Processing Quantifiers in Object Position

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Background

- Realtime studies of semantic composition focus on the time course and resource demands of semantic *coercion*.
- "coercion" = a basic/preferred meaning is enriched/ changed in favor of a richer/less accessible meaning due to compositional properties of the local environment.

(1) The boy *started*/saw the fight /*puzzle* ...

cf. Traxler, et al. 2002

(2) Because it was cold, the team *sprinted*/huddled into/*inside* the gym ...

cf. Acland et al. 2004

The problem of quantifiers in object position.

Quantifiers in object position constitute one of the most well-known cases of syntax/semantics mismatch. (Montague'73)

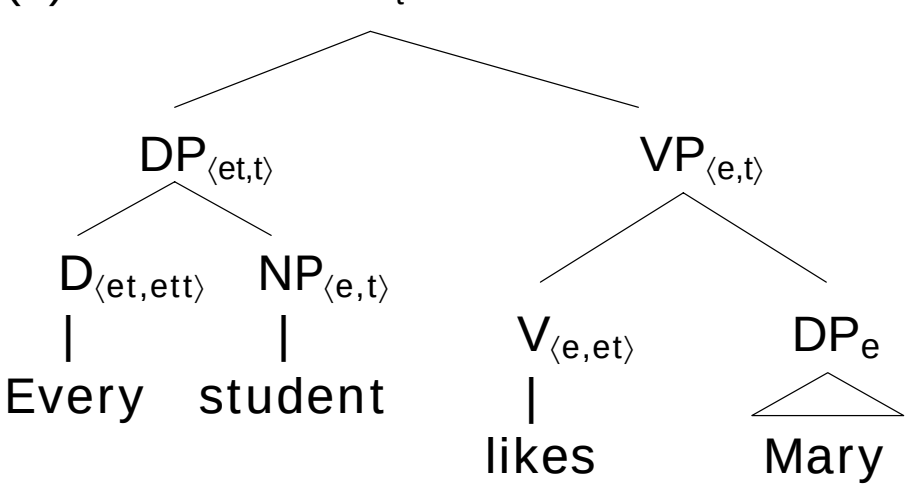
- Quantifiers do not refer.
- Quantifiers can appear in internal argument positions that are reserved for referring expressions.
- "Quantifier-hood" needs to be syntactically visible.

(3) Every student likes Mary.
(4) Mary likes every student.

Statement of the problem within type-theory.

- Quantifiers in subject position take the VP as argument.
- Quantifiers in object position cannot combine with the verb.

(1)



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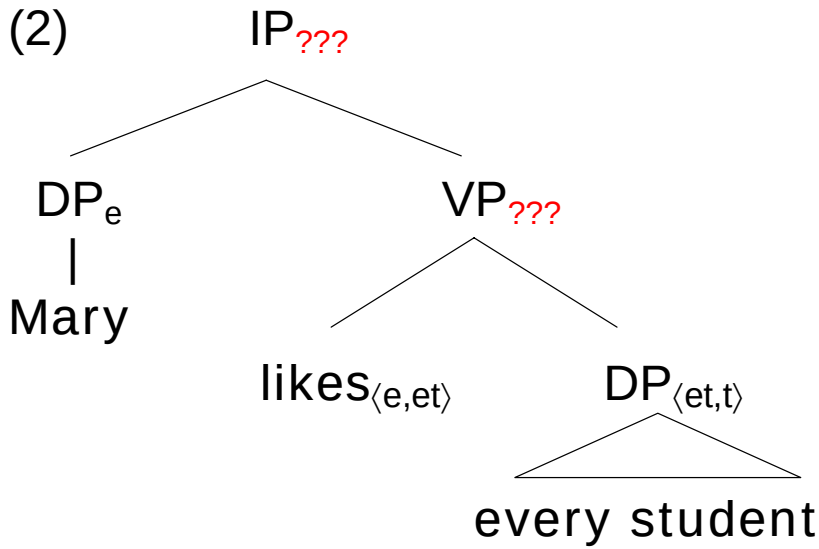

Possible Solutions.

There are at least 3 types of solutions that have been proposed in the literature.

- Typeshifting (e.g. Montague'73)
- Quantifier Raising (e.g. May'77)
- ϵ-Calculus (e.g. Kempson et al.'01)

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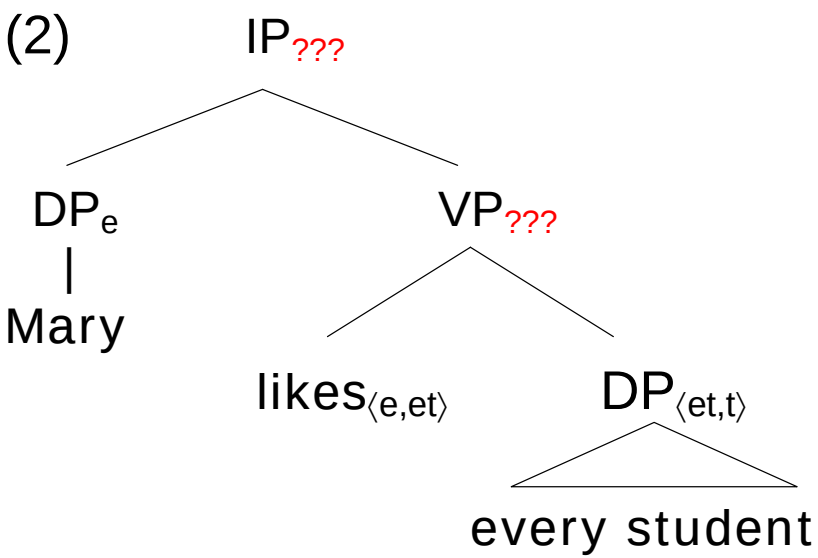
Type-Shifting（e.g. Montague'73）.

