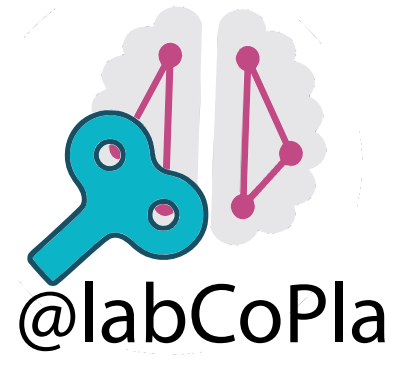


# Contribution of cognitive control resources to natural language comprehension across the adult life span



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## Introduction

- During reading, upcoming linguistic input is predicted on multiple time scales, from single words (short time scale) to paragraphs (long time scale) [1].
- It remains unclear how much these internal predictions rely on domain-general cognitive resources [2].
- Healthy aging is linked to a decline of different cognitive control domains like working memory and processing speed. Language processes however usually remain stable across the life span [3, 4].
- It is unclear to what extent age moderates the construction of internal linguistic predictions.

## Research questions

- How is natural language prediction during text reading affected by increasing cognitive control demands through a non-verbal task?
- Which impact does cognitive aging have on these processes?

## Methods

### Participants:

- Online**
- 74 adults (M 33.6, SD 11.6, 18-60 years)
- Lab**
- 20 young adults (M 33, SD 4.7, 23-40 years)
  - 40 older adults (M 72, SD 6.7, 60-85 years)

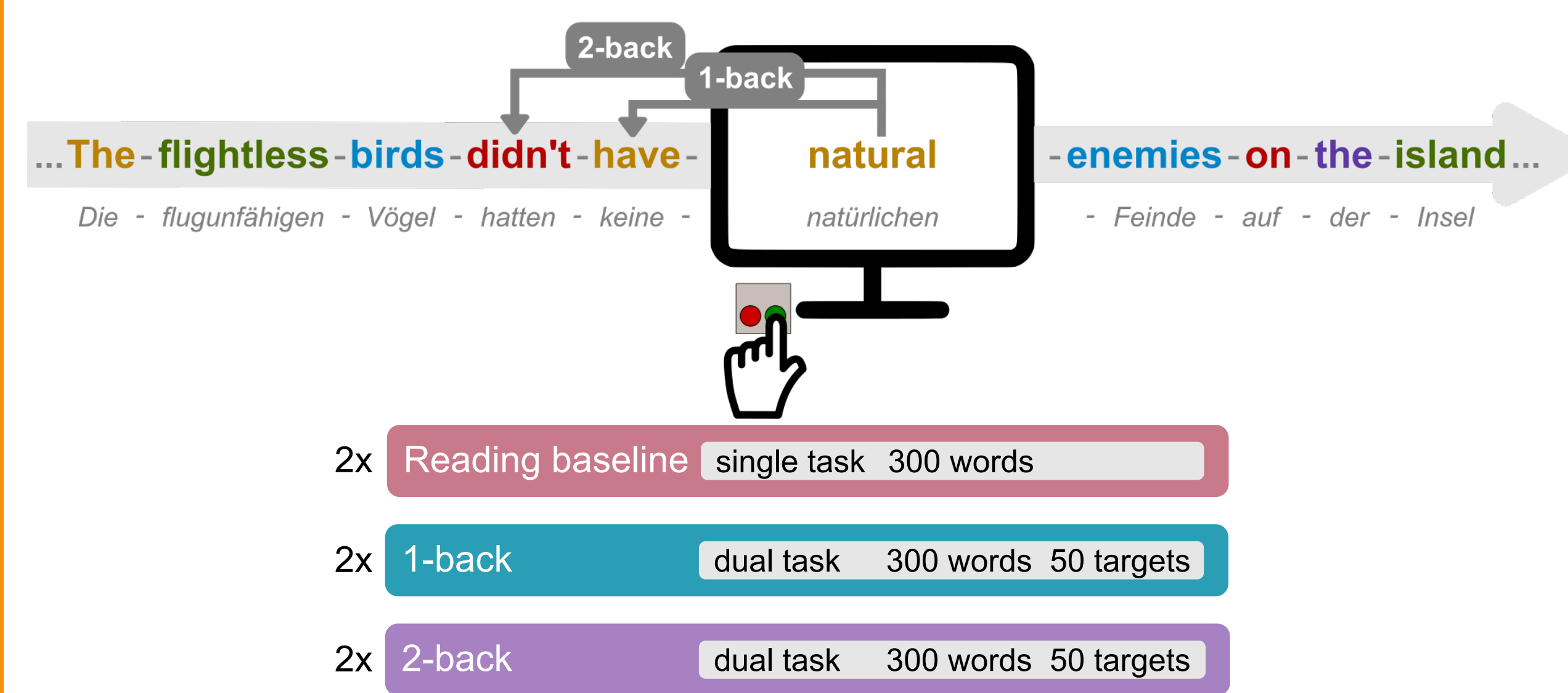
### Design:

