

Mouse Sleep Deprivation Device

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Abstract

Dr. Rama Maganti is researching epilepsy in mice in order to better understand how and why epileptic seizures occur and what effects they have. To accomplish this research, he conducts experiments wherein mice are deprived of sleep and the incidence of epileptic seizures are recorded. He is dissatisfied with his current mouse sleep deprivation product because of its lack of stability, lack of options for programming, and cost. We have created a prototype that uses more durable materials and gives the users more options for use. Additionally, the prototype system can be easily programmed and expanded to fit more modules of this design or different experimental products in the future.

Motivation

Medical Motivation

Epilepsy is a chronic brain disorder that is characterized by seizures. It affects over 50 million people worldwide and in 30% of these people (15 million) seizures cannot be controlled with current treatments (1). Additionally, in 70% of cases the cause of epilepsy is not known (2). It has been seen that sleep loss increases the incidence and severity of epileptic seizures, but the exact mechanism for this is not well known (3).

Product Motivation

Commercial sleep deprivation cages currently available for mice have effective mechanisms for waking mice but have several deficiencies. Most notably they are:

- Often built with less than satisfactory materials
- Very limited in user options
- Narrow in scope in terms of use (expansions and add-ons must be made within the brand of product)
- Expensive



Figure 1: Client's current product from Afasci

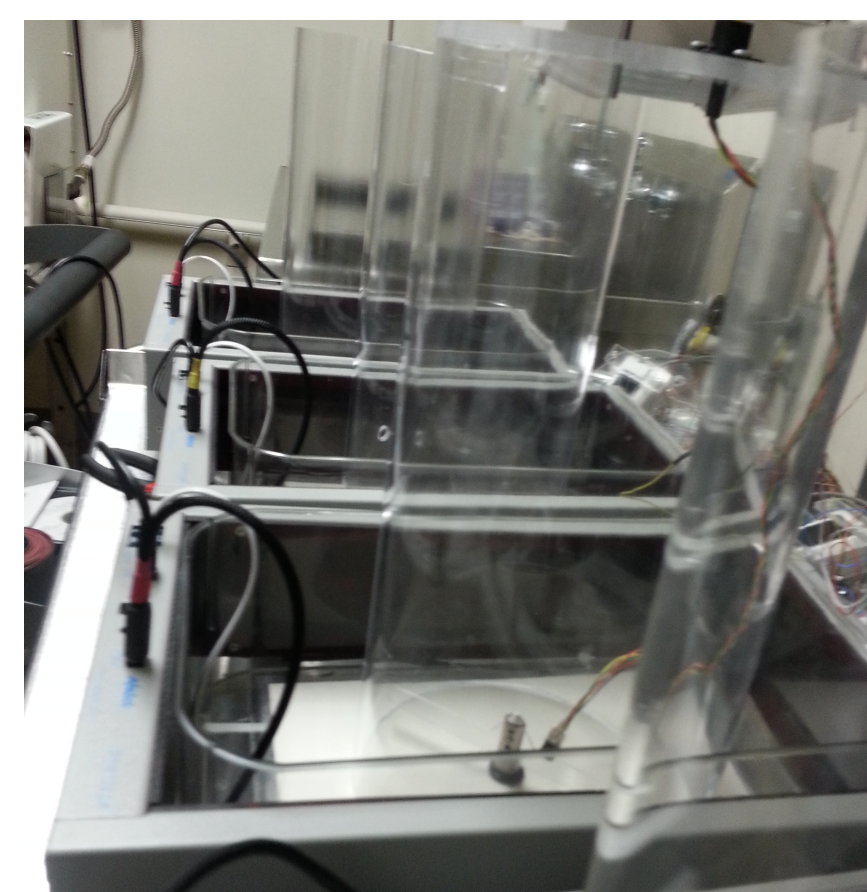


Figure 2: Current client experimental setup

Design Criteria

- Stable housing for 1 mouse that fits within 25 by 35 cm area
- Delivers a stimulus that can awaken the mouse
- Intuitive user interface for programming multiple speeds, frequencies, and durations in one user action.
- Continuously operable for up to 3 weeks at
- Sterilizable at a temperature of 82 degrees C
- Must meet standards for animal care
- Budget is \$125

