The extent of upper-bound construals among different modified numerals

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Inferences and modified numerals

- Modified numerals give rise to wide variety of inferences
- Example 1: variation inferences (Nouwen, 2015)

(1) The CNN crew got that bit of video, and everyone in the world has seen it at least twenty times.
$\rightarrow$ there is no specific *n* such that everyone has seen the video *n* many times

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$\rightarrow$ there is no specific *n* such that everyone has seen the video *n* many times

(2) A: According to a random sample every bag contains at least 22 sweets.
B: ?Do they all contain the same number of sweets?

Alexandropoulou (to appear)

Inferences and modified numerals

- Example 2: scalar inferences (Krifka, 1999; Fox and Hackl, 2006)

(3) John has three children.
$\rightarrow$ John doesn't have four children.

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Inferences and modified numerals

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(3) John has three children.
$\rightarrow$ John doesn't have four children.

(4) John has more than three children.
$\not\rightarrow$ John doesn't have more than four children

(5) I can say with certainty that John has more than three children.
$\rightarrow$ I cannot say with certainty that John has more than four children

Inferences and modified numerals

- Another factor: granularity/distance (Cummins et al., 2012)

(6) 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.

Inferences and modified numerals

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- Class A/B distinction (Nouwen, 2010*a*): class B numeral modifiers give rise to obligatory ignorance inferences

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(7) **Class A**
I know exactly how much memory my laptop has, and it's { more than / less than / under / over } 4GB.

(8) **Class B**
#I know exactly how much memory my laptop has, and it's { at least / at most / minimally / maximally / up to } 4GB.

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- NPI licensing data suggest that *up to* is different from other class B modifiers that set an upper bound (Schwarz, Buccola, & Hamilton, 2012):

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- This suggests *at most* is downward monotone, which is expected given the fact that it sets an upper bound
- What about *up to*?

The bounds of modified numerals

- Blok (SALT 2015): Schwarz et al.'s findings extend to directional numeral modifiers crosslinguistically

(11) Greek: **mehri**

a. Perpatisame mehri tin akri tis limnis.
We walked MEHRI the edge of the lake.
'We walked up to the edge of the lake.'

b. Ston anelkistira khorane mehri 5 atoma.
In the elevator fit MEHRI 5 people.
'Up to 5 people can fit in the elevator.'

The bounds of modified numerals

- Blok (2015): there are two additional differences between directional numeral modifiers and expressions like *at most*:
  1. Directional numeral modifiers have a cancellable upper bound
  2. Directional numeral modifiers set a non-cancellable lower bound

The bounds of modified numerals

- The upper bound of directional numeral modifiers can be cancelled:

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

(13) a. #Leftovers keep in the refrigerator for at most one week or more.
b. Leftovers keep in the refrigerator for up to one week or more.

The bounds of modified numerals

- The lower bound of directional numeral modifiers cannot be cancelled:

(14) a. At most three students will show up to the lecture, if any.
b. #Up to three students will show up to the lecture, if any.

The bounds of modified numerals

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- Directional numeral modifiers do not license NPIs; expressions like *at most* do
- Directional numeral modifiers have a cancellable upper bound; expressions like *at most* have a non-cancellable upper bound
- Directional numeral modifiers have a non-cancellable lower bound; expressions like *at most* do not

An implicature-based account

Central proposal (Blok, SALT 2015):

- Directional numeral modifiers assert a lower bound
- Directional numeral modifiers only implicate an upper bound

An implicature-based account

- Directional numeral modifiers convey that the degree predicate they combine with holds for an interval on a scale
- Directional numeral modifiers assert a lower bound: the lowest number on the scale it quantifies over cannot be 0
- There is no maximality operator or other mechanism that sets an upper bound in the semantics

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- Directional numeral modifiers convey that the degree predicate they combine with holds for an interval on a scale
- Directional numeral modifiers assert a lower bound: the lowest number on the scale it quantifies over cannot be 0
- There is no maximality operator or other mechanism that sets an upper bound in the semantics
- (15) conveys that for every number on a scale [1...10], the speaker considers it possible that that many people died in the crash — without excluding any other possibilities

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

An implicature-based account

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- As directional numeral modifiers assert a lower bound an implicate an upper bound, the cancellation facts follow straightforwardly from the account
- The fact that directional numeral modifiers are upward entailing is compatible with the fact that they do not license NPIs

An implicature-based account

Additional evidence: the interaction with evaluative adverbs

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

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

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b. Fortunately, the soup is warm.

- This also holds for *up to* and *at most*

(17) a. Fortunately, up to 100 people will attend my wedding.
b. Fortunately, at most 100 people will attend my wedding.

An implicature-based account

Related notion: *directivity* (Nouwen, 2010*b*)

(18) a. In the airplane crash, {few / not quite all / at most 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.

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b. ?In the airplane crash, {a few / almost all / up to ten} passengers were killed, which is a good thing.

(19) [In a commercial]

a. Get a discount of up to 50%!

b. ?Get a discount of at most 50%!

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  (future research)
- Does distance play a role?
  (experiment 2)

Experiments

- Compare at most vs. up to: cancellable upper bound
- Control: fewer than: asserted upper bound (Hackl, 2000; Nouwen, 2010*a*)

Outline

Experiment 1

- Greek
- NMs:
  - *lighoteros/-i/-o' apo*, adj, 'fewer than' / *lighotero apo*, adv., 'less than'
  - *to poli*, *lit.* the much, 'at most'
  - *mehri*: DNM, also used in spatial & temporal domains

Experiment 1

Coherence judgement task

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Interns in advertisement companies get $\left\{\begin{array}{c} \textit{less than} \\ \textit{at most} \\ \textit{up to} \end{array}\right\}$ 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

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- 1st sentence:
  - Naturally occurring sentences adapted from *HNC (Hellenic National Corpus)* (2009)
  - n: No real round number

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- 2nd sentence:
  - Claim about a subset which is compatible or incompatible with the assertion in the 1st sentence
  - m: $m < n$ ('under') or $m > n$ ('over') (m close to n)

