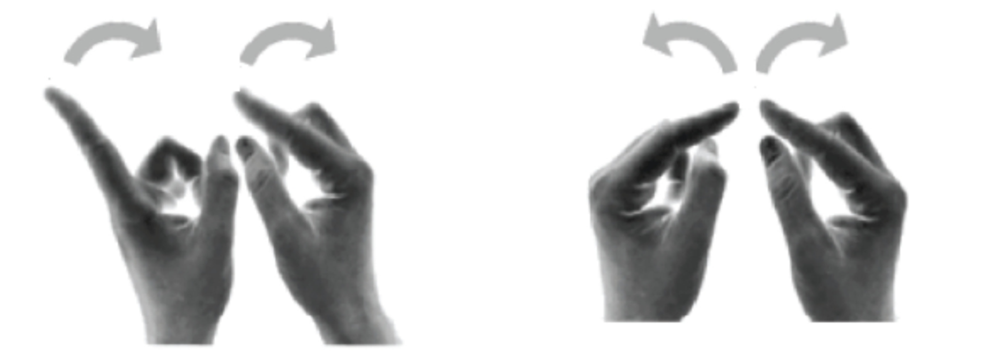
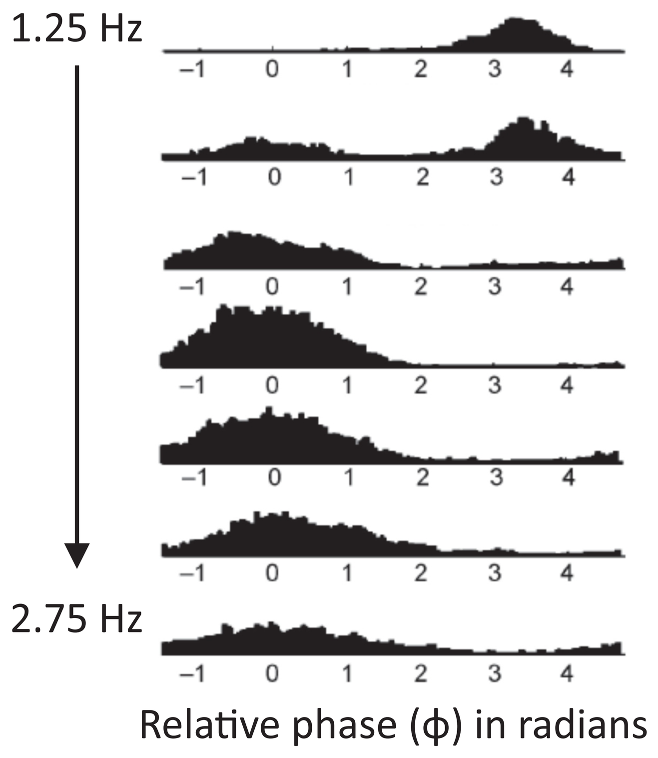
Anodal tDCS over SMA decreases mean relative phase error during anti-phase movements

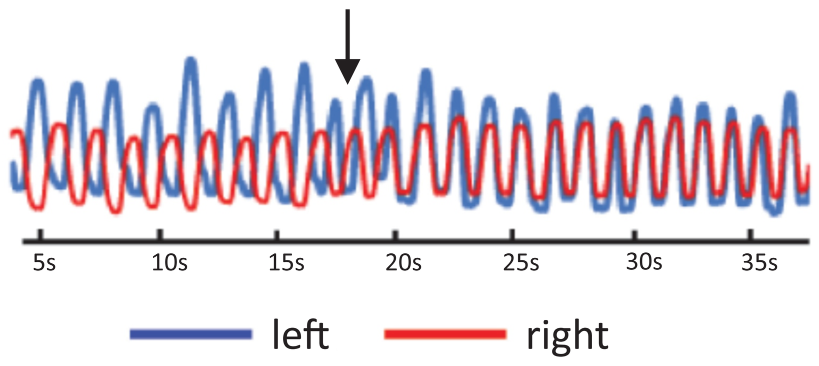
Michael J Carter, Neil M Drummond, and Anthony N Carlsen; *School of Human Kinetics*

