http://encefalus.com/neurology-biology/single-neurotransmitter-provide-basis-explanation-social-phenomena/

FACE NEUROMODULATION STIMULATOR

Lauren Eichaker Kimberli Kamer Kenneth Xu Laura Zeitler

Client: Kurt Kaczmarek, PhD[1] **Advisor**: Walter Block, PhD[2]

[1]Dept. of Orthopedics and Rehabilitation Medicine – University of Wisconsin-Madison

[2]Dept. of Biomedical Engineering – University of Wisconsin-Madison

THE UNIVERSITY of WISCONSIN MADISON

Abstract

Neuromodulation takes advantage of brain plasticity to modify and recruit new neural connections to compensate for loss of motor or sensory function with other areas of the brain. One way to catalyze the formation of new connections is through electrotactile stimulation. Stimulation of the tongue in this manner has shown promising rehabilitative results for patients with balance disorders; however, not all patients are able to hold a tongue stimulator in its proper position. A face mask design that stimulates the same neural branch was thus requested for research purposes. The chosen design utilizes flexible silicone custom-molded to an individual's face to administer electrical stimulation. The prototype successfully applied random stimulation to one subject. Processes used to create this design proved to be specific to only one individual and while stimulation was successful, the stimulation threshold results were less repeatable than desired. Future work includes making the electrode-skin interface more reliable, creating a non-specific mask for use by multiple face shapes and increasing the coverage are of the mask.

Background

Neuromodulation

- Electrotactile stimulation or drugs to manipulate the neural connections in the brain[1]
- Takes advantage of brain plasticity
- New neural pathways form in damaged areas for rehabilitation

Tongue Stimulator

- Electrode array stimulates surface of tongue
- Random patterns of stimulation has shown promise to rehabilitate balance disorders
- Stimulates trigeminal nerve
- Device must be held in the mouth to be effective

Figure 1: Subject using tongue stimulator. [2]

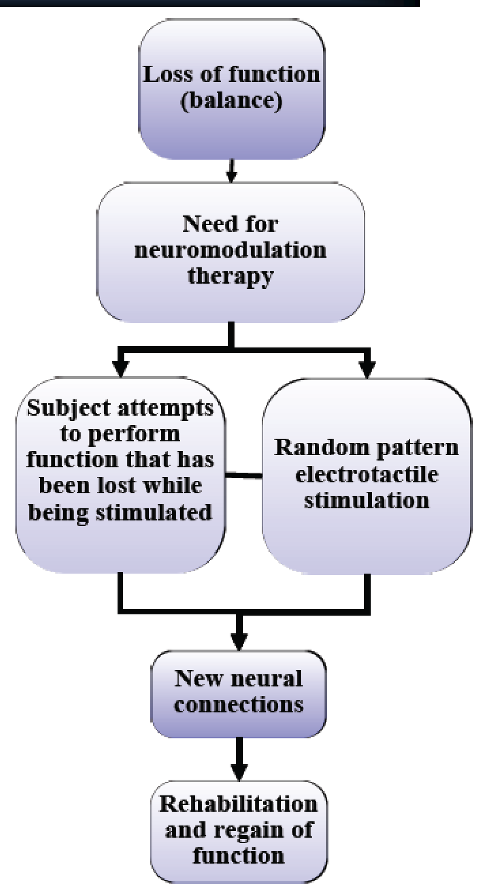


Figure 2: Flowchart describing rehabilitation using neuromodulation.

Motivation

The tongue stimulator is not ideal for all test subjects such as those who
•cannot hold the device in their mouths
•require the use of their mouths during rehabilitation.

Additionally, research may show that effects of stimulating the face is greater or can be used for different applications than those of the tongue stimulation.

Goal: To create a device so that our client may test the effectiveness of neuromodulation through a facial sensory channel.

References

[1] Tactile Communication & Neurorehabilitation Laboratory at UW-Madison (TCNL). 2008. http://tcnl.med.wisc.edu/home.php. (Retrieved September 4, 2009).

[2] Kaczmarek, K.A., Webster, J.G., Bach-y-Rita, P. and Tompkins, W.J. 1991. Electrotactile and vibrotactile displays for sensory substitution systems. *IEEE Transactions on Biomedical Engineering*. 38(*1*):1-16.

[3] Kajimoto, H., Kanno, Y., Tachi, S. 2006. Forehead electro-tactile display for vision substitution. *Proceedings of EuroHaptics,* 75-79.

