DEPARTMENT OF

Biomedical Engineering

UNIVERSITY OF WISCONSIN–MADISON

Primate Portal

Lab Section 304
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Team Members

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Advisor and Client

Prof. Dhananjay Bhaskar	Advisor
Prof. David Herzfeld	Client

Figure 1: Primate Portal Team Picture - Left to Right: Charlie, Jackson, Andrew, Kalob, Logan, Sameer

Outline

- Introduction
  - Client Description
  - Client's Problem Statement
  - Existing Designs
- Product Design Specification (PDS)
  - Design Alternatives
  - Design Matrix
- Final Design
  - Mechanical
  - Electrical
  - Software
- Future Work
- Conclusion

Client Description

- Professor David Herzfeld
- Department of Neuroscience
- Works with Rhesus Macaque

Figure 2: Dr. David Herzfeld

Figure 3: Rhesus Macaque

Problem Statement

Project Description

- Develop a cage-mounted touchscreen device that delivers liquid rewards to primates

Client Requirements

- Safe (Water resistant, no exposed wiring, failsafes, durability)
- Efficient liquid delivery in a home environment
- Data storage locally, ethernet compatible, standard power inputs, open API
- Modularity focused and extensible for expansion

Cost Considerations

- $5,000 budget allocated for research and development

Background

- Training monkeys with positive reinforcement to understand complex cognitive behavior
- Complex neural response, easier to research
- In cage training benefits
  - Ease of Use
  - Stress Free

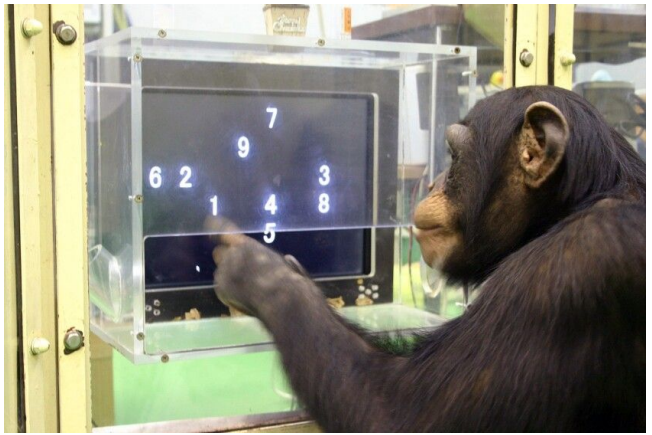


Figure 4: Example of primate using training system

Competing Design

Thomas Primate In Cage Training System (ICTS)

- Only in-cage system known to be commercially available [1]
- Shock- and waterproof 8” touchscreen
- Microprocessor control unit can control external devices (camera, eye tracker)
- **Prohibitively expensive (~$100K)**
- **Limited extensibility for new tasks**

