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# A MOUSE-TRACKING STUDY OF THE COMPOSITE NATURE OF THE STROOP EFFECT AT THE LEVEL OF RESPONSE EXECUTION

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## Introduction

The Stroop effect refers to the finding that font colour identification times are longer for colour-incongruent words (i.e., BLUE) than for colour-congruent words (i.e., BLUE). While often described as a single process [1], alternative accounts suggest that the Stroop effect may actually be a composite effect reflecting conflict and facilitation at different levels of processing [2]. Our objective was to investigate the contribution of interference and facilitation components, particularly response and semantic conflict/facilitation, to the overall Stroop effect using a mouse-tracking task. Through measures of mouse deviations, mouse-tracking methods permit the continuous examination of decision-making and automatic processing during Stroop task performance [3], especially when combined with a movement initiation deadline.

## Method

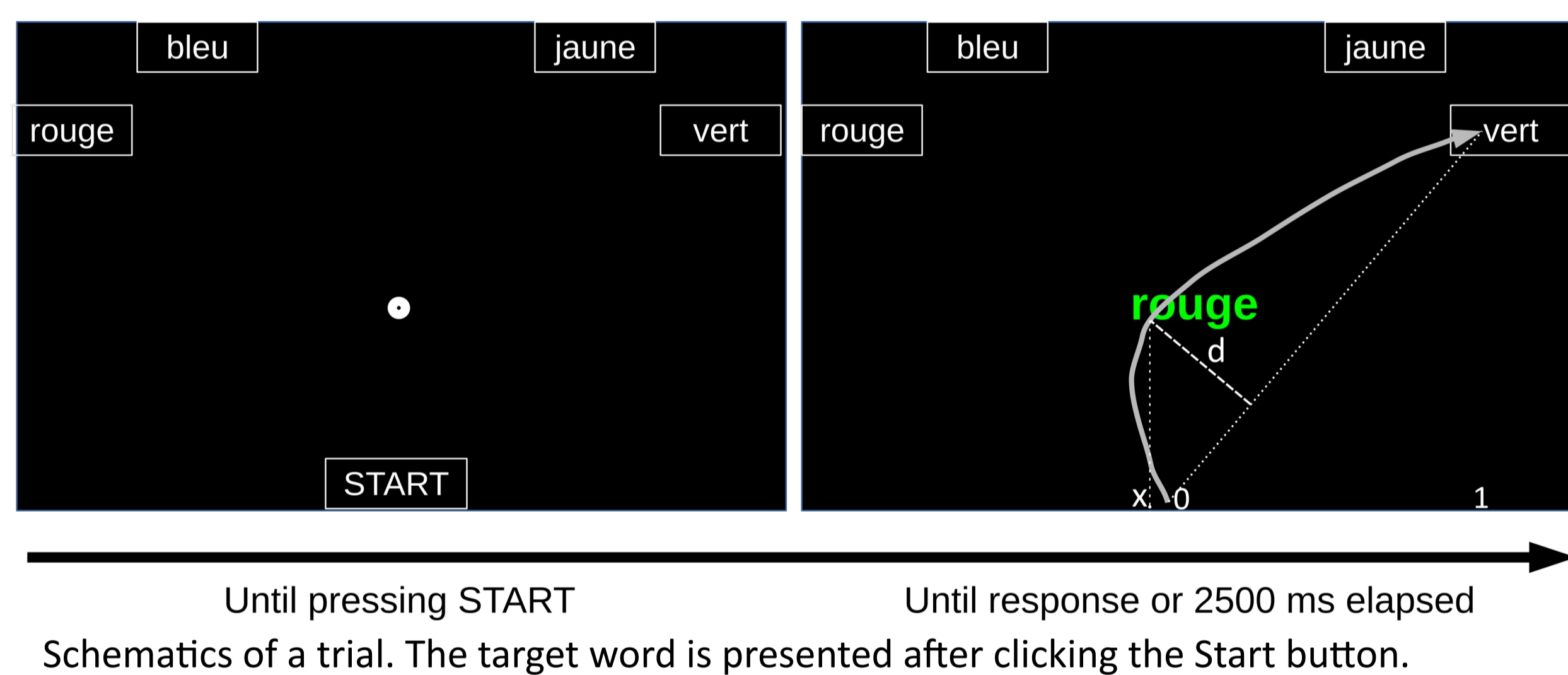
**Participants:** 83 psychology students (70 female,  $M_{age} = 20$ ,  $SD_{age} = 2.3$ )