- The type of the verb (or determiner) is shifted so that it can combine directly with a quantifier (or verb).

(2)



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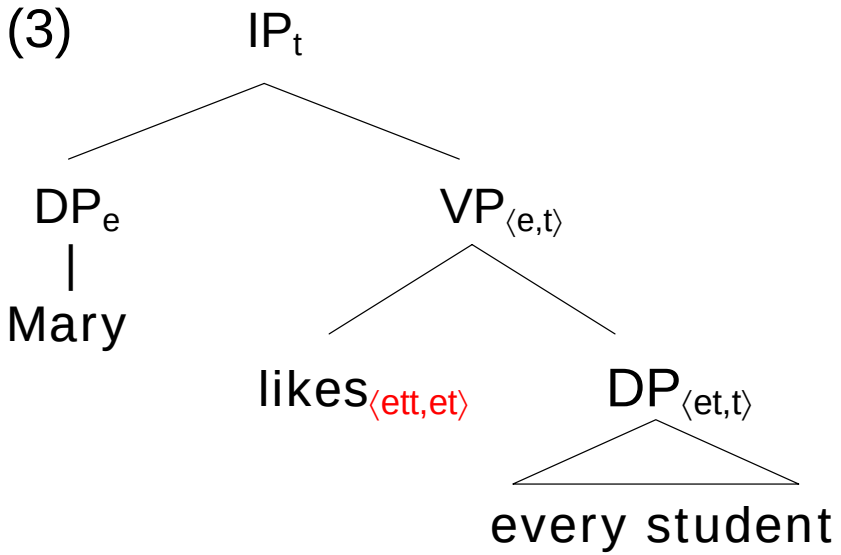
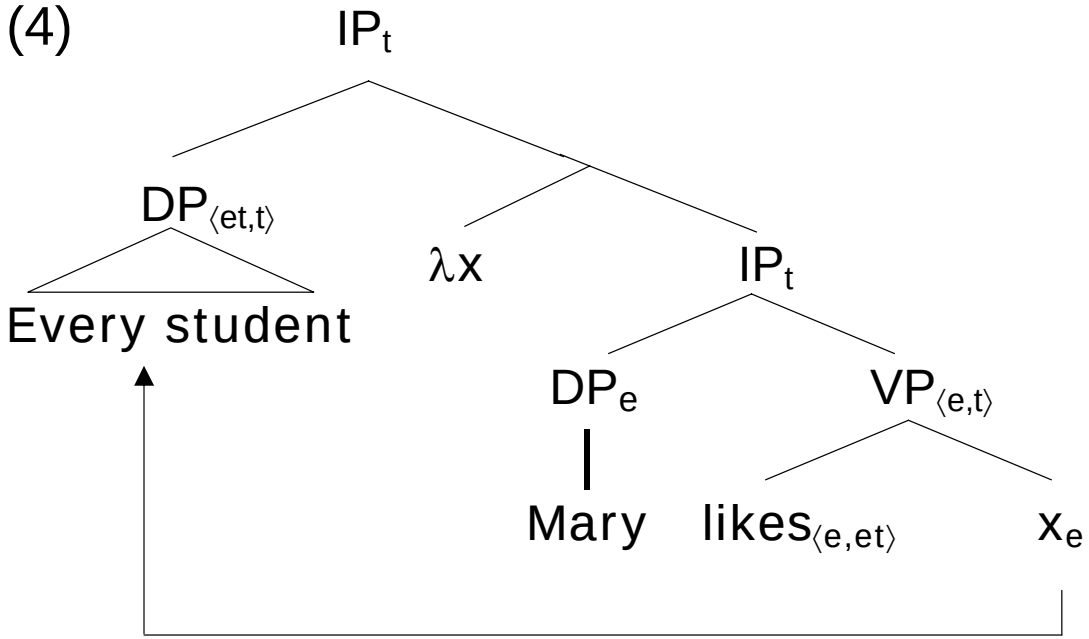


$[\![\text{likes}_1]\!] = \lambda x : x \in D_e . \lambda y : y \in D_e . y \text{ likes } x.$

$[\![\text{likes}_2]\!] = \lambda f : f \in D_{\langle ett \rangle} . \lambda y : y \in D_e .$
$f(\lambda x . [\![\textbf{likes}_1]\!](x)(y)=1)=1$

Quantifier Raising (e.g. May'77).

- The quantifier is moved by a syntactic operation to the top of the clause just like quantifiers in PL are always prefixed.



ϵ-Calculus (e.g. Kempson et al. '01).

Assume that the semantic complexity of quantifiers is not visible to the compositional engine.

- ϵ-Calculus treats quantifiers *syntactically* like any other DP.
- Interpreting quantifiers in object position is as complex as interpreting quantifiers in subject position.
- Quantifiers in object position do NOT constitute a syntax-semantics mismatch.
- Realtime processing effects of quantifiers in object positions undermine the ϵ-Calculus solution.

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The Basic Idea

- If the increased complexity of quantifiers in object position is visible to the parser we expect that . . .
  - Subject QPs are easier to process than object QPs.

The Basic Idea: NP/S-Ambiguity Resolution with QPs

- QPs can be a factor in local ambiguity resolution.
- Example: NP/S Ambiguity

(1) The judge believed every witness ...
  a. ...was at the scene of the crime.
  b. ...who was at the scene of the crime.

- A direct comparison of (1)a and b won't be informative!

NP/S-Ambiguity with Quantifiers.

- 2x2 Design: "Determiner by Attachment"

(1) The judge believed the witness ...
  a. ...was at the scene of the crime.
  b. ...who was at the scene of the crime.