Experiment 1

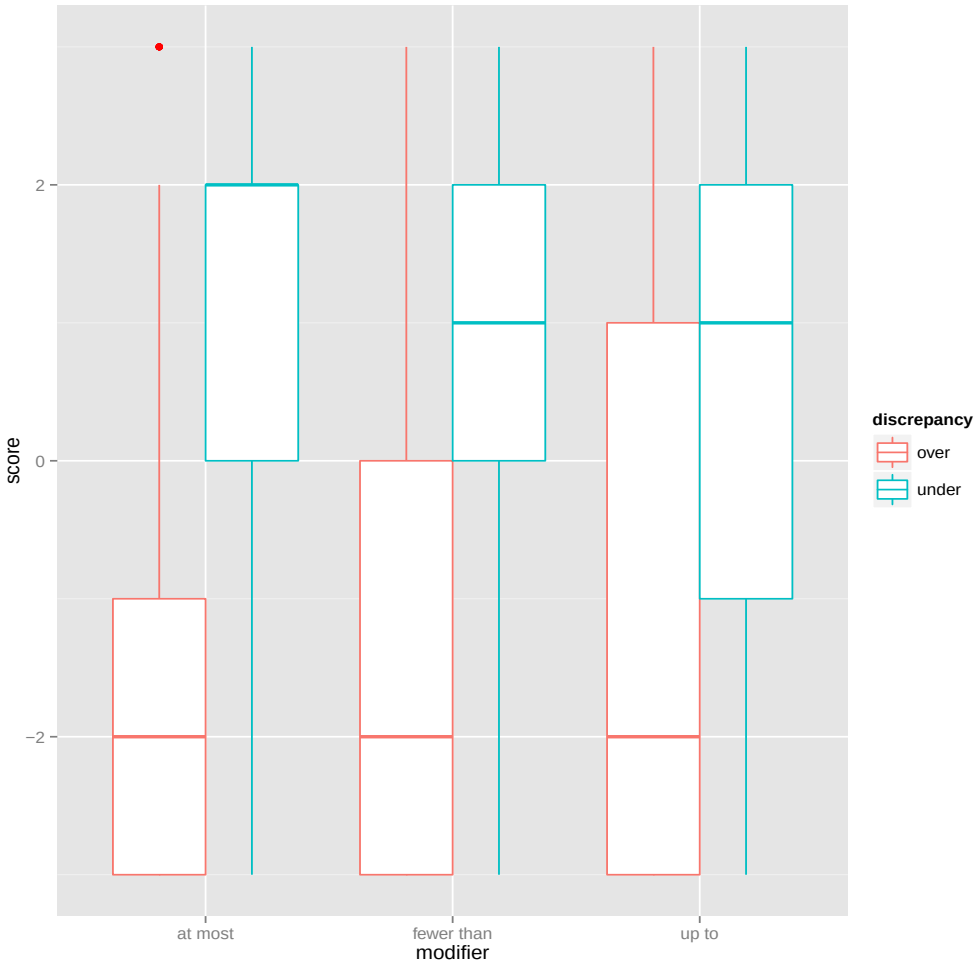
Methods

- Modifier (*lighotero(s) apo* 'less than/fewer than', *to poli* 'at most', *mehri* 'up to') x Discrepancy ($m < n$ 'under', $m > n$ 'over')
- 12 items, rotated through 6 lists
- 14 fillers (7 coherent discourses & 7 contradictory discourses), all appearing in every list
- 143 native speakers of Greek*
- Filled in on-line (created on `www.surveymonkey.com`)

* 98 Female, 2 no gender info; Mean age: 32.8; Age range: 19–67

Experiment 1

Results



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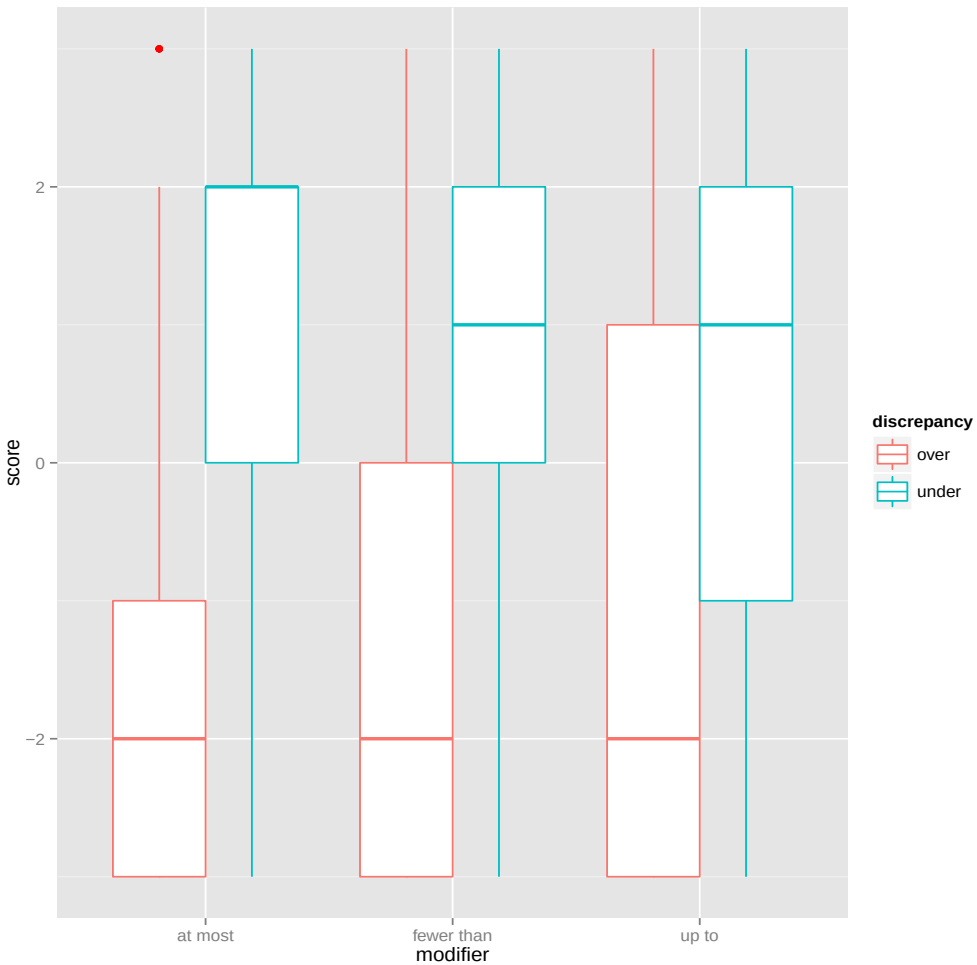

- 'Over' condition: Significantly higher coherence rates for up to than for fewer than and at most ($\beta = .188$, $SE = .089$, $p < .05$ and $\beta = .277$, $SE = .09$, $p < .01$, respectively)

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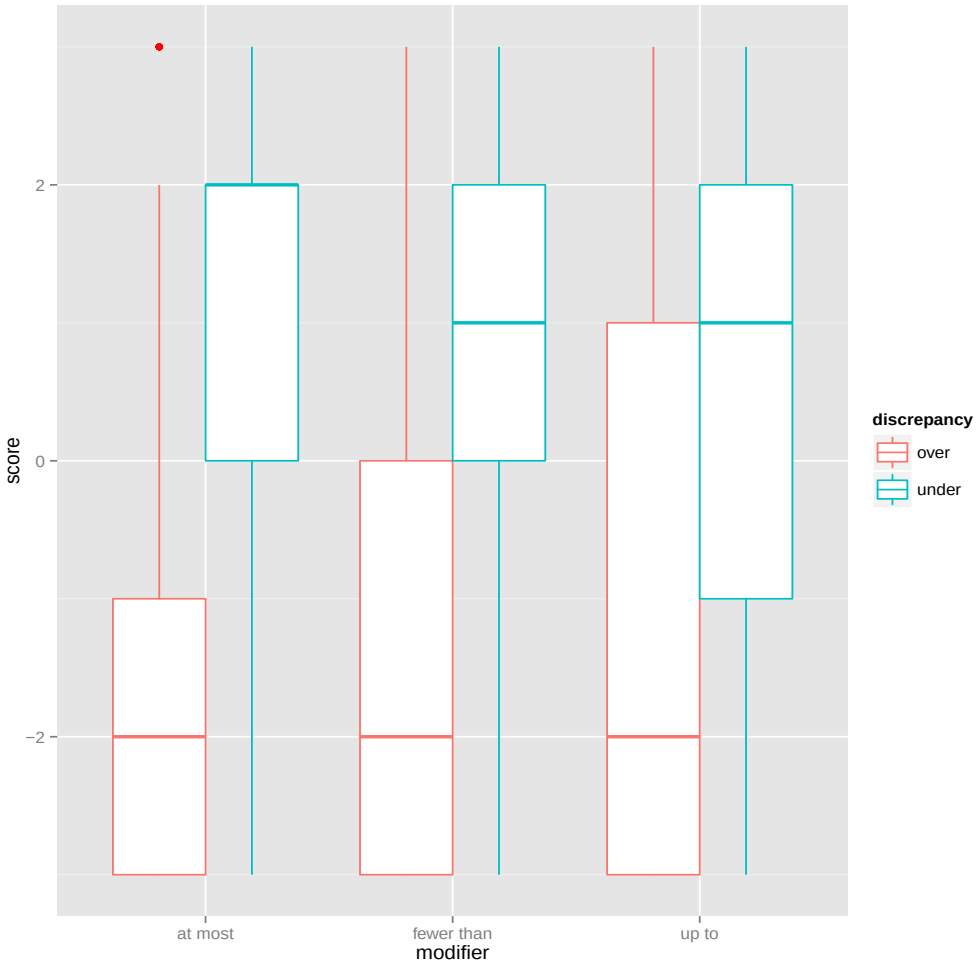

