Automatic Facial Feature Detection and Taste Reactivity Evaluation Using DeepLabCut

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INTRODUCTION

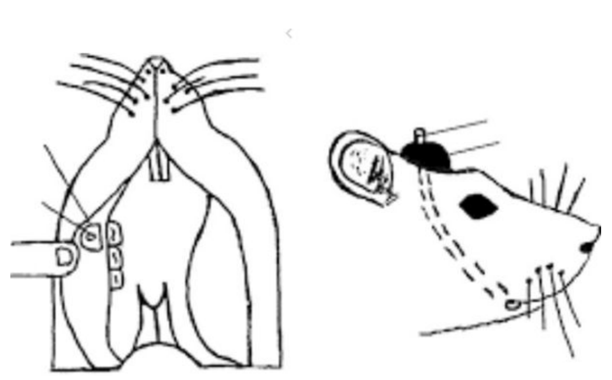
- Taste plays a critical role in our food preferences and nutrition. Human research can rely on verbal reports of individual likes and dislikes, but this is not possible in non-verbal research models, like rodents.
- However, many mammalian species, including humans and rodents, display stereotypic oromotor and somatic reactions to taste stimuli that are associated with hedonic ratings.[1] This is called taste reactivity (TR).
- In a typical TR test, the rat is infused with a taste solution into the oral cavity while its reactions are video-recorded. These videos are then viewed in slow motion and the reactions are manually categorized and quantified by an experimenter. This process is extremely tedious and slow. For example, it can take up to 30 minutes to analyze a short 30 second clip.
- DeepLabCut is a python package that detects features and estimates poses of a subject to efficiently catalog behavior.[2]

The goal of this project is to develop a network that automatically detect and score the taste reactivity using a machine learning approach (DeepLabCut[2]).

