Cortical Activity Associated with Axial Postural Tone

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Background

- **Postural tone** is the background muscle activity necessary for organizing movement. Tone must be high enough to stabilize against unwanted disturbances, yet low enough to permit movement. [1]
- **Twister** is a custom device that can deliver passive motion to the body axis and measure resistance to assess postural tone. [2]
- **Electroencephalography (EEG)** examines the differences in cortical rhythmic activity associated with differences in activity of postural tone.
- Little is known **about cortical influence on postural tone**. Frontal executive-motor regions of cortex may contribute to adaptation, consistent with associations of cognitive factors with balance and postural alignment. [3]

Hypotheses

Primary Hypothesis

Postural tone adaptivity is associated with differential cortical rhythmic activity.

Study 1 Hypothesis

Participants with highly adaptive postural tone will show greater mid-central cortical activity during slow axial rotation compared to minimally adaptive participants.

Study 2 Hypothesis

Cortical activity will differ as a function of both postural tone adaptivity and task condition (Active vs. Passive rotation).

Methods

Study 1 Methodology

- A cross-sectional design compares participants in the top and bottom quartiles of postural tone adaptivity.
- During slow axial rotation (±8°), participants complete six 120-second trials, with 6-second pauses serving as baseline.
- Opaque goggles minimize visual input.

Study 2 Methodology

- A mixed design examines differences between passive (128-second continuous rotation) and active replication of the same movement.
- Tests how motor planning interacts with tone adaptivity in modulating cortical activity.

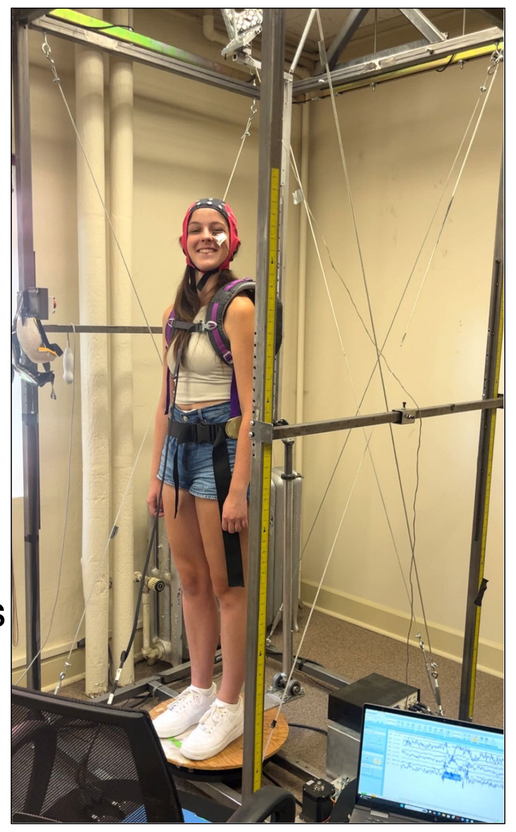

Figure 1. *Twister setup.*

Data Analysis Plan

- **Adaptivity of postural tone** is defined by how low the peak torque is during Twister rotation; higher torque indicates lower adaptability.
- We use **Event Related Spectral Perturbations** (ERSPs) to identify when desynchronization and synchronization occurs in the alpha and beta frequency bands during Twister rotation.
- We compare the **Event Related Potentials** (ERPs), ERSPs, alpha and beta spectral fluctuation waveforms, and alpha and beta peak power between adapters and non-adapters.
- EEG signals are recorded from a 64-channel cap (ANTNeuro, Waveguard Original) into 21 channels based on a modified template of the **10-20 international electrode placement** [4] focused on the frontal, central, and parietal lobes.