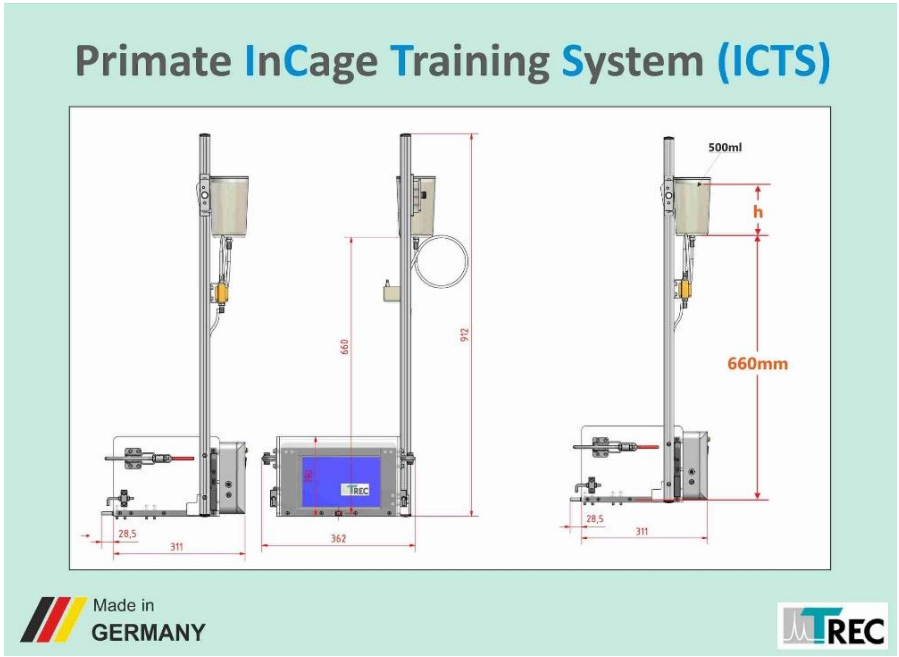


Figure 5: Thomas Primate In Cage Training System

Product Design Specifications (PDS)

- Safety by following IEC 60601 and Animal Welfare Act [2][3]
- Dispense juice when primate completes task
- Notification system if there is a failure
- Electronics Enclosed - ip54
- Secured Touchscreen
- Modular for future improvements
- Data Accessible through USB or SSH
- Easy to use for operator

Display & Circuit Box Clasp

- Very compact combined casing.
- Freely movable nozzle.
- Detachable hinge on the right side with a latch on the left.

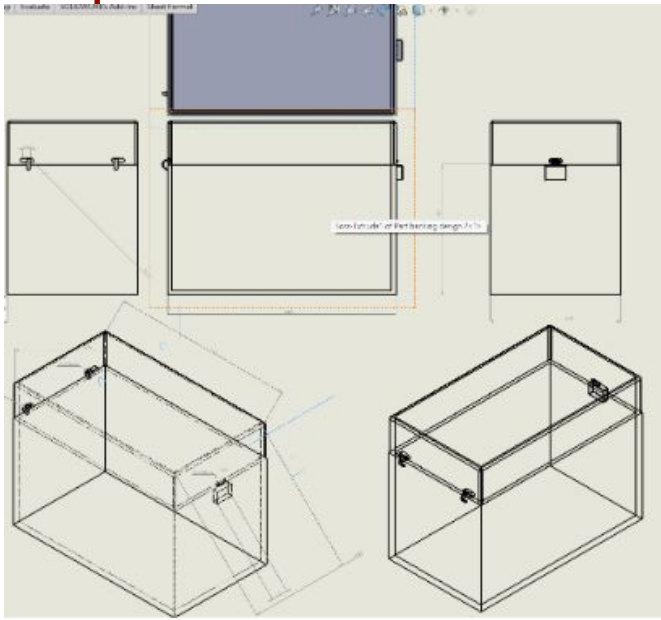


Figure 6: Display and Circuit Box Clasp CAD design

Horizontal Display

- Hole for nozzle on the right side of the screen.
- Hole in the back of the casing for wiring to the screen.
- Slidable side panels for easy access to the pump and screen.

