Somatosensory Stimulation Apparatus for Rodent Cages
Product Design Specification

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Function

Peripheral nerve injuries are common, debilitating and costly. Approximately 2.8%-5% of all trauma patients in the US sustain such an injury. Many peripheral nerve injuries are a result of amputations, which affect an estimated 185,000 people in the US each year. Prosthetics are continually improving, but a large issue that remains is the patient's lack of tactile perception. Many researchers, including Dr. Aaron Dingle, are designing devices to solve this problem. The functional outcome of these devices can be assessed in humans by asking the patient questions, but this technique is not an option in animal models. Rats are commonly used as animal models as a precursor to human subject testing. In order to receive functional outcome data from rats, a healthy rat can be trained to respond in a certain way to a somatosensory stimulus. A peripheral nerve can then be surgically cut and the novel device implanted. The device can then be used to apply what should be recognized as the same somatosensory stimulus the rat was trained with. Observations on the percent of correct reactions can be used to determine success. This project aims to design the somatosensory stimulation device used to train the rats. The device should be able to apply a graded stimulus to at least two limbs individually, while allowing the rat to respond differently to the graded potentials. The device will consist of a cage or cage insert as well as a microcontroller to control the stimulus grade.

Client Requirements

- Stimulate the two hind limbs of the rat independently and extend the stimulation to the front limbs if possible
- Avoid using electrical stimulation since it might interfere with the electrodes
- Incorporate a graded stimulation to the rat
- Create a system that allows the rat to respond uniquely to different levels of stimulation
- The stimulation must be applied to the rat in the confinement of a cage that does not restrict the rat's movement

Physical and Operational Characteristics

a. Performance requirements: The device will need to comfortably fit a 250-350g Lewis rat. There should be 2-4 individual locations for stimulus to be supplied to the limbs of the rats. The device will be used multiple times in a row for up to 60 minutes at a time until the rat has 50 correct responses. It needs to be able to accommodate testing on

addition rats afterwards. The device will have a permanent power supply (most likely a laptop), so battery life is not a concern.

b. Safety: Rats must not be harmed during use of the device. This requires standard electrical safety standards such as eliminating exposed wires. If temperature is the adjustable stimulus, it must remain in a comfortable range of 16-26℃. If vibration is the stimulus, it must not exceed 3000 rpm. If the device has parts that get attached to the limbs, it must not excessively restrict the rats motion.

c. Accuracy and Reliability: The device must be able to provide stimulus in a precise, repeatable manner. Initially, the team will focus on obtaining a single, consistent stimulus, but eventually the client would like graded levels of stimuli. Success of the device is first determined by the ability to generate an accurate and reliable signal along with a system that allows for different levels of response by the rat. Success will also be determined by the ability to fit a sigmoidal curve to the data collected by plotting percent correct response vs. stimulus amplitude.

d. Life in Service: The device should be used on the rat for 60 mins at a time, until the rat achieves 50 correct responses. It must be able to undergo many consecutive trials for several days in a row. The device will be plugged in, so operating life will not be an issue.

e. Shelf Life: The device will be stored in a temperate, dry lab environment. The device itself does not have a shelf life, but like any other device, as technology improves, the device may become outdated.

f. Operating Environment: The device will be used in a lab environment, which includes normal room temperature, pressure, and humidity. The largest concern is ensuring that the electrical and mechanical components stay dry and out of reach from the rat to ensure that it does not damage the components.

g. Ergonomics: If temperature is the adjustable stimulus, it must remain in a comfortable range of 20-28℃. If vibration is the stimulus, it must not exceed 3000 rpm. If vibration is the stimulus, the noise caused by the vibration must be inaudible or another noise must be produced so that the auditory stimulus between all stimulation amplitudes is the same. The device should be able to accommodate any small variations in the size of the rats, and must not cause them any discomfort to avoid false stimulus responses.

h. Size: The device must be a cage or fit inside a cage that is a minimum of 35x25x18cm. There are no restrictions of the size of the circuitry/ complementary components outside of the cage.

i. Weight: The device will be used on a table or a lab bench, so weight is not a major concern. Nevertheless, a target weight of less than 5 lbs will allow researchers to easily carry, move, and store the device.

j. Materials: No material should be used that could potentially cause irritation to the rats. The cage floor and walls should be made out of plastics such as polypropylene or polycarbonate with a wire mesh top. For the components outside the cage, there are no material restrictions.

k. Aesthetics, Appearance, and Finish:The cage should be made from a clear plastic or thin wire to allow for observation of the rat during the training and testing periods. The device is for testing purposes so the aesthetics/ appearance is not the primary concern.

Production Characteristics

a. Quantity: The client only needs one device, but it must provide multiple stimulations for testing

b. Target Product Cost: A max budget of $1000 was given. The client gave the team access to the lab's Quartzy group, which will allow us to easily get supplies ordered. There are no existing products on the market to compare with the cost of this project.

Miscellaneous

a. Standards and Specifications: The device must be consistent with the Animal Welfare Act (1966). This act regulates the treatment of animals in research, exhibition, transportation, and by dealers. We must also follow normal standards for electrical safety.

b. Customer: Client likes idea of having a vibrating floor in the cage and believes it will be easy to train the rats to respond toward this type of stimulation. However, they are open to other potential sources of stimulation.

c. Patient-related concerns: Device must be able to be sterilized. This can be done using by wiping the device with cleaning solution after each use.

d. Competition: There are a variety of companies out there that create product for rat testing, such as Vulintus and Harvard Apparatus. None of these companies make a product that performs this type of specific hind leg stimulation for research on nerve regeneration.