Mapping Haptic-Induced Zonal Brain Activation – an fNIRS Study

By: Rajpal Tiger[1]
Mentor: Aurel Coza PhD[1]
[1]School of Biological and Health Systems Engineering, Arizona State University, Tempe, AZ

Introduction

PROBLEM: Can specific changes in brain activity be distinguished when switching from comfortable to uncomfortable shoe-wear haptics?

- Primary Somatosensory Cortex plays a critical role in pain response [1].
- OxyHb (Oxyhemoglobin) is the most sensitive indicator of changes in rCBF (regional cerebral blood flow) [2].
- Hemodynamic variance helps to map specific areas of activation within the brain in response to a given stimuli [3].
- FNIRS offers a strong combination of spatial (2-3cm) and temporal resolution (sampling rate up to 150 Hz) [4].

HYPOTHESIS: Discomfort will elicit a neurological response, specifically in the primary somatosensory (S1) cortex.

Background

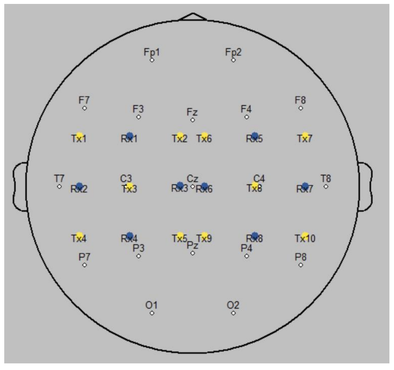


Figure 1: 2x12 Optode Configuration used for testing.

Figure 2: Wireless Brite Cap used for experimentation.

Why choose fNIRS?

- Movement-friendly: Allows participants to move freely.
- Non-Invasive: Uses light absorption between transmitters (Tx) & receivers (Rx) to monitor real-time hemodynamic flow.
- Flexibility: Optode arrangements allows for specific areas of the brain to measured.

Methods

- Participation involves one 30-minute recording session.
- Participants must bring their own comfortable footwear.
- After giving informed consent, participants will wear a BRITE cap (Fig. 2) equipped with NIRS optodes continuously recording of OxyHb across all channels to monitor neural activity.

Experiment phases:

i. **First Phase:** 30 second walking period meant for treadmill acclimation.
ii. **Second Phase:** 5-minute treadmill walking period at 2.0mph wearing comfortable footwear.
iii. **Third Phase:** Repeat second phase under the same conditions with the uncomfortable padding inserted (Fig. 3).

A) B)

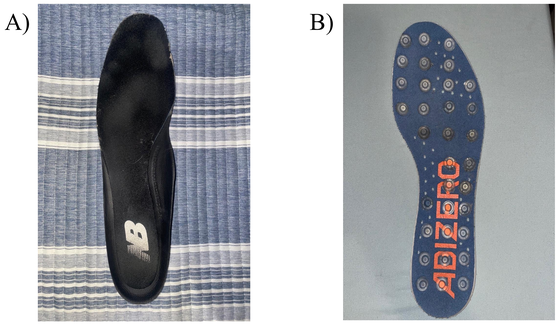


Figure 3: Footwear insoles used for this experiment: (A) comfortable padding and (B) textured, uncomfortable insole.

Results

Hypothesis Validation: Discomfort should primarily activate the primary somatosensory cortex, showing the greatest neural variance in right-hemisphere channels (Rx1-Tx1, Rx2-Tx1, Rx2-Tx3, Rx1-Tx3) and left-hemisphere channels (Rx5-Tx7, Rx5-Tx8, Rx7-Tx8, Rx7-Tx7).

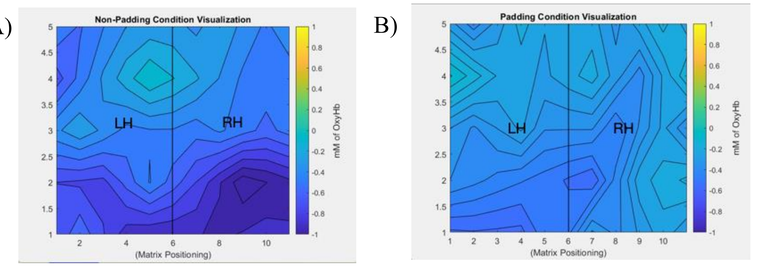
Key Results:
Significant OxyHb increases in:

- **Right hemisphere**: Rx1-Tx1–Tx3, Rx3-Tx2–Tx5, Rx4-Tx5
- **Left hemisphere**: Rx5-Tx7–Tx8, Rx6-Tx6–Tx9, Rx7-Tx8

Significant OxyHb decrease: Rx7-Tx10

Results Cont…

A) B)



C) D)

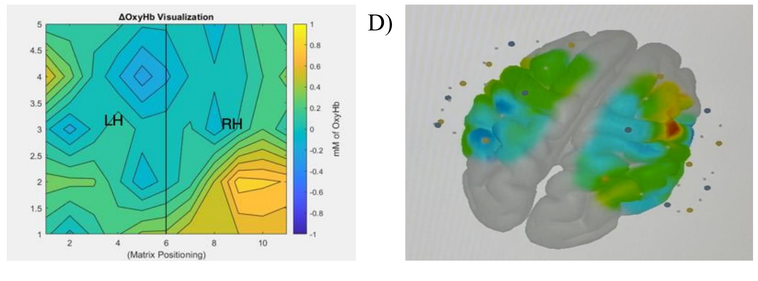


Figure 4: Brain Activity mapping of: A) Non-padded footwear condition B) Padded footwear condition C) Differential response (ΔOxyHb) between padded and non-padded conditions D) 3D cortical activation meshes reconstructed from fNIRS data in OxySoft.

Conclusions and Future Direction

Conclusions

- **Primary finding:** 6/8 predicted channels showed significant OxyHb increases, indicating uncomfortable shoe padding activated the primary somatosensory cortex in participants.
- **Expanded activation:** Additional unexpected OxyHb increases in the Parietal lobes (Rx3-Tx2/Tx3/Tx5, Rx4-Tx5, Rx6-Tx6/Tx9, Rx7-Tx10*) suggest shoe padding engages a wider neural network than initially predicted.

Future Steps

- Future studies should prioritize larger participant cohorts ($n \geq 30$) to enhance statistical power.
- Varying Optode templates to test neurological activity in other portions of the brain.

Acknowledgements

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References

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