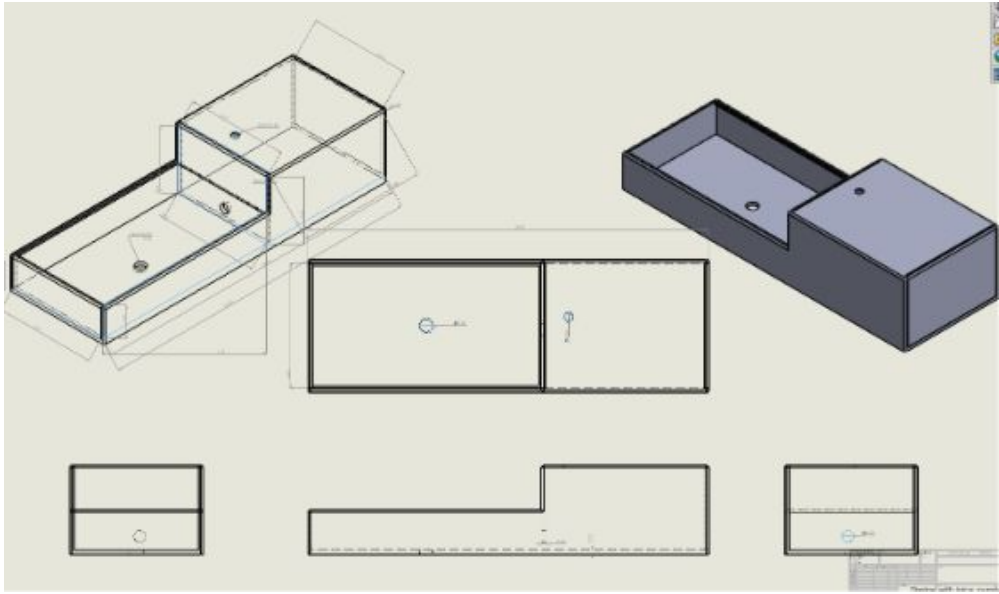


Figure 7: Horizontal Display CAD design

Vertical Display

- Hole for the nozzle under the screen.
- Hole in the back of the casing for wiring to the screen.
- Slidable side panels for easy access to the screen and pump system.

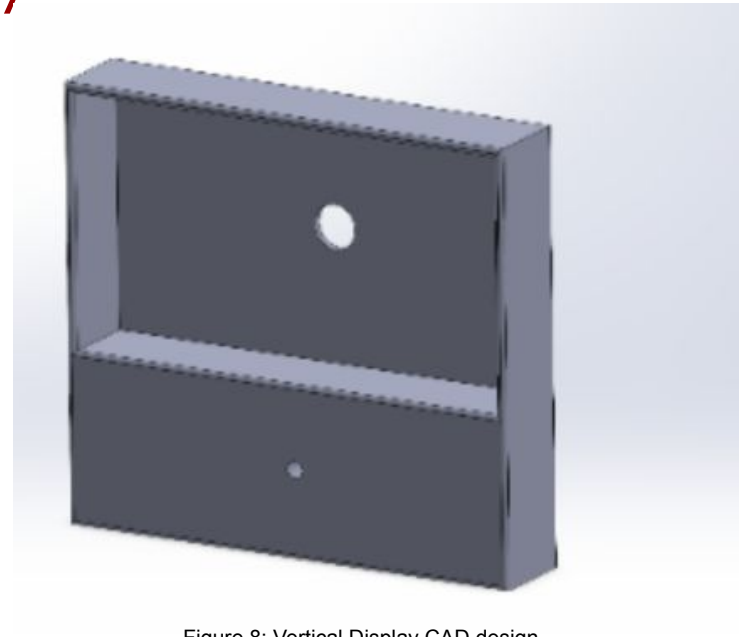
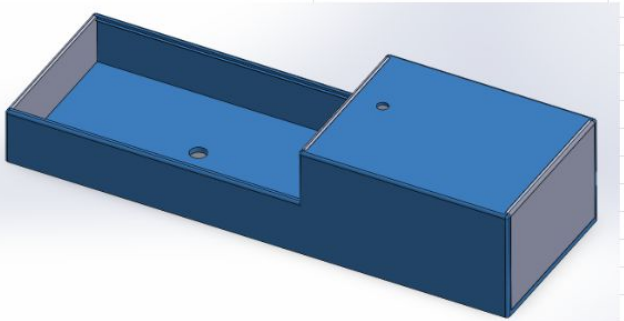
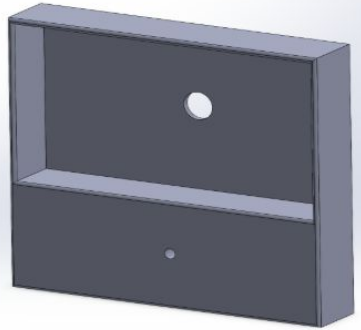


Figure 8: Vertical Display CAD design

Design Matrix





Criteria (weight)	Design 1 Raw Score	Design 1 Weighted Score	Design 2 Raw Score	Design 2 Weighted Score	Design 3 Raw Score	Design 3 Weighted Score
Safety (35)	3/5	21/35	4/5	28/35	5/5	35/35
Ease of Use (25)	4/5	20/25	4/5	20/25	5/5	25/25
Cost (5)	5/5	5/5	4/5	4/5	4/5	4/5
Ease of Fabrication (15)	5/5	15/15	4/5	12/15	4/5	12/15
Ease of Assembly/Disassembly (20)	3/5	12/20	4/5	16/20	4/5	16/20
	Sum	73/100	Sum	80/100	Sum	92/100

