Recalling attachment ambiguities as mixture process

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Sentence interpretation relies, in part, on our ability to create dependencies between phrases. Yet mental representations of phrase dependencies are imperfect and rapidly loose activation (Christiansen & Chater, 2016). For example, Christianson et al. (2001) found that people tend to remember "the deer" in *While the man hunted the deer run into the woods* as object of "hunted" even after reanalysis of an initially incorrect parse. In this work we present evidence that recalling structural ambiguities is resource demanding (Exp. 1) and compare two possible explanations (Exp. 2): (1) incorrect parses interfere during recall (e.g. Christianson et al., 2001); (2) recall involves the regeneration of syntax from a conceptual representation (e.g. Potter, 2012).

In two experiments participants read sentences and typed each sentence from memory. Dependent variable was the sentence recall-onset latency. In Exp. 1, participants (N=64) were presented with 24 items taken from Christianson et al. (2001) with temporary ambiguities, example above, and unambiguous controls (i.e. comma after "hunted"). Bayesian mixed effects models showed that temporary ambiguities delayed the recall by 53ms (95% PI: 10, 96).

In Exp. 2, participants (N=160) were presented with 24 items from Van Gompel et al. (2001), involving global (1) and temporary ambiguities with high (2) or low attaching PPs (3).

1. The caretaker cleaned the pail with the brush. (global ambiguity)
2. The caretaker cleaned the suit with the brush. (high attachment)
3. The caretaker cleaned the pail with the holes. (low attachment)

To contrast two explanations for increased recall demands, we implemented five Bayesian models in Stan. First, we fitted linear mixed effects models (LMM) with and without attachment type as predictor to test whether temporary ambiguities involve a systematic correction of incorrect parses and therefore result in longer latencies (Van Gompel et al., 2001). Second, in another set of three models we implemented sentence recall as mixture of two log-normal distributions in which the distributions' mixing ratio captures the probability of recall difficulty (long latencies) to occur. The mixing ratio was estimated for (i) temporary and (ii) global ambiguities, and (iii) for all ambiguity types separately. An increased probability of long latencies for temporary ambiguities is consistent with the correction of incorrectly created attachments. However any difficulty found for global ambiguities can only be explained as demands associated with the (re)generation of the syntactic parse itself (Potter, 2012). This is because either interpretation is correct.

Models were compared using their expected log predictive density ($\widehat{elpd}$). The highest predictive performance was found for the model with by-attachment type mixing ratios; Tab. 1. Fig. 1 shows the recall-onset latency estimated by the LMM (A) and the probability of long latencies estimated by the mixture model (B). While the LMM suggests a slowdown for temporary ambiguities (Traxler et al., 1998), the mixture model revealed that recall difficulty is more likely to occur in the high attachment condition than in the low attachment condition. Importantly, global ambiguities were found to be more prone to increased recall demands than low attachment sentences.

Concluding, the systematic slowdown for temporary ambiguities is better accounted for by a mixture process that applies to both temporary and global ambiguities. The correction of an incorrect attachment can explain onset delays associated with temporary ambiguities but cannot explain increased demands for global ambiguities. Increased recall demands found for global ambiguities and for high-attachment are better explained as difficulty associated with those trials for which encoding of the sentence syntax from the conceptual representation did not operate incrementally but happened prior to typing onset. In other words, incremental encoding might be less readily available for high-attachment interpretations and, therefore, requires preplanning.

Table 1: Model comparisons. The difference in expected log predictive density ($\Delta\widehat{elpd}$) and standard errors (SE) are shown in comparison to the model with the highest predictive performance (top row).

Model	$\Delta\widehat{elpd}$	SE
MM: by-attachment type slowdown probability	0	0
MM: slowdown probability for temporary ambiguities	-15.6	9.1
LMM: attachment-type differences	-29.6	11.1
MM: slowdown for high-attachment interpretations	-29.9	9.9
LMM: intercept-only	-32.6	10.7

Note. MM = mixture model; LMM = linear mixed effects model; all models were fitted with random intercepts for subjects and items and recall latency was modelled as log-normal distribution.

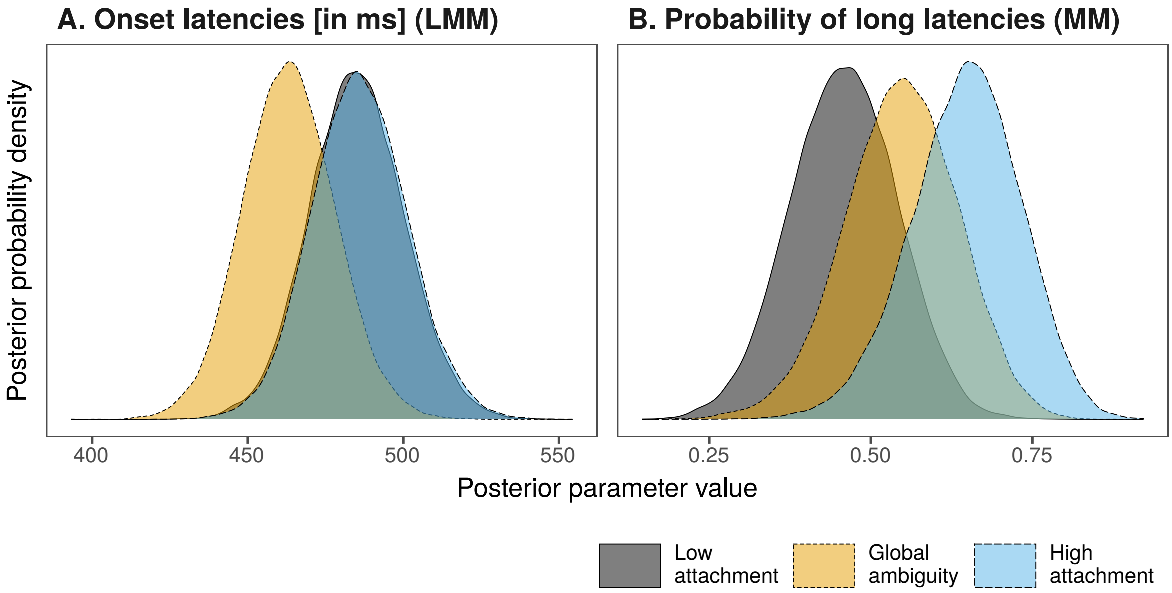

Figure 1: Posterior density of parameter values. Panel A shows the marginal by-attachment type onset latency predicted by the linear mixed effects model (LMM). Panel B showed the probability of long onset latencies by attachment type inferred from the best fitting mixture model (MM).

References

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