- One experimental session (online or in lab)
- Six short and easy to read newspaper articles
- N-back task with colors
- Single-task blocks (n = 6) and dual-task blocks (n = 4)

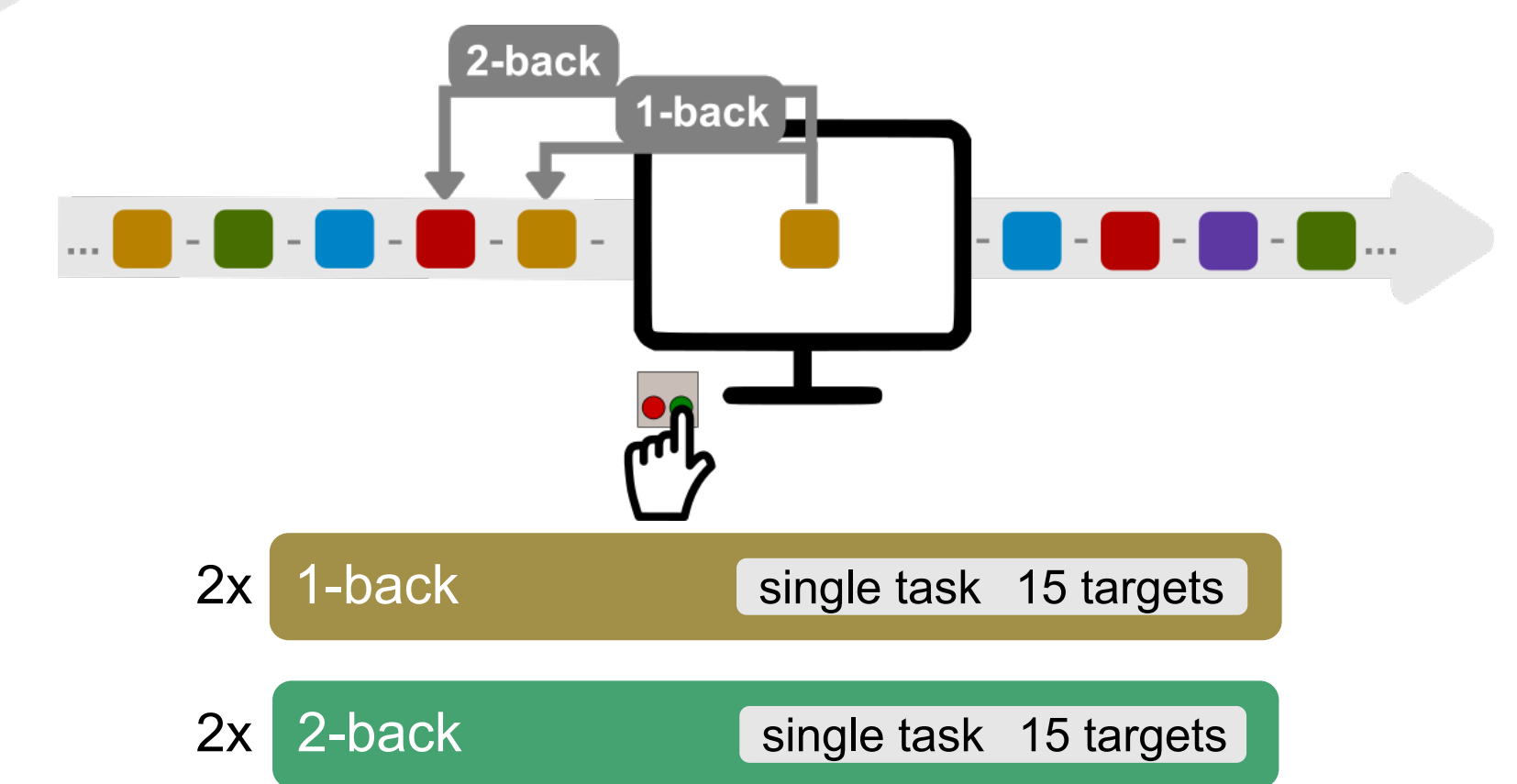
### Data analysis:

