# An investigation of the time-course of syntactic and semantic interference in online sentence comprehension

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**Introduction.** One central question in sentence comprehension research is when syntactic and semantic information are used during the formation of non-adjacent dependencies (e.g., [1:6]). In the cue-based parsing literature, this question has been addressed by studying the time-course of similarity-based interference effects (e.g., [9:14]). Cue-based parsing theories assume that items are encoded and later retrieved from memory using retrieval cues [7:10]. These cues can be syntactic or semantic, and both sources of information can be used in parallel during retrieval. Interference occurs when the retrieval cues cannot uniquely identify a target item because other syntactically and/or semantically similar (distractor) items are encoded in memory. In subject-verb dependencies, interference from syntactically similar distractors was observed at the retrieval point (a verb), while semantic interference was reported at a later, sentence-final region [10]. This finding may suggest that syntactic information is used to reactivate dependents in memory before semantic information. A similar proposal was made for antecedent-reflexive dependencies in [14] [see also 12]. However, the time-course for semantic interference remains unclear: [11] reports a different time-course than [10] for semantic interference in subject-verb dependencies. Cue-based theories predict that syntactic and semantic interference occur simultaneously during retrieval. We reinvestigated this prediction in English. Furthermore, to study the generality of these effects, we conducted a second, large-sample experiment in German.

**Design and materials.** Our two eye-tracking (reading) experiments (English, N=61; German, N=121) used a 2 x 2 design with the factors distractor subjecthood (–subject, +subject) and distractor animacy (–animate, +animate) [10]. Table 1 shows an English example item. In all conditions, the manipulated distractor (the meeting/visitor) intervenes between the critical verb (complained) and the target subject (the attorney).

**Predictions.** Cue-based theories predict a reading time slowdown for +subject compared to –subject conditions, indicating syntactic interference. Similarly, a reading time slowdown is expected for +animate compared to –animate conditions (semantic interference). Crucially, both effects should be observable at the critical verb.

**Results.** Figure 1 shows the results from our Bayesian analysis. For both languages, +subject conditions showed reading time slowdowns in regression-path durations and total reading times at the critical verb, consistent with a syntactic interference effect. Only English exhibited semantic interference (a slowdown for +animate conditions) at the critical verb; in German there was an indication of this slowdown post-critically. Surprisingly, both languages exhibited slower reading times at the pre-critical adverb for +subject and +animate distractors.

**Discussion.** In English, the observed reading time slowdowns indicate that both syntactically and semantically similar distractors can cause interference during retrieval. These results are compatible with cue-based theories' predictions. The pattern in our German data is consistent with the observation that semantic effects can continue to slow down processing in later sentence regions [10]. In both languages, the unexpected pre-critical effects are consistent with spillover from prior regions. Further analyses are underway to investigate this possibility.

**Conclusions.** We tentatively conclude that both syntactic and semantic interference can arise simultaneously, i.e., both types of information can be used in parallel during real-time dependency formation. However, in line with previous research, the German data show that semantically similar distractors may continue to interfere further downstream in the sentence.

**Table 1. English example item.** The critical target subject and the critical verb (the retrieval point) are shown in bold. The manipulated distractor is underlined. +/–subject: distractor is (not) a subject; +/–animate: distractor is (not) animate.

*a.        –subject, –animate*
It turned out that **the attorney** whose secretary had forgotten about the important <u>meeting</u> frequently **complained** about the salary at the firm.
*b.        –subject, +animate*
It turned out that **the attorney** whose secretary had forgotten about the important <u>visitor</u> frequently **complained** about the salary at the firm.
*c.        +subject, –animate*
It turned out that **the attorney** whose secretary had forgotten that the <u>meeting</u> was important frequently **complained** about the salary at the firm.
*d.        +subject, +animate*
It turned out that **the attorney** whose secretary had forgotten that the <u>visitor</u> was important frequently **complained** about the salary at the firm.