(2) The judge believed every witness ...
  a. ...was at the scene of the crime.
  b. ...who was at the scene of the crime.

- We expect an interaction between Determiner type and Attachment type: Object QPs should be relatively harder.

Self-Paced Reading Studies of QP-processing

- To get a handle on possible interference from verb preferences (cf. Trueswell et al.'93, etc.) we ran two versions of the experiment:
  - Experiment 1: S-biased verbs
  - Experiment 2: NP-biased verbs
- Methods
  - 20 undergraduates from Claremont Colleges, native speakers of English.
  - Single word, self-paced, moving window reading paradigm.
  - 32 target items (8 in each cell), 92 filler items.
  - Each sentence was followed by a comprehension question.

Experiment 1: S-bias

Materials

- 4 versions of target sentences were constructed as exemplified below.
- S-biased verbs were chosen from Trueswell et al.'93 (verb bias was checked against Brown and Wall Street Journal Corpus of Penn Tree Bank).

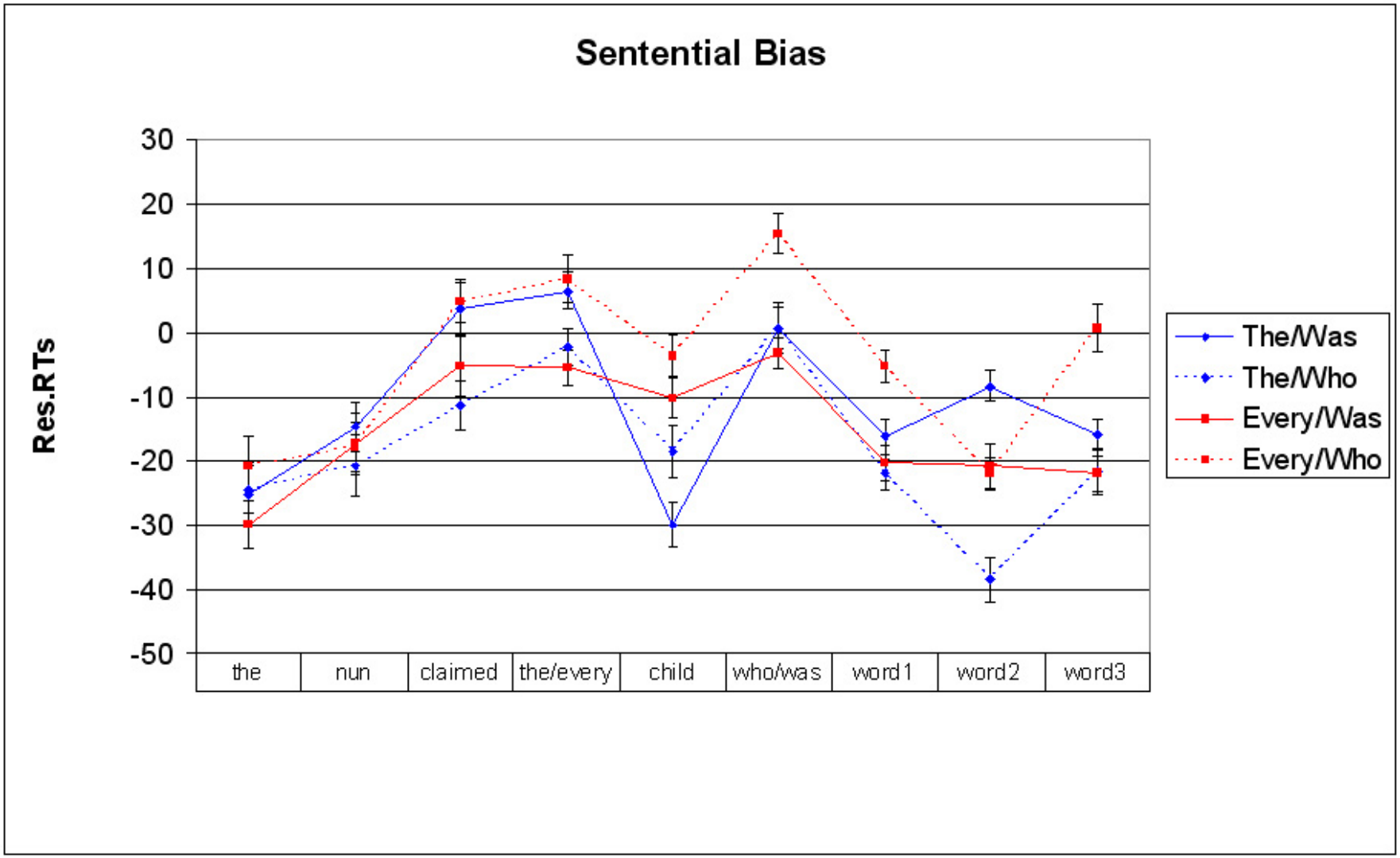
(1) The nun claimed the child ...
  a. ...who was abused and malnourished.
  b. ...was abused and malnourished.

(2) The nun claimed every child ...
  a. ...who was abused and malnourished.
  b. ...was abused and malnourished.

Analysis

- Residual reading times were calculated from sentences whose follow-up question was answered correctly.
- RRTs were trimmed by 3 stdv across subjects.
- Repeated Measures ANOVA on mean RRTs (word by word and across regions).