- Mixed-effects models for reaction time and accuracy (D-prime)
- Surprisal scores (word probability) on different hierarchical time scales (1, 4, 12, and 60 words) for texts generated in GPT-2 [5]

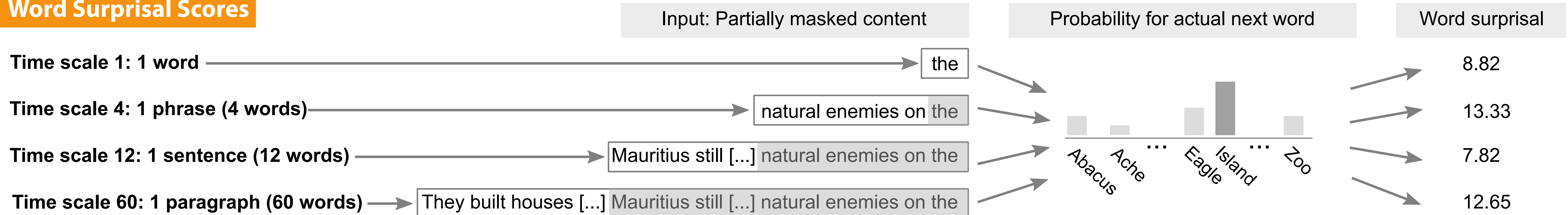
### Reading task (single and dual-task design)



