

# Electrical stimulation of human prefrontal cortex improves multitasking

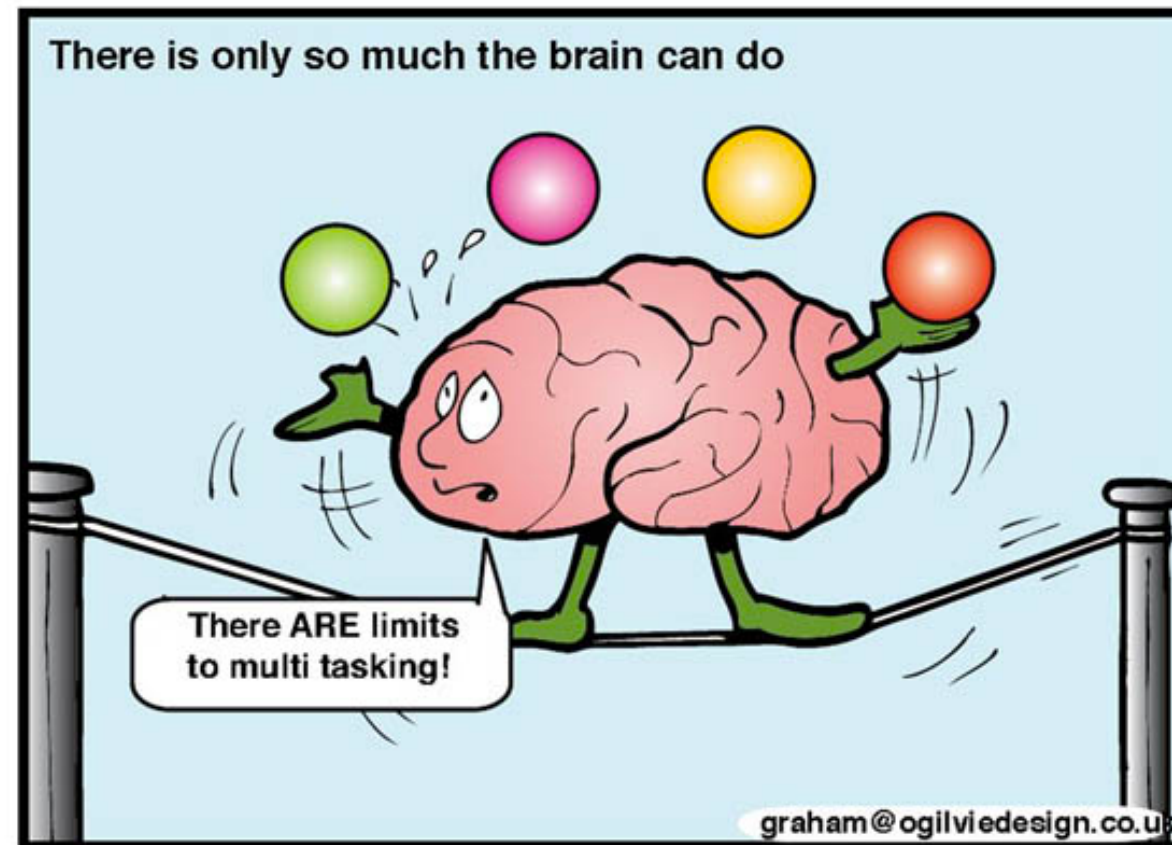
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Paul E. Dux

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ICON Brisbane  
July 2014



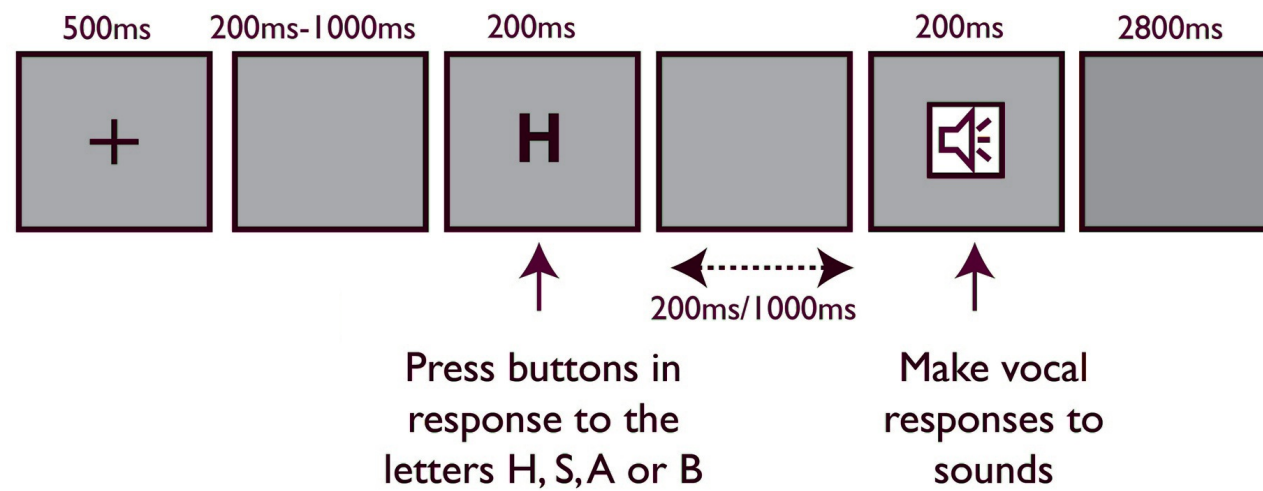
# Decision making limits



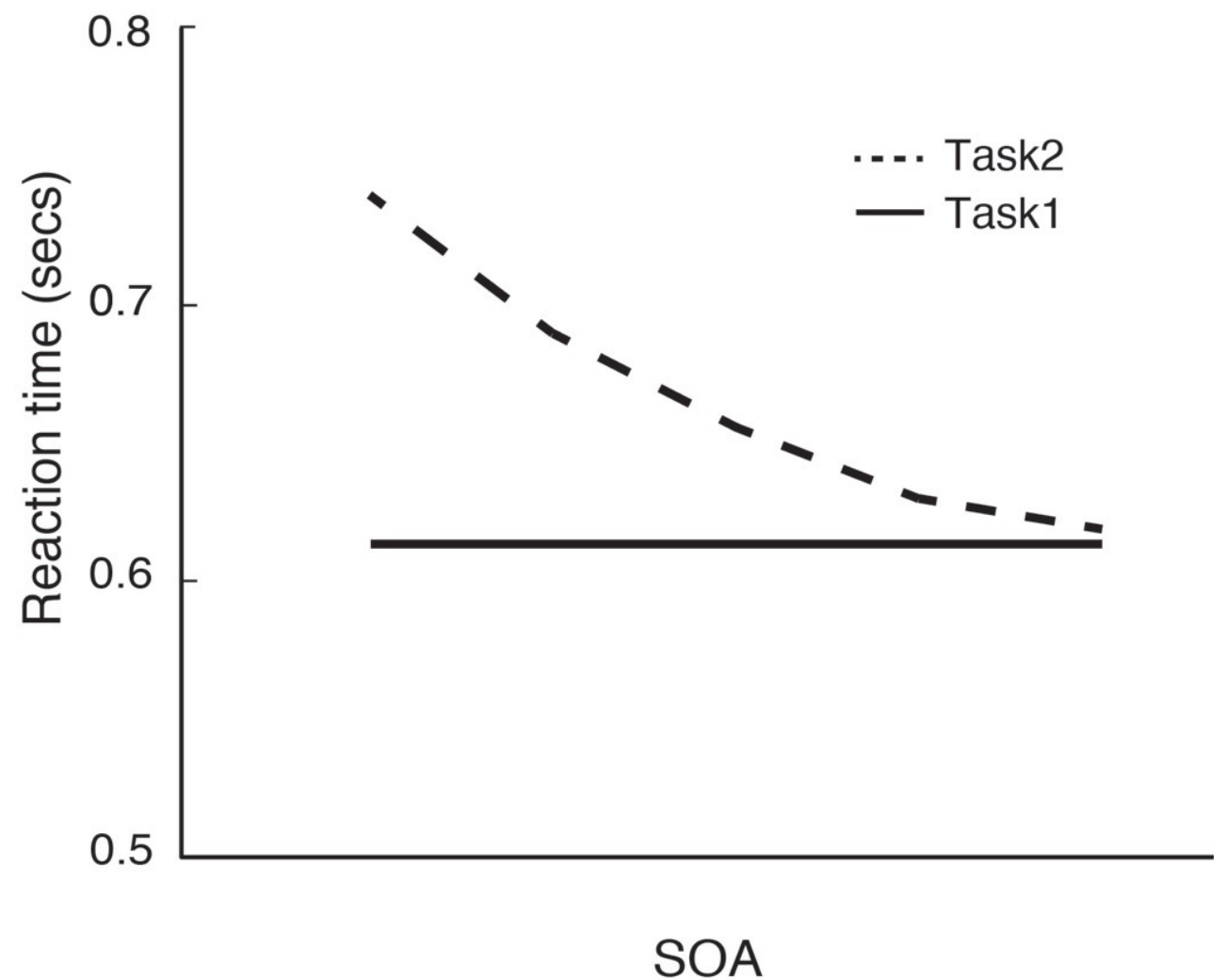
- We are capable of making complex decisions, and do so everyday
- BUT under time pressure, or if making two decisions at the same time, decision making abilities are limited

# Decision making limits

- Limits to decision making can be studied with multitasking paradigms like the PRP, and with single task paradigms where the difficulty to choose is manipulated
- These paradigms are thought to tap a very basic form of decision making - response selection

