

## No scope for planning – language pre-planning as mixture process

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Speaking obligates pre-planning of some minimal linguistic unit. The phrase has been proposed to be the “default scope” (Martin et al., 2010) of this unit. Evidence for this comes from the observation that, when a sentence starts with a conjoined subject NP (*The A and the B*), speaking onset is delayed compared to matched sentences starting with a simple NP (*The A*). An alternative view is that planning beyond the first noun is not obligated by the linguistic encoder: Incremental theories of sentence planning hold that the minimum obligated planning unit might, in fact, encompass just the first determiner-noun pair. Under the latter view extended onset latencies may occur for sentences starting with a conjoined NP but this will be sporadic across trials and for reasons other than obligatory planning scope. For example, pre-planning for conjoined NPs might happen when planning in parallel to production is not readily available. We contrasted these two views directly in a series of Bayesian models implemented in Stan.

Linear mixed models (LMM) were used to determine the slowdown for conjoined NPs as test of the hypothesis that sentence planning requires a phrasal scope. The alternative hypothesis, that there is no consistent effect of NP complexity (and therefore no phrasal-scope obligation in the production system) but that pre-planning is more likely for conjoined NPs, was implemented as mixture model. Under this account latencies come from a mixture of two log-normal distributions. The mean and variance parameters of each of these distributions were fixed across condition, but the mixing proportion – the probability of a trial being associated with long latencies – was allowed to vary for each NP type. This mixture model therefore allowed us to test whether extreme values were more likely for conjoined NPs even if the latency distribution was held constant across NP types, after accounting for variation associated with participants and items.

First, we reanalysed onset latencies from 8 studies, in which participants described image arrays starting with a conjoined or a simple NP. The LMM showed a systematic slowdown of 59ms (PI: 35, 86) overall for conjoined NPs (see Fig. 1A) supporting the phrasal-scope hypothesis. A higher predictive performance was found for the mixture model compared to the LMM ( $\Delta\widehat{elpd}=-980$ , SE=101). The majority of experiments showed a larger probability of long latencies for conjoined NPs; see Fig. 1B. Two follow-up experiments isolated the contrast between simple and conjoined NPs (Exp. 1) and challenged its syntactic interpretation by eliciting lists of words (Exp. 2).

Exp. 1 asked participants ( $N=78$ ) to describe arrays of images starting either with a conjoined (*A and the B moved . . .*) or a simple NP (*A moved . . .*). The leftmost image depicting a face was assigned a two-syllable proper name to reduce the variability associated with the first noun. Exp. 2 was identical but participants ( $N=45$ ) were asked to name images as list (*A, the B, the C*). In line with the phrasal-scope hypothesis we found longer latencies for conjoined NPs for sentential utterances (Exp. 1) but not when images were named as lists (Exp. 2); see Fig. 2A. The alternative hypothesis, that longer latencies are more likely but not obligated for conjoined NPs, was supported for Exp. 1 ( $\Delta\widehat{elpd}=-513$ , SE=56) and for identical stimuli in Exp. 2 ( $\Delta\widehat{elpd}=-362$ , SE=44) with similar slowdown probabilities; see Fig. 2B. This slowdown was 680ms (PI: 558, 833) for Exp. 1 and larger than the slowdown for Exp. 2 (520ms, PI: 411, 659).

We therefore found a greater tendency for longer latencies for conjoined NPs. These longer latencies remained in the minority. The majority of observations were associated with the same underlying distribution as was found for simple NPs. This is not consistent with obligatory phrasal scope, but rather that advance planning is scoping, at most, over the sentence-initial noun. We found a larger probability of long latencies for the production of both sentences and word lists suggesting that this effect depends on the visual stimulus rather than the utterance. We suggest that the frequently replicated slowdown for conjoined NPs might be better explained by a linking from object representations to a conceptual structure that acts only on a subset of trials.