[4] Canavero, S., Bonicalzi, V., Paolotti, R., Castellano, G.,Greco-Crasto, S., Rizzo,L., Davini, O., Maina, R. 2003. Therapeutic extradural cortical stimulation for movement disorders: A review. *Neurol Res 25:* 118-122.

Design: Initial Prototypes, Final Prototype and Testing

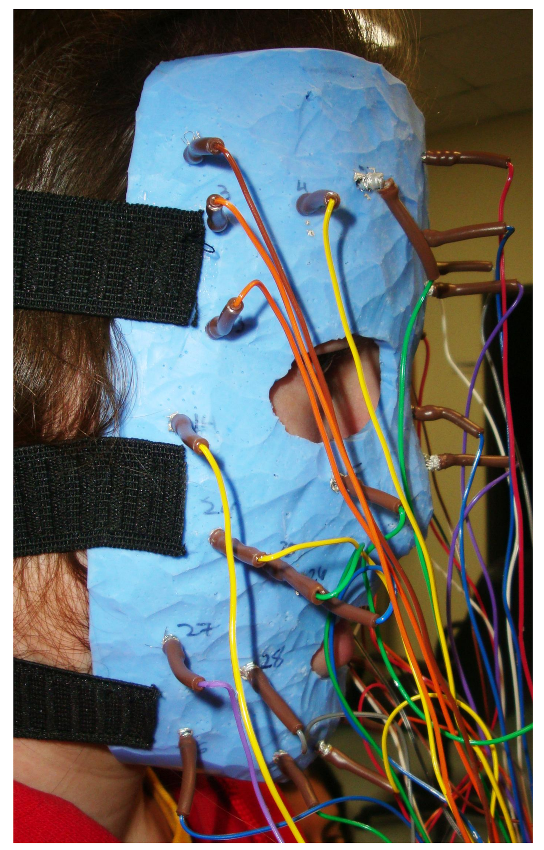


Figure 3: Final prototype on a subject.

Final Prototype

•Cost ≈ $90
•Mass = 200 g
•Electrodes=u-drive screws
  -2.46 mm long
  -7.85 mm head diameter
•36 electrodes
•Silver Flexible Cure conductive epoxy
•Heat-shrink tubing over connections
•3 x 25 mm wide elastic banding for straps sewn with thread
•Improvements from initial prototypes
  -more stable electrode connections
  -covered entire face
  -easier to put on

Initial Prototypes

Figure 4: First prototype using a pre-made plastic mask to mold the silicone.

Figure 5: Second prototype made from a ski mask.

Prototype 1
•Cost ≈ $75
•Silicone poured into pre-made mask
•18 electrodes
•Electrodes=u-drive screws
  -1.48 mm long
  -1.24 mm head diameter
•Pros
  -easy to mold
  -electrical stimulation worked
•Improvements to be made
  -lack of specificity to face
  -didn't cover half of face
  -poor electrode-wire connections

Prototype 2
•Cost ≈ $45
•Polyester and elastin ski mask
•50 electrodes
•Electrodes=u-drive screws as in Prototype 1
•Pros
  -conformed to most of face
  -no additional attachment needed
•Improvements to be made
  -poor electrode attachment
  -uneven contact force
  -not contacting entire face

