The interpretation of superlative modifiers and deontic modals: an experimental investigation

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Superlative modifiers

- Superlative modifiers (aka: superlative quantifiers) are modifiers involving superlative morphology (Geurts and Nouwen, 2007; Büring, 2008; Cummins and Katsos, 2010; Schwarz, 2011; Cohen and Krifka, 2011; Coppock and Brochhagen, 2013).

  (1) a. There were at least 20 students in the seminar.
  b. There were at most 20 students in the seminar.

- The focus of this study is the interpretation of *at least* and *at most* in combination with deontic modals and the inferences they give rise to.

  (2) a. There have to be at least 20 students in the seminar.
  b. There can be at most 20 students in the seminar.

Outline

1. Superlative modifiers
   - Ignorance inferences
   - Interaction with deontic modals

2. Experimental studies
   - Ignorance inferences of SupMod-modal combinations
   - Interpretation of SupMod-modal combinations
   - General discussion

SupMods and ignorance inferences

Geurts and Nouwen (2007)

- Geurts and Nouwen (2007) observe that SupMods give rise to ignorance inferences:

(3) a. John had at least five beers last night.
b. John had at most five beers last night.
$\rightsquigarrow$ The speaker doesn't know the precise number.

- In a context where all that is relevant is that the number of children is three or more:

(4) #I have at least three children.

Interaction with deontic modals

Geurts and Nouwen (2007) also observe that the effect of speaker ignorance can vanish in certain combinations of superlative modifiers and deontic modals:

- When *at least* is embedded under a necessity modal:

  (5) One must have at least three children in order to be eligible for child benefit.

- When *at most* is embedded under a possibility modal:

  (6) Your luggage is allowed to weigh at most 20 kg.

- In the other two combinations, the effect of speaker ignorance persists:

  (7) a. The paper is required to be at most 10 pages long.
  b. The paper is allowed to be at least 10 pages long.

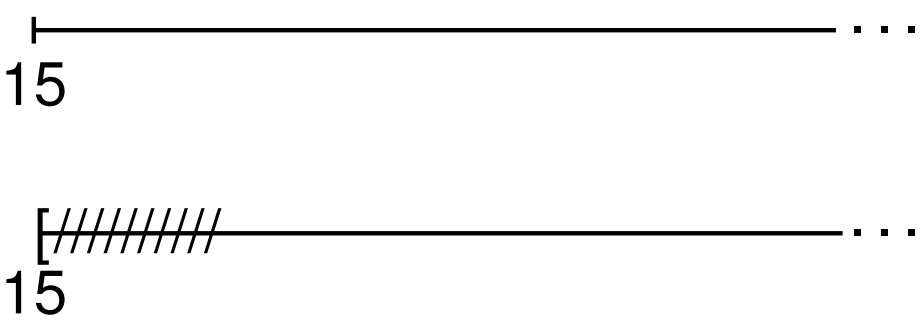
SupMods and ignorance inferences

Accounts on the auction block I

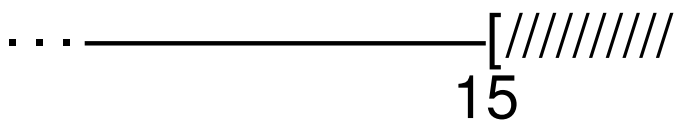
- Geurts and Nouwen (2007) account for ignorance inferences by incorporating epistemic ignorance into the lexical entries of SupMods.
  - They also appeal to a rule of modal concord, which strips off a layer of modality in case the primary epistemic operator in the lexical entry of the SupMod matches the modal force of the modal.

Readings for *at least* and deontic modals

- □ + *at least*: Your paper has to be at least 15 pages long.



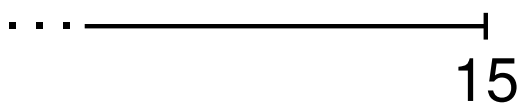
- ◇ + *at least*: Your paper can be at least 15 pages long.

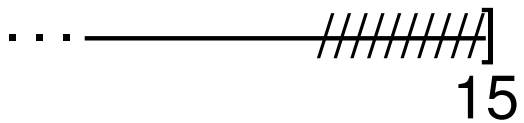


The interval marker by — · · · signifies the deontic range
The interval marked by /// signifies the epistemic range.

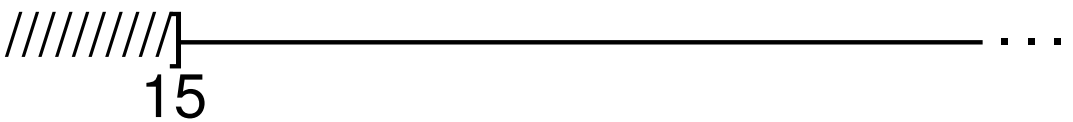
Readings for *at most* and deontic modals

- ◇ + *at most*: Your paper can be at most 15 pages long.





- □ + *at most*: Your paper has to be at most 15 pages long.



The interval marker by — · · · signifies the deontic range
The interval marked by /// signifies the epistemic range.

SupMods and ignorance inferences

Accounts on the auction block II

- Nouwen (2010): Epistemic ignorance is derived from a covert possibility modal embedded under the superlative modifier.
- Büring (2008) and Schwarz (2011): Ignorance inferences of superlative modifiers are derived as pragmatic inferences under a neo-Gricean approach, similarly to scalar implicatures (Sauerland, 2004).
- Coppock and Brochhagen (2013), casting their analysis in Inquisitive Semantics, analyze superlative modifiers as expressions that denote stronger (for *at least*) and weaker (for *at most*) possibilities. Speaker ignorance follows from the listener's inference that the information state of the speaker includes those possibilities.

Outline

1. Superlative modifiers
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   - General discussion

Experimental studies

In order to examine the extent of ignorance inferences and possible readings of superlative modifiers in combination with deontic modals, we conducted two experimental studies addressing the following questions:

- Which of the four SupMod-modal combinations convey speaker ignorance?
- Which readings are available for each of the four SupMod-modal combinations?

Outline

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Experiment 1

- Which SupMod-modal combinations convey speaker ignorance?
- Participants (N=40[1]) on MTurk were asked to rate the coherence of a speaker uttering a sentence with a SupMod and a modal on a scale of -5 to +5, where -5 is definitely not coherent and +5 is definitely coherent.
- The scale provides a way to differentiate between semantic falsity and pragmatic infelicity (Cummins and Katsos, 2010).
- We compared coherence in three types of contexts varying the epistemic stance of the speaker (as a between-subject factor):
  - $\pm$knowledgeable:
    speaker may or may not have the knowledge
  - +knowledgeable:
    context makes explicit that the speaker has the knowledge
  - $-$knowledgeable:
    context makes explicit that the speaker doesn't have the knowledge.

[1] 18 Female; Mean Age: 43.8; Age range: 26-62

Experiment 1

Stimuli: ±knowledgeable contexts

Hannah and Alice want to go on a spontaneous trip to Ibiza. After some research they've found a last minute deal. Since they haven't yet figured out what dates they were both free on, they asked the travel agent about the booking conditions. The travel agent said:

"You $\left\{ \begin{array}{lll} \text{have to} & \text{book the trip} & \text{at least} \\ \text{have to} & \text{book the trip} & \text{at most} \\ \text{can} & \text{book the trip} & \text{at least} \\ \text{can} & \text{book the trip} & \text{at most} \end{array} \right\}$ 5 days

before the day of departure."

Experiment 1

Stimuli: +knowledgeable contexts

Shelly is a 3rd grade teacher and is planning a day trip to the Children's Museum for her class. She called the museum's ticket office to ask for a group price and the number of people it applies to. Dan at the ticket office checked this information for her and said:

"There $\left\{ \begin{array}{lll} \text{have to} & \text{be} & \text{at least} \\ \text{have to} & \text{be} & \text{at most} \\ \text{can} & \text{be} & \text{at least} \\ \text{can} & \text{be} & \text{at most} \end{array} \right\}$ 10 children in the group."

