Costs of newness during referential processing – self-paced reading and ERP data

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Indirect anaphors (Schwarz-Friesel 2007, also known by the term bridged inferences) (e.g., *Theo read an article about waste disposal. <u>The author</u> wrote very well.*) encompass two different dimensions of newness: they represent new information and they introduce a new discourse referent into the mental model. Previous event-related potential (ERP) studies show an enhanced Late Positivity effect for indirect anaphors relative to (coreferential) direct anaphors (*An author$_i$ worked all night. <u>The author$_i$</u> will publish a new book soon.*), which has been associated with the processing of newness, in addition to N400 modulations, which in contrast have been associated with predictive processing (Burkhardt 2006, Schumacher 2009). An open question remains whether the increased processing costs of indirect anaphors arise from the integration of a *new informational aspect* or through the integration of a *new discourse referent*. This question is addressed in three experiments via a comparison of indirect anaphors and so-called specification anaphors (*Lisa$_i$ worked all night. <u>The author$_i$</u> will publish a new book soon.*). Specification anaphors resemble indirect anaphors in as far as they convey new information (about an already given referent, i.e*. the author=Lisa*) and they resemble direct anaphors by indicating a coreference relation. By contrast, indirect anaphors do not encompass coreference and require the introduction of a new discourse referent.

First a self-paced reading (SPR) experiment was conducted where the reading times (RTs) of German direct and indirect anaphors were compared to the RTs of specification anaphors (see Table1). The results indicate that the RTs of specification anaphors pattern with indirect anaphors in the critical noun phrase region (see Fig.1), suggesting that the increased processing costs of indirect anaphors arise from the integration of new information. However, the RTs in the spill over regions show longer RTs for specification anaphors. We suggest that this pattern indicates that specification anaphors are initially analyzed as new discourse referents and are subsequently recognized as being coreferential with an already given entity, when discourse unfolds. This reanalysis exerts costs. This leads to the conclusion that the increased processing costs of indirect anaphors observed in previous investigations of direct and indirect anaphors arise from the integration of a new discourse referent.

To follow up on this, we adapted the material for the second SPR study to preclude that the specification anaphor was interpreted as a new referent: names of famous personalities were used as antecedents and commonly known information about them as the specification anaphor (e.g., *Joanne K. Rowling* and *the author* in Table1). The results show a three-way modulation in the critical region (indirect anaphor > specification anaphor > direct anaphor). This pattern indicates that names of famous personalities as antecedents facilitate the coreference relation to referential expressions that introduce a new informational aspect, compared to generic first names. Also, the stable RTs of specification anaphors in the spill over region suggest that they were immediately interpreted as coreferential. These findings supports the conclusion of the first experiment that the increased processing costs of indirect anaphors, relative to direct anaphors, arise from the integration of a new discourse referent.

In addition, an ERP study was carried out to contrast again the three different types of anaphors and shed more light on the functional contribution to newness of the Late Positivity observed in previous research. The adapted material of the second experiment was used. The ERPs revealed a three-way modulation in the N400 window (300-500ms: indirect anaphor > specification anaphor > direct anaphor), reflecting different degrees of predictability, as well as in the Late Positivity window (600-800ms: indirect anaphor > specification anaphor > direct anaphor) (see Fig.2). Together these data indicate that the increased Late Positivity of indirect anaphors is associated with the establishment of a new discourse referent, lending support to the view that the positivity signals *newness of the discourse referent* rather than of information per se.

Table 1: Experimental Design & Sample Stimuli

	Informational aspect	Discourse Referent	Translated Example (Tested language was German)
Indirect anaphor	new	new	*Theo read an article about waste disposal. I heard that **the author** wrote very well about that topic.*
Specification anaphor	new	given	1st SPR Item: *Lisa$_i$ worked the whole night through. I heard that **the author$_i$** is going to publish a new book soon.* ERP / 2nd SPR Item: *Joanne K. Rowling$_i$ worked the whole night through. I heard that **the author$_i$** is going to publish a new book soon.*
Direct anaphor	given	given	*An author$_i$ worked the whole night through. I heard that **the author$_i$** is going to publish a new book soon.*

Figure 1: Reaction times of the 1st SPR Experiment. Standardized logarithmic reaction times on the y-axis and each region of the target sentences on the x-axis. Region 5 ("die Autorin" – the female author) is the region of interest.
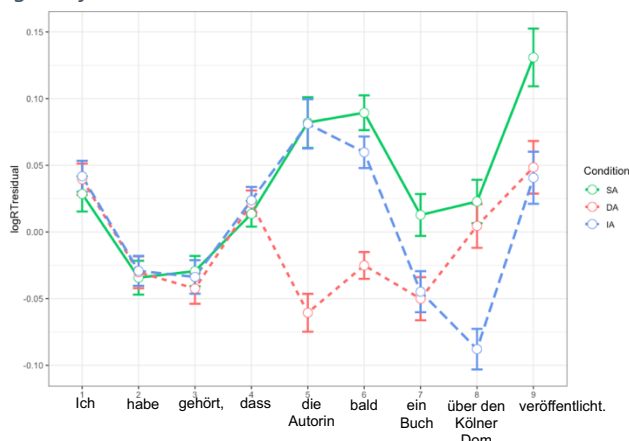

"I heard that the author will publish a book about the cathedral of Cologne soon."

Figure 2: Reaction times of the 2nd SPR Experiment. Standardized logarithmic reaction times on the y-axis and each region of the target sentences on the x-axis. Region 5 ("die Autorin" – the female author) is the region of interest.

"I heard that the author will publish a book about the cathedral of Cologne soon."

Figure 3: Grand-average-ERPs recorded to the onset of the critical anaphor (onset at the vertical line). Window presentation spans from 200 ms before until 1200 ms after onset of the anaphor. The voltage scale ranges from -4 to 4 μV and negative voltage is plotted upward. Indirect anaphor (blue), direct anaphor (red), specification anaphor (green)
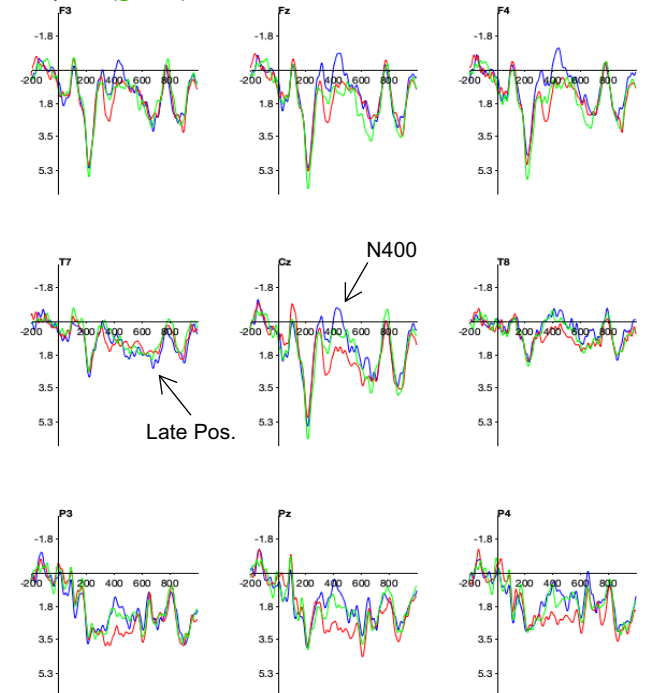
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