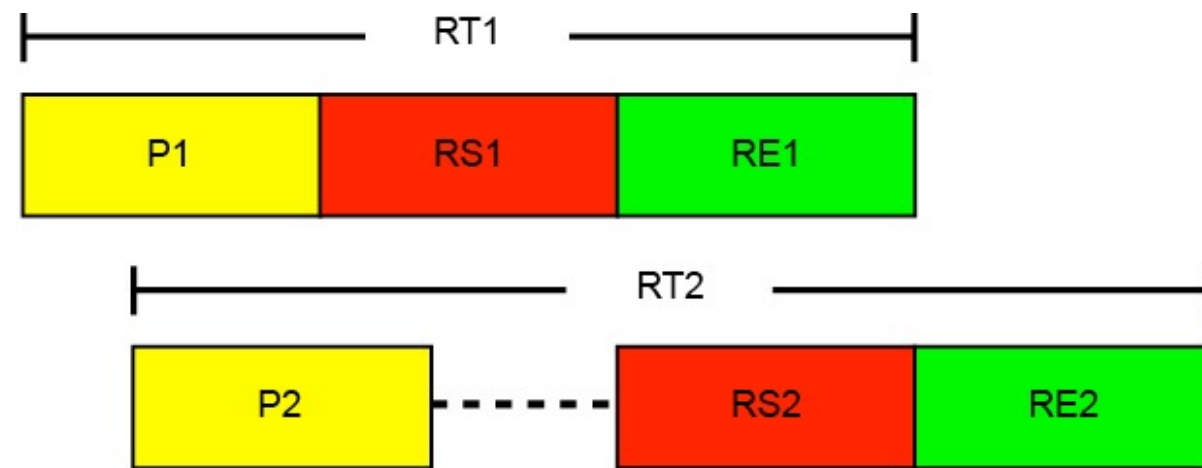


# Psychological Refractory Period (PRP)



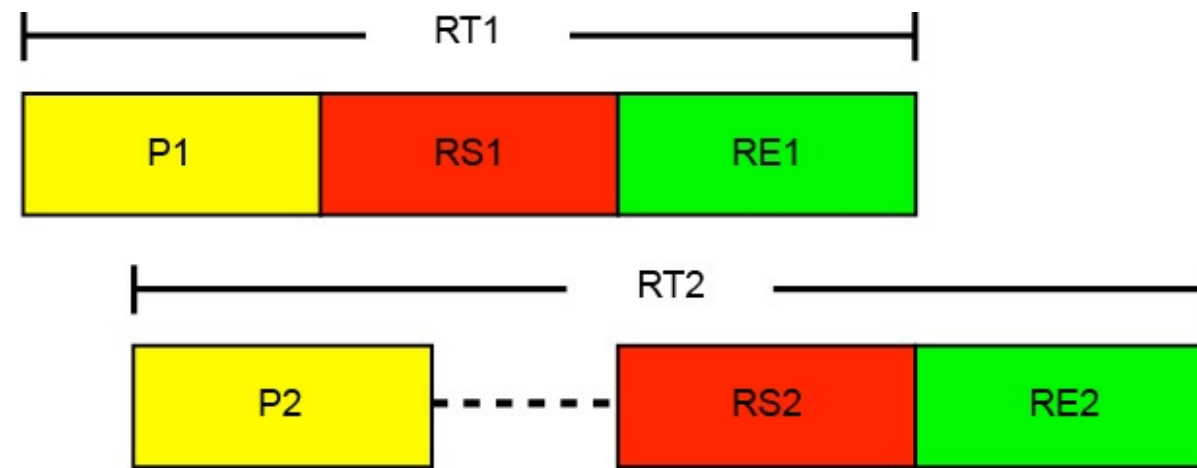
# Response selection bottleneck

Short SOA

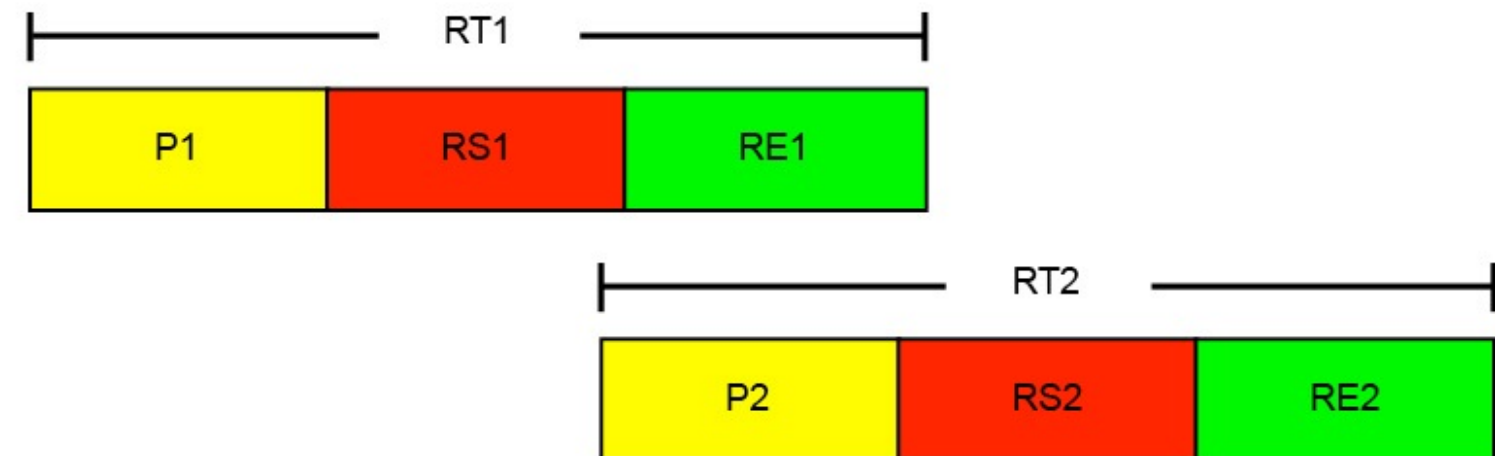


# Response selection bottleneck

Short SOA



Long SOA



# Decision making limits

Training can reduce response selection capacity limits and improve how well people can make decisions and perform tasks

# Response selection in the brain

- Several experiments have now used fMRI to investigate the neural locus of response selection
- Results converge on an area of the posterior lateral prefrontal cortex (pLPFC), likely to be a lateralisation to the left hemisphere
- Training experiments have found the left pLPFC is involved in performance improvements



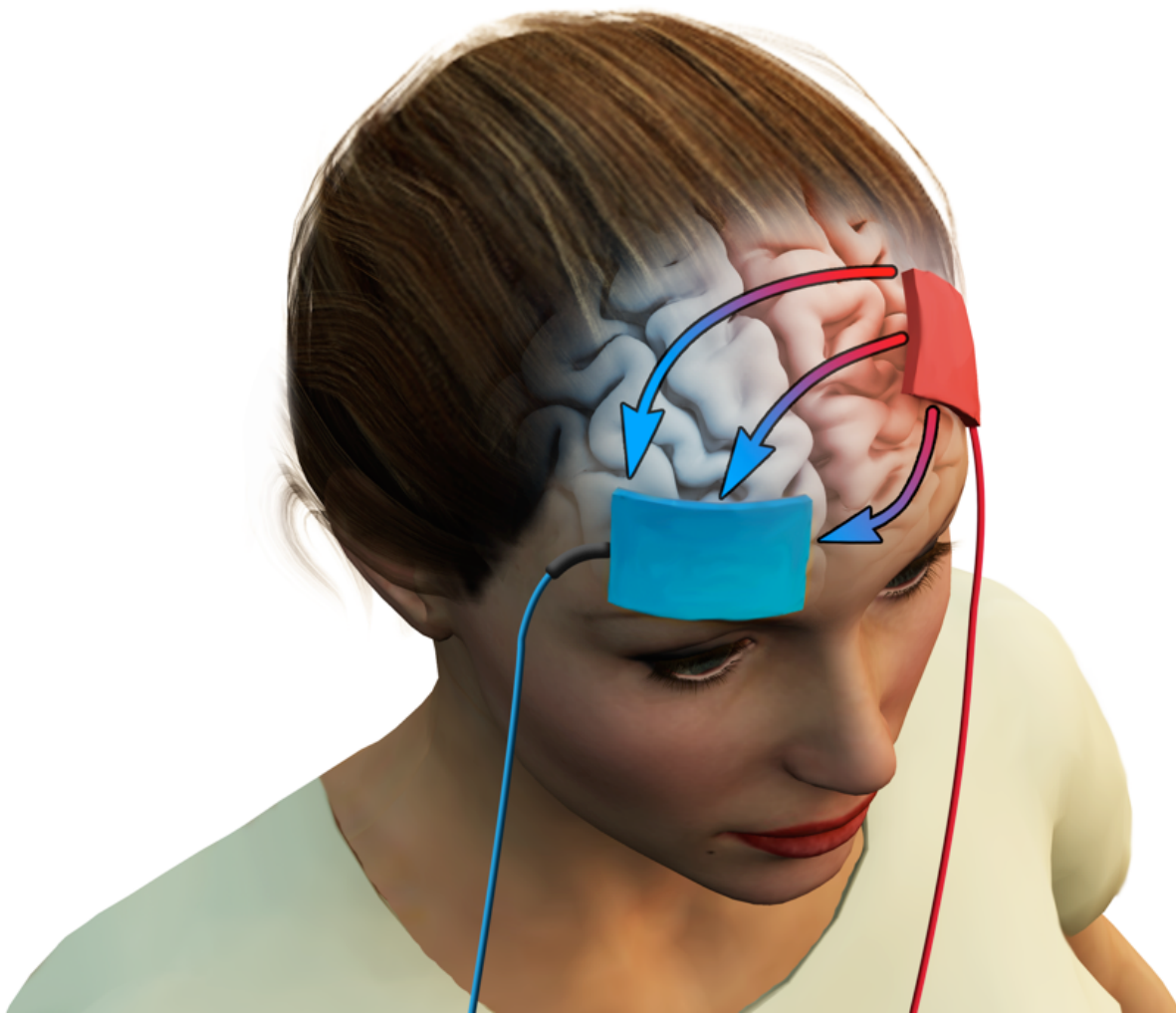
# Transcranial direct current stimulation (tDCS)

Two electrodes - an anode and a cathode

Increased cortical excitability with anodal stimulation

Decreased cortical excitability with cathodal stimulation

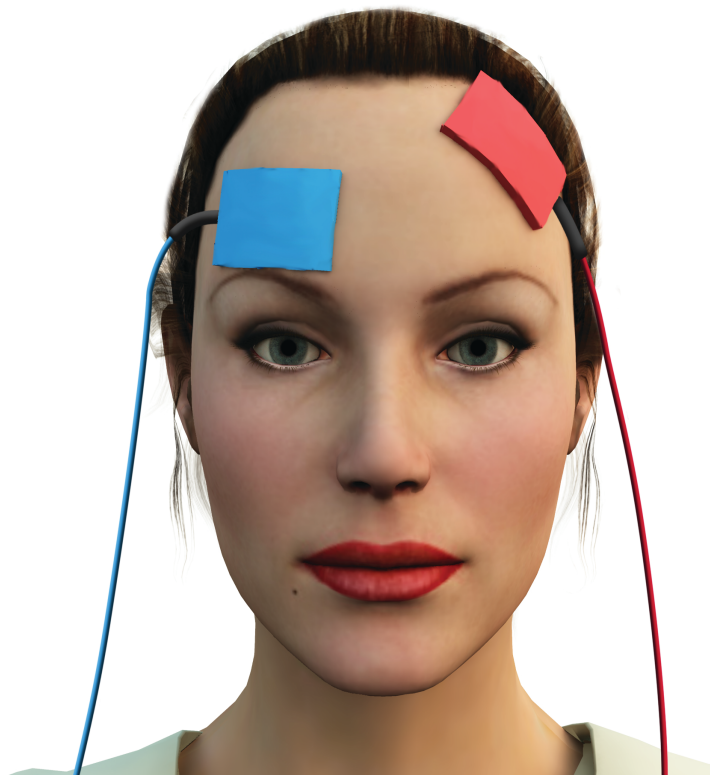
0.7mA, 9 minutes, 25cm<sup>2</sup> electrodes



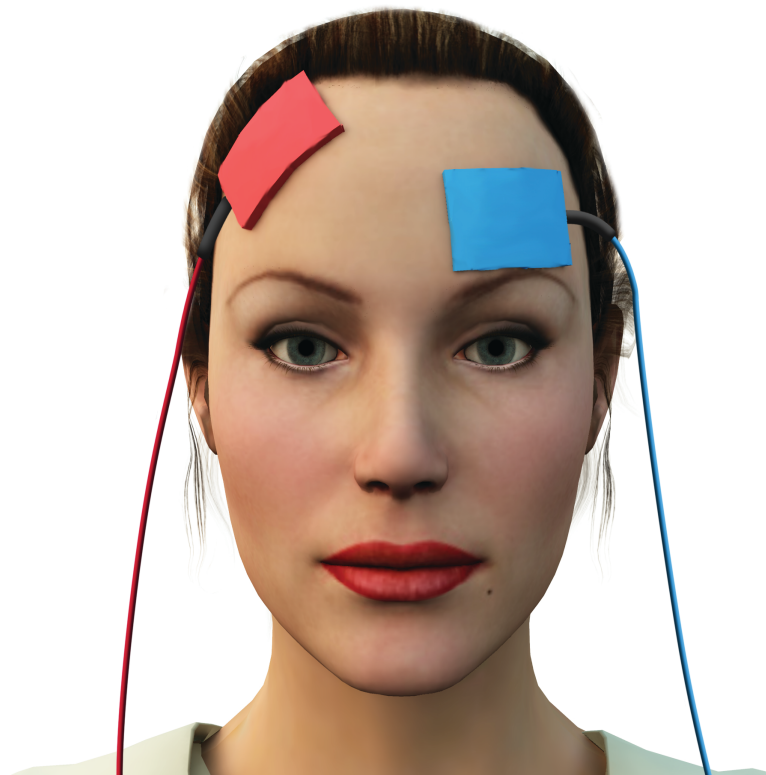
# Causal evidence for left pLPFC involvement in response selection - tDCS

- High (6AD) and low (2AD) response selection load conditions
- Complete blocks before, immediately after, and 20 minutes after tDCS intervention
- Three sessions - participants had new stimuli in each session and received a different type of stimulation
- Stimulation = anodal, cathodal, & sham
- Stimuli = coloured circles, symbols, or sounds

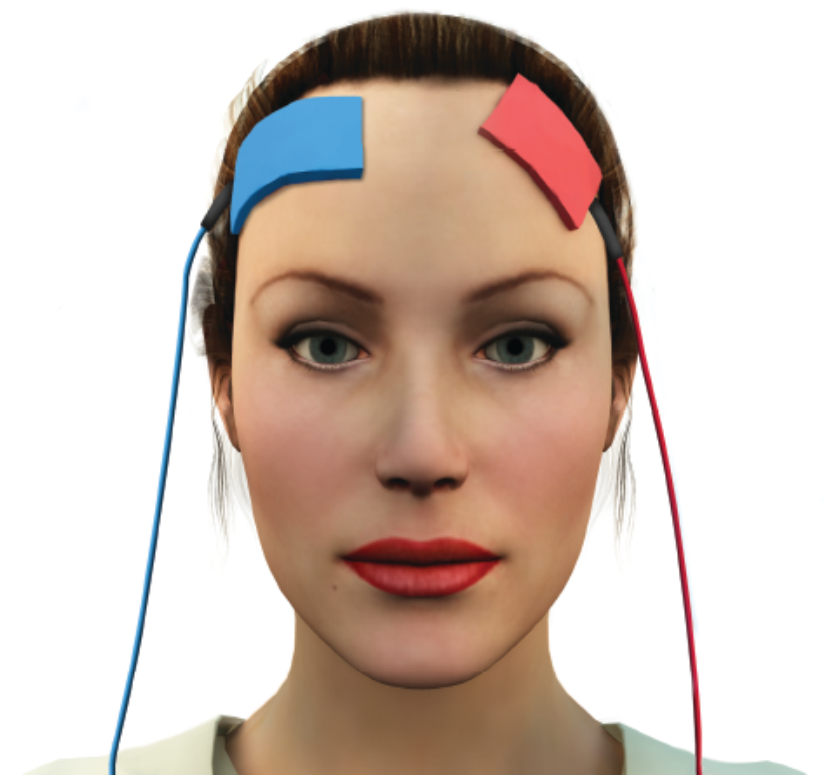
# Three experiments...



