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A Cautionary Tale About the Importance of Taking Individual Differences into Account When Examining Whether tDCS can Enhance Cognitive Control

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INTRODUCTION

Cognitive control: Ability to disregard irrelevant information while attending to relevant information, supported by the prefrontal cortex (PFC) (Miller & Cohen, 2001).

Can this important ability be enhanced?

Transcranial direct current stimulation (tDCS): Weak electrical current delivered to scalp, modulating likelihood of neuronal firing.

Recent meta-analysis suggests anodal tDCS over PFC may enhance cognitive control, with some setups (small anodes, extra-cranial cathodes; Imburgio & Orr, 2018)

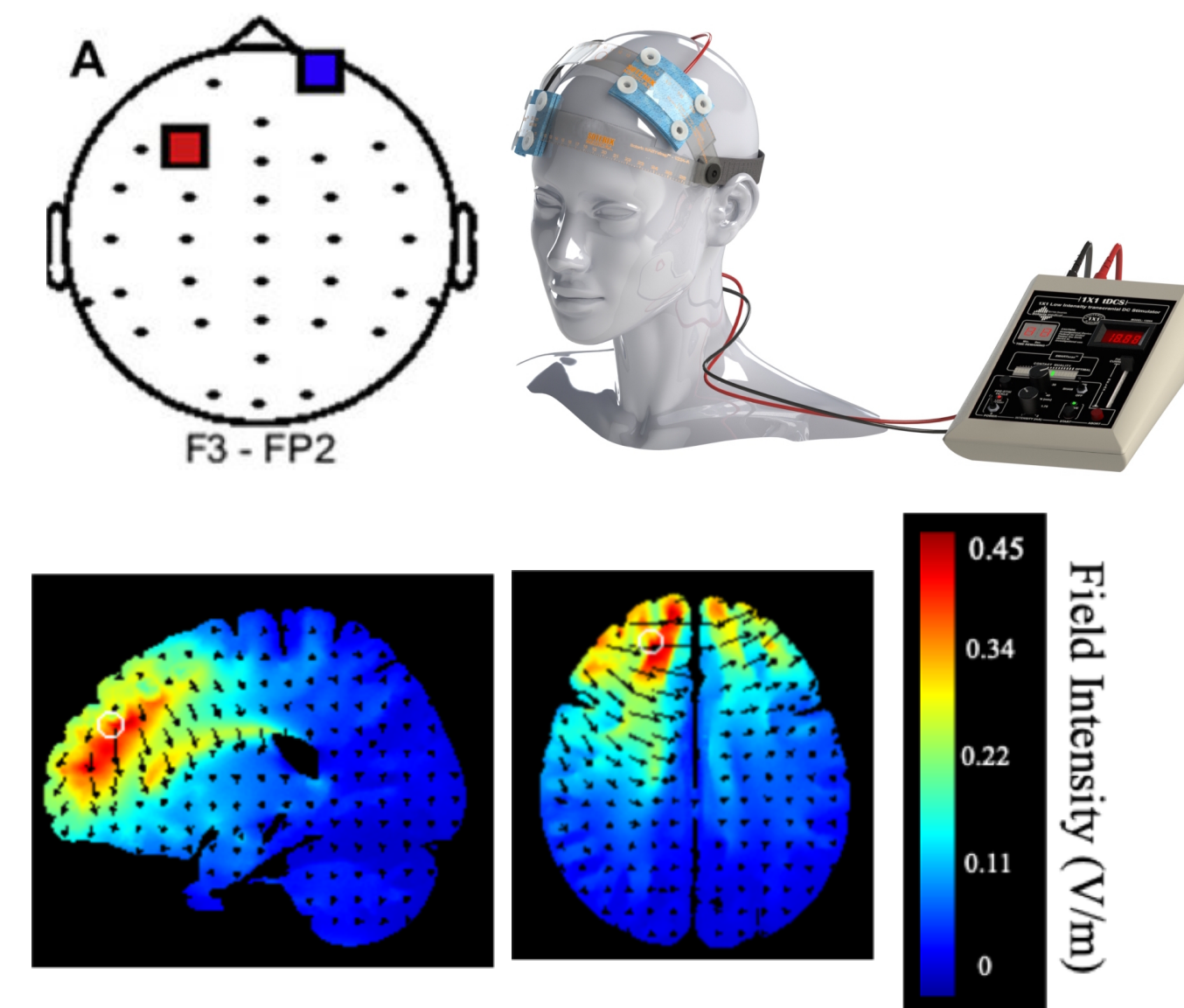
- But even using these setups, results vary.
- Baseline individual differences in cognitive control may account for some variability in results across studies
 - Most studies have fewer than 20 Ss/group and do not examine whether tDCS modulates changes from pre-test to post-test

