

Evidence for the prediction of modifiers during sentence processing

Manabu Arai, Frank Keller & Vera Demberg

School of Informatics, University of Edinburgh

AMLaP, September 4-6th, 2008, Cambridge, UK

Introduction

Question:

“Does the processor predict not only obligatory syntactic elements but also modifiers?”

Background:

- *Prediction* of upcoming linguistic information has been demonstrated in various forms (e.g., Altmann & Kamide, 1999; Arai et al., 2007; Kamide et al., 2003; Knoeferle et al., 2005; Konieczny, 2000; Staub & Clifton, 2006; Van Berkum et al., 2005)
- But almost all the evidence to date has only dealt with the prediction of *grammatical heads and their complements*.
- It is unknown whether the processor predict linguistic information even when it is *not required* by the current input.
- The current study investigated the *prediction of modifiers* by manipulating preceding context.

Although previous studies found a discourse-based effect on the processing of modifiers (e.g., Spivey & Tanenhaus, 1998; Spivey-Knowlton & Sedivy, 1995), the effect was only observed after a content word(s) of a modifier phrase/clause was encountered, which make the interpretation difficult between prediction and integration.

Experiment

Participants read a combination of sentences below.

(1) Preceding context

- Mary boiled an egg and Peter fried an egg. (Two egg context)
- Mary boiled an egg and Peter fried a sausage. (One egg context)

(2) Target sentence

- Max ate the egg which Mary boiled. (relative clause modifier)
- Max ate the egg while Mary slept. (*while*-clause non-modifier)

Expected Outcome:

Do people make a prediction about a modifier phrase/clause after the two egg context (but not after the one egg context)?

⇒ The complementizer *which* should be processed more easily after the two egg context than after the one egg context.

Thus, we expect to observe an interaction between context and modifier type at the words *which* and *while*.

References

- Altmann, G. T. M., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition*, 73, 247–264.
- Arai, M., van Gompel, R. P. G. and Scheepers, C. (2007). Priming ditransitive structures in comprehension. *Cognitive Psychology*, 54, 218–250.
- Demberg, V., & Keller, F. (2008). Data from eyetracking corpora as evidence for theories of syntactic processing complexity. *Cognition*, accepted.
- Kamide, Y., Scheepers, C., & Altmann, G. T. M. (2003). Integration of syntactic and semantic information in predictive processing: Cross-linguistic evidence from German and English. *Journal of Psycholinguistic Research*, 32, 37–55.
- Knoeferle, P., Crocker, M. W., Scheepers, C., & Pickering, M. J. (2005). The influence of the immediate visual context on incremental thematic role-assignment: evidence from eye-movements in depicted events. *Cognition*, 95, 95–127.
- Konieczny, L. (2000). Locality and parsing complexity. *Journal of Psycholinguistic Research*, 29, 627–645.
- Spivey, M. J. & Tanenhaus, M. K., (1998). Syntactic ambiguity resolution in discourse: Modeling the effects of referential context and lexical frequency. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 24, 1521–1543.
- Spivey-Knowlton, M. J., & Sedivy, J. C. (1995). Resolving attachment ambiguities with multiple constraints. *Cognition*, 55, 227–267.
- Staub, A., & Clifton, C., Jr. (2006). Syntactic prediction in language comprehension: evidence from either... or. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 32, 425–436.
- Van Berkum, J. J. A., Brown, C. M., Zwitserlood, P., Kooijman, V., & Hagoort, P. (2005). Anticipating upcoming words in discourse: Evidence from ERPs and reading times. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 31, 443–467.

Methods

Recorded eye-movements while participants read the sentences (both preceding context and target sentence).

Design: 2 (Context) x 2 (Modifier Type) within-item manipulation

Regions of Interest

(Preceding context) Max ate / the egg / which / Mary / boiled.

