Modeling the effects of DC stimulation on presynaptic vesicle release

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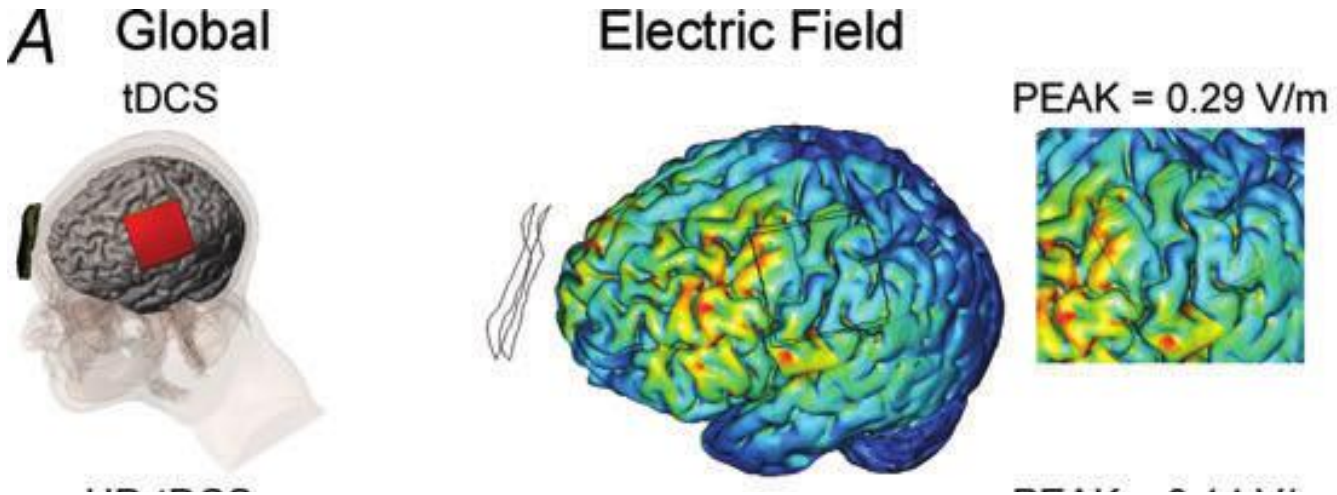
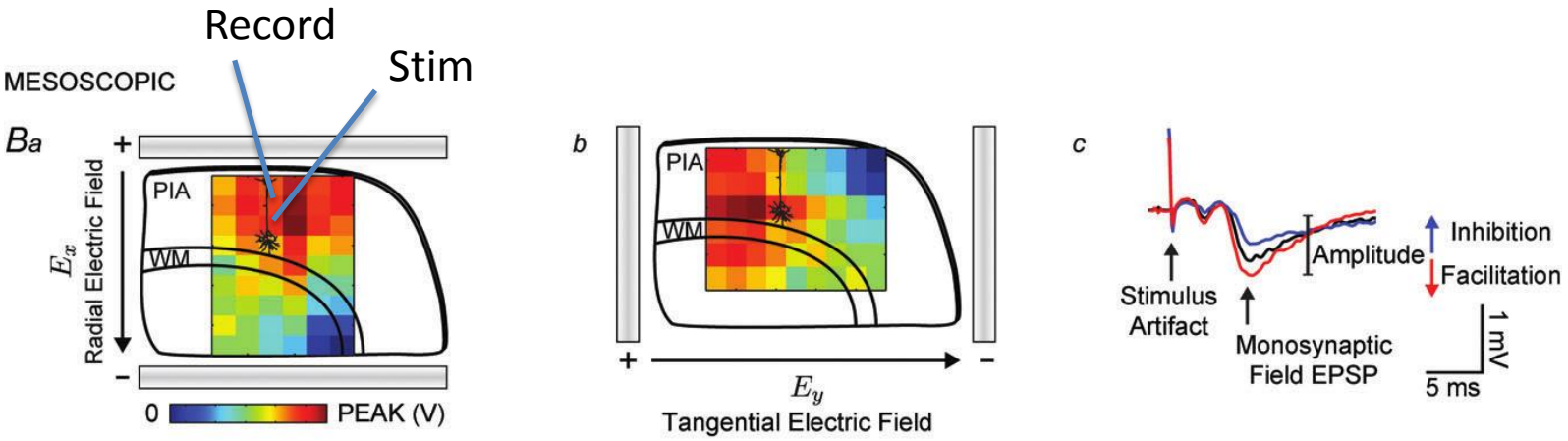
Transcranial Direct Current Stimulation



