

Pragmatic effects attested in online interpretation of *more than* and *at least*

Stavroula Alexandropoulou¹, Jakub Dotlačil² & Rick Nouwen¹

¹Utrecht University, ²University of Amsterdam

We present results of an eye-tracking reading study on the interpretation of two types of numeral modifiers (NMs), viz., *at least* and *more than*, in three kinds of context, thereby probing the inferences triggered by such modifiers, and their status.

Motivation. Since Geurts & Nouwen (2007), it's been an uncontroversial and well-established fact that superlative NMs, unlike their comparative counterparts, trigger ignorance effects. Only very recently has this fact been called into question: Westera & Brasoveanu (2014) and Mayr & Meyer (2014) argue that comparatives too give rise to ignorance, if there is a *how many* Question Under Discussion (QUD). Coppock et al. (2016) too observe that, while an answer to a polar question, see (1), could imply that B knows the exact number of apples in the case of *more than* but not of *at least*, the use of either NM in B's answer in (2) conveys speaker ignorance, as B is explicitly asked to name the precise number of apples Joe ate.

- (1) A: Did Joe eat any apples? (2) A: How many apples did Joe eat?
 B: Yes, he ate *at least/more than* 3 apples. B: He ate *at least/more than* 3.

The present study sets out to directly probe ignorance effects with *more than* and *at least* with a *how many* QUD by means of an online experiment. We are, moreover, concerned with yet another type of inference of NMs, which has been neglected by the existing literature, namely, *speaker indifference*. In B's answer with *at least*, in either (1) or (2), if 3 is a relevant number in the context, there is an additional reading whereby B knows the exact quantity of apples but s/he regards it as relevant to only mention a lower bound, not caring about the exact number. This inference together with ignorance as well as *acknowledgment of disagreement* appears to form a family of inferences, also displayed by free relatives (Condoravdi, 2015), epistemic indefinites (Chierchia, 2013), disjunction (Lauer, 2013), and has often been treated on a par with ignorance in the sense that it is derived via a (similar) pragmatic mechanism (see, e.g., Lauer, 2013). In this study, we investigate speaker indifference effects with both *at least* and *more than*, and further evaluate their status relative to ignorance.

Present study. In order to directly examine speaker ignorance and indifference effects of *at least* and *more than*, we ran an eye-tracking reading experiment measuring what happens in real time when interpreting those NMs in a context with an ignorant, an indifferent or a plain knowledgeable/authoritative speaker, and an implicit *how many* QUD. So we manipulated the factors **Context** and **NM** in a 3×2 design. Dutch native speakers read texts in Dutch like the following (translated into English; *target* is in glosses):

Intro: Sophie is a figure skater and very dedicated. Normally, she trains for four hours in the weekend, but last weekend she trained as intensively as possible.

IGNORANCE: I'm not sure how much exactly, but this is what I think:

INDIFFERENCE: I could tell you exactly how much, but it's not that important.

AUTHORITY: I can tell you how much because I talked to her yesterday.

Target: Sophie has last weekend AT LEAST/MORE THAN eight hours on the ice practiced.

The context setup is inspired by Breheny et al. (2006), who tested the online interpretation of scalar terms in a self-paced reading task. They found a slowdown at the region of the scalar expression when the preceding context supported a scalar implicature vs. when being compatible with the lower-bound-only reading, and attributed this finding to online implicature calculation being costly. Our starting point is an analysis in which ignorance and indifference inferences behave in a way fully parallel to the finding of Breheny et al. (2006) on scalar implicatures: ignorance and indifference inferences are computed online

and come about via a costly pragmatic mechanism. If such an analysis is on the right track, we expect to find a slowdown in IGNORANCE and in INDIFFERENCE contexts at the modified numeral. Lastly, the semantic meaning of *at least* and *more than* is fully compatible with AUTHORITY contexts. Such contexts are incompatible with ignorance effects, but not with indifference effects, so such contexts are expected to yield no or optional indifference inferences. For this reason, AUTHORITY was the baseline for the **Context** factor in our study. MORE THAN was the reference level for the **NM** factor. We tested 36 items, with 72 fillers and a Latin square design. 37 native speakers of Dutch (33 female, mean age: 23.7, age range: 18–42) participated in the experiment. The **NM** type did not affect text coherence ($z = .840$, $p = .401$) in a pretest where people had to judge how compatible the *Target* is given the preceding context, on a Likert scale from 1 (*not compatible*) to 7 (*compatible*).

Results & discussion. Linear mixed-effects regression analyses revealed:

(i) a processing penalty for IGNORANCE contexts with AT LEAST at the region of “eight hours” in re-reading probability (positive AT LEAST*IGNORANCE interaction in overall analysis & positive IGNORANCE effect in AT LEAST subset analysis, both $z > 2$, $p < .05$) as well as for INDIFFERENCE contexts with AT LEAST. In a previous experiment testing *at least* (Alexandropoulou et al., 2016), we found the same effect in IGNORANCE contexts (vs. AUTHORITY) at the region “eight hours”, where the interpretation of the whole modified numeral phrase is completed. We interpreted this effect as being due to ignorance implicature calculation, in support of pragmatic accounts of ignorance like that in Büring (2008) or in Schwarz (2016) (a.o.), which derive ignorance as a Quantity implicature. As the present study gets rid of previous possible confounds (e.g., using a round number in *Target* or introducing a contrast with another number, see *Intro*, makes the ignorant speaker’s *Target* utterance more natural), the replication of our previous finding strengthens our conclusion that ignorance with *at least* is a pragmatic inference computed online. The INDIFFERENCE effects we found are likewise to be attributed to a costly pragmatic mechanism responsible for the derivation of indifference effects, exhibiting a status similar to that of ignorance.

(ii) a slowdown in IGNORANCE contexts with MORE THAN at the spillover region “on the ice” (negative AT LEAST*IGNORANCE interaction, positive IGNORANCE effect in overall & in MORE THAN subset analyses, in early & late measures, all $t/z > 2$, $p < .05$) and likewise in INDIFFERENCE contexts with MORE THAN in “last weekend” (where subjects already see *more than*) up to “on the ice”. One possibility is that these effects suggest that ignorance and indifference inferences are available with *more than* too, and are in fact derived by a pragmatic process. This would go against the claim that *more than* has no ignorance implication (see Coppock and Brochhagen, 2013). Another possibility, which could potentially explain the different processing profiles of the two NMs in our experiment, is that the attested processing cost is due to a Manner implicature: subjects find *at least* a better cue to ignorance and indifference and, hence, wonder why the speaker did not use *at least* instead, with this reasoning inducing a slowdown (cf. Degen & Tanenhaus, 2011 for similar results due to competition between *some* and number terms).

Conclusion. We provide evidence of the unexplored speaker indifference effects with numeral modifiers and of their pragmatic status, similar to ignorance. Furthermore, we replicated our previous finding suggesting that ignorance effects of *at least* are pragmatic inferences that are computed online. Crucially, we found a processing penalty for *more than* in contexts with an ignorant or an indifferent speaker, showing that pragmatic reasoning is involved in real-time comprehension of *more than*, too, in such contexts, as a Manner and/or an ignorance/indifference implicature. More generally, our findings contribute extra evidence that pragmatic reasoning occurs online and is costly.

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