When baseline differences in cognitive control are accounted for: Does anodal tDCS over PFC (applied using a common montage: F3-RSO) enhance cognitive control in Flanker or Stroop tasks?

METHODS

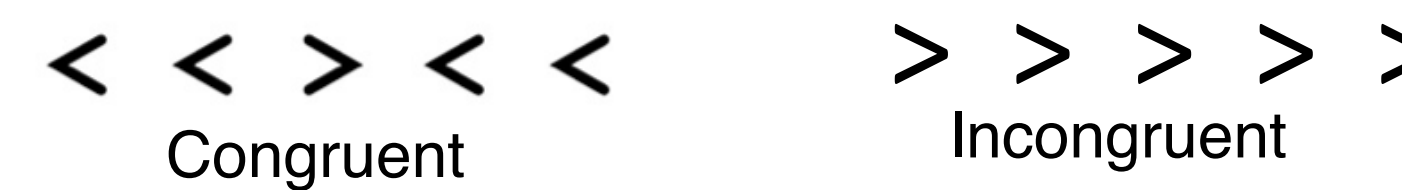
Anodal tDCS:

- Montage: F3-RSO
- 5x7cm saline-soaked sponges
- 1.5 mA stimulation begins 3 min before tasks, and continues throughout tasks



Flanker Task

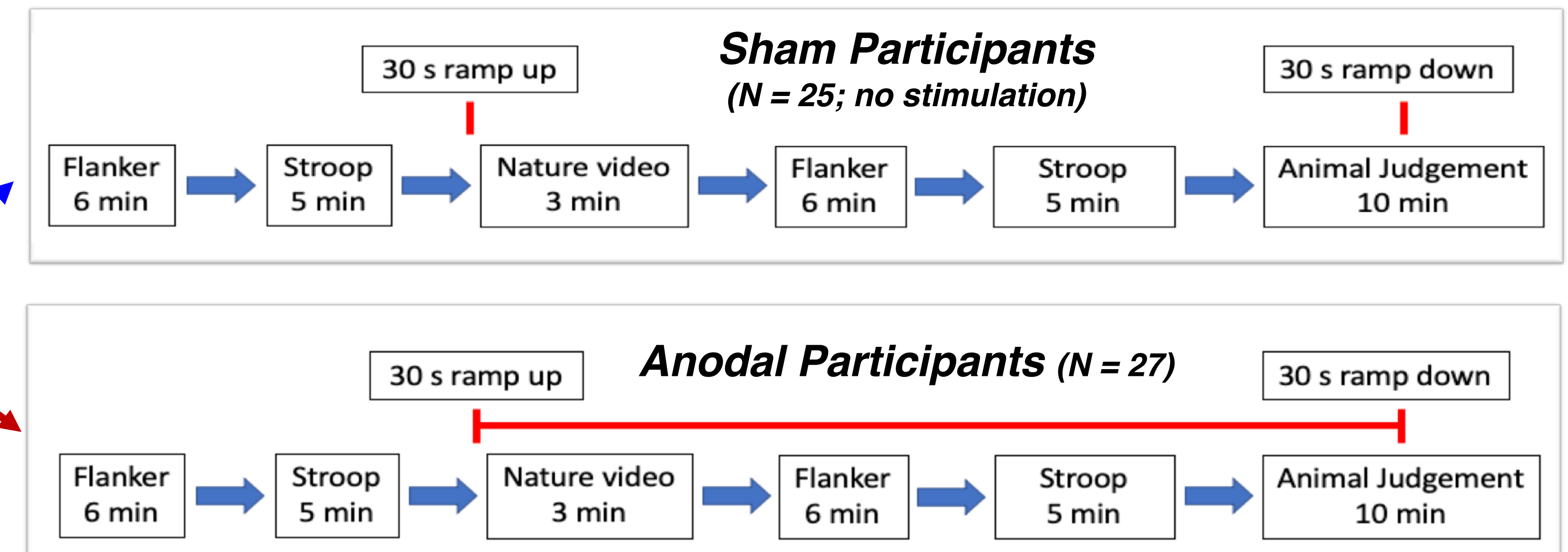
Respond to central arrow



Stroop Task

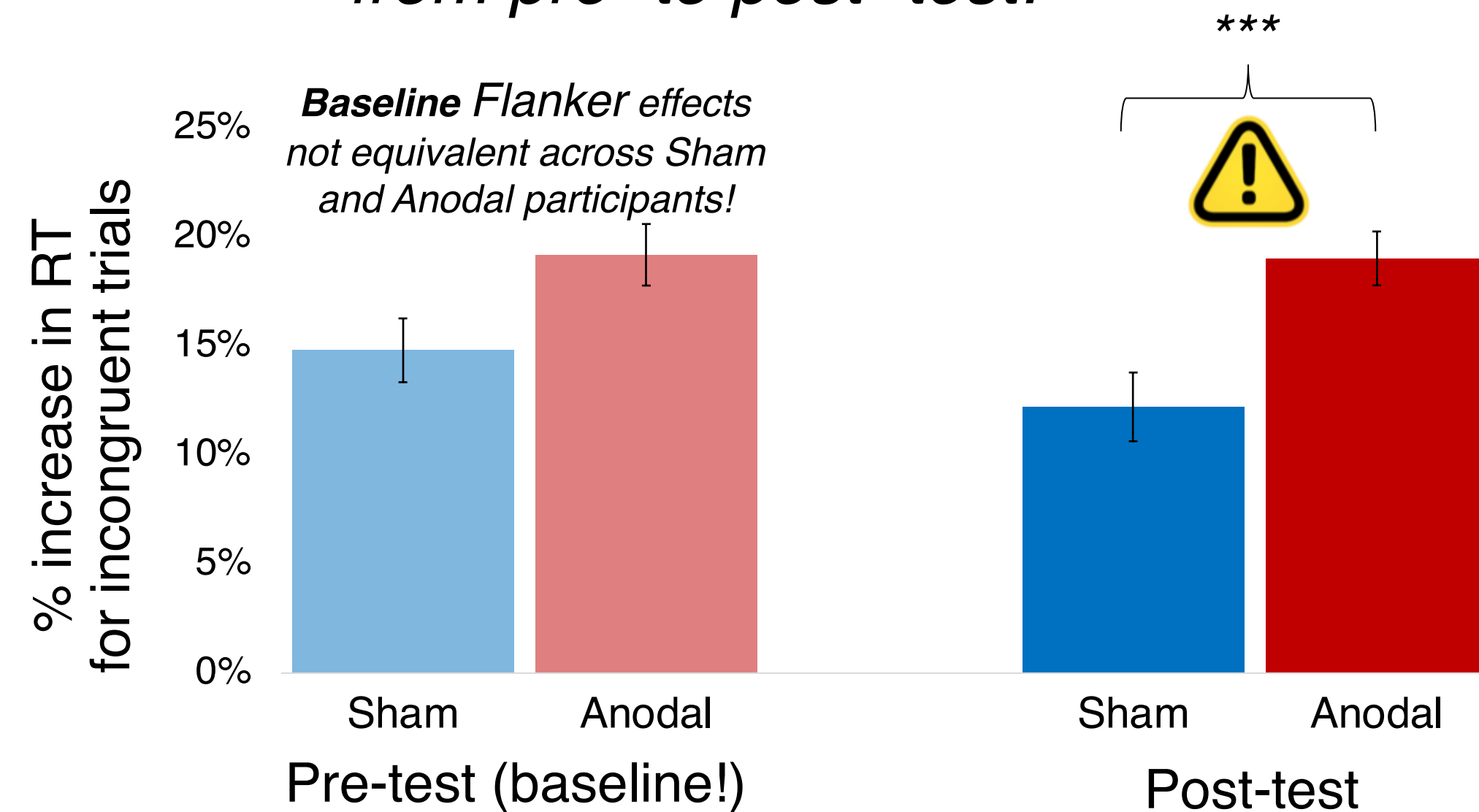
- 5 Colors: Blue, Red, Green, Yellow, Black
- 50% incongruent
- Respond to ink color – not text