**Procedure:**

- Target words (French): blue (sky), red (tomato), yellow (corn), green (salad)
- Components of the Stroop effect (with examples):

Total Stroop effect	BLUE Std. colour-incongruent	–	BLUE Std. colour-congruent
Stroop interference	BLUE	–	WALL/WALL Colour-neutral
Response conflict	BLUE	–	PURPLE/PURPLE Non-response set
Semantic conflict	SKY Colour-associated incongruent	–	WALL/WALL
Semantic relevance	PURPLE/PURPLE	–	SKY
Stroop facilitation	WALL/WALL	–	BLUE
Semantic facilitation	WALL/WALL	–	SKY Colour-associated congruent
Response facilitation	SKY	–	BLUE

- Mouse-tracking task: determining the ink colour of the target word  
→ with response initiation deadline (500 ms)

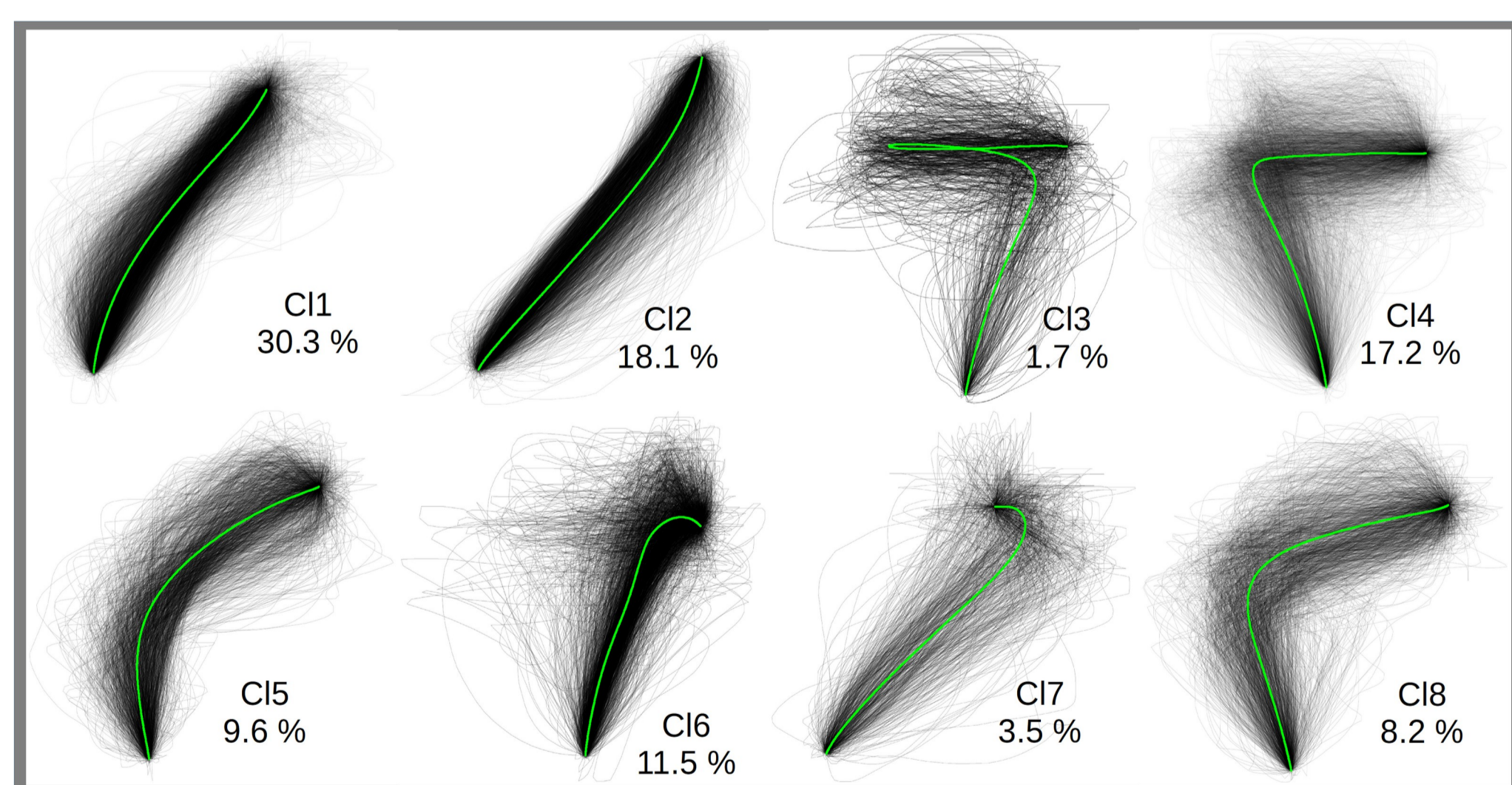


**Measures:**

- Response time
- Deviation (e.g., d) & x-coordinate (e.g., x) as a function of (normalized) time
- Partial error rate, i.e. movements directed towards incorrect side [4]
- Maximal deviation (d in Figure above)

Hierarchical Clustering Analysis of trajectories for estimating partial error rates  
Partial error clusters:  
→ C13, C14 and C18