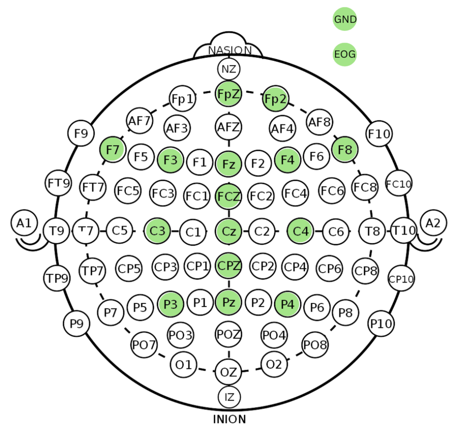

Figure 2. *Modified 10-20 international electrode template.*

Preliminary Results

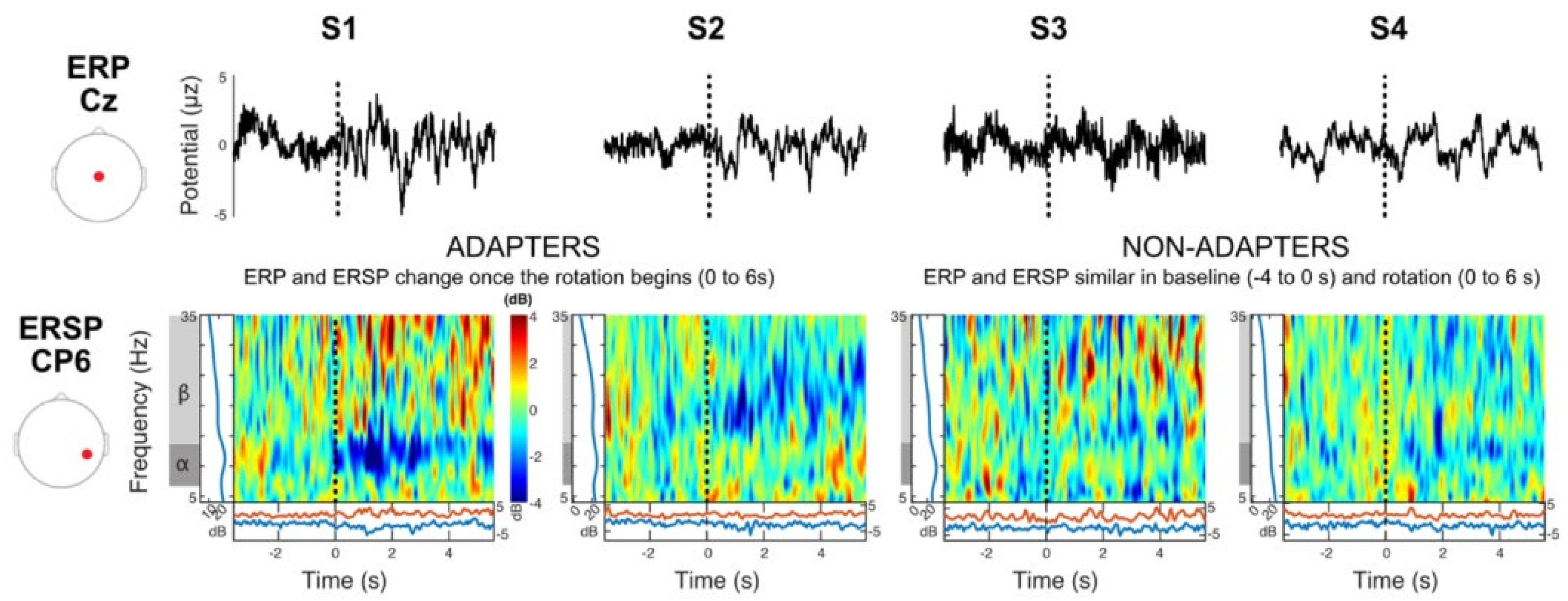

Figure 3. *Event-related potentials (ERPs) for the Cz electrode and the event-related spectral perturbation plots (ERSPs) for the CP6 electrode for four subjects. Dotted lines indicate start of Twister rotation.*

- ERPs for the **Cz** electrode over the **primary motor cortex** show that subjects who adapted their postural tone had large slow frequency components that emerged when the rotation began, whereas there was no change in the non-adapters.
- ERSPs for the **CP6** electrode near the **temporopartietal junction** (associated with sensorimotor integration) show that adapters have greater alpha and beta desynchronization during the Twister rotation compared to non-adapters.

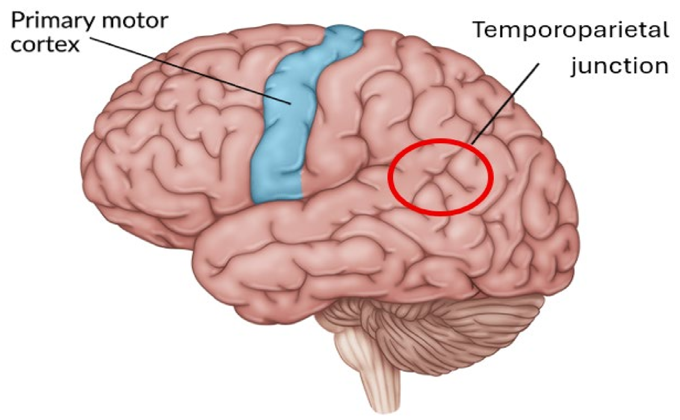

Figure 4. *Diagram of brain regions associated with changes in activity during rotation.*

Preliminary Interpretation

- Preliminary data suggest that participants with ***highly adaptive postural tone*** show **mid-central cortical activity** during the movement, while participants with non-adaptive tone do not.
- The surprising finding that some adaptive participants show activity in the alpha range while others show activity in the beta range suggests that there may be two different paths to success at adapting postural tone.