Experiment 1

Stimuli: −knowledgeable contexts

Professor Samsa is teaching an Introduction to Semiotics class but hasn't decided on the syllabus and the length of the term paper. Jeremy, a student in his class, asked him about the length of the paper for the class, and Professor Samsa said:

"Your term paper $\left\{\begin{array}{lll} \text{has to} & \text{be} & \text{at least} \\ \text{has to} & \text{be} & \text{at most} \\ \text{can} & \text{be} & \text{at least} \\ \text{can} & \text{be} & \text{at most} \end{array}\right\}$ 15 pages long."

Experiment 1

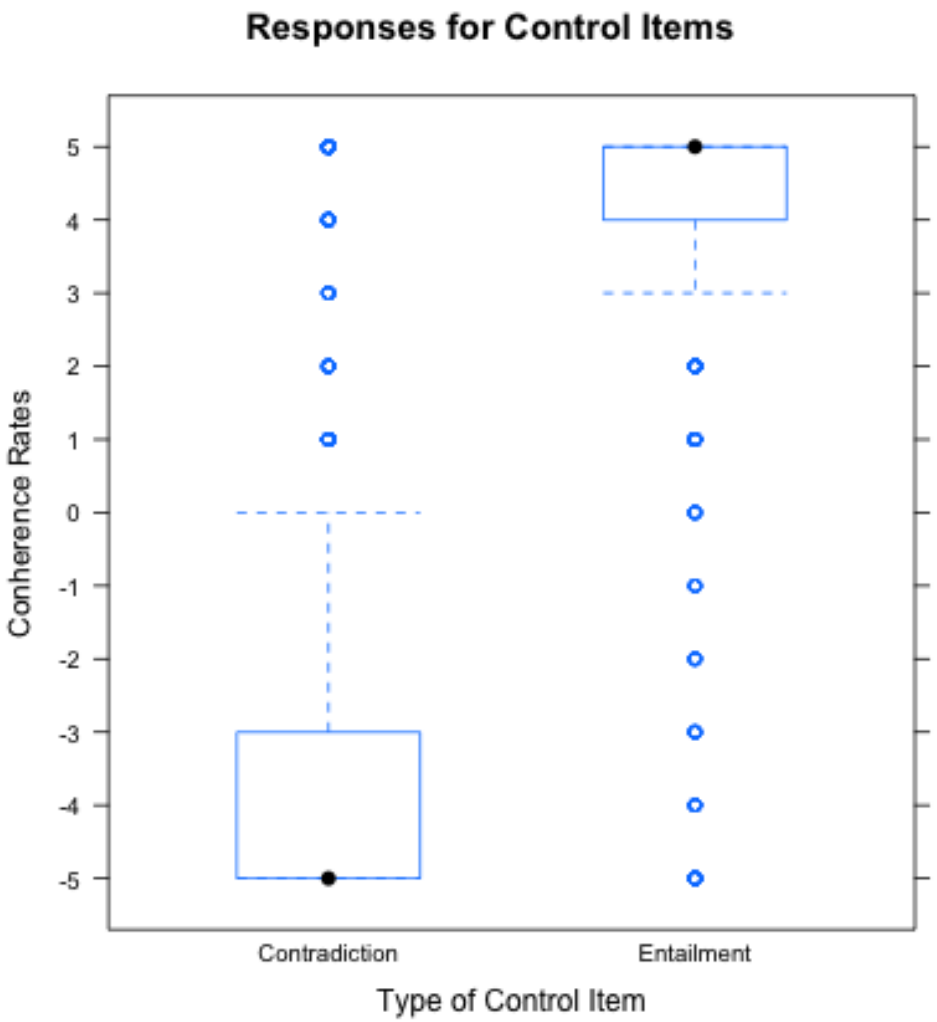
Rationale and Predictions

We expect that the three different types of contexts would lead to different judgments of coherence:

- $\pm$knowledgeable:
  In principle, these contexts should allow for both utterances conveying speaker ignorance and utterances not conveying speaker ignorance.
- $-$knowledgeable:
  Participants should judge an unknowledgeable speaker uttering a sentence **not** conveying speaker ignorance as incoherent.
- $+$knowledgeable:
  Participants should judge a knowledgeable speaker uttering a sentence conveying speaker ignorance as incoherent.

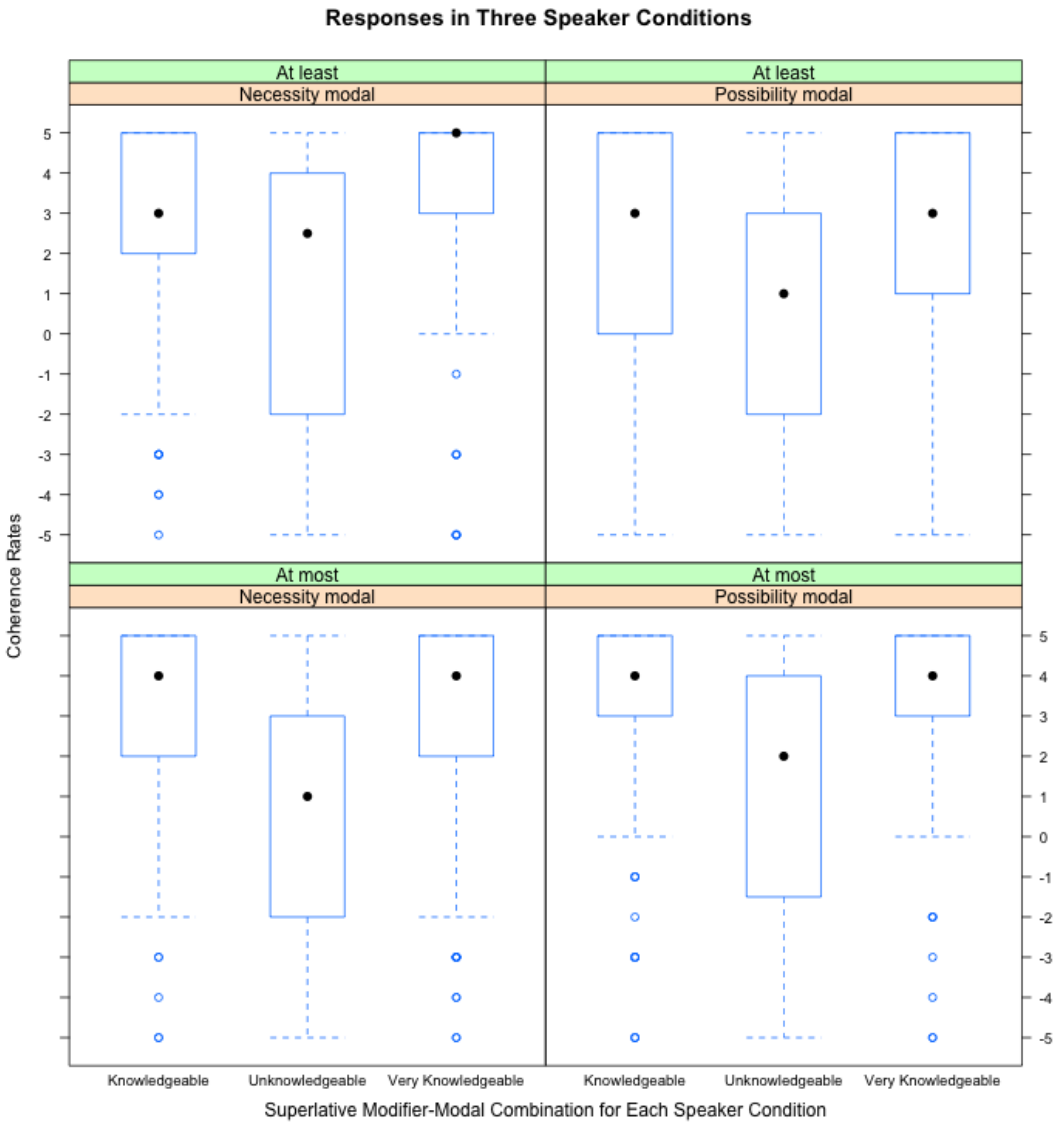
Results of Experiment 1: Control Items

Controls were adapted from Doran et al. (2012)