Final Design

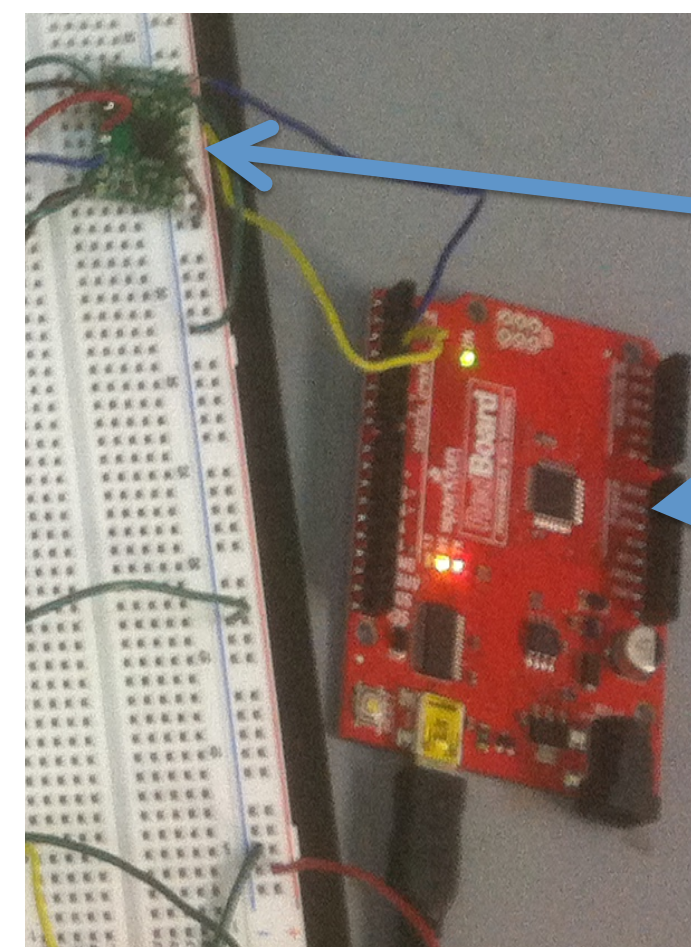


Figure 3: Prototype Circuit

Circuitry

- Stepper motor: Bipolar DC Stepper
- Driver: Interface between motor and arduino: helps smooth the motor motion and separates power needed for both parts
- Arduino: single board designed make microcontroller use less technical
- Arduino sends signals to the STEP and DIR pins on the driver, which then sends high/on signals to the four leads connecting to the motor in the proper sequence for it to spin

Software

- LabVIEW user interface
- Allows programming of 8 separate start times, end times, iterations, frequencies, and speeds
- Saves data input by user
- LED indicates that the propeller is turning
- LabVIEW in conjunction with Arduino IDE programs the circuit