### N-back task



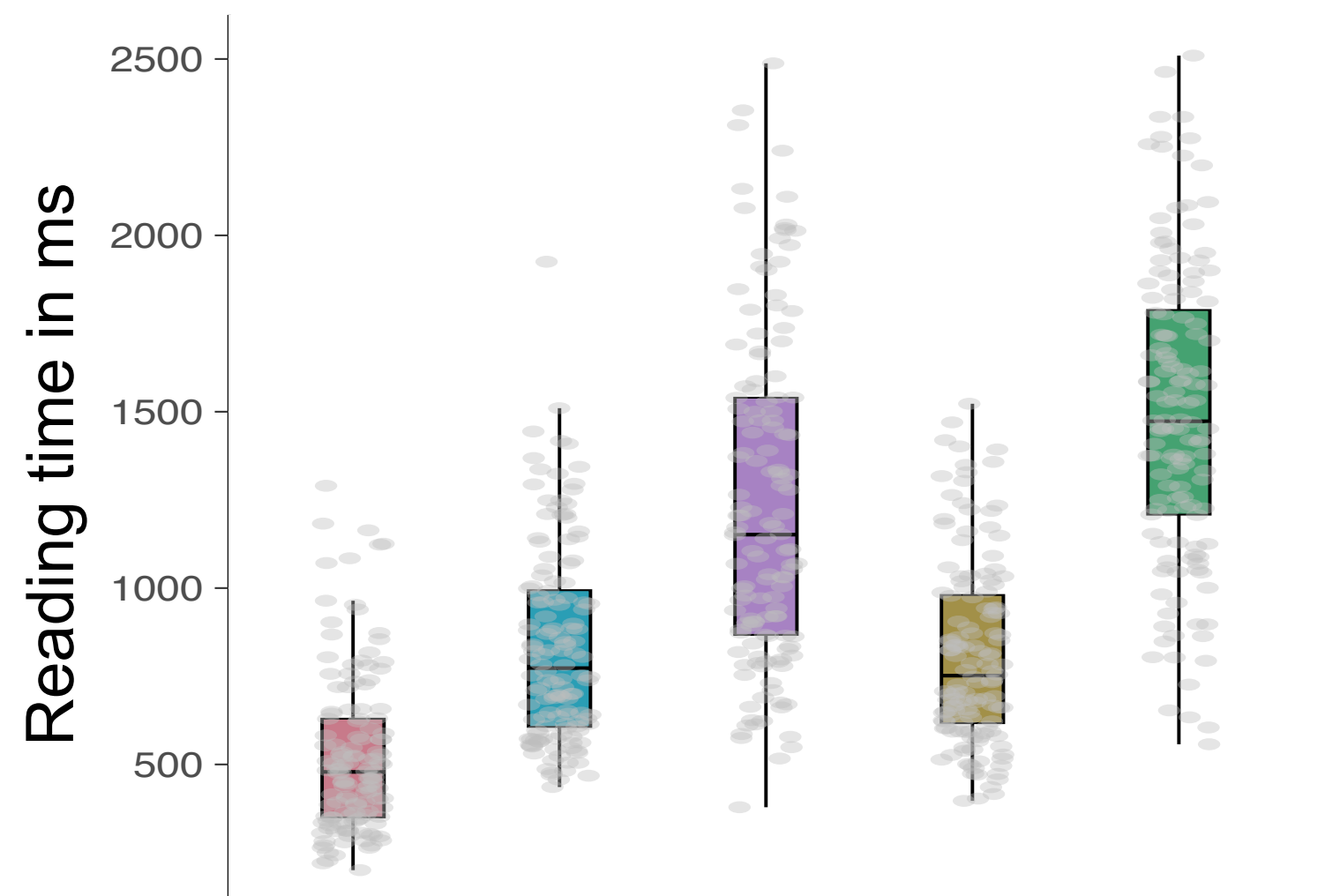
## Word Surprisal Scores



## Results

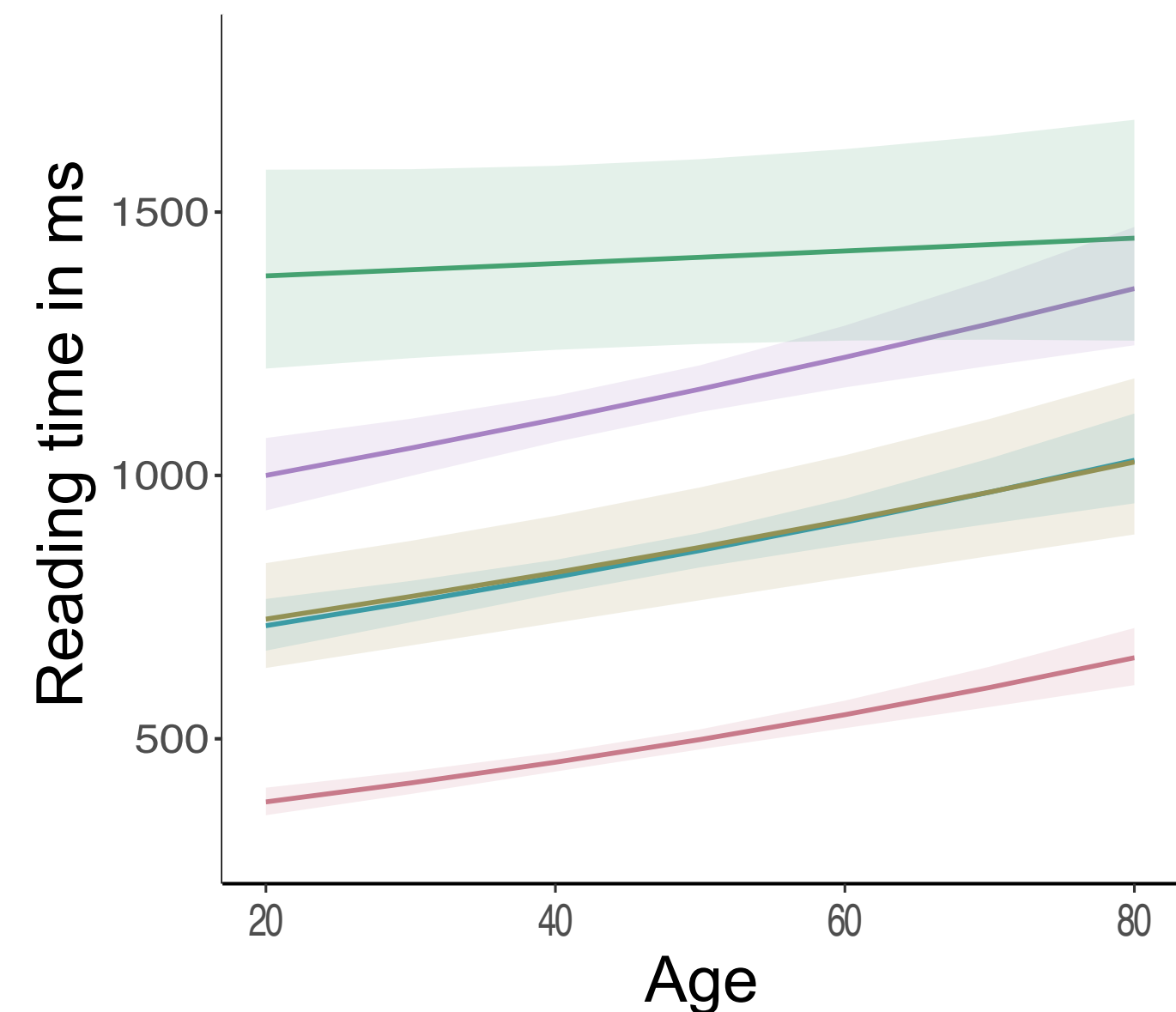