Residual Reading Times: S-Bias



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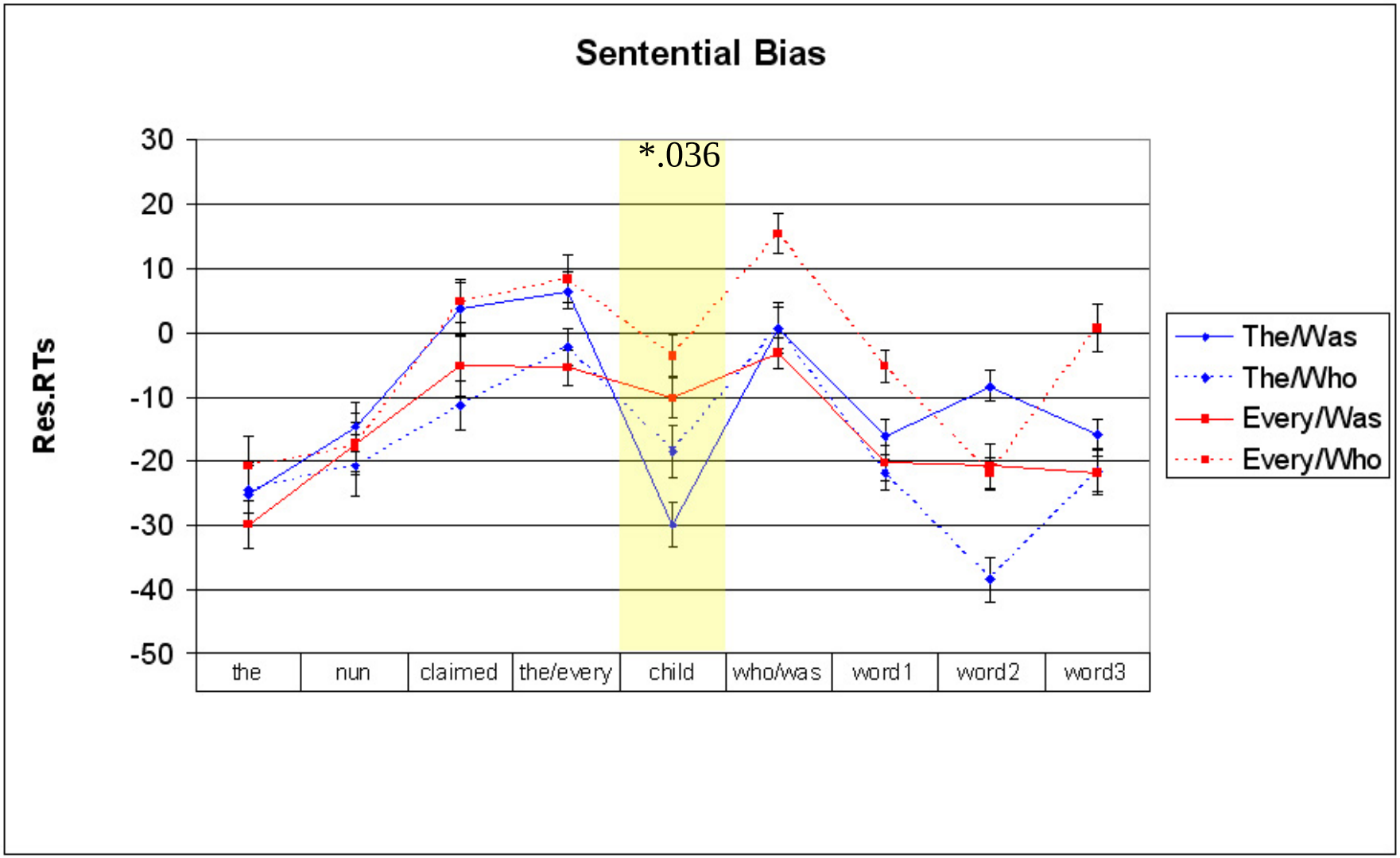

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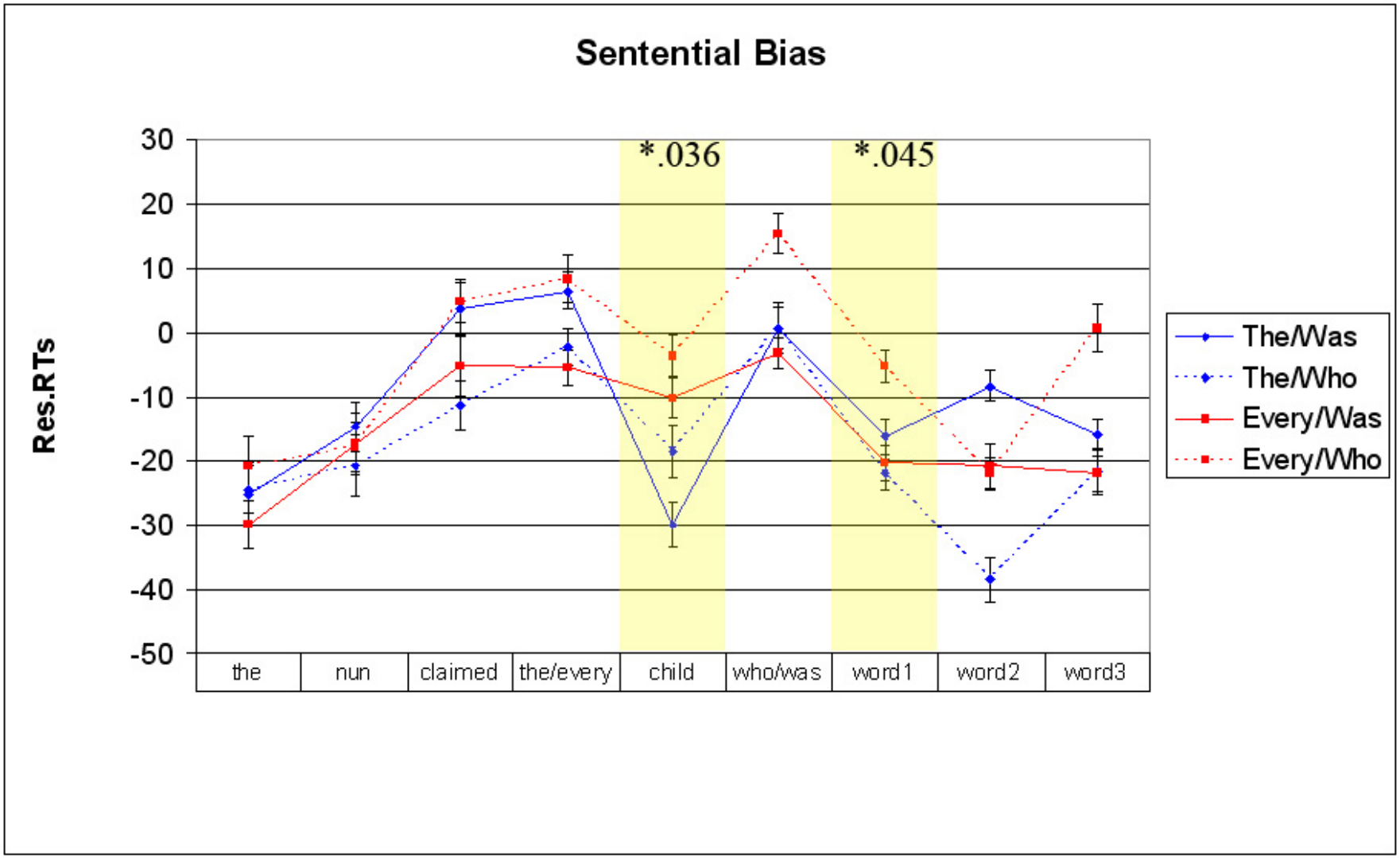