Correct side: right  
Incorrect side: left



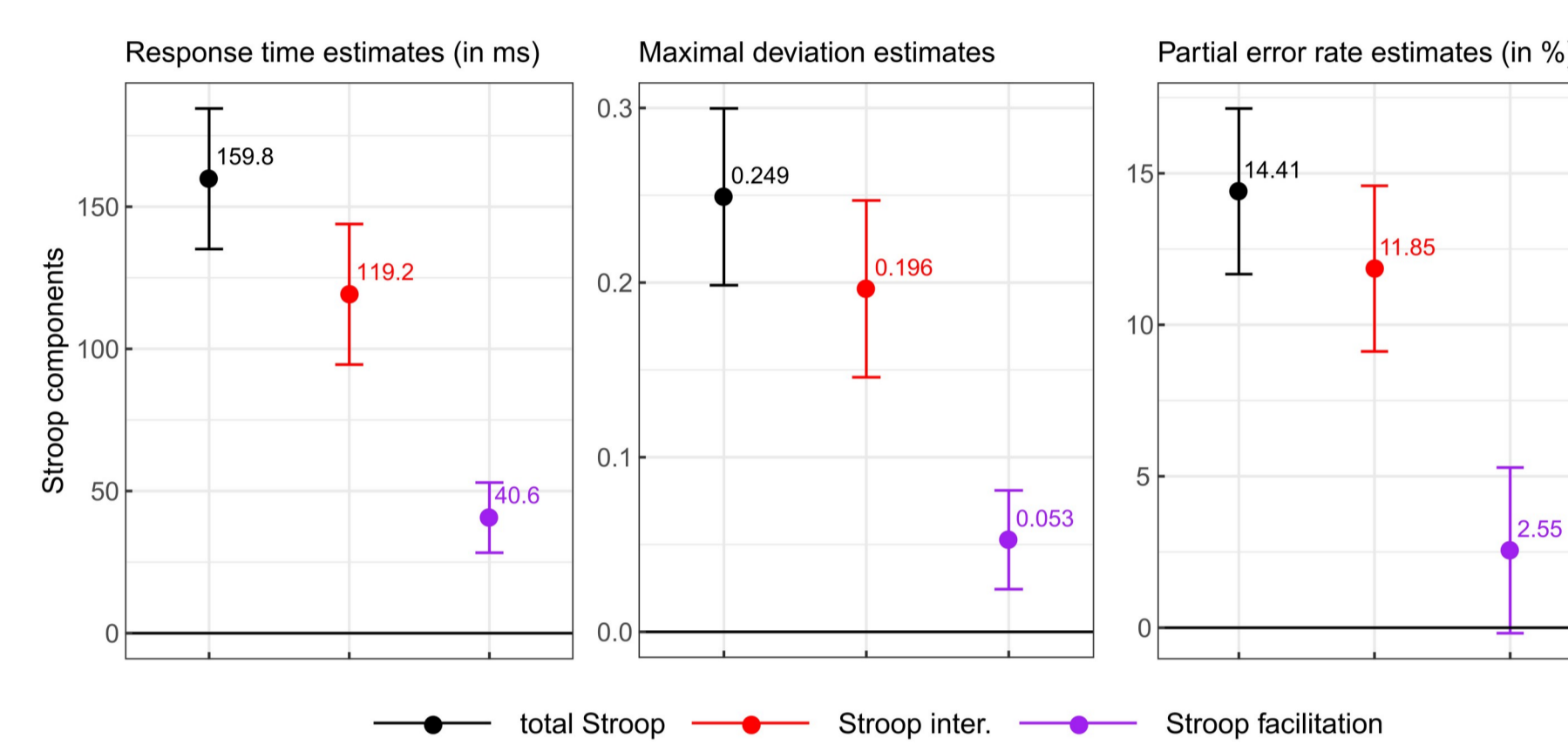
## Results

**Analysis:**

- We used linear mixed models (random variable: participants; slopes: dummy variables with colour neutral as reference level) and estimated the marginal means and marginal effects from the fitted model.