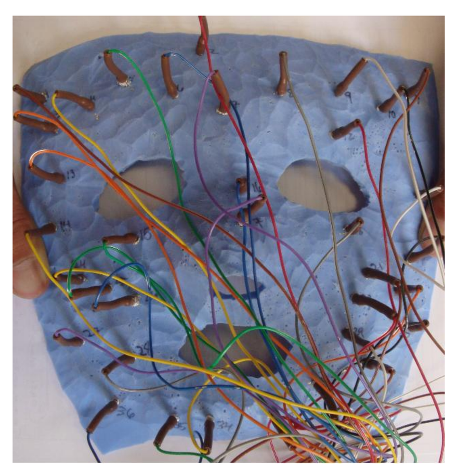


Figure 7: Flat view of the final prototype

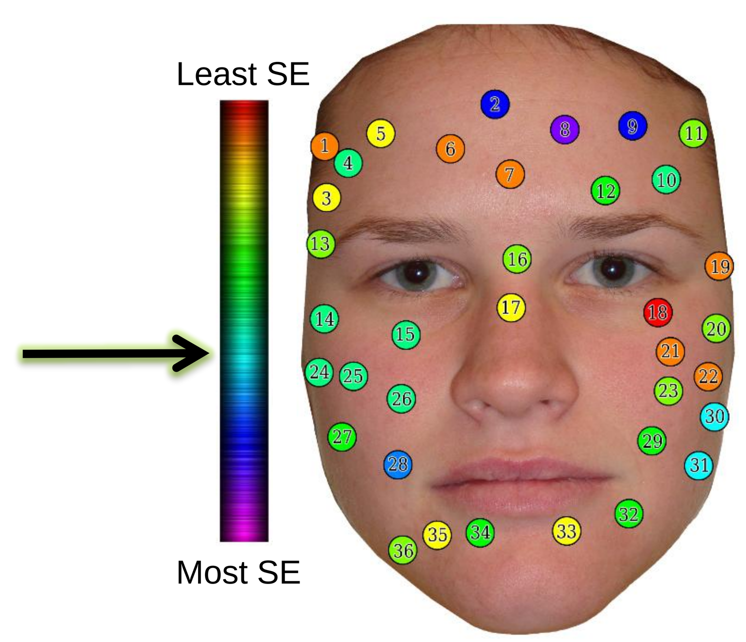
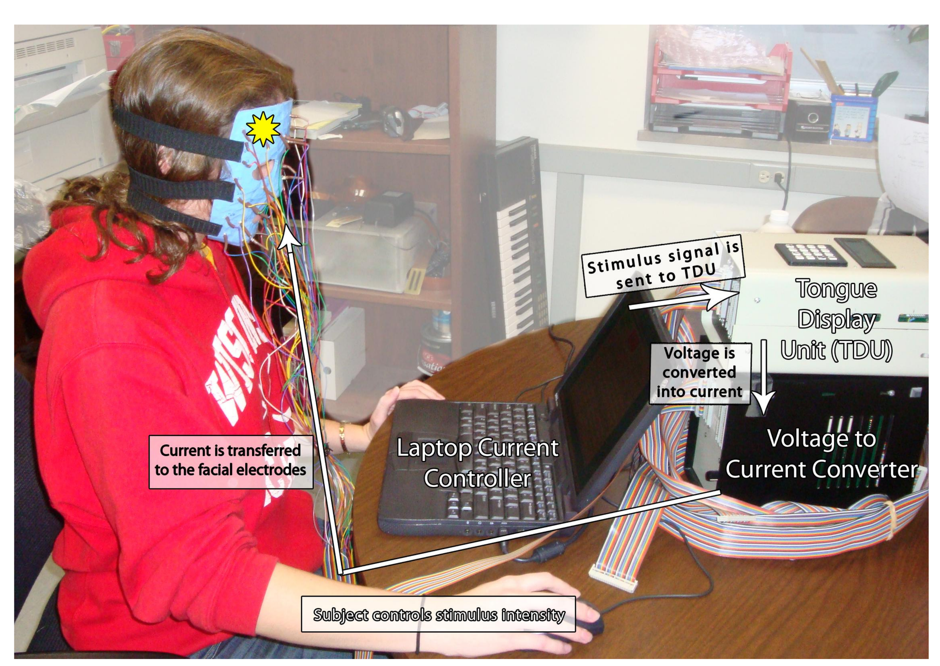


Figure 8: Positioning of the electrodes on the subject's face, indicating where each electrode touches and the relative standard error (SE) in the three separate threshold reproducibility tests (shown in Figure 9). The scale is shown to the left, with red representing least SE and purple, most SE.

Figure 8: Testing procedure setup. In testing, the subject controlled the stimulation intensity of each electrode individually and the device was current-controlled to ensure safety.