N = 52
(data collection paused)
Alternating assignment

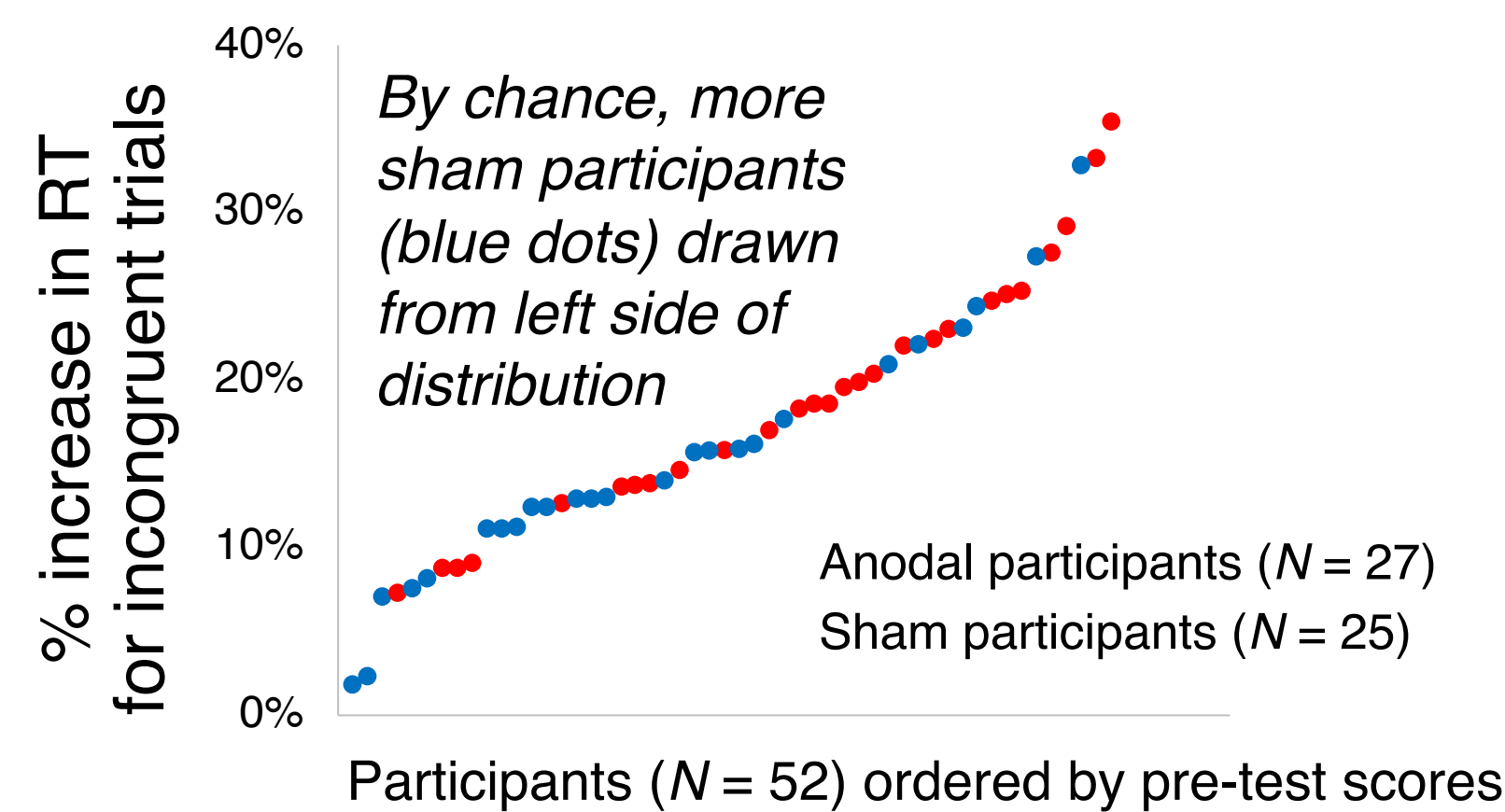


RESULTS (N = 52)

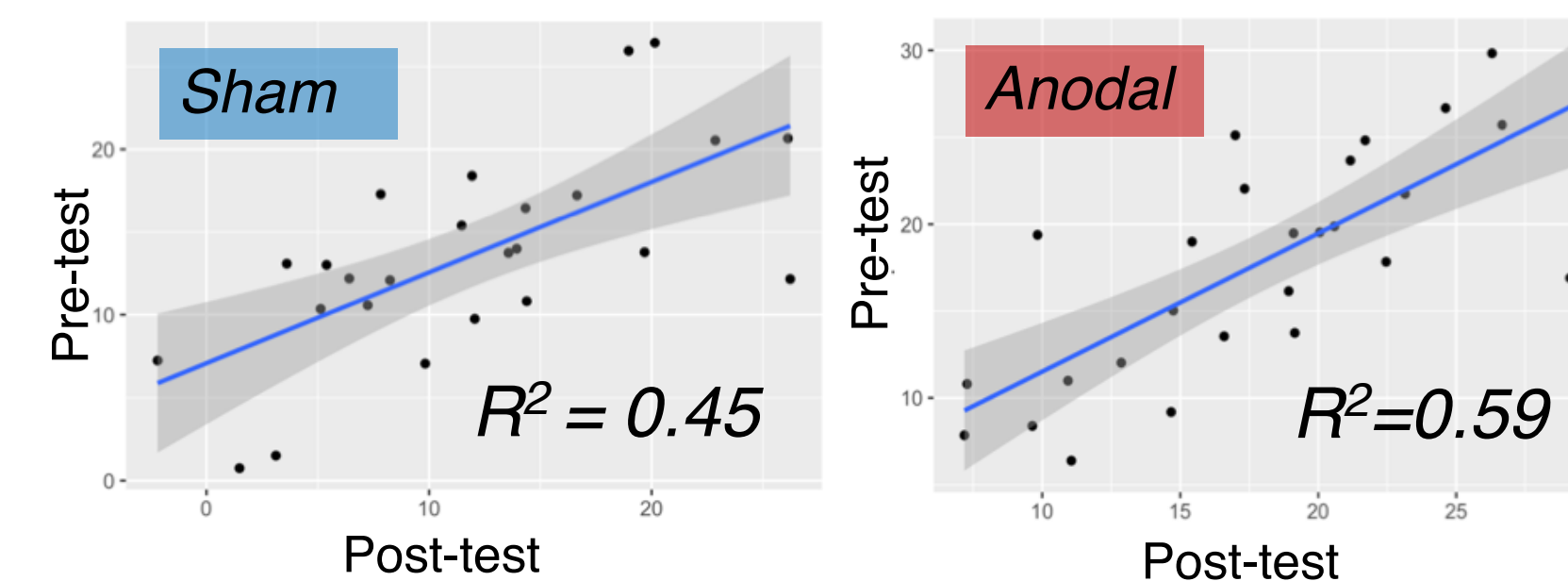
Flanker: No tDCS induced changes from pre- to post- test:



Baseline differences in Flanker unsurprising given broad range of pre-test scores across participants: (and modest N)



Despite broad range of Flanker scores, test-retest reliability was relatively good... Suggesting that, had it existed, an effect of tDCS on Flanker should have been detectable (after controlling for baseline differences)



DISCUSSION

Data collection may(?) resume (target was 60/condition)

Currently...