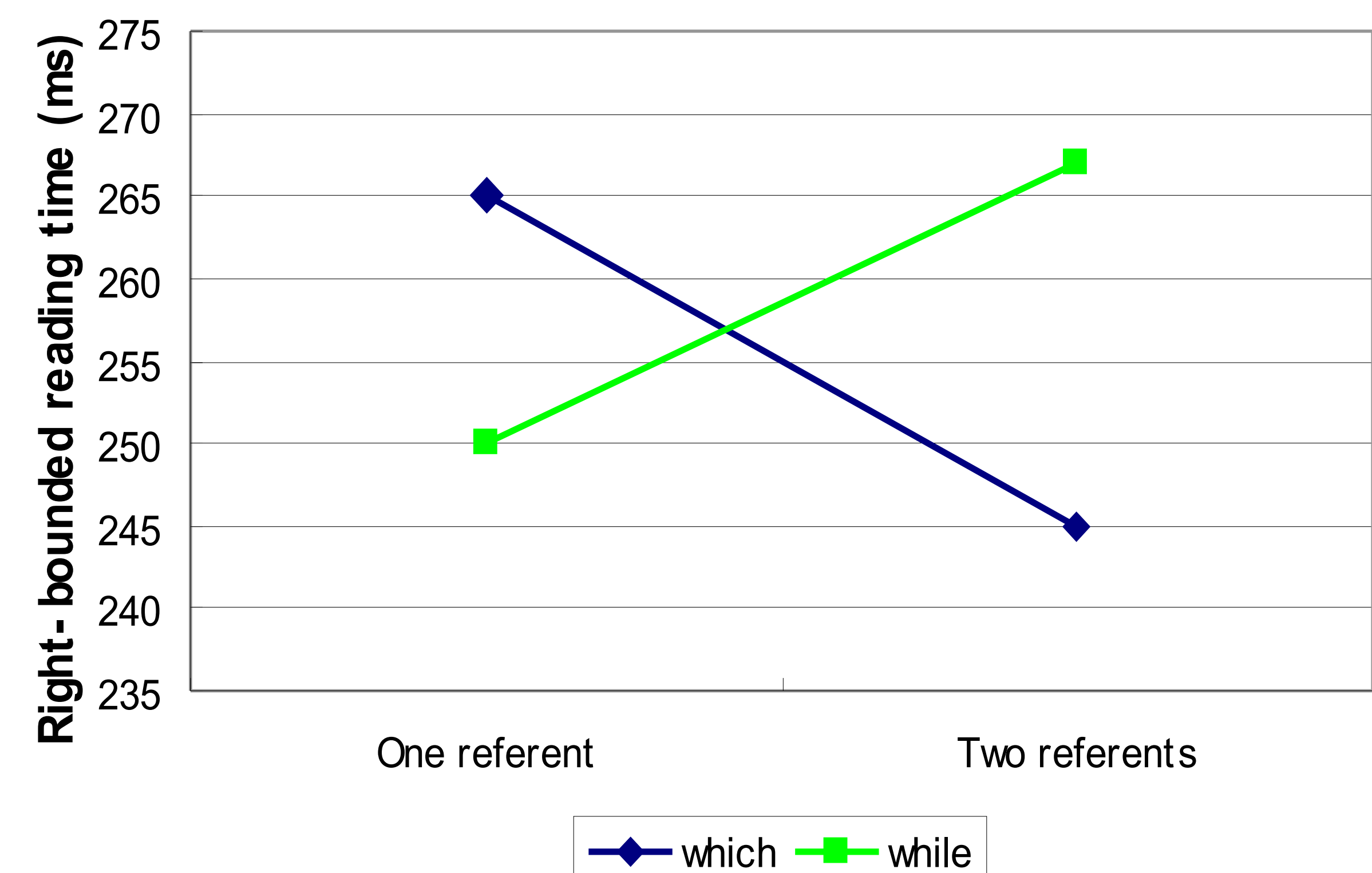
Results

We analysed various reading time measures (First pass, Regression path, Right-bounded, Second pass, Total time) using Linear Mixed-Effects model (Demberg & Keller, in press).

Critical Region (Region 2: which/while)

Early measures suggest interaction between Modifier Type and Context.

Statistically, it is marginal for Regression path ($p < .10$), significant for Right-bounded ($p < .05$) (for First pass, $p = .12$)



Late measures (second pass and total time) showed no interaction.

Second pass showed a main effect of Modifier Type ($p < .01$), suggesting that *which* was read faster than *while*.

Other Regions

No effects in early measures.

Region 1 (the NP before which/while): A main effect of Modifier Type in Regression path, Right-bounded, Second pass, Total time: NP preceding *which* was read faster than NP preceding *while*.

Region 3 (the noun following which/while): Late measures showed a main effect of modifier type ($p < .05$ for Second Pass and $p < .01$), suggesting that *which* was read faster than *while*.

Discussion

The results confirmed our predictions:

- A significant interaction was observed at *which/while*. Importantly, the effect was observed in a first-pass measure (right-bounded time), showing that the effect occurred before readers have seen any content word of the modifier clause.
- Suggest that participants made a prediction about a modifier phrase/clause on the basis of preceding context.
- This finding is the first demonstration of the discourse-driven prediction of modifiers in early stages of processing.