402 - Excellence - 12 - Hindlimb_Stim - Executive Summary

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Phantom limb pain (PLP) is a neuropathic disorder, often described as a shooting or burning sensation that is caused by the misfiring of nerves damaged during amputation. There are approximately 185,000 amputations each year in the U.S. and between 42.2-78.8% of amputees suffer from PLP immediately following surgery or years later. The average health care costs for an individual's PLP treatment totals nearly $100,000. Treatments consist of both pharmacological and nonpharmacological approaches, but due to the lack of knowledge about the mechanism behind the pain, these treatments are often ineffective. A proposed solution to PLP currently being investigated is an electronic interface for peripheral nerves. This interface contains electrodes that are implanted around the nerve(s) deafferented during amputation to alleviate PLP and potentially serve as a means to restore the amputee's sense of touch through tactile sensors embedded in a prosthetic limb. The device is in the animal testing stage of the FDA approval process, and a device to provide proof of concept testing in a rat model is needed.

Current rat training enclosures on the market from companies such as Coulbourn accommodate training modules with a shocking floor and nose poke holes with olfactory stimuli. While a shocking floor could provide stimulus to a rat's hind limbs, it does not allow for isolation of the stimulus to a single limb. This detail is critical for testing efficacy of the new electrode device. Our device must be able to mechanically stimulate a single rat hindlimb at a range of frequencies from 50-250 Hz. It must not cause any residual artifacts from the stimulus that may lead the rat to give a correct response without proper functioning of the electronic interface.

An enclosure made out of clear acrylic was designed with nose poke holes for providing rewards and a base with two cutouts with vibrating platforms. These platforms are slightly smaller than the openings to prevent conductance of the vibration throughout the rest of the test enclosure. The platforms are attached to surface transducers, which provide linear vibrations and the transducers are rested in a highly damping foam for further vibrational isolation. The system is controlled using an Arduino Due microcontroller with corresponding code to produce precise sine waves at the desired operating frequency. A laptop user interface allows for real-time frequency variation of each hindlimb platform individually.

Bench testing confirmed that the frequencies of the sine waves were accurate for the user input both before and after amplification. Accelerometers were used to measure the displacement at various locations on the chamber to confirm that the mechanical stimulation was isolated to each platform and matched the frequency input by the user in real-time. Platform frequencies were within one Hz of the input value and displacements elsewhere in the enclosure were negligible. These results validated that the device can accurately produce sine waves at the correct frequency and drive the motors at the right frequency as well. Therefore, the device may be used for rat training as well as further research and testing of the electronic interface devices.

The corresponding code allows the user to adjust the operating frequency isolated on each platform and the device contains nose poke holes for recording rat responses. These features create a user-friendly device for accurately completing proof of concept testing of electronic interfaces in rat models. Validation of the efficacy of these interfaces to restore tactile sensation in rats will allow these devices to move toward human clinical trials and eventually FDA approval. Approval of this technology holds the potential to make a lasting impact in the field of electronic interface and improve the quality of life of amputees all over the world.