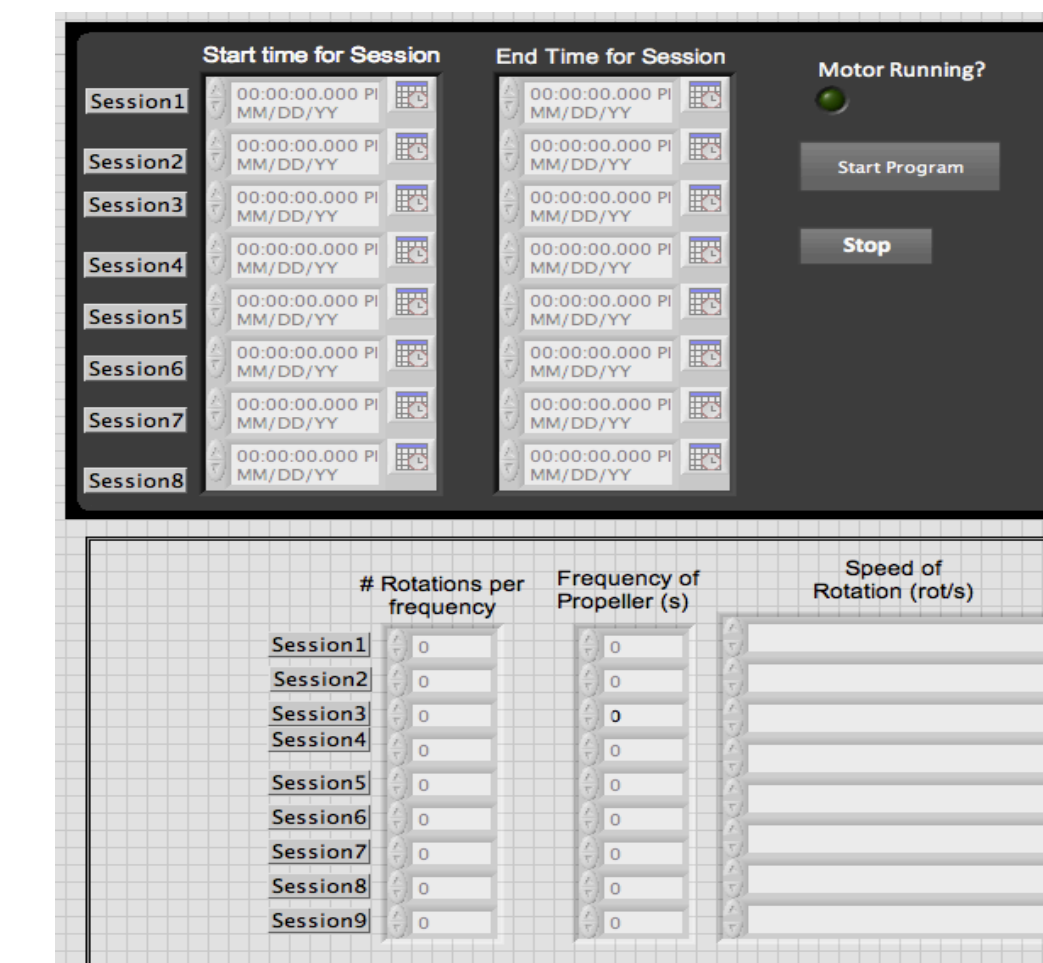


Figure 4: Screenshot of user interface

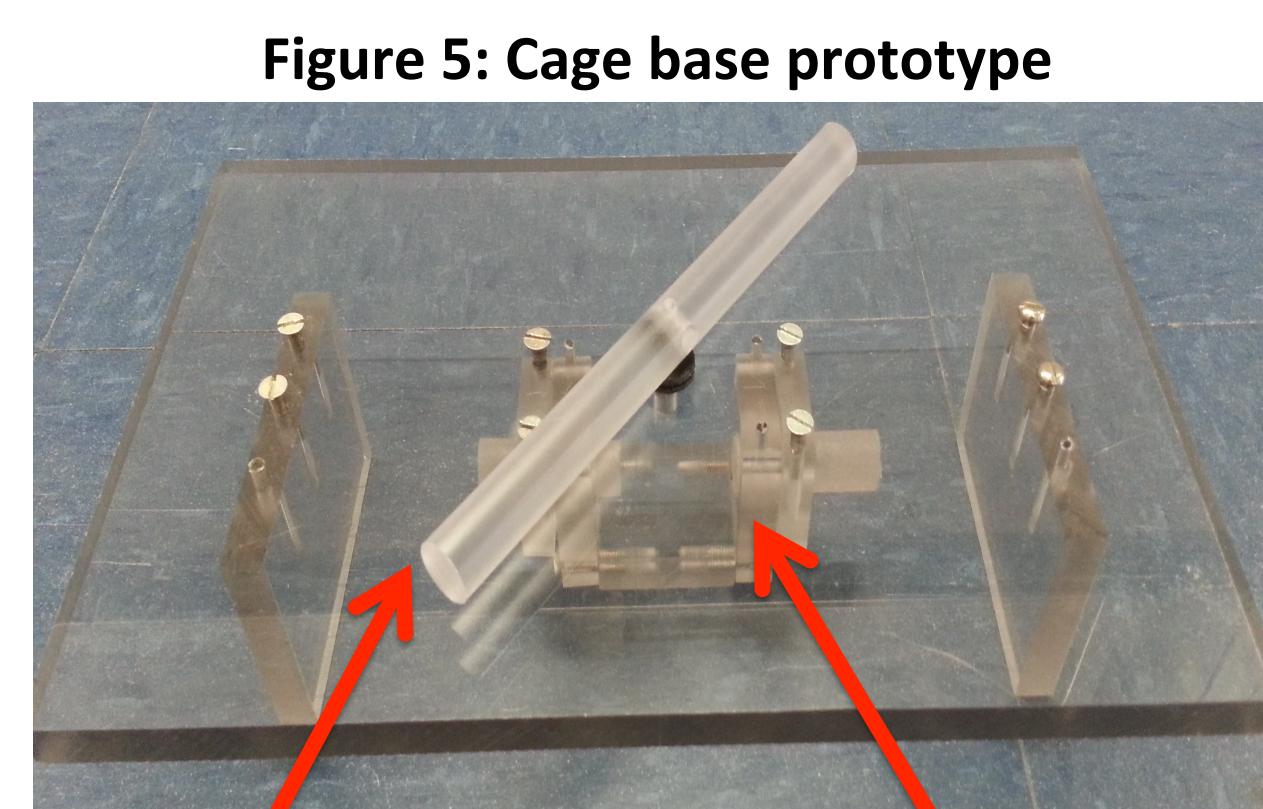


Figure 5: Cage base prototype

Cage

- Constructed with simple mechanics and materials; allows for the product to be easily reproducible
- Sturdily built with polycarbonate that is autoclavable (sterilizable at 82 degrees C)
- Cage design allows for easy access to the stepper motor
- Dimensions compatible with current product