### Effect of cognitive load

Reading time increases with ...  
... cognitive load



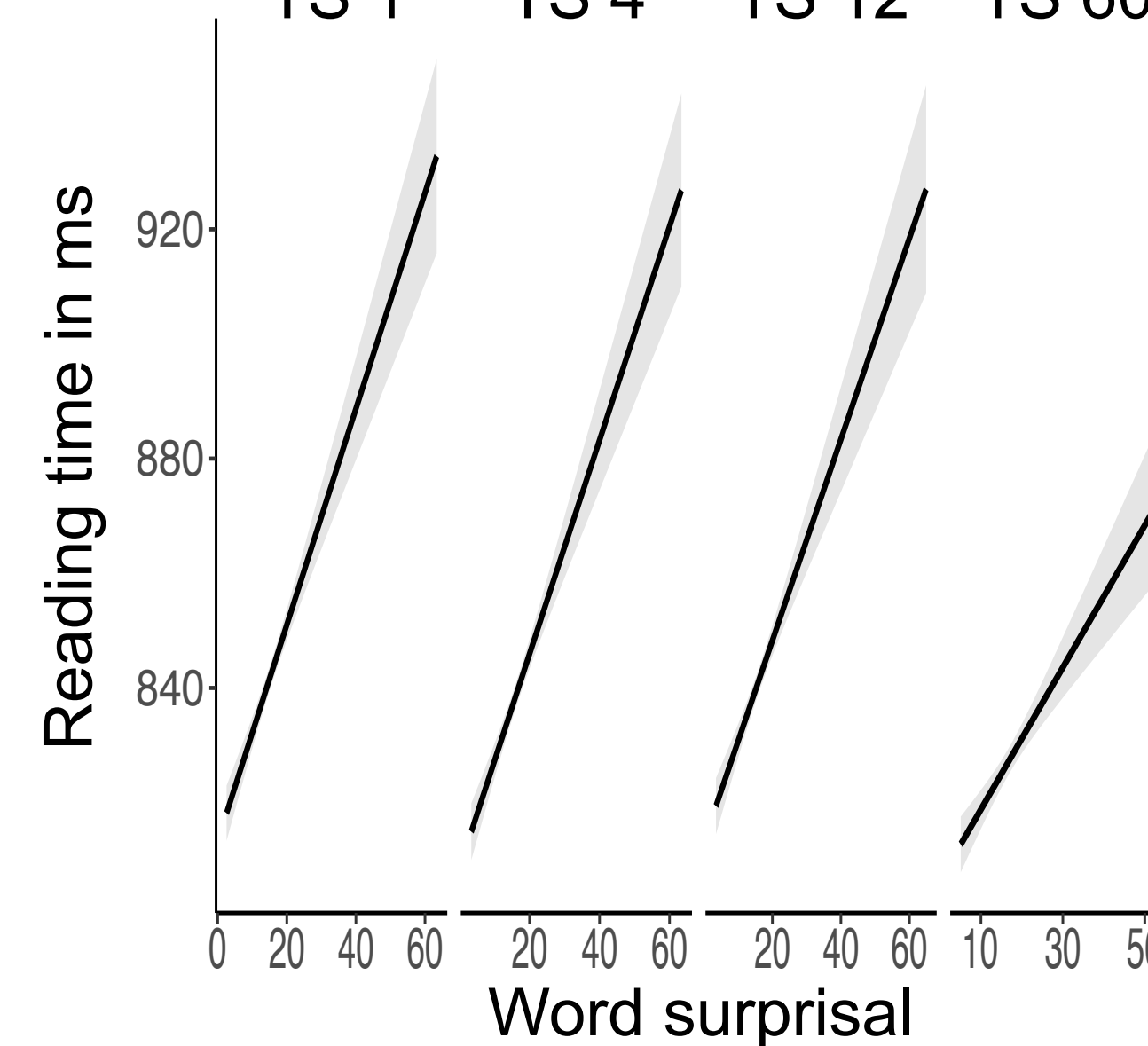
### Effect of age by cognitive