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- 'Under' condition: Significantly lower coherence rates for up to than for fewer than and at most ($\beta = -.215$, $SE = .088$, $p < .05$ and $\beta = -.266$, $SE = .088$, $p < .001$, respectively)

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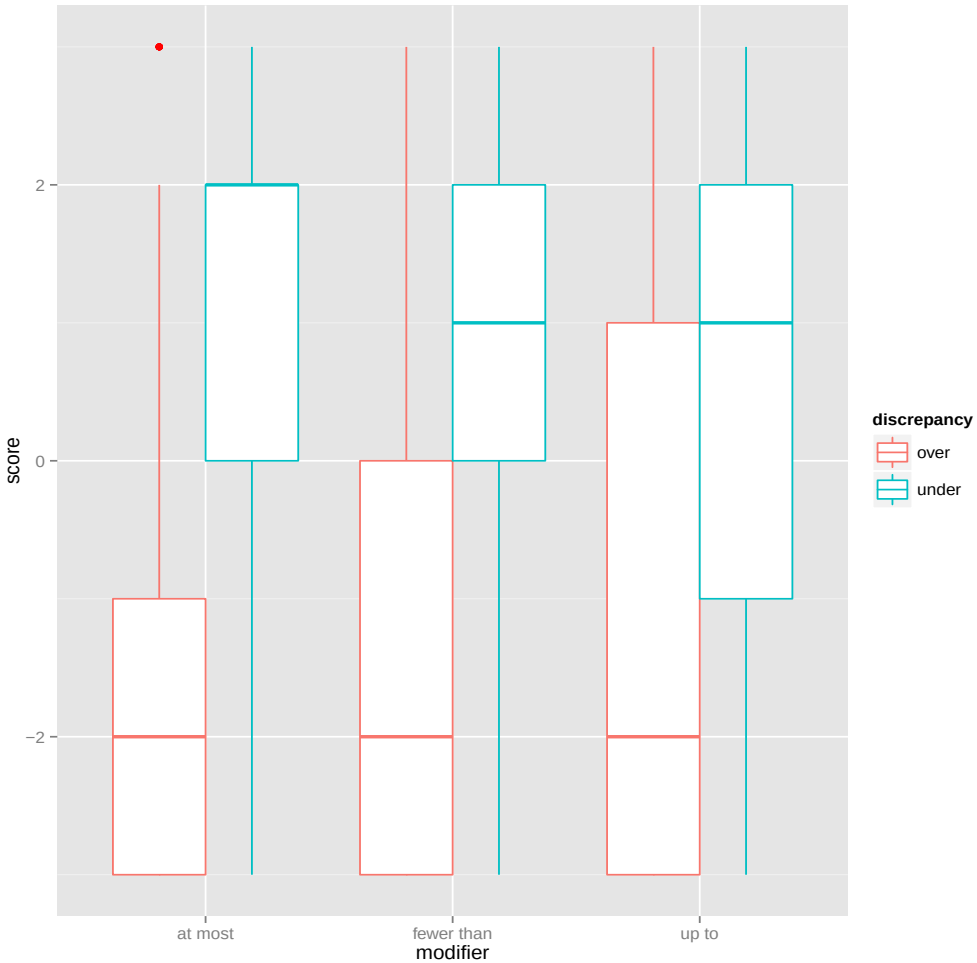

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- No difference between fewer than and at most ($p > .05$)

Experiment 1

Conclusions

- Differences in 'over' condition:
  - The upper bound of up to in Greek is pragmatically derived (Note also: wider range of scores) $\rightarrow$ in favour of Blok's (2015) account
  - The upper bound of at most in Greek is part of its lexical semantics $\rightarrow$ in favour of Blok (2015)

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  - The upper bound of at most in Greek is part of its lexical semantics $\rightarrow$ in favour of Blok (2015)
- Differences in 'under' condition:
  - Up to associated with directivity: $m < n \rightarrow$ less felicitous

    Interns in advertisement companies get up to 980 dollars per month; the interns in some of them are paid 950 dollars per month.

Outline

Experiment 2

- English
- Utterances with up to Num drawn from COCA Davies (2008)

Modifications in Experiment 2

- 2nd sentences as exceptions in discourse setting $\rightarrow$ different task
- Control for granularity: clearly non-round numbers
- m close to n $\rightarrow$ distance between m and n manipulated

Example stimulus

CLAIM: Clarendon High School used its smart classrooms 50 times last year with $\left\{\begin{array}{c} \textit{fewer than} \\ \textit{at most} \\ \textit{up to} \end{array}\right\}$ 39 students participating in this classroom environment.

FACT: On one occasion, the smart classroom was used at Clarendon High School last year, $\left\{\begin{array}{c} 10 \\ 37 \\ 41 \\ 68 \end{array}\right\}$ students participated.

How compatible is the CLAIM with the FACT?