- No effect of anodal tDCS over PFC on cognitive control (i.e., Flanker or Stroop incongruency effects) ... with our montage and stimulation parameters
- Results highlight importance of taking individual differences into account: **If we had only compared post-test performance, we would have erroneously concluded that anodal tDCS produces a highly significant (7%!) detriment in cognitive control in Flanker!**

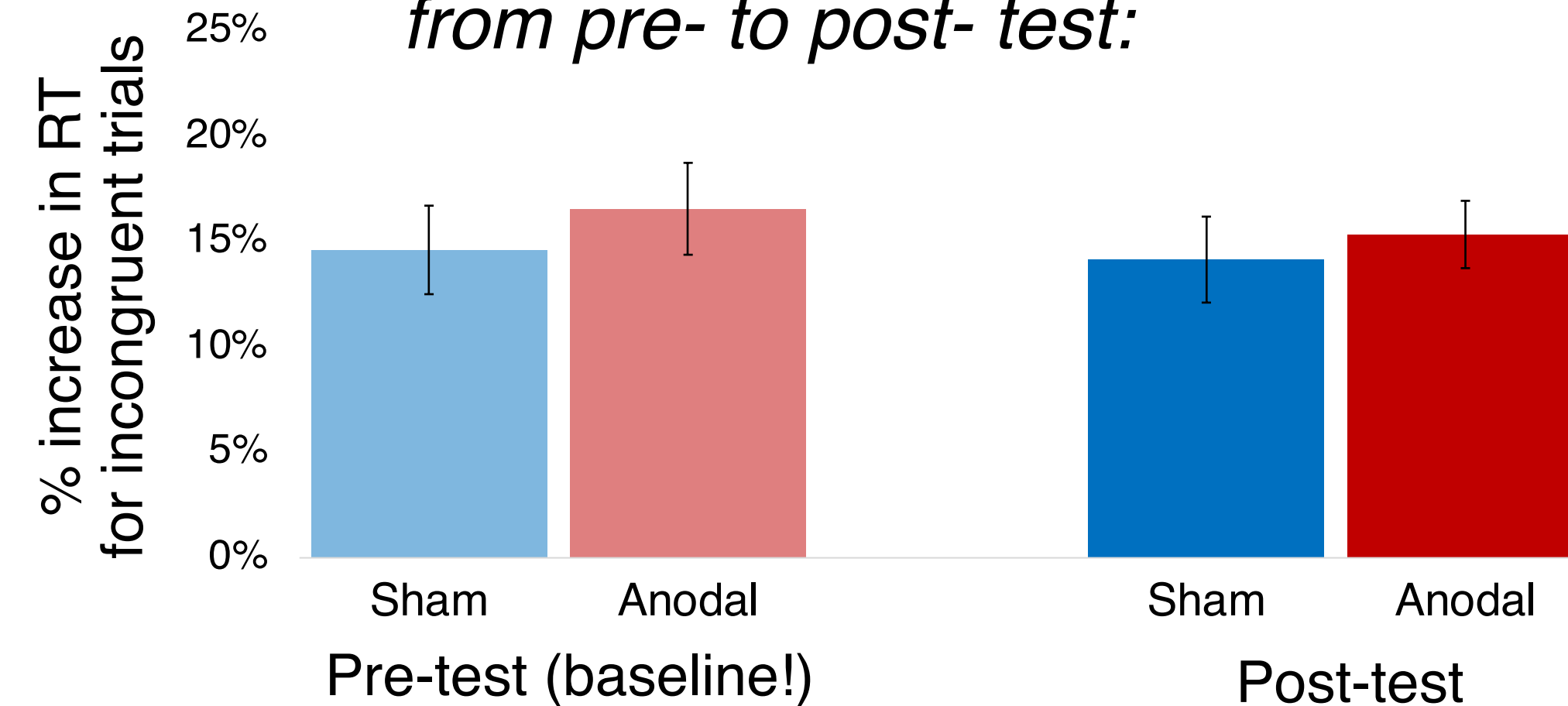
Reminders:

