Sentence comprehension in German speaking individuals with aphasia: A study using varying structures, tasks and test points

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Individuals with aphasia (IWA) seem to show variable performance patterns in sentence comprehension across different tasks, which can for example be explained within the scope of the resource reduction hypothesis (Caplan et al., 2006, 2007, 2015). This hypothesis predicts that sentence processing capacities in IWA are reduced, and, as a consequence, some sentence comprehension tasks might be more difficult to perform than others. Studies on sentence comprehension in IWA that use varying tasks or test the same participants repeatedly are scarce. In this study, we investigate the variability in two phenomena across different tasks and test points: 1) canonicity effects, that occur in sentences with a non-canonical as opposed to canonical word order, and 2) interference effects, that arise when memory representations overlap in features. Difficulties in IWA should arise in both non-canonical and high interference conditions.

Method. In order to investigate the effect of type of task, three different tasks were used: acting-out, sentence-picture matching at a normal speech rate, and sentence-picture matching at a self-paced speed. Each task was completed at two test points: In a test phase and in a retest phase after a two-month break. In order to investigate the influence of sentence structure, canonicity effects were assessed in declarative sentences and relative clauses, and interference effects were assessed in sentences with pronouns and PRO. Examples for the structures are given in (1) and (2) below. We tested 18 IWA (mean age = 60, range = 38-76 years, 1-26 years post onset) and a control group (n = 50, mean age = 48, range = 19-83 years), all native speakers of German.

Results. The data were analyzed using Bayesian linear mixed models. We included all predictors (participant group, test phase, task, and sentence structure nested in participant group) and their interactions in one model. Control participants had 33% Credible Interval (CrI) [25.6%, 41.2%] higher accuracies than IWA. Both participant groups reached higher accuracies in canonical vs. non-canonical declarative sentences, and IWA displayed more correct answers in subject vs. object relative clauses (figure 1, table 1). Both language unimpaired and impaired participants exhibited interference effects with lower accuracies in the high vs. low interference conditions (figure 1, table 1). Taken together, participants had 1.4% CrI [0.5%, 2.4%] higher accuracies in acting out than in sentence-picture matching, but this effect was driven by the control group. All participants reached 1% CrI [0.3%, 2.0%] higher accuracies in the retest phase as compared to the test phase, and this effect did not interact with the factor participant group.

Discussion. The type of the task did not affect the accuracy in IWA and there was only a minor change in accuracies between the test and retest phase. Sentence complexity, on the other hand, had an influence on the performance of IWA in all assessed sentence structures (declaratives, relative clauses, pronouns, PRO). Furthermore, the direction of the canonicity and interference effects was the same across language unimpaired and impaired participants because both groups showed positive effects with more correct responses in the less complex conditions. Therefore, we conclude that IWA were affected by sentence complexity. Unexpectedly, the interference effects were smaller than the canonicity effects in IWA. The greater impairment in more complex sentence structures is consistent with theories which assume that processing mechanisms are limited in IWA such as the resource reduction hypothesis (Caplan et al., 2015).

Example stimuli & additional information

Word order canonicity manipulation. In German, arguments can be distinguished by case marking on the determiners (bold-faced): The subject is nominative while the object is accusative. In canonical sentences, the subject precedes the object while it follows the object in non-canonical sentences. Canonical declarative sentences (1a) should be easier to process than non-canonical declaratives (1b). Likewise, subject relative clauses (1c) should be easier to process than object relative clauses (1d).

(1)   Canonicity effect

    declarative sentence
a.   Hier füttert **der**$_{nom}$ Igel   **den**$_{acc}$ Hamster.
b.   Hier füttert **den**$_{acc}$ Igel   **der**$_{nom}$ Hamster.
    here feeds the   hedgehog the   hamster
    relative clause
c.   Hier ist der Igel,   **der**$_{nom}$ **den**$_{acc}$ Hamster füttert.
d.   Hier ist der Igel,   **den**$_{acc}$ **der**$_{nom}$ Hamster füttert.
    here is the hedgehog who   the   hamster feeds

Interference manipulation. To study interference, we used sentences with control readings. In German, a control reading can be established between PRO or a pronoun in the subordinate clause and an argument in the matrix clause (Stiebels, 2015). Interference occurs when the distractor (bold-faced) influences the formation of the control relation. In (2a) and (2b), target and distractor mismatch or match in gender. Interference should be higher in the match case (2b). In (2c) and (2d), the distractor precedes or follows the target. Interference should be higher when the distractor intervenes between the target and PRO (2d).