Left PFC

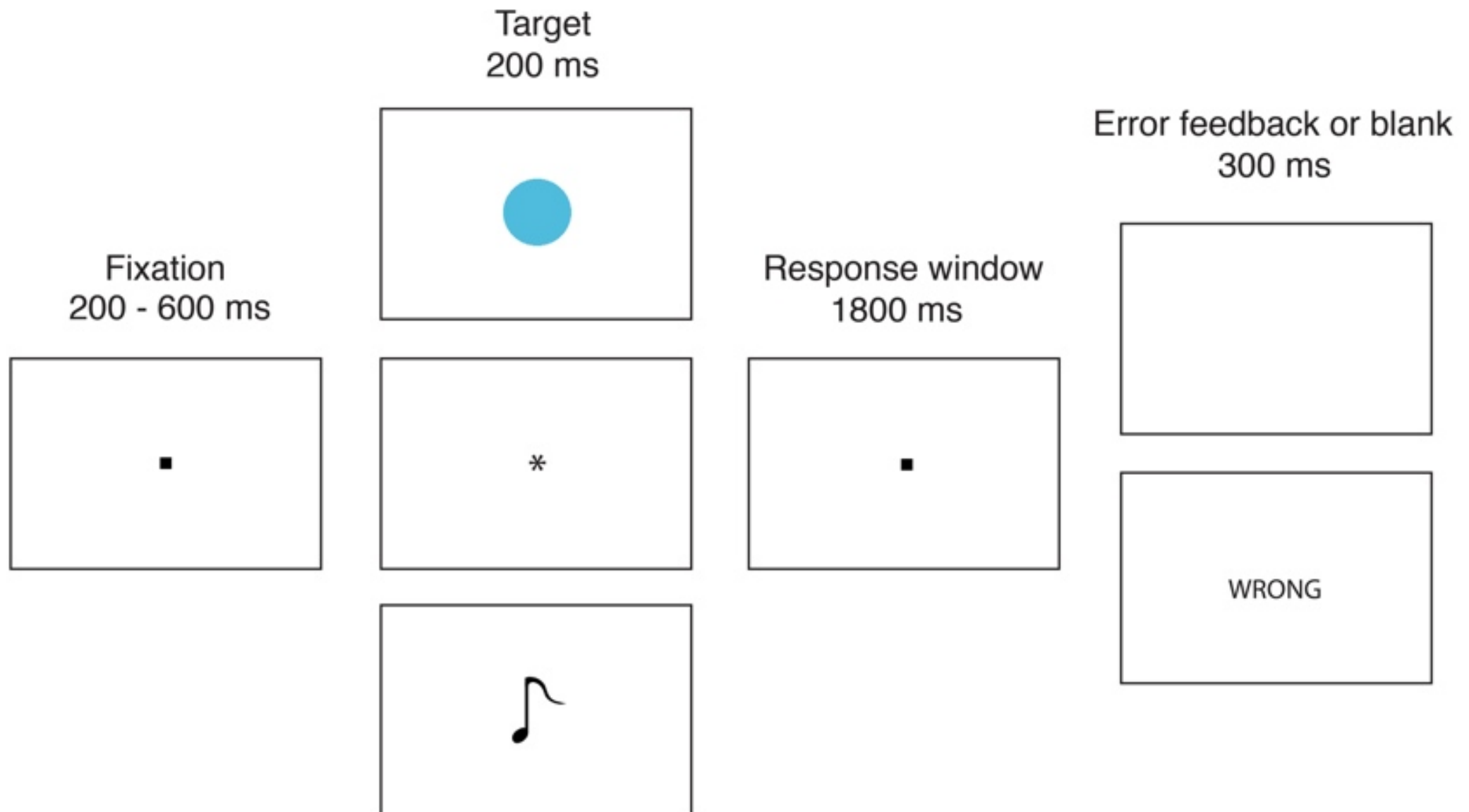


Right PFC

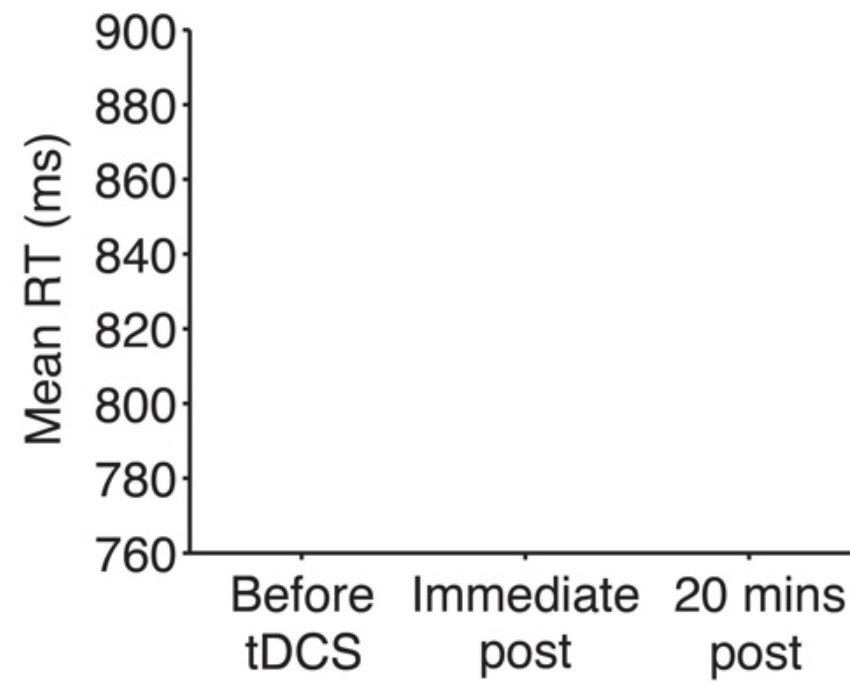


Left PFC

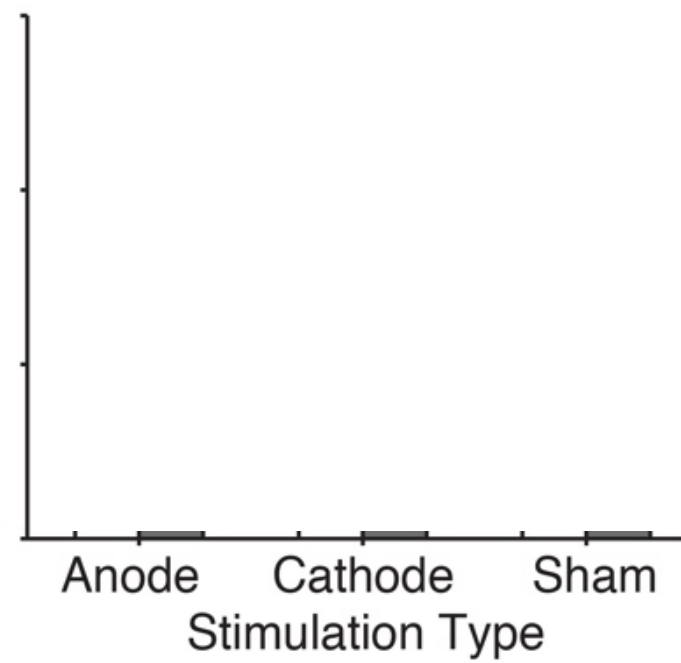
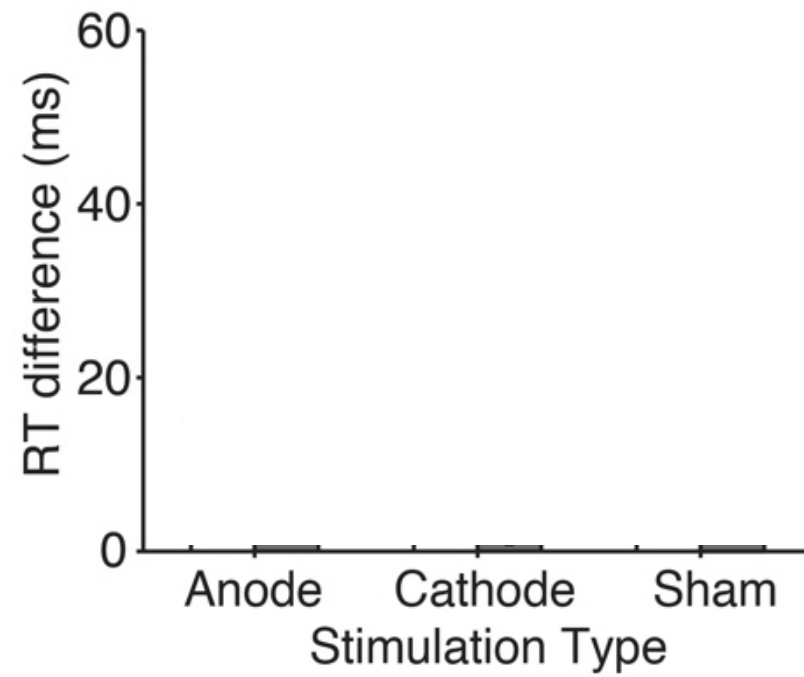
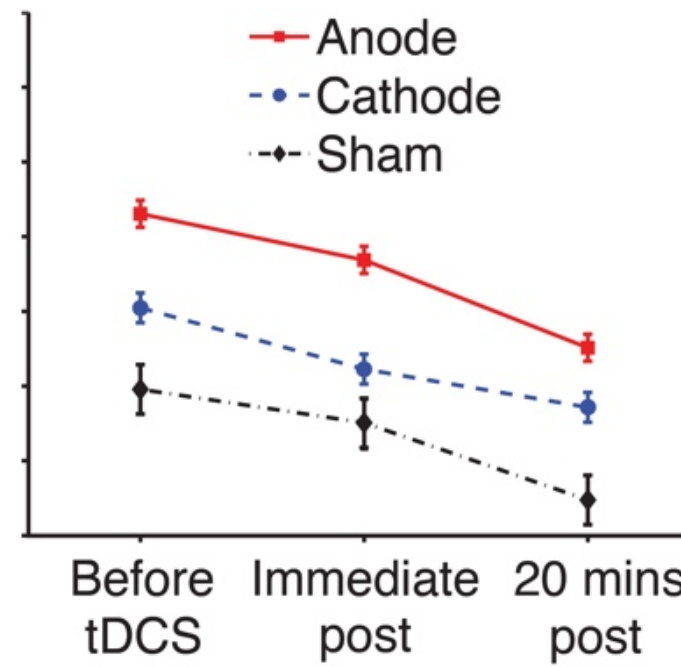
# Trial outline



