Anticipatory eye movements are modulated by working memory capacity: Evidence from older adults

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Keywords: anticipatory eye movements; individual differences; older adults; sentence processing; working memory.

Recent theoretical accounts of language processing assume an important role for the prediction of up-coming linguistic input (Altmann & Mirkovic, 2009; Chang, Dell, & Bock, 2006; Federmeier, 2007; Pickering & Garrod, 2007) which is supported by much experimental evidence (e.g., Altmann & Kamide, 1999; DeLong, Urbach, & Kutas, 2005). Little is known about the underlying principles and mechanisms driving such prediction. Here we investigated whether differences in working memory capacity predict the degree of anticipatory sentence processing. We chose older adults for our investigation. Older adults are less likely than younger adults to show prediction-related benefits during sentence processing (Federmeier et al., 2002) but it is yet unclear what cognitive processes underlie this difference. We conducted two visual world eye-tracking experiments and administered two working memory (WM) tests: a non-word repetition task and a backwards-recall digit span task.

Method

Thirty-eight older adults (mean age 68, screened for good hearing and vision, native speakers of Dutch) previewed visual displays containing four objects for four seconds, then a Dutch auditory sentence was initiated which they listened to while continuing to view the display. In the experimental condition of Experiment 1 the declarative sentence contained a verb (e.g., "write") which strongly biased one of the displayed objects (e.g., a letter: the complete sentence being "The boy writes a letter"). The control condition was identical except that the verb (e.g., "look at") did not bias towards any of the objects. In Experiment 2 the same participants received instructions (e.g., "look at the displayed piano" in Dutch) while viewing similar four object displays. Importantly, the articles were gender-marked such that the article agreed in gender only with the target object and thus participants could use gender information from the article to predict the target object.

Results

In both eye-tracking experiments, on hearing the biasing information (verb or article), participants anticipated the target object well before noun onset. We calculated participants' degree of prediction (target fixation proportions divided by the sum of target fixation proportions and averaged distractor proportions) between verb (or article) onset and noun onset. Participants' degree of prediction significantly correlated between both experiments. Degree of prediction also correlated with performance in the non-word repetition task (two-tailed, Exp 1 (verbs): .46, $p=.003$; Exp 2 (articles): .45, $p=.004$) and digit span backwards (Exp 1: .33, $p=.045$; Exp 2: .24, $p=.153$, one-tailed controlling for hearing: .28, $p<.05$). All correlations remained significant when age or hearing sensitivity was partialled out.

Conclusion

Predicting which object an interlocutor will refer to next requires the building of online models allowing for arbitrary objects to be linked to unfolding linguistic information, places, times, and each other. Our data suggest that limitations in working memory capacity are a significant source of limitations in language-mediated anticipatory eye gaze in older adults. Moreover, the finding that the linguistic WM task shows stronger correlations with predictive processing than the digit span WM task may be taken as indicative that language-mediated anticipatory eye gaze is modulated by partially distinct underlying WM components.