Encoding and Retrieval Interference in Dependency Resolution

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I. Background

- Structurally inaccessible NPs have been found to slow down processing at the anaphor site when they match the anaphor in certain features (e.g., gender in English reflexives *himself*/*herself*; Badecker & Straub 2002, Patil et al. 2014, Sturt 2003).

- Two alternative explanations:

i Retrieval Mutual features of linguistic constituents lead to cue-overload at the retrieval site (e.g., Gordon et al. 2006, Van Dyke & McElree 2011).

→ Inhibition of the antecedent due to the presence of a feature-matching structurally inaccessible NP.

ii Encoding Feature sharing of items in working memory leads to degradation of memory traces (e.g., Nairne 1990, Oberauer & Kliegl 2006).

→ Feature overlap of antecedent and structurally inaccessible NP causes partial feature deletion of the antecedent during encoding. This reduces the quality of the antecedent's memory trace leading to a slowdown at the moment of retrieval (Dillon 2011).

II. Research Question

Q: *What is the source of slowdown observed at the anaphor site?*

→ **Retrieval** processes: Cue-overload due to feature match of antecedent and structurally inaccessible NP

→ **Encoding** processes: Degraded memory trace of the antecedent due to partial feature deletion

III. 2×2 Design

Factor I Anaphor type (gender marked, gender unmarked)

Factor II Gender match (gender of antecedent and structurally inaccessible NP matched or mismatched)

Swedish distinguishes between locally free possessive pronouns *hans* 'his'/ *hennes* 'her' in (1) which agree in gender with their antecedent and gender unmarked locally bound possessive reflexives *sina* 'his'/ 'her' in (2).

Regions of interest

Pre-critical region: *jobbade med* in (1)/ *ringer* in (2) **Critical region:** *hans* in (1)/*sina* in (2) **Spillover region:** *sysslingar*

IV. Predictions

i Retrieval

If a gender-matching inaccessible NP causes cue-overload at the retrieval site, we should observe a slowdown **only** in case of gender-marked anaphors, but no effect in case of gender-unmarked anaphors.

ii Encoding

If a gender-matching inaccessible NP causes representational degradation of the antecedent's memory trace, we should observe a slowdown **regardless** of gender marking at the anaphor.

V. Materials

(1) { Gender match | Gender mismatch } – Gender marked (Possessive pronoun)

Åke$_i$ säger att { Alf$_j$ | Eva$_j$ } jobbade med **hans$_i$**   sysslingar på helgerna.

Åke$_i$ [M] says   that { **Alf$_j$ [M]** | **Eva$_j$ [F]** } worked   with   **his$_i$ [M]** siblings   at the weekend

'Åke says that Alf/ Eva worked with his siblings at the weekend.'

