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## Modeling Offline and Online (Eye Movements) Sentence Comprehension in Aphasia using the Cue-Based Retrieval Architecture

Umesh Patil<sup>a,\*</sup>, Sandra Hanne<sup>a</sup>, Shravan Vasishth<sup>a</sup>, Frank Burchert<sup>a</sup>, Ria De Bleser<sup>a</sup>

<sup>a</sup> University of Potsdam

### Introduction

Individuals with aphasia (IWA) have difficulty in comprehending reversible non-canonical word order sentences compared to canonical word order. Representational accounts (e.g. Grodzinsky, 1995) assume that this difficulty with non-canonical sentences reflects disturbances in underlying syntactic representations. In contrast, according to processing accounts structural representations are unimpaired, but sentence comprehension is affected by a processing deficit, which leads to slowed processing or intermittent breakdowns of the parser. Studies investigating aphasic online sentence processing in addition to traditional off-line performance measures provide new evidence towards structurally unimpaired but delayed syntactic processing in aphasia.

In order to gain a better insight into deficits in IWA, it is instructive to examine sentence comprehension in aphasia within a computational architecture designed for modeling unimpaired processing. Existing computational models of syntactic processing in aphasia (e.g. Haarmann et al., 1997) are limited to modeling only offline measures.

### Method

We employ the cue-based retrieval architecture (Lewis & Vasishth, 2005) to model offline as well as online sentence processing in IWA. The architecture has already been shown to account for several key sentence comprehension phenomena in healthy individuals. The model, grounded in ACT-R (Anderson et al. 2004), consists of declarative and procedural memory where parsing unfolds through a series of memory retrievals guided by the application of production rules.

As a test set, we used eye movement data from a visual-world paradigm study in Hanne et al. (2011). The data consists of the eye movement patterns of controls (n=8) and individuals with aphasia (n=7) during a sentence-picture matching task for German reversible canonical and non-canonical sentences (see 1.a-1.b).

#### 1.a) Canonical:

Der Sohn fängt den Vater  
the\_NOM son is\_catching the\_ACC father  
'The son is catching the father'

#### 1.b) Non-canonical:

\* Corresponding author.

E-mail address: [umesh.patil@gmail.com](mailto:umesh.patil@gmail.com).

Den Sohn fängt der Vater  
 the\_ACC son is\_catching the\_NOM father  
 'The father is catching the son'

We modeled eye movements as well as accuracy and reaction time data. We introduced a linking hypothesis based on retrievals in order to model visual-world paradigm data. Data from controls was modeled without modifying the existing parameter values. For modeling IWA data, we assumed:

- (i) No impairment in grammatical knowledge: IWA rely on the same grammatical representations as controls;
- (ii) Slowed Processing: Production rules in procedural memory are executed slower;
- (iii) Intermittent Deficiencies: Additional noise in the declarative memory representations.

### Results & Discussion

The results of the simulations revealed qualitatively similar patterns for eye movements as well as accuracy and reaction time data for both- controls and IWA. We conclude:

- (i) aphasic sentence comprehension for reversible sentences can be modelled without assuming impairments in grammatical representations;
- (ii) both assumptions — slowed processing and noisy representations — are necessary to achieve a good model fit;
- (iii) the existing sentence processing model can explain offline as well as online data from aphasic sentence processing, with minimal changes to the existing architecture.

### References

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