- **Contradiction:**
  Mark's sister is 4'7"(139 cm) and has black hair. When Claus was sent to pick her up at the train station, he asked Mark what she looked like so he could recognize her when he saw her. Mark said in response: "She's a tall redhead."
  (Mean: −3.15, SD: 3.18)
- **Entailment:**
  Lynn owns a red Porsche, which she likes to drive around town. Tod, who hasn't seen her car, asked her what kind of car she owned, and Lynn said in response: "I own a Porsche."
  (Mean: 3.79, SD: 2.19)

Results of Experiment 1



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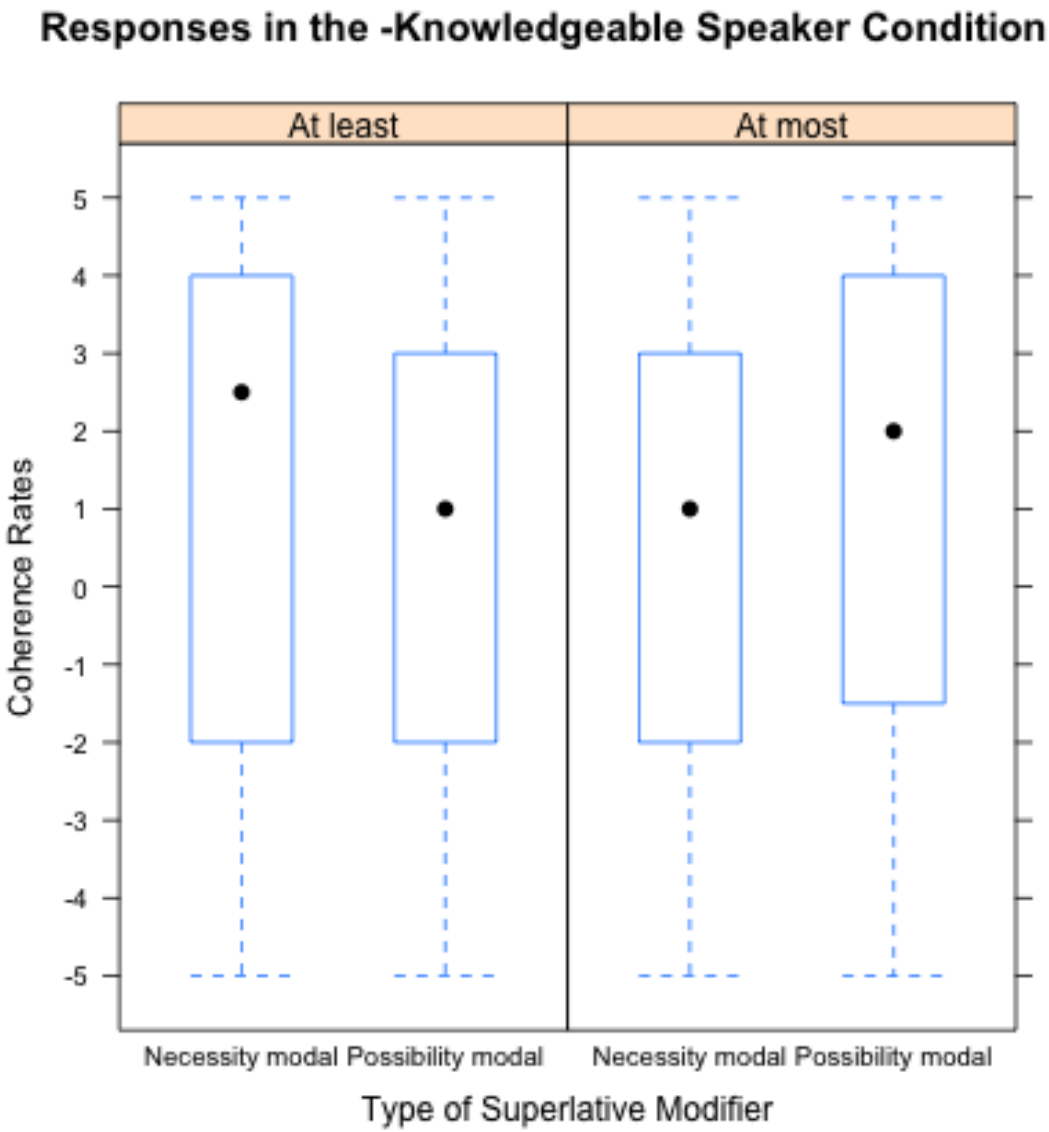
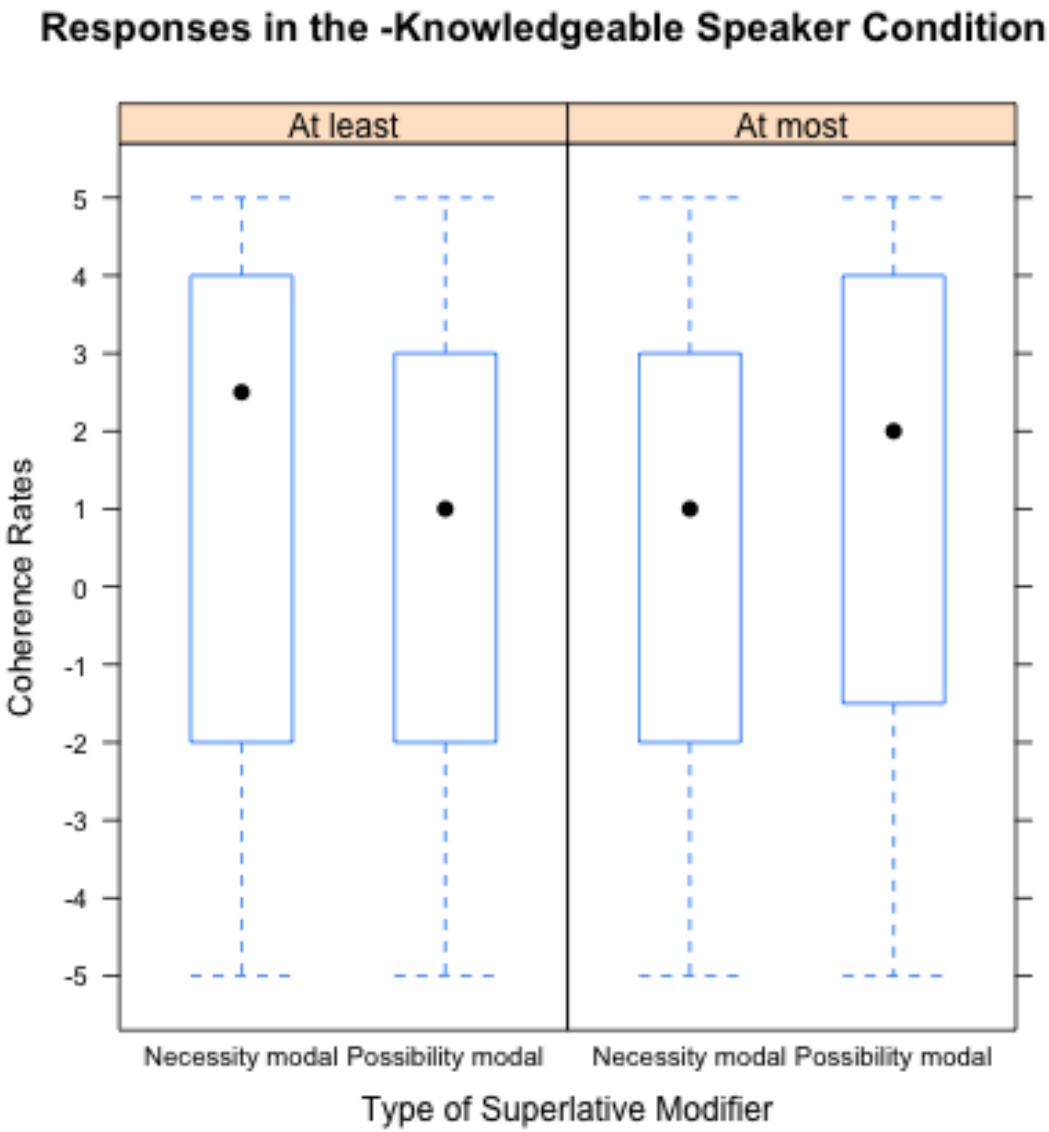
- Participants found statements uttered by an unknowledgeable speaker less coherent than statements uttered by knowledgeable speakers in general. ($p<0.01$)

