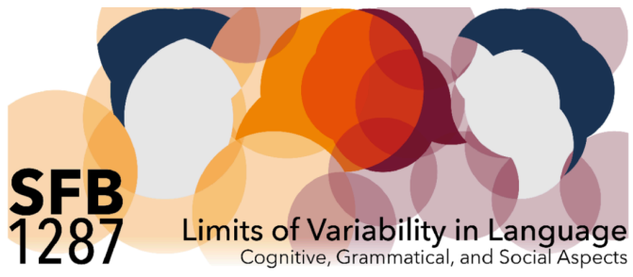
A cross-linguistic investigation of similarity-based interference

Daniela Mertzen, Anna Laurinavichyute, Brian Dillon & Shravan Vasishth

March 21, 2020
33rd Annual CUNY Human Sentence Processing Conference



Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

- Language comprehension requires rapid formation of dependencies

encoding			**storage**		**retrieval**
The journalist	who	saw	the thief	yesterday	lied

- Successful long-distance dependency resolution requires use of working memory system to temporarily store previously encoded items in memory

- Cue-based retrieval theories model sentence comprehension drawing on general principles of human memory system

Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

- Language comprehension requires rapid formation of dependencies

encoding			**storage**		**retrieval**
The journalist	who	saw	the thief	yesterday	lied

- Successful long-distance dependency resolution requires use of working memory system to temporarily store previously encoded items in memory

- Cue-based retrieval theories model sentence comprehension drawing on general principles of human memory system

Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

- Language comprehension requires rapid formation of dependencies

encoding			**storage**		**retrieval**
The journalist	who	saw	the thief	yesterday	lied

- Successful long-distance dependency resolution requires use of working memory system to temporarily store previously encoded items in memory

- Cue-based retrieval theories model sentence comprehension drawing on general principles of human memory system

Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

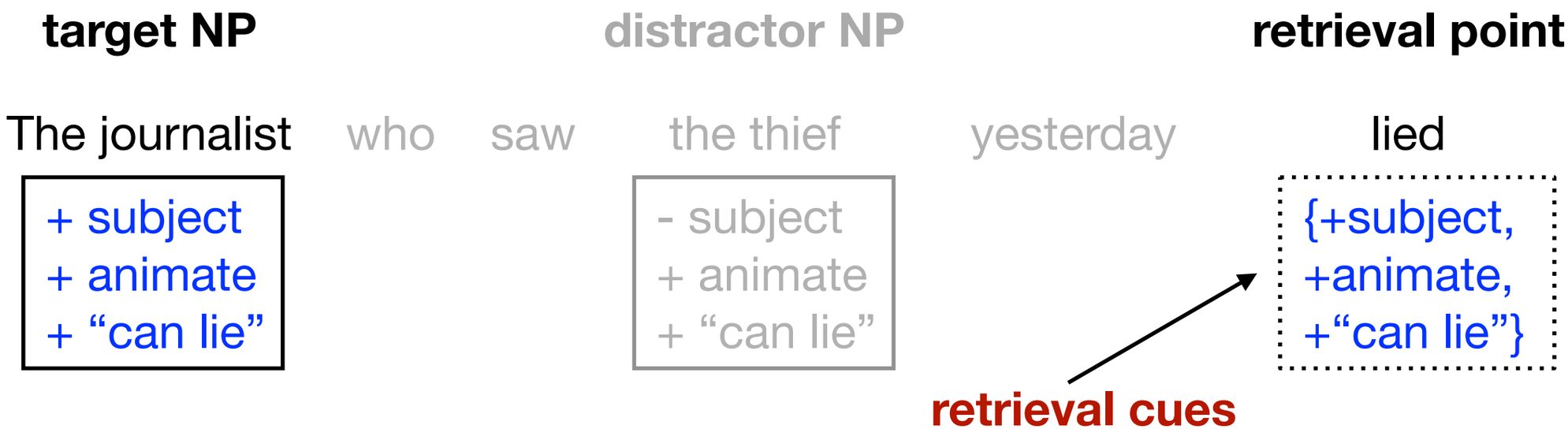
- dependency formation relies on **cue-based retrieval** of syntactic encodings in memory

target NP			**distractor NP**		**retrieval point**
The journalist	who	saw	the thief	yesterday	lied
+ subject + animate + “can lie”			- subject + animate + “can lie”		{+subject, +animate, +“can lie”}

- retrieval mechanism is prone to **similarity-based interference**

Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

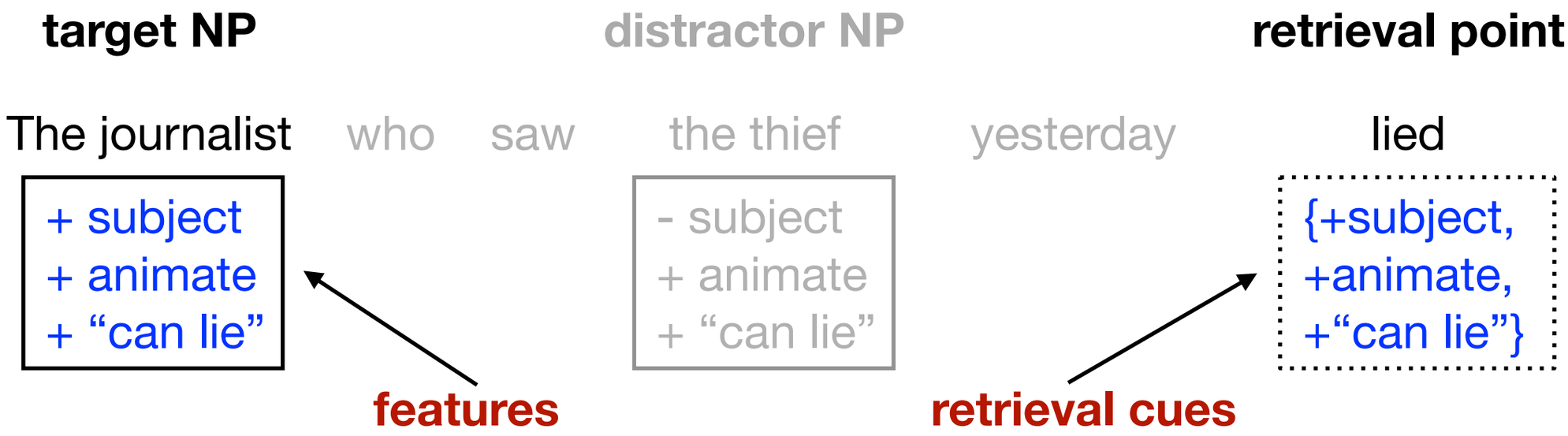
- dependency formation relies on **cue-based retrieval** of syntactic encodings in memory



- retrieval mechanism is prone to **similarity-based interference**

Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

- dependency formation relies on **cue-based retrieval** of syntactic encodings in memory



- retrieval mechanism is prone to **similarity-based interference**

Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

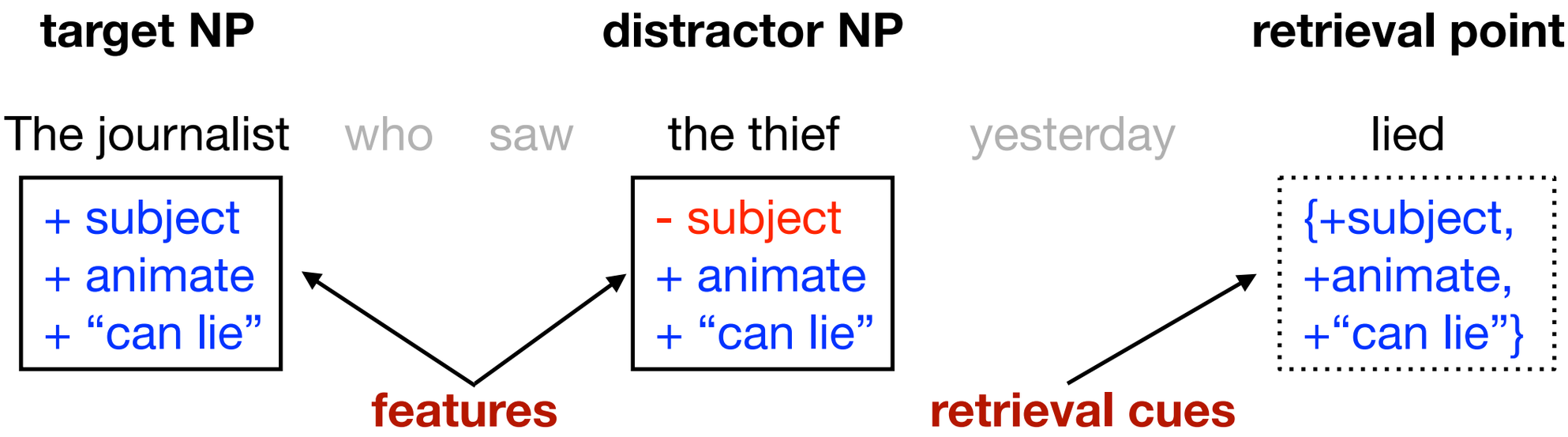
- dependency formation relies on **cue-based retrieval** of syntactic encodings in memory

target NP			**distractor NP**		**retrieval point**
The journalist	who	saw	the thief	yesterday	lied
+ subject + animate + “can lie”			- subject + animate + “can lie”		{+subject, +animate, +“can lie”}

- retrieval mechanism is prone to **similarity-based interference**

Cue-based retrieval theories (McElree, 2000; Van Dyke & Lewis, 2003; Lewis & Vasishth, 2005)

- dependency formation relies on **cue-based retrieval** of syntactic encodings in memory



- retrieval mechanism is prone to **similarity-based interference**

Research questions

- What are the memory mechanisms that subserve sentence comprehension?

- Can semantic similarity-based interference effects during real-time sentence comprehension be observed cross-linguistically?

Research questions

- What are the memory mechanisms that subserve sentence comprehension?
- Can semantic similarity-based interference effects during real-time sentence comprehension be observed cross-linguistically?

Van Dyke & McElree (2006) Self-paced reading + recall task

<u>Memory load conditions</u>
table sink truck

No interference
It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.
Interference
It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

Van Dyke & McElree (2006)

<u>Memory load conditions</u>
table sink truck

No interference
It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.
Interference
It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

Van Dyke & McElree (2006)

Memory load conditions

table sink truck

+ FIXABLE

No interference

It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.

Interference

It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

+ FIXABLE

Van Dyke & McElree (2006)

Memory load conditions
table sink truck

No interference
It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.
Interference
It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

Van Dyke & McElree (2006)

Memory load conditions

table sink truck

- SAILABLE

No interference

+ SAILABLE

It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.