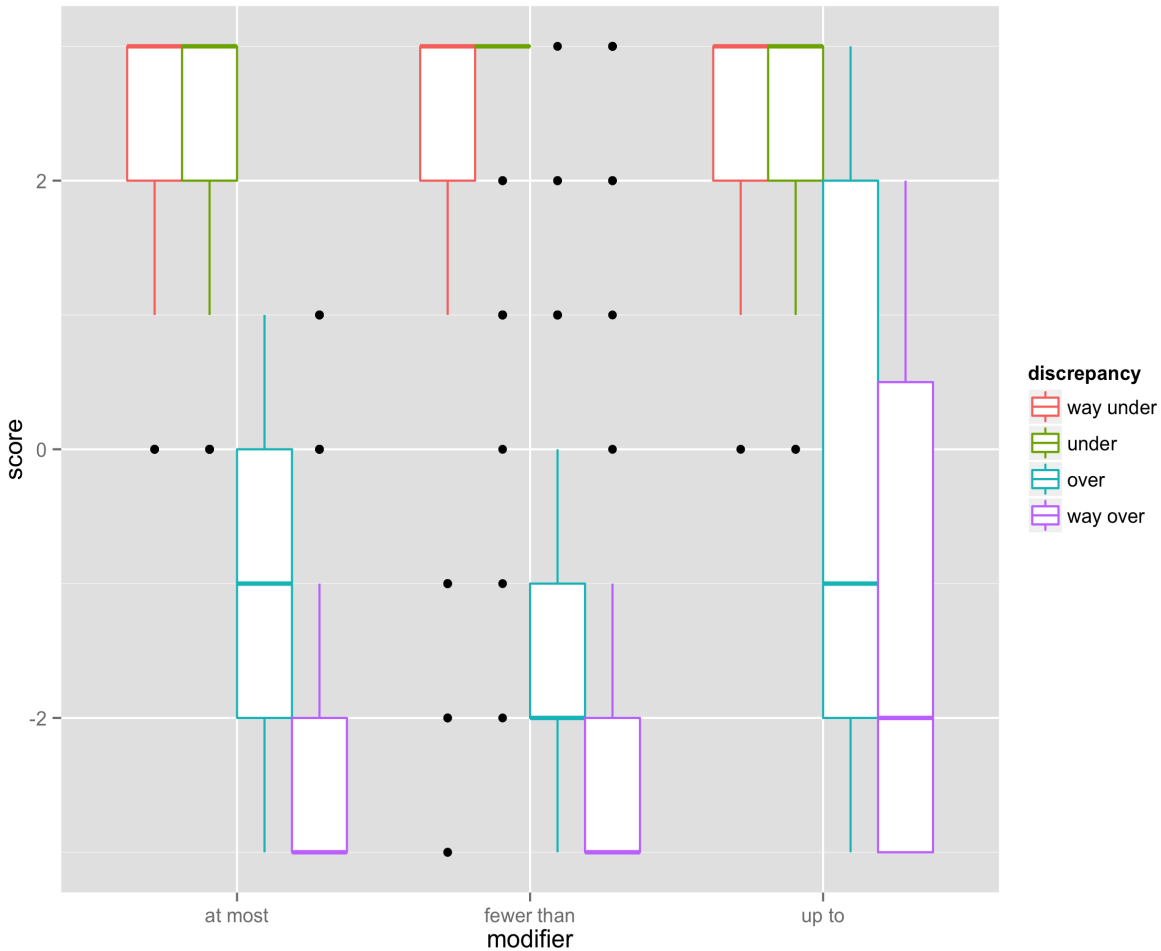
–3	–2	–1	0	1	2	3
completely incompatible						completely compatible

Experimental design

- Numeral modifier factor: fewer than / at most / up to
- (n_{claim}) vs. (m_{fact}) discrepancy conditions:
  - under ($m_{fact} < n_{claim}$):
    - under ($m_{fact} = n_{claim} * 0.95$)
    - way under ($m_{fact} = n_{claim} * 0.25$)
  - over ($m_{fact} > n_{claim}$):
    - over ($m_{fact} = n_{claim} * 1.05$)
    - way over ($m_{fact} = n_{claim} * 1.75$)
- 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

Results

Differences between modifiers



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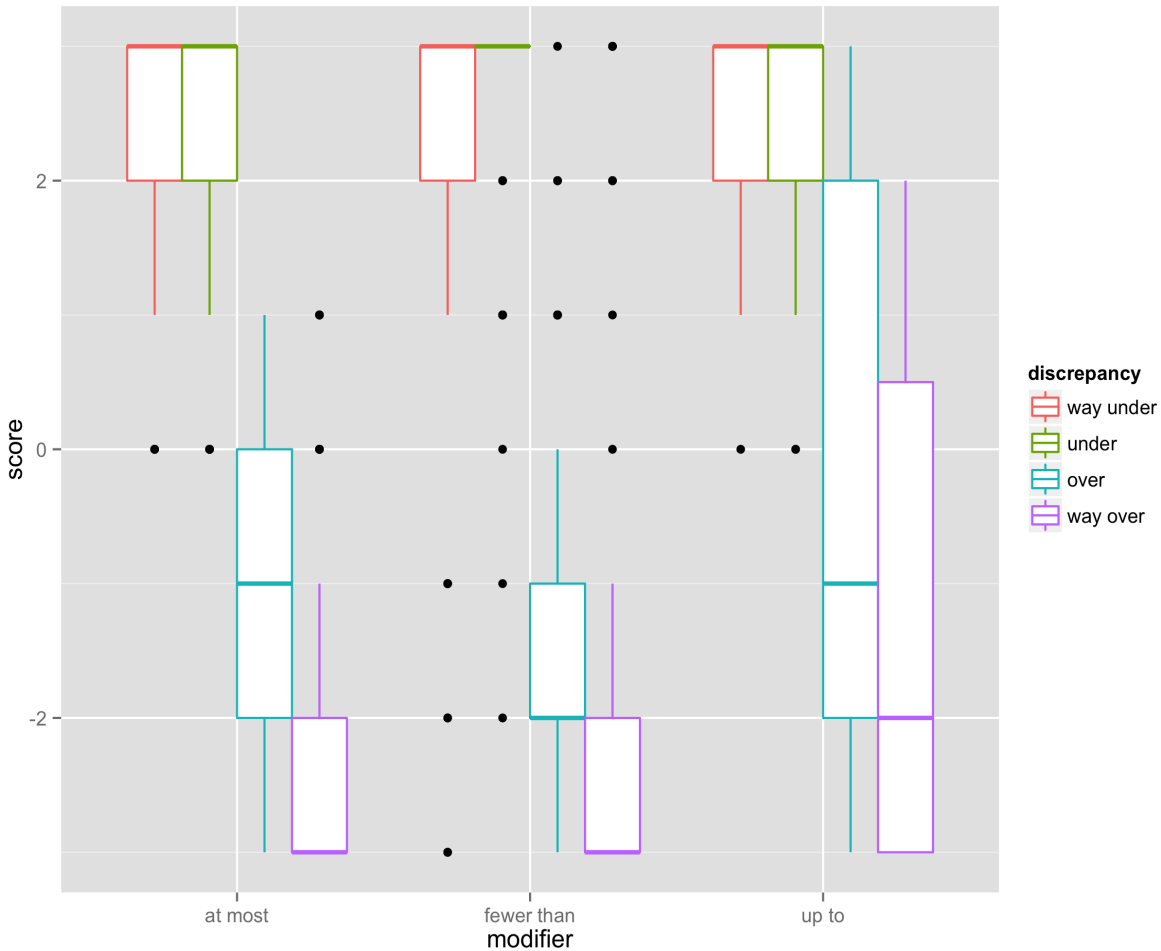