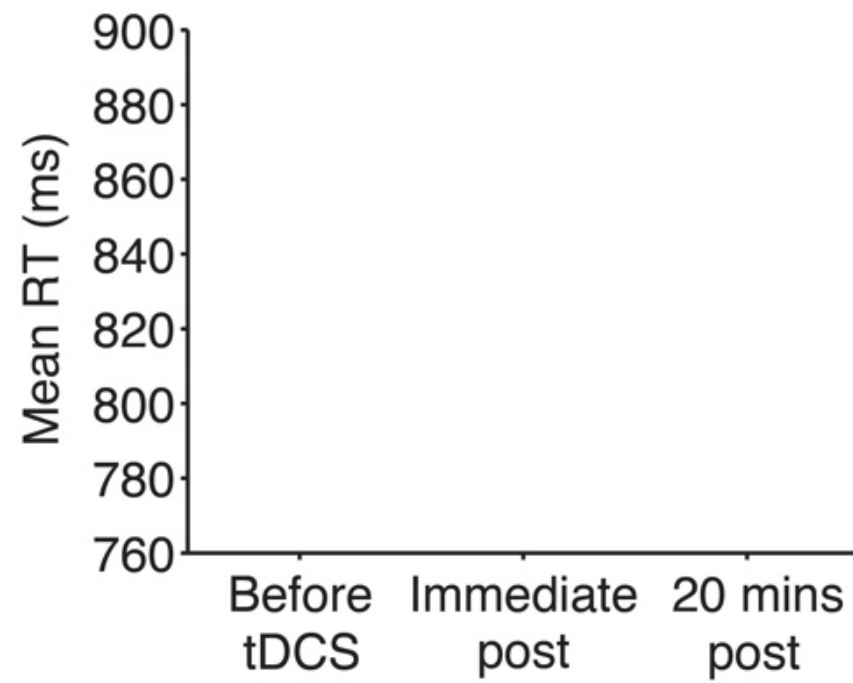
Left PFC



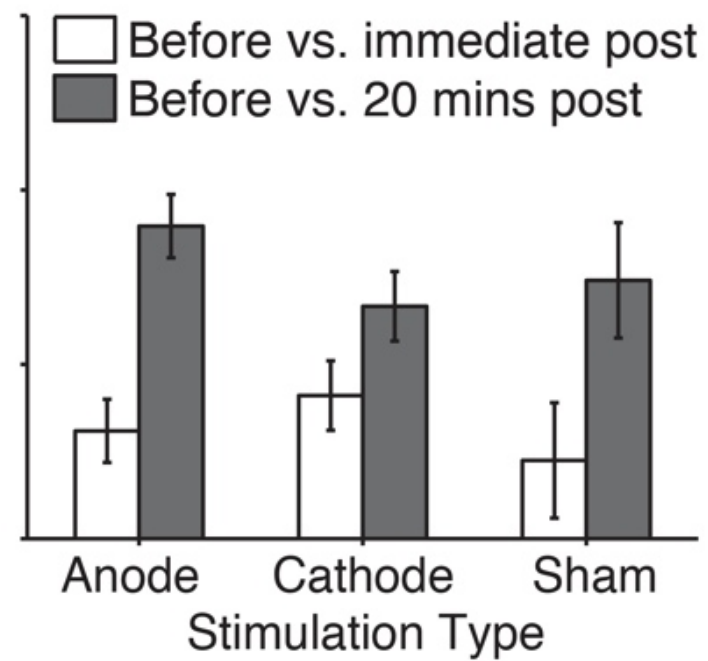
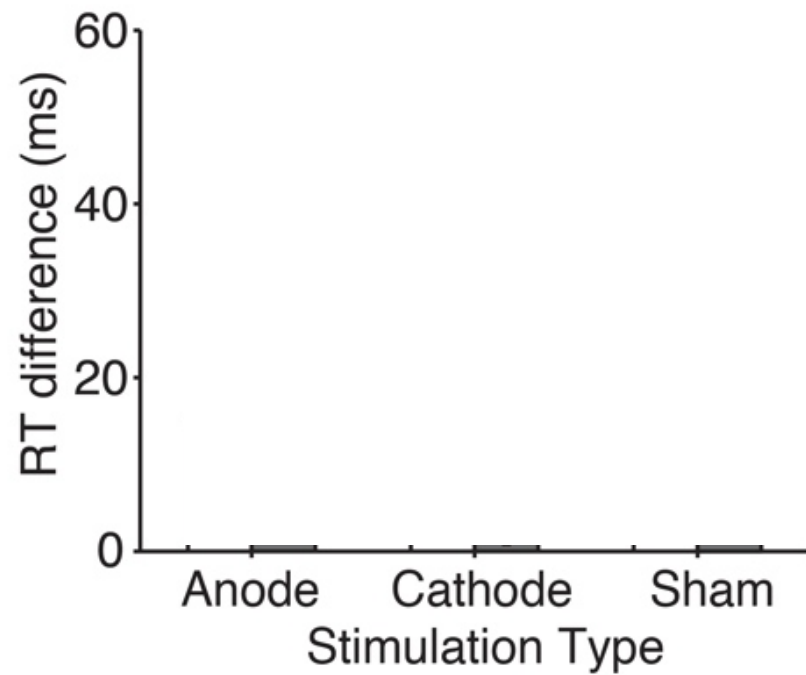
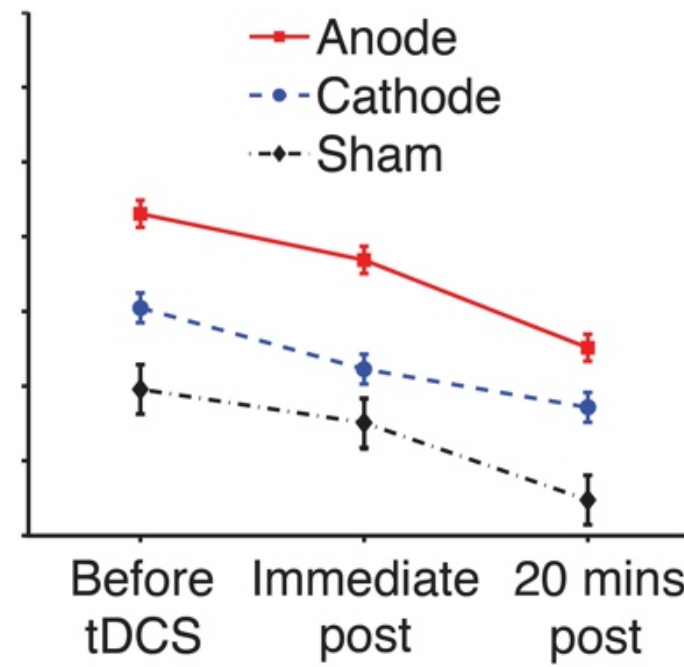
Right PFC



## Left PFC

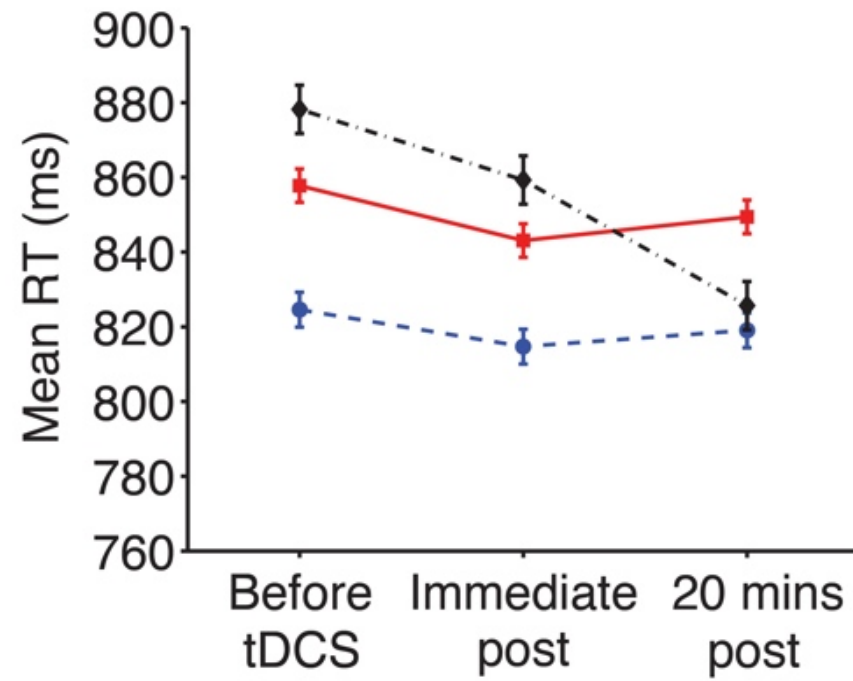


## Right PFC

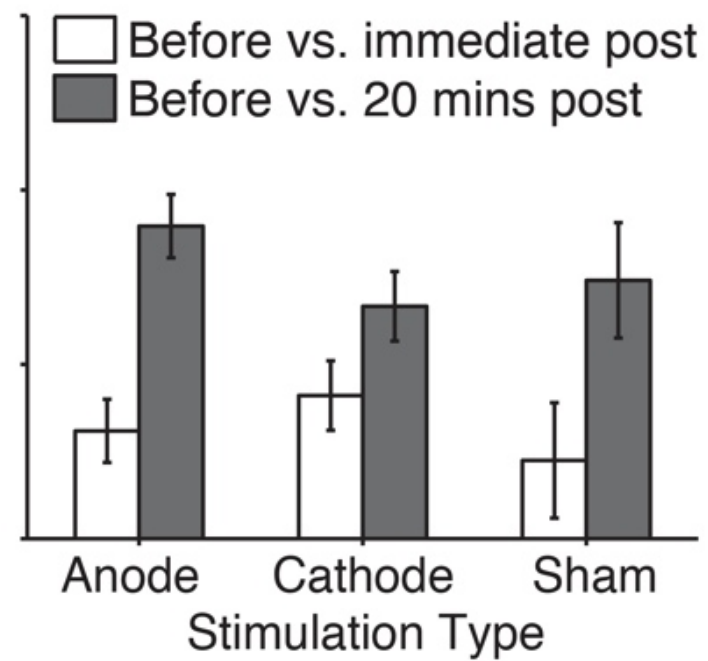
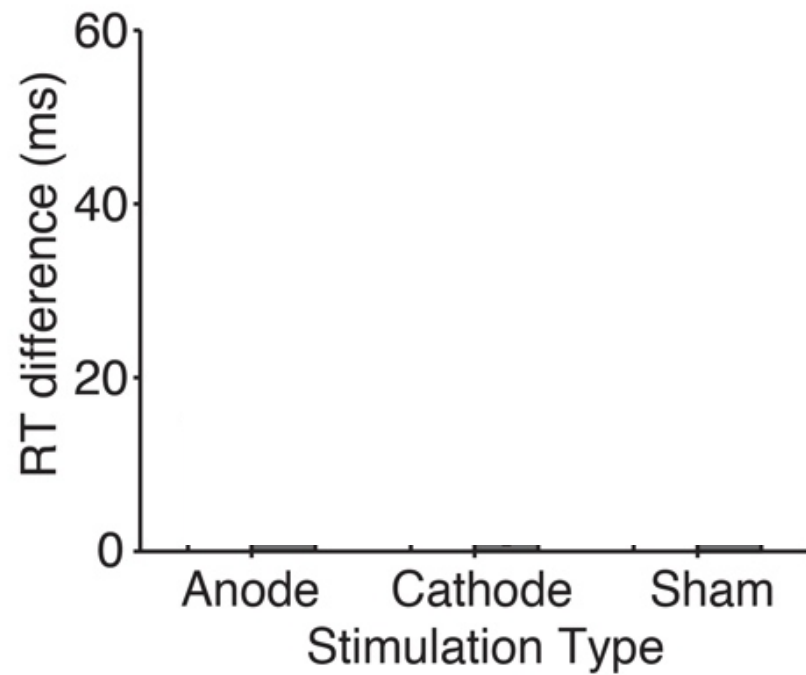
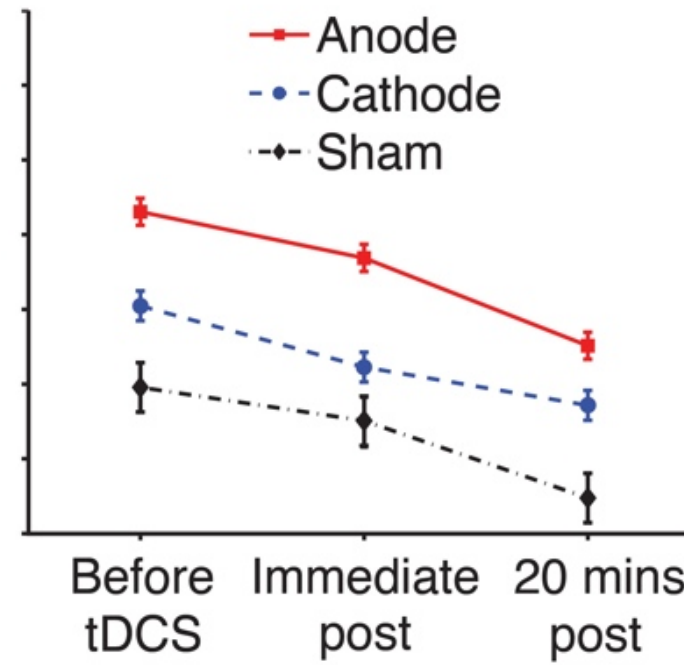




