The RatBot: A broad overview of the capabilities of an in-cage, automated pellet reaching device

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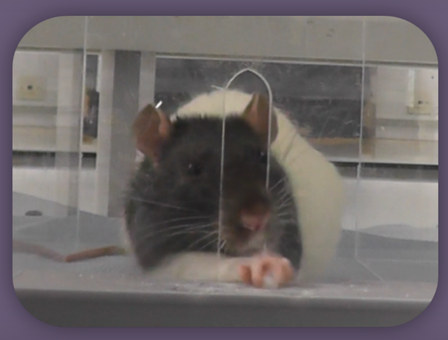
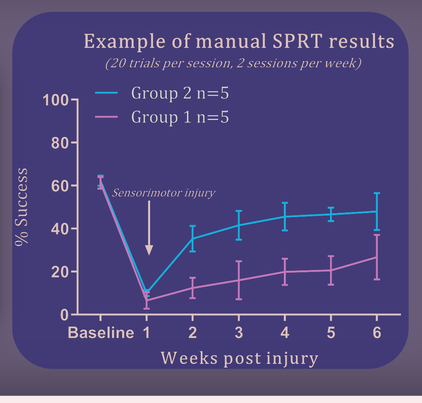
INTRO

One well known behavioural task for evaluating fine motor control and dexterity in rodents is the single pellet reaching task (SPRT)

In this task the animal must successfully retrieve, with one forelimb, a sucrose pellet placed on a pedestal beyond a 1cm slit

Rodents are trained on this task until their performance plateaus at which point a relevant injury to the sensorimotor system is introduced and the animal experiences a deficit





Despite being the current gold standard for evaluating fine forelimb motor control, manual SPRT is labour-some, time intensive and very limited regarding how many trials can be completed within a given time.

The data acquired can also be quite small given the amount of time usually spent training and testing each animal (~30 minutes per animal)

It is also undertaken during the day at which point rodents are naturally asleep and less motivated.

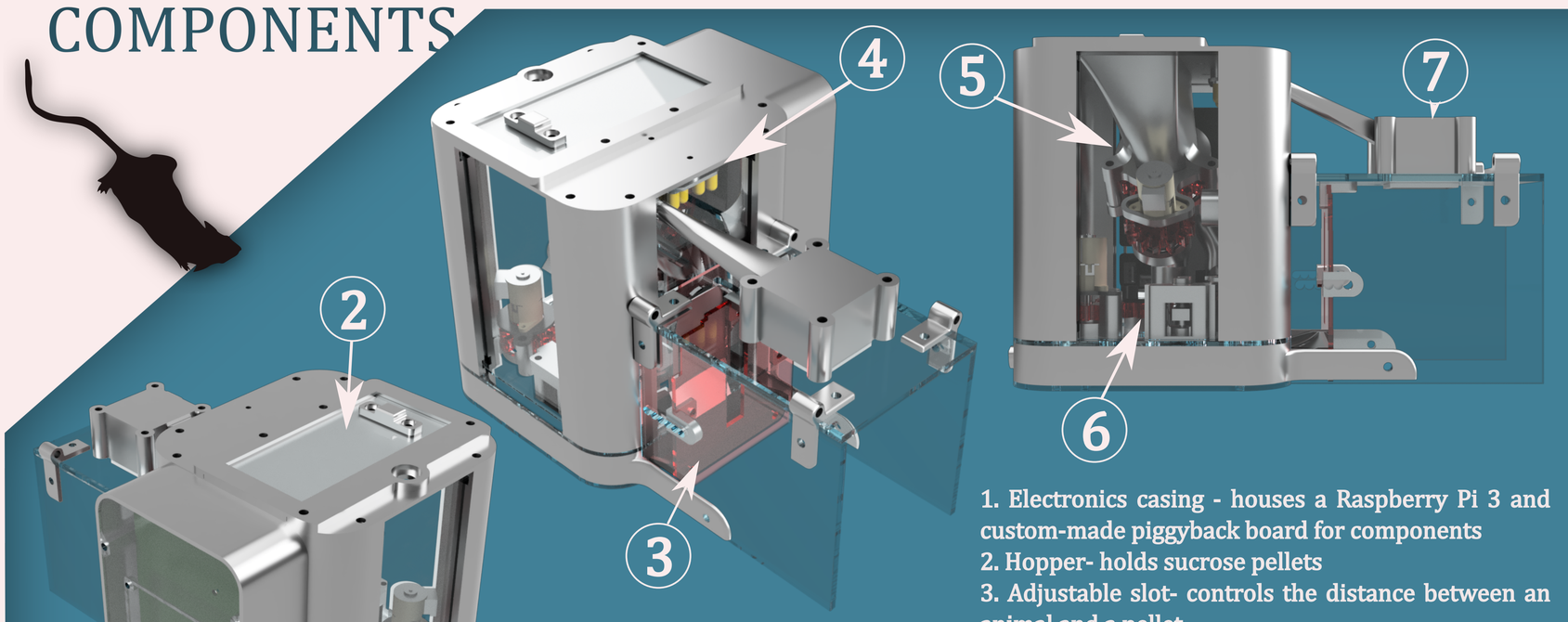
RATBOT BENEFITS

In an attempt to eliminate some of the issues addressed above we have created an in cage pellet reaching device which allows for overnight home cage testing in a socially housed environment.