Figure 9: Enclosure Design Matrix

Hardware Diagram

6 Pin Connection to Motor Controller:

- 5V
- GND

- R_EN - Forward enable
- L_EN - Reverse Enable

- RPWM - Forward Signal
- LPWM - Reverse Signal

In progress:

- Dedicated power supply
- Magnetic interlocks

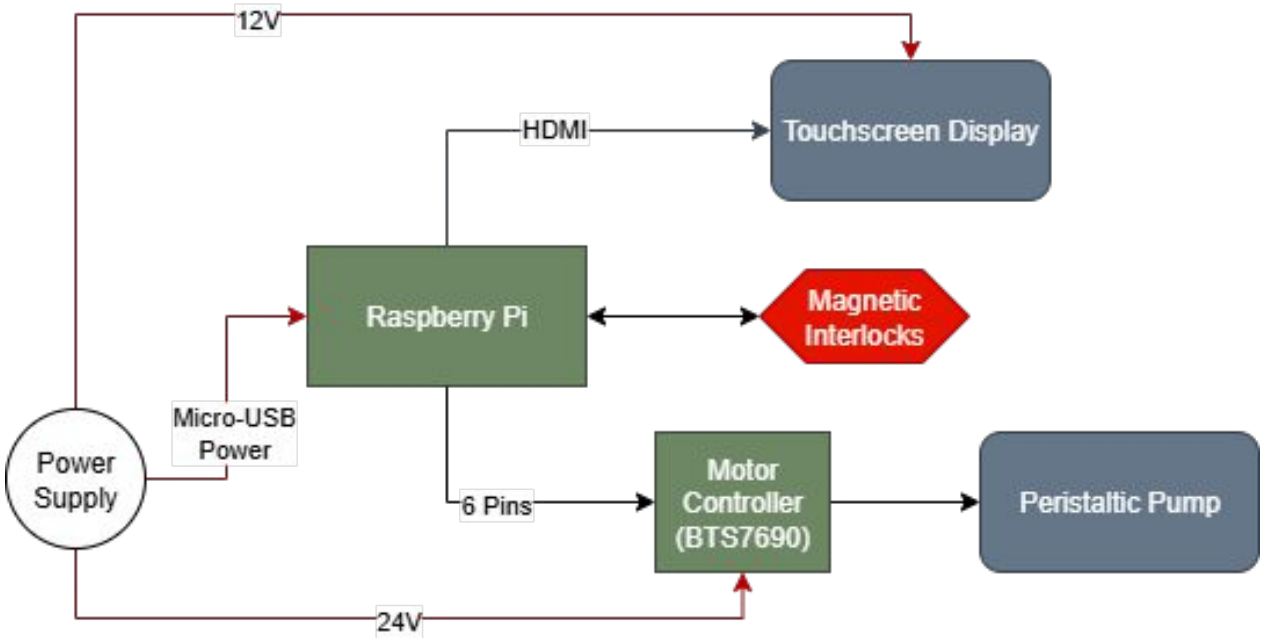


Figure 10: Hardware Diagram

Hardware Components

Raspberry Pi Details:

- Raspberry Pi 3B+
- Unix based OS with python control
- PWM wave output (pins 23 & 26) for motor control - 20,000 Hz communication
- SSH and VNC capabilities

Motor Controller and Peristaltic Pump

- MOSFET based motor controller [4] (acts as transistor to control voltage to pump)
- Protects back emf from motor
- Pump is positive displacement pump (pushes on tubing)
- No contact with inside of tubing