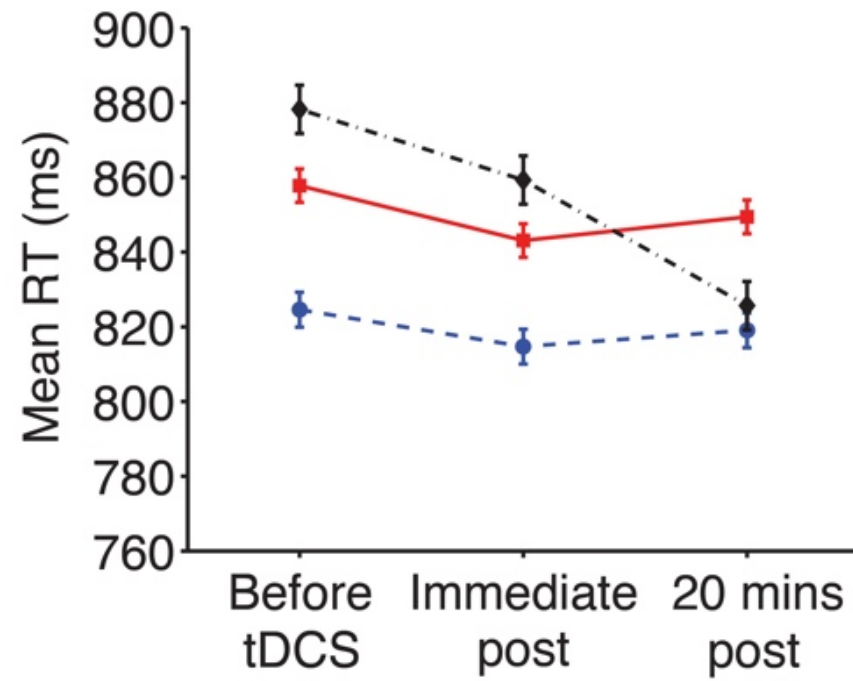
Left PFC



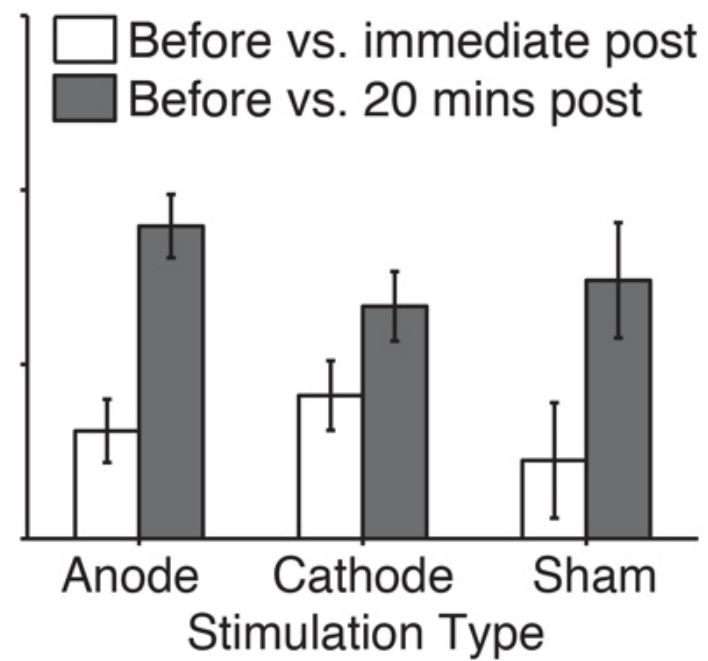
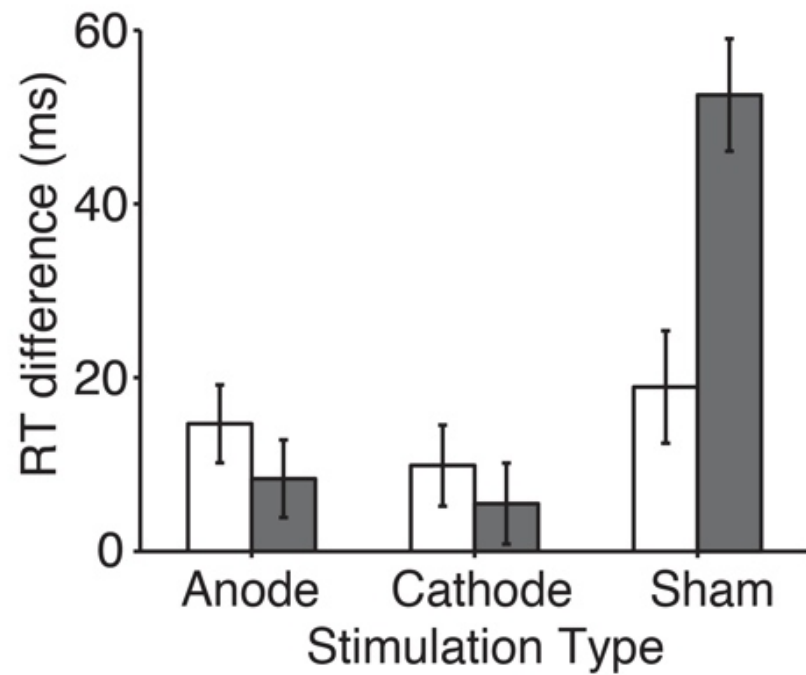
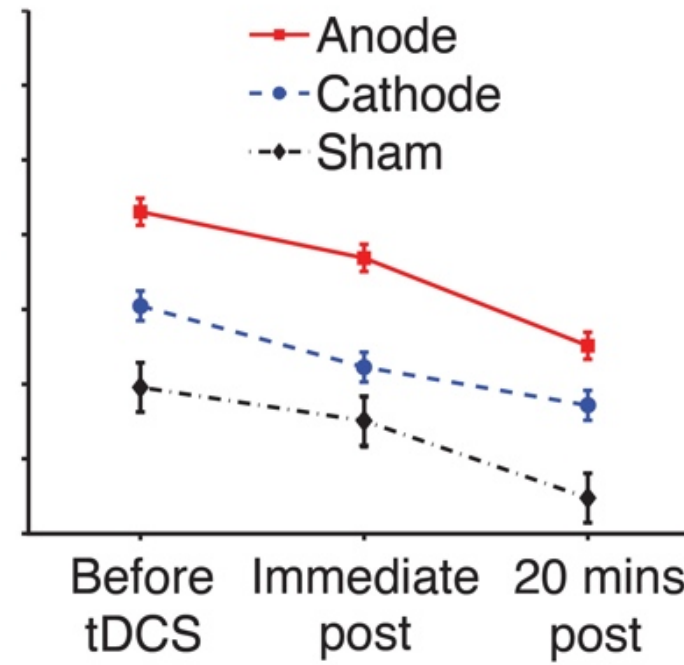
Right PFC



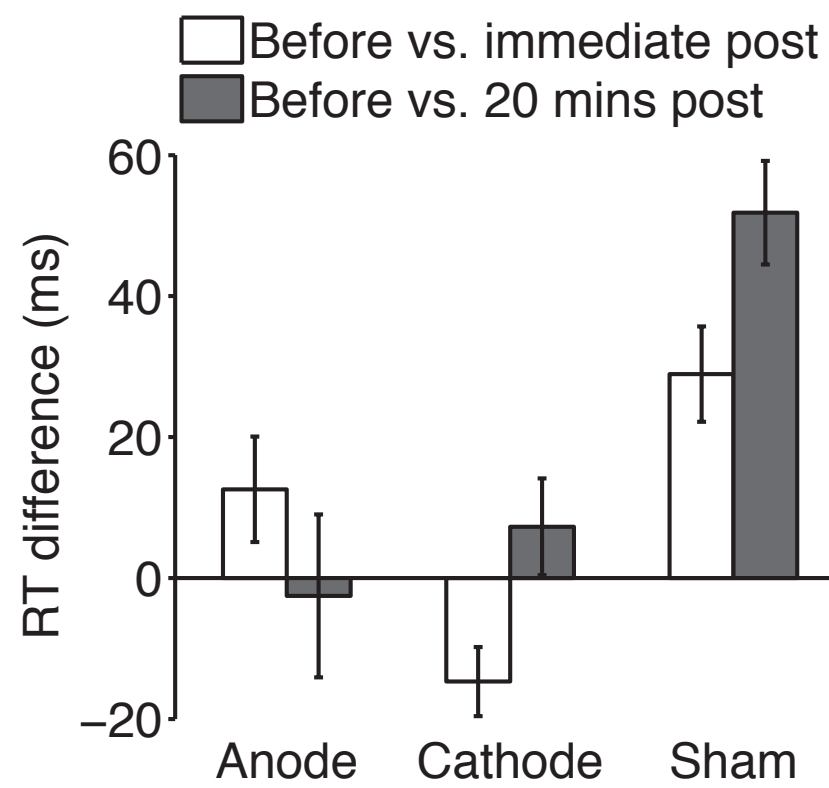
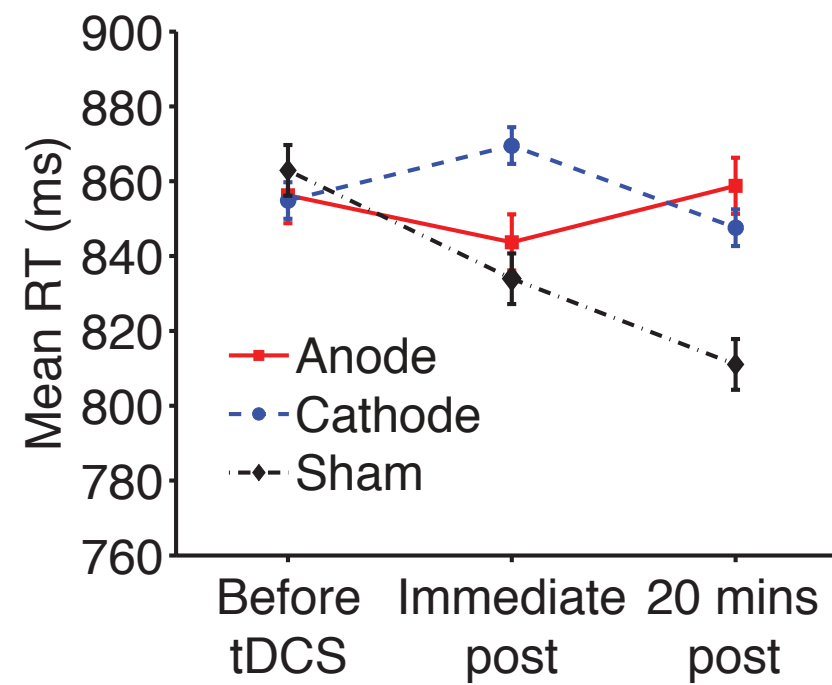
Left PFC



Right PFC







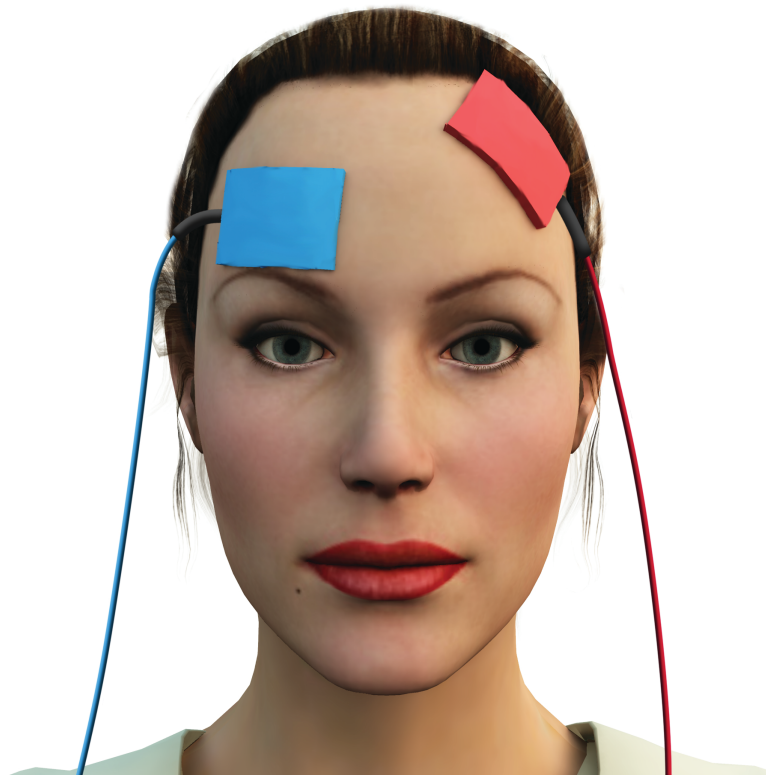
Stimulating the left PFC selectively disrupts  
response selection training

No causal evidence to date for involvement of  
the left PFC in dual task response selection

# Design

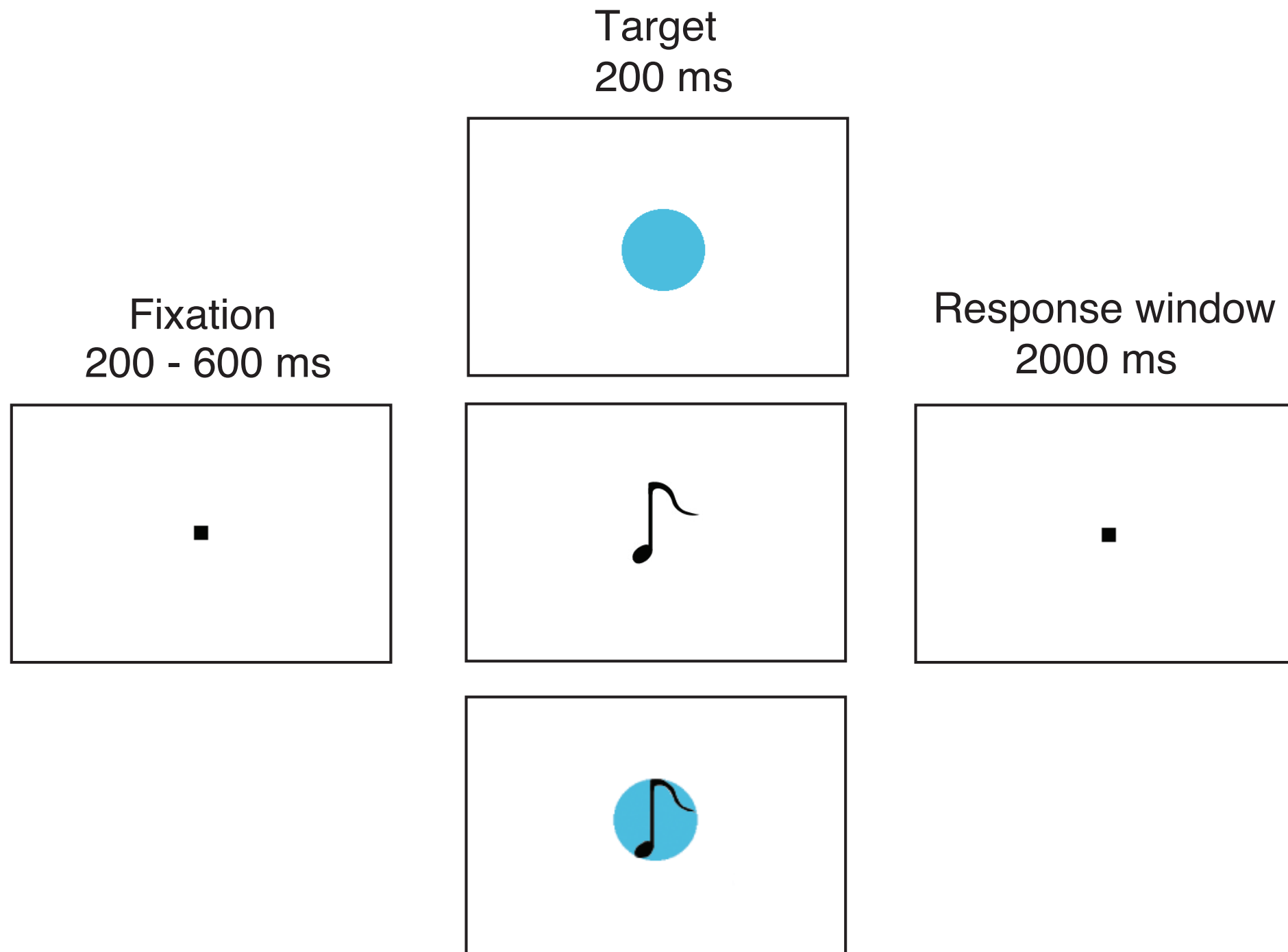
- Participants completed single and dual task trials before, immediately after, and 20 minutes after stimulation
- Three sessions, each one with a different type of stimulation - anodal, cathodal, and sham
- Two tasks - one discriminating between images, and one between sounds