Results of Experiment 1: −knowledgeable contexts



- □ + *at least* (mean = 1.23) is significantly more coherent ($p<0.01$) than ◇ + *at least* (mean = 0.26)
- There is no significant difference between ◇ + *at most* (mean = 1.33) and □ + *at most* (mean = 0.94)
- We can't conclude that the natural combinations and unnatural combinations were all different from one another in the −knowledgeable speaker condition.

Results of Experiment 1: −knowledgeable contexts



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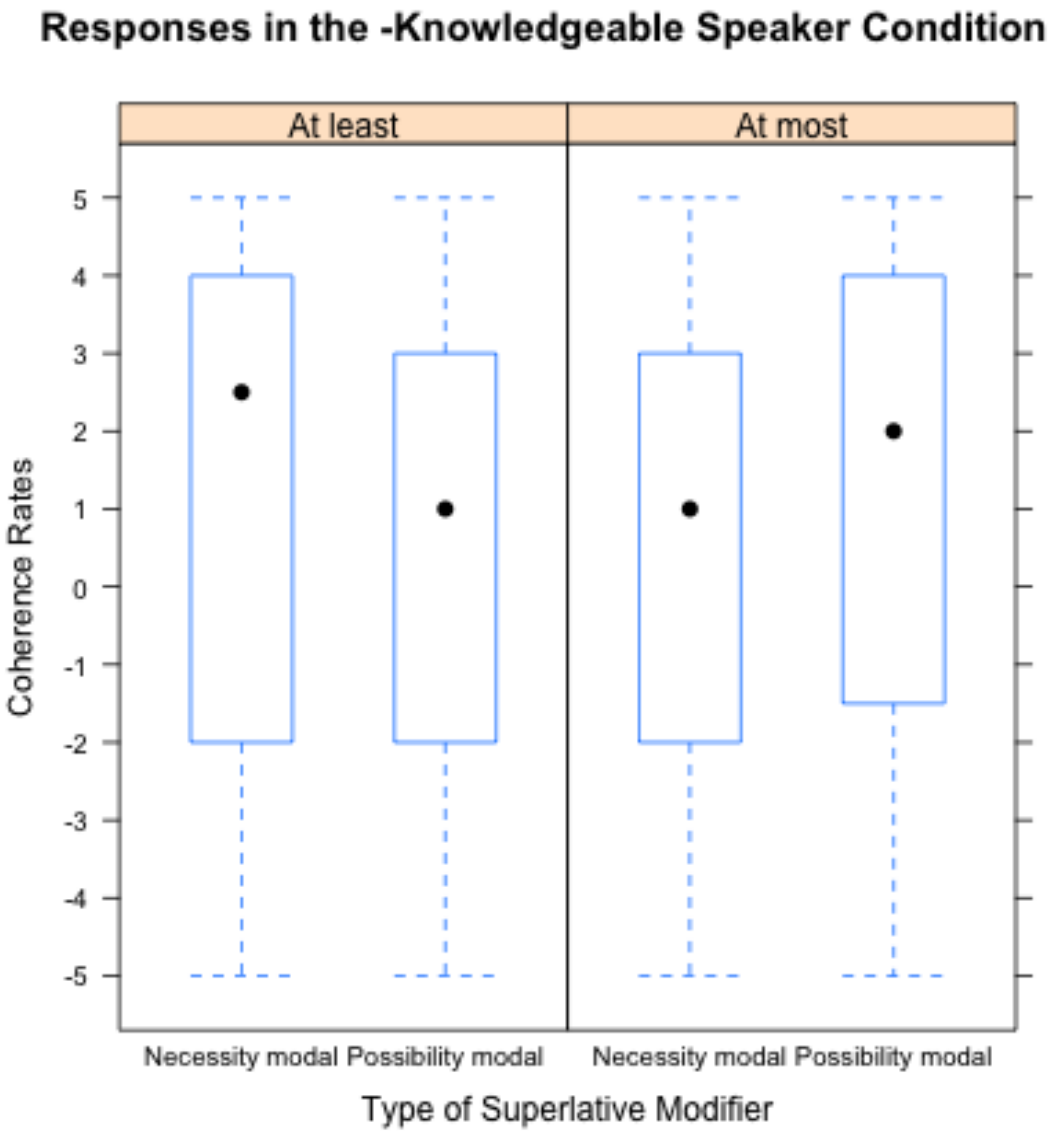