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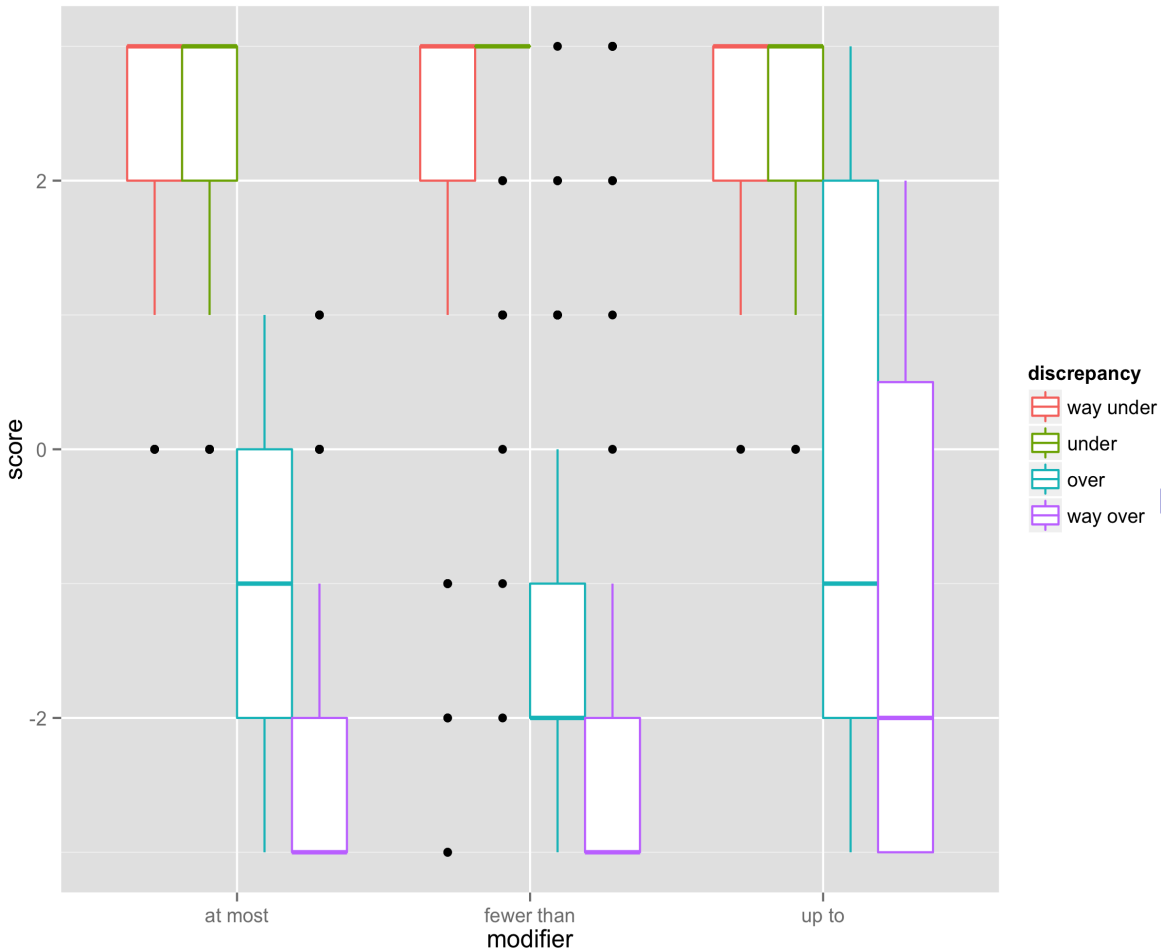
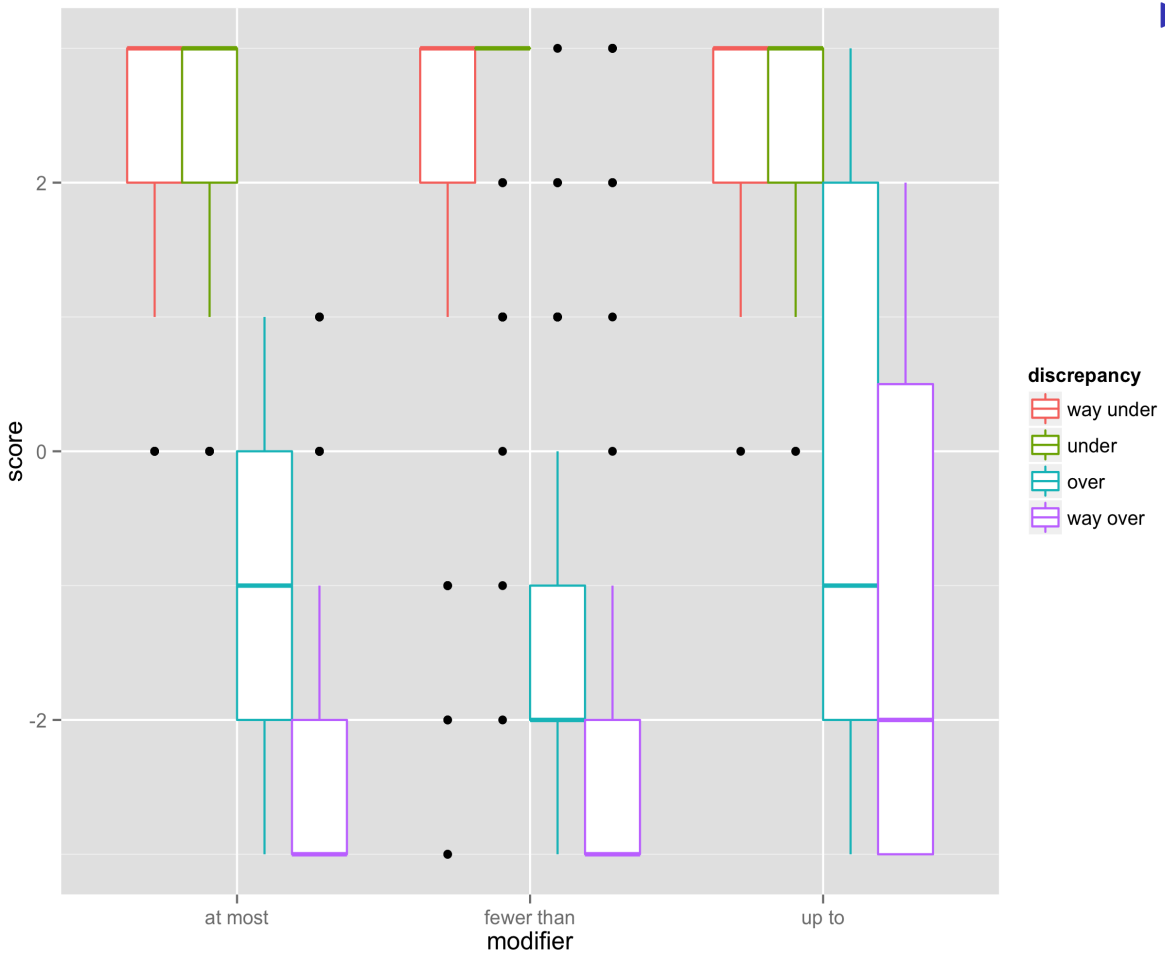


- 'Over' condition: Significantly higher coherence rates for up to than for fewer than and at most ($\beta = .7879$, $SE = .1756$, $p < .01$ and $\beta = .639$, $SE = .17$, $p < .01$, respectively)
- 'Way over' condition: Higher coherence rates for up to than for fewer than (significantly) and at most (marginally) ($\beta = .41$, $SE = .176$, $p < .05$ and $\beta = .348$, $SE = .19$, $p = .07$, respectively)

Results

Distance



- Rate for 'over' sig. higher than for 'way over' for each modifier, with the smallest effect for fewer than ($\beta = .69$, $SE = .170$, $p < .01$ vs. $\beta = .842$, $SE = .192$, $p < 0.01$ for at most and $\beta = .824$, $SE = .164$, $p < 0.01$ for up to)