- When using tasks with large individual differences, test large sample and/or use pre- vs. post-test design
- Also consider test-retest reliability (not great for Stroop)

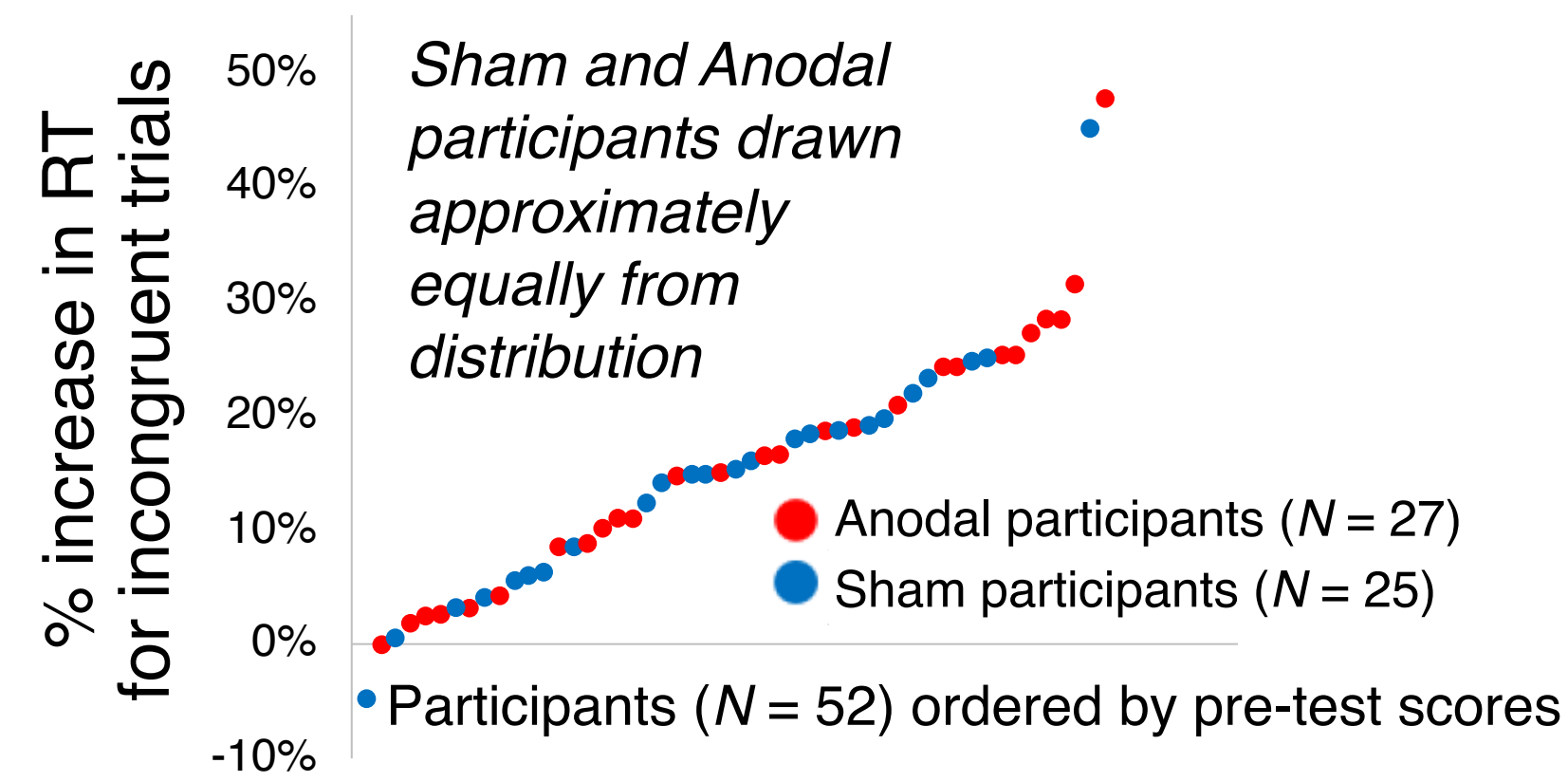
Future

- Test montage which current modeling suggests may better stimulate PFC: anode placed posterior to PFC, so midpoint of current is over PFC (Datta et al., 2012)