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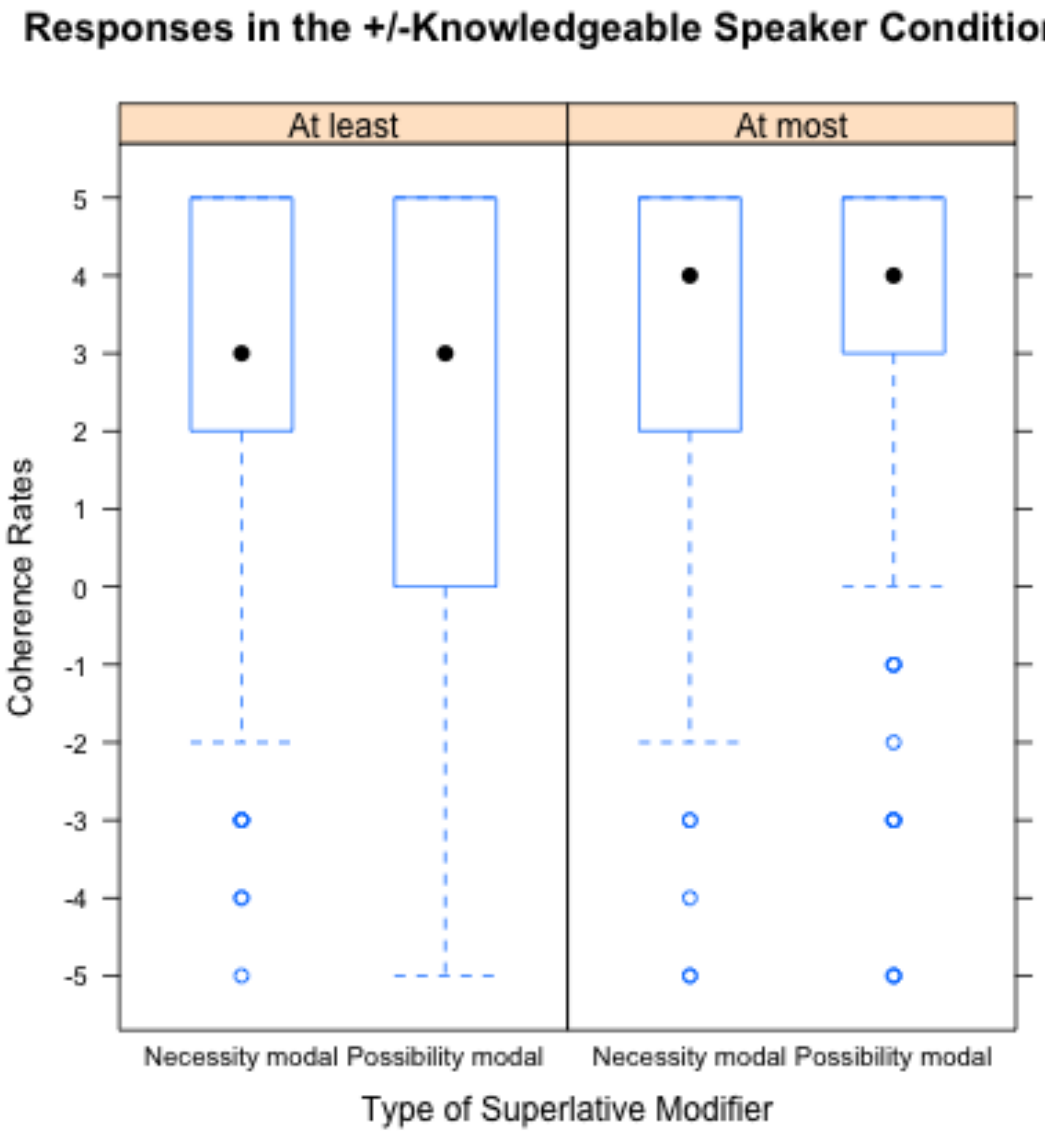
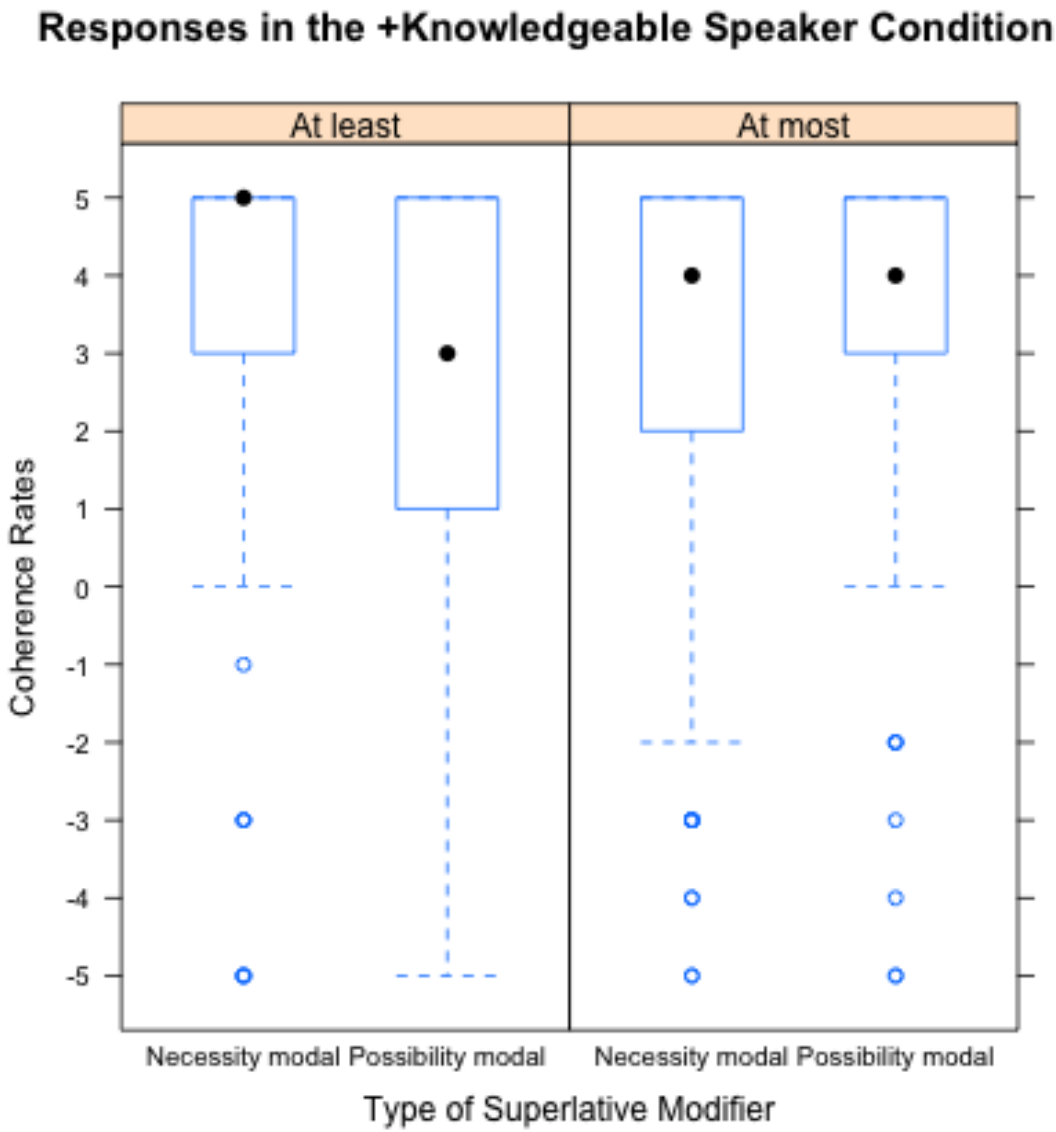
Results of Experiment 1: ±knowledgeable contexts



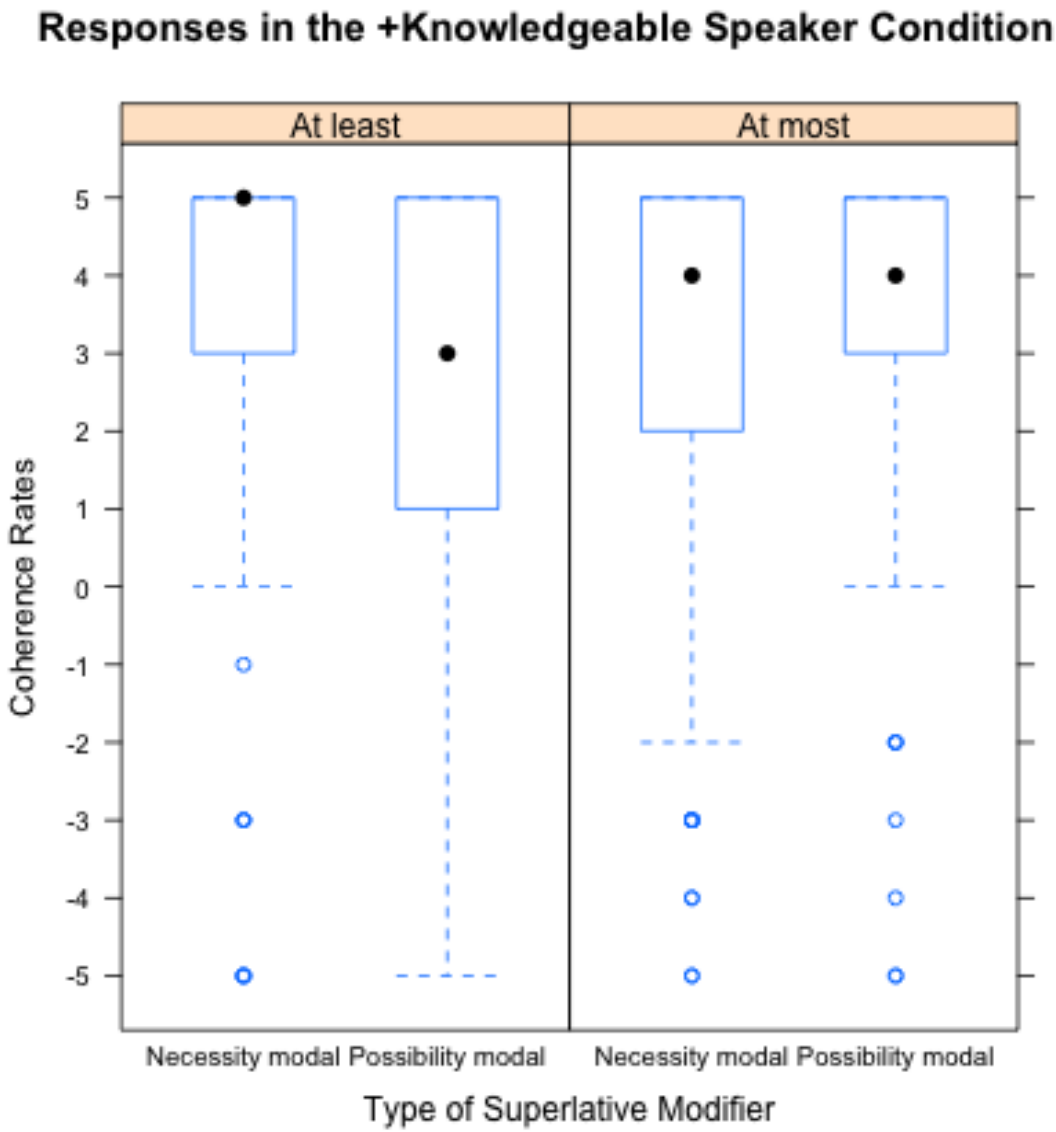
- As expected, we found no significant difference between the natural combinations and the unnatural ones in contexts in which the speaker may or may not have had the knowledge.

