Designing a Device to Stimulate the Sternocleidomastoid to Validate the Usage of Neck EMG in EEG Data Cleaning

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Abstract

Electroencephalography (EEG) is a neuroimaging technique commonly used to understand the ways in which the human brain and body interact. Traditional EEG studies have taken place in stationary lab settings because of noise artifacts that are introduced during active behavior. When mobile EEG data is recorded, artifacts from various sources (e.g., line-noise, cable sway, muscle activity) mask the target brain data (Muthukumaraswamy, 2013; Somenidou, Nordin, Hairston, & Ferris, 2018). Eliminating artifactual noise remains a significant obstacle in mobile EEG studies, though advances in EEG hardware and signal processing methods have helped alleviate this problem. For example, independent component analysis (ICA) is a statistical method that has been successfully used to clean EEG data (Makeig, Jung, Lee, & Sejnowski, 1997). This project aims to validate the use of neck electromyograms (EMG) in ICA with the goal of removing these muscle artifacts from the EEG signals.

Design Objective

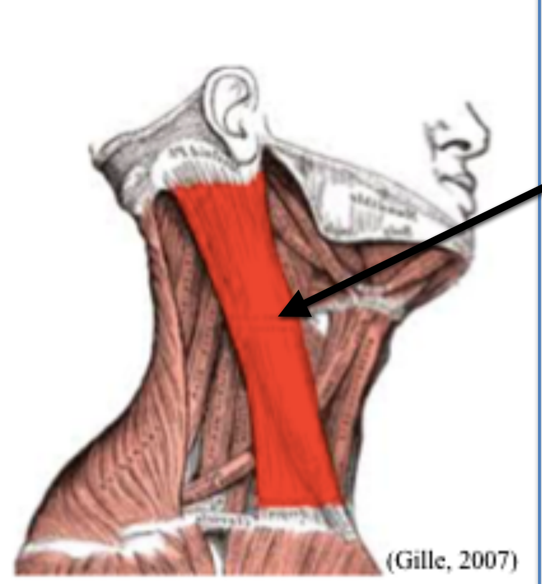

Figure 1. The sternocleidomastoid, highlighted in red.

The device must **engage the sternocleidomastoid** at 50% maximum voluntary contraction to isolate muscle artifacts and validate EEG cleaning methods.

During data collection, the device must be used in tandem with an EEG cap on the scalp and one HD EMG patch on each side of the neck. To minimize electrode movement, the device **must not physically interfere with the EEG or EMG electrodes**.

Figure 2. Participants must wear an EEG cap and HD EMG patches.

Design Requirements

- No electrode interference
- 50% muscle engagement
- High stability
- Size adjustability

Additional Considerations

- High tensile strength
- Low cost
- Comfort
- Safety

Final Design

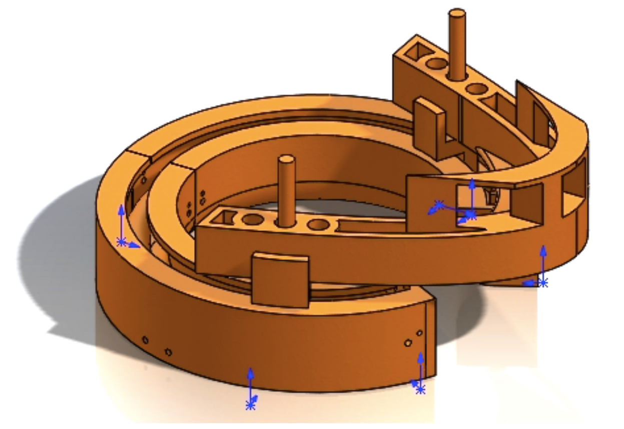

Figure 3. The device was designed in SolidWorks and 3D printed using nGen co-polyester filament. The final design includes an assembly of seven parts.