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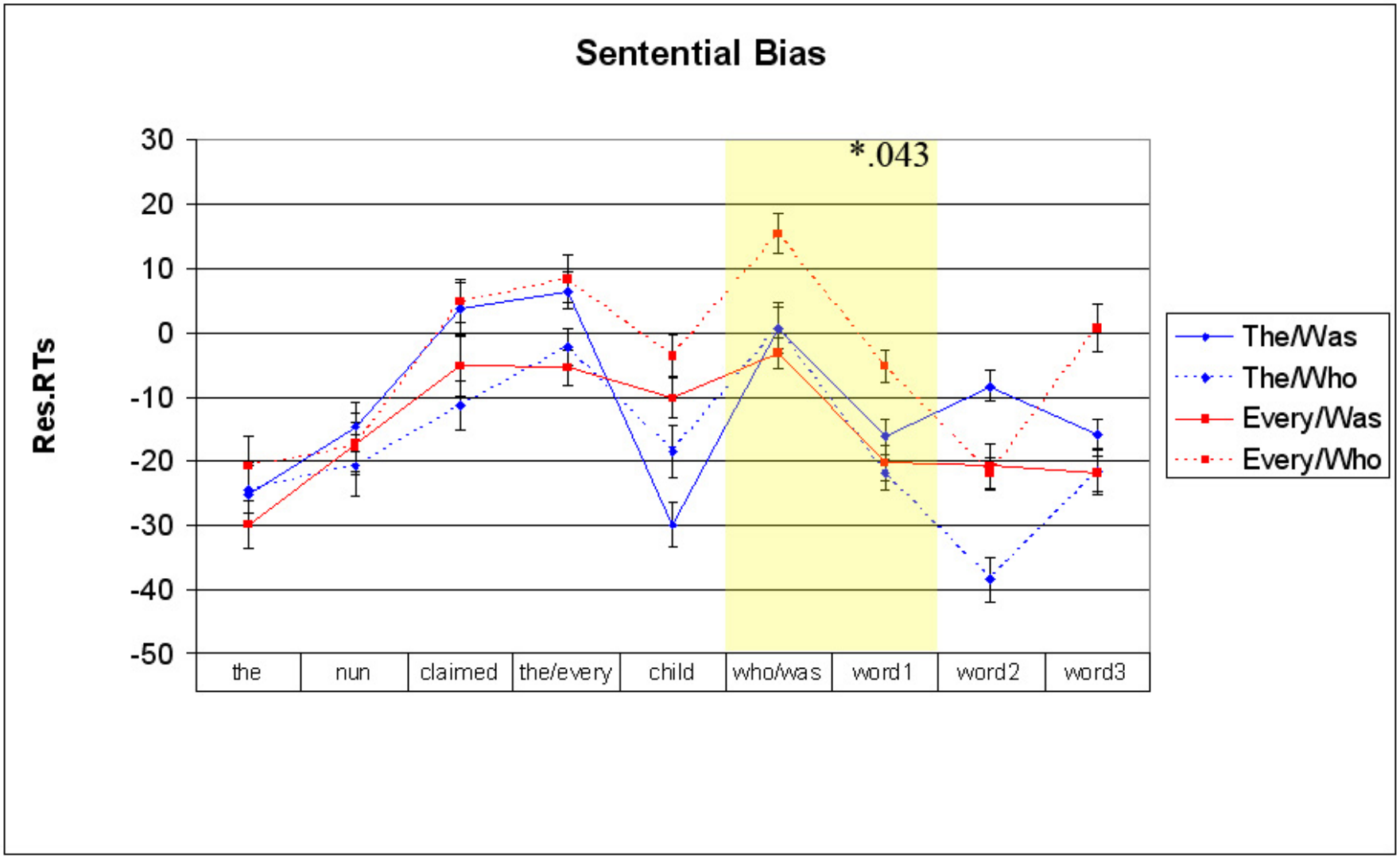

