Reanalysis difficulty modulates cumulative structural priming effects in sentence comprehension

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Cumulative structural priming effect refers to the observations that repeated exposure to a syntactically infrequent structure could facilitate the subsequent processing of similar structures. For example, it was found in [1] that participants who were repeatedly exposed to reduced relative clause sentences (**RR**) such as "*The experienced soldiers* <u>*warned*</u> *about the dangers conducted the midnight raid*" showed a reduced garden-path ambiguity effect after the exposure phase, compared to participants in a control group; conversely the same participants also showed increased difficulty for the originally preferred matrix verb parse (**MV**) "*The experienced soldiers* <u>*warned*</u> *about the dangers before the midnight raid*". A number of recent replication studies [2, 3], however, failed to find any robust effects, suggesting that the original effect, if exists at all, has a very small effect size. One possible reason for the small effect size is that the garden-path ambiguity in the above RR prime sentence spans over a relatively long region, i.e. "warned about the dangers", creating a "digging in" effect [4,5] that reduces the likelihood of successful reanalysis towards the RR parse in the first place. In three experiments, the current study investigates whether increasing the likelihood of the RR parse on the prime sentences facilitates the priming effect.

Procedure Three self-paced-reading experiments (n=240 total) were conducted on Ibex Farm, with participants answering a comprehension question after reading each sentence. Each experiment consists of three blocks. In <u>**Block 1**</u>, in a between-participant design, half of the participants (**Exposure Group 1A**, n=40) read 16 target sentences (8 ambiguous RR and 8 unambiguous RCs), and the other half (**Control Group 1B**, n=40) read 16 filler control sentences (examples in Table 1). Both groups of participants were then tested on the RR ambiguity in <u>**Block 2**</u> and MV ambiguity in <u>**Block 3**</u>. In Block 2, participants read 16 target sentences (8 RR ambiguity and 8 unambiguous RCs) and 16 fillers. In Block 3, participants read 16 target sentences (8 MV ambiguity and 8 unambiguous sentences) and 16 fillers. The three experiments only differ in their exposure Block 1A. The RR sentences in Experiment 1 Block 1A always contained a salient disambiguating by-phrase right after the ambiguous verb, making reanalysis relatively easy. The RR sentences in **Experiment 2** Block 1A further made the subject noun phrases inanimate, providing more cues for the correct RR parse. In these two experiments, the verbs used in Block 1 were repeated in Block 2&3. **In Experiment 3**, morphologically unambiguous verbs (e.g. *taken*) were used to signal the RR parse in Block 1A. These three experiments therefore gradually increased the likelihood of the RR parse in the exposure block. The critical sentences used in the exposure blocks were adapted from [6,7].

Analysis and results For each experiment, we performed linear mixed effects models on the log-transformed RTs on the disambiguating region and the next spill-over region, using the Bayesian statistical analysis R package brms [8] (Figure 1). The analyses reported here focus on the critical Group (exposure vs. control) x Ambiguity interaction in order to answer two questions.: (i) whether the RR ambiguity is *reduced* in Block 2 for participants from the exposure group compared to those from the control group; (ii) conversely whether there is a *larger* MV ambiguity in Block 3 for participants from the exposure group. For the RR ambiguity in Block 2, we found some evidence for a critical Group x Ambiguity interaction on the spill-over region in Experiment 1 (*got*, Figure 1, Estimate 0.016, SE 0.009, 95% CrI [-0.001, 0.048]); and the interaction effect is present on the critical disambiguating region in Experiment 2 (*by the doctor*, Figure 1, Estimate 0.024, SE 0.011, 95% CrI [0.001, 0.046]). No interaction was found in Experiment 3. For the MV ambiguity in Block 3, no interaction was found for any experiment.

Conclusion By making the prime RR sentences easier to reanalyze/parse than previous studies, we observed reduced RR ambiguity effect after repeated exposure to RR primes (Experiment 1&2). Relative to Experiment 1, the effect came online earlier in Experiment 2 when the exposure RR sentences contain an additional facilitating animacy cue on the subject, despite the fact that the same animacy cue is absent on the post-exposure target sentences, suggesting that the priming effect is not simply based on surface statistical contingencies. However, verb overlap between the exposure and the post-exposure targets is required for structural priming to take place, even when the prime sentences are unambiguously RR (Experiment 3), confirming that structural priming in comprehension is mediated through the lexical representation of the verb [9]. Finally, we found no evidence that repeated exposure to RR ambiguity increases the processing difficulty of the originally preferred MV parse, replicating the findings in [2,3].

