

Modeling aphasic sentence comprehension in a cue-based retrieval architecture

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Introduction

Sentence processing deficits in aphasia become evident whenever patients have to rely on syntactic structure in order to derive the correct sentence interpretation. Individuals with aphasia (IWAs) are known to have difficulty in comprehending reversible non-canonical word order sentences compared to canonical word order (Mitchum & Berndt, 2008). Our aim is to understand the source of this deficit through a computational modeling approach. We employed an existing sentence processing architecture (Lewis & Vasishth, 2005) to explain data from offline as well as online (eye movements) measures.

Sentence comprehension deficits in aphasia

There are two dominant classes of explanation for aphasics' difficulty in comprehending reversible non-canonical sentences

► Representational accounts

- Breakdown in declarative knowledge — disturbances in underlying syntactic representations are responsible for problems in sentence comprehension.

► Processing accounts

- Procedural breakdown — representations are preserved, but the syntactic processing system is affected by capacity limitations.

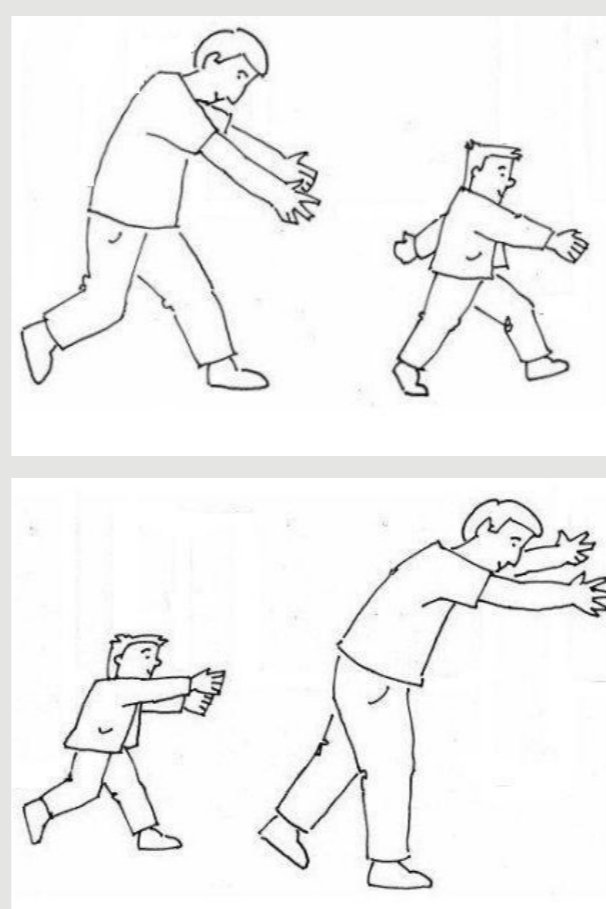
Research questions

- What is the underlying impairment in sentence comprehension in aphasia?
 - qualitatively different syntactic representations (structural impairment)? or
 - only a pathological slowdown in the parsing system?
- What kinds of manipulations in the model's architecture are necessary in order to achieve a good fit to the aphasic sentence processing data?

Data: Hanne et al. (2011)

- Visual-world study
- Stimuli

- **Canonical:** Der Sohn fängt den Vater
the_{NOM} son is catching the_{ACC} father
'The son is catching the father'
- **Non-canonical:** Den Sohn fängt der Vater
the_{ACC} son is catching the_{NOM} father
'The father is catching the son'



Cue-based retrieval architecture (Lewis & Vasishth, 2005)

A computational cognitive architecture designed to model the parsing process in healthy individuals

► Declarative Memory

- Consisting of lexical representations stored as chunks (set of feature-value pairs feature bundles that can be related to other chunks)
- Each chunk has base level activations, which fluctuate as a function of usage and time-based decay
- Activation value affects a chunk's probability and latency of retrieval

► Procedural Memory

- Acts on declarative memory
- Procedural encoding of grammatical knowledge through a set of production rules that embody skilled parsing
- Sentence processing happens through a series of memory retrievals guided by the application of production rules

Assumptions

► No impairment in grammatical knowledge

Model: Chunks in declarative memory and rules in procedural memory are structurally unimpaired