Used to treat: depression, stroke rehab, alzheimer's, epilepsy, addiction, many more

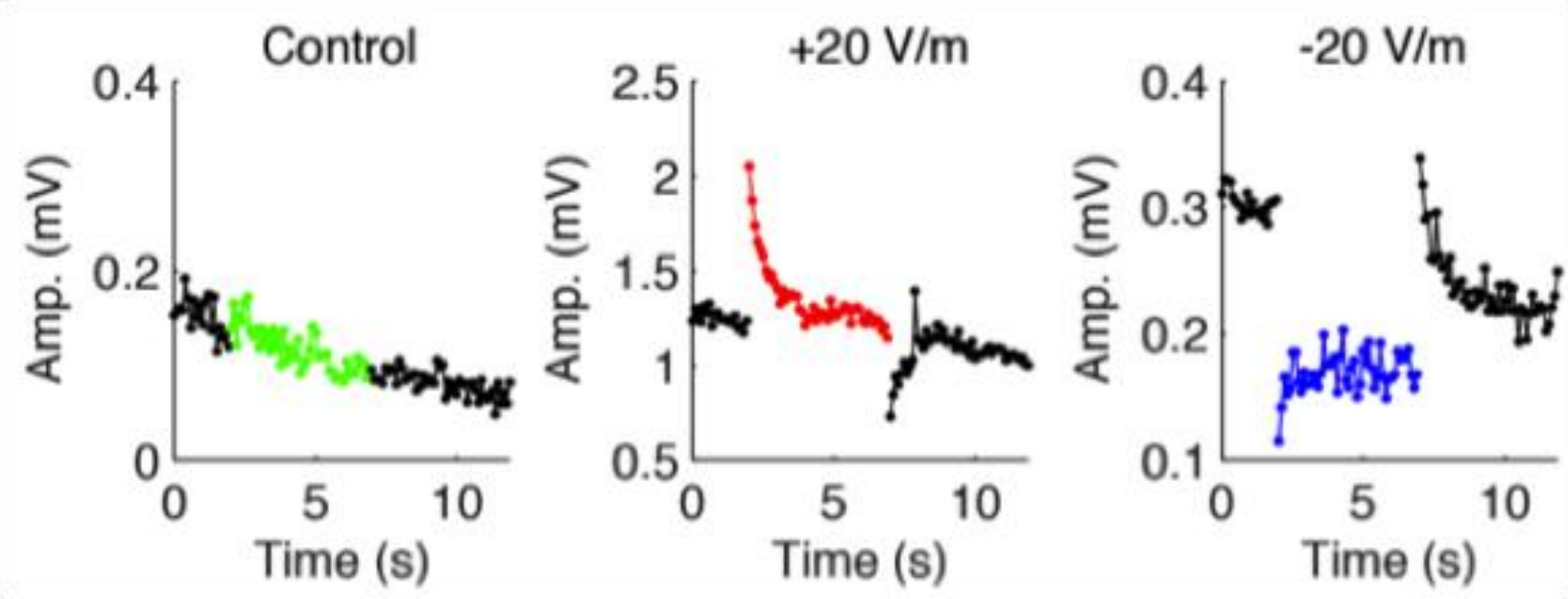
Rahman et al. 2013 Journal of Physiology