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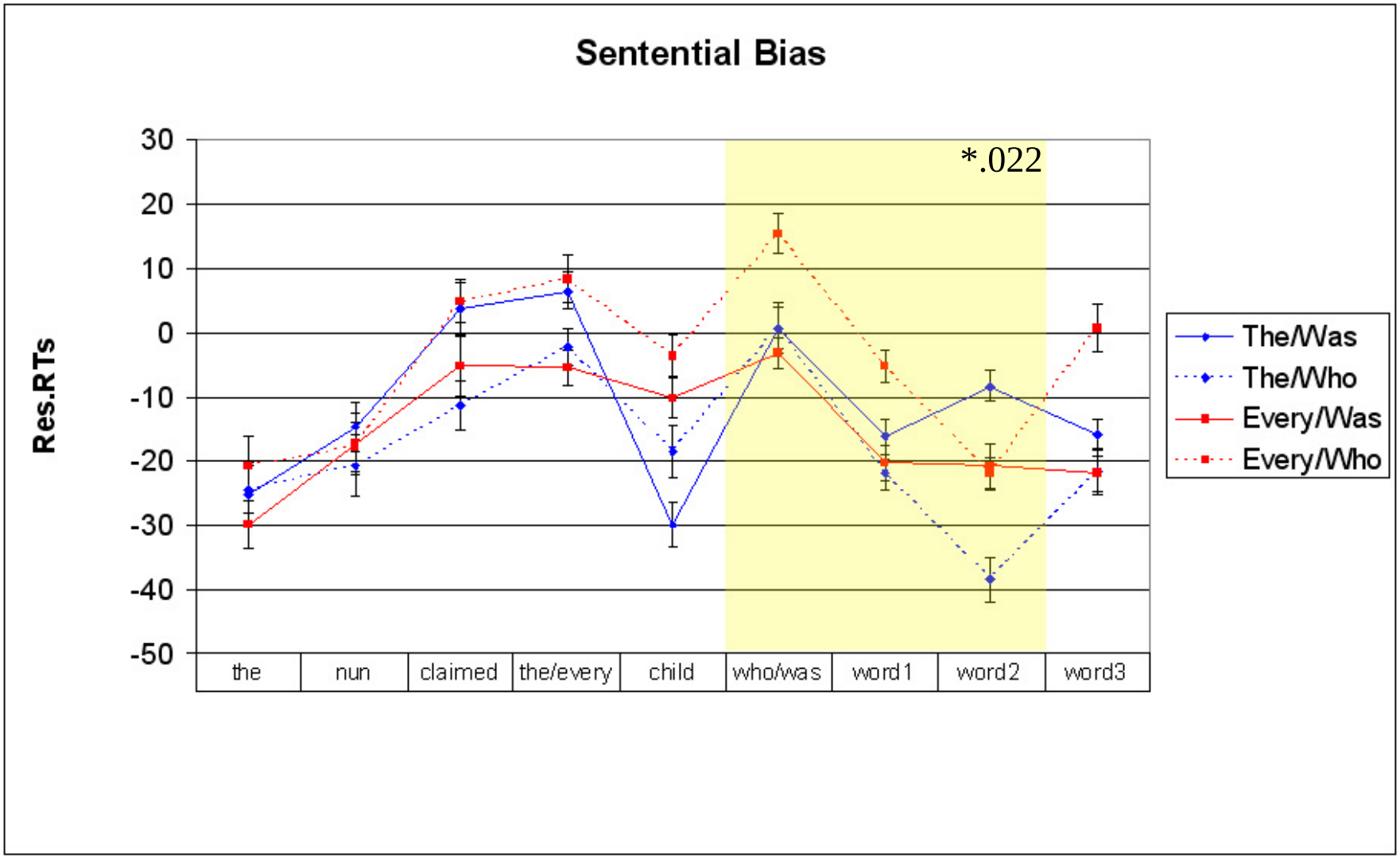