(2) { Gender match | Gender mismatch } – Gender unmarked (Possessive reflexive)
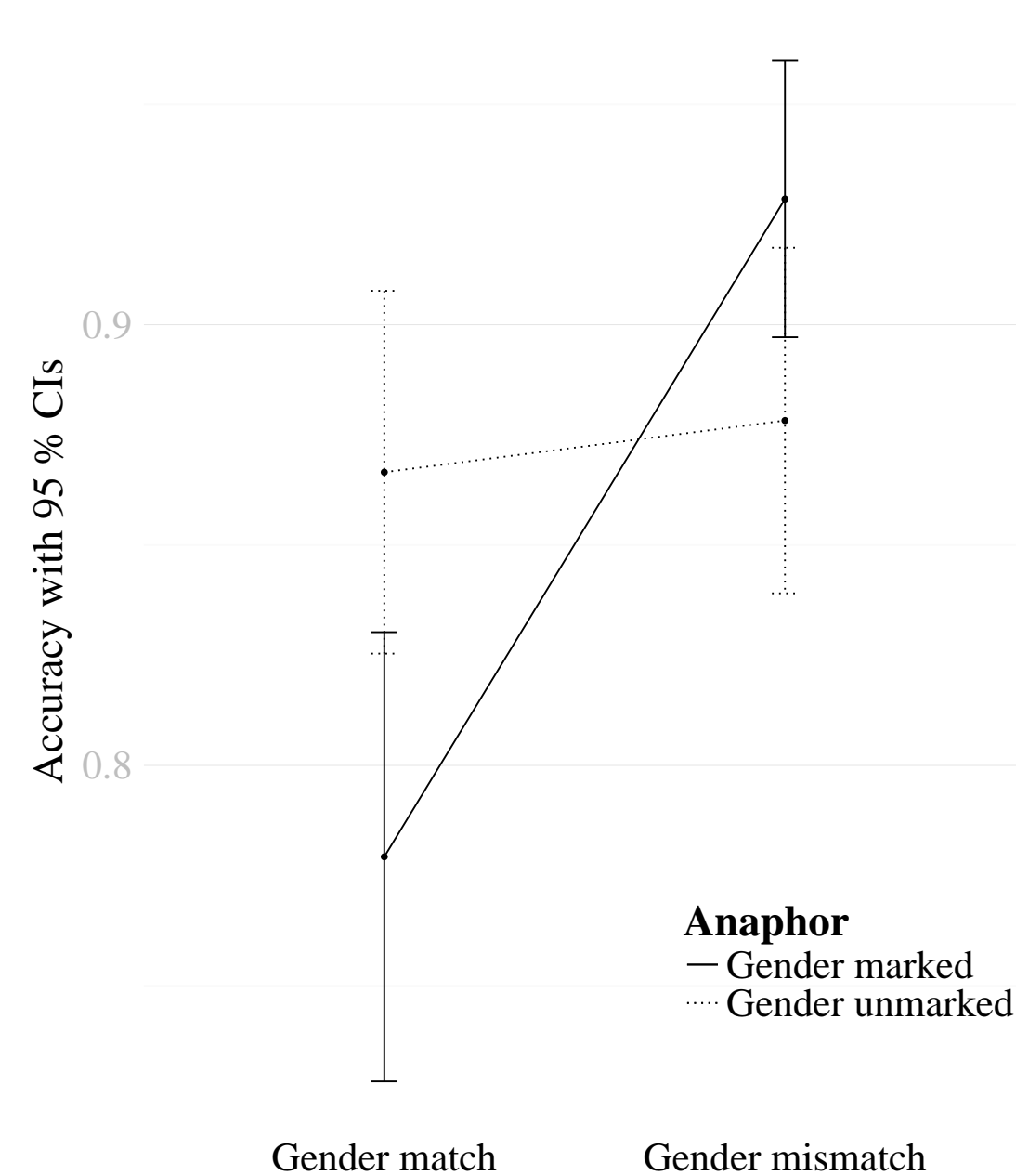
Åke$_i$ som { Alf$_j$ | Ann$_j$ } tackade ringer **sina$_i$**   sysslingar på kvällen.

Åke$_i$ [M] who { **Alf$_j$ [M]** | **Ann$_j$ [F]** } thanked   calls   **his$_i$ [∅]** siblings   in the evening

'Åke who Alf/ Ann thanked calls his siblings in the evening.'

VI. Procedure

- Eye tracking in reading task

- 48 items (Latin square); 70 fillers

- Comprehension question: dependency resolution (in 3/4 of the items)