In vitro model of tDCS



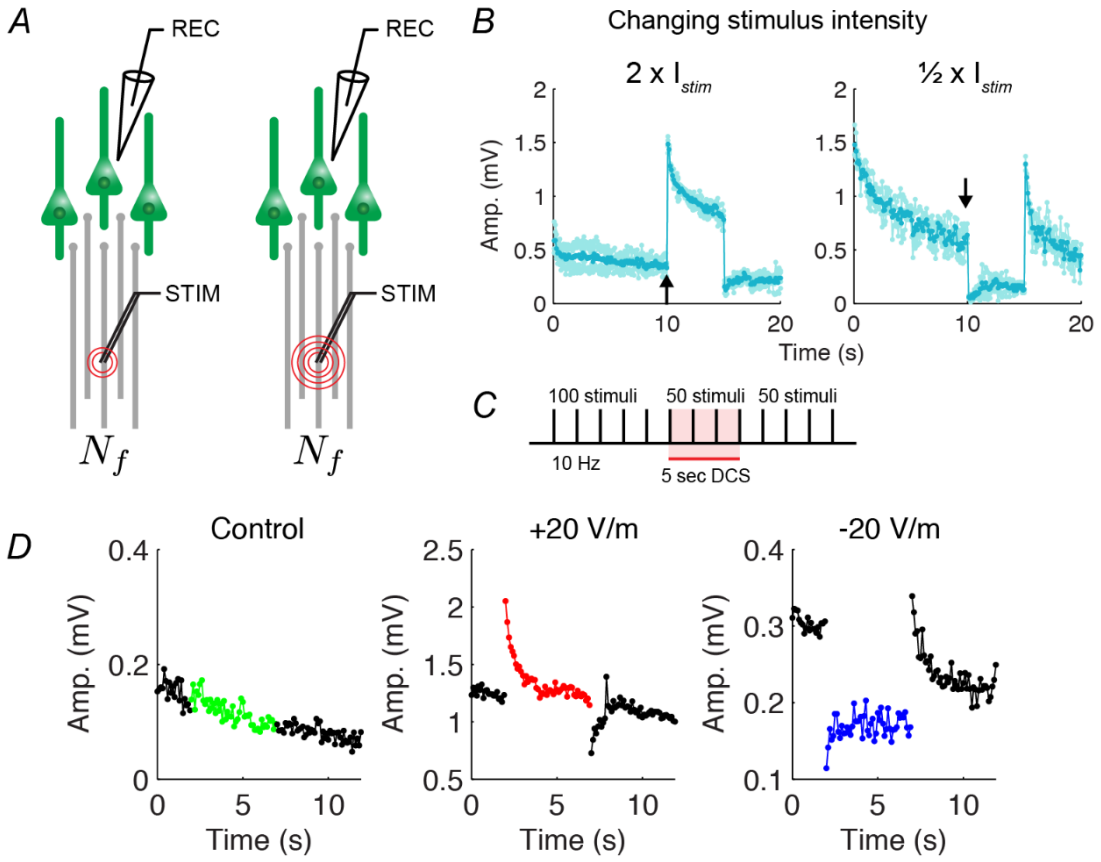
Rahman et al. 2013 Journal of Physiology

Adaptation during DCS



Rahman et al. in preparation

Adaptation during DCS



Results are consistent with presynaptic effects

Rahman et al. in preparation

Modeling presynaptic release

- A group of nsyn synapses
- Given stimuli at time t, terminal i has probability pap_i of firing
- All terminals have poisson docking/undocking (mean rates α/β) at finite number of release sites ns with initial release probability p0

$$\sum_{i=1}^{nsyn} \overline{N^i} = \sum_{i=1}^{nsyn} \frac{p_{ap}^i p_0 ns_* (1 - e^{-g\Delta t})}{1 - (1 - p_{ap} p_0) e^{-g\Delta t}}$$

