Given that skin-sensation and skin irritation are the primary risks of tDCS, proper electrode preparation and then monitoring of electrode resistance during tDCS are considered important to ensure the stimulation is reproducible and well tolerated (as well as sham reliability in clinical trials). Conventional resistance measurement methods do not isolate individual electrode resistance and for HD-tDCS devices, cross talk across electrodes makes concurrent resistance monitoring unreliable.

### Methods for Specific Electrode Resistance Measurement during Transcranial Direct Current Stimulation

**Niranjan Khadka** (nironzan@gmail.com)

**Asif Rahman, Dennis Q Truong, Marom Bikson** (bikson@gmail.com)

Department of Biomedical Engineering, The City College of New York, CUNY

### Introduction

Lumped-parameter models of two and multi-electrode tDCS with and without a sentinel electrode were solved and underlying assumptions were identified. Assumptions were tested and parameterized in healthy participants using forearm stimulation combining tDCS (2 mA) and sinusoidal test-signals (38 μA and 76 μA peak to peak at 1 Hz, 10 Hz, and 100 Hz) and an *in vitro* test. DC and AC component voltages across the electrodes were compared and participants were asked to rate subjective pain.

### Methods

**Non-triviality of resistance measurement during two electrode tDCS**

- Illustrations of four electrodes and three electrodes assembly problem (where tissue resistance confounded electrode resistance) and proposed solutions using a test signal and a sentinel electrode.

**Governing Equation for multi electrode problems and solutions.**

1. $V_{1} = (3R_{1} + R_{2} + R_{3})$ (Problem).  
2. $V_{1} = (3R_{1} + R_{2} + R_{3}) + Z_{1}$ (Solution using a sentinel electrode).

**Cross talk during resistance measurements in multi-electrode tDCS**

**Testing of assumptions and identification of effective test signals**

**Application of Solutions in Experiments**

- Type A error & Method of Correction (A1, B1)
  - Failure of anode (increment in DC-resistance) is tracked by AC-impedance.
- Type B error & Method of Correction (A2, B2)
  - Contamination of DC resistance (across S1) by the voltage produced when S2 is energized - unaffected the AC-impedance.

### Conclusions

- Using our developed method, a test signal can predict DC resistance of individual tDCS electrode-process made still more robust by the use of a sentinel electrode.
- Findings provide the first method to monitor individual electrode resistance during tDCS that integrated into tDCS devices may minimize irritation at electrodes.

### Reference