Less than a Sentence is not Enough – An Eyetracking Study on the Incremental Interpretation of Negative Expressions

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Online studies of quantifier and negation processing suggest that not all aspects of semantic operators are interpreted immediately. A number of previous studies concluded that downward entailing (DE) quantifiers such as *less than half* lead to severe processing delays as compared to upward entailing (UE) ones, such as *more than half* (e.g. [1]), as does the interpretation of negation (e.g. [2]). Perhaps unsurprisingly, then, the non-incremental interpretation of scopal operators seems to extend to multiply quantified sentences, as suggested by an eyetracking during reading study on the relative scope of quantifiers by [3] with scope interpretation delayed until the end of the sentence.

The purported violation of incrementality has not gone unchallenged, though. In particular, it has been shown that pragmatic factors such as world knowledge and discourse context bear important influences on the time course of scope interpretation (e.g. [4,5,6]). For negation, [7,8] have proposed the Dynamic Pragmatic Account based on *Questions under Discussion* (QUDs, [9]) essentially claiming that the delay is caused by the need to accommodate an appropriate QUD. The present eyetracking during reading study thus investigated the time course of comprehending sentences with quantifiers and negation (see ex. (1)-(5)) with and without discourse context.

Eyetracking Study: Exp. 1 ($N = 48$) established clear complexity differences with overadditive effects of operators, though was not intended to address incrementality yet. Participants read sentences containing UE vs. DE quantifiers in initial position and negated vs. positive predicates (e.g. *not blue* vs. *blue*; see ex. (1)) in the sentence-final region of interest (ROI). Linear scope was fixed because negation appeared in a scope island. The final ROI contained the negation, provided the second semantic argument of the quantifier and completed the sentence. It was this ROI where our manipulation of semantic complexity showed the expected interaction between operators: Regression path durations (RPDs) were longer for DE than UE quantifiers, with a bigger difference in negated conditions than in the positive control condition (Fig. 1 a; all reported effects were significant in (G)LMER analyses). Exp. 2 ($N = 40$) employed these complexity differences as indication of compositional interpretation during reading more natural quantifier-negation sentences out of discourse context. To test for the influence of event information encoded in lexical verbs [cf. 3], the position of the main verb was another factor manipulated (cf. ex. (2) vs. (3)). A pretest established an overwhelming surface-scope preference for the experimental items. Delayed semantic interpretation may be expected in (3) because here the event information of the main verb was presented several words after the negation. In (2), we considered incremental effects likely, hoewever, since the negation was presented simultaneously with the main verb and, as in Exp. 1, completed a minimal sentence [10]. Contrary to this Verb-Dependent Incrementality assumption, complexity effects were delayed to the final ROI, irrespective of verb position, as in [3] (Fig. 1 c). Exp 3. ($N = 48$) embedded clefted versions of the same sentences (ex. (5)) in discourse contexts that introduced positive and negative properties (e.g. *to play* or *not to play*) establishing the QUD "how many" individuals have or lack the property in question. Based on the literature [7,8], we expected incremental effects in such sentences with contextually licensed negation. Contextual embedding led to earlier and sustained effects of negation (Fig. 1 b), but monotonicity of the quantifier still only affected the final ROI of the relative clause and none of the earlier ROIs.

Conclusions: The different time course observed for Exps. 2 and 3 resulting from the contextual establishment of the QUD shows that discourse pragmatics is an important prerequisite for the realtime interpretation of scope. However, finding an effect of monotonicity still only at the end of the clause indicates that multi-operator interpretation proceeds in an essentially non-incremental
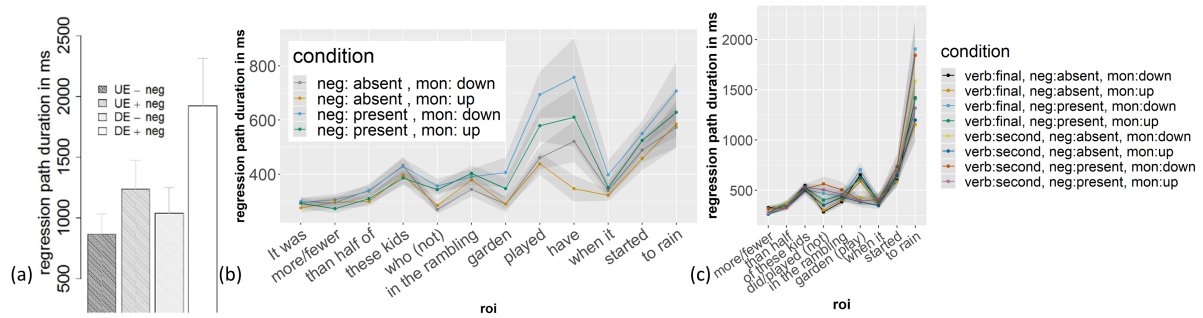
Figure 1: Regression path durations (+95% confidence intervals), i.e. the time of all fixations summed up from first entering a ROI until it is left to the right (a: sentence final ROI in Exp. 1; b: all ROIs in Exp. 3; c: all ROIs in Exp. 2).

way. We consider this a highly interesting finding because the verbal information was information already given in the discourse context. The processing of negative operators thus depends on a larger domain than just the operators themselves such as a complete minimal sentence.

Sample Item Experiment 1 (picture verification task not shown here, results fully consistent with complexity results of the reading stage):

(1) Auf| $\left\{ \frac{\text{mehr}}{\text{weniger}} \right\}$ als die Hälfte der Quadrate |trifft zu, |dass sie |(nicht) blau sind.
For| $\left\{ \frac{\text{more}}{\text{fewer}} \right\}$ than the half of squares |it's true |that they |(not) blue are

Sample Item Experiment 2:

(2) $\left\{ \frac{\text{Mehr}}{\text{Weniger}} \right\}$ als |die Hälfte |dieser Kinder |spielten (nicht) |im weitläufigen |Garten, |als es |anfing |zu
$\left\{ \frac{\text{More}}{\text{Fewer}} \right\}$ than |half |of these kids |played (not) |in the rambling |garden |when it |started |to
regnen.
rain

(3) $\left\{ \frac{\text{Mehr}}{\text{Weniger}} \right\}$ als die Hälfte |dieser Kinder |haben (nicht) |im weitläufigen |Garten gespielt, |als ...
$\left\{ \frac{\text{More}}{\text{Fewer}} \right\}$ than half |of these kids |have (not) |in the rambling |garden played |when ...

Sample Item Experiment 3:

(4) Preceding Context: Ida's parents invited the kids from the neighborhood to her birthday party. After lunch they all played in the garden. When it started to rain, Ida's parents decided to open up the living room for the kids. Some of the kids didn't want to play in the garden anymore whereas others stayed outside and played in the rain.

(5) Es waren| $\left\{ \frac{\text{mehr}}{\text{weniger}} \right\}$ |als die Hälfte |dieser Kinder, |die (nicht) |im weitläufigen |Garten |gespielt |haben,
It was| $\left\{ \frac{\text{more}}{\text{fewer}} \right\}$ |than half |of these kids |who (not) |in the rambling |garden |played |have
|als es |anfing |zu regnen.
|when it |started |to rain

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