Interference

It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

Van Dyke & McElree (2006)

Memory load conditions
table sink truck

No interference
It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.
Interference
It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

No memory load conditions
— — —

No interference
It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.
Interference
It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

Van Dyke & McElree (2006)

Memory load conditions
table sink truck

No interference
It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.
Interference
It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

No memory load conditions
— — —

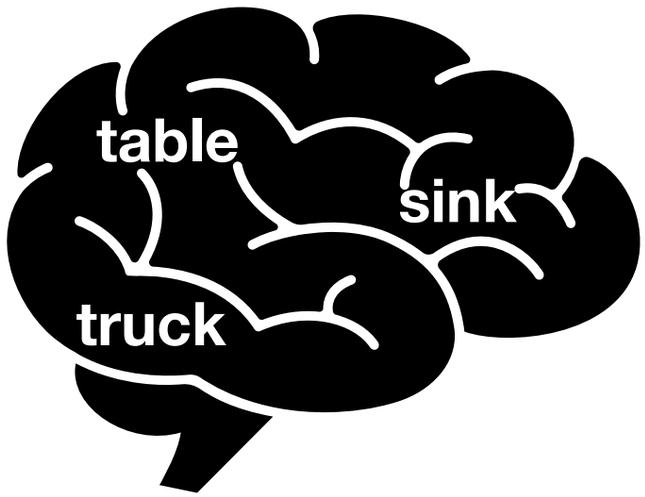
No interference
It was **the boat** that the guy who lived by the sea **sailed** in two sunny days.
Interference
It was **the boat** that the guy who lived by the sea **fixed** in two sunny days.

Comprehension question: *Did the guy live by the sea?*
Recall: _____ _____ _____

Van Dyke & McElree (2006) results

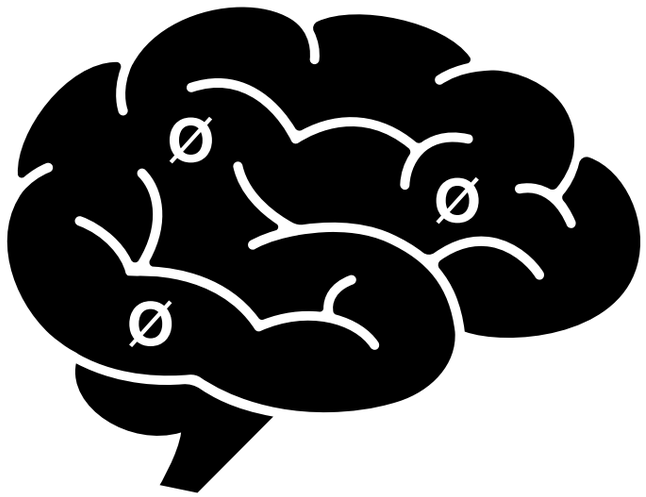
Memory load x Interference interaction (critical verb)

Load conditions:



fixed > sailed

No load conditions:



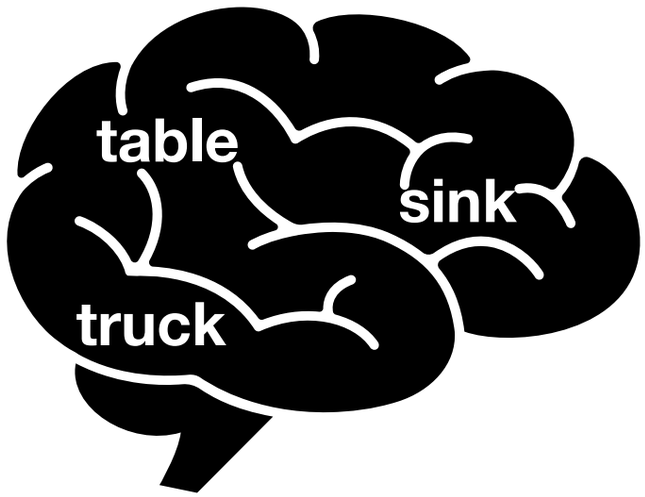
fixed ≈ sailed

→ Pattern consistent with cue-dependent retrieval interference

Van Dyke & McElree (2006) results

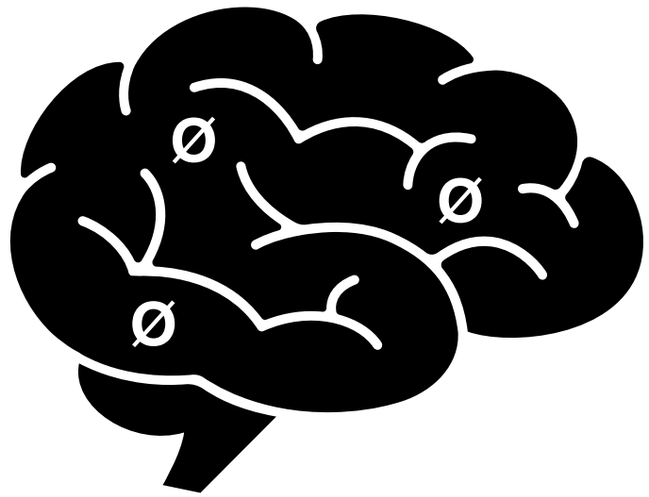
Memory load x Interference interaction (critical verb)

Load conditions:



fixed > sailed

No load conditions:



fixed ≈ sailed

→ Pattern consistent with cue-dependent retrieval interference

Van Dyke, Johns & Kukona (2014)

No evidence of Memory load x Interference interaction

Our study Eye-tracking + recall task

- re-examined similarity-based interference

English

Our study Eye-tracking + recall task

- re-examined similarity-based interference

- Investigated similarity-based interference cross-linguistically

English

German

Russian

Design

For each   

2 x 2 fully-crossed factorial design

Factor 1: Memory load (*load* vs. *no load*)
Factor 2: Interference (*no interference* vs. *interference*)

Design

Memory load conditions
table sink truck

No interference
The boat that the guy who lived by the sea **sailed** in the morning seemed to be very old.
Interference
The boat that the guy who lived by the sea **fixed** in the morning seemed to be very old.

No memory load conditions
— — —

No interference
The boat that the guy who lived by the sea **sailed** in the morning seemed to be very old.
Interference
The boat that the guy who lived by the sea **fixed** in the morning seemed to be very old.

Design

Memory load conditions

table sink truck

- SAILABLE + FIXABLE

No interference

The boat that the guy who lived by the sea **sailed** in the morning seemed to be very old.

Interference

The boat that the guy who lived by the sea **fixed** in the morning seemed to be very old.

No memory load conditions

— — —

No interference

The boat that the guy who lived by the sea **sailed** in the morning seemed to be very old.

Interference

The boat that the guy who lived by the sea **fixed** in the morning seemed to be very old.

Design

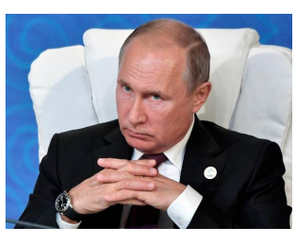
Memory load conditions
table sink truck

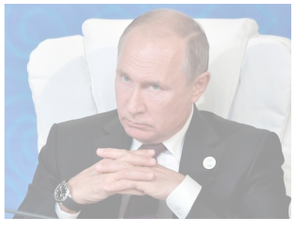
No interference
The boat that the guy who lived by the sea **sailed** in the morning seemed to be very old.
Interference
The boat that the guy who lived by the sea **fixed** in the morning seemed to be very old.

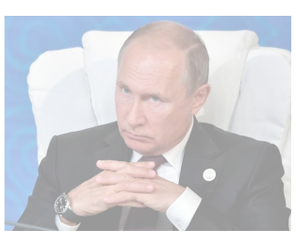
No memory load conditions
_ _ _

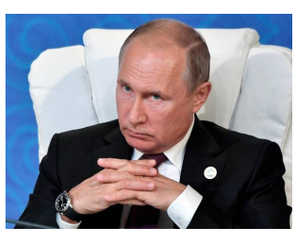
No interference
The boat that the guy who lived by the sea **sailed** in the morning seemed to be very old.
Interference
The boat that the guy who lived by the sea **fixed** in the morning seemed to be very old.

Comprehension question: *Did the guy live by the sea?*
Recall: _____ _____ _____

Language	Memory load	Sentence (schematic)
	∅ CASE + FIXABLE table sink truck	∅ CASE + FIXABLE ∅ CASE {+FIXABLE} **The boat** that the guy **fixed**
	- ACC + SMELLABLE Parfum *perfume* Rauch *smoke* Leder *leather*	+ ACC + SMELLABLE {+ACC} {+SMELLABLE} **Der Kaffee** *The.NOM coffee* den *that.ACC* der Mann *the man* **roch** *smelled*
	- ACC + DISCOVERABLE бардак *mess* пропажа *loss* ампула *ampoule*	+ ACC + DISCOVERABLE {+ACC} {+DISCOVERABLE} **Та болезнь** *That.NOM illness* которую *that.ACC* врач *doctor* **обнаружил** *discovered*

Language	Memory load	Sentence (schematic)
	∅ CASE + FIXABLE table sink truck	∅ CASE + FIXABLE **The boat** that ∅ CASE {+FIXABLE} the guy **fixed**
	- ACC + SMELLABLE Parfum *perfume* Rauch *smoke* Leder *leather*	+ ACC + SMELLABLE **Der Kaffee** *The.NOM coffee* den *that.ACC* {+ACC} {+SMELLABLE} der Mann *the man* **roch** *smelled*
	- ACC + DISCOVERABLE бардак *mess* пропажа *loss* ампула *ampoule*	+ ACC + DISCOVERABLE **Та болезнь** *That.NOM illness* которую *that.ACC* {+ACC} {+DISCOVERABLE} врач *doctor* **обнаружил** *discovered*

Language	Memory load	Sentence (schematic)
	∅ CASE + FIXABLE table sink truck	∅ CASE + FIXABLE **The boat** that the guy ∅ CASE {+FIXABLE} **fixed**
	- ACC + SMELLABLE Parfum *perfume* Rauch *smoke* Leder *leather*	+ ACC + SMELLABLE **Der Kaffee** *The.NOM coffee* den *that.ACC* der Mann *the man* {+ACC} {+SMELLABLE} **roch** *smelled*
	- ACC + DISCOVERABLE бардак *mess* пропажа *loss* ампула *ampoule*	+ ACC + DISCOVERABLE **Та болезнь** *That.NOM illness* которую *that.ACC* врач *doctor* {+ACC} {+DISCOVERABLE} **обнаружил** *discovered*

Language	Memory load	Sentence (schematic)
	∅ CASE + FIXABLE table sink truck	∅ CASE + FIXABLE ∅ CASE {+FIXABLE} **The boat** that the guy **fixed**
	- ACC + SMELLABLE Parfum *perfume* Rauch *smoke* Leder *leather*	+ ACC + SMELLABLE {+ACC} {+SMELLABLE} **Der Kaffee** *The.NOM coffee* den *that.ACC* der Mann *the man* **roch** *smelled*
	- ACC + DISCOVERABLE бардак *mess* пропажа *loss* ампула *ampoule*	+ ACC + DISCOVERABLE {+ACC} {+DISCOVERABLE} **Та болезнь** *That.NOM illness* которую *that.ACC* врач *doctor* **обнаружил** *discovered*

Depth of processing manipulation
(within-subjects)

Version 1: 40 items

- **difficult questions**

inducing deep processing

Did the guy live by the sea?