load

... age across different cognitive loads



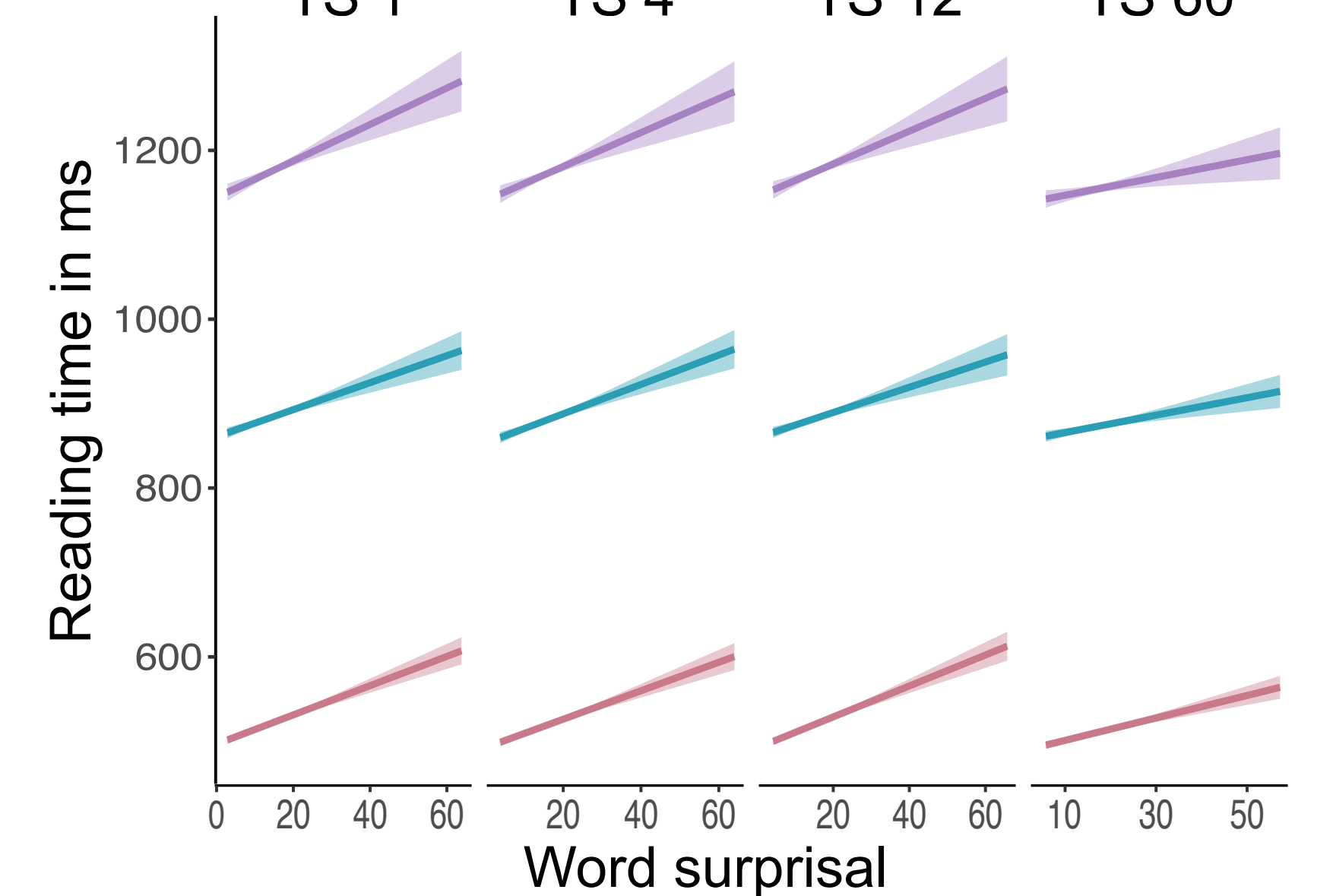
### Effect of surprisal

... higher word surprisal