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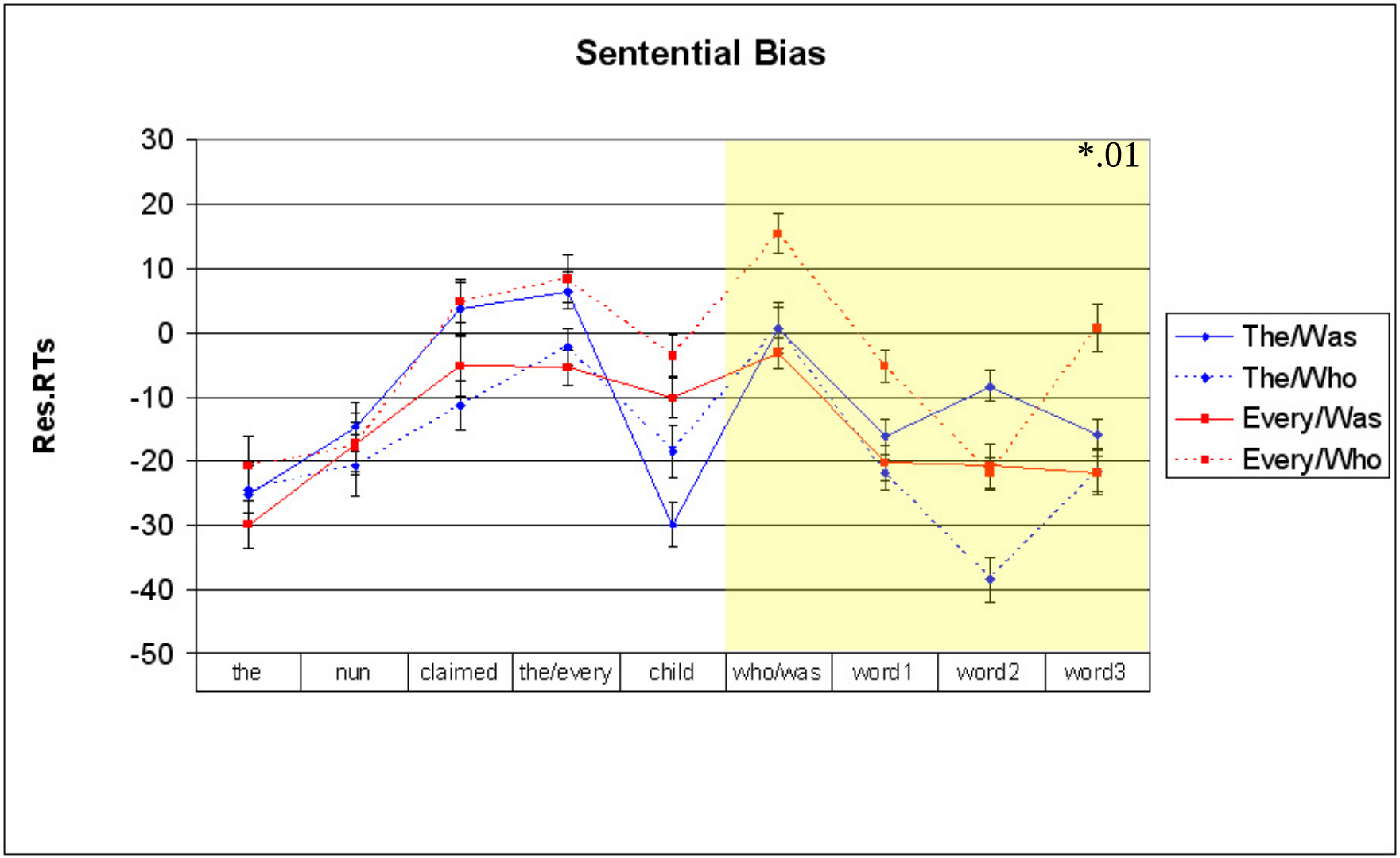


Summary of Results: Experiment 1

Findings of Experiment 1

- Main effect of Determiner Type one word after the determiner.
- Interaction as early as one word after disambiguation.
- Interaction stable over region from disambiguation to 3 words after.