Depth of processing manipulation
(within-subjects)

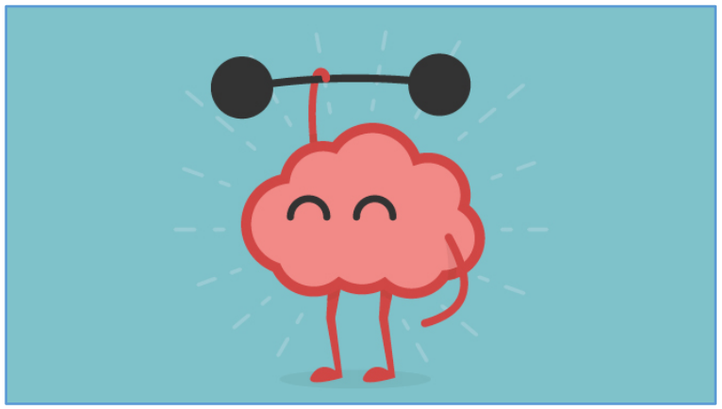
Version 1: 40 items
- **difficult questions**

inducing deep processing

Did the guy live by the sea?

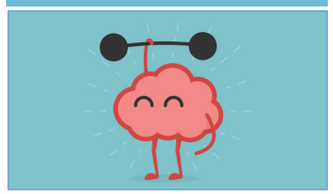
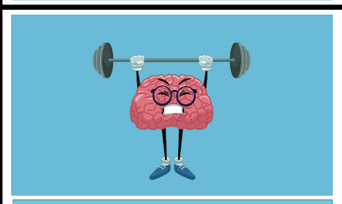
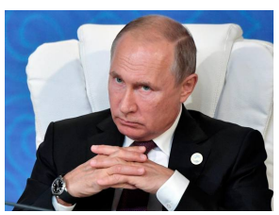
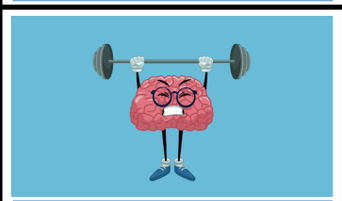
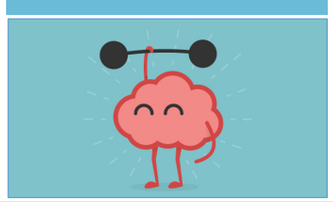
Version 2: 40 new items
- **simple questions**

inducing shallow processing



Did the word sea appear in this sentence?

Our study Eye-tracking + recall task

Language	Version	Subjects	Items
		66	40
			40
		122	40
			40
		109	40
			40

Pre-registered predictions

For each

Memory load x Interference interaction at the critical verb (fixed/sailed) in total reading time

Predictions: Language

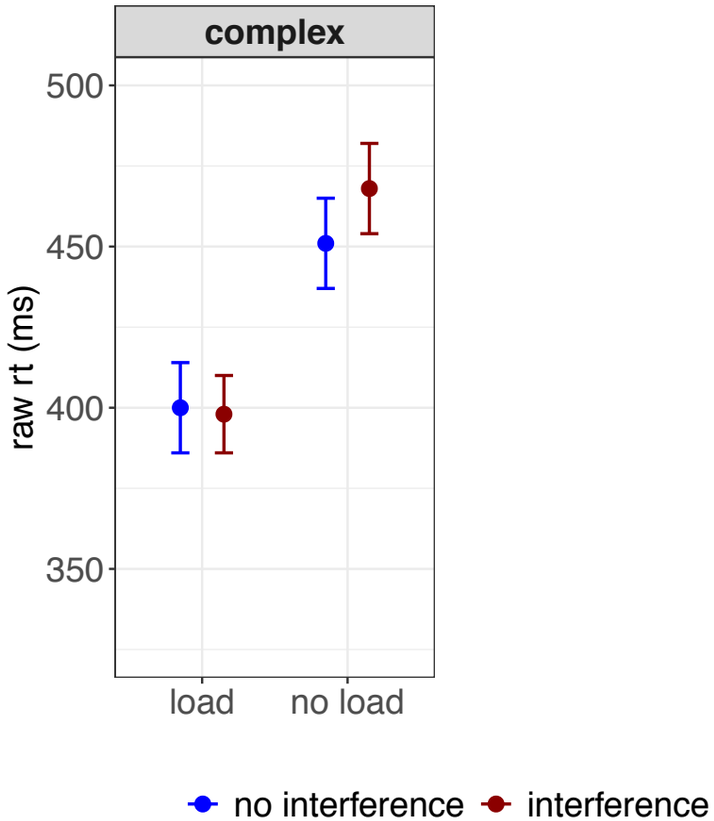
Memory load x interference interaction

>

≈

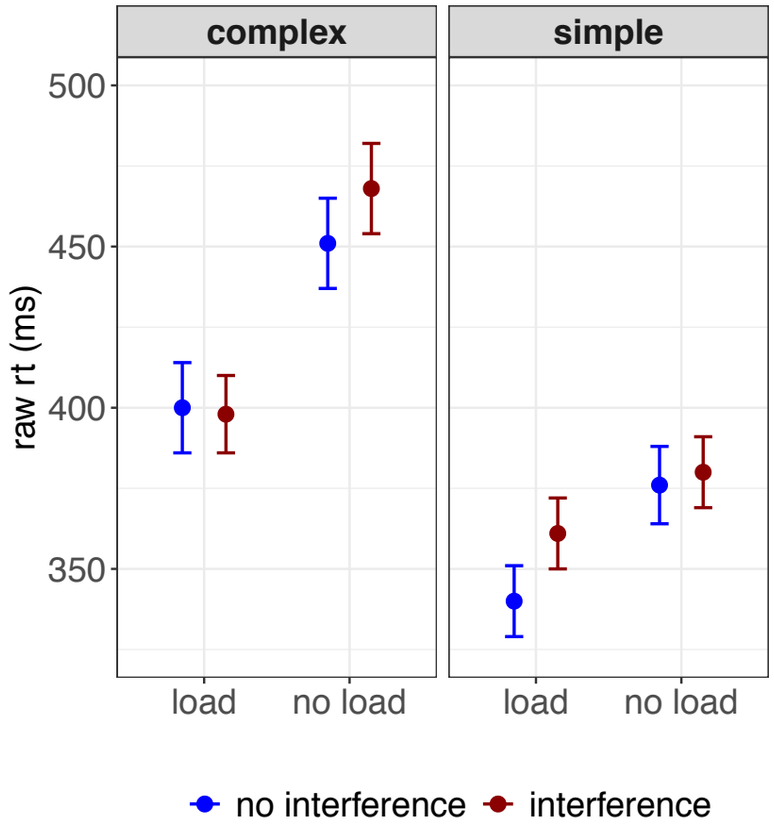
Raw data (Total fixation times)

English: raw TFT condition means and 95% CIs (critical verb)



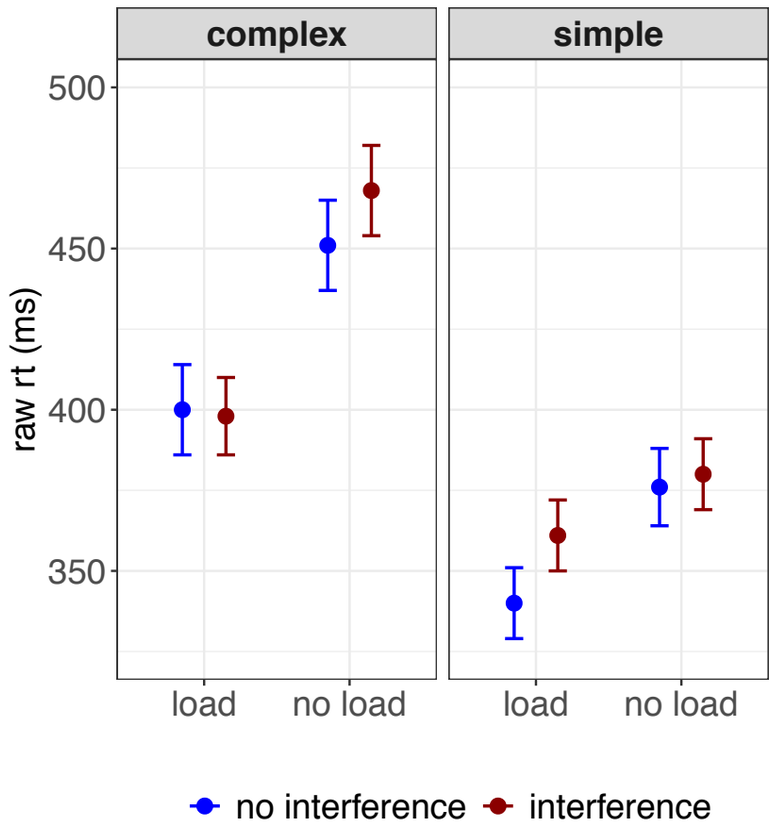
Raw data (Total fixation times)

English: raw TFT condition means and 95% CIs (critical verb)