Results of Experiment 1: +knowledgeable contexts



- □ + *at least* (mean: 3.59) is significantly more coherent ($p<0.01$) than ◇ + *at least* (mean = 2.42)
- ◇ + *at most* (mean = 3.44) is significantly more coherent ($p<0.05$) than □ + *at most* (mean = 2.6)
- The natural combinations were rated more coherent than the less natural ones.

Results of Experiment 1: +knowledgeable contexts



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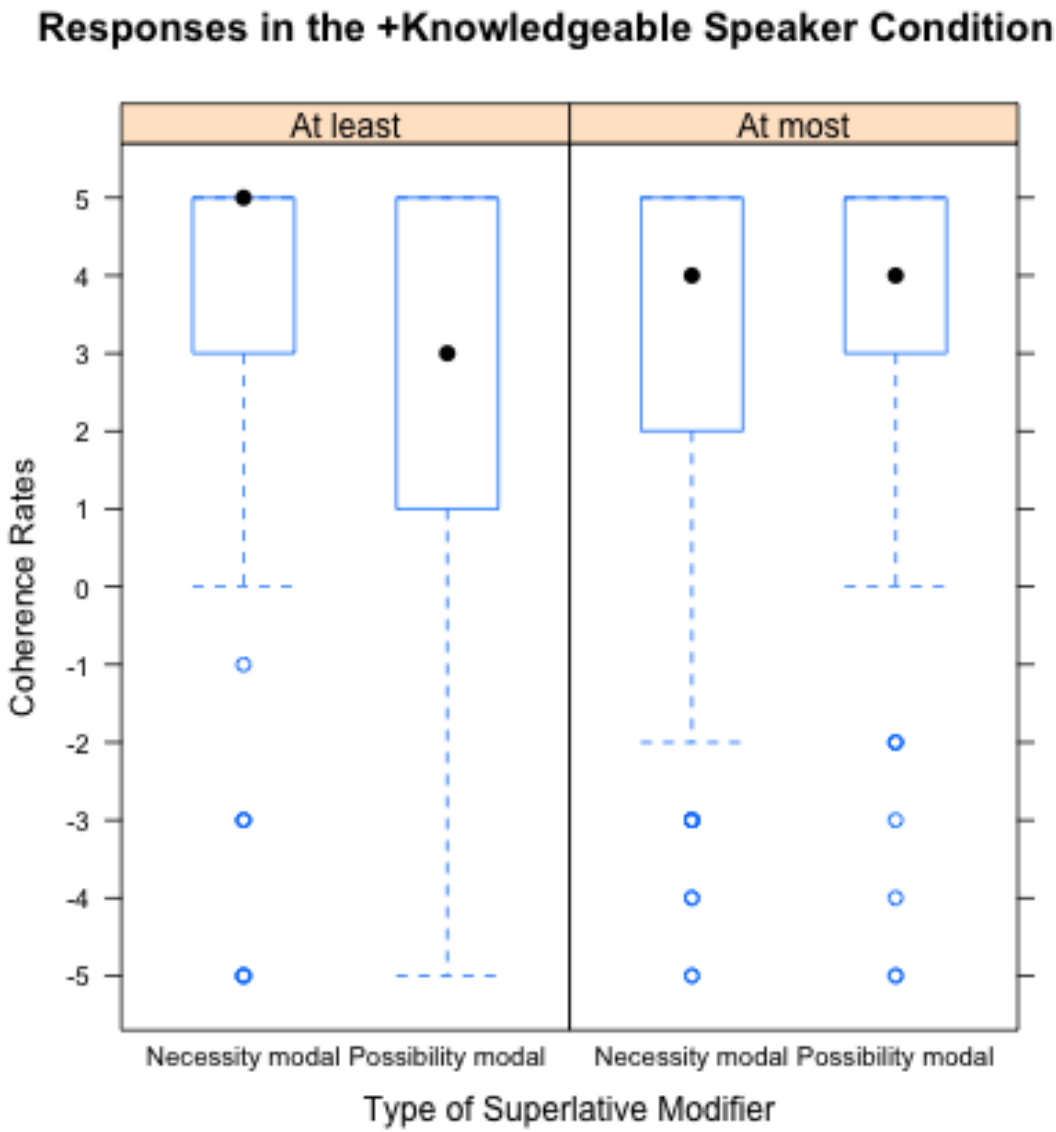

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- The natural combinations were rated more coherent than the less natural ones.

Experiment 1: Discussion

. . . in the +knowledgeable speaker condition

- The following combinations are judged as more coherent:
  - $\Box$ + *at least*
  - $\Diamond$ + *at most*
- And the following combinations are judged as less coherent:
  - $\Diamond$ + *at least*
  - $\Box$ + *at most*
- We observe a mismatch between the unnatural SupMod-modal combinations and the contexts in which the speaker is certain. This suggests that the unnatural combinations convey speaker ignorance.
- The lower coherence rates for the unnatural combinations are significantly different than those for Contradictions ($p<0.01$). This suggests that ignorance inferences are pragmatic rather than semantic (contra Geurts and Nouwen 2007 and in line with e.g. Cummins and Katsos 2010; Schwarz 2011).

Discussion of experimental results

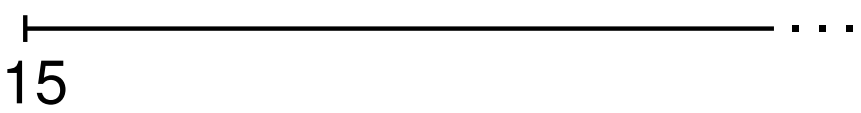
Obviation of speaker ignorance

- Combinations that show obviation of speaker ignorance in our study:
  - $\Box$ + *at least*
  - $\Diamond$ + *at most*
- Geurts and Nouwen (2007) account for this pattern by appealing to a rule of modal concord.
- Nouwen (2010) predicts that SupMods generally obviate speaker ignorance when they combine with $\Diamond$. This prediction is not confirmed by the results of our study (namely for $\Diamond$ + *at least*).
- Büring (2008) and Schwarz (2011) predict that SupMods generally obviate speaker ignorance when they combine with $\Box$. This prediction is not confirmed by the results of our study (namely for $\Box$ + *at most*).

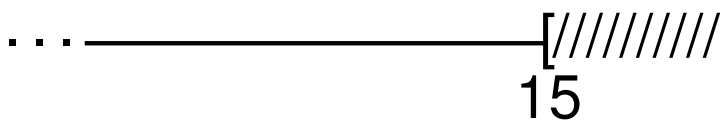
Outline

Readings for *at least* and deontic modals

- □ + *at least*: Your paper has to be at least 15 pages long.