### Effect of surprisal by cognitive load

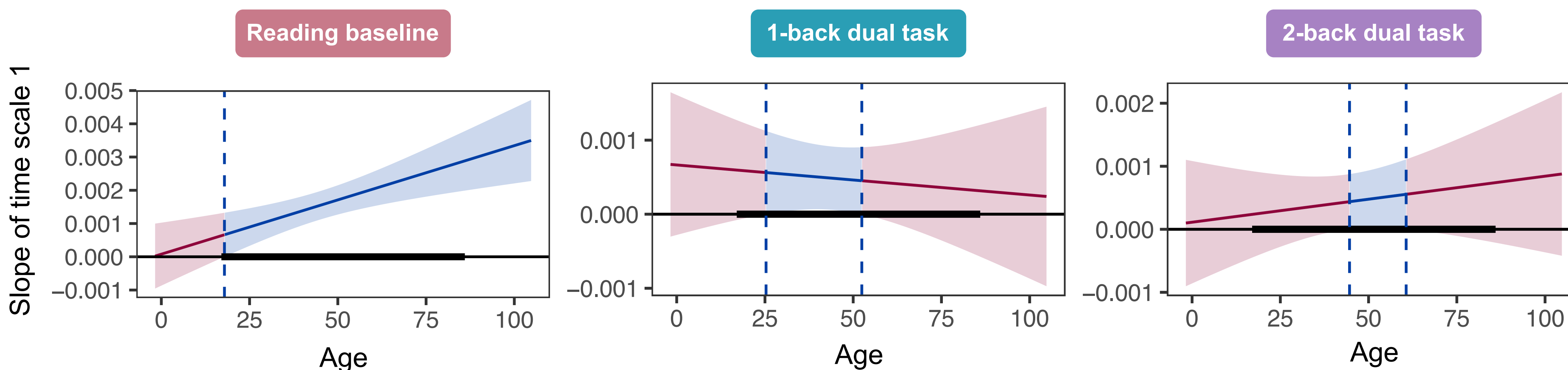
Higher cognitive load reduces beneficial effect of word predictability.