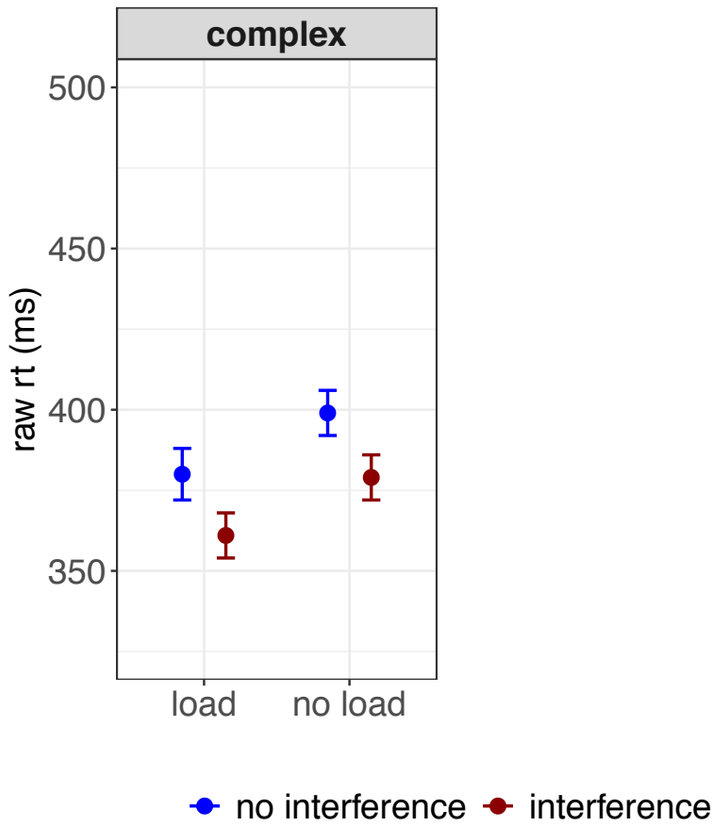


Raw data (Total fixation times)

English: raw TFT condition means and 95% CIs (critical verb)

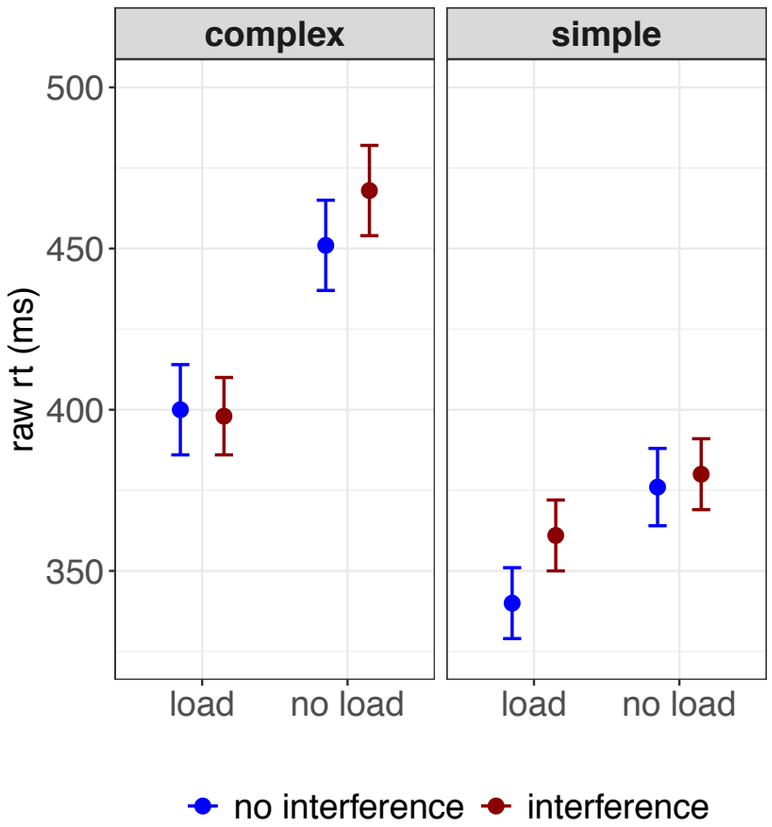


German: raw TFT condition means and 95% CIs (critical verb)

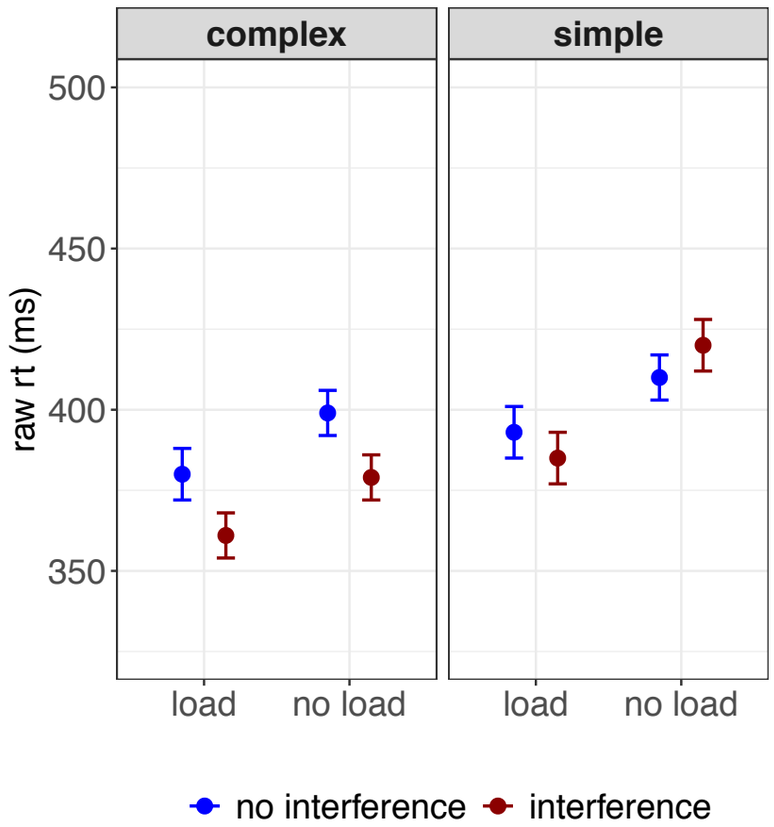


Raw data (Total fixation times)

English: raw TFT condition means and 95% CIs (critical verb)



German: raw TFT condition means and 95% CIs (critical verb)

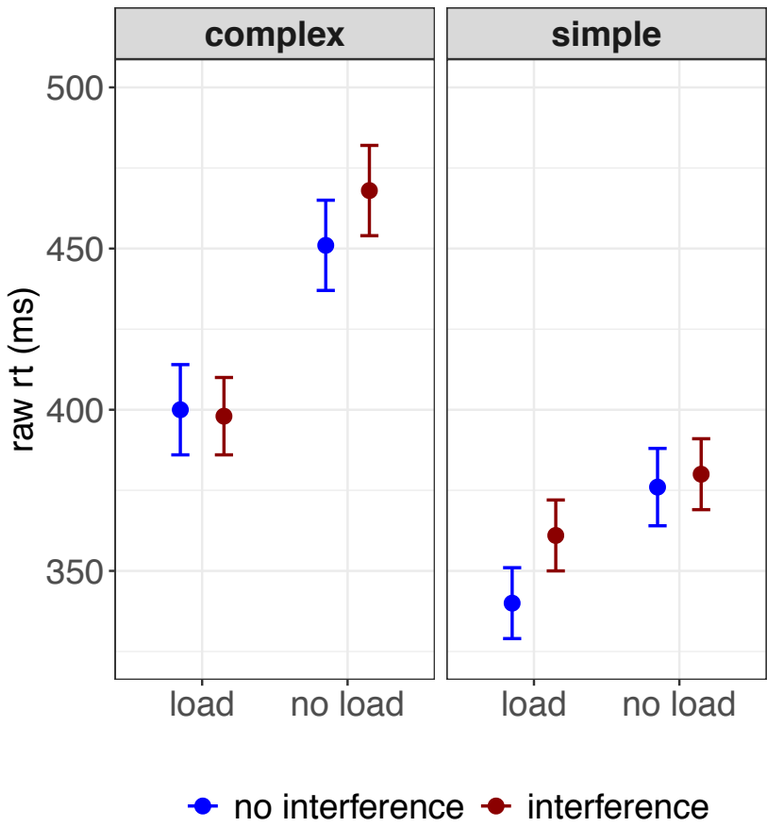


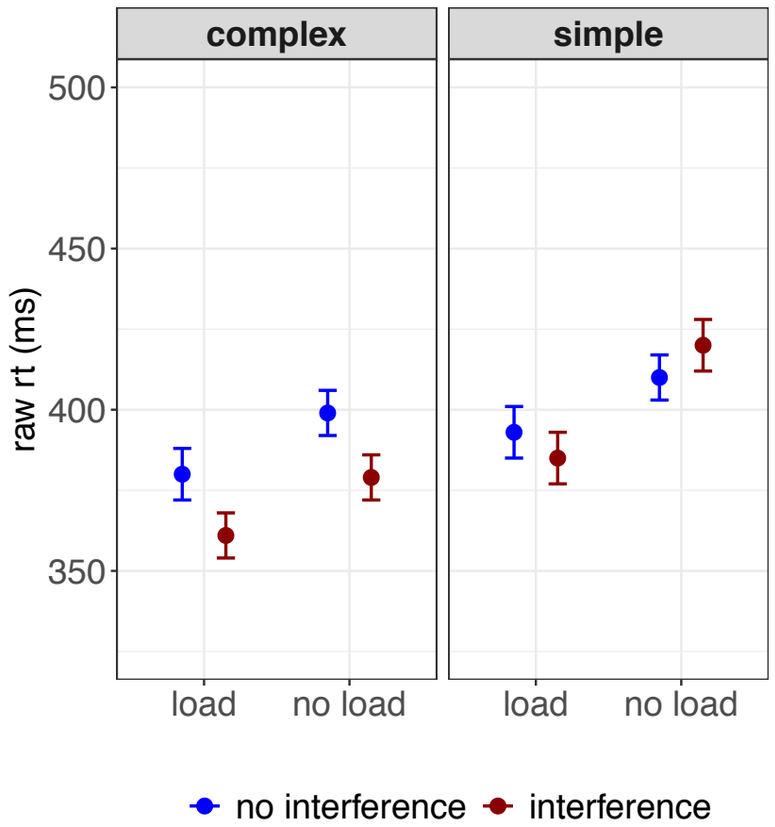
Raw data (Total fixation times)