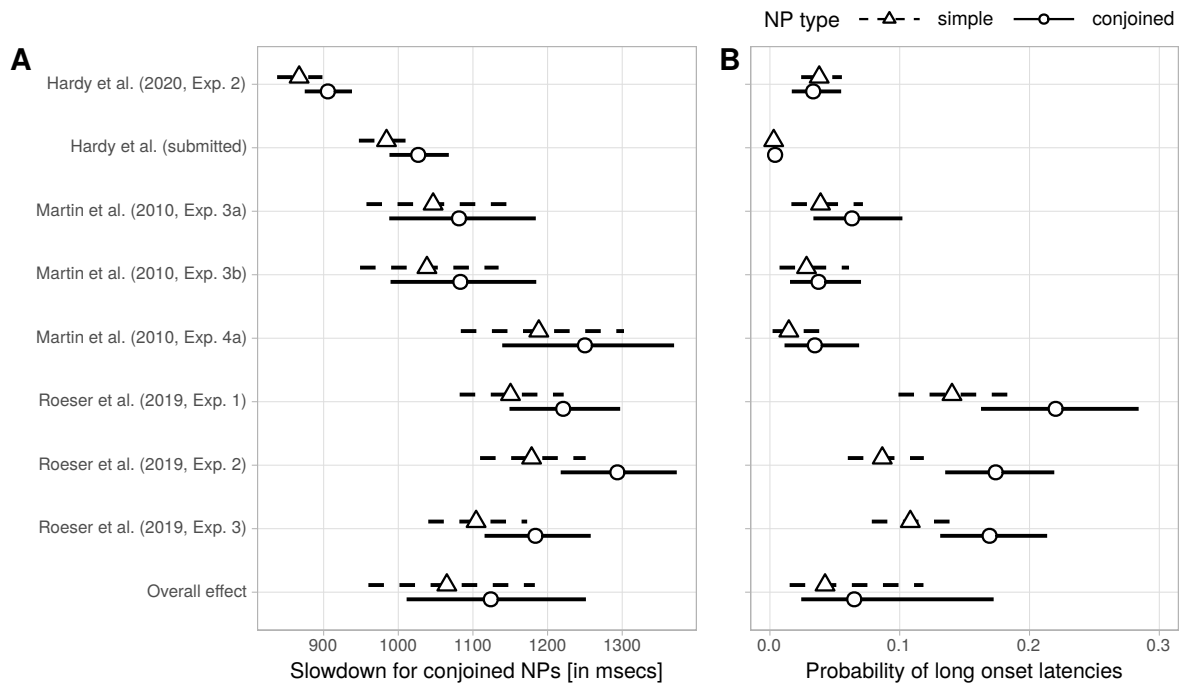


Figure 1: Estimated values of the pooled analysis (with 95% PIs); onset latency effect of LMM (panel A) and probability of long latencies estimated by the mixture model (panel B).

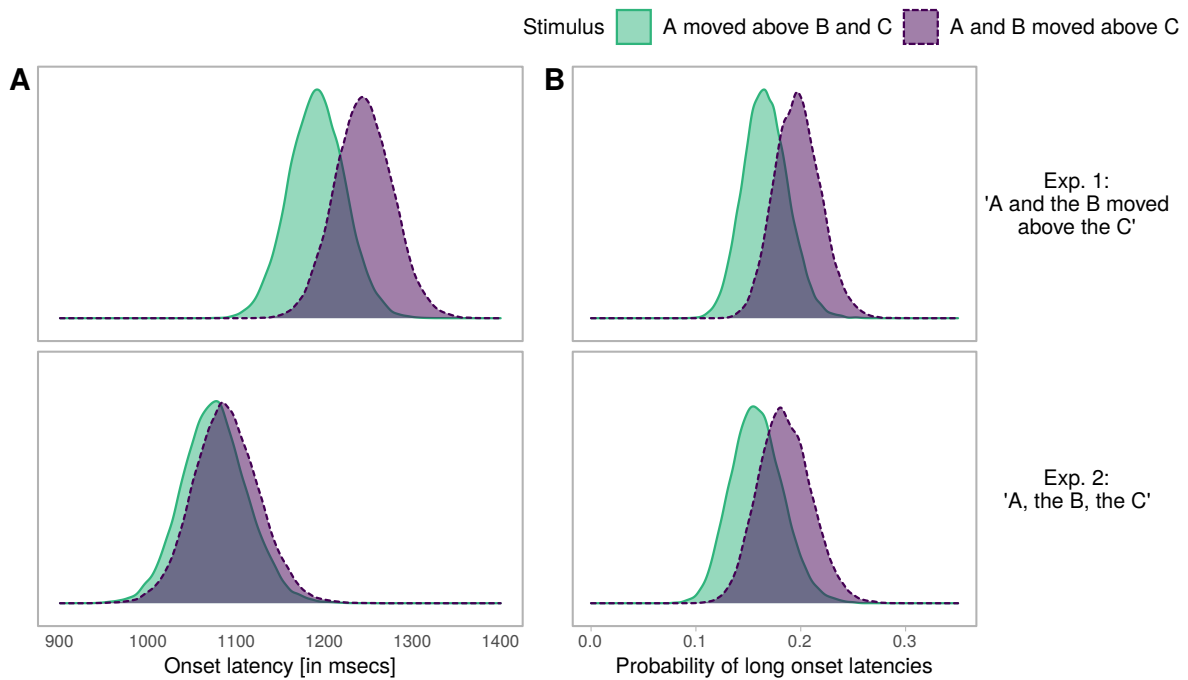


Figure 2: Exps. 1 and 2; onset latency estimated by the LMM (panel A) and probability of long latencies determined by the mixture model (panel B).

## References

Martin, R. C., Crowther, J. E., Knight, M., Tamborello II, F. P. & Yang, C.-L. (2010). Planning in sentence production: Evidence for the phrase as a default planning scope. *Cognition*, 116(2), 177–192.