Depth of processing influences referential ambiguity resolution

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Studies on the processing of ambiguous pronominal reference have led to contradictory results: some suggest that pronominal ambiguity hinders processing [1-2], while others show an ambiguity advantage [3] similar to what has been shown for structural ambiguities [4]. We examine the extent to which the discrepancy in results is caused by depth of processing, as it has been argued that comprehenders may underspecify certain linguistic relations when the depth of processing they engage in is only shallow [1,5,6]. We test the hypothesis that pronoun resolution may remain underspecified under shallow processing, leading to an ambiguity advantage, while deeper processing leads to an ambiguity penalty. We provide a conceptual replication of Stewart et al. [1], but use updated methodology, a larger sample size, and up-to-date statistical analyses.

Methods Participants were 156 native speakers of Dutch (determined through an a-priori power analysis). We used a 2×3 mixed design, consisting of a between-participants factor DEPTH OF PROCESSING (shallow/deep), and a within-participants factor SENTENCE TYPE (ambiguous/first/second character reference). We included 60 Dutch sentences that were ambiguous (1) or disambiguated through gender features (2-3). A norming study with a different sample of 40 Dutch native speakers established that the first and second character reference interpretations were equally plausible. The different versions of each item were rotated across three lists, which also included 30 filler sentences. Participants read sentences in an online word-by-word self-paced reading paradigm. Each sentence was followed by a two-choice comprehension question. For shallow processing, all questions probed the content of the main clause (e.g. *Who lent the book to Gijs?*). For deep processing, all questions probed the content of the subordinate clause, which required resolving the pronominal reference (e.g. *Who went on holiday?*).

Analysis Log-transformed reading times were regressed against word length and the log list position of the sentence in the stimuli [7]. Outliers were identified and removed, after which the remaining residuals were analyzed for three separate regions: the pronoun itself (PRONOUN), and the two words following the pronoun (PRONOUN+1, PRONOUN+2) to capture spill-over effects. Linear mixed-effects models were fitted with fixed effects of SENTENCE TYPE (Helmert contrasts) and DEPTH OF PROCESSING and their interaction, and random intercepts for subjects and items.

Results Reading times were strongly affected by processing depth: shallow processing conditions led to faster average reading times (M=274 ms) than deep processing (M=335 ms) and a main effect of DEPTH was found for each region of interest. The results (Figure 1) further showed a significant interaction between TYPE and DEPTH in the PRONOUN region when comparing the ambiguous and the unambiguous sentences (p=0.020). Post-hoc comparisons showed a marginally significant difference between second character reference and the ambiguous conditions under shallow processing (p=0.059), with shorter reading times for ambiguous sentences, but not under deep processing (p=0.510). The PRONOUN+1 region did not show significant differences between sentences types. The PRONOUN+2 region again showed an interaction between TYPE (ambiguous vs. unambiguous sentences) and DEPTH p=0.017). Post-hoc tests revealed that ambiguous sentences were read significantly slower than unambiguous sentences under deep processing (first vs. ambiguous: p=0.005; second vs. ambiguous: p=0.011) but not under shallow processing (first vs. ambiguous: p = 0.921; second vs. ambiguous: p=0.85).

Conclusions The significant interaction in the PRONOUN and PRONOUN+2 regions suggests that depth of processing affects how ambiguous sentences are read. The results showed an ambiguity penalty under deep processing in the PRONOUN+2 region and a marginally significant ambiguity advantage under shallow processing (when comparing ambiguous and second character reference sentences). These findings replicate the results in Stewart et al. [1] and provide further evidence that ambiguity resolution in particular, and language processing in general, may depend on the depth of processing that participants engage in [5,6].

Sample stimuli:

(1) *Ambiguous*: Abel$_i$ leende Gijs$_j$ het boek voor hij$_{i/j}$ op vakantie ging.
(Translation: Abel$_i$ lent Gijs$_j$ the book before he$_{i/j}$ went on holiday.)

(2) *First character reference*: Abel$_i$ leende Zoë$_j$ het boek voor hij$_i$ op vakantie ging.
(Translation: Abel$_i$ lent Zoë$_j$ the book before he$_i$ went on holiday.)

(3) *Second character reference*: Zoë$_i$ leende Abel$_j$ het boek voor hij$_j$ op vakantie ging.
(Translation: Zoë$_i$ lent Abel$_j$ the book before he$_j$ went on holiday.)

