Expectation-based Syntactic Processing: Anti-locality outside of Head-final Languages

In English, increasing the distance between an argument (e.g., a subject) and the verb generally leads to comprehension difficulty at the verb. Such locality effects provide evidence for memory-based comprehension theories (Gibson00). Memory-based theories are, however, challenged by "anti-locality" effects from verb-final languages (German, Hindi), where increased argument-verb distance *facilitates* processing. Anti-locality is seen as evidence for expectation-based comprehension (Konieczny00). We demonstrate that anti-locality effects are not limited to verb-final languages. More crucially, our results argue against a recent memory-based proposal accounting for anti-locality in verb-final languages (VasishthLewis06). The anti-locality effects reported here are only consistent with expectation-based theories.

We report four self-paced reading experiments in English, where subject-verb distance and the probability of the verb was manipulated by attaching prepositional phrases (PPs, italics in E1-E4 below) to the verb of an intervening relative clause (RC). Expectation-based comprehension theories predict faster RTs on the matrix verb (bold in E1-E4) for longer RCs, because the probability of a matrix verb increases with each PP (confirmed by a corpus study). Memory-based theories, however, predict the opposite (because of increasing subject-verb distance). VasishthLewis06's model does *not* predict faster RTs either. VasishthLewis06 attribute facilitation of clause-final verbs to repeated prior activation of their arguments. In (E1), Verb facilitation would therefore only be predicted if the subject was repeatedly activated (e.g. via repeated modification). Instead, the PPs attach to and repeatedly activate the *RC-verb*.

In **EXPERIMENT 1**, one to three PPs attached to the RC verb (E1). To avoid confounds due to spillover, the PP immediately preceding the matrix verb was held constant. As predicted only by expectation-based theories, RTs on the matrix verb decrease as more PPs are attached to the RC-verb ($F1(2,78)=9.0$; $F2(2,70)=9.5$; $ps<.001$). Note that the PPs were selected not to increase the probability of a *specific* matrix verb, but rather of a general verb category.

However, E1 contains a positional confound: when more PPs attached to the RC-verb, the matrix verb was further away from the sentence beginning. Reading is often reported to speed up towards the end of the sentence. **EXPERIMENTS 2-4** were designed to address this problem: PPs attached to the RC-verb were topicalized to the matrix clause (E2), were part of a preceding main clause (E3), or part of a preceding subordinate clause (E4). All experiments confirmed the prediction of expectation-based theories: RTs on the matrix verb decrease with longer RCs (i.e. with higher probability of a matrix verb).

Further support comes from **a new type of mixed effects analysis**. After accounting for random subject effects, spillover, word length, word position, and stimulus order (in all cases allowing non-linear components), the matrix verb is still read significantly faster for longer RCs ($p<0.05$; based on conservative MCMC sampling).

IN CONCLUSION, we find the first reliable signatures of anti-locality effects in English. These effects are not accounted for by existing memory-based models (including VasishthLewis06). Comprehenders appear to pre-activate structures they have not yet seen. This is evidence for expectation-based comprehension. We describe how to extend VasishthLewis06's model to integrate expectation-based processing.

Italics: *PP manipulation*; bold: **matrix verb**; critical region: matrix verb and two words spill-over region

E1:EXPERIMENT 1, sample item

The player that the coach met *at 8 o'clock (near the gym at 8 o'clock / near the gym by the river at 8 o'clock)* **bought** the house (by the river / by the river at 8 o'clock) […]

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E2:EXPERIMENT 2

(In early November / In early November before the elections) the mayor that the advisor called (*in early November* / *in early November before the elections*) after the poll results **updated** the report, […]

E3:EXPERIMENT 3

The chief executive disappeared (approximately two weeks ago) after the document the manager gave to the lawyer (*approximately two weeks ago*) **was published** by […]

E4:EXPERIMENT 4

According to the administrator (in the emergency room), the nurse who helped the doctor who was tired after the night shift (*in the emergency room*) **complained** about […]