# Electrode montage

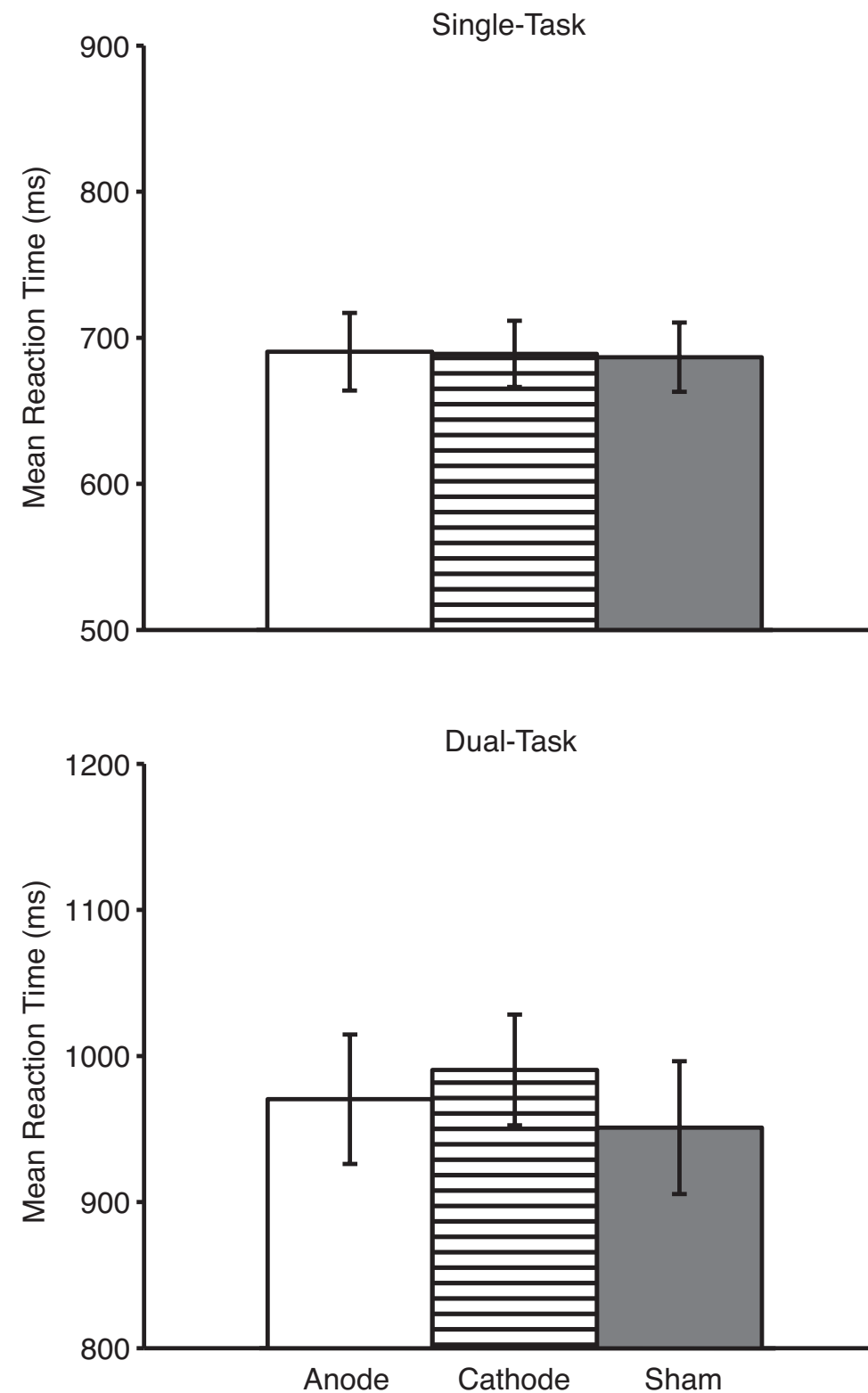


Left PFC

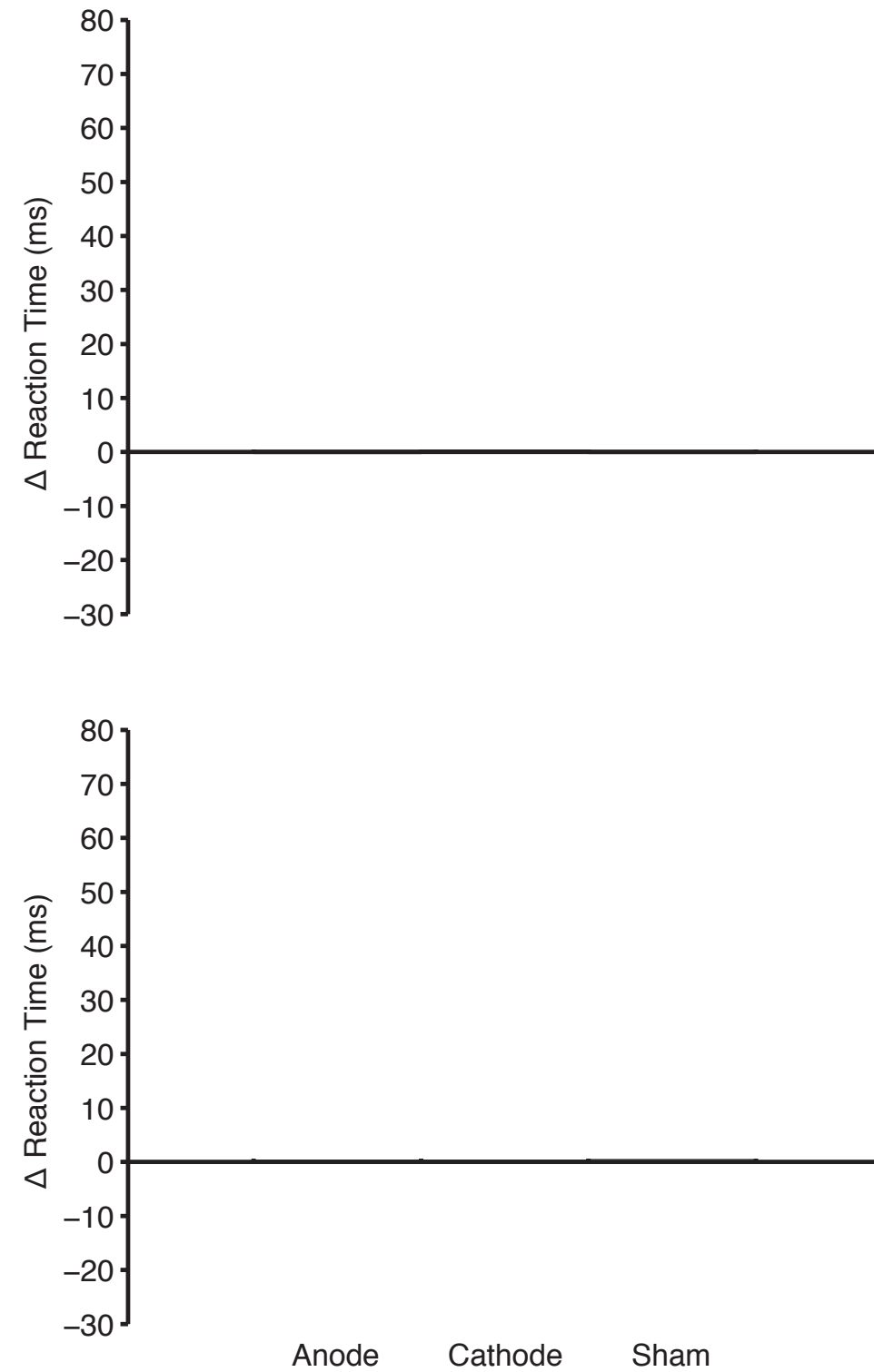
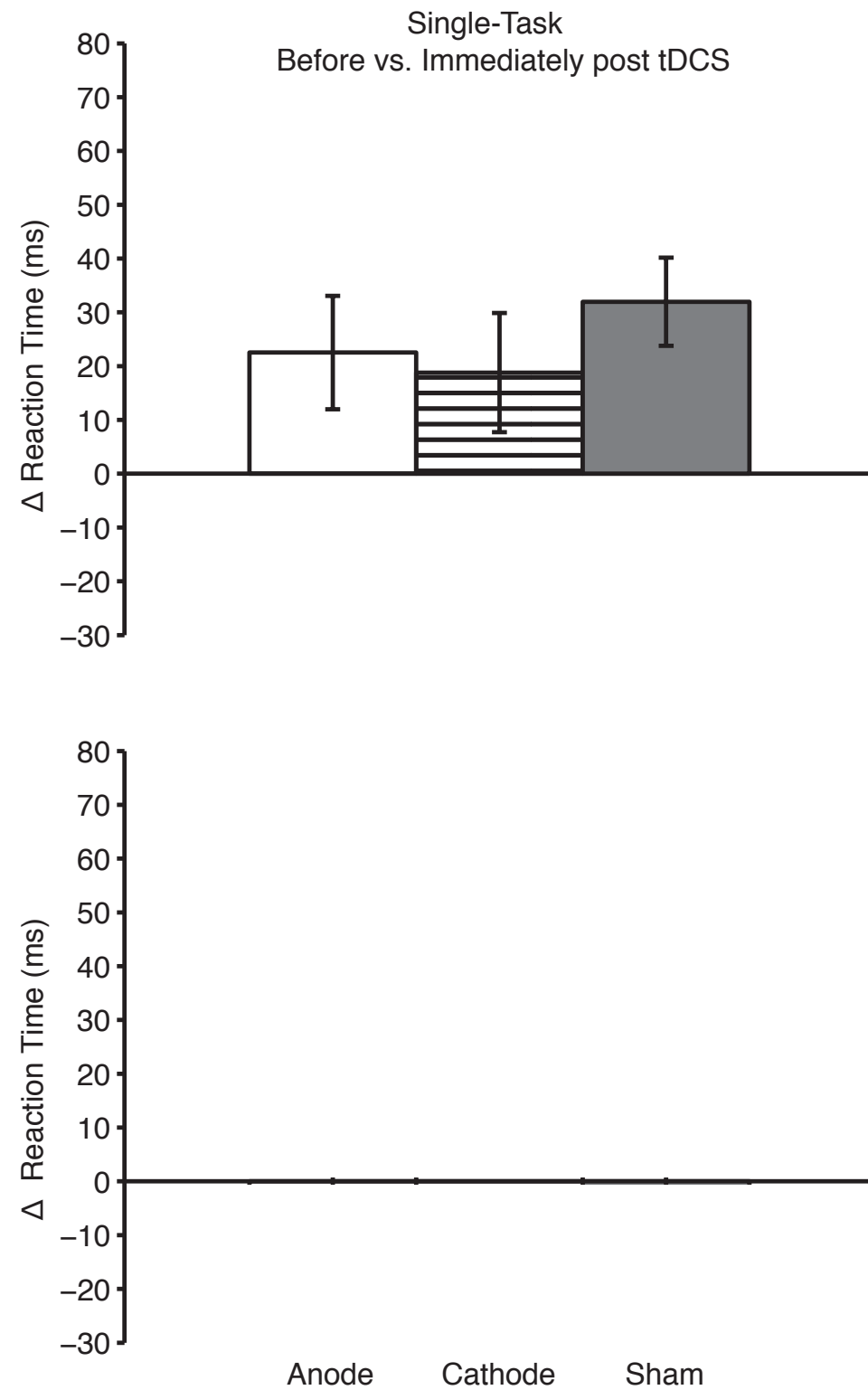
# Task outline