Experiment 2: NP-bias

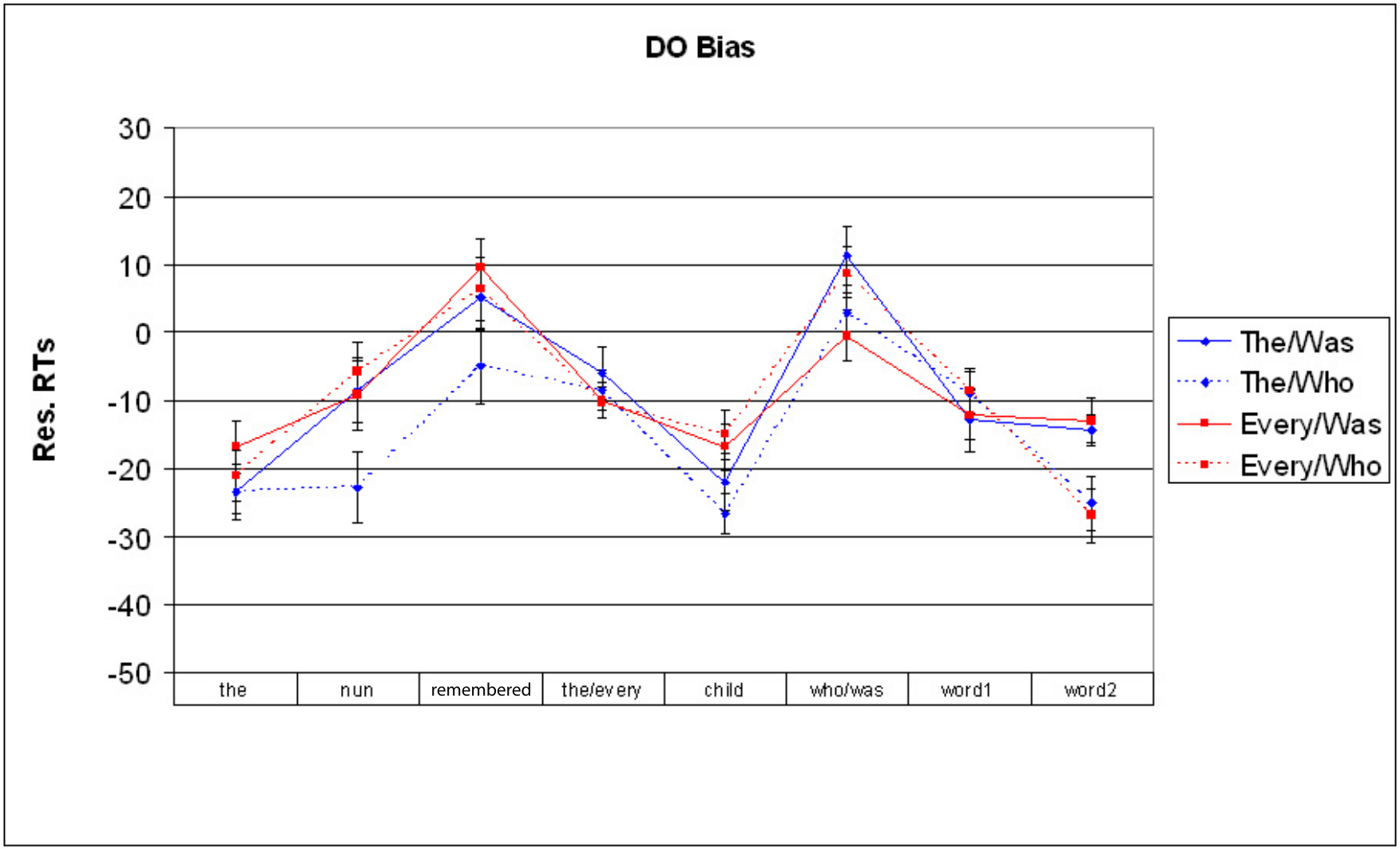
Materials

- Sentence frames as in Experiment 1.
- NP-biased verbs were chosen from Trueswell et al.'93 (verb bias was checked against Brown and Wall Street Journal Corpus of Penn Tree Bank).

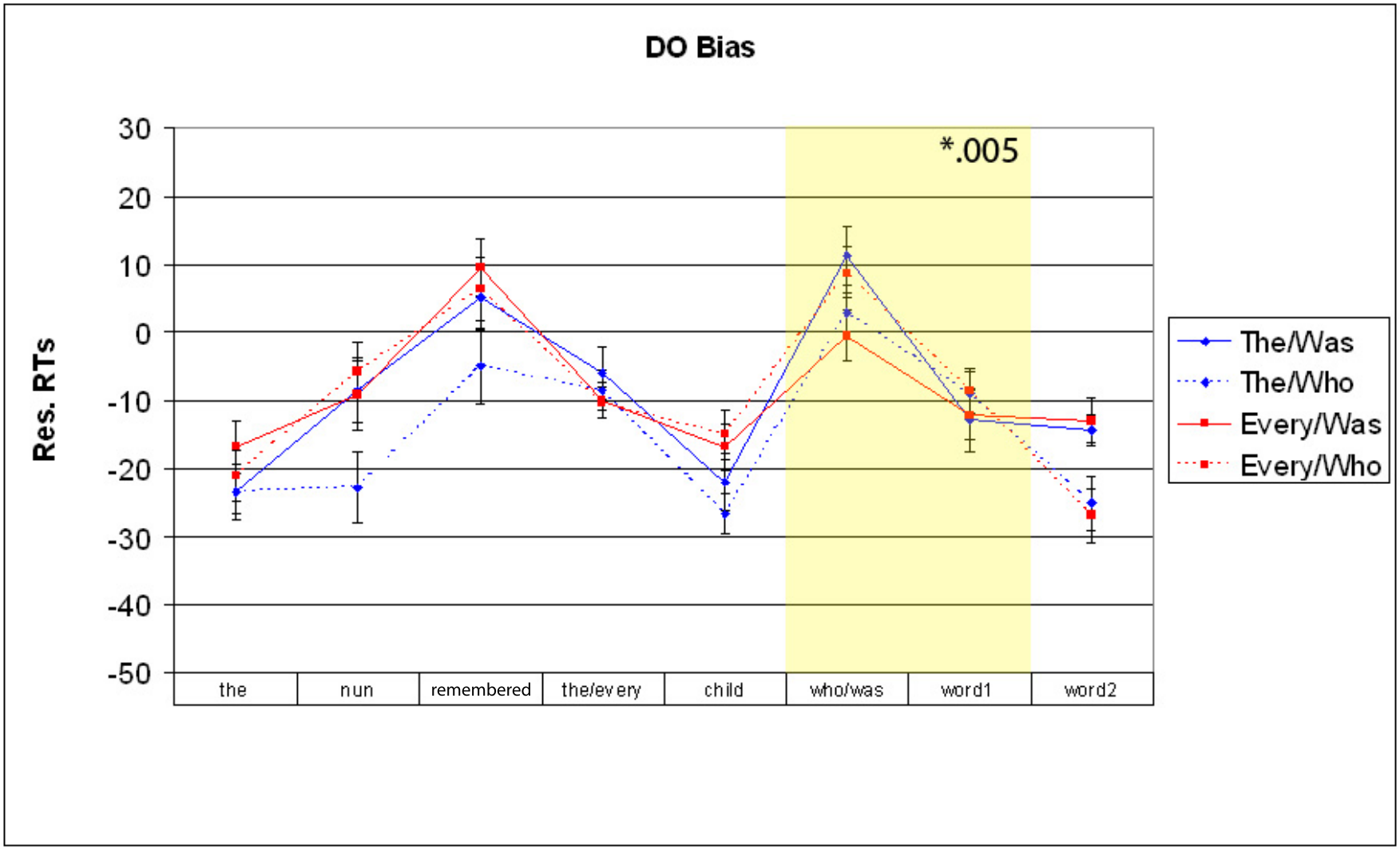
(1) The nun remembered the child ...
   a. ...who was abused and malnourished.
   b. ...was abused and malnourished.

(2) The nun remembered every child ...
   a. ...who was abused and malnourished.
   b. ...was abused and malnourished.

Residual Reading Times: NP-Bias



Residual Reading Times: NP-Bias



Summary of Results: Experiment 2

Findings of Experiment 2

- Difference on word after the determiner approaches significance.
- Significant Interaction in region from POD to the following word.

Summary

Conclusions

- Quantifiers are a factor in local (first pass) ambiguity resolution.
- The parser is sensitive to ”purely formal” semantic complexity as presented by quantifiers in object position.
- Semantic complexity of quantifiers is syntactically visible.

Acknowledgements

We would like to thank the Psycholinguistics class of 2005 at Pomona College, David Clausen, Stephen Conn, Jorie Koster-Moeller, Ted Gibson, and Robert Thornton for helpful comments.

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