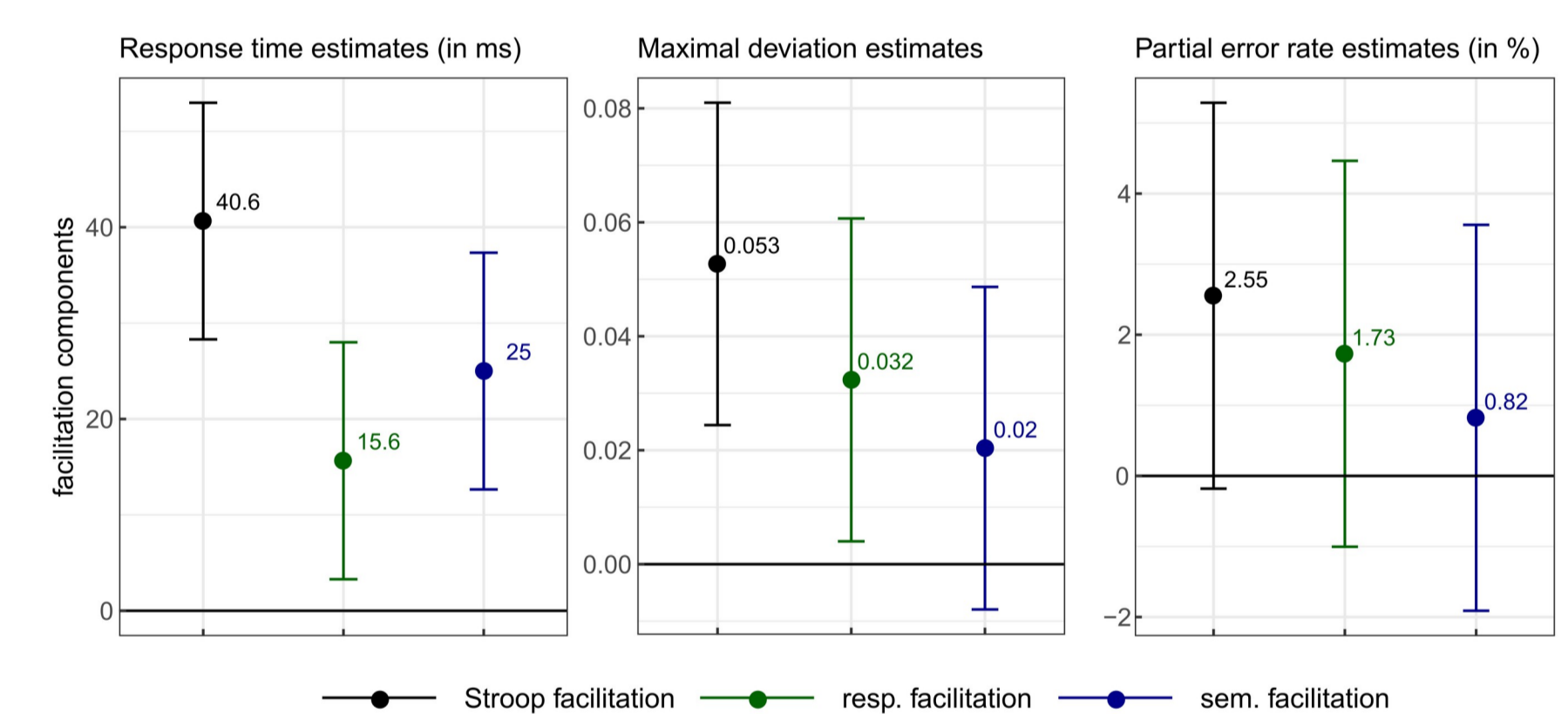
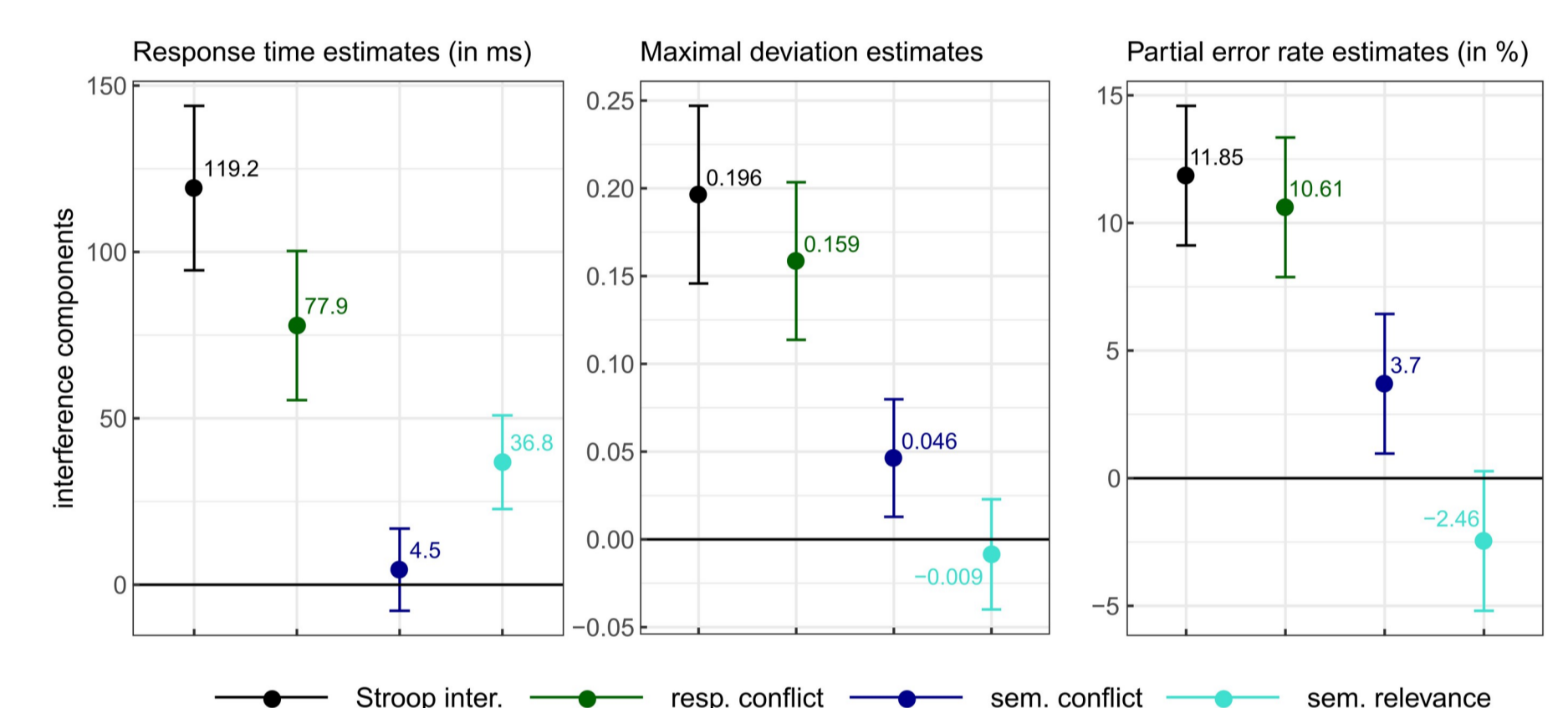
**Summary variables**

from left to right: response times (RT), maximal deviation (MD) and partial error rates (PE)