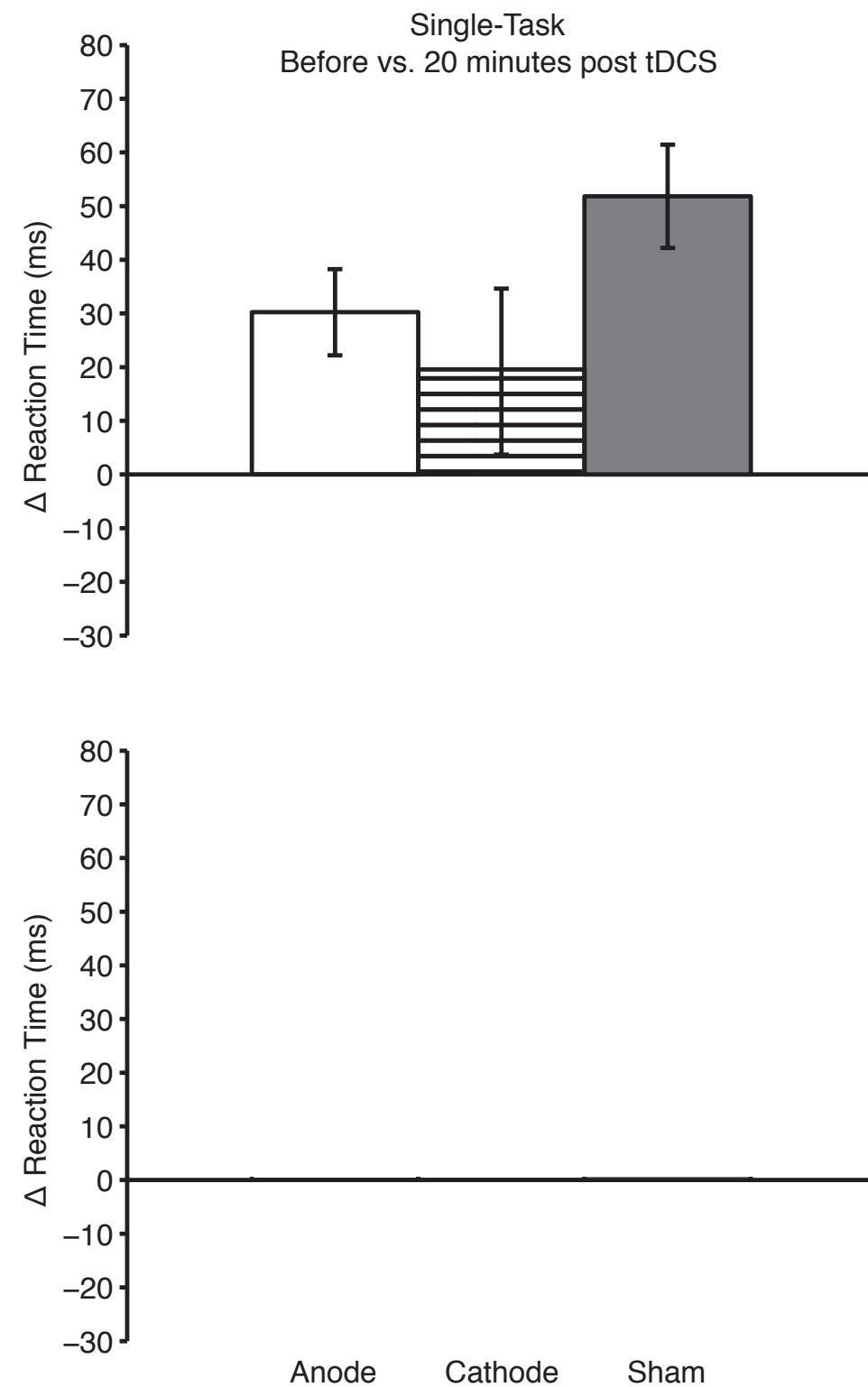
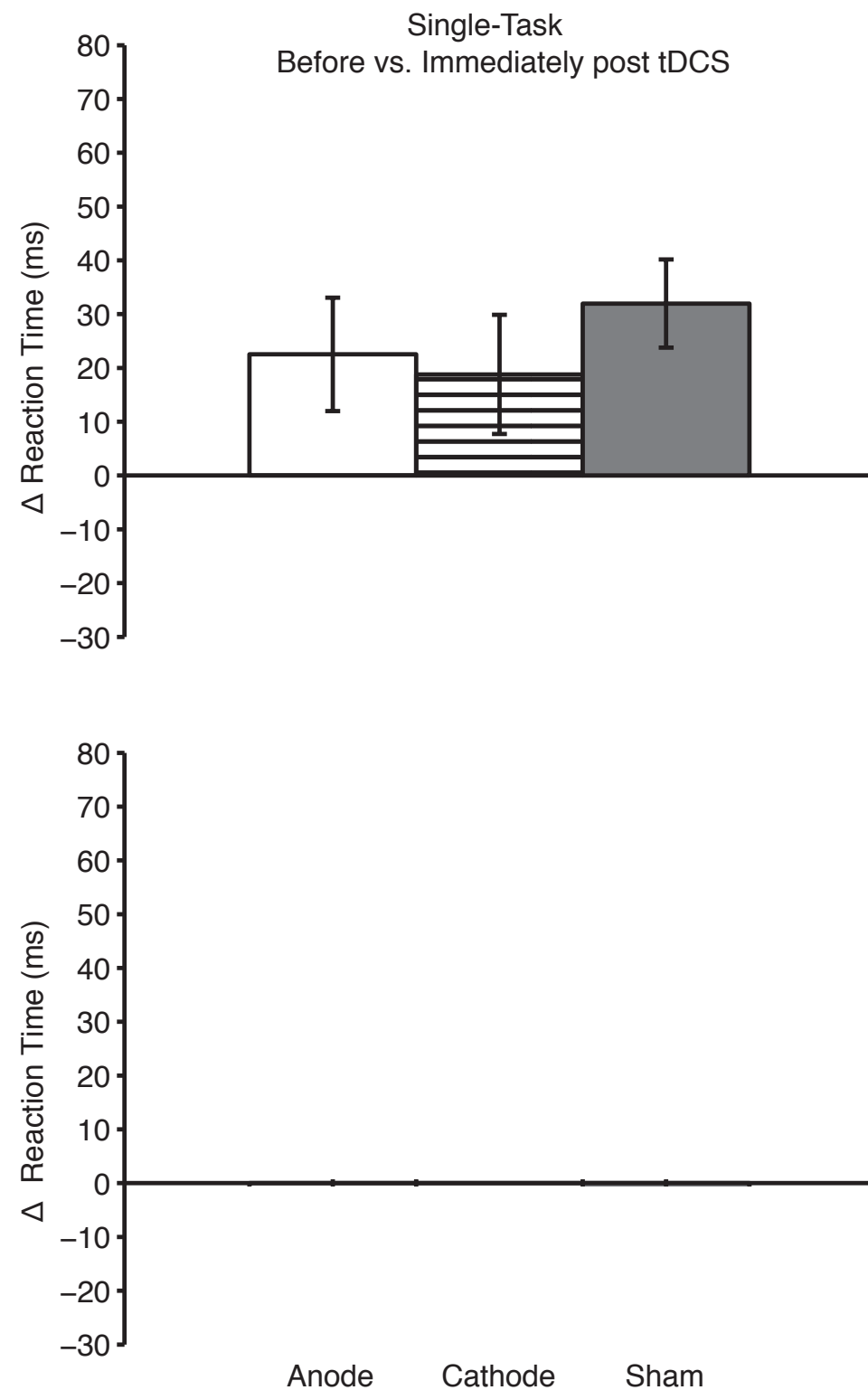
# Pre-tDCS baseline performance



# Reaction time changes post-tDCS

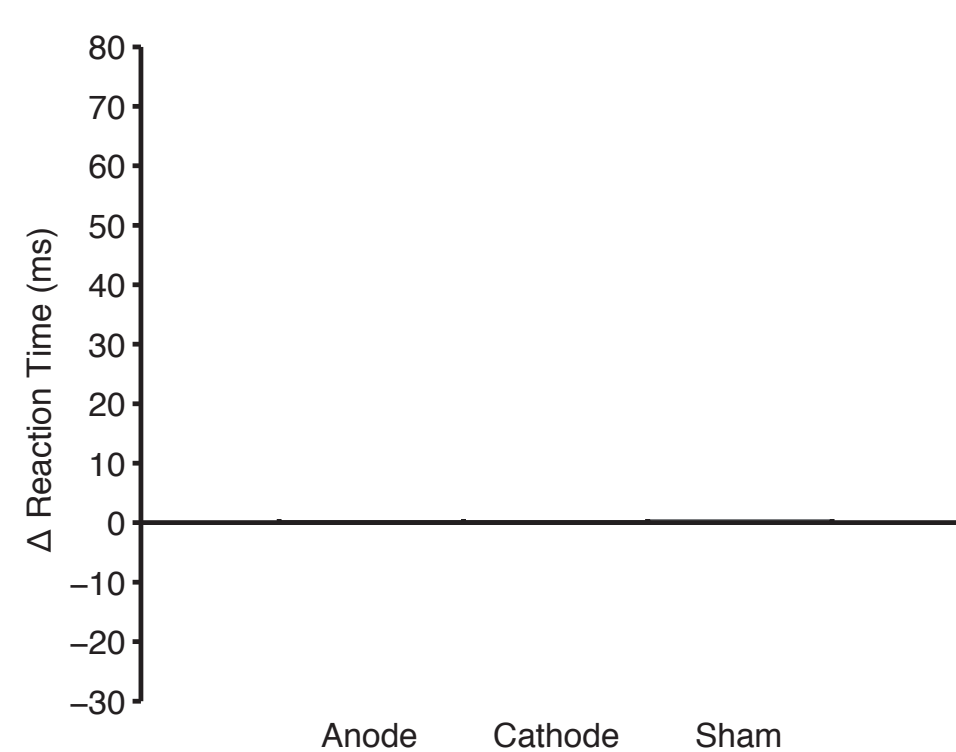
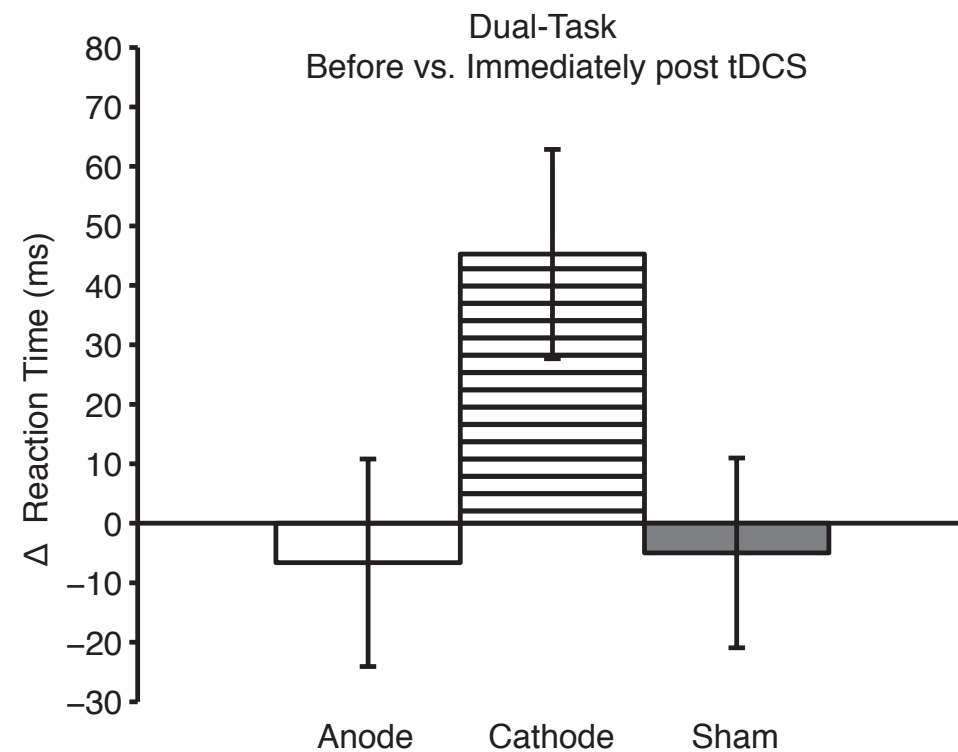
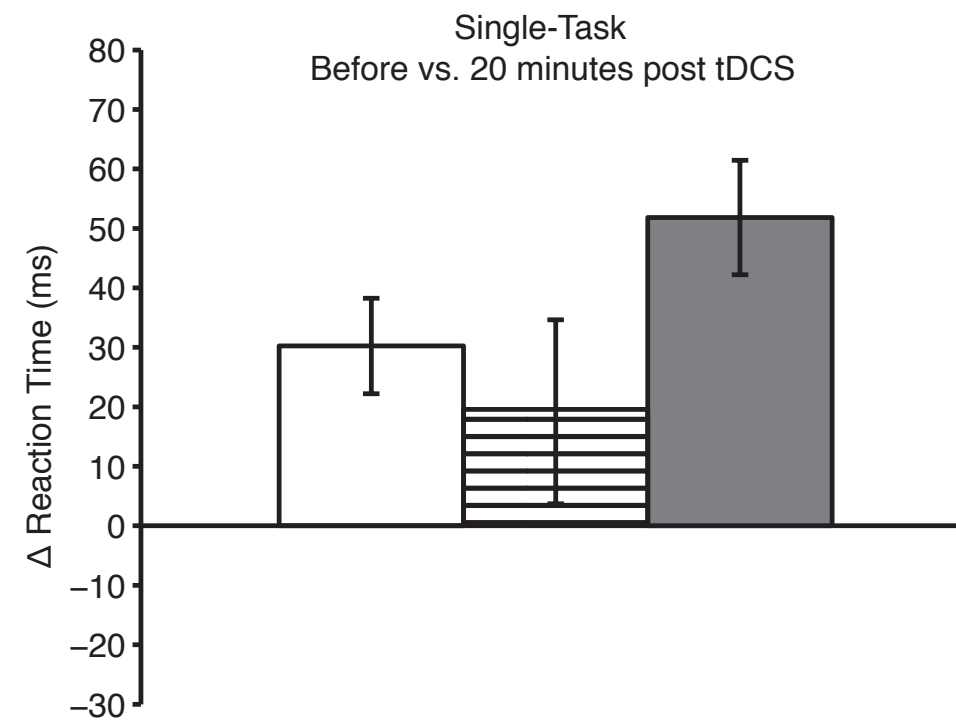
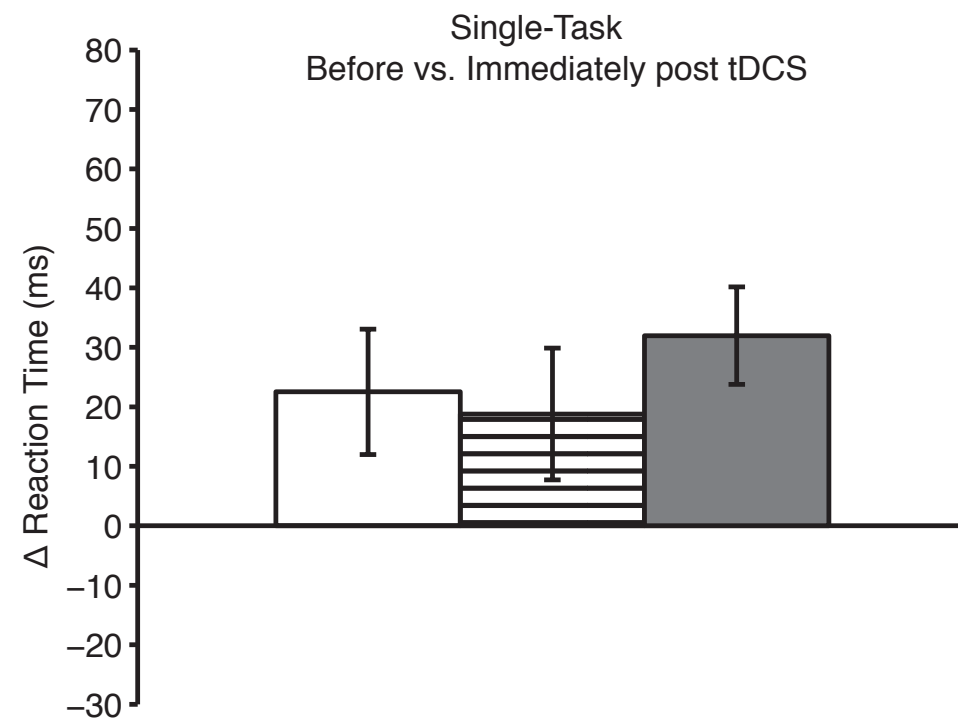


