

**Evidence for global pronoun resolution**  
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**Summary:** By presenting data from a study conducted on cataphoric pronouns in German we show that the semantics of different temporal connectives determines whether people are looking for a referent immediately or delay the pronoun resolution.

**Theory:** In previous experimental work, it has been shown that the process of looking for a referent happens immediately upon encountering a pronoun (Chow 2014). Moreover, under a standard semantic view a sentence is considered inappropriate if it contains pronouns without a referent (Heim & Kratzer 1998). We will adopt a dynamic semantic framework where the meaning of a sentence is a function from contexts to contexts. Contexts are modelled as world-assignment pairs. We model a context update where a proposition  $p$  is added to the current context with the help of the operator “Assert”. The operator introduces definedness conditions which make sure that all free occurrences of indices on pronouns are part of the assignment function  $g$  and all presuppositions of  $p$  are satisfied in the context (see the definition in (1)).

$$(1) \quad \llbracket \text{Assert}_c \rrbracket = \lambda p \in D_{\langle \text{gst}, \text{gst} \rangle} : \forall w, g [c(w)(g) \rightarrow i \in \text{dom}(g) \ \& \ p(w)(g) = 1 \ \text{or} \ p(w)(g) = 0].$$

$p(c)$

In the case of “and” we assume a stepwise update to prevent asymmetries as in (2).

- (2) a. #He also cooked dinner and Peter cleaned the kitchen.  
 b. Peter cleaned the kitchen and he also cooked dinner.

The lexical entry of “and” in (3) captures that the first conjunct is updated before the second. The ASSERT operator must thus be in the first conjunct, see (4).

$$(3) \quad \text{a. } \llbracket \text{and} \rrbracket = \lambda q \in D_{\langle \text{gst}, \text{gst} \rangle} . \lambda p \in D_{\langle \text{g}, \text{st} \rangle} . \lambda c . p(q)$$

$$\text{b. } \llbracket [ \text{ASSERT } q ] [ \text{and } p ] \rrbracket = \llbracket \text{and} \rrbracket (\llbracket p \rrbracket) (\llbracket \text{ASSERT} \rrbracket (\llbracket q \rrbracket))$$

For sentences with subordinate temporal clauses headed by “before” and “after” the same asymmetry does not arise (see (4)).

- (4) a. Before he also cooked dinner, Peter cleaned the kitchen.  
 b. Peter cleaned the kitchen before he also cooked dinner.

Following an adapted version of “before” and “after” in Penka (2008), “after” (and parallel “before”) relates a temporal phrase and a point in time at which another temporal phrase took place (see (5) and the analysis of (6-a.) in (6-b.)).

$$(5) \quad \text{a. } \llbracket \text{after} \rrbracket = \lambda t . \lambda t' . \lambda P \in D_{\langle i, t \rangle} . P(t) \ \& \ t' > t.$$

b. Mary arrived after John left.

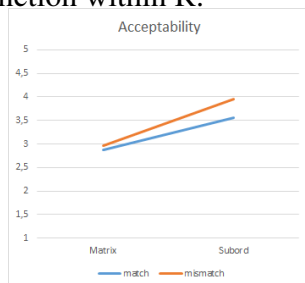
c.  $(\exists t'' < t_{\text{now}})$  Mary arrives at  $t''$  &  $t'''$  > the earliest  $t$  such that  $(\exists t' < t_{\text{now}}) t' = t$  & John left at  $t$

In this analysis, the tense of the matrix clause is dependent on the interpretation of the temporal phrase. Consequently, “Assert” can only scope above the overall clause. On the basis of this analysis, our hypothesis for the study is that participants delay the update process when they hear “before” or “after”. To test this, we used a 2x2 design crossing the conditions CLAUSE TYPE and GENDER MATCH. We created items where a cataphoric pronoun appeared in the matrix or temporal clause and either ambiguously or unambiguously referred to a given referent. The ambiguity was created by a match of the gender of the previously introduced referent and the pronoun. These cases were counterbalanced with mismatching pronoun and referent pairs. See one sample item in the four conditions below:

- (6) Eine Unternehmerin kommt ins Büro.  
 An entrepreneur.FEM enters the office.
- a. Er bringt einen Kaffee, bevor der Sekretär die Unternehmerin spricht.  
 He brings a coffee, before the secretary.MASK the entrepreneur.FEM talks-to.  
 (MATRIX CLAUSE, MISMATCH)

- b. Bevor er einen Kaffee bringt, spricht der Sekretär die Unternehmerin.  
Before he a coffee brings, talks-to the secretary.MASK the entrepreneur.FEM.  
(SUBORD CLAUSE, MISMATCH)
- c. Sie bringt einen Kaffee, bevor die Sekretärin die Unternehmerin spricht.  
She brings a coffee, before the secretary.FEM the entrepreneur.FEM talks-to.  
(MATRIX CLAUSE, MATCH)
- d. Bevor sie einen Kaffee bringt, spricht die Sekretärin die Unternehmerin.  
Before she a coffee brings, talks the secretary.FEM the entrepreneur.FEM.  
(SUBORD CLAUSE, MATCH)

**The Study:** 24 German native speakers participated in the experiment. They were asked to judge the acceptability of the sentences within the given context on a scale from 1 - 5 (5 meaning fully acceptable). The analysis was done using linear mixed effect models using the lmer function within R.



Gender	Matrix	Subordinate
match	2,88	3,55
mismatch	2,96	3,96

There was a significant interaction between clause type and gender match ( $p < .05$ ). There were moreover significant main effects of both gender match ( $p < .03$ ) and clause type ( $p < .001$ ): Mismatching pronouns were overall judged better since they disambiguate the reference. In addition, subordinate clauses containing the pronoun were judged better than main clauses. The interaction by a simple effect showing that subordinate clauses containing a mismatching pronoun were judged significantly better than matrix clauses with a mismatching pronoun ( $p < .001$ ). This suggests that in matrix clauses people immediately look for a referent. In the mismatch condition, the unavailability of a referent was clear from the start and even when the sentence later on provided one this was not found appropriate. In subordinate clauses, however, the mismatching pronoun was found more acceptable, suggesting that participants knew that more information was to come and waited for the possibility of resolution rather than rejecting the sentence at this point.

**Conclusion:** Our results suggest that, indeed, participants are aware of the fact that a context update is delayed in the case of subordinate clauses. However, when encountering a matrix clause, people expect to update the context and want to assign a referent right away.

## References

- Chow W.Y. & Lewis, S. & C. Phillips (2014). "Immediate sensitivity to structural constraints in pronoun resolution." In: *Frontiers in Psychology*.
- Penka, D. & A. von Stechow (2008). "Phrasal complements of *before* and *after*." In: *Empirical Issues in Syntax and Semantics 7*. Ed. by O. Bonami & P. Cabredo Hofherr, pp. 1–17.