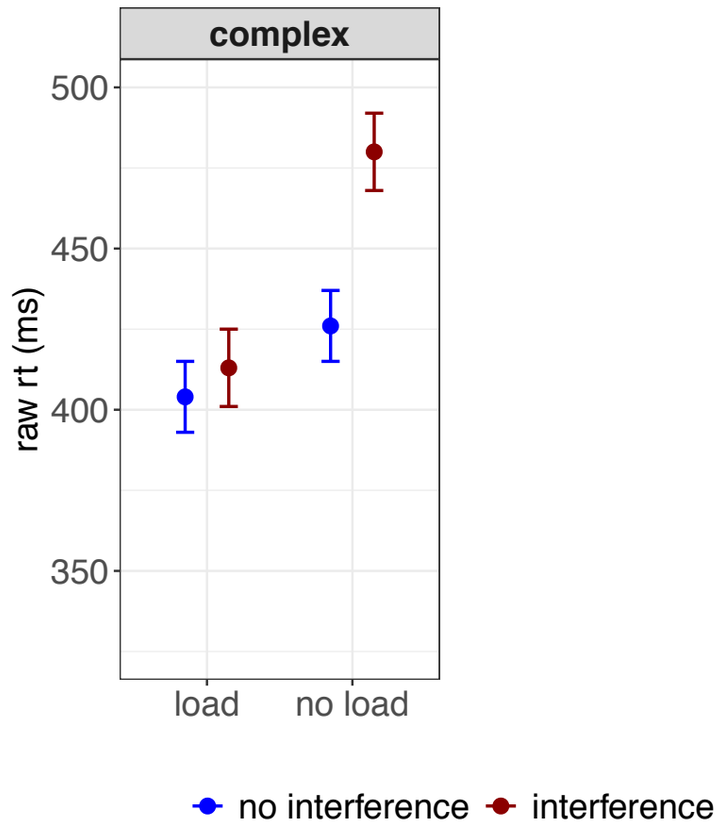
English: raw TFT condition means and 95% CIs (critical verb)

German: raw TFT condition means and 95% CIs (critical verb)

Russian: raw TFT condition means and 95% CIs (critical verb)





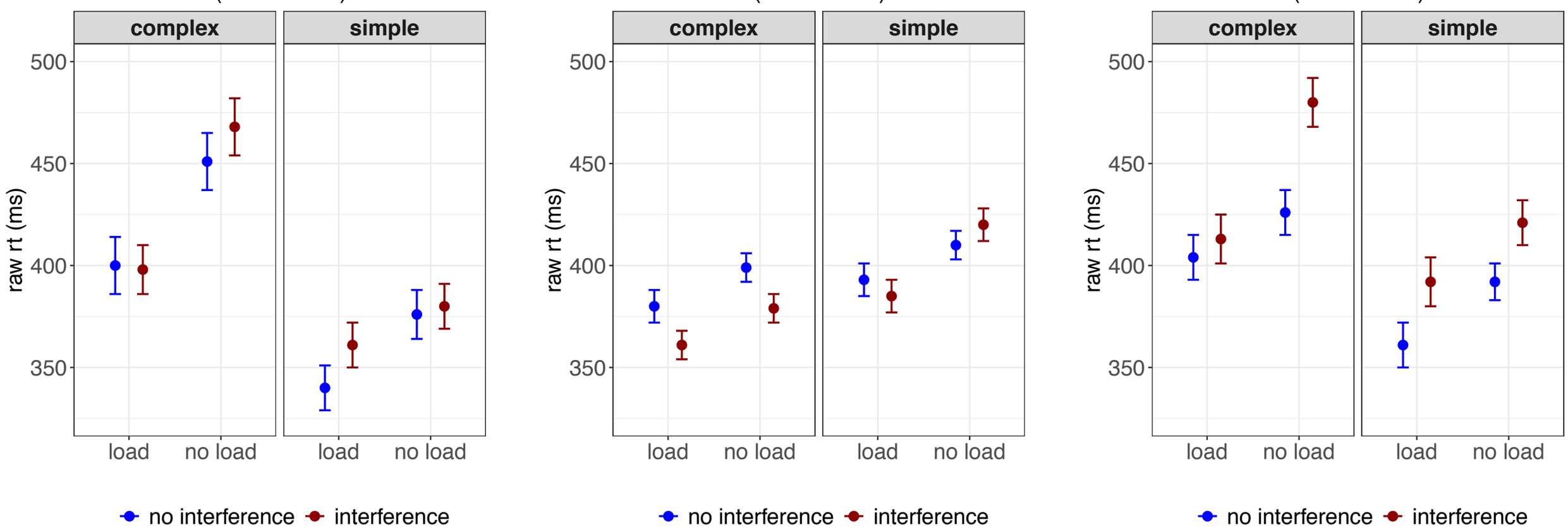


Raw data (Total fixation times)

English: raw TFT condition means and 95% CIs (critical verb)

German: raw TFT condition means and 95% CIs (critical verb)

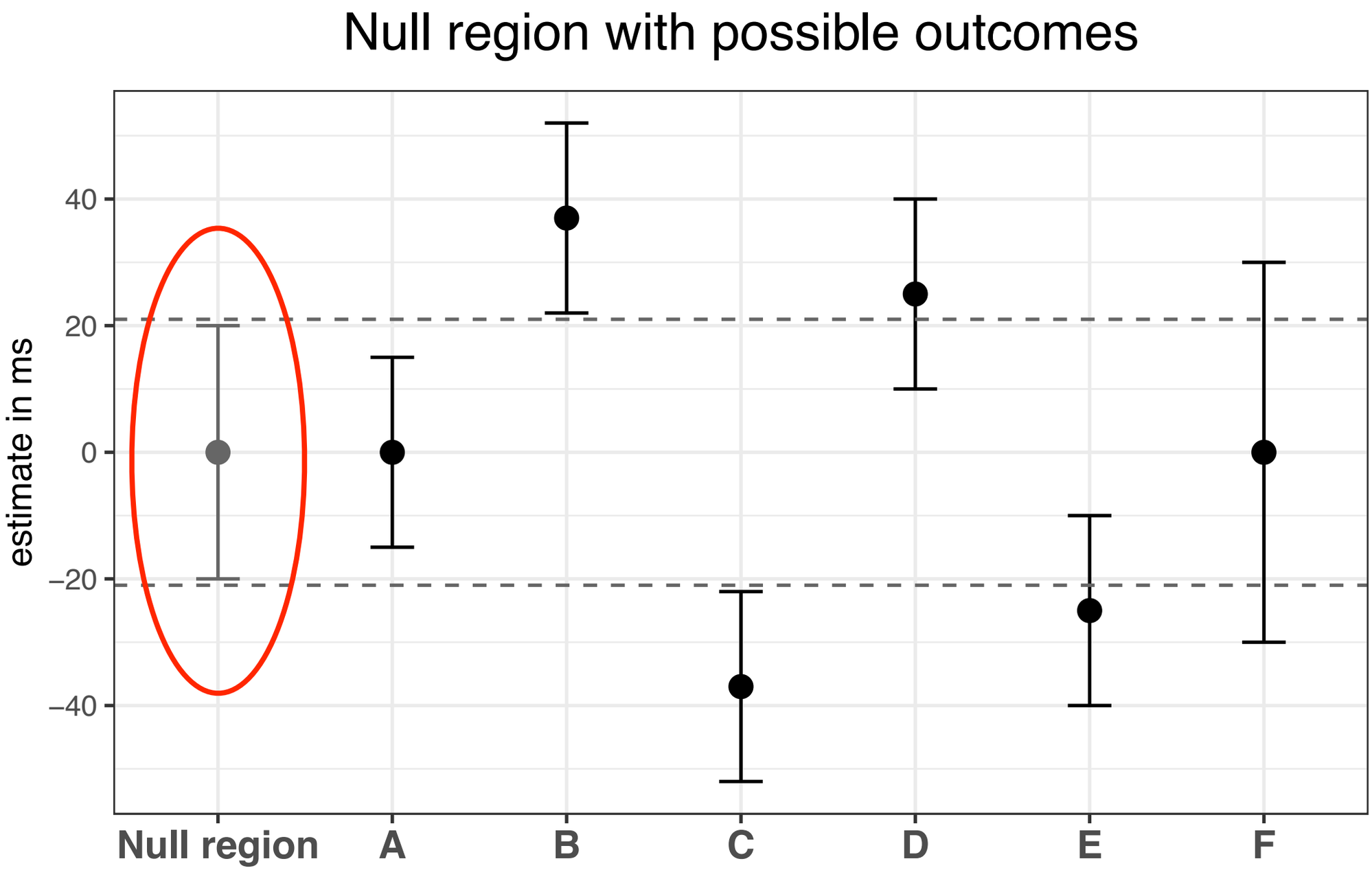
Russian: raw TFT condition means and 95% CIs (critical verb)



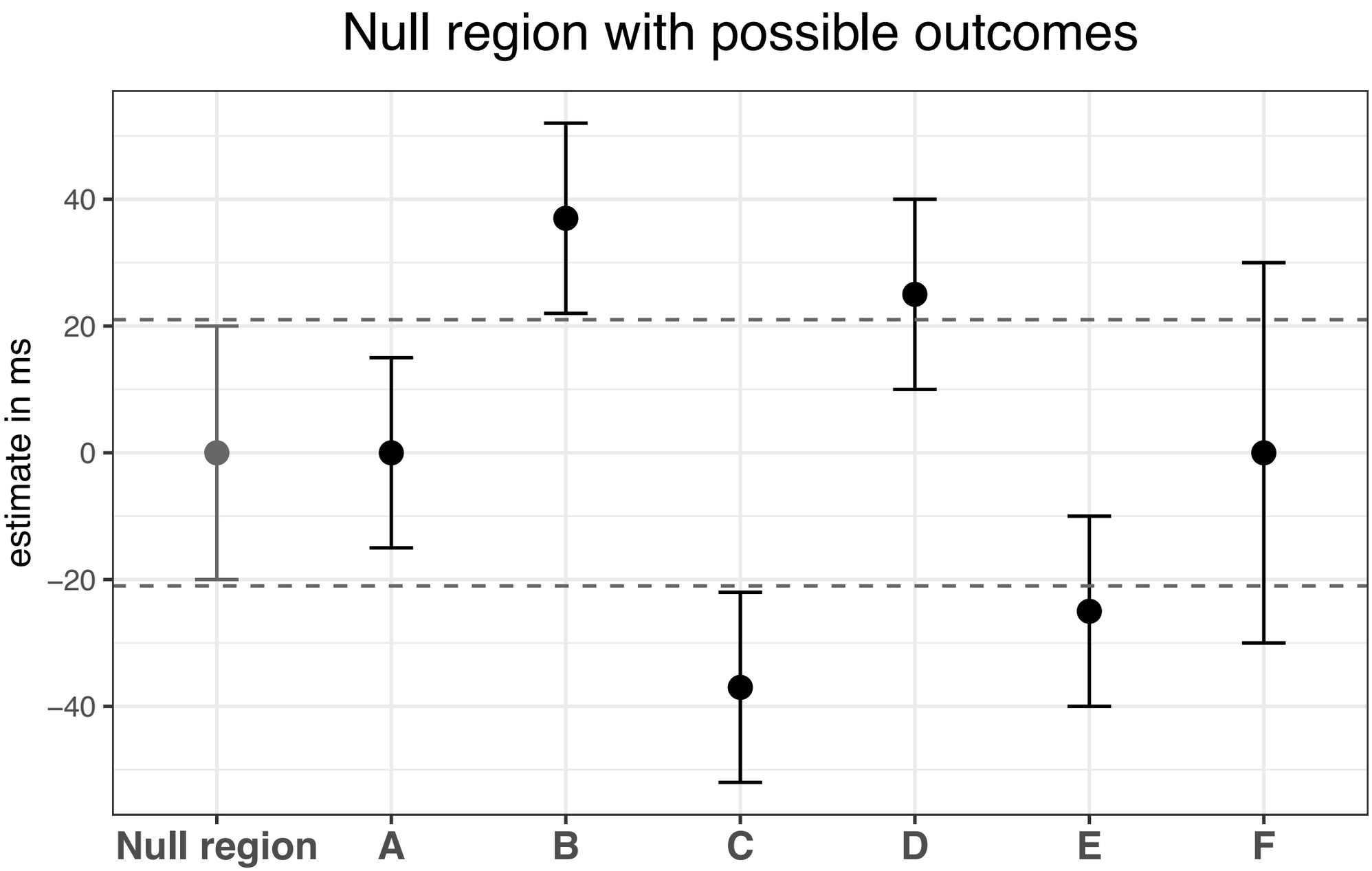
Region of practical equivalence (ROPE)