# Reaction time changes post-tDCS

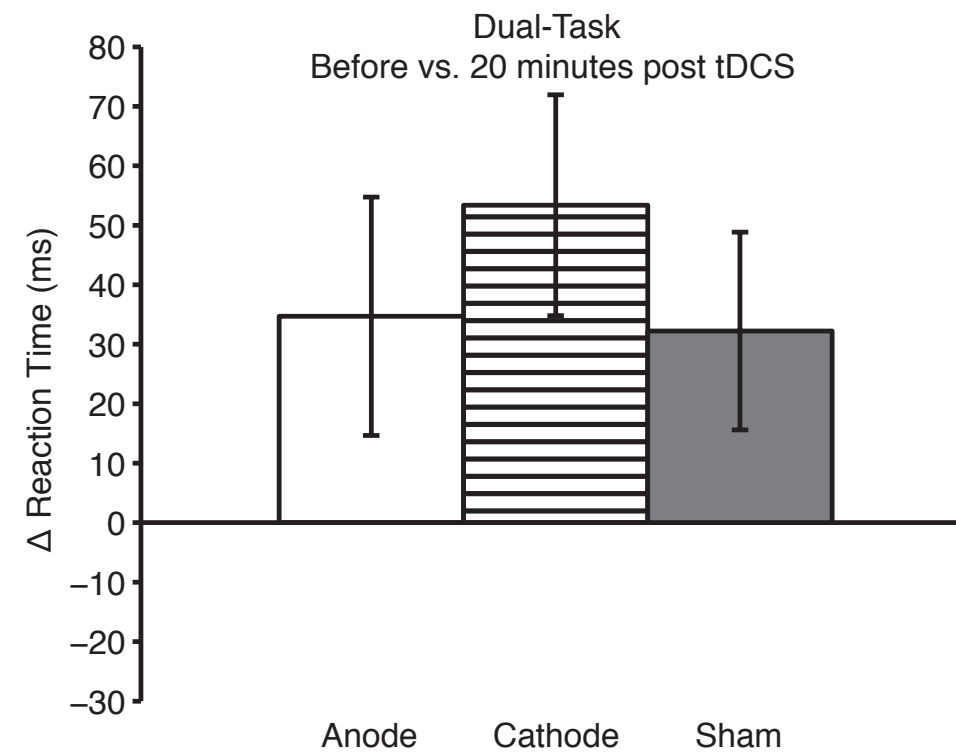
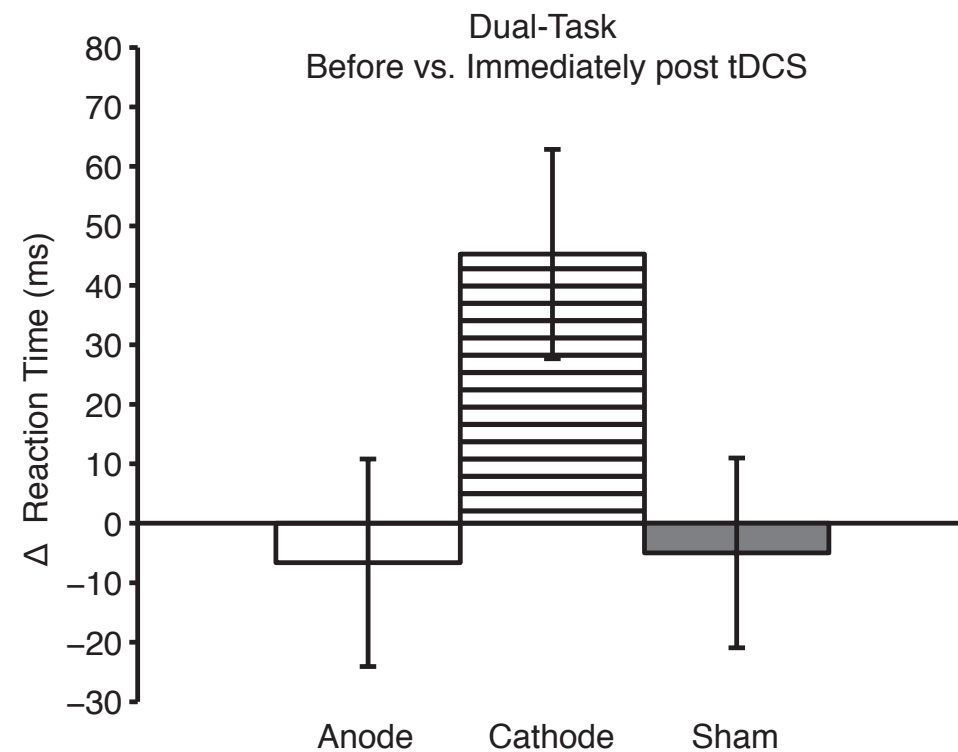
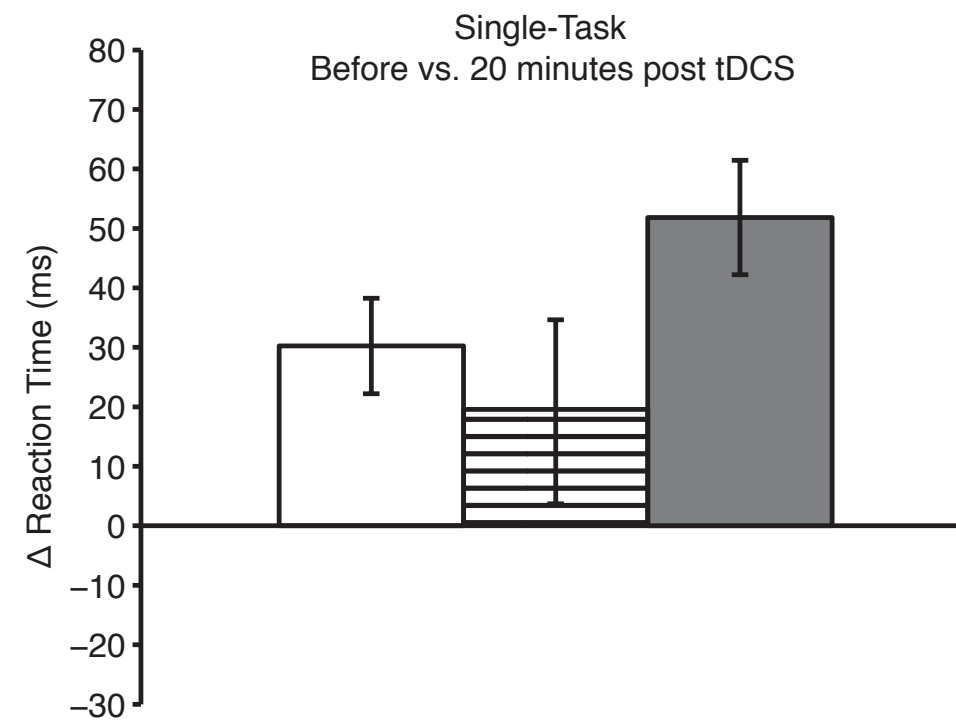
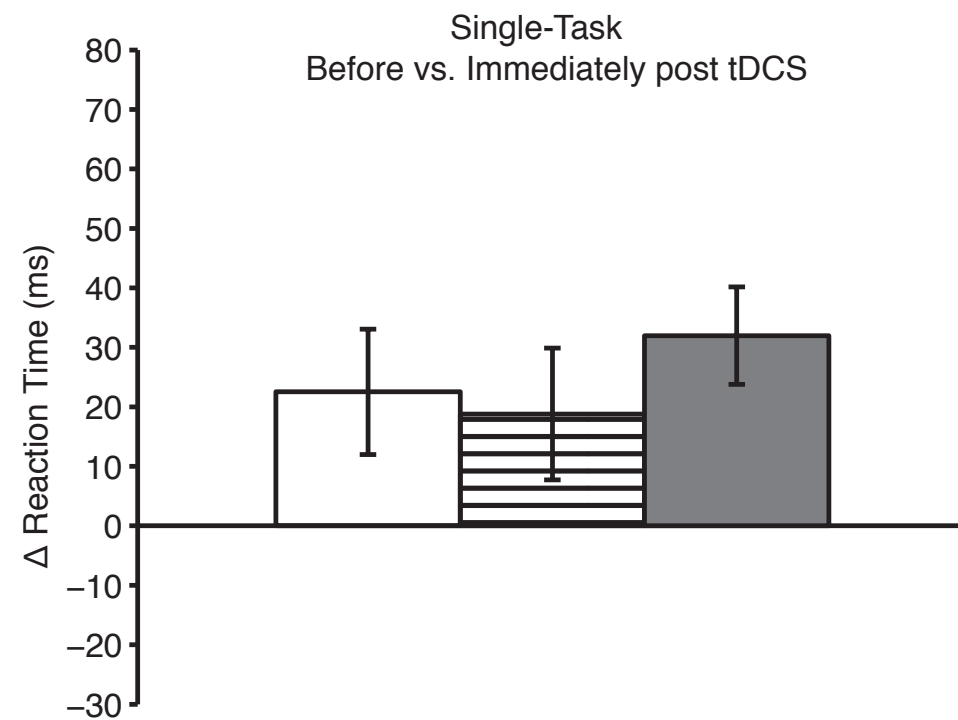




# Reaction time changes post-tDCS



# Reaction time changes post-tDCS



# Conclusions

- Stimulation of left PFC with cathodal tDCS facilitates dual task responses
- Stimulation of left PFC with either anodal or cathodal stimulation disrupts response selection training
- This is *causal* evidence that the left PFC is a key structure in single and dual task response selection, including single task response selection training
- The findings may hint at a dissociation between single and dual task response selection within left PFC

Thanks

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