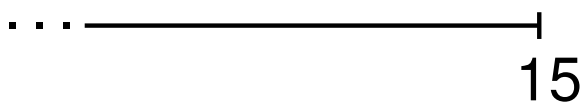
- ◊ + *at least*: Your paper can be at least 15 pages long.



The interval marker by — · · · signifies the deontic range
The interval marked by /// signifies the epistemic range.

Readings for *at most* and deontic modals

- ◊ + *at most*: Your paper can be at most 15 pages long.



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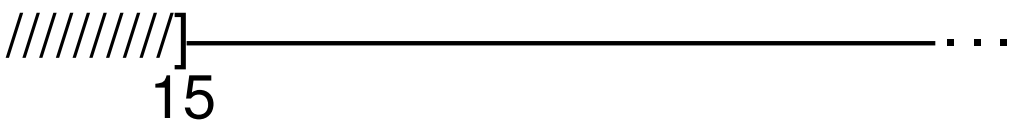


The interval marker by — · · · signifies the deontic range
The interval marked by /// signifies the epistemic range.

Experiment 2

- Which interpretations (specifying upper and lower bound) are available for which SupMod-modal combinations?
- Participants (N=40[2]) on MTurk had to decide whether an action or state of affairs is in accordance with an utterance involving a SupMod-modal combination.
- Contexts were underspecified regarding the knowledge of the speaker, i.e. they should allow for an interpretation with speaker ignorance or without.
- Contexts were intuitively compatible with a range of allowed values, i.e. they allowed for both a minimum (lower bound) and a maximum (upper bound).

[2] 17 Female; Mean Age: 34.5; Age Range: 22-60

Experiment 2

Target items (N=40)

Professor Samsa is teaching an Introduction to Semiotics class. Jeremy, a student in his class, asked him about the length of the paper for the class, and Professor Samsa said:

"Your term paper $\left\{ \begin{array}{lll} \text{has to} & \text{be} & \text{at least} \\ \text{has to} & \text{be} & \text{at most} \\ \text{can} & \text{be} & \text{at least} \\ \text{can} & \text{be} & \text{at most} \end{array} \right\}$ 15 pages long."

Jeremy handed in a $\left\{ \begin{array}{l} 13 \\ 17 \end{array} \right\}$ page-long paper.

Did the length of Jeremy's term paper comply with Professor Samsa's specifications?

Experiment 2

Experimental conditions

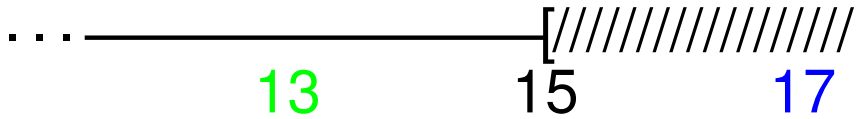
- Utterance: . . .
  - Modal: $\left\{ \begin{array}{c} \textit{can} \\ \textit{have to} \end{array} \right\}$
  - SupMod: $\left\{ \begin{array}{c} \textit{at least} \\ \textit{at most} \end{array} \right\}$ n . . .
- Description: . . . m $\left\{ \begin{array}{l} > \text{n (Over)} \\ < \text{n (Under)} \end{array} \right\}$ . . .

Readings for *at least* and deontic modals

Jeremy handed in a . . .

- □ + *at least*: Your paper has to be at least 15 pages long.

- ◊ + *at least*: Your paper can be at least 15 pages long.

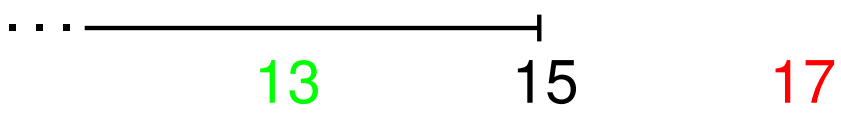


. . . page-long paper.

Readings for *at most* and deontic modals

Jeremy handed in a . . .

- ◇ + *at most*: Your paper can be at most 15 pages long.



- □ + *at most*: Your paper has to be at most 15 pages long.

. . . page-long paper.

Experiment 2: Results

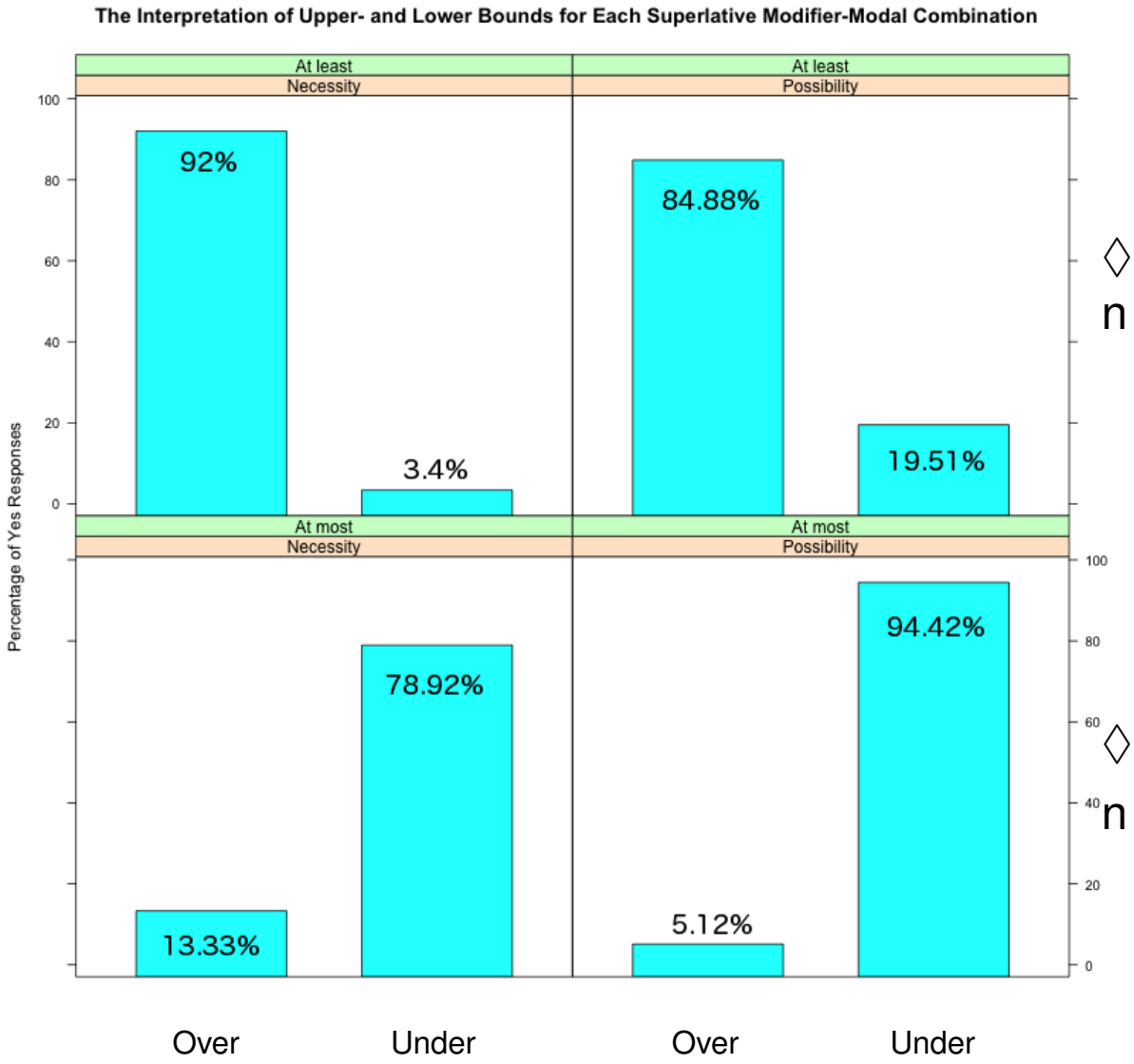
Control items (N=20)

- Professor Covalent handed out a take home final exam for the Organic Chemistry course Claire is in. After going over the questions on the exam he said:
  "Please hand in your exam tomorrow, Tuesday, March 25, by 5 p.m."
  - 'Compliance' condition: Claire handed in her exam on Tuesday, March 25, at 4 p.m.
  - 'Violation' condition: Claire handed in her exam on Wednesday, March 26, at 2 p.m.