**Figure 1.** Reading measure results for the English and the German experiment. We fit maximal Bayesian hierarchical models [15]. Shown are the means of the posterior distributions with their 95% Bayesian credible intervals. These give the range in which the true parameter lies with 95% probability, given the data and model. A positive sign means that a slowdown is observed for +subject or +animate conditions. FPRT = first-pass reading times, RPD = regression-path duration, TFT = total fixation times. Pre-critical: adverb, critical: verb, post-critical: prepositional phrase



Reading time results (in ms)

English (N=61)          German (N=121)

● FPRT  ▲ RPD  ■ TFT
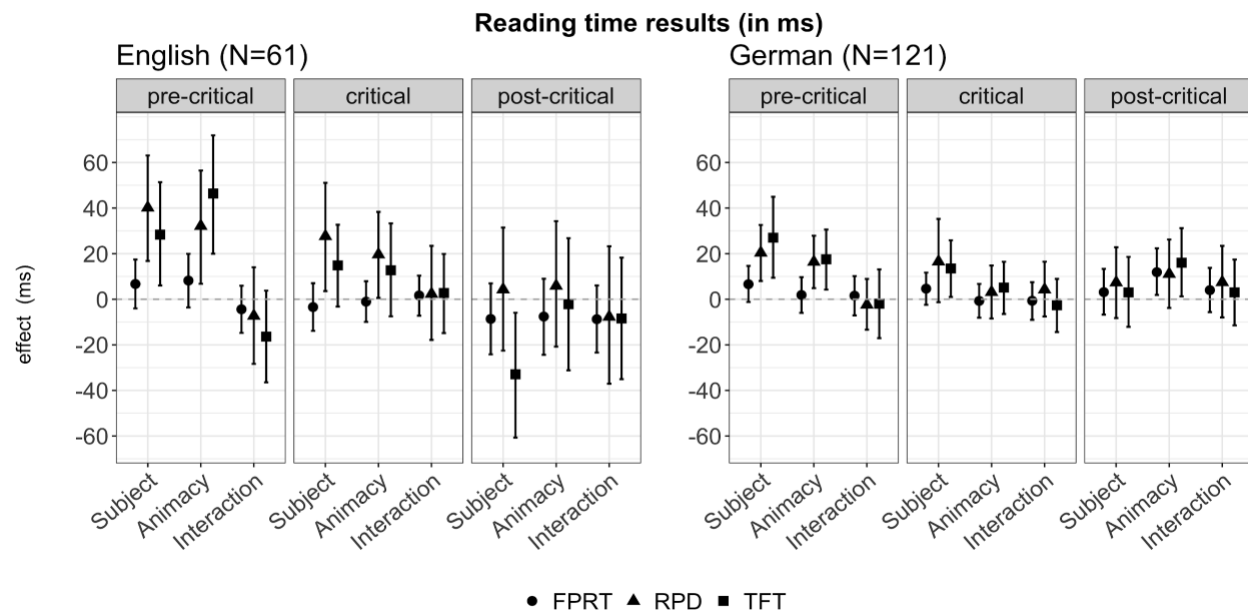
**References.** [1] Frazier & Rayner (1982). Cogn Psychol.  [2] Clifton et al. (2003). J Mem Lang. [3] MacDonald et al. (1994). Psychol Rev. [4] McRae et al. (1998). J Mem Lang. [5] Tabor et al. (2004). J Mem Lang. [6] Van Gompel et al. (2005). J Mem Lang. [7] Lewis & Vasishth (2005). Cogn Sci. [8] McElree (2000). J Psycholinguist Res. [9] Van Dyke & Lewis (2003). J Mem Lang. [10] Van Dyke (2007). J Exp Psychol. Learn Mem Cogn. [11] Van Dyke & McElree (2011). J Mem Lang. [12] Dillon et al. (2013). J Mem Lang.  [13] Cunnings & Sturt (2018). J Mem Lang.  [14] Sturt (2003). J Mem Lang. [15] Gelman et al. (2014).