Individual variation in the interpretation of complex sentences

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It is well-known in cognitive-linguistic research that elderly people show difficulties with the processing of syntactically complex sentences (e.g., Emery, 1985; Zurif, Swinney, Prather, Wingfield, & Brownell, 1995). It is also known that cognitive factors such as working memory capacity and reading experience can mediate reading times on temporarily ambiguous sentences in elderly adults (Payne et al., 2014). Nevertheless, no consensus has been reached about which cognitive factors exactly influence complex sentence processing in elderly adults, and little is known about the potentially different influence of cognitive abilities on the processing of less vs. more complex sentences. We therefore ran a broad test battery to examine ***which cognitive abilities predict the interpretation and processing of complex sentences by elderly adults***.

We used an auditory sentence-processing paradigm followed by a picture-selection task with two pictures: one correct and one with thematic role-reversal. In German, structurally complex object-before-subject sentences can be formed. By manipulating subject-object order and adjunct position we created 4 sentence orders (see Table 1), with object-before-subject sentences expected to be more complex than subject-before-object sentences. In addition, cognitive tests tapping into simple working memory (backwards *Digit_Span* test), cognitive flexibility (*Trail_Making* test), vocabulary size (*Vocabulary* test), cognitive impairment (Montreal Cognitive Assessment; *MoCA*), and self-reported memory (*Memory_Assessment* Clinics Questionnaire) were used. Moreover, participants' *Age* and years of formal *Education* were recorded. 20 Elderly adults (age 51-70, mean age 60) with age-normal hearing were tested.

Analysis of the correct responses per condition (Fig.1) with linear mixed-effects models showed lower performance on object-before-subject sentences (OVAS and AVOS) than on subject-before-object sentences (SVAO and AVSO; $p < 0.001$). On these more complex object-before-subject sentences, **participants show large individual variation** (see Fig. 1). Separate correlation analyses showed main correlations of *Digit_Span* ($p < 0.001$), *Trail_Making* ($p < 0.01$), *Vocabulary* ($p < 0.001$), and *Memory_Assessment* ($p < 0.01$), but no correlations of *MoCA, Age,* and *Education,* with overall response accuracy. We found interactions between subject-object order and *Digit_Span* ($p < 0.001$), *Trail_Making* ($p < 0.05$), and *Vocabulary* ($p < 0.001$), indicating stronger correlations of these factors with the object-before-subject conditions.

As scores on cognitive tasks are often intercorrelated, we additionally investigated **which factors in combination,** taking into account their intercorrelations, explain performance on complex sentences best. We performed a conditional inference tree analysis, which provides non-parametric tree-based regression models to investigate which factors most strongly predict sentence comprehension scores; stronger predictors are higher up in the tree. The results (Fig. 2) indicate that our complexity manipulation, subject-object order, is the strongest predictor, followed by *Vocabulary* size for more complex object-before-subject sentences. Additionally, *Digit_Span*, *Trail_Making*, and *MoCA* are significant predictors for performance on complex sentences (see p-values in Fig. 2), indicating that these factors explain different parts of the data.

Concluding, our analyses identify several cognitive factors that can serve as predictors of the interpretation of complex object-before-subject sentences in elderly adults, which are largely different from the factors that predict the interpretation of simpler sentences. The study thus highlights the **influence of individual differences in cognitive abilities on language processing**, and emphasizes the need to consider not only working memory capacity, but also factors such as cognitive flexibility and vocabulary size when investigating complex sentence processing. The influence of vocabulary size is most striking, and could indicate that people with a broader and deeper vocabulary can access and process words more easily, thereby freeing up capacity for higher-level processing.

Subject-object order	Adjunct position	Condition	Example sentence
sub-before-obj	3	SVAO	Der Igel berührt am Montag den Hasen
obj-before-sub	3	OVAS	Den Hasen berührt am Montag der Igel
sub-before-obj	1	AVSO	Am Montag berührt der Igel den Hasen
obj-before-sub	1	AVOS	Am Montag berührt den Hasen der Igel
			On Monday the$_{NOM}$ *hedgehog touches the*$_{ACC}$ *hare*

Table 1. Examples of the four experimental conditions. Note that although the conditions use different word orders, their meaning remains the same.