(Freedman, Lowe, & Macaskill, 1984; Spiegelhalter, Freedman, & Parmar, 1994; Hobbs & Carlin, 2008; Kruschke, 2015)

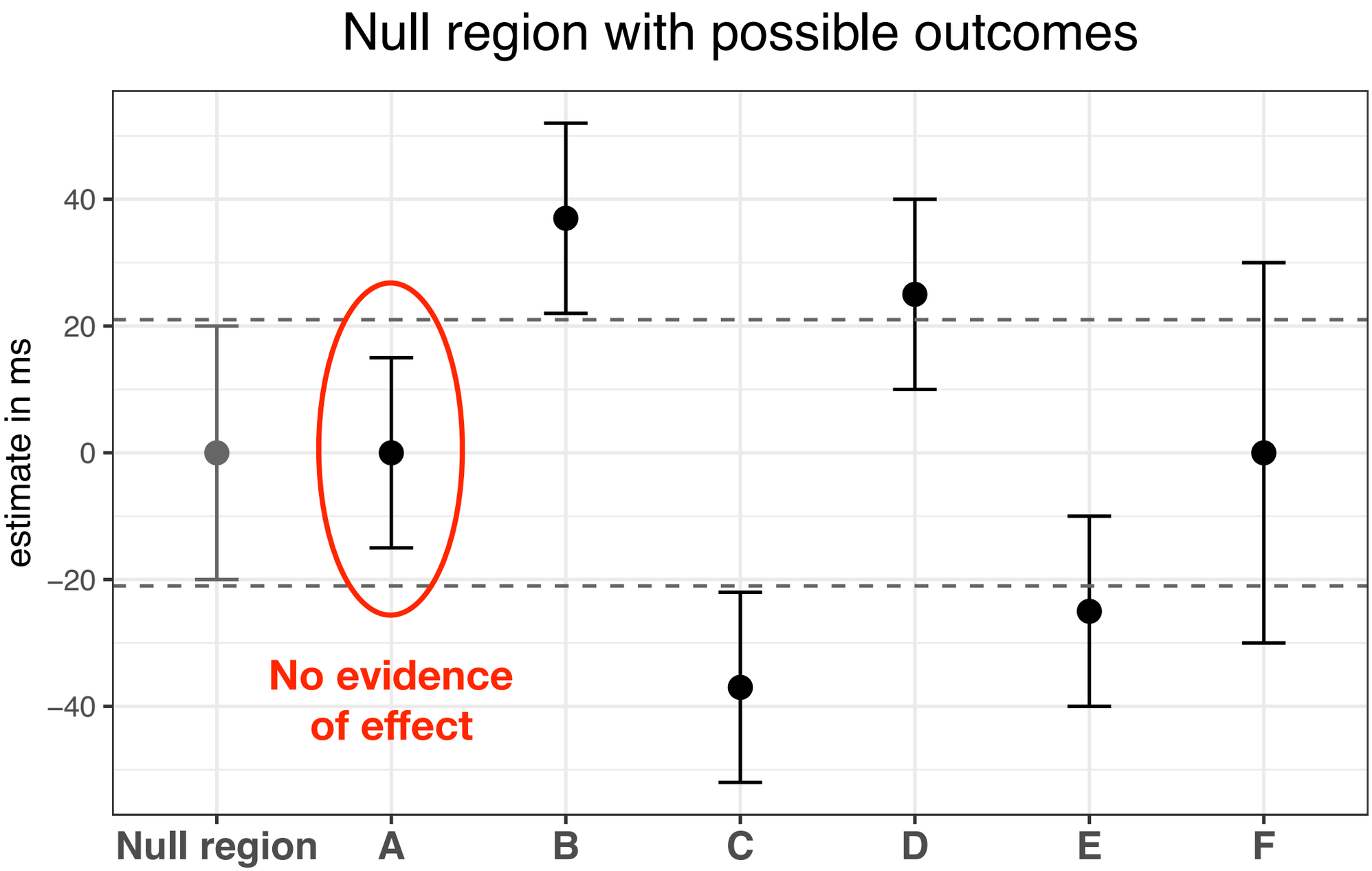
Region of practical equivalence (ROPE)



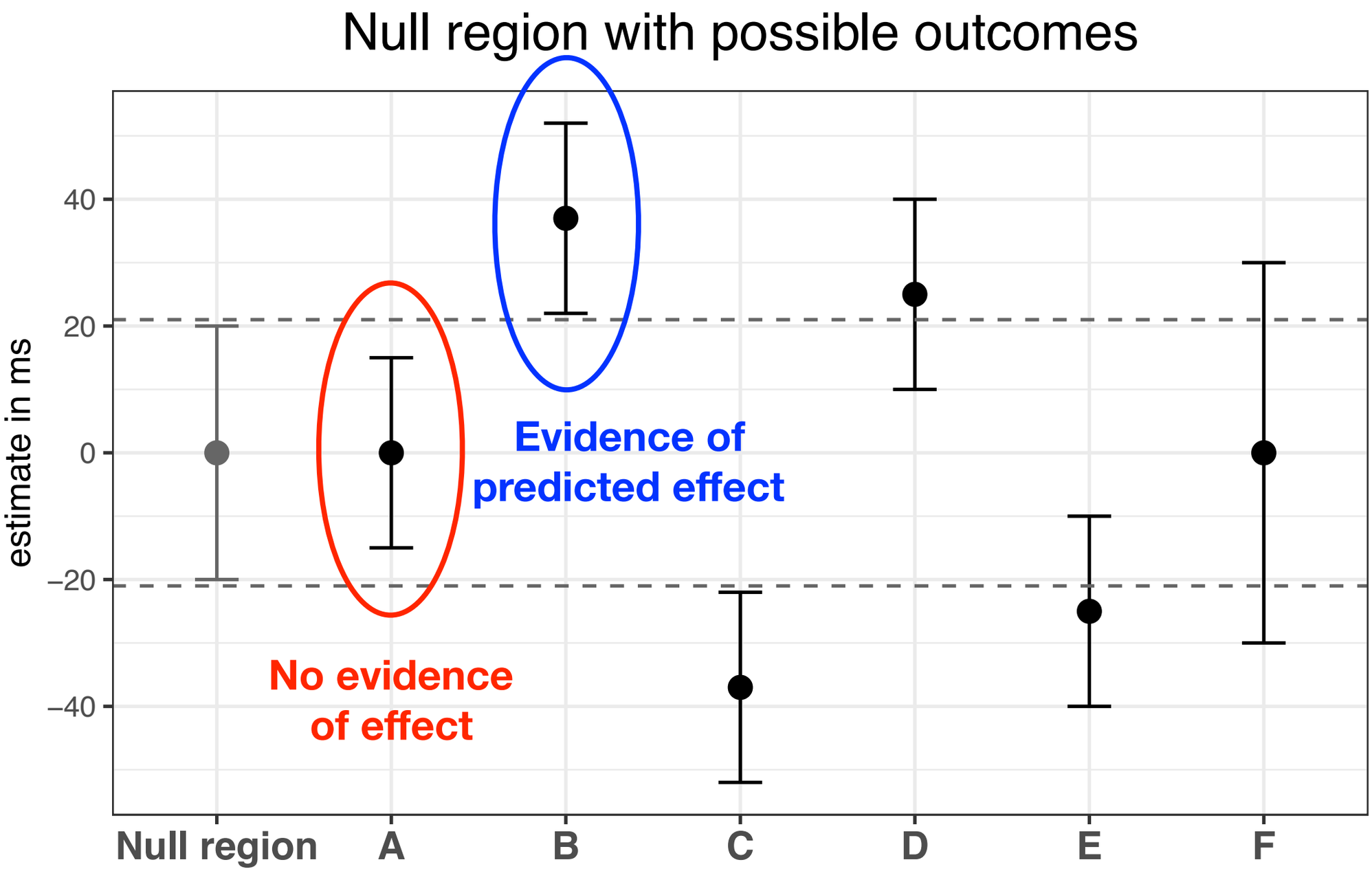
Region of practical equivalence (ROPE)