Propeller Motor housing

System

- Stepper motor is housed below cage
- Propeller is affixed to stepper motor with screw on the side of the propeller
- Software does not need LabVIEW license to run on client computer

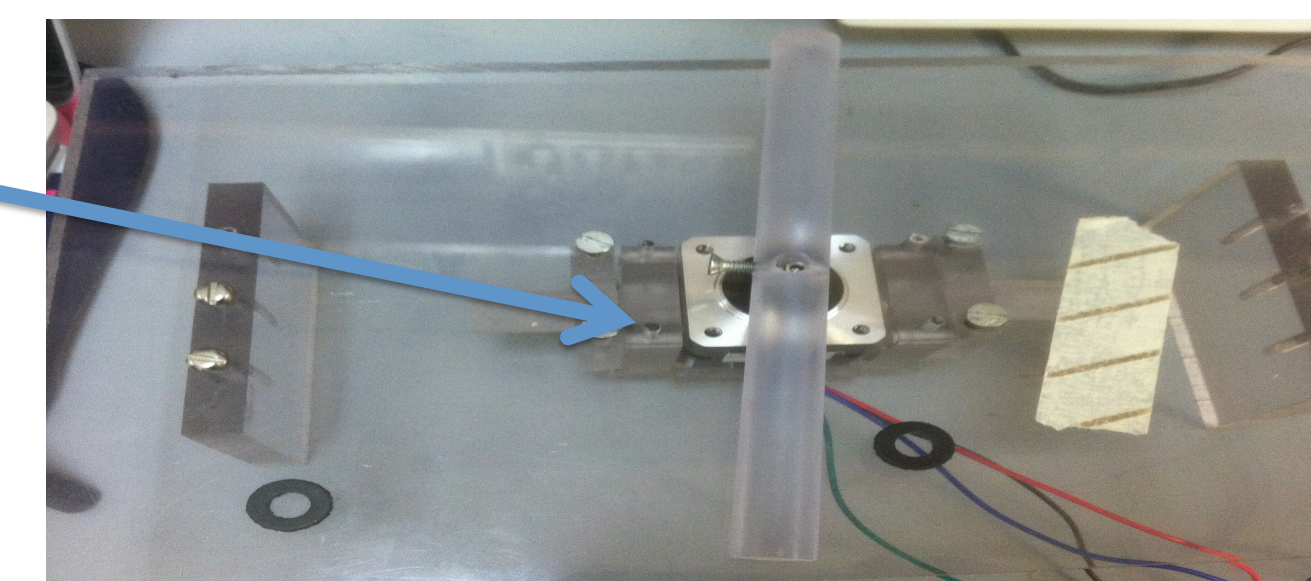


Figure 6: Final Prototype

Testing and Results

Testing Procedure

21 participants were asked to complete 4 increasingly difficult tasks that demonstrated their ability to understand how to enter parameters into the user interface of the software. Participants were then asked to fill out a short survey concerning their computer ability, perceived ease and intuitiveness of using the program, and likes and dislikes about the program.

Results

- Average user successfully completed 3.24 tasks without direction or example (80.9% average success)
- After being shown 1 example, 85% of users successfully completed remaining tasks