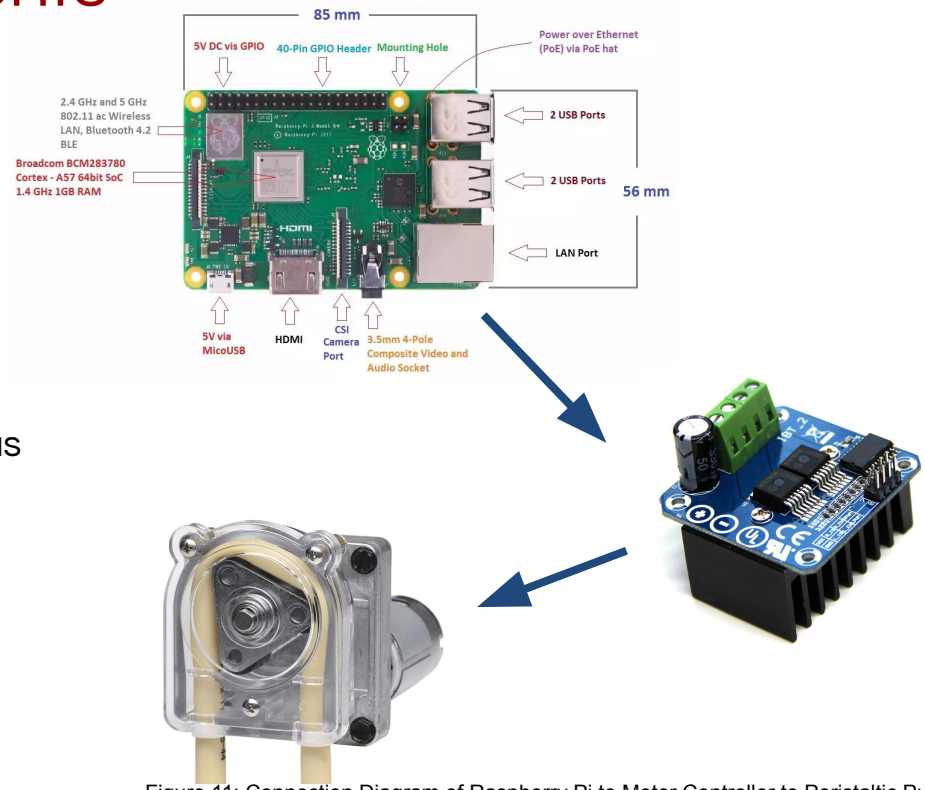
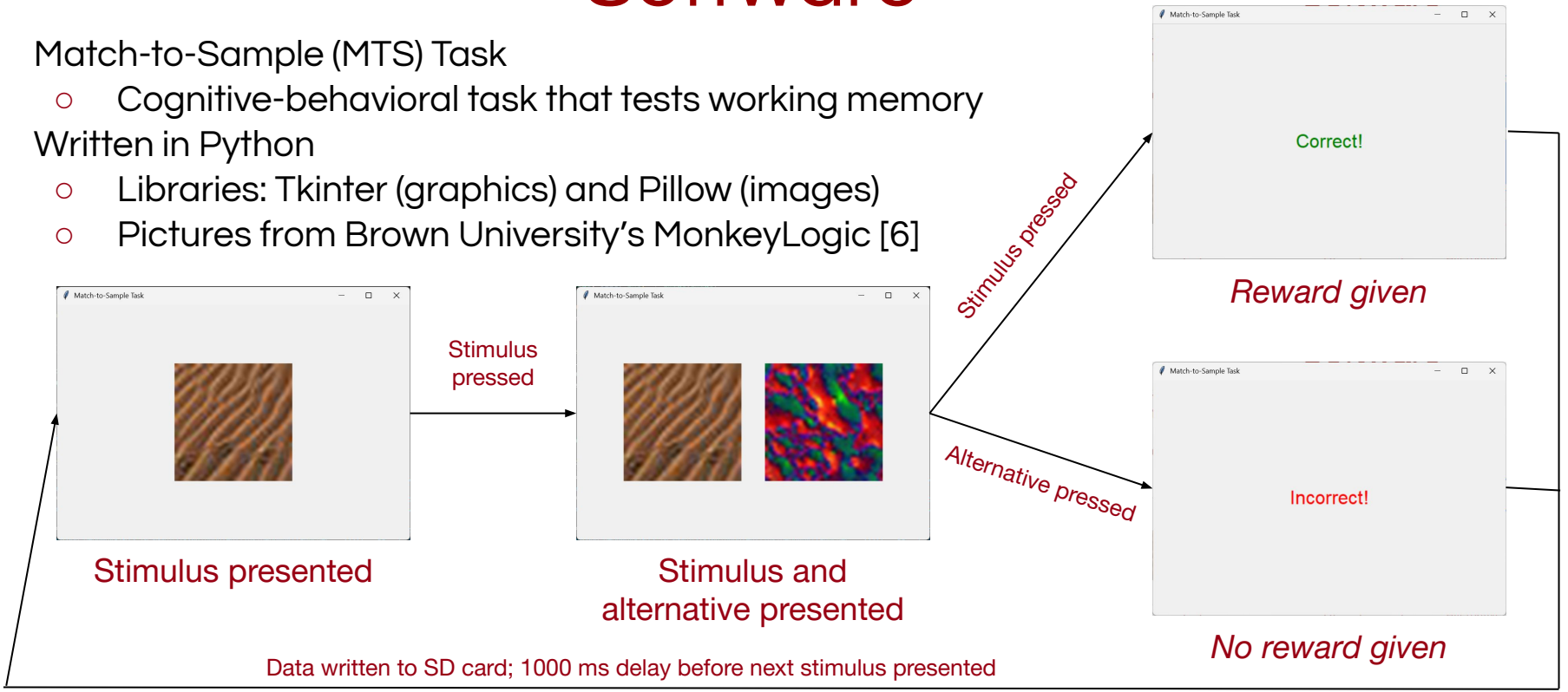