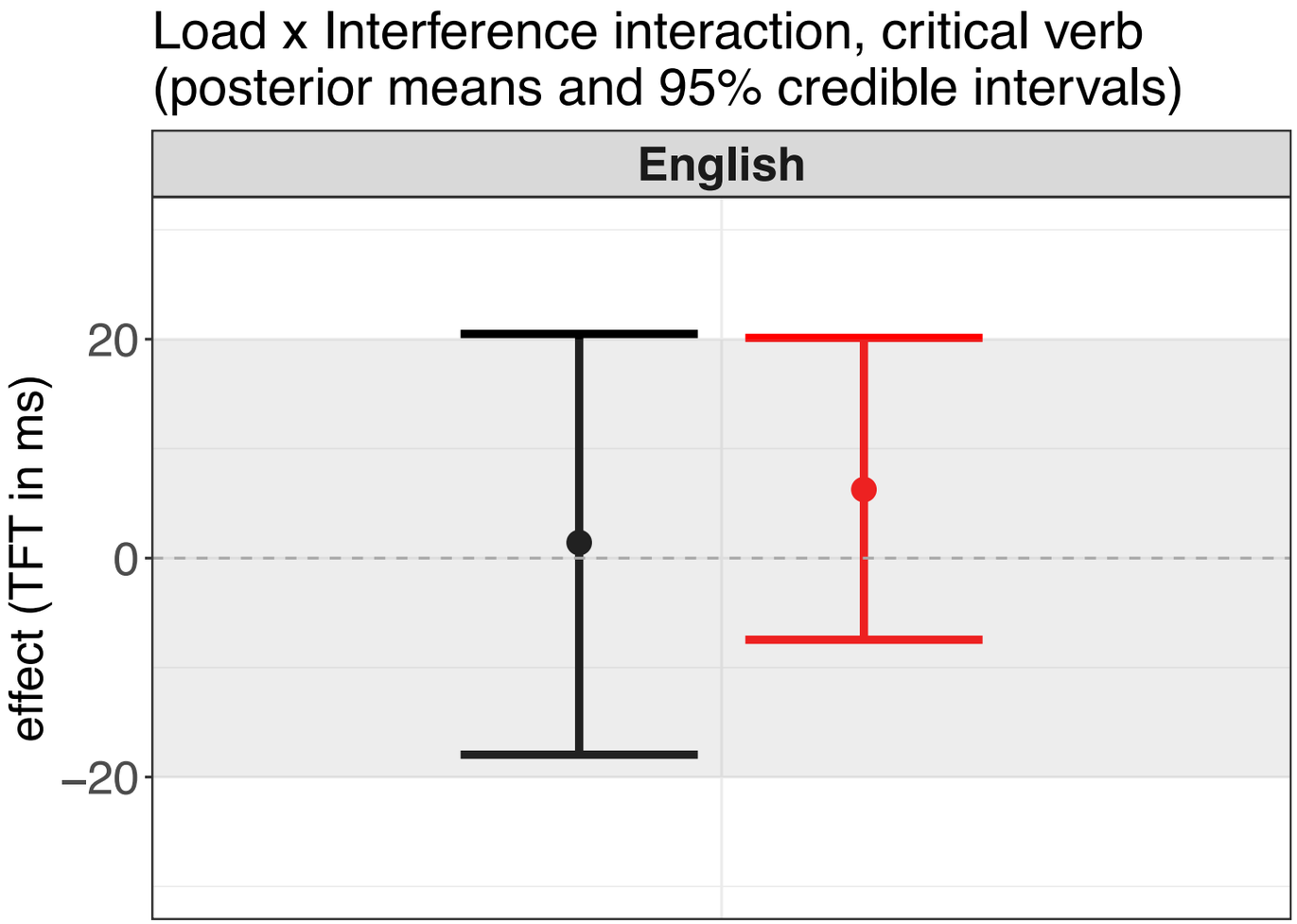
Region of practical equivalence (ROPE)

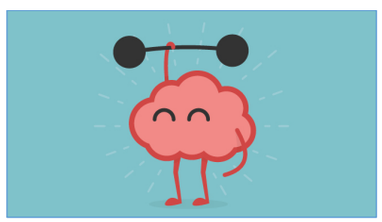


Region of practical equivalence (ROPE)

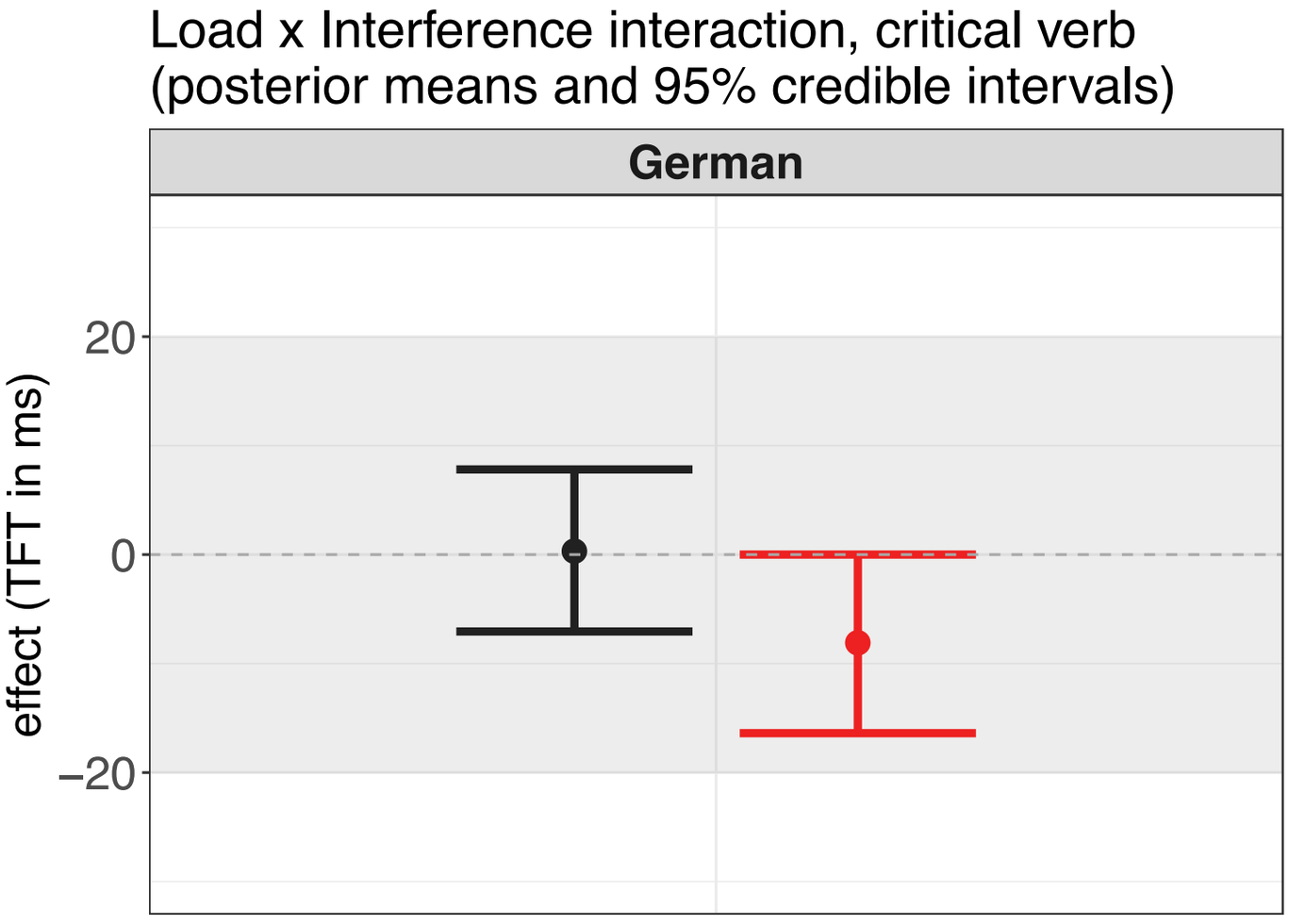


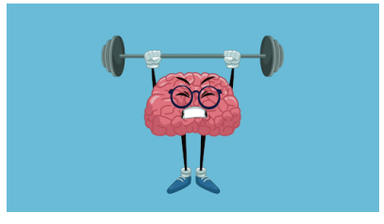
Total fixation time results (preregistered analysis)

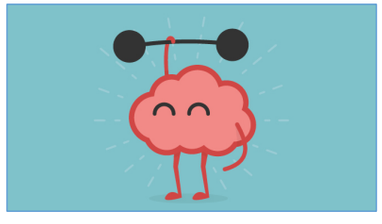




Total fixation time results (preregistered analysis)

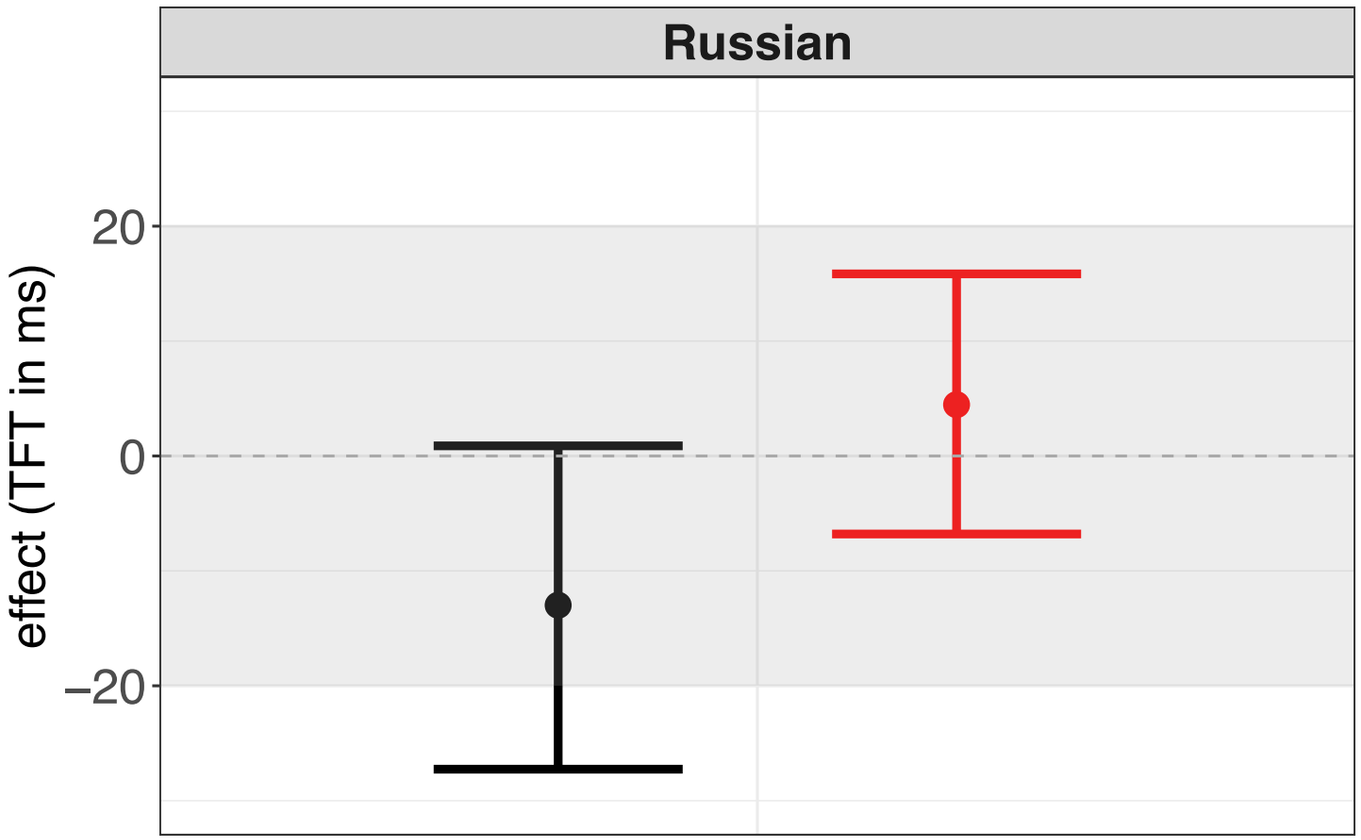




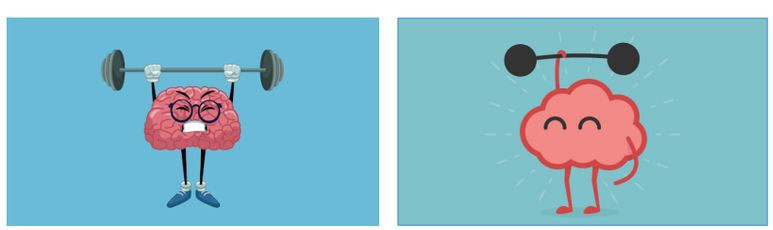


Total fixation time results (preregistered analysis)