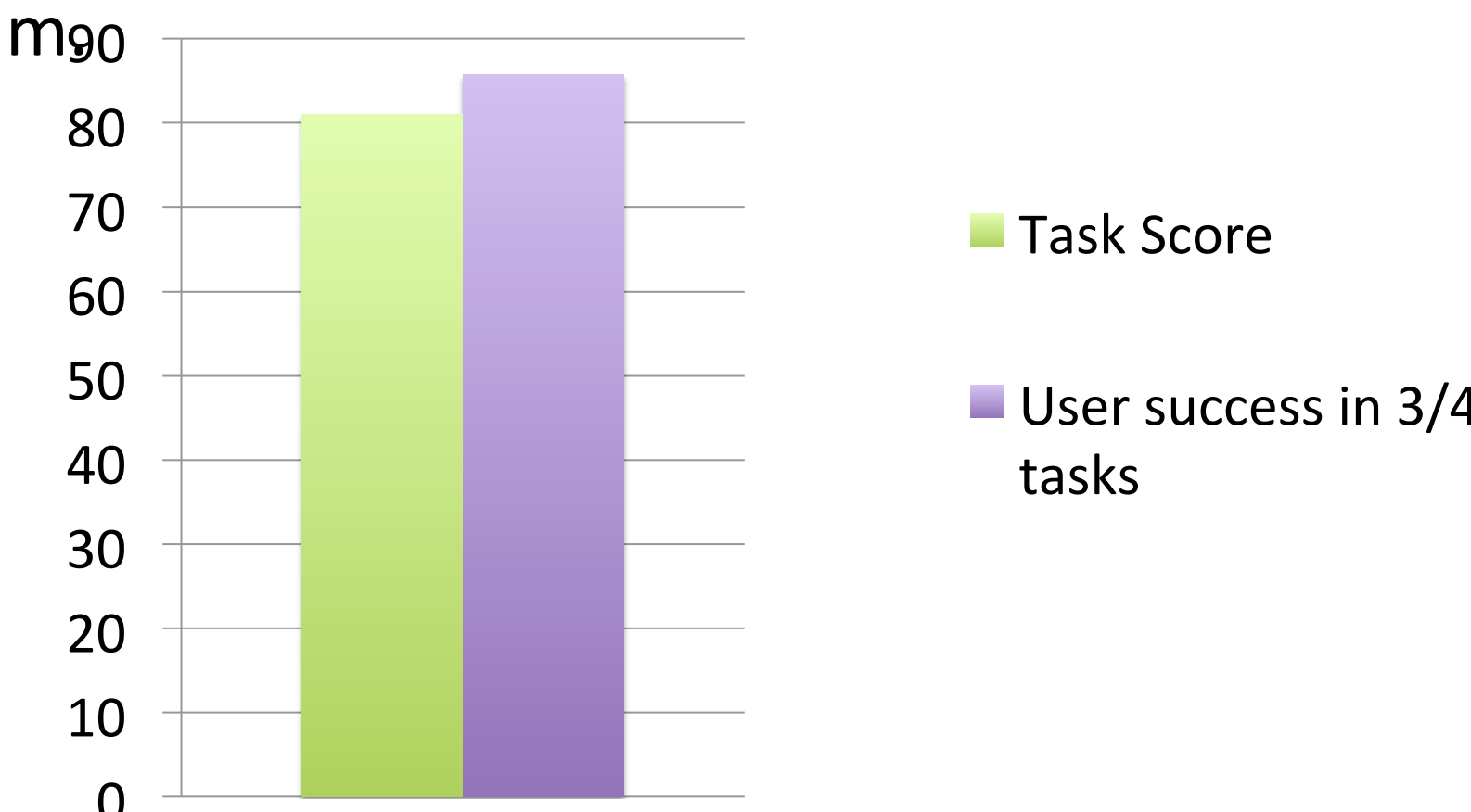


Figure 7: User testing results

Results (continued)

- Average user "Easiness" rating: 3.88/5
- Average user "Intuitiveness" rating: 3.90/5
- Most common positive comment: Variation of "System is easy to use" (11 incidences)
- Most common negative comments: Variation of "Include directions" (7 incidences) and variation of "Better define units/labels" (6 incidences)

Budget

Item	Cost
Polycarbonate Sheet and Rod	\$38.77
Stepper Motor	\$19.90
Driver Chip	\$24.90
Arduino	\$24.95
Shipping for Circuit Components	\$10.01
Nails, screws	Donated
Total Cost	\$118.51

Future Work

Current Prototype Alterations

- Refine propeller design to better reflect mouse size and ability
- Create housing for circuitry
- Alter software to be able to direct multiple cages at once

Testing

- Stability and strength testing of design materials
- Accuracy and longevity testing of the prototype
- Animal testing
- Test possible user and circuit errors

Improvements to Design

- Create motion sensing system that automatically moves propeller when it detects a lack of mouse movement
- Change system so that it operates wirelessly
- Integrate current client data acquiring mechanisms into prototype

References

Acknowledgements

- Dr. Chris Brace
- Eli Wallace
- Dr. John Puccinelli
- Dr. Rama Maganti
- Matt Bollom

References

1. "What is Epilepsy." *The Epilepsy Foundation*. Epilepsy Foundation of America, 2012. 29 Apr. 2013
2. "Causes of Epilepsy." *The Epilepsy Foundation*. Epilepsy Foundation of America, 2012. 29 Apr. 2013