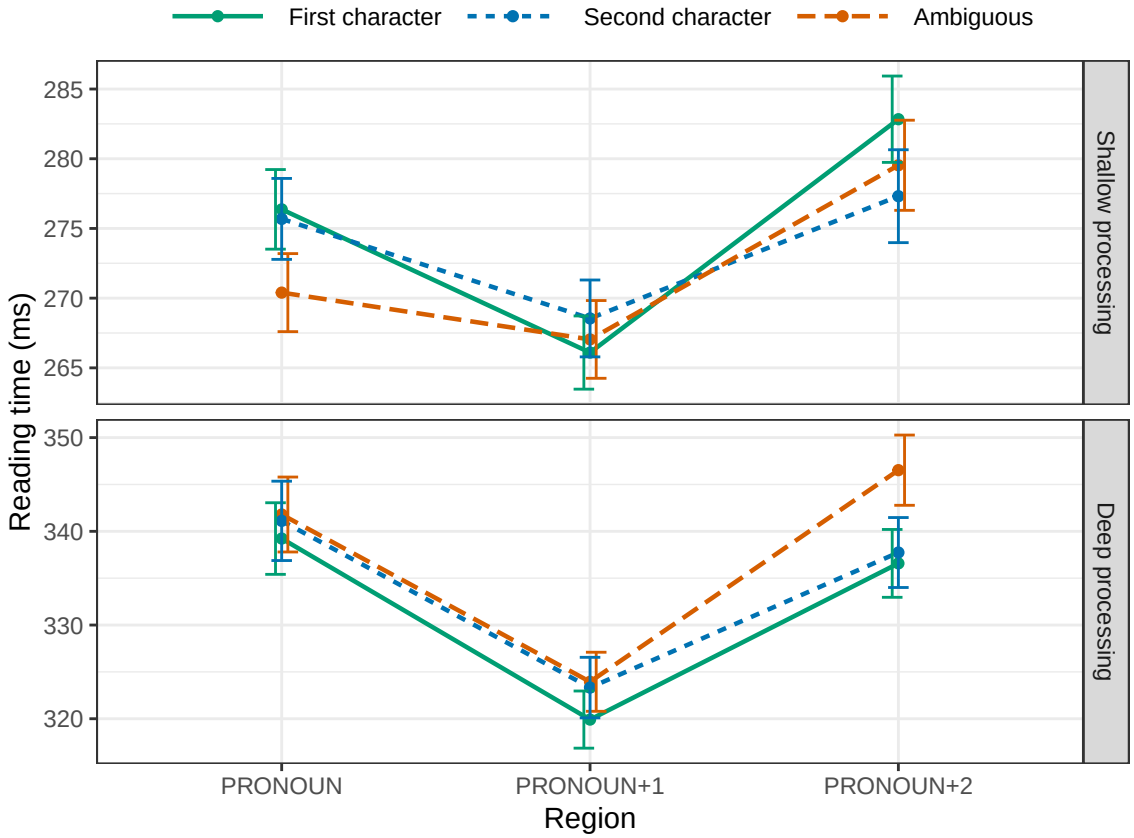

Figure 1: Reading times in the regions of interest: the prounoun itself (PRONOUN), and the two words following the pronoun (PRONOUN+1, PRONOUN+2), for ambiguous, first character reference, and second character reference sentences. Error bars represent ± 1 standard error from the mean. This figure shows non-transformed reading times for interpretability (note also the different scales on the y-axis), but analyses were conducted on residual log reading times.

References: [1] Stewart, Holler, and Kidd (2007). Shallow processing of ambiguous pronouns: Evidence for delay. *QJEP*, 60(12):1680–1696. • [2] Badecker and Straub (2002). The processing role of structural constraints on interpretation of pronouns and anaphors. *JEP: LMC*, 28(4):748–769. • [3] Grant, Sloggett, and Dillon (2020). Processing ambiguities in attachment and pronominal reference. *Glossa*, 5(1):77. • [4] Clifton and Staub (2008). Parallelism and competition in syntactic ambiguity resolution. *Lang Linguist Compass*, 2(2):234–250. • [5] Swets, Desmet, Clifton, and Ferreira (2008). Underspecification of syntactic ambiguities: Evidence from self-paced reading. *Mem. Cogn.*, 36(1):201–216. • [6] Logačev and Vasishth (2016). A multiple-channel model of task-dependent ambiguity resolution in sentence comprehension. *Cogn. Sci.*, 40(2):266–298. • [7] Hofmeister (2011). Representational complexity and memory retrieval in language comprehension. *Lang Cogn Process*, 26(3):376–405.