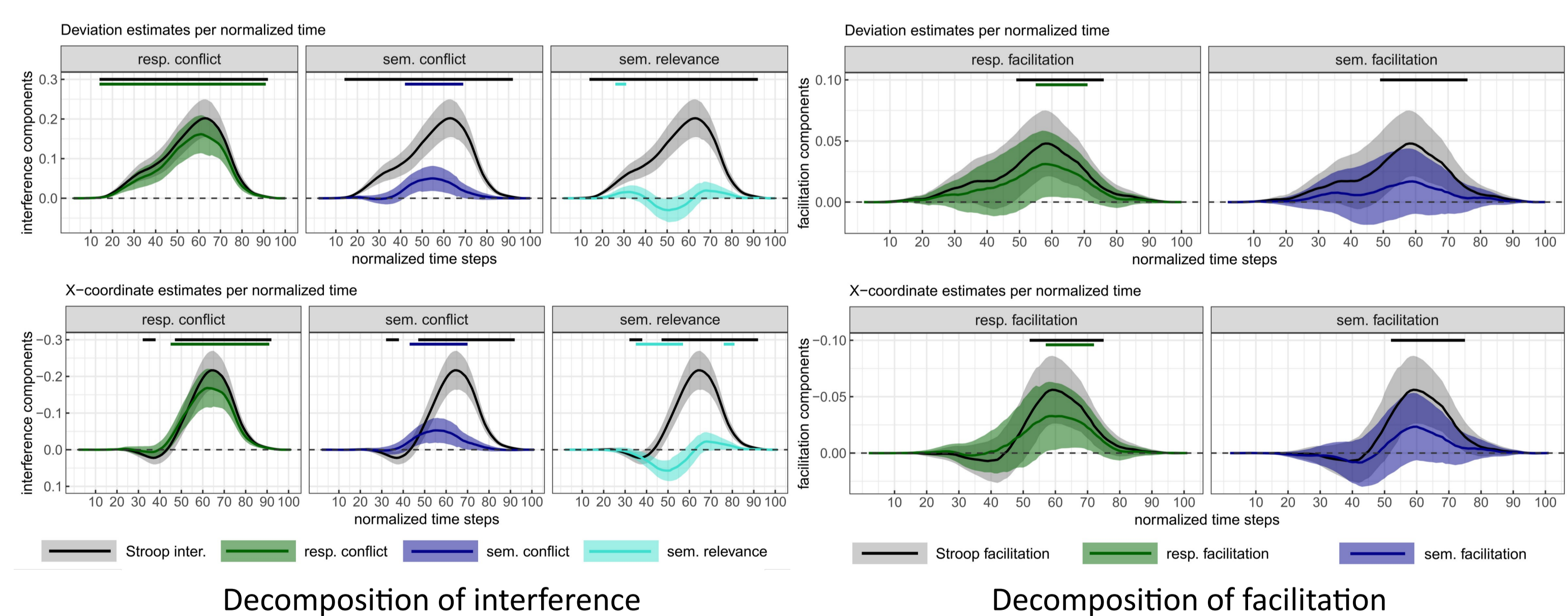


Decomposition of interference into:

- Response conflict  
→ 95% CI includes 0 in RT
- Semantic conflict  
→ 95% CI includes 0 in MD, PE
- Semantic relevance



**Deviation and x-coordinate as a function of (normalized) time**



→ These analyses tend to confirm the results obtained with maximal deviation

## Conclusion

- The imposition of a response deadline led to cascading effects from response selection to execution and permitted the observation of controlled and automatic processing during Stroop task performance, although previous Stroop mouse-tracking studies without response initiation deadlines (e.g. [3]) indicate that this is not limited to such temporal constraints.
- However, in a unique finding, our results distinguished contributions of response and semantic conflict and response facilitation on response time and deviation measures. Our method was not sensitive enough for assessing semantic facilitation on deviation measures.  
→ Partial errors were particularly revealing by showing movements corrected during response selection. (See [5] for partial errors in button pressing conflict tasks.)
- Using a 2-to-1 Stroop setup should also be more adapted to mouse-tracking.

## Affiliations

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