

Testing a Parallel Model of Prediction by Production via Visual World Paradigm in Eye-Tracking: Can Phonological Prediction Precede Semantic Prediction?

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This study investigated the temporal dynamics of semantic and phonological prediction during sentence comprehension, focusing on whether phonological prediction can precede semantic prediction. The sequential model of Prediction-by-Production [1] proposed that prediction occurs hierarchically, cascading from semantics to syntax and then phonology. A later, parallel revision [2] posits that all representations are accessed simultaneously during an initial “ignition” phase, followed by a “reverberation” phase in which task demands determine which components become most prominent. However, this claim has not yet been tested at the sentence level.

To address this gap, 96 native Belgian-Dutch speakers viewed four-image displays while listening to poems (e.g., “*Uis, uis, uis; de melk is voor de... kat/muis*”, “*uis, uis, uis; the milk is for the... cat/mouse*”) in a 2×2 design, manipulating phonological and semantic cue presence, such that phonological and semantic cues were always linked to different, competing co-present images. We had four experimental conditions, each containing 14 trials: P+S+, P+S-, P-S+, P-S-. The first verse repeated three non-words (phonological cues), and the second verse contained both the semantic cues and the uttered words. We defined three windows: phonological (first verse), semantic (semantic cue onset to target onset), and target (target onset to 800ms post-offset).

Comparing effects across the three windows established phonological precedence. We used LMMs to predict P/S log ratio (log phonological/semantic fixations) by phonology×semantics in all time windows. We also tested two forms of dominance in the semantic window where both cues were available: a *main-effect* dominance of phonology, reflected by a larger phonological effect size; and an *interactive* dominance (phonology attenuating semantic prediction), which was tested in two ways: an interaction of phonology and semantics in the LMMs, and a delayed semantic divergence point in P+ vs. P- conditions via DPA.

The results showed that phonology and semantics modulated anticipatory looks (see Figure 1). Phonological prediction emerged in the phonological window and persisted into the semantic window, preceding the semantic prediction. Given that phonological cues did not carry any semantic weight, phonological fixations should have relied solely on the phonological form, challenging the sequential model of prediction.

Testing dominance directly: phonology showed a larger effect size in the semantic window ($\beta = 0.62$ vs. $\beta = -0.16$); however, P+S+ showed a negative P/S log ratio (see Figure 2). In addition, the interaction of phonology and semantics was not significant, and the semantic divergence point did not differ between P+ and P- conditions, indicating phonological cues did not delay semantic prediction. Rather than one cue dominating the other, phonological and semantic cues additively activated their respective predictions, consistent with the parallel model's task-dependent prominence. This pattern reflects prediction under task demands favoring phonology, not a claim that phonological prediction is typical in everyday comprehension.

Appendix

[1] Pickering, M. J., & Gambi, C. (2018). Predicting while comprehending language: A theory and review. *Psychological Bulletin*, 144(10), 1002–1044. <https://doi.org/10.1037/bul0000158>

[2] Pickering, M. J., & Strijkers, K. (2024). Language production and prediction in a parallel activation model. *Topics in cognitive science*. <https://doi.org/10.1111/tops.12775>

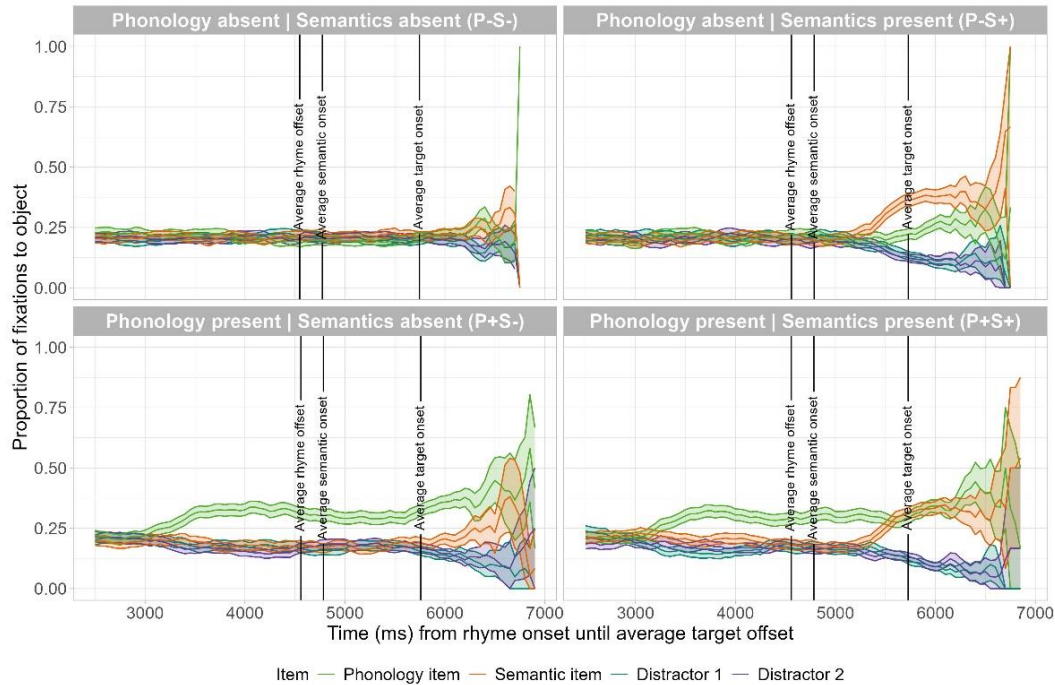


Figure 1: Fixation proportions on different items across all conditions. Shaded areas represent the bootstrapped confidence interval around the mean.

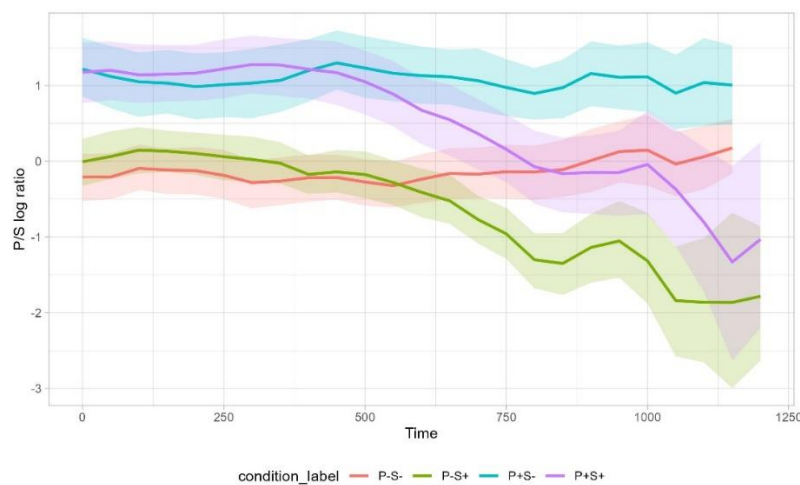


Figure 2: Proportion of P/S log ratio fixation in the semantic window across conditions. Positive values indicate more fixation on the phonological item, whereas negative values indicate more fixations on the semantic items. Shaded areas represent the bootstrapped confidence interval around the mean.