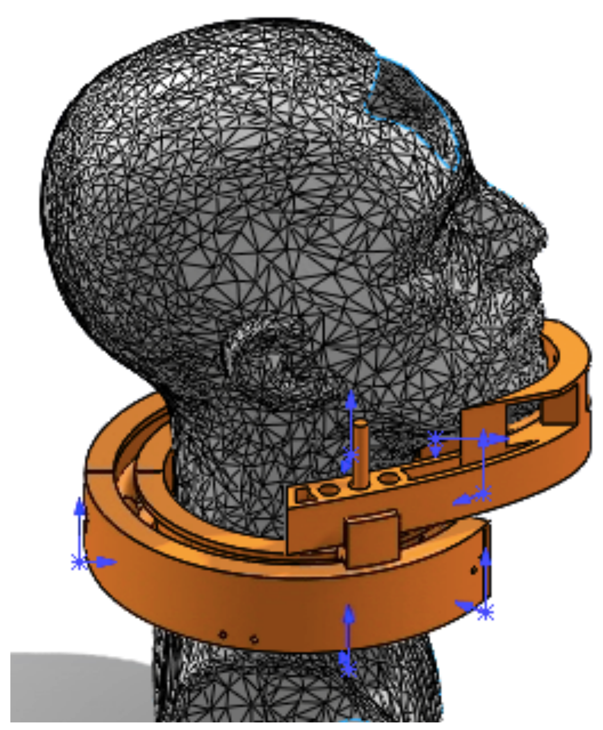

Figure 4. A 3D scan of a human head was imported to SolidWorks and used to make various sizing adjustments.

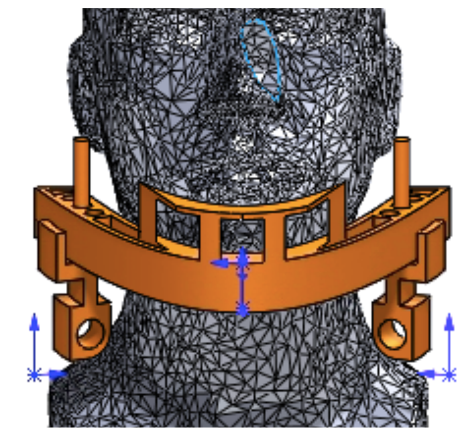

Figure 5. A jaw piece supports and moves with the jaw during head rotation. On each side, the jaw piece connects to a plunger.

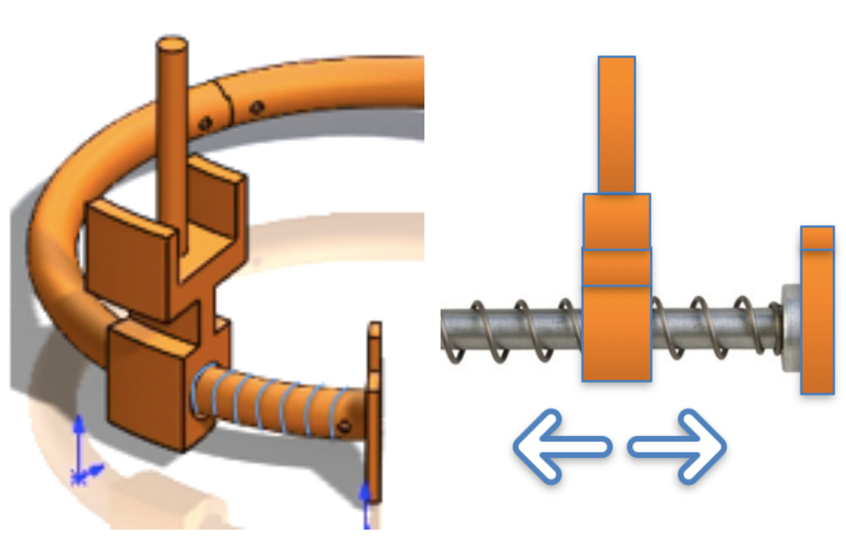

Figure 6. Inside the device, springs surround a cylindrical track. The springs are positioned so that they are stretched and compressed by the plungers as the user's jaw rotates.

