Quantifier scope ambiguity and the timing of algorithmic processing

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Recent work by Ferreira and colleagues (Christianson et al., 2001; Ferreira, 2003; Swets et al., 2008) argues that language comprehension occurs using simple heuristics, in addition to using syntactic algorithms. However, at present, it is unclear how heuristic processes are coordinated with the output of syntactic algorithms. In the present work, I argue that results of 3 self-paced reading experiments examining the processing of quantifier scope ambiguous (QSA) sentences argue that heuristic processes apply FIRST, and algorithmic processes SECOND.

The processing of two-sentence discourses as in (1) was investigated, where context sentences exhibited QSA. Note that plural continuation sentences are consistent with surface scope interpretation as in (1), and singular continuations with inverse scope, as in (2). Below, stimuli were separated by previous norms that indicated biases for plural vs. singular continuations (Dwivedi et al., 2010). From a processing perspective, the logical interpretation of scope, which is an algorithmic process, should show a surface scope bias, since this interpretation is consistent with surface linear order. Experiment 1 (*N*=80) used stimuli that were heavily biased for a plural continuations, yet surprisingly, demonstrated no difference in reading times (RTs) to plural vs. singular continuations, compared to controls (3) (cf. Fodor, 1982). While this effect mirrored our previous ERP study of QSA (Dwivedi et al., 2010), it ran counter to other findings, (e.g., Kurtzman & MacDonald, 1993).

In order to address this, we added questions (4) to the design of the experiment, in order to ensure deeper processing of the discourses, in Experiment 2 (*N*=48). Results indicated that RTs for continuation sentences now did show a difference; indicating that participants were paying more attention. Plural continuation sentences overall were read faster than singular ones. In other words, RTs were consistent with the lexical-pragmatic interpretation of number associated with context sentences, and were not indicative of scope computation. However, question-response accuracy was consistent with the algorithmic computation of scope. That is, accuracy rates were only at chance when questions queried inverse scope conditions as in (2). In Experiment 3 (*N*=40), stimuli that were equi-biased between singular and plural continuations were used (5). Again, RTs for continuation sentences were consistent with the lexical-pragmatic bias of context sentences, now continuation sentences following unambiguous control contexts took less time to read than those following scope ambiguous sentences. However, interestingly, question-response accuracy rates were exactly the same as in Experiment 2. This indicates that while reading QSA sentences, people are only sensitive to their lexical-pragmatic bias; that is, they are engaged in fast and frugal heuristic processing. In other words, it's only when participants are actually queried about scope interpretation that they interpret the sentences deeply using algorithmic rules of logical form interpretation. As a result, there is a huge complexity effect for inverse scope conditions (even though these college-aged participants just read singular continuation sentences) such that accuracy rates for these sentences are below chance. These results suggest that for certain constructions, language processing is superficial and deeper processing sensitive to structure only occurs if required. Implications for recent studies of scope ambiguity are discussed.

(1) Every kid climbed a tree. The trees were in the park. Ambiguous Context-Plural continuation

(2) Every kid climbed a tree. The tree was in the park. Ambiguous context-Singular continuation

(3) Every kid climbed that/those trees. The tree(s) was/were in the park. Unambiguous Control (singular/plural)

(4) How many trees were climbed? ONE SEVERAL

(5) Every jeweler appraised a diamond. The diamond(s) was/were clear and flawless.