Figure 11: Connection Diagram of Raspberry Pi to Motor Controller to Peristaltic Pump

Software

- Match-to-Sample (MTS) Task
  - Cognitive-behavioral task that tests working memory
- Written in Python
  - Libraries: Tkinter (graphics) and Pillow (images)
  - Pictures from Brown University's MonkeyLogic [6]



Touchscreen

Requirements

- Water Resistant
- Impact Resistant
- 6 to 9 Inches
- Affordable
- Raspberry Pi Compatible

GreenTouch Features

- IP65 Rating
- 3-cm Tempered Glass
- 8 Inches
- $200
- Linux Compatible

Figure 12: GreenTouch Touchscreen

GreenTouch 8″ Touchscreen [5]

Final Design

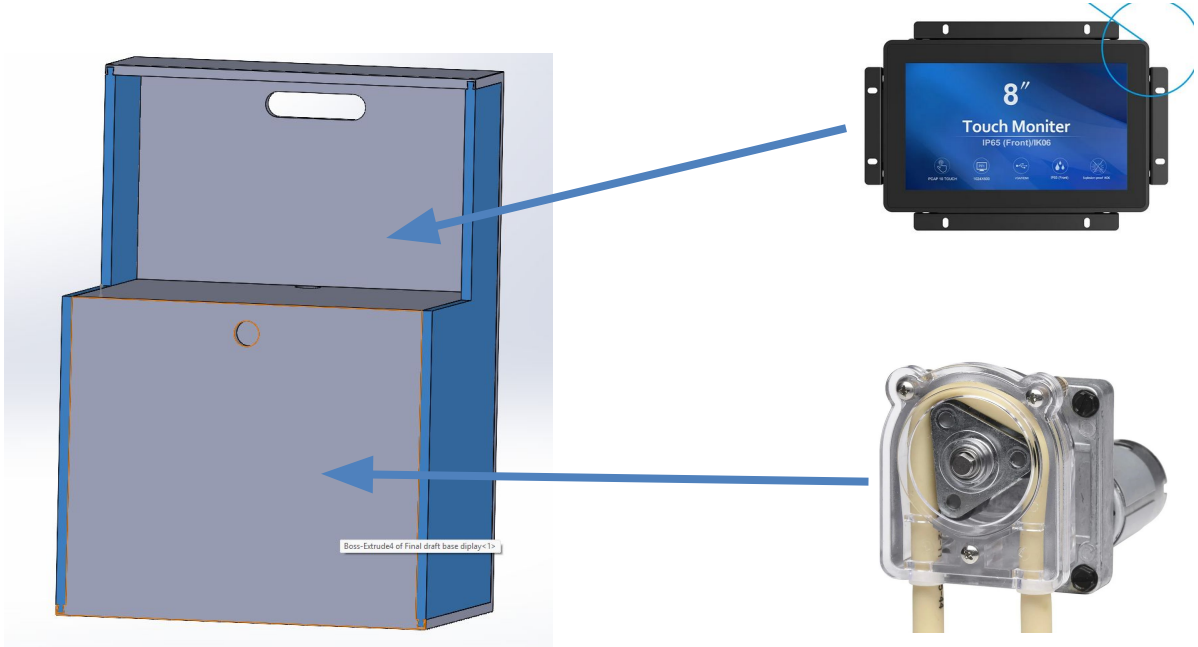


Figure 13: Final Design CAD Model + Planned Layout

- Circuitry enclosed in bottom portion with pump
- Touchscreen held in slot in top part
- MTS software used to give correct signal to hardware and output reward