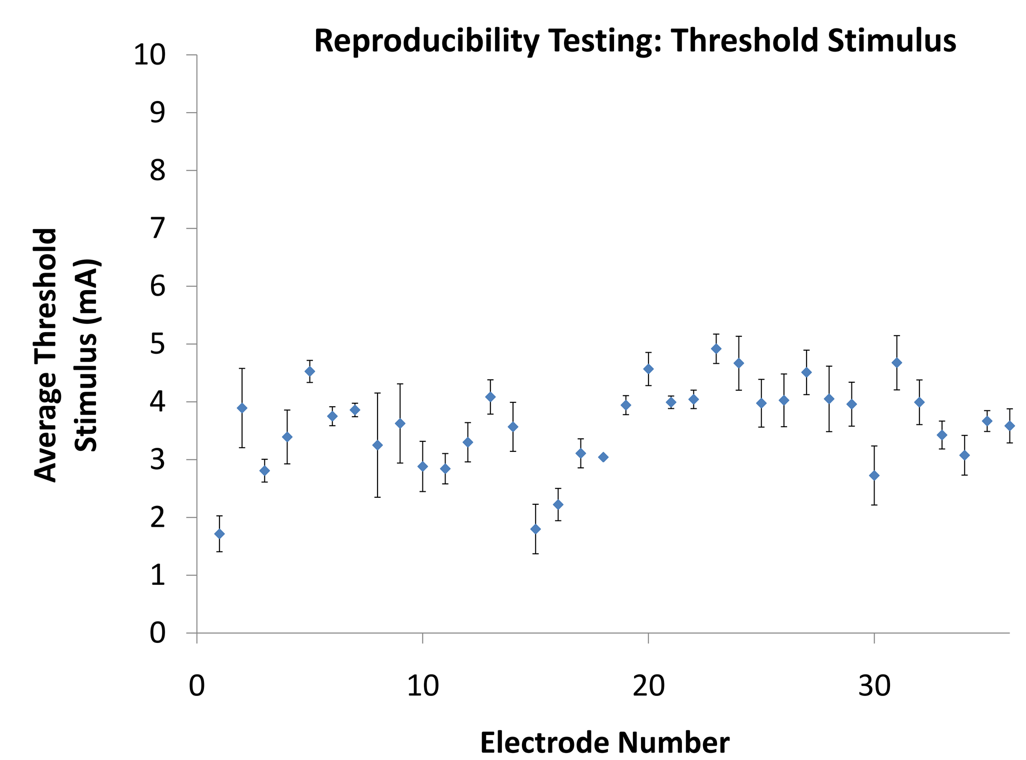


Figure 9: The face mask was placed on the subject's face three separate times and each electrode was stimulated individually to the minimum threshold of current at which the subject noticed stimulation. This threshold stimulus was recorded and the average of the three replicates is plotted above (±1 standard error [SE]). The range of threshold stimuli for all 36 electrodes was 1.2-5.3 mA with an average SE of 0.345 mA.

Competition

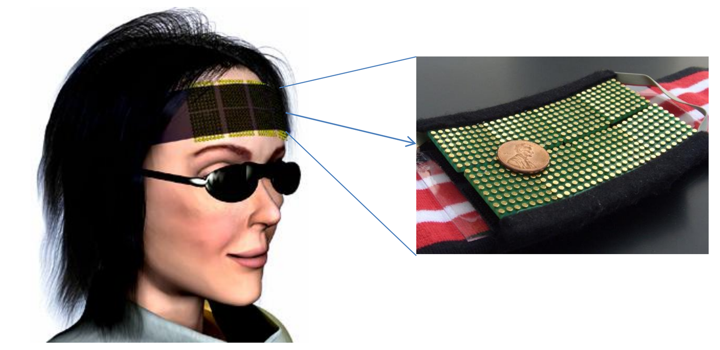


Figure 10: Competition for facial stimulation involves a forehead stimulator model made for vision replacement.[3]

Figure 11: Extradural cortical stimulation is a competitive treatment for balance disorders that is highly invasive and involves the implantation of electrode paddles directly onto the cortex.[4]

Design Criteria

-Must not be uncomfortable to wear
  -30-min./session once a week
  -Possibly > 1 year
-Conductivity– withstand and utilize perspiration
-Weigh less than 250 g
-Good mechanical contact and electrical connection
-Safe
  -Current-controlled (<10 mA) for safety
  -Virtual ground
  -Nontoxic materials
-Electrodes
  -Should not react with skin (gold, stainless, platinum)
  -Smooth head (minimal edge effect)
-Prototype cost <$3,000

Safe + Good Contact

Future Work

-Straps
  -Need a more adjustable format
  -Application of Velcro could alleviate this issue
-Manufacture Process
  -Must take less time
  -Less specific final product
  -Use MRI (Figure 12)
  -Use rapid prototyping technique for mold
-Increase Coverage Area
-Electrode contact improvements

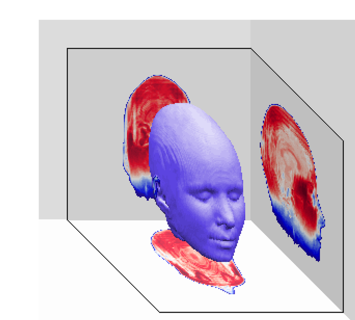


Figure 12: An MRI scan could provide a 3D rendition of the face.
(taken from http://web2.uwindsor.ca/courses/physics/high_schools/2006/Medical_Imaging/mri.html)

Conclusions

Overall, our final prototype met our goals:
1. Can electrically stimulate the face.
2. Conforms to most areas of subject's face.
3. Has stable electrode connections.

However, there are also a few key areas which could be improved:
1. Better conform to concave areas of face.
2. Better position reproducibility of mask on face (as measured by very low standard error in stimulation threshold reproducibility testing).

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