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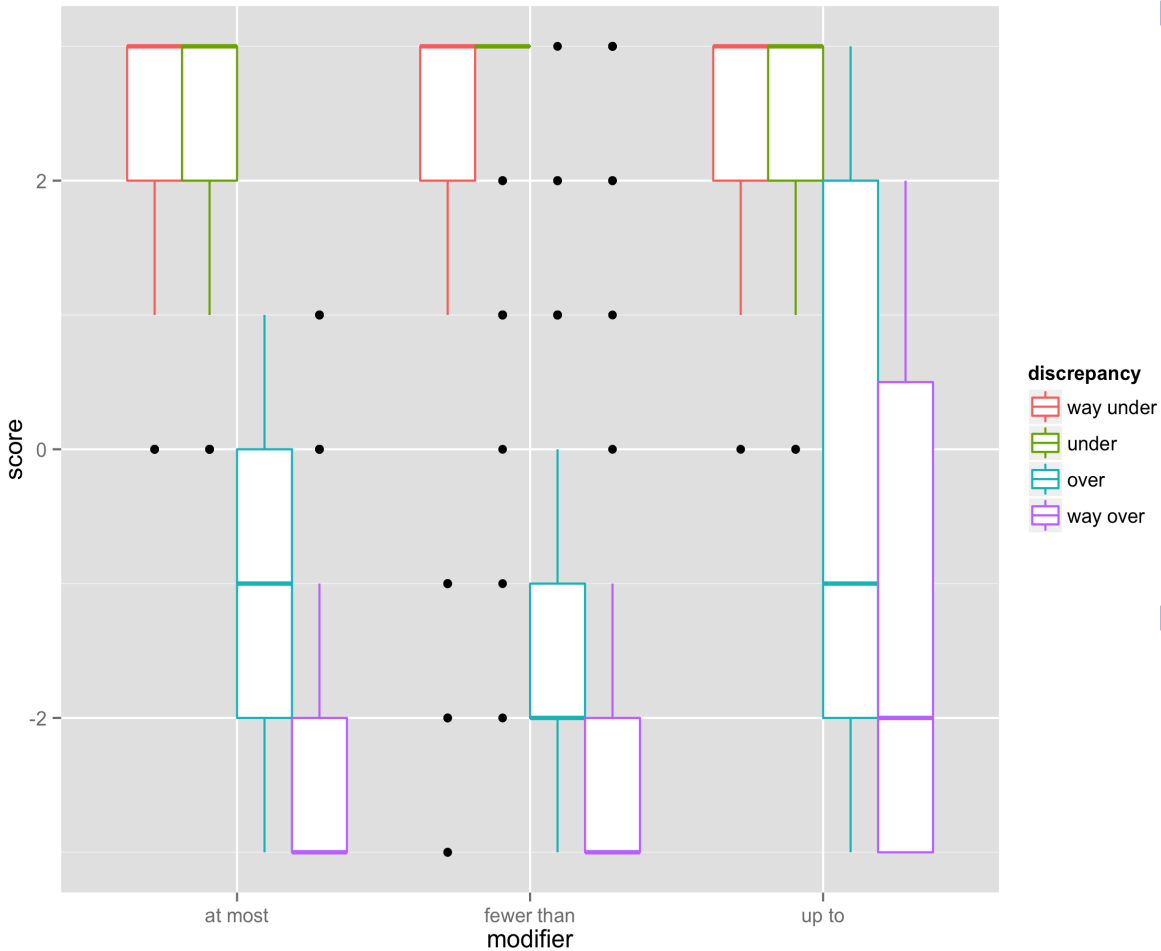

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- 'Under' and 'way under' conditions: no differences between the modifiers and within each modifier

Conclusions

- Differences in 'over' and 'way over' conditions:
  - Blok (2015): at most provides an upper-bound entailment
  - Blok: up to's upper bound is pragmatically-derived
    $\rightarrow$ over & way over conditions: up to better than at most and fewer than
- Differences wrt Distance:
  - Distance affects the upper bound construal

General findings

- Semantic vs. pragmatic upper bound in two different tasks $\rightarrow$ In favor of Blok's pragmatic account
- Distance affects upper bound construal (Experiment 2)
- Up to associated with directivity, thus less compatible with a follow-up focussing on a subset (Experiment 1)

Up for 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

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  - If so, greater range of ratings also a criterion (variation among speakers)?
- No difference between at most and fewer than – semantic identity or failure to find a difference?

Other points?

Thank you!

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Bottom-of-the-scale effect

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b. At most one person died in the crash.

(21) a. Up to ten people died in the crash.
b. #Up to one person died in the crash.

Bottom-of-the-scale effect

- The bounds in combination with the range requirement explain the bottom-of-the-scale effect
- *All* class B numeral modifiers that set an upper bound require quantification over a range of values and display the bottom-of-the-scale effect as a result

Bottom-of-the-scale effect

- The bounds in combination with the range requirement explain the bottom-of-the-scale effect
- *All* class B numeral modifiers that set an upper bound require quantification over a range of values and display the bottom-of-the-scale effect as a result

(22) a. #Up to one person died in the crash. $\{p_1\}$

Bottom-of-the-scale effect

- The bounds in combination with the range requirement explain the bottom-of-the-scale effect
- *All* class B numeral modifiers that set an upper bound require quantification over a range of values and display the bottom-of-the-scale effect as a result

(22) a. #Up to one person died in the crash. $\{p_1\}$

(23) a. #At most zero people died in the crash. $\{p_0\}$

Bottom-of-the-scale effect

- The bounds in combination with the range requirement explain the bottom-of-the-scale effect
- *All* class B numeral modifiers that set an upper bound require quantification over a range of values and display the bottom-of-the-scale effect as a result

(22) a. #Up to one person died in the crash. $\{p_1\}$
b. Up to two people died in the crash. $\{p_1, p_2\}$

(23) a. #At most zero people died in the crash. $\{p_0\}$

Bottom-of-the-scale effect

- The bounds in combination with the range requirement explain the bottom-of-the-scale effect
- *All* class B numeral modifiers that set an upper bound require quantification over a range of values and display the bottom-of-the-scale effect as a result

(22) a. #Up to one person died in the crash. $\{p_1\}$
b. Up to two people died in the crash. $\{p_1, p_2\}$

(23) a. #At most zero people died in the crash. $\{p_0\}$
b. At most one person died in the crash. $\{p_0, p_1\}$

Experiment 1: n & m's

Item No	n	m_{under}	m_{over}
1	3	2	4
2	2	1.5	3
3	96.500	95,000	96,900
4	5.5	4	6
5	4	3	5
6	9	7	10
7	1	.8	1.2
8	43	40	45
9	152,000	150,000	152,700
10	980	950	1,000
11	249,000,000	242,000,000	249,300,000
12	7	5	8

- Not 100% round n's, but small distance between $n \& m_{over}$ $\rightsquigarrow$ possible granularity effects
- Same effects after excluding those items

Experiment 1: Translated example filler items

Contradictory fillers ('Bad fillers')