► Slowed Processing

Model: Production rules in procedural memory are slower

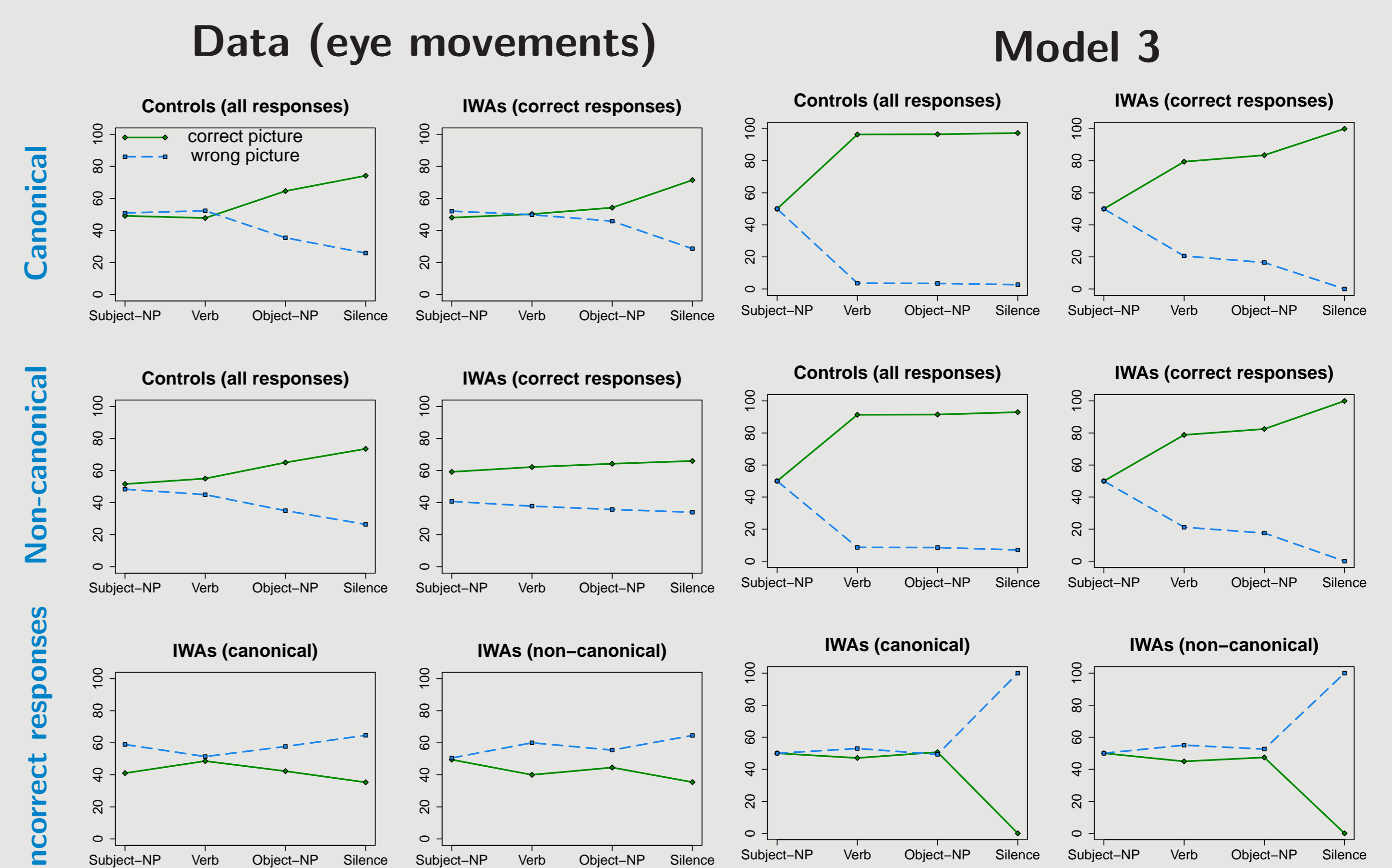
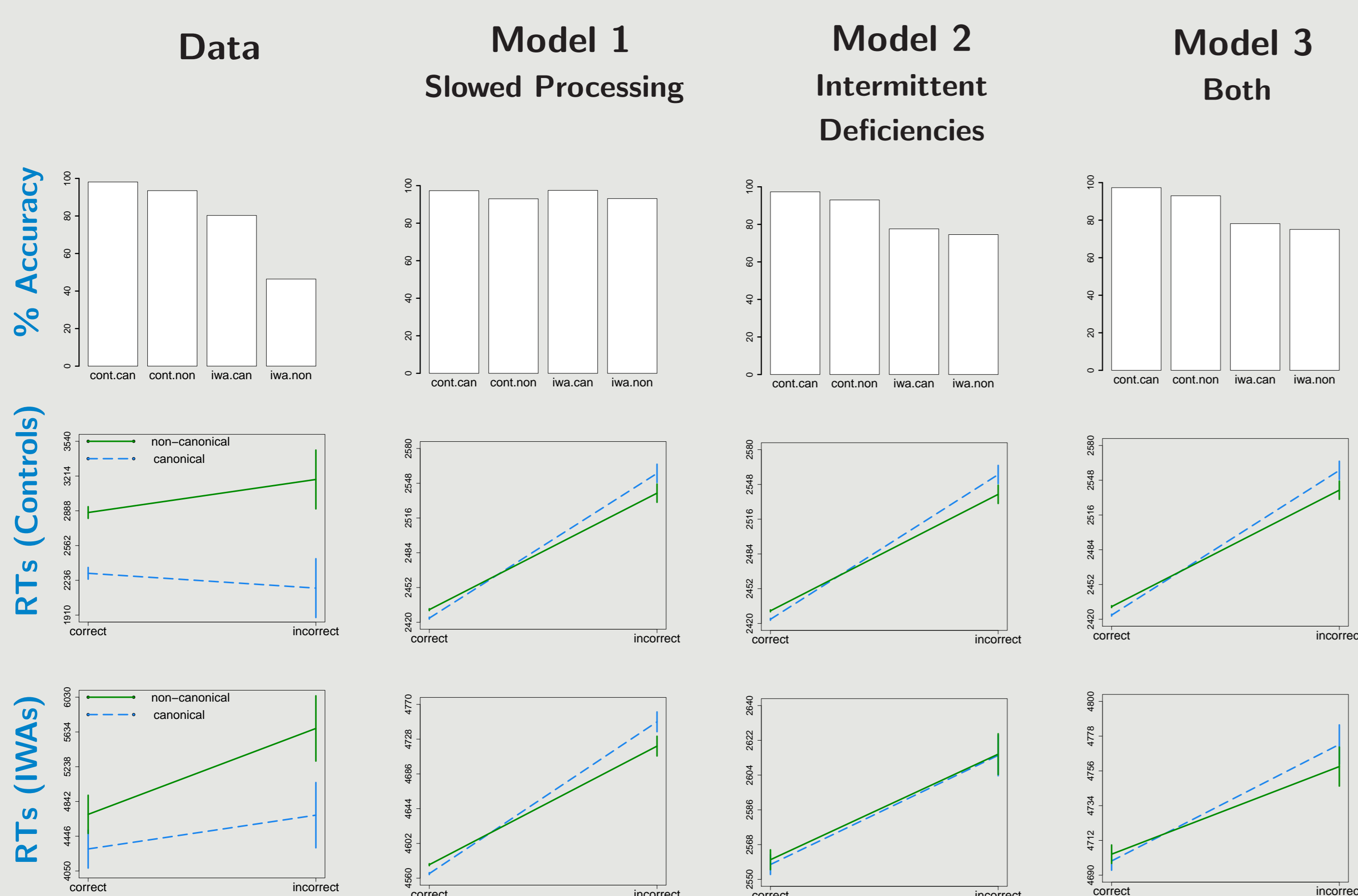
► Intermittent Deficiencies

Model: Additional noise component affecting the activation of chunks in declarative memory

Linking hypothesis

Connecting memory retrievals and eye movements in a sentence-picture matching task: The parser creates two separate semantic representations of the two pictures on the screen. These semantic representations are stored as chunks in the declarative memory. At each input word, the parser incrementally updates the partial representation of the sentence. On the basis of this partial representation, it matches the picture. The picture matching is done by retrieving one of the two picture chunks from the declarative memory. The retrieved picture is assumed to be the picture fixated by the parser.

Modeling results



Conclusions

► No structural impairment

Aphasic online and offline sentence comprehension can be modeled without assuming a breakdown in declarative or procedural memory.

► Only slowed processing is not enough

Assuming solely slower application of grammatical rules is not sufficient to model the data satisfactorily.

► Slowed processing & intermittent deficiencies

In addition to slowed processing, instantaneous noise, affecting activation of chunks at the time of retrieval, has to be assumed to explain the data.

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