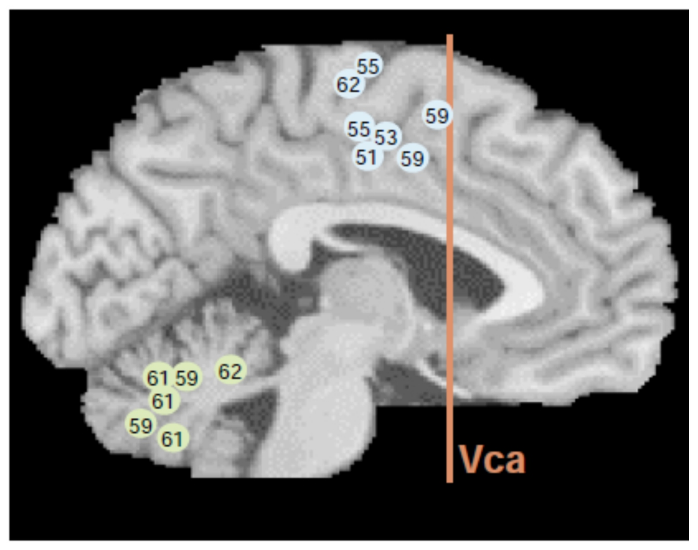
uOttawa

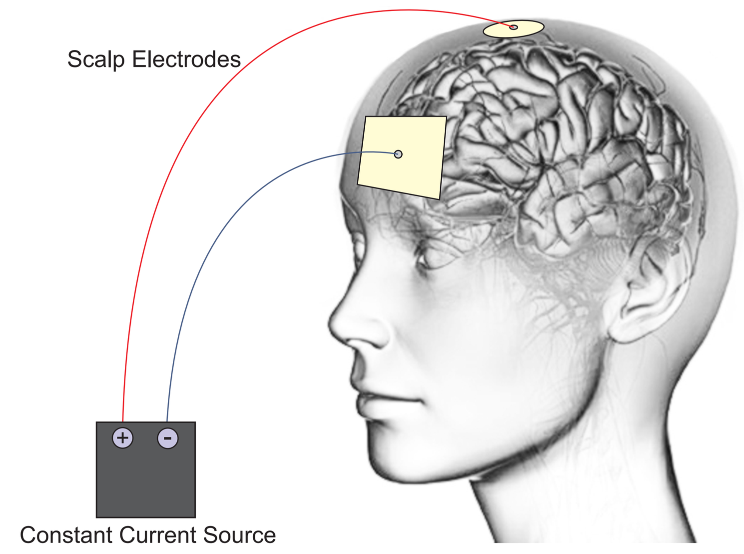
What we know...[1-8]











Question: Will modulating the excitability of SMA increase pattern stability and delay transition times during rhythmic anti-phase bimanual movements?

Methods

Task

- Cyclical in-phase and anti-phase supination-pronation bimanual movements (± 5° displacement from starting position)

Experimental procedure

- Testing consisted of 2 sessions separated by a minimum of 48 hours
- Each session involved 2 testing blocks (pre- and post-tDCS) consisting of 14 trials (7 per coordination mode and randomly presented)
- Each trial last 56 s and metronome (i.e., limb oscillation) frequency was systemically increased from 1.75 Hz to 3.25 Hz in .25 Hz increments (7 frequency plateaus each 8 s in duration)
- tDCS (1 mA for 10 mins; current density of 0.128 mA/cm^2) polarity was randomly determined and counterbalanced

