

On the scalar interpretation and the processing of numerals.

Numbers have (at least) two interpretation: a weak one (the ‘at least’ reading) and a strong one (the ‘exactly’ reading). There is a dispute on how such interpretations come about. The dispute centers around the following three theses

- (1) (a) Numerical expressions are lexically ambiguous (e.g. Horn)
- (b) Numerical expressions are underspecified (e.g., Carston, Breheny)
- (c) Numerical expression have a weak interpretation that gets strengthened via a scalar implicature (Grice, early NeoGriceans, Chierchia)

The present paper addresses experimentally a factual claim pertaining to this debate. The claim is the following:

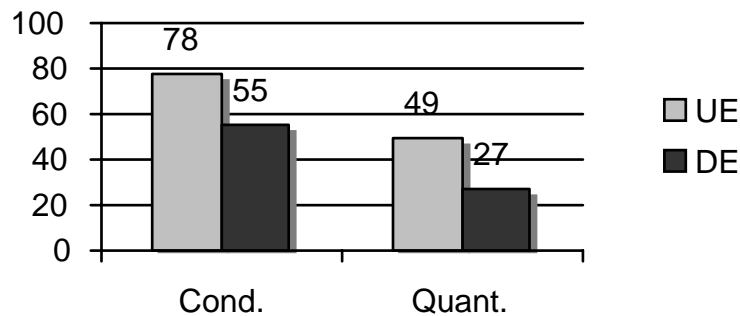
MAIN CLAIM: *The strong interpretation of number words occurs preferentially in UE contexts. The weak interpretation occurs preferentially in DE contexts.*

‘Preferentially’ here means both ‘more often’ and ‘with less of a processing cost’. Theses similar to MC have been put forth in the literature, specifically in the context of theory (c). They remain controversial. Native speakers intuitions of the type used in current linguistic theorizing are arguably not sufficient to establish this claim. Replicable testing seems to be called for. We address MC in two ways. First, we tackle the preference issue by means of an off-line questionnaire. Then we address the processing cost issue through an eye tracking experiment.

In the first experiment participants had to read sentences containing a numeral determiner in the first clause, embedded in either a positive upward entailing (UE) context or in a downward entailing (DE) one (antecedent of conditionals or restriction of universal quantifiers, e.g.: “John parked two cars in the garage and he parked a motorcycle in the courtyard” vs. “If John parked two cars in the garage, he will park a motorcycle in the courtyard”). Participants were asked to choose a preferred paraphrase that disambiguated the sentence towards the weak or the strong construal of the numeral (“at least two cars” vs. “exactly two cars”). The results show a significant difference in the interpretation of numerals: subjects selected more often the strong value when the numeral was embedded in a UE context. The second experiment taps on line processing of numerals. Participants were asked to read the same sentences used in the first experiment in three circumstances: (i) with a neutral continuation, (ii) with a positive continuation (e.g.: If John parked two cars in the garage, he will park a third car in the courtyard”), and with a negative continuation (e.g.: “..., he will not park a third car in the courtyard”). Both continuations contain an ordinal linked to the substantive appearing in the first clause. Only the *positive* continuation, however, forces a strong interpretation of the numeral, which would occur in a DE context and hence be costly, according to MC. (While the negative continuation may also appear to induce a strengthened interpretation, it can be shown that this is not so, and thus it provides an interesting control for our hypothesis). Summing up, our experimental design is constituted of 2 factors (monotonicity: DE vs. UE; continuation: positive, neutral, negative). We found that the numeral in the first clause (for which participants showed a preference in choosing the “exactly N” meaning in the first

experiment) were more difficult to read in the first-pass reading times in the UE condition. Furthermore, there were significant interactions in the second-pass reading times on the same region depending on continuation type. Numerals were re-read more often when embedded in a DE context, whereas in the other two conditions the opposite pattern emerged. Moreover, our results show an early slowdown in UE contexts (as, presumably, processing of the scalar implicature takes place more often in such contexts). Finally, if people are forced to strengthen the numeral meaning in DE contexts (as in the *DE-positive* condition) they make more second-pass fixations. Overall, these results seem to support our main claim and the scalar approach.

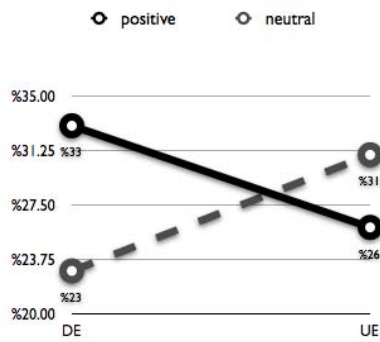
Percentage of strengthened interpretations (Experiment 1)



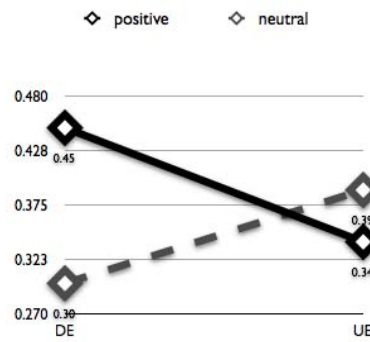
Item examples.

<p>(4a) <i>UE</i> Giovanni ha due macchine in garage e John has two cars in the garage <u>and</u></p>	<p>(5a) <i>neutral continuation</i> parcheggia una motocicletta nel cortile esterno. he parks a motorcycle in the courtyard.</p>
<p>(4b) <i>DE</i> <u>Se</u> Giovanni ha due macchine in garage <u>If</u> John has two cars in the garage</p>	<p>(5b) <i>positive continuation</i> parcheggia una terza macchina nel cortile esterno. he parks a third car in the courtyard.</p> <p>(5c) <i>negative continuation</i> non parcheggia una terza macchina nel cortile esterno. he doesn't park a third car in the courtyard.</p>

Second-pass fixation probability and second-pass fixation number on the numeral region. Positive vs. Neutral continuation comparison.

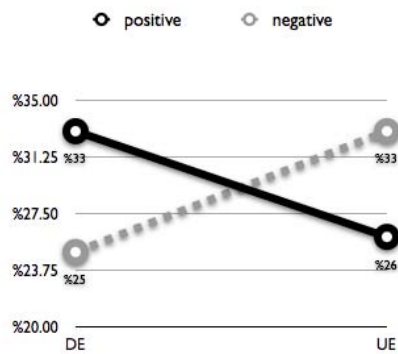


LMM $p < .02$

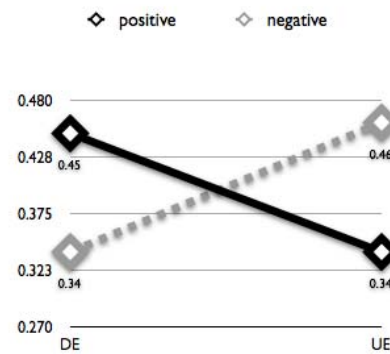


LMM $p < .02$

Second-pass fixation probability and second-pass fixation number on the numeral region. Positive vs. Negative continuation comparison.



LMM $p < .02$



LMM $p < .02$

References:

Horn, L. (1972). *On the Semantic Properties of Logical Operators in English*, Ph. D. Diss., UCLA; distributed by IULC.

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Chierchia, G. (2004). *Scalar Implicatures, Polarity Phenomena and the Syntax/Pragmatics Interface*. A. Belletti (ed) Structures and Beyond, Oxford University Press.