Adaptation to complex sentences in people with aphasia and unimpaired adults in German

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Complexity effects during sentence processing are reported for both people with aphasia (PWA, e.g., Caramazza & Zurif, 1976) and language unimpaired adults (e.g., Staub et al., 2017). Complexity effects are expressed in prolonged reading times or reduced response accuracy in structurally complex sentences such as object relative clauses (2-b) in contrast to structurally simpler sentences such as subject relative clauses (2-a). Wells et al. (2009) found for healthy speakers that complexity effects decreased after four sessions of exposure to relative clauses (RCs) suggesting that they can adapt to complex sentences in the input. The current study aims to investigate variability in sentence processing in aphasia. Here, we report one interesting pattern of results relating to adaptation effects.

Methods A total of 50 control participants (mean age = 48, range = 19–83 years) and 21 PWA (mean age = 60.2, range = 38–78 years), all native speakers of German, participated in the study. Participants were exposed to canonical and non-canonical declarative sentences (n=20, see (1)) and subject and object RCs (n=60, see (2)). Sentences were presented in pseudo-randomized order. Sentence comprehension was assessed in two test phases separated by two months. In both phases, participants were exposed to the sentences three times in three different tasks. Tasks tested auditory sentence comprehension and consisted of two variants of sentence-picture matching (SPM with self-paced listening, SPM with visual world eye-tracking, see example below) and acting out. No feedback on the correctness of the responses was provided. Data were analyzed using Bayesian hierarchical linear models. Models of response times and accuracy included the predictors participant group, test phase, task, sentence complexity nested within participant group, and their interactions. Visual world data were analyzed separately for each participant group and included the predictors test phase, sentence complexity, accuracy and time bin. We report the estimated means and 95% credible intervals (CrI) of the effects.

Results[1] The control group gave 26% CrI: [19, 34] more correct answers and responded 2082ms [1491, 2761] faster than the PWA. Accuracy was higher and response times were shorter in the retest phase in both groups (1% [0.3, 2], 153ms [72, 234]), with no interactions with participant group. Both participant groups were affected by sentence complexity: Responses were faster and more accurate in simple sentences (see Table 1 below). Turning to the interaction of test phase and complexity, control participants showed smaller complexity effects in the retest phase. Differences between conditions decreased by –2.9% [–5.8, –0.7] and –89ms [–144, –34] in declaratives and by –0.7% [–1.5, 0.2] and –25ms [–58, 7] in RCs in the retest phase. By contrast, for PWA, the estimated test-retest differences in complexity effects in response times showed no change (declaratives: 33ms CrI: [–108, 176] relative clauses: 8ms [–71, 87]). In response accuracy, in the retest phase, the complexity effect in PWA increased by 3.5% [0, 7.3] in declaratives and showed negligible changes in RCs (0.1% [–2, 2.2]). Turning to the eye-movements, fixation paths are shown in Figure 1. Control participants showed delayed looks to the target picture in complex compared to simple sentences. Differences in fixation paths between subject and object RCs decreased in the retest. Conversely, PWA showed similar fixation paths in simple and complex sentences in the test phase, whereas in the retest, target fixations increased later in complex compared to simple declaratives.

Discussion Both participant groups had difficulties in processing complex compared to simple sentences. Similar to Wells et al. (2009), controls adjusted to the sentences after repeated exposure, visible in the decrease of complexity effects. In contrast, PWA displayed no changes or increases in complexity effects in the retest phase, suggesting that PWA did not adjust to the input in the same way as controls. This is consistent with the proposal of Cope et al. (2017) within the predictive coding account that PWA have difficulties adjusting expectations about the upcoming structure to the input.

[1] Similar results were obtained with an age and education-matched subset of 22 controls. We report the results of the entire control group because the precision of the estimates increases with more observations.

Sentence examples

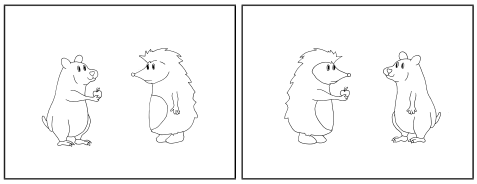
(1) a. *canonical declarative sentence (SO)*
Hier füttert der$_{nom}$ Igel den$_{acc}$ Hamster.
here feeds the$_{nom}$ hedgehog the$_{acc}$ hamster
'Here, the hedgehog feeds the hamster.'

b. *non-canonical declarative sentence (OS)*
Hier füttert den$_{acc}$ Igel der$_{nom}$ Hamster.
here feeds the$_{acc}$ hedgehog the$_{nom}$ hamster
'Here, the hamster feeds the hedgehog.'

