Online use of relational structural information in processing bound-variable pronouns
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Recent findings in psycholinguistics motivate a parser that relies on parallel access mechanisms in content addressable memory [1]. In such an architecture non-local syntactic relations are not easily encoded. Evidence for this architecture comes from interference of grammatically-illicit licensors [2,3] and non-effects of syntactic dependency length [4,5]. On the other hand, some studies have shown that antecedent-retrieval procedures for reflexives are immune to interference [6-10], which suggests the need for a structure-sensitive access mechanism, and therefore, explicit encoding of syntactic relations in memory. The reflexive findings, while important, do not conclusively show retrieval’s general sensitivity to relational information, since they involve local retrievals that could be computed heuristically (e.g., through a clause-mate feature). What is needed is a non-local relation that unambiguously obeys c-command constraints. Bound variable anaphora (1) provide such a test case. In two experiments (one self-paced reading, one eye-tracking) we show the parser’s immediate sensitivity to structural constraints on bound variables. These results imply a structure-guided access mechanism that can implement such constraints.

Both experiments investigated reaction times at a critical pronoun (he, in 2). A feature-matching NP (janitor) served as a potential antecedent. The potential antecedent’s ability to c-command the pronoun was manipulated by varying the attachment height of the pronoun’s embedding clause. In Command conditions, the pronoun was embedded in a when-clause, in NoCommand conditions a but-clause was used. In addition to c-command relations, the potential antecedent’s quantificational status was manipulated by changing its determiner: any in Quant conditions, the in Referential conditions. This allowed for comparison between binding of the pronoun and coreference. Coreference is insensitive to c-command restrictions, so the janitor could serve as antecedent for the pronoun equally well in both Ref conditions. However, the quantificational any janitor could only bind he in the Command-Quant condition, because c-command between any janitor and he obtains. Thus, the only condition in which the pronoun does not have an intra-sentential antecedent is NoCommand-Quant.

In Experiment 1 (self-paced reading, n=24) immediate sensitivity to the constraint on bound variable pronouns was demonstrated in a significant slowdown at the pronoun, in the NoCommand-Quant condition relative to all others (p<.05 - data were fit to linear mixed-effect models with subject and item as as random effects [11]). In Experiment 2 (eye-tracking, n=32), like in Experiment 1, we found that the Command manipulation affected reading times following the pronoun in the quantificational conditions but not in the referential conditions, confirming that the clause-type effects are specifically associated with bound variable anaphora, and indicating immediate sensitivity to c-command constraints. However, the clause-type manipulation affected the different eye-tracking measures in different ways. Probability of regression mirrored the self-paced reading results, showing more regressions in the NoCommand-Quant condition. While the overall interaction effect was marginal (p<.10), pair-wise comparisons within Quant conditions showed a significant effect of increased regressions in NoCommand-Quant compared to Command-Quant (p<.01). Interestingly, second pass showed the opposite pattern, with elevated times in only the Command-Quant condition (p<.01). That is, only the condition where binding was available showed elevated reading times. This suggests that the impact of c-command constraints is not adequately captured in terms of more/less difficulty. Failure of licensing leads to regressive eye-movements, whereas successful variable-binding leads to longer dwell time on the pronoun region itself (see, e.g. [12]).

In sum, these findings show that the parser exhibits immediate sensitivity to relational structural constraints during on-line comprehension, and hence call for models of memory access in which relational structural information is readily available.