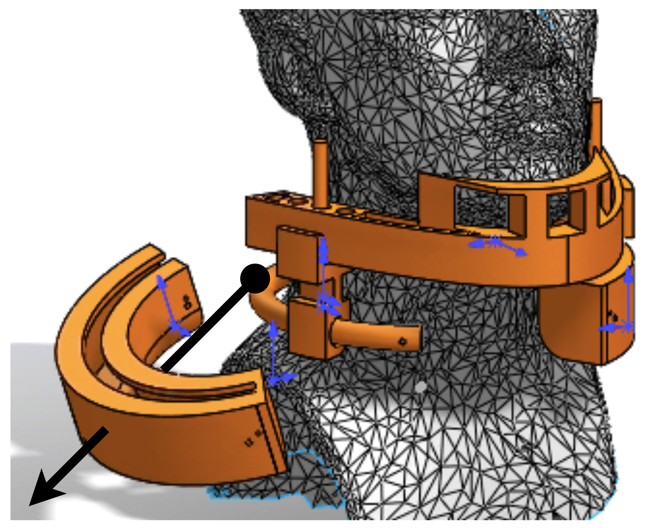

Figure 7. An exploded view of the device (indicated by the black arrow) shows that the inner spring track is contained within an outer shell. This isolates spring movement.

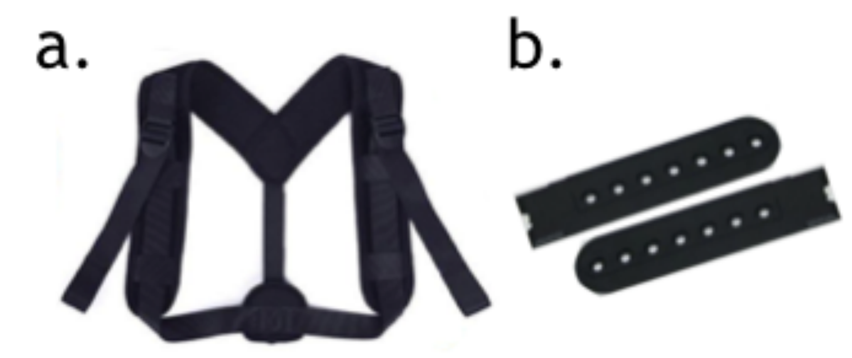

Figure 8. A) The outer shell of the device is anchored to a commercial back support product to promote stability. The straps are adjustable, making them suitable for all users. B) Plastic adjustable straps are used to fasten the device around the user's neck.

Conclusion

The final design was functional and met all of the established design requirements. Several efficacy metrics were outlined in order to quantify the device's success in meeting each of the design requirements, and a protocol was developed in order to ensure proper usage of the device during data collection. The data the device aids in collecting will validate the use of neck EMG to improve EEG ICA. This advancement will be useful for removing neck muscle artifacts from EEG data in future locomotive neuroimaging studies.

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References

Gille, U. (2007). *Sternocleidomastoideus*. Retrieved July 18, 2019, from https://en.wikipedia.org/wiki/Sternocleidomastoid_muscle#/media File:Sternocleidomastoideus.png (Originally photographed 2007, July 31)
Makeig, S., Jung, T., Lee, T., & Sejnowski, T. J. (1997). Independent component analysis of steady-state responses. PsycEXTRA Dataset.doi10.1037e526112012-059
Muthukumaraswamy, S. D. (2013). High-frequency brain activity and muscle artifacts in MEG/EEG: A review and recommendations. *Frontiers in Human Neuroscience,7*. doi:10.3389/fnhum.2013.00138
Somenidou, E. A., Nordin, A. D., Hairston, W. D., & Ferris, D. P. (2018). Effects of Cable Sway, Electrode Surface Area, and Electrode Mass on Electroencephalography Signal Quality during Motion. *F1000 - Post publication Peer Review of the Biomedical Literature*. doi10.3410/f733200157.793550616

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