- 32 participants, Swedish natives

- Eyelink 1000, Desktop mounted

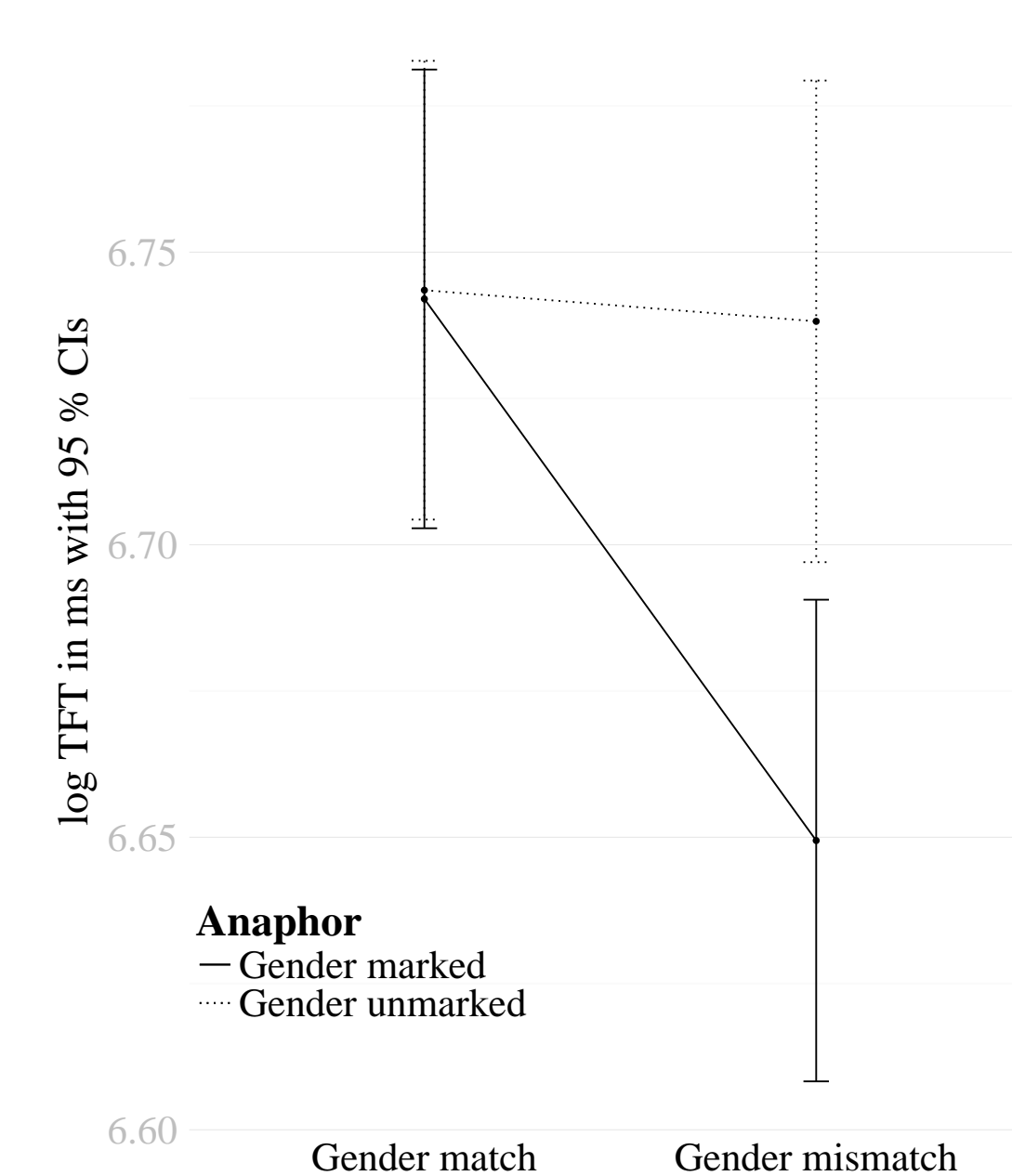## VII. Results

Question response accuracy — **Re–reading time regressive (pre–critical region)** — **Total–fixation time (pre–critical region)** — **First–pass regression probability (spillover region)**