Load x Interference interaction, critical verb
(posterior means and 95% credible intervals)

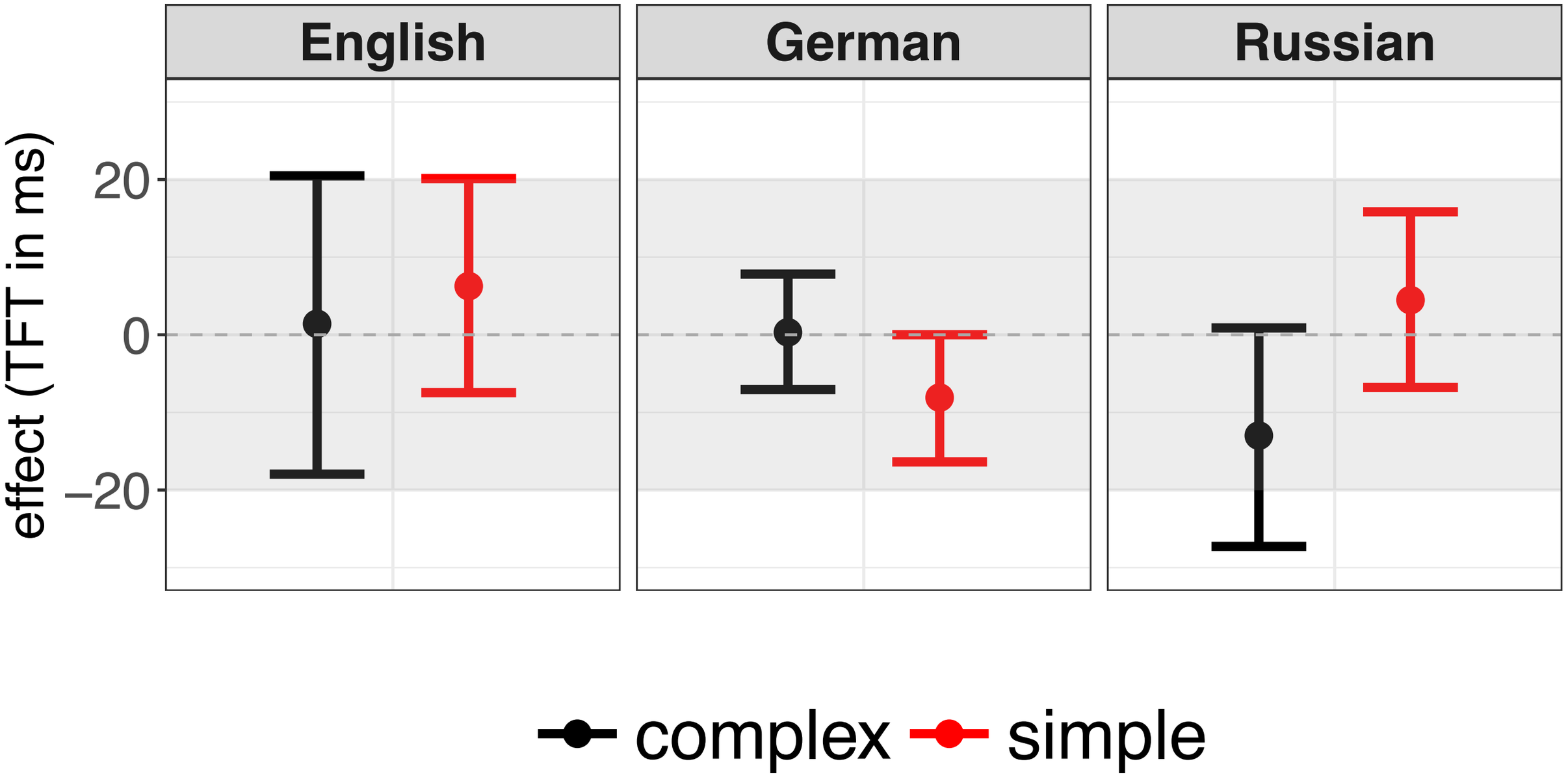


complex simple



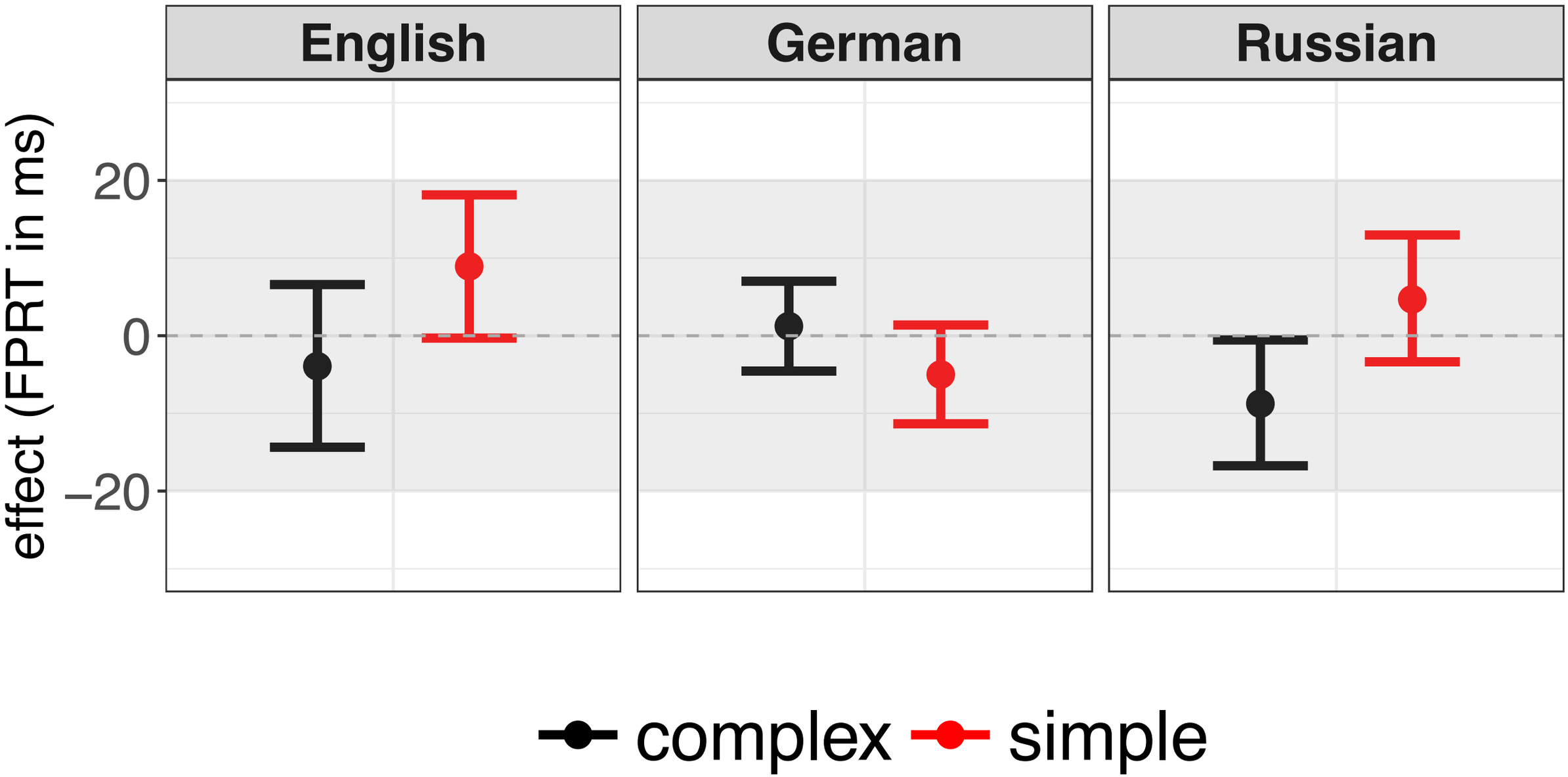
Total fixation time results (preregistered analysis)

Load x Interference interaction (critical verb)



First pass reading time results

Load x Interference interaction (critical verb)



Main finding

- No evidence of the predicted Memory load x Interference interaction in any tested language

Implications

- No support for hypothesis that sentence-external items in working memory interfere with retrieval during sentence processing

- Interference effects caused by sentence-external distractors may be very small and difficult to detect

or

- interfering distractors play a role only when they appear within a sentence: currently being tested cross-linguistically

Implications

- No support for hypothesis that sentence-external items in working memory interfere with retrieval during sentence processing

- Interference effects caused by sentence-external distractors may be very small and difficult to detect

or

- interfering distractors play a role only when they appear within a sentence: currently being tested cross-linguistically

Implications

- No support for hypothesis that sentence-external items in working memory interfere with retrieval during sentence processing

- Interference effects caused by sentence-external distractors may be very small and difficult to detect

or

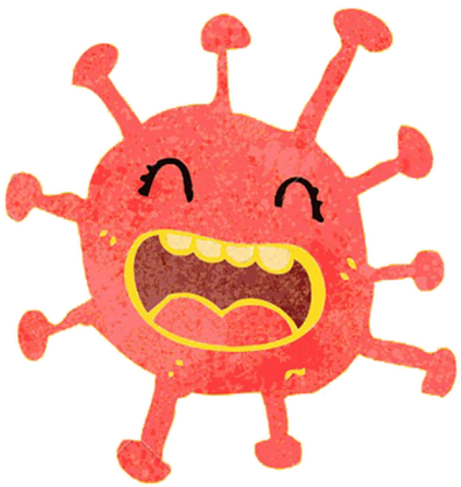
- interfering distractors play a role only when they appear within a sentence, particularly when distractor intervenes between target dependency (Van Dyke & McElree, 2011)

→ currently being tested cross-linguistically

Thank you

Questions: mertzen@uni-potsdam.de



Stay safe!