How WM load influences pronoun interpretation

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Introduction

We have implemented a computational model to investigate how WM capacity can influence the interpretation of pronouns in a linguistic context. From our cognitive model the prediction follows that adults' comprehension of pronouns can decrease with WM load. We performed an experiment to test this prediction.

How do listeners determine the referent of a pronoun? Generally, pronouns (*he*) are used when reference is intended to the topic, which is the most salient character in the linguistic context. More specific forms such as full noun phrases (*the soccer player*) or proper names (*Eric*) are used when reference is intended to less salient or new characters. Different factors have been found to affect the saliency of characters in the linguistic context, such as the grammatical role. The subject of the previous sentence is likely to be the current topic (Grosz, Weinstein, & Joshi, 1995). As a result, listeners will often interpret a pronoun as referring to the previous subject (a.o., Stevenson, Crawley, & Kleinman, 1994). However, for children up to the age of 7, the grammatical role seems to be a less important cue than for adults (Koster, Hoeks, & Hendriks, 2011). Children's use of grammatical information in pronoun comprehension seems to increase with a higher working memory (WM) capacity score (Koster et al., 2011).

Cognitive model

Within the cognitive architecture ACT-R (Anderson, 2007), we implemented a computational model to simulate the production and comprehension of referring expressions. The model's task is to find the interpretation of a referring expression given the preceding linguistic context.

To find the interpretation of a pronoun, the model needs to know which referent is the current discourse topic. The discourse topic is modeled as the referent with the highest saliency, i.e., with the highest activation in declarative memory. The activation of referents is dependent on the preceding discourse (i.e., frequency and recency), but is also influenced by the model's working memory (WM) capacity (cf. Daily, Lovett, & Reder, 2001). With a high WM capacity, the activation of the discourse referent that was mentioned as the subject of the previous utterance remains high. This boost of activation implements the idea that the subject of the previous utterance is likely to be the current topic (Grosz et al., 1995; Stevenson et al., 1994). Thus, only when WM capacity is sufficient will grammatical function be used in determining the discourse topic.

A new empirical prediction following from our model is that adult listeners will show difficulties comprehending a topic shift if their WM capacity is limited. For example, if their WM is taxed by another task, they will be less likely to use the grammatical function of the referents in the discourse to determine the discourse topic. Rather, they will solely rely on the frequency and recency of the referents.

Experiment

Using a dual-task experiment, we have investigated the effect of additional WM load on the interpretation of pronouns in different discourse contexts. Participants had to memorize a sequence of either three (low WM load condition) or six digits (high WM load condition) for recall at the end of the trial. While memorizing the digits, participants had to read short stories with or without topic shift (indicated by new or same subject). The final sentence of the stories started with an ambiguous pronoun. The story was followed by a comprehension question to elicit the referent of the ambiguous pronoun.

The data of 52 participants was analyzed. As predicted, WM load affected adults' interpretation of subject pronouns in stories with a topic shift (Figure 1): with high WM load adults less often selected the subject of the previous sentence as referent of the pronoun, but more often selected the firstly introduced referent (which was also more frequently mentioned). No significant effect of WM load was found in the stories without a topic shift, were the firstly introduced character was the subject in all sentences.

These results support the prediction following from our cognitive model that the interpretation of pronouns in discourse is dependent on the amount of WM capacity available for interpretation.

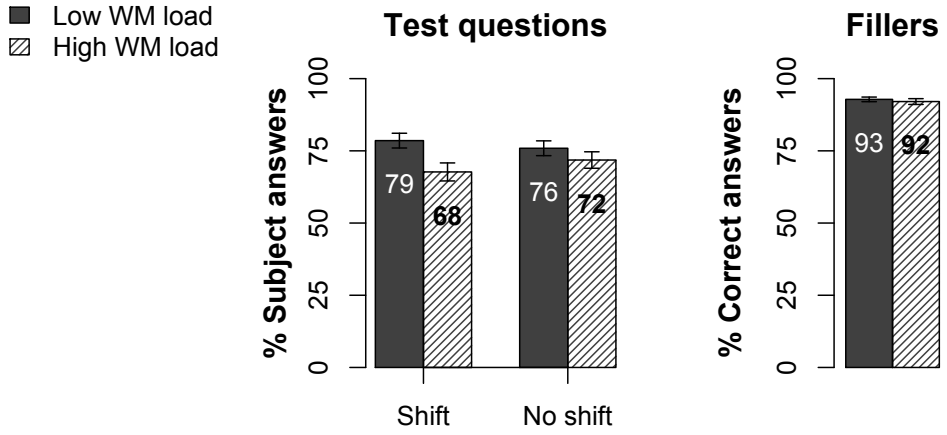

Figure 1: The percentage (±SE) that the previous subject was selected as referent of the pronoun (left) and the percentage correct answers on the filler questions (right) following stories with and without topic shift. The filled bars show the answers in the low WM load condition, the striped bars show the answers in the high WM load condition..

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