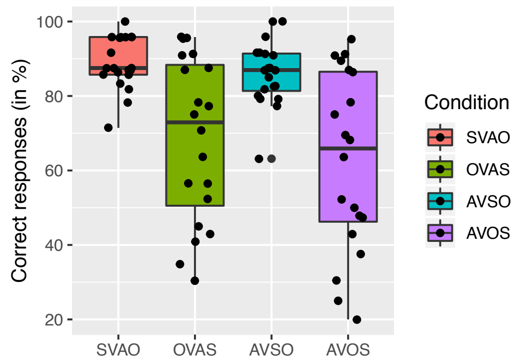

Figure 1. Percentages of correct responses and distribution of these responses on the picture-selection task per condition. Each dot indicates the mean score of a participant on a condition.

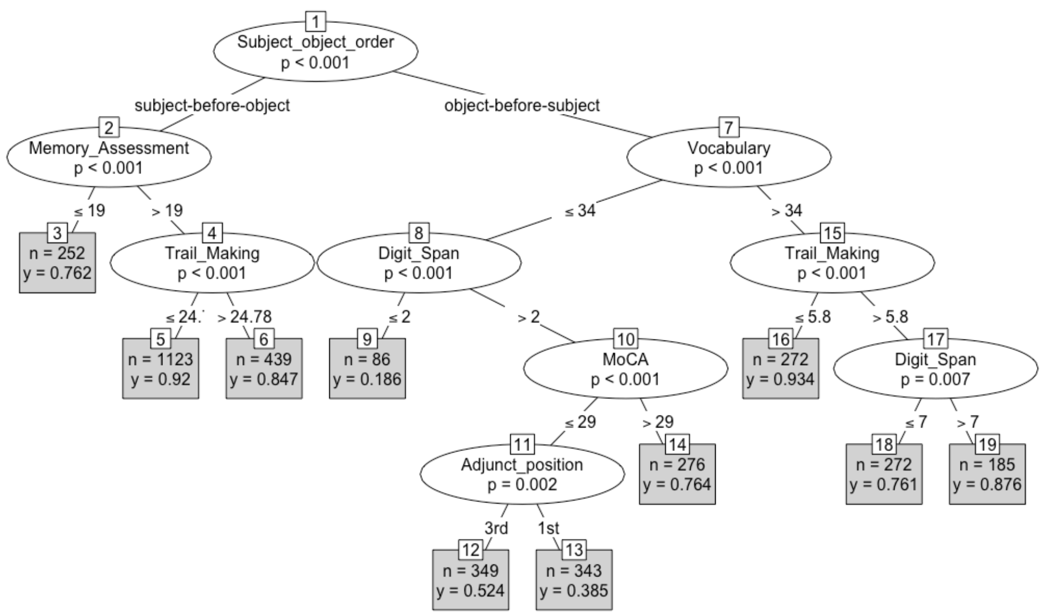

Figure 2. Conditional inference tree showing which of the tested predictors (*Subject-object order, Adjunct position, Digit_Span, Trail_Making, Vocabulary, MoCA, Memory_Assessment, Age, and Education*) are the best predictors of response accuracy (n = number of trials).

References Emery, O. B. (1985). Language and aging. *Experimental Aging Research*, *11*(1), 3–60. | Payne, B. R., Grison, S., Gao, X., Christianson, K., Morrow, D. G., & Stine-Morrow, E. A. L. (2014). Aging and individual differences in binding during sentence understanding: evidence from temporary and global syntactic attachment ambiguities. *Cognition*, *130*(2), 157–73. | Zurif, E., Swinney, D., Prather, P., Wingfield, A., & Brownell, H. (1995). The allocation of memory resources during sentence comprehension: Evidence from the elderly. *Journal of Psycholinguistic Research*, *24*(3), 165–182.