(2) a. *subject relative clause (SRC)*
Hier ist der Igel, der$_{nom}$ den$_{acc}$ Hamster füttert
here is the hedgehog who$_{nom}$ the$_{acc}$ hamster feeds.
'Here is the hedgehog who feeds the hamster'

b. *object relative clause (ORC)*
Hier ist der Igel, den$_{acc}$ der$_{nom}$ Hamster füttert
here is the hedgehog who$_{acc}$ the$_{nom}$ hamster feeds
'Here is the hedgehog who the hamster feeds.'

Sentence-picture matching example



Estimates complexity effects

Table 1: Mean and 95% credible intervals of the complexity effect in healthy controls (HC) and people with aphasia (PWA) in accuracy (in %) and response times (in ms).

	mean [95% CrI]
HC, declaratives	1.6% [0.7, 2.8]
	220ms [144, 298]
HC, relative clauses	0.2% [–0.2, 0.6]
	65ms [14, 118]
PWA, declaratives	37% [22.9, 50.4]
	720ms [–69, 1567]
PWA, relative clauses	14.3% [-9, 35.6]
	112ms [-332, 1567]

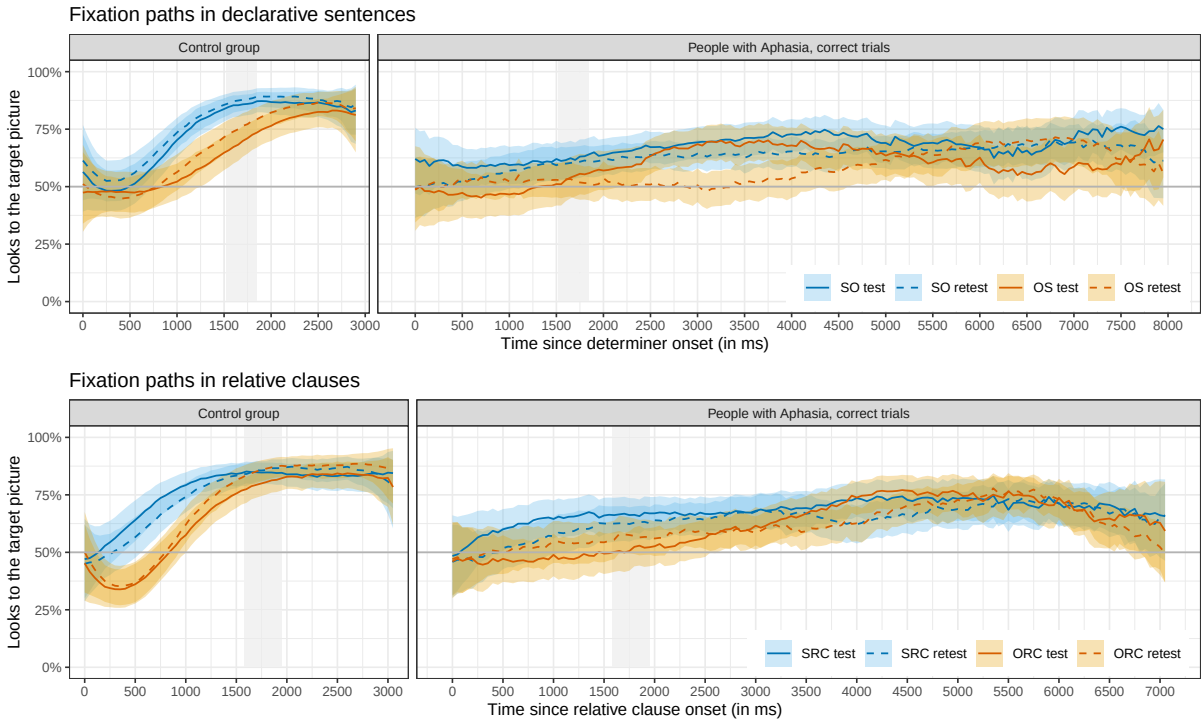


Figure 1: Estimated fixation curves of the control group and the people with aphasia from the onset of the first noun phrase (canonical and non-canonical declaratives, SO and OS, top) or the subclause (subject and object relative clauses, SRC and ORC, bottom) until a picture was selected. Solid and dashed lines represent the mean fixations and shaded areas represent the 95% credible intervals around the mean. Vertical bands shaded in grey mark the sentence end.

References

Caramazza & Zurif (1976). *Brain and Language, 3*. Cope et al. (2017). *Nature Communications, 8*. Staub et al. (2017). *Cognitive Science, 41*. Wells et al. (2009). *Cognitive Psychology, 58*.