Table 1: Example stimuli. Disambiguating regions in bold; slashes indicate SPR regions.

Block 1: Exposure Group 1A (item n=16) (unambiguous version in the parenthesis), Latin square distribution of the items

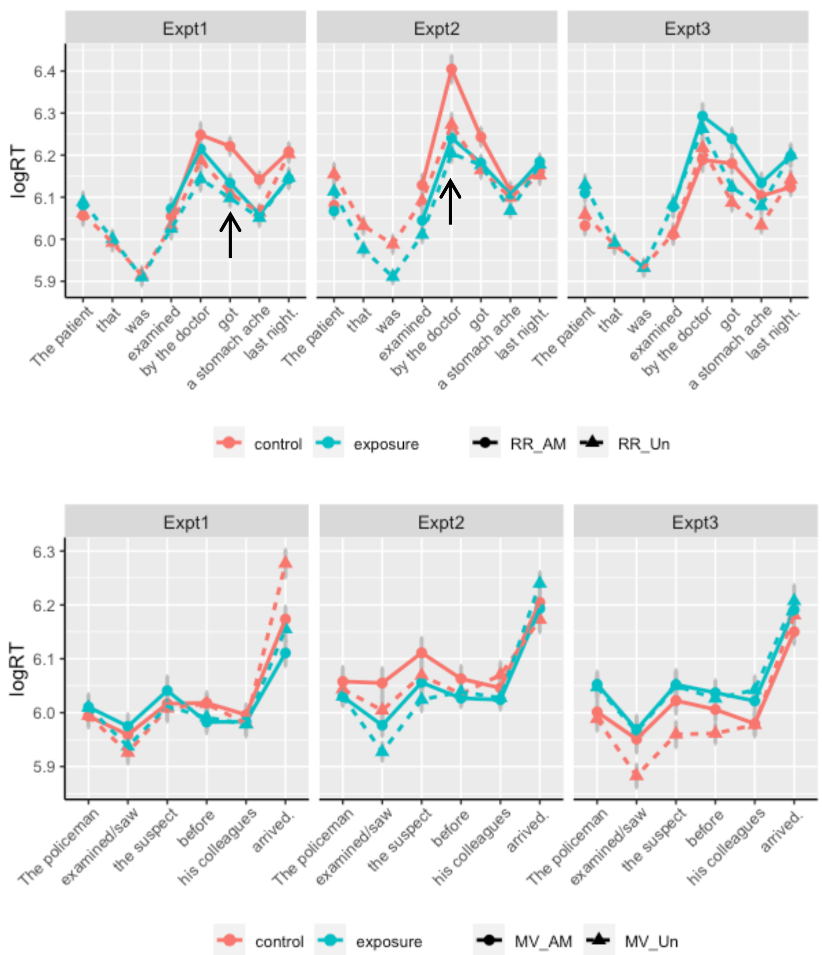
Experiment 1: The defendant\ (that was) examined\ **by the lawyer**\ turned out to be\ unreliable.
Experiment 2: The evidence\ (that was) examined\ **by the lawyer**\ turned out to be\ unreliable.
Experiment 3: The money\ (that was) taken\ **by the student**\ was\ finally\ returned.

Block 1: Control Group 1B (item n=16)
The apples on that tree are surprisingly delicious.

Block 2 (16 targets + 16 fillers), Latin square distribution of the target items
RR Ambiguous: The patient \examined\ **by the doctor**\ got\ a stomach ache\ last night.
RR Unambiguous: The patient \that was examined\ **by the doctor**\ got\ a stomach ache\ last night.

Block 3 (16 targets + 16 fillers), Latin square distribution of the target items
MV Ambiguous: The policeman\ examined\ **the suspect**\ before\ his colleagues\ arrived.
MV Unambiguous: The policeman\ saw\ **the suspect**\ before\ his colleagues\ arrived.

Figure 1. Top: Block 2 RR ambiguity**; Bottom:** Block 3 MV ambiguity



Linear mixed effects model for Block 2&3 separately, under each experiment, on the disambiguating region and the spill-over region:
logRT~ ExposureGroup*Ambiguity+RT.previous.region+(1+Ambiguity|participant)+(1+ExposureGroup*Ambiguity|Item)

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