- Interaction of Gender match and Anaphor type ($\hat{\beta} = 0.63$, $SE = 0.2$, $z = 3.16$, $p < 0.002$)
- Lower response accuracy due to gender match in gender marked pronouns ($\hat{\beta} = -1.36$, $SE = 0.29$, $z = -4.66$, $p < 0.0001$)
- No difference for gender match in gender unmarked reflexives ($\hat{\beta} = -0.1$, $SE = 0.27$, $z = -0.38$, $p = 0.71$)
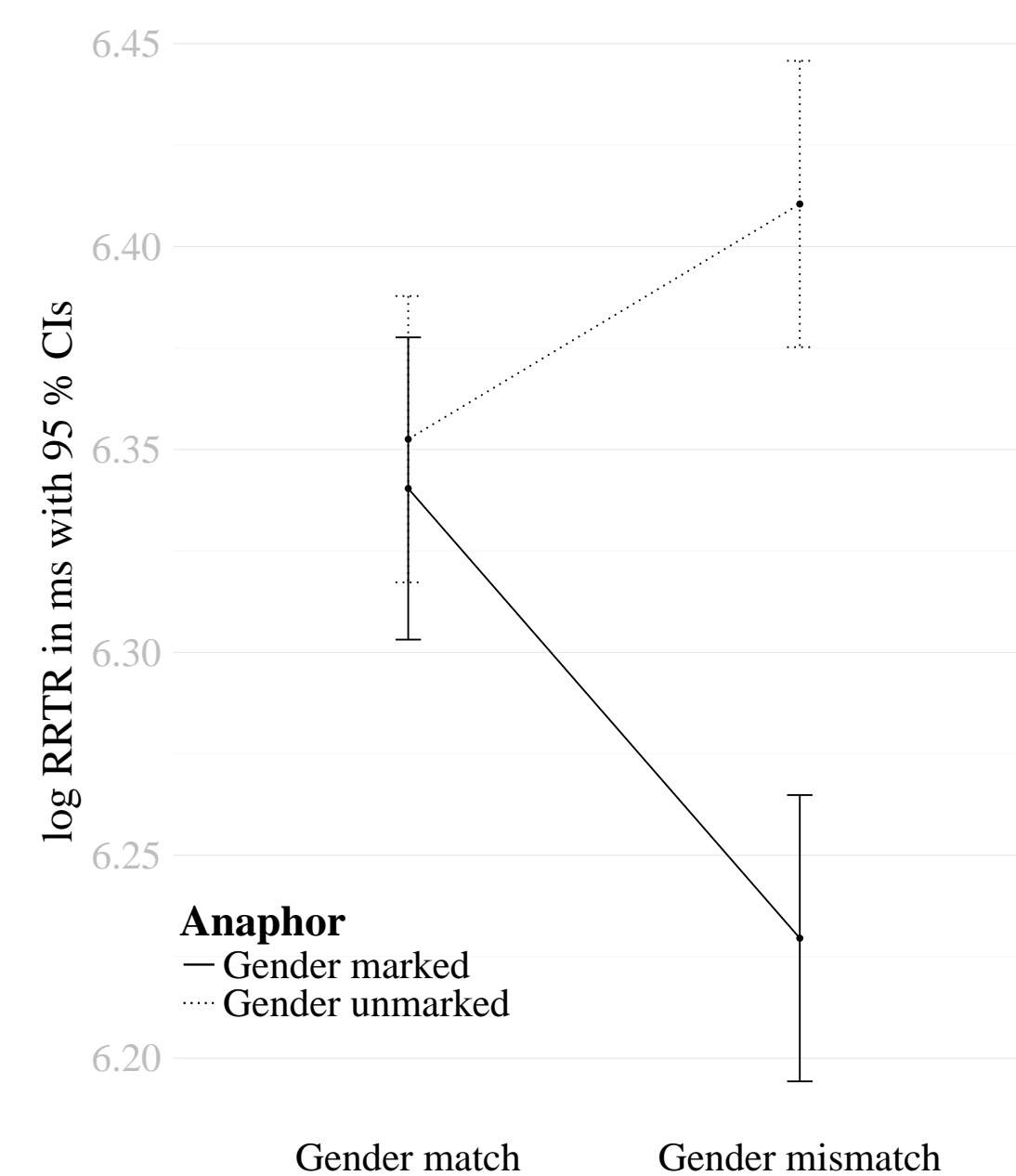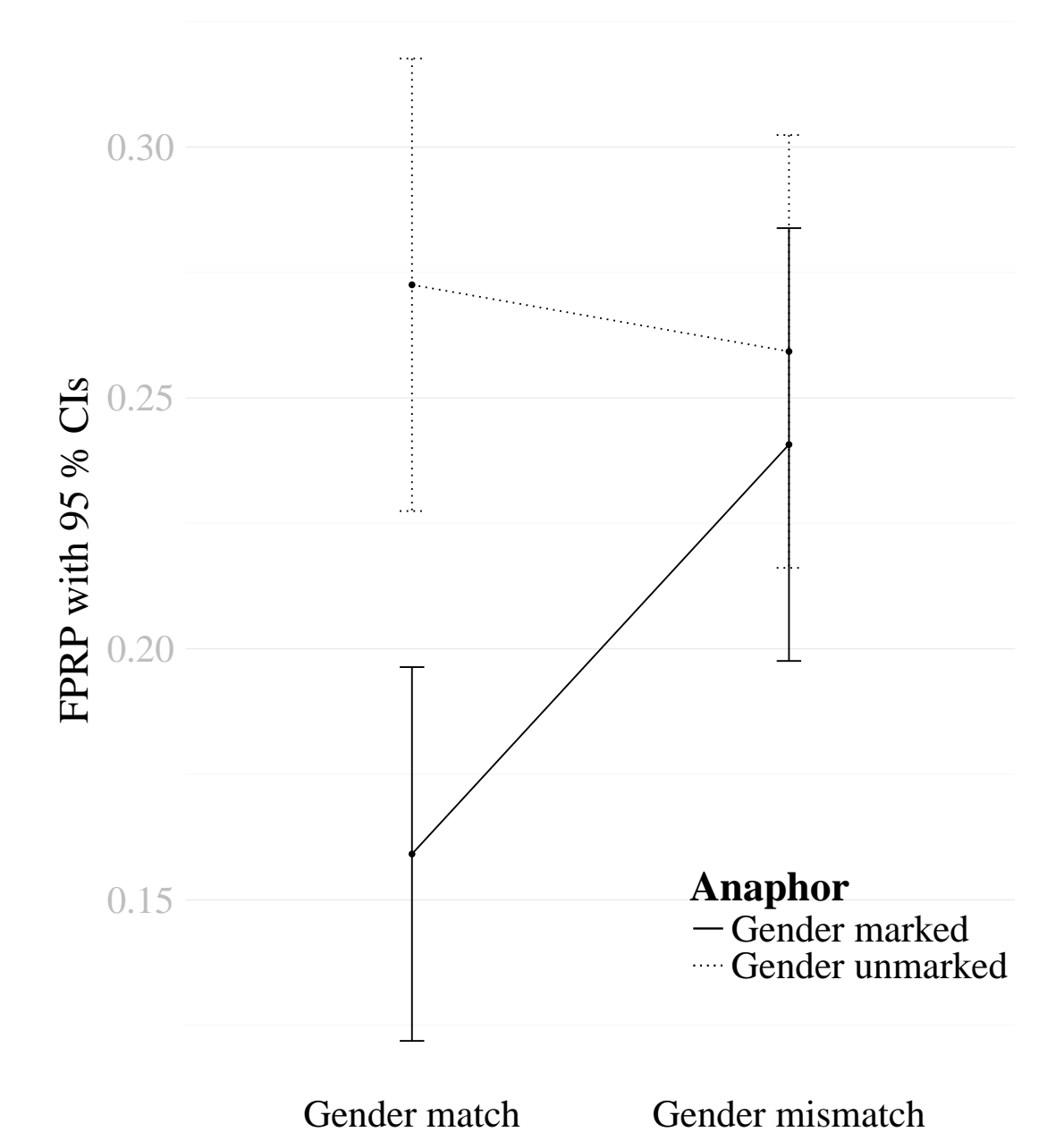
- Interaction of Gender match and Anaphor type ($\hat{\beta} = 0.09$, $SE = 0.04$, $t = 2.18$)[a]
- Longer fixation time due to gender match in gender marked pronouns ($\hat{\beta} = 0.12$, $SE = 0.06$, $t = 2.16$)
- No difference for gender match in gender unmarked reflexives ($\hat{\beta} = -0.05$, $SE = 0.06$, $t = -0.94$)

