  - ***n***: clear cases of non-round numbers
- Fact:
  - Highlights a specific instance
  - ***m*** (discrepancy conditions):
    - $\boldsymbol{m = n * 0.95}$ 'under'
    - $\boldsymbol{m = n * 0.25}$ 'way under'
    - $\boldsymbol{m = n * 1.05}$ 'over'
    - $\boldsymbol{m = n * 1.75}$ 'way over'

Methods (b)

- Numeral modifier x Discrepancy
- Target items (N=28) rotated through lists
- 30 filler items with quantifiers (10 contradictions, 10 entailments, 10 implicatures)
- 45 participants on Amazon's Mechanical Turk (31 female participants; mean age: 38.98; age range: 21–59)

Results



- 'Over' condition: Significantly higher scores for *up to* than for *fewer than* and *at most* (β = **.7879**, ***SE*** = **.1756**, ***p*** < **.01** and β = **.639**, ***SE*** = **.17**, ***p*** < **.01**, respectively)
- 'Way over' condition: Higher scores for *up to* than for *fewer than* (significantly) and *at most* (marginally) (β = **.41**, ***SE*** = **.176**, ***p*** < **.05** and β = **.348**, ***SE*** = **.19**, ***p*** = **.07**, respectively)
- Scores for 'over' significantly higher than for 'way over' for each modifier, with the smallest effect for *fewer than* (β = **.69**, ***SE*** = **.170**, ***p*** < **.01** vs. β = **.842**, ***SE*** = **.192**, ***p*** < **0.01** for *at most* and β = **.824**, ***SE*** = **.164**, ***p*** < **0.01** for *up to*)
- 'Under' and 'way under' conditions: No differences between the modifiers and within each modifier (***p*** > **.1**)
- No significant difference between *fewer than* and *at most* (***p*** > **.1**)

'Over' conditions: Overall conclusions

- The upper-bound construal of
  - *up to* is pragmatically derived
  - *at most* is part of its lexical semantics

  } **in favour of Blok (2015)**
- Distance affects the degree to which the upper-bound construal is drawn

Discussion

- Effect of distance
  - Scalar/semantic distance – similar findings for other scalar terms (Beltrama and Xiang, 2013; van Tiel et al., 2014): e.g., many/some $\rightsquigarrow$ not all > many/some $\rightsquigarrow$ not most
  - Distance in rates may be mapped onto actual numeric distance → Effect for all numeral modifiers
  - Extreme values ruled out by Relevance → Effect for all numeral modifiers
- Likert scale (vs. binary judgment task): Good metric for semantic ≠ pragmatic inferences (Cummins & Katsos, 2010; Hansen & Chemla, 2013)
  - Choice of the particular Likert scale is irrelevant (contra Cummins & Katsos, 2010)
  - Criterion: Difference from contradictions (here: difference from control items with *fewer than* in the 'over' condition)
  - Greater range of ratings also a criterion (variation among speakers)?