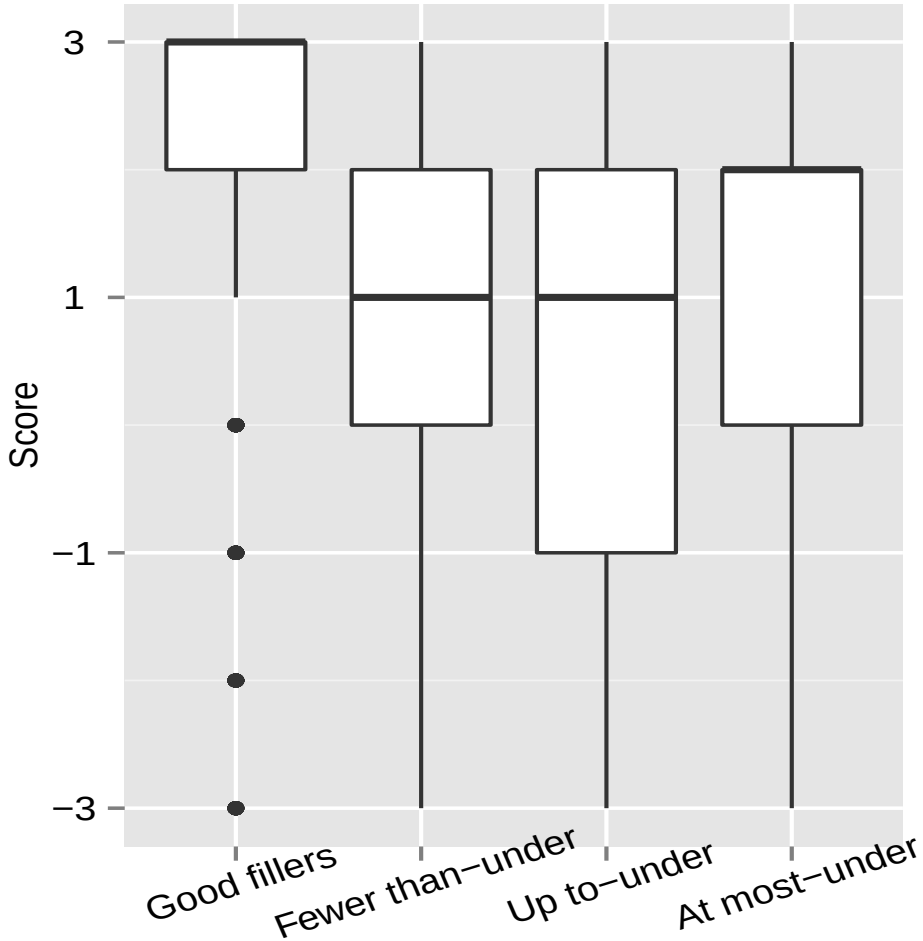
(24) The Panhellenic examinations started at the end of May; specifically, the examination of the first subject took place on the 10th of June.

Coherent fillers ('Good fillers')

(25) Several countries have more than one official language; for example, Belgium has three official languages: Dutch, French and German.

Experiment 1: Targets vs. Good fillers

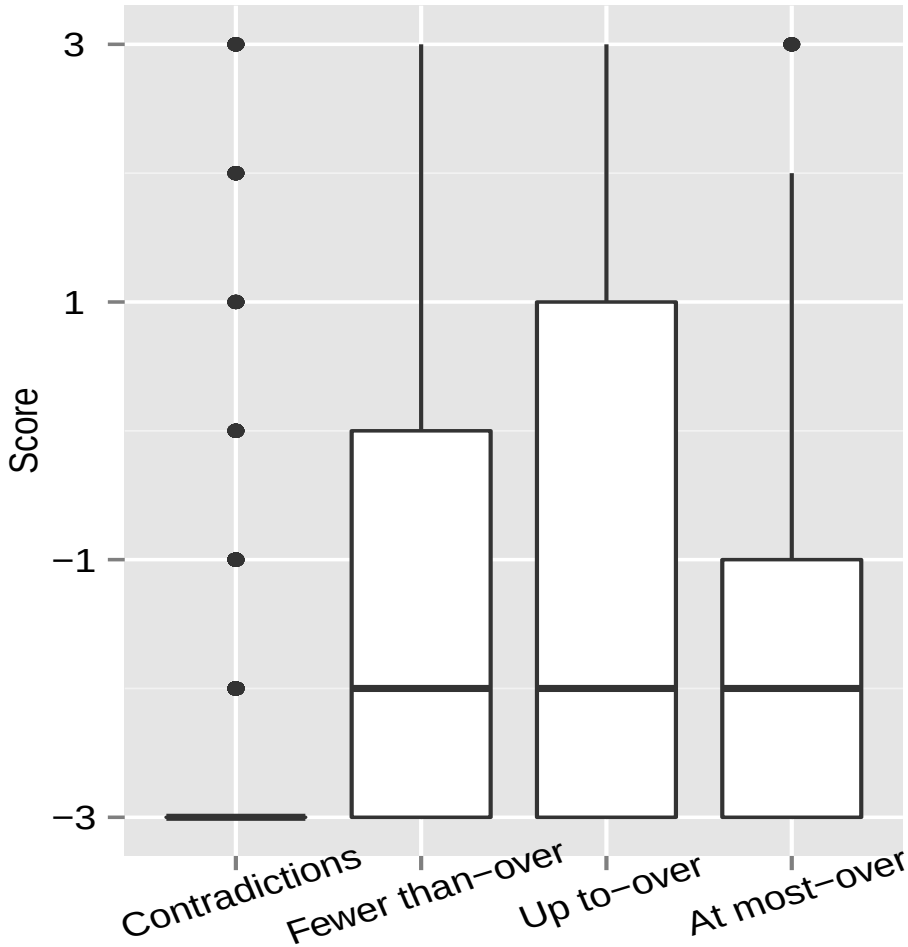
Results



- Scores for Good fillers significantly higher than scores for 'over' condition for fewer than ($\beta = 1.224$, $SE = .181$, $p < .0001$), for up to ($\beta = 1.444$, $SE = .181$, $p < .0001$), and for at most ($\beta = 1.18$, $SE = .181$, $p < .0001$)

Experiment 1: Targets vs. Bad fillers

Results



- Scores for Contradictions significantly lower than scores for 'over' condition for fewer than ($\beta = -1.32$, $SE = .2$, $p < .0001$), for up to ($\beta = -1.515$, $SE = .2$, $p < .0001$), and for at most ($\beta = -1.244$, $SE = .2$, $p < .0001$)

Experiment 2: Example filler items

All = implicature; some = entailment; none = contradiction

CLAIM: The community looked as peaceful as it had through the view point's telescope. *Several* of the houses on the near edge of town were holding yard sales.