  Did Clair follow the professor's instructions?
- Compliance (N=10): 94.4% Yes responses
- Violation (N=10): 7.87% Yes responses

Experiment 2: Results

□ + *at least* n:
n = Lower bound



◊ + *at least* n:
n = Lower bound

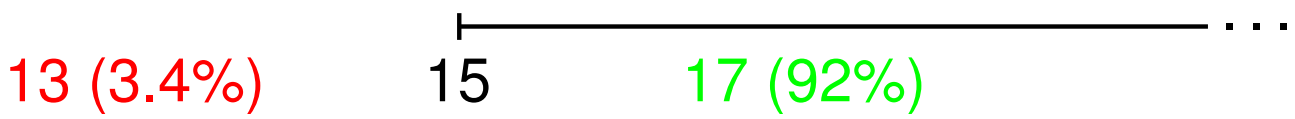
□ + *at most* n:
n = Upper bound

◊ + *at most* n:
n = Upper bound

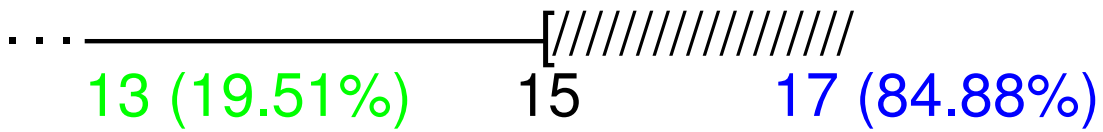
Observed readings for *at least* and deontic modals

Jeremy handed in a . . .

- □ + *at least*: Your paper has to be at least 15 pages long.



- ◊ + *at least*: Your paper can be at least 15 pages long.



. . . page-long paper.

Observed readings for *at most* and deontic modals

Jeremy handed in a . . .

- ◇ + *at most*: Your paper can be at most 15 pages long.

- □ + *at most*: Your paper has to be at most 15 pages long.

. . . page-long paper.

Results of Experiment 2

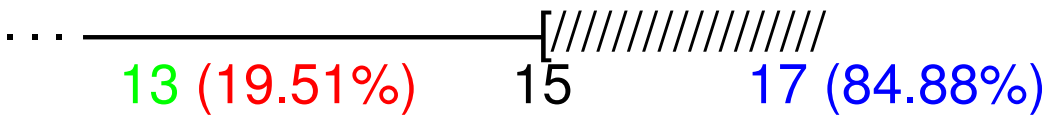
- The two natural combinations clearly have one available interpretation:
  - $\Box$ + *at least* n: n = Lower bound
  - $\Diamond$ + *at most* n: n = Upper bound
- The other two combinations exhibit a less robust contrast but still show a clear tendency:
  - $\Diamond$ + *at least* n: n = Lower bound
  - $\Box$ + *at most* n: n = Upper bound

Experiment 2: Discussion

Readings of SupMod-modal combinations

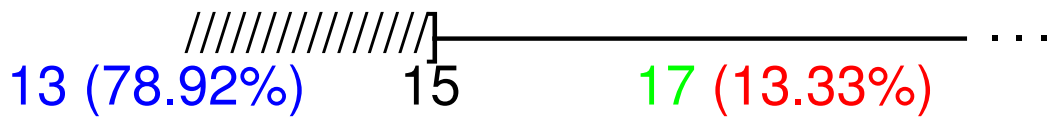
- The predictions made by Geurts and Nouwen (2007) are disconfirmed by the results of our study:
  - ◇ + *at least* n: n is the lower limit of the upper bound

    Your paper can be at least 15 pages long.

  - □ + *at most*: n is the upper limit of the lower bound

    Your paper has to be at most 15 pages long.

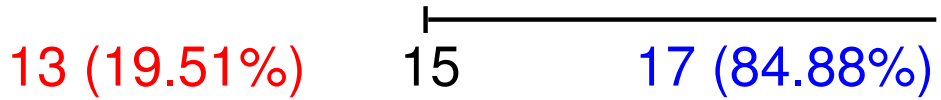
    

Experiment 2: Discussion (continued)

Readings of SupMod-modal combinations

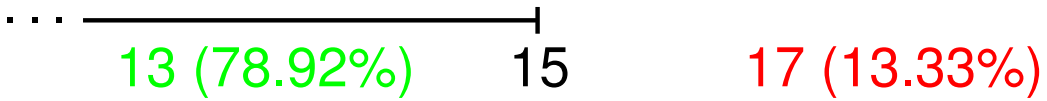
- Nouwen (2010) predicts:
  - ◇ + *at least* n: n specifies the lower bound of the deontic range

    Your paper can be at least 15 pages long.



- Büring (2008) and Schwarz (2011) predict:
  - □ + *at most* n: n specifies the upper bound of the deontic range

    Your paper **has to** be at most 15 pages long.



- However, the components of the analyses in Nouwen (2010) and Büring (2008) and Schwarz (2011) are incompatible (distinct assumptions about the semantics of SupMods).

How to interpret the results for the unnatural combinations I

In most cases:

- . . . n in ◊ + *at least* n specifies the lower bound (84.55%).
  → The unnatural ◊ + *at least* is reinterpreted as its natural □ + *at least* counterpart.
- . . . n in □ + *at most* n specifies the upper bound (78.92%).
  → The unnatural □ + *at most* is reinterpreted as its natural ◊ + *most* counterpart.

How to interpret the results for the unnatural combinations II

In the remaining cases

- . . . n in ◊ + *at least* n is interpreted as specifying the upper limit of the lower bound (19.51%).
  → That is, the compositional analysis
- . . . n in □ + *at most* n is interpreted as specifying the lower limit of the upper bound (13.33%).
  → That is, the compositional analysis

Why is modal reanalysis preferred over the compositional reading?

- The compositional analysis is the less frequent and dispreferred one, because it creates a situation in which there are no prohibited values, as the deontic and epistemic ranges cover the entire range of values (modulo pragmatic restrictions).
- This unrestricted reading is at odds with the speaker's utterance, which includes two expressions that normally communicate restriction, namely deontic modals and superlative modifiers.
- In most cases, then, participants resorted to a reanalysis of the modal to arrive at a clearer reading in order to complete the task.
- Between- and within-subject analyses suggest that some participants consistently chose one interpretive strategy and some alternated between the two.

Outline

General discussion

- Unnatural SupMod-modal combinations convey speaker ignorance.
- Natural combinations can suppress speaker ignorance.
- These inferences are pragmatic rather than semantic
- The natural combinations have only one reading each:
  - n is the lower bound for □ + *at least* n
  - n is the upper bound for ◊ + *at most* n
- The unnatural combinations have
  - a preferred reading:
    - ★ n is the lower bound for ◊ + *at least* n
    - ★ n is the upper bound for □ + *at most* n
  - and a dispreferred one (the compositional one):
    - ★ n specifies the upper limit of the lower bound in ◊ + *at least* n
    - ★ n specifies the lower limit of the upper bound in □ + *at most* n

Remaining issues and future research

The two experiments test different properties of SupMod-modal combinations (obviation of speaker ignorance and interpretation).

- Results from an interpretation task that measures also reaction times will enable us to test the speaker ignorance implications as well as the interpretation of upper/lower bounds:
  - We would expect the unnatural combinations to incur slower reaction times.
  - We would expect differences in reaction times w.r.t. the type of reading assigned to the unnatural SupMod-modal combinations
    - ★ What would be the difference in reaction times between the modal reanalysis strategy and the compositional strategy?

Thanks!

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