Results

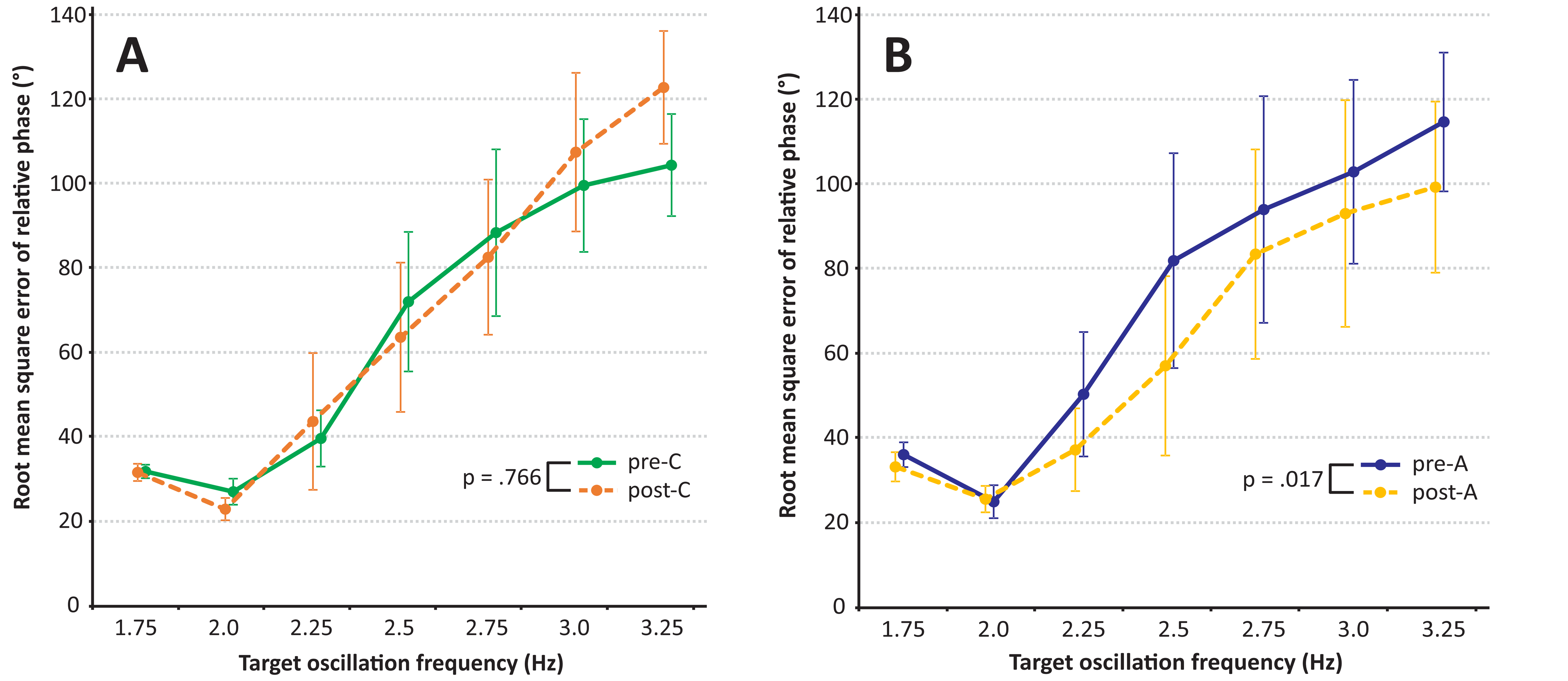


Figure 1. Root mean square error (±SE) of relative phase for anti-phase coordination as a function of frequency plateau (Hz) for pre- and post-cathodal (panel A) and pre- and post-anodal (panel B) trial blocks. Pre and post refer to pre-tDCS and post-tDCS blocks respectively. Note a significant main effect of frequency (i.e., greater RMSE as target oscillation frequency increased independent of trial block; [$F(6, 30) = 15.02$, $p < .001$, $\eta_p^2 = .75$]); and a significant Stimulation x Time interaction (i.e., lower RMSE following anodal but not cathodal tDCS; [$F(1, 5) = 12.96$, $p = .016$, $\eta_p^2 = .72$]).