(2)   Interference effect

    gender manipulation
a.   Peter$_i$ verspricht **Lisa**$_{fem}$,   dass er$_i$ das Lamm streichelt.
b.   Peter$_i$ verspricht **Thomas**$_{masc}$, dass er$_i$ das Lamm streichelt.
    Peter promises Lisa/Thomas that he the lamb pets
    distance manipulation
c.   **Peter**$_i$ erlaubt Lisa$_j$, PRO$_j$ das Lamm zu streicheln.
    Peter$_i$ allows Lisa$_j$ PRO$_j$ the lamb to pet
d.   Peter$_i$ verspricht **Lisa**$_j$, PRO$_i$ das Lamm zu streicheln.
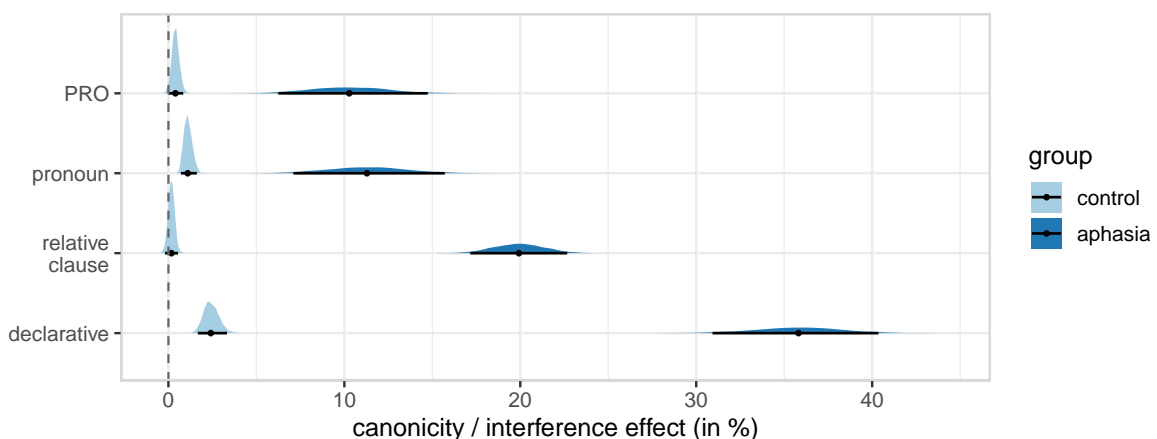   Peter$_i$ promises Lisa$_j$ PRO$_i$ the lamb to pet

Figure 1: Effect of canonical / low-interference conditions over non-canonical / high-interference conditions in response accuracies for the different sentence structures. The distributions display the posterior probabilities of the effects. The black dots and lines are the distribution means and 95% credible intervals respectively. The dashed line represents an effect size of 0%. Distributions that are shifted to the right denote higher accuracies in the less complex (canonical or low-interference) vs. complex (non-canonical or high-interference) conditions. The aphasia group is more affected by complexity.

Table 1: Accuracy in sentence comprehension across three tasks and two test sessions in individuals with aphasia and control participants.

		Canonicity Experiment				Interference experiment			
		SO	OS	SRC	ORC	mismatch	match	o-ctrl	s-ctrl
IWA	Mean	72.5	40.2	64.5	44.4	69.6	60.2	70.8	59.8
	SE	1.3	1.5	0.8	0.9	1.3	1.5	1.3	1.5
HC	Mean	98.9	95.6	96.9	97.1	99.8	97.9	99.2	98.2
	SE	0.2	0.4	0.2	0.2	0.1	0.3	0.2	0.2

Note. IWA=individuals with aphasia, HC=healthy controls, SO/OS=canonical/non-canonical declarative sentence, SRC/ORC=subject/object relative clause, match/mismatch=gender of the main clause nouns is the same/different, s-ctrl/o-ctrl=subject/object control.

References
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