Some of the advantages of this system over the manual SPRT are as follows:

- Less time consuming
- Handle free testing
- Multiple rats per cage
- Overnight operation
- Much higher trial number should give more precise estimate of animal's true ability
- Higher trial number can also be used for rehab.
- Greater manipulation of study parameters
- Higher quality/quantity of data from the same task

COMPONENTS



Hardware was modelled in Autodesk fusion-360 CAD software and printed in house using biodegradable polylactic acid. Clear parts are laser cut acrylic.

Firmware is written in python by Dr. Sotiris Kakanos notably using OpenCV for pellet blob detection and video processing

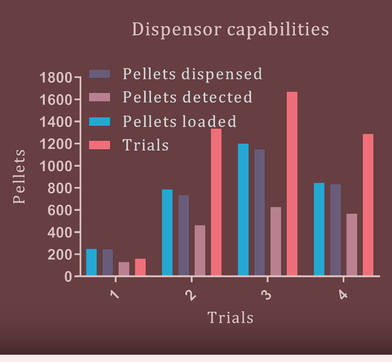
1. Electronics casing - houses a Raspberry Pi 3 and custom-made piggyback board for components
2. Hopper- holds sucrose pellets
3. Adjustable slot- controls the distance between an animal and a pellet
4. Camera- Detects pellets and records trials
5. Dispenser- Dispenser pellets
6. Moving spoon- presents pellet to animal
7. RFID reader – reads Radio Frequency Identification tag unique to each animal

INCREASED TRIAL FREQUENCY

RatBots allow hundreds of automated trials per night

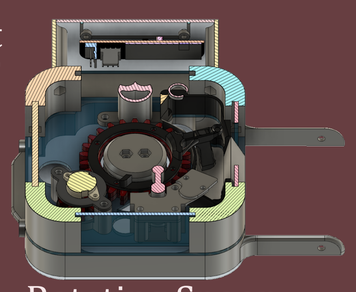
A noteworthy benefit of the RatBot system is the ability to administer a high number of trials whereby socially housed rats can attempt to reach many times throughout the night

One way this is achieved is through the use of a dispenser designed and built in house, capable of delivering and positioning up to 120 pellets per hour. Initial desktop testing data is shown below

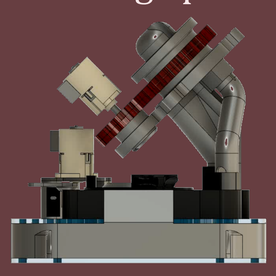


Another is through the use of a moving spoon that can position a single pellet accurately to either side of the front slit.

Positioning and monitoring of the pellet is recorded via a small BrightPi Camera above the spoon

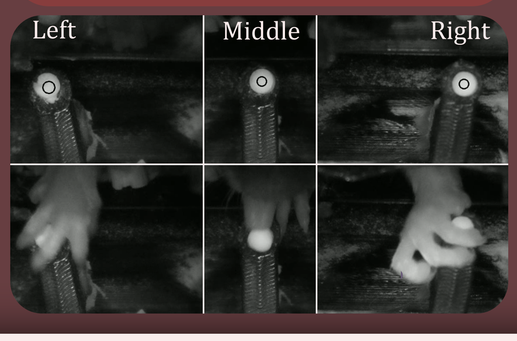


Rotating Spoon



Dispenser

Since the RatBot can conduct hundreds of trials per night, the quantity of single pellet reaching data far surpasses the manual method. As we can see on the graph even with 50 trials per night these animals are variable in their success, however there is still an upwards trend in most. Identifying poor performers earlier would also help remove unenthusiastic animals from the study.

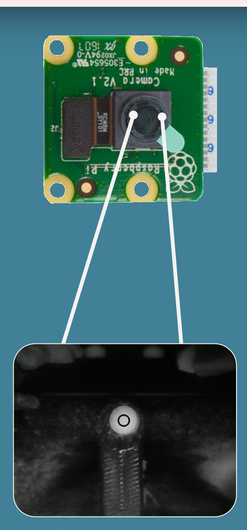


In the panels to the left we can see tiles of different camera views. The top row shows respective pellet positioning while the bottom row shows a reach attempt. These high-resolution videos at taken at an average of 120 fps which allows for excellent post processing with tracker-type software. Future plans include implementing automated scoring using DeepLabCut, an open source neural network specifically designed for animal behaviour.