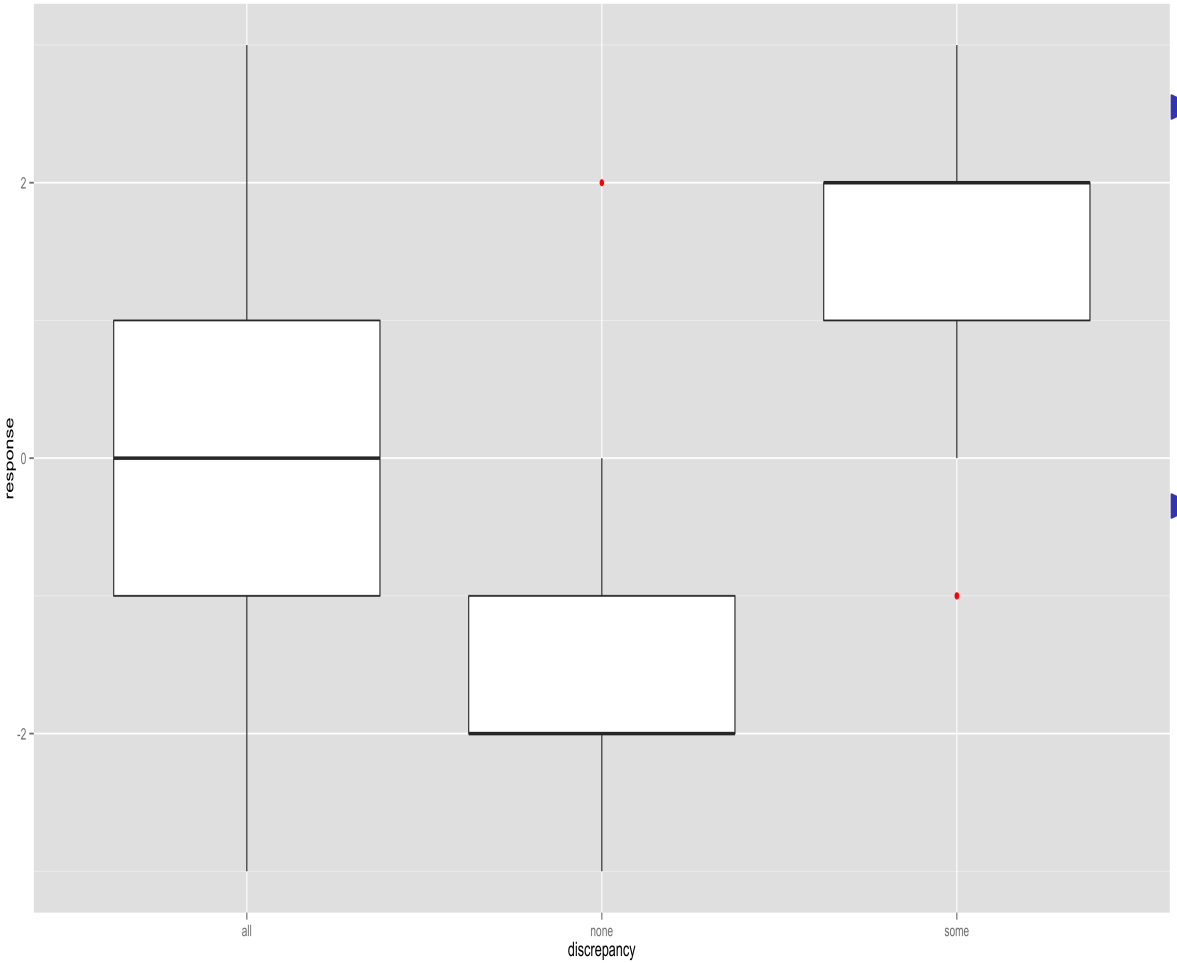
FACT: { *All* / *Some* / *None* } of the houses on the near edge of town were holding yard sales.

How compatible is the CLAIM with the FACT?

–3	–2	–1	0	1	2	3
completely incompatible						completely compatible

Experiment 2: Fillers

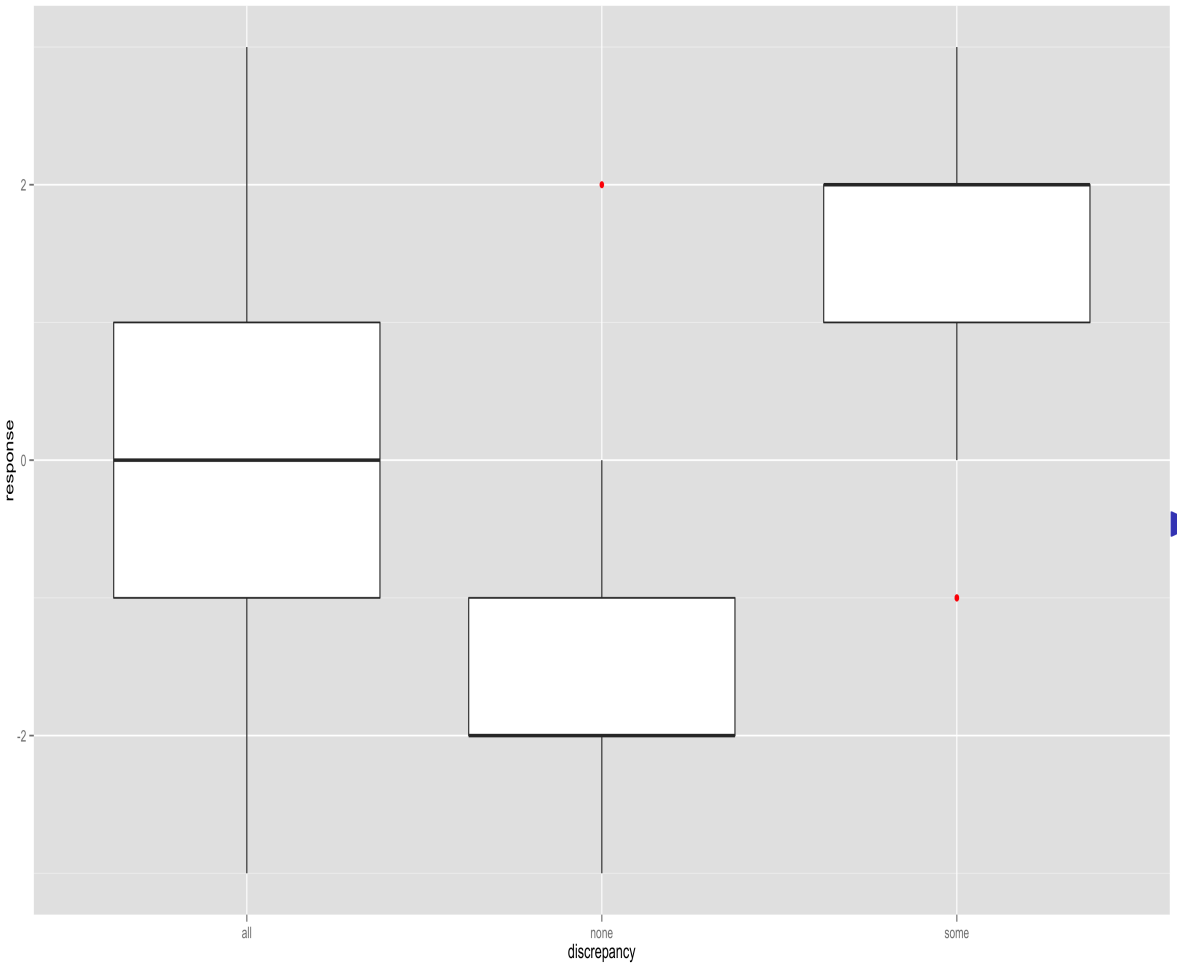
Results



- Scores for 'all' (implicature) condition sig. higher than scores for 'none' (contradiction) condition ($\beta = -2.48$, $SE = .338$, $p < .01$
- Scores for 'all' (implicature) condition sig. lower than scores for 'some' (entailment) condition ($\beta = -2.00$, $SE = .306$, $p < .01$

Experiment 2: Targets vs. fillers

Results



- Scores for 'all' (implicature) condition sig. higher than scores for 'over' condition for at most ($\beta = -1.16$, $SE = .286$, $p < .01$ and for fewer than ($\beta = -1.52$, $SE = .269$, $p < .01$ but not for up to ($\beta = -.05$, $SE = .278$, $p = 0.843$
- Scores for 'some' sig. lower than score for 'under' for each modifier (fewer than: ($\beta = 2.65$, $SE = .357$, $p < .01$; at most: $\beta = 1.361$, $SE = .294$, $p < 0.01$; up to: $\beta = 1.93$, $SE = .313$, $p < 0.01$)