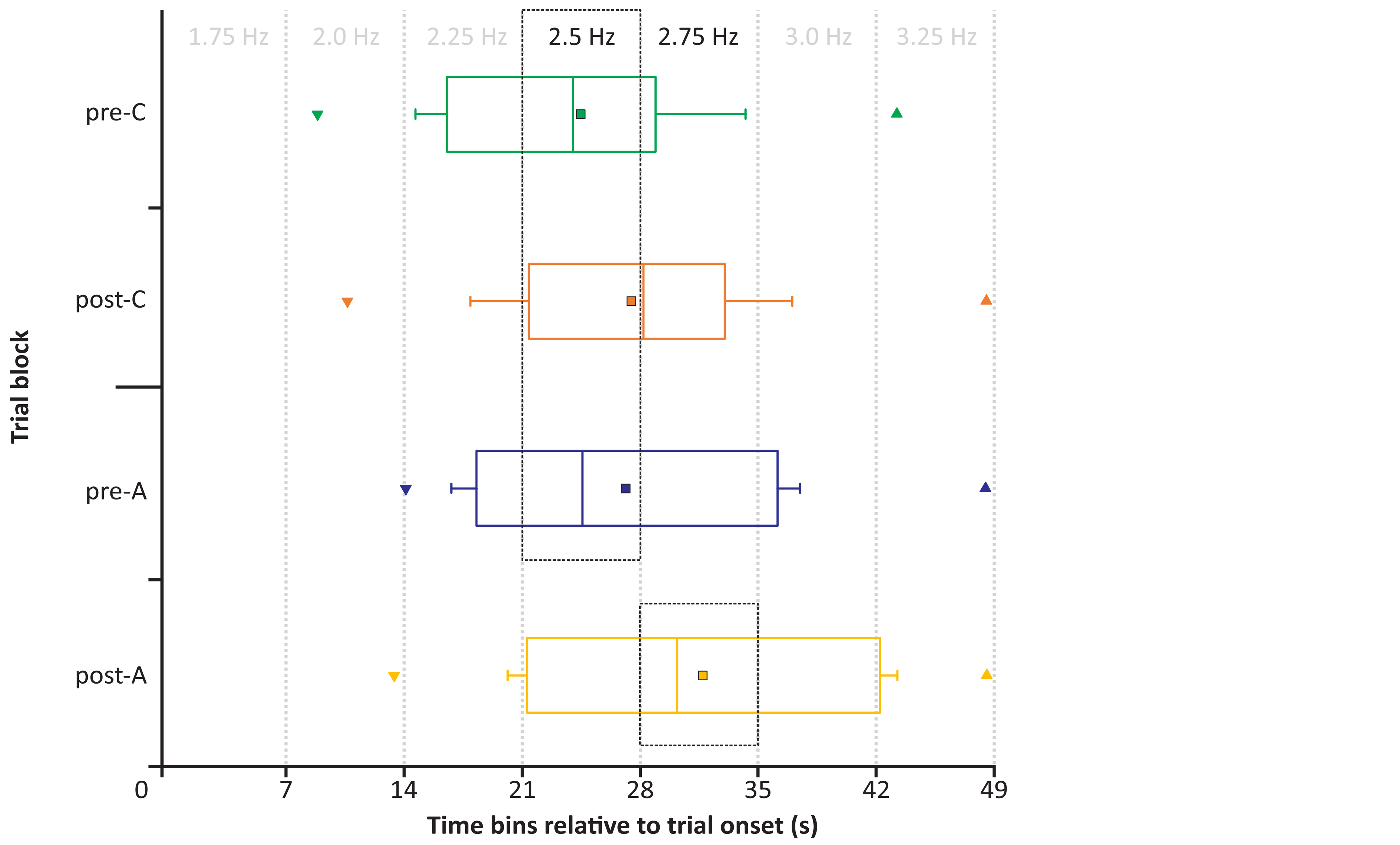


Figure 2. Mean time to phase transition (i.e., anti- to in-phase) boxplots for each trial block. Box boundaries represent the first and third distribution quartiles and the vertical line represents median transition time. The inner small squares represent the mean transition time and 1 standard deviation error bars are shown. Note a significant difference of transition time ($p = .033$) between pre- ($M = 27.5$, $SE = 1.62$) and post-anodal ($M = 32.06$, $SE = 1.78$) blocks. There were no differences ($p = .106$) between pre- ($M = 24.82$, $SE = 1.51$) and post-cathodal blocks ($M = 27.16$, $SE = 1.62$).

Discussion and Conclusions

- In-phase coordination is the most stable pattern of the human motor system[1-5] and in the present study, neither anodal or cathodal tDCS over the SMA had an effect on in-phase coordination (*Note.* Not presented on poster).
- Following anodal tDCS of the SMA, relative phase between the hands was significantly less errorful during anti-phase coordination across all target oscillation frequencies; however, anti-phase performance at each frequency was unchanged following cathodal tDCS.
- According to Dynamic Pattern theory,[e.g., 2, 3] when movement speed is systematically increased from slow to fast (i.e., a change in a control parameter), an order parameter (e.g., relative phase) may remain stable or change its stable state characteristic (e.g., phase transition[4]). Here, anodal tDCS of the SMA delayed the point at which an initially prepared anti-phase movement abruptly transitions to an in-phase movement due to a change in a control parameter.
- These findings suggest increased SMA activity induced by anodal tDCS can improve anti-phase performance and adds to the accumulating evidence of the pivotal of SMA in bimanual coordination.[e.g., 1, 5]

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Michael

Neil

Tony

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