System Testing

Tests to be completed:

- Electronics Testing
  - Ensure correct input ALWAYS leads to liquid reward
  - Data storage testing
  - System Response Time: How fast liquid gets dispensed after a correct input
  - Calibrate liquid dispensing rate in ml/s
- Mechanical Testing
  - Stability of device while clamped onto the cage
  - Waterproof testing

Future Plans

- Purchase materials for fabrication
  - Touchscreens
  - Mechanical Materials
- Design clamping mechanism to fit device to the cage
- Begin mechanical prototyping
- Test electronics and software

Budget

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	Date	QTY	Cost Each	Total	Link
Electronics										
Raspberry Pi Model 3 B+	Advanced Raspberry Pi used to send out signals for motor controller	N/A	SC0073	UW Makerspace	SC0073	9/15/2025	1	$45.00	$45.00	https://www.raspberrypi.com/products/raspberry-pi-3-model-b-plus/
Wiring	Wiring to connect Raspberry Pi	N/A	N/A	UW Makerspace	N/A	9/22/2025	1	$1.00	$1.00	
Micro SD	Store Research data for researchers	N/A	N/A	UW Makerspace	N/A	9/15/2025	1	$4.00	$4.00	
Motor Controller	Connects to Raspberry Pi to initiate pump	Hiletgo	3-01-833	Amazon	3-01-833	9/22/2025	1	$10.99	$10.99	https://www.amazon.com/dp/B00WSN98DC?ref=ppx_yo2ov_dt_b_fed_asin_title
Mechanical										
A300BXS- Pump	Pump to push fluids	Anko	A302BX-300-S	Anko	A302BX-300-S	9/15/2025	1	Gifted	$0.00	ANKO A300BX-S | OEM Peristaltic Pump | Serial Control | Brushless DC | Models to 1700 mL/min
								TOTAL:	**$60.99**	

Figure 14: Spreadsheet Outlining Budget for Design

Conclusion

- Behavioral tasks in neuroscientific research
  - Advantages of in-cage training
  - Disadvantages of competing system
- Our system
  - Extensible
  - Affordable
  - Runs and stores data locally
  - Easy for researcher use
  - Safe for NHP use
  - Notification system in case of failure

Acknowledgements

- Professor David Herzfeld – Client
- Professor Dhananjay Bhaskar – Advisor
- Dr. John Puccinelli – Advisor

References

[1] “Thomas Incage training system (icts),” Thomas RECORDING, https://www.thomasrecording.com/thomas-incage-training-system-icts (accessed Oct. 3, 2025).

[2] “IEC 60601-1:2024 Ser,” IEC, https://webstore.iec.ch/en/publication/2603 (accessed Oct. 3, 2025).

[3] “Animal Welfare Act,” Animal Welfare Act | National Agricultural Library, https://www.nal.usda.gov/animal-health-and-welfare/animal-welfare-act (accessed Oct. 3, 2025).

[4] “Hiletgo BTS7960 43A high power motor driver Module/ smart car driver module for Arduino,” HiLetgo BTS7960 43A High Power Motor Driver Module/ Smart Car Driver Module for Arduino,Shenzhen HiLetgo Technology Co., Ltd, https://www.hiletgo.com/ProductDetail/1958385.html (accessed Oct. 3, 2025).

[5] "GreenTouch 8 inch open frame 1024x600 HDMI PCAP touch monitors for consumer, hospitality markets,” https://www.walmart.com/ip/GreenTouch-8-Inch-Open-Frame-1024x600-HDMI-PCAP-Touch-Monitors-for-Consumer-Retail-POS-and-Hospitality-Markets/15594114325 (accessed Oct. 3, 2025).

[6] “MonkeyLogic: Behavioral control in MATLAB,” Brown University, https://www.brown.edu/Research/monkeylogic/ (accessed Oct. 3, 2025).