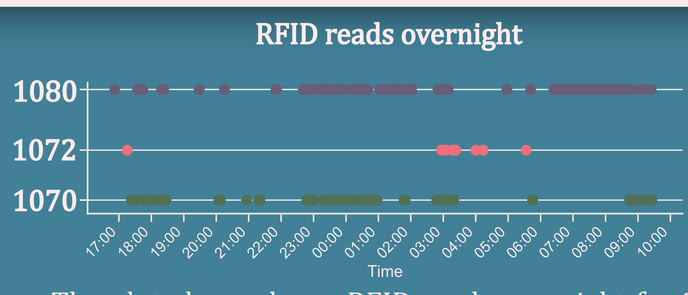
OVERNIGHT MONITORING

Infrared cameras allow overnight monitoring and targeted video capture

By logging all RFID reads we are able to map out animal activity throughout the night, which could help determine rodent activity, potential dominance over the device or give a general overview. A video of each trial is saved individually: only the final frames showing the pellet removal are retained, compressed and saved to play in slow motion. This removes the need for the user to navigate endless hours of footage and instead view a 13 second video of just the relevant trial.

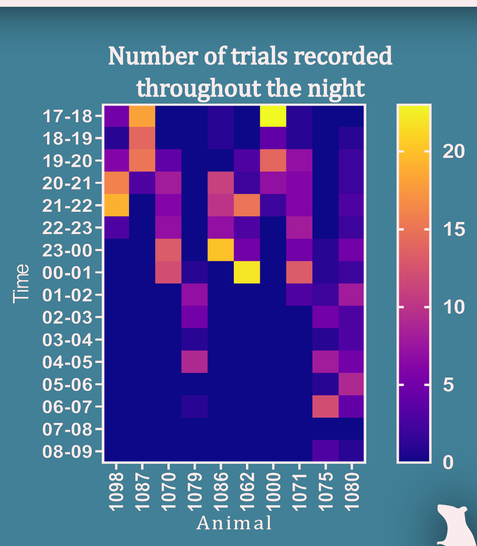


BrightPi Camera



The plot above shows RFID reads overnight for 3 animals in the same cage. This can be used with the heatmap on the right to infer new training paradigms

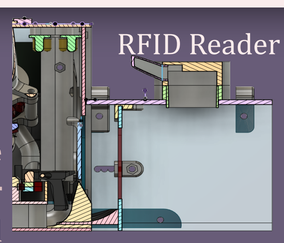
The heatmap shows the frequency of trials voluntarily taken by rats over the course of one night. Taking both figures together we can see that the RFID activity coincides with great trial recording per animal



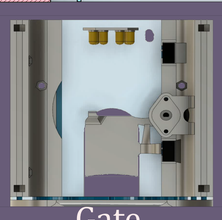
RFID CONTROLLED GATE

Trial frequency per rat can be controlled by a Gate

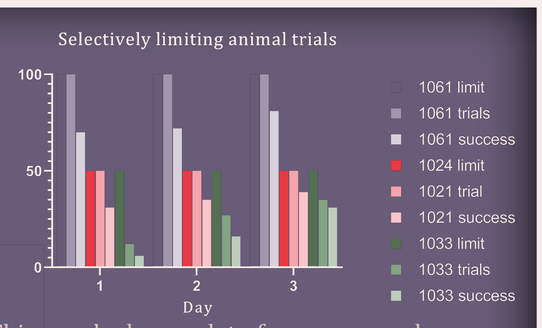
Ratbot also gives researchers the ability to create and customise behavioural training paradigms to better suit the needs of their study. Using an RFID (wireless ID tag) animal monitoring method paired with an automated gate and pellet positioning system users are able to specify a given number of trials per animal to either paw position. This is useful when administering a high number of trials to a rehabilitation arm within the study. It could also stop overactive animals preventing novice animals from attempting trials.



RFID Reader



Gate



This graph shows data from a cage where one animal was allowed 100 trials whereas the others were cut off at 50. Note that 1024 participated more than 1033. In a given cage there is often one rat of three who participates very little

CONCLUSION

The RatBot system allows single pellet reaching to be conducted in a socially housed home cage environment.

This increases data quality, allows administration of rehabilitation levels of single pellet reaching and increases animal welfare.

Alongside single pellet reaching, the RatBot also allows evaluation of home-cage rodent activity, application of customised behavioural paradigms and eventually kinematic analysis of forelimb reaching