- Marginally significant interaction of Gender match and Anaphor type ($\hat{\beta} = 0.05$, $SE = 0.03$, $t = 1.72$)
- Longer fixation time due to gender match in gender marked pronouns ($\hat{\beta} = 0.1$, $SE = 0.04$, $t = 2.41$)
- No difference for gender match in gender unmarked reflexives ($\hat{\beta} = -0.0005$, $SE = 0.04$, $t = -0.01$)

- Interaction of Gender match and Anaphor type ($\hat{\beta} = -0.3$, $SE = 0.13$, $z = -2.39$, $p < 0.05$)
- Lower regression probability due to gender match in gender marked pronouns ($\hat{\beta} = -0.53$, $SE = 0.19$, $z = -2.84$, $p < 0.005$)
- No difference for gender match in gender unmarked reflexives ($\hat{\beta} = 0.07$, $SE = 0.17$, $z = 0.41$, $p = 0.68$)

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[a]RRTR: The sum of all second-pass fixation durations in a region after a fixation further to its right.

VIII. Discussion

- No interference was observed for gender unmarked reflexives, but gender marked pronouns showed processing facilitation in FPRP in the spillover region and slowdown in late measures in the pre-critical region.

- At the anaphor itself, no effect reached significance.

- Our results are compatible with accounts assuming that interference effects at the anaphor site are rather caused by retrieval than encoding processes (e.g., Jäger et al. 2013; Van Dyke & McElree 2006).

- The pattern found cannot be explained by encoding interference but only by retrieval interference:

→ Facilitation in FPRP might be caused by a higher proportion of mis-retrievals of inaccessible gender matched NPs. This is in line with lower question response accuracy for gender match in gender marked pronouns.

→ Inhibition in late measures is in line with previous results (e.g., Sturt 2003, Van Dyke & McElree 2011).

References

Badecker, W. & Straub, K. (2002). The processing role of structural constraints on the interpretation of pronouns and anaphors. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 28:B13-B26.

Dillon, B. W. (2011). *Structured access in sentence comprehension*. PhD thesis, Maryland.

Gordon, P.C., Hendrick, R., Johnson, M., & Lee, Y. (2006). Similarity-based interference during language comprehension: Evidence from eye tracking during reading. *Journal of Experimental Psychology: Learning, Memory & Cognition*, 32:1304-1321.

Jäger, L., Benz, L, Dillon, B. & Vasishth, S. Teasing apart encoding from retrieval interference in reflexives. Poster session at: AmLaP, 2013, Marseille.

Nairne, J. S. (1990). A feature model of immediate memory. *Memory & Cognition*, 18(3):251-269.

Oberauer, K. & Kliegl, R. (2006). A formal model of capacity limits in working memory. *Journal of Memory & Language*, 55:601-626.

Patil, U., Vasishth, S., & Lewis, R. L. (2014). Retrieval interference in syntactic processing: The case of reflexive binding in English. MS under revision.

Sturt, P. (2003). The time-course of the application of binding constraints in reference resolution. *Journal of Memory & Language*, 48:542-562.

Van Dyke, J. A. & McElree, B. (2006). Retrieval interference in sentence comprehension. *Journal of Memory & Language*, 55:157-166.

Van Dyke. J. A. & McElree, B. (2011). Cue-dependent interference in comprehension. *Journal of Memory & Language*, 65:247-263.