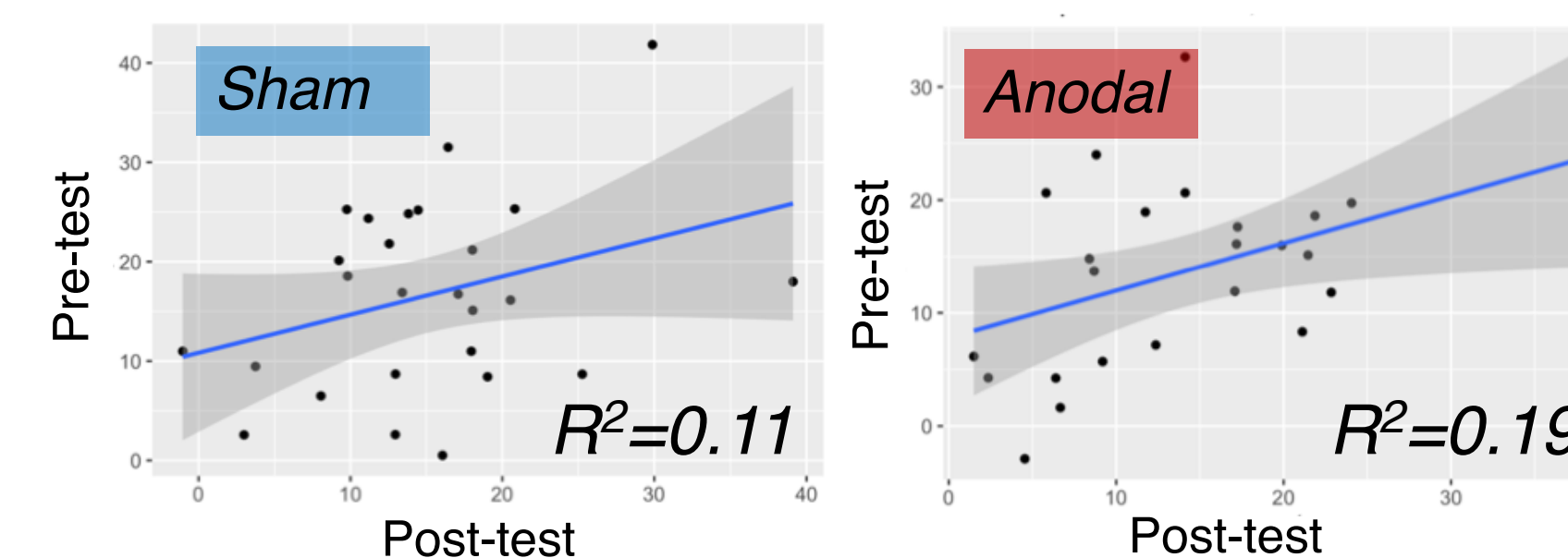
Stroop: No tDCS induced changes from pre- to post- test:



Broad range of Stroop pre-test scores across participants also, but:



For Stroop, test-retest reliability was not very good... Suggesting that, if it exists, an effect of tDCS on Stroop would be hard to detect (i.e., individual performance may be unstable and thus an unreliable dependent variable)



Datta, et al. (2012). Inter-individual variation during transcranial direct current stimulation and normalization of dose using MRI-derived computational models. *Frontiers in Psychiatry*, 3, 1-9.
 Imburgio MJ, Orr JM. (2018). Effects of prefrontal tDCS on executive function: Methodological considerations revealed by meta-analysis. *Neuropsychologia*. 117:156-166.
 Keye, et al. (2009). Individual differences in conflict-monitoring: Testing means and covariance hypothesis about the Simon and the Eriksen Flanker task. *Psychological Research*, 73, 762-776.
 Miller, E. K., & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Reviews Neuroscience*, 24, 167-202.