### Effect of age on interaction of cognitive load and word predictability

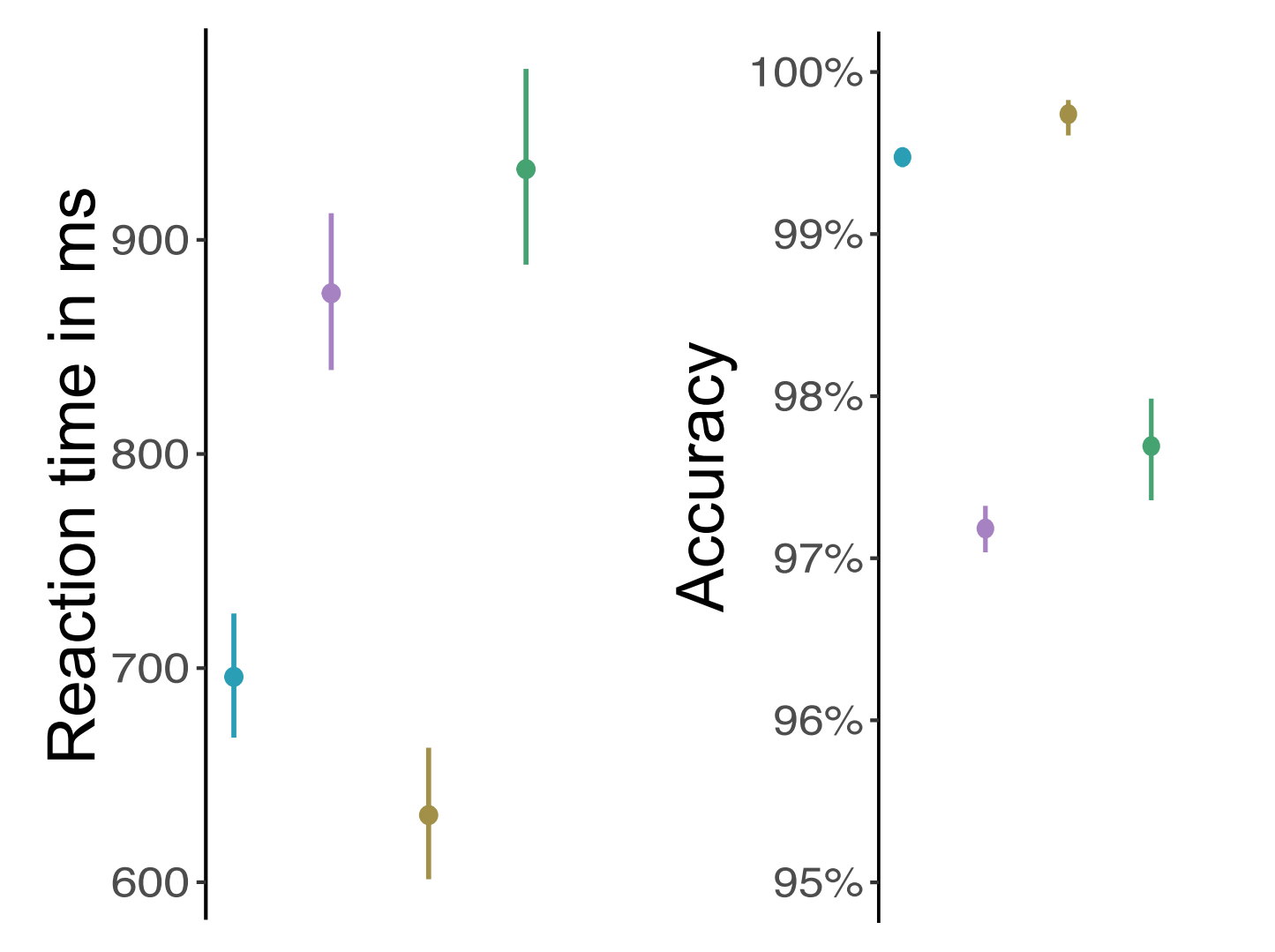
The effect of word predictability on reading times is moderated by age and cognitive load.  
The effect of age on the slope of word surprisal reduces with increasing cognitive load.

— Range of observed data    ■ n.s.    ■ p < .05



### N-back task

Increasing cognitive load leads to slower and poorer performance.



## Discussion

- Across different time scales, language predictions during text reading rely on cognitive control resources.
- When the cognitive load of a task increases and cognitive resources are limited, the beneficial effect of word predictability on reading speed is reduced.
- Older age is linked to slower reading speed in general. With increasing cognitive task load, the detrimental effect of age diminishes.
- Low word predictability has a stronger negative effect on reading as we get older. This effect reduces when task loads increase in general.
- Our results support a strong role of domain-general cognitive control resources during construction of natural language predictions. Higher cognitive task load and increasing age lead to reduced availability of these resources, so that predictions might no longer be formed.

## References

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- [5] Hugging Face (2023). GPT-2 [dbmdt/german-gpt-2] https://huggingface.co/dbmdt/german-gpt2