At Most Readings for Bare Numerals under Necessity Modality

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Background

Bare numerals can have a number of different interpretations, whose saliency varies by context::

(1) a. Jim ate three cookies. [*exactly*]
b.Everyone who ate three cookies felt sick. [*at least*]
c. You can eat three cookies. [*at most*]

Previous accounts of the semantics of numerals predict that *at most* readings have a very restricted distribution:

- Only under possibility modality (Kennedy, 2012)
- Only in downward entailing environments (Breheny, 2008; Spector, 2013)

However, *at most* readings can also be found under necessity modality:

(2) a. Jim wears shorts whenever he can. It has to be 40 degrees for him to wear jeans.
b. You must have $5 in your account before you can declare bankruptcy.

Can *at most* readings be reliably found under necessity modality? What role does context play?

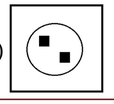
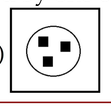
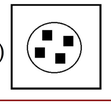
Experiment 1 - Method

Participants: 149 people on Amazon MTurk

Instructions:
(3) Mike, Al, Jim and Dave are learning to play a card game. Each card has shapes on it. The rules determine which cards can be picked. You will see statements made by the players of the game or descriptions of situations that arose while it was being played, accompanied by a picture of a card. You will be asked a question about the picture and the accompanying text.

Procedure:
Participants saw two test stimuli embedded among non-numeric controls, one with *can* and one with *must*, each accompanied by a different image. They rated whether the rules were followed on a scale of 1 (not at all) to 7 (completely).

Test stimulus:
(4) Dave {can/must}pick a circle which contains three squares. This is the circle he picked. Did he follow the rules?
This was accompanied by one of these three images:

(a)  (b)  (c) 

Experiment 1 - Results

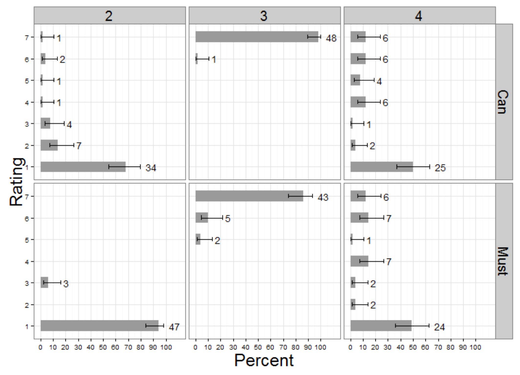


Figure 1: Ratings under *can* and *must* by number of squares seen

- When a circle with 2 squares was shown as the card played, under *can* (compatible with *at most* reading), a rating of 1 (not following the rules at all) was given by 66% (mean = 1.76, sd= 1.46).
- When a circle with 2 squares was shown as the card played, under *must* (compatible with *at most* reading), a rating of 1 was given by 94% (mean = 1.12, sd= .48).

Interim Summary

Findings of Experiment 1:

- No evidence of *at most* readings under *must*.

But:

- Also no evidence of *at most* readings under *can*, where they are expected to be most salient.

This indicates that the availability of *at most* readings is not due only to the presence of the modal in the context.

This suggests that the broader context is playing more of a role than previous accounts predicted.

Experiment 2 is designed to provide context encouraging *at most* readings and investigate how more detailed context influences the availability of this reading.

Experiment 2 - Method

Participants: 308 people on Amazon MTurk

Instructions:
(5) Mike, Al, Jim and Dave are learning to play various card games, each with its own rules. Each card has shapes on it. The rules determine which cards can be played. You will see statements made by players of the games or descriptions of situations that arose while they were being played, accompanied by a picture of a card. You will be asked a question about the picture and the accompanying text. Please keep in mind that each question will refer to a different game.

Procedure:
Participants saw two test stimuli embedded among non-numeric controls, one with *can* and one with *must*, like in Experiment 1, but prefaced by a rule. Each stimulus was accompanied by a different image (identical to the images in Experiment 1). Participants rated whether the rules were followed on a scale of 1 (not at all) to 7 (completely).

Test stimulus:
(6) In this game, one of the rules is that you have to play lower (fewer squares) than the player before you, or draw a card. Al {can/must} play a circle which contains three squares. This is the card he played. Did he follow the rules?

Conclusion

- Context plays an important role in determining the salience of the different interpretations of bare numerals.
- For some people it is possible to get *at most* interpretations of numerals under necessity modality with appropriate contextual support.
- This demonstrates the importance of having a semantic account for numerals which is flexible enough to allow for these interpretational possibilities.

References

Breheny, Richard. 2008. *A New Look at the Semantics and Pragmatics of Numerically Quantified Noun Phrases.* Journal of Semantics 25:93-139.

Kennedy, Christopher. 2012. *A Scalar Semantics for Scalar Readings of Number Words*. semanticsarchive.net/Archive/zIyMjg1Y/numberwords-ck.pdf.

Spector, Benjamin. 2013. *Bare Numerals and Scalar Implicatures.* Linguistics and Language Compass 7:273-294.

Acknowledgments

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Experiment 2 - Results

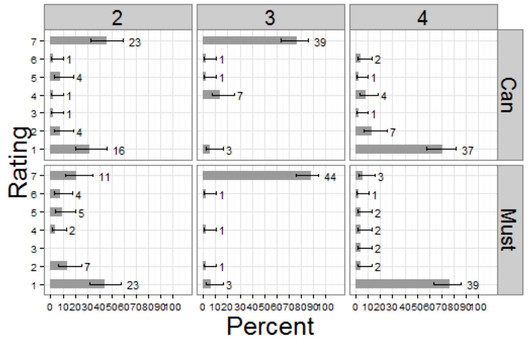


Figure 2: Ratings by environment and by number of squares seen

- The pattern observed under *can* is very different from that in Experiment 1. In this case, when 2 squares were seen, the *at most* interpretation is now the preferred reading, with 46% rating it a 7, completely following the rules (mean = 4.46, sd = 2.74).
- Under *must* with 2 squares there is now also evidence of an *at most* reading, with 21% rating it a 7 (mean = 3.29, sd = 2.54), though this is not the most popular response (44% rated it at 1, not allowing this reading).
- The distribution of ratings under *must* when a circle with 2 squares was seen in Experiment 2 is significantly different than that seen in Experiment 1 (Mann-Whitney test, UA = 627.5, $z = 4.39$, $p < .0001$).