$$g = a + b$$

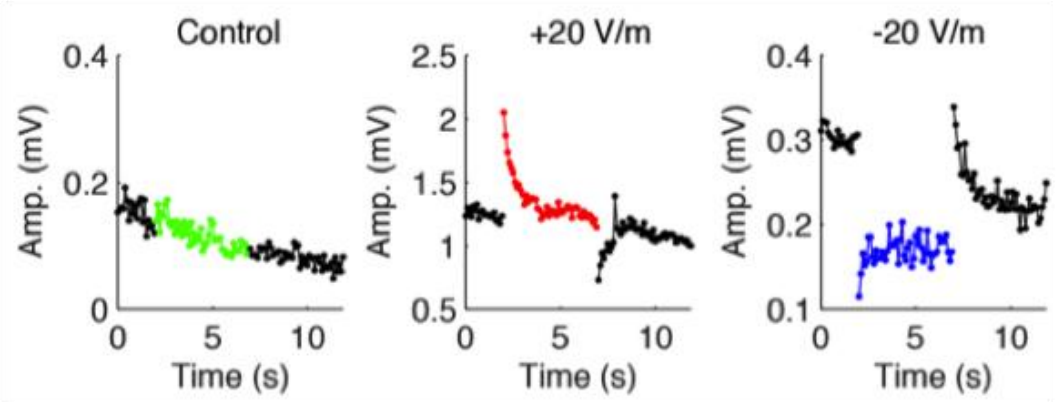
$$ns_* = \frac{a\,ns}{a + b}$$

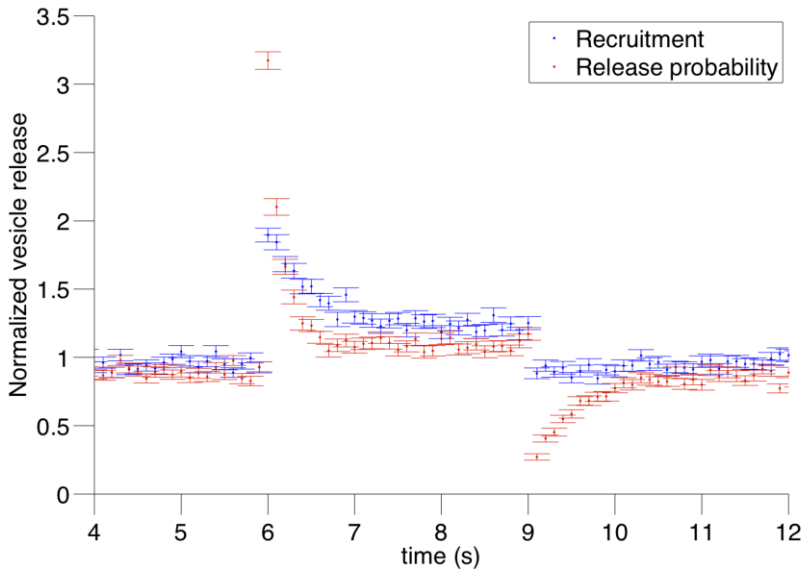
Modeling presynaptic release with DCS

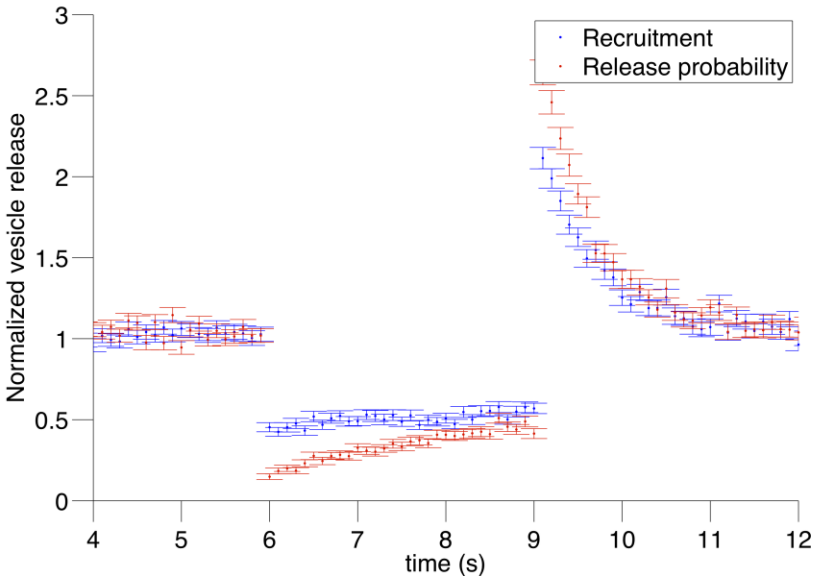
- DCS is known to modulate membrane potential at axon terminals
- Here it is modeled as having either of two effects
  - Recruitment
    - Modulate pap
  - Release
    - Modulate p0

$$\sum_{i=1}^{nsyn} \overline{N^i} = \sum_{i=1}^{nsyn} \frac{p_{ap}^i p_0 ns_* (1 - e^{-g\Delta t})}{1 - (1 - p_{ap} p_0) e^{-g\Delta t}}$$

Modeling presynaptic release with DCS







Modeling presynaptic release with DCS

- Modulation of p0 better reproduces edge detect when DCS is turned off
- Results depend on initial distribution of p0 and pap