Future Directions

- Test 20 adaptive and 20 non-adaptive subjects.
- Add a measure of proprioceptive acuity.
- Add surveys of possible covariates, such as mindfulness.
- Assess effects of postural instructions. [4]

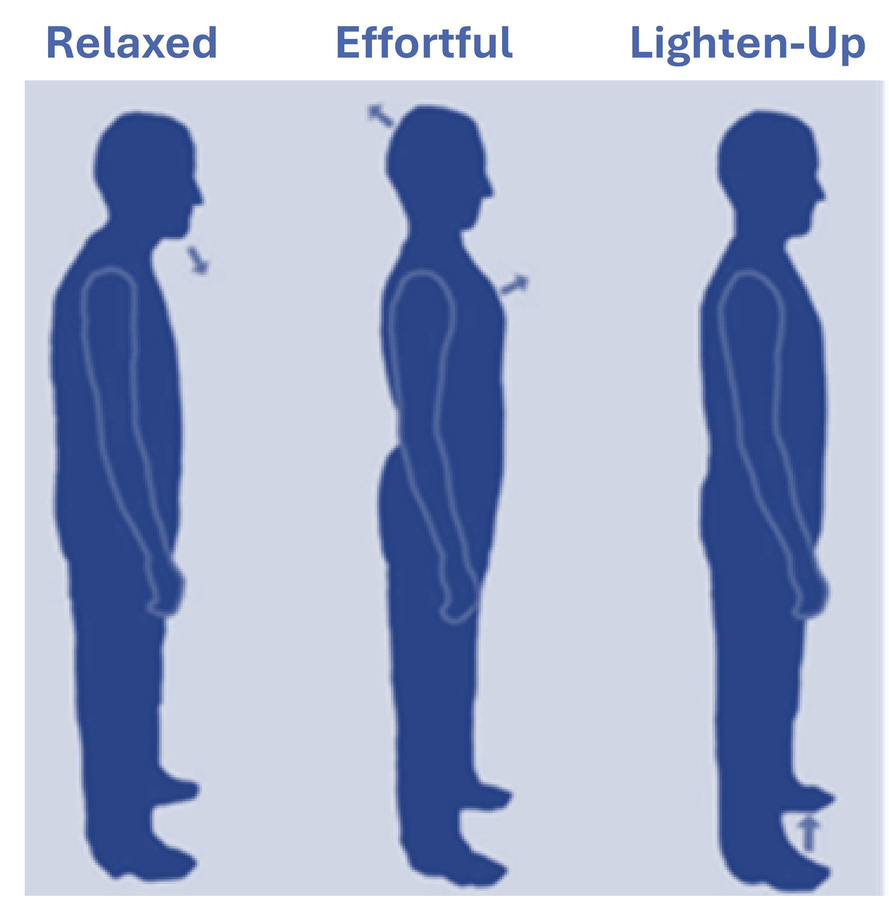

Figure 5. *Illustration of postural instruction embodiments.*

References

[1] Cacciatore, T. W., Anderson, D. I., & Cohen, R. G. (2024). Central mechanisms of muscle tone regulation: implications for pain and performance. *Frontiers in neuroscience*, *18*, 1511783. https://doi.org/10.3389/fnins.2024.1511783

[2] Gurfinkel, V., Cacciatore, T. W., Cordo, P., Horak, F., Nutt, J., & Skoss, R. (2006). Postural muscle tone in the body axis of healthy humans. *Journal of neurophysiology*, *96*(5), 2678–2687. https://doi.org/10.1152/jn.00406.2006

[3] Klem, G. H., Lüders, H. O., Jasper, H. H., & Elger, C. (1999). The ten-twenty electrode system of the International Federation. The International Federation of Clinical Neurophysiology. *Electroencephalography and clinical neurophysiology. Supplement*, *52*, 3–6.

[4] Cohen, R. G., Baer, J. L., Ravichandra, R., Kral, D., McGowan, C., & Cacciatore, T. W. (2020). Lighten up! Postural instructions affect static and dynamic balance in healthy older adults. *Innovation in aging*, *4*(2), igz056.

Acknowledgements

- Helen Huang provided guidance for EEG analysis.
- Delaney Jepson and Katey Sacchi prepared the poster.