For a minute there, I lost myself… dosage dependent increases in mind wandering with prefrontal tDCS

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Mind wandering

- The shifting of our attention to an internal state
- Lapses in concentration can have negative outcomes
- Often occurs without awareness or intention
- Frequent - possibly as much as 50% of time
Overview

• Network of regions in mind wandering

• Causal approaches

• Dosage and polarity brain stimulation

• Role of stimulation polarity and dosage in modulating mind wandering

• Two pre-registered studies

• Large samples (150 subjects in each)
Imaging mind wandering
fMRI

Christoff et al., 2009, PNAS
Transcranial Direct Current Stimulation
Modulating mind wandering with tDCS

Axelrod et al., 2015, PNAS
Modulating mind wandering with tDCS

Axelrod et al., 2015, PNAS
Modulating mind wandering with tDCS

Axelrod et al., 2015, PNAS

Axelrod et al., 2018, Scientific Reports
Modulating mind wandering with tDCS

Axelrod et al., 2015, PNAS
Axelrod et al., 2018, Scientific Reports
Modulating mind wandering with tDCS

- Targeting the prefrontal and parietal cortex simultaneously can decrease mind wandering

Kajimura & Nomura, 2015, Neuropsychologia
Stimulation dosage?

• Previous mind wandering papers used a standard dosage of 1-1.5 mA, with 5 x 7 cm electrodes

• But dosage of stimulation could be important, and not necessarily in a linear fashion
Is there an effect of stimulation polarity on mind wandering?

How do any modulations to mind wandering interact with dosage of stimulation?

What happens if the prefrontal AND parietal cortices are targeted simultaneously?
Experiment 1 - the prefrontal cortex
Task design

To what extent have you experienced task unrelated thoughts prior to the thought probe?
1 (minimal) - 4 (maximal)
Session overview

• Practice a target and a TUT trial
• Stimulate
• Complete task (~ 40 mins)
Stimulation & groups

• Offline stimulation, 20 mins, electrodes 5 x 5 cm

• Five groups (30 subjects per group):
  • Anodal, 1mA
  • Cathodal, 1mA
  • Cathodal, 1.5mA
  • Cathodal, 2mA
  • Sham
Mean TUT ratings
Experiment 2 - combined prefrontal and parietal stimulation
Task design

Non-targets

Target

Thought probe

To what extent have you experienced task unrelated thoughts prior to the thought probe?

1 (minimal) - 4 (maximal)
Design

• Identical to Experiment 1, with two differences:
  • The rating scale was increased to 1-7 (previously 1-4)
  • The groups were as follows:
    • 1mA anodal prefrontal, cathodal parietal
    • 2mA anodal prefrontal, cathodal parietal
    • 1mA cathodal prefrontal, anodal parietal
    • 2mA cathodal prefrontal, anodal parietal
    • Sham
Mean TUT ratings

- 2mA +PFC/-PC
- 1mA +PFC/-PC
- Sham
- 1mA -PFC/+PC
- 2mA -PFC/+PC
Conclusions

• The dosage effect of stimulation to the prefrontal cortex alone was linear - stronger stimulation led to larger effects

• Cathodal tDCS to the prefrontal Cortex increased mind wandering, but only in the absence of parietal stimulation

• Anodal tDCS to the prefrontal, and cathodal to the parietal cortex, led to an increase in mind wandering that was relatively dose independent