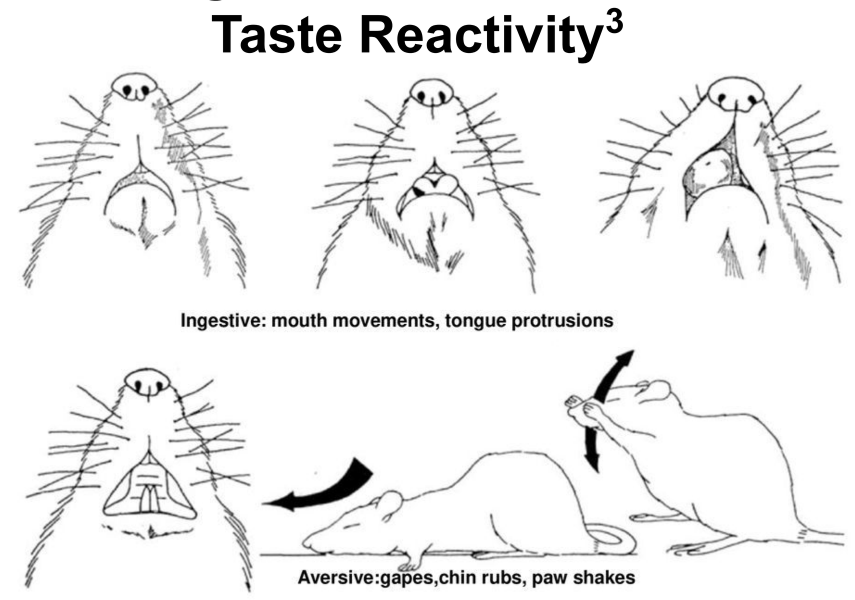
METHODS

1. Taste Reactivity

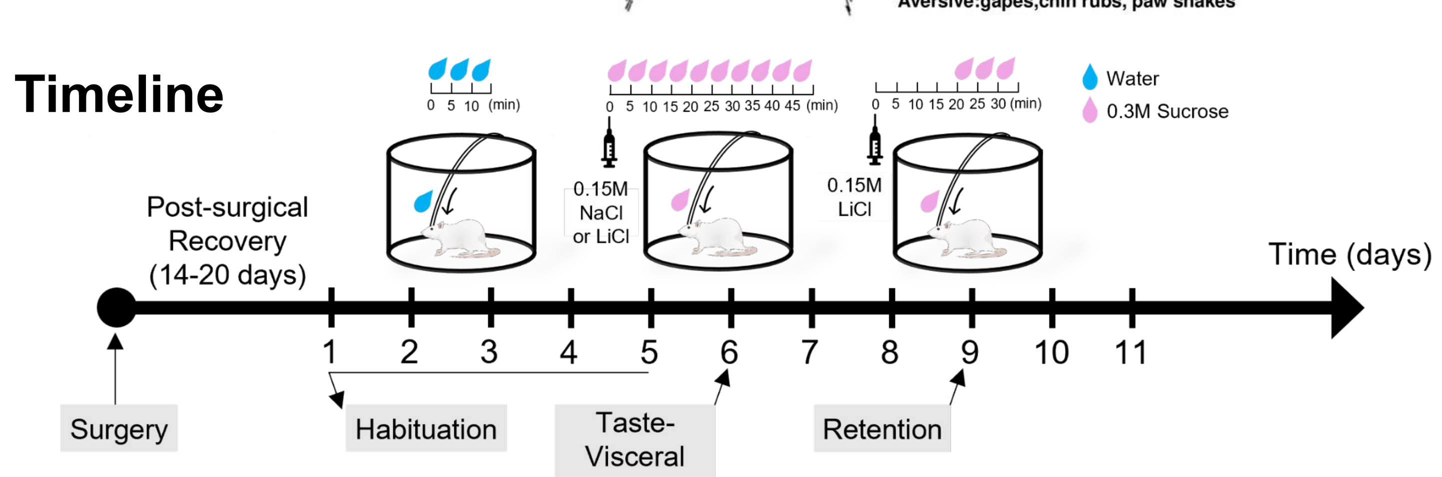
Intraoral Cannulation



Ingestive vs Aversive Taste Reactivity[3]



Timeline



2. Taste Reactivity Scoring

Manual Counting of Taste Reactivity

Each intraoral infusion during the taste reactivity sessions was video-recorded and a subset of them were later scored offline in slow motion. Ingestive and aversive behaviors were individually counted for in each video and summed by an experimenter blind to the subjects' training histories. Importantly, this data was used to evaluate the accuracy of the program generated.

Training a Network to Recognize Facial and Body Features

STEP 1: Extract/Label Frames from Rat Videos — DeepLabCut extracts a variety of frames from the videos with a range of different environments and behaviors.

STEP 2: Create Training Datasets — Extracted frames are split into testing vs training datasets while still representing the range of behaviors.

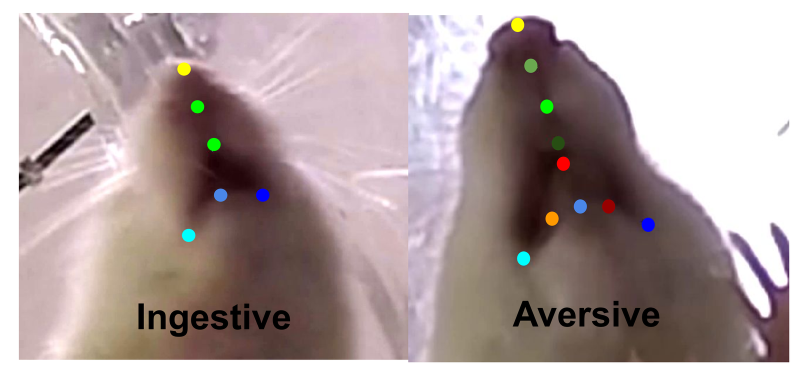
STEP 3: Train Network — The model is fitted to the training data to adapt the network to identify facial features of the rat.

STEP 4: Evaluate and Improve Network — The efficacy of the network is evaluated using the testing dataset. If the accuracy is under 95%, the network will be retrained to improve results.

STEP 5: Applying the Network to Score Behavior — Write a computer program **utilizing the network to** detect the difference between behaviors.

RESULTS

STEP 1: Manual Labeling



Approximately 1400 frames extracted from the taste reactivity videos were labeled by hand and used to train the network. The user then labeled the mouth, tongue, paws, and nose of the rat in each frame. This can be done for both ingestive and aversive taste reactivity as shown on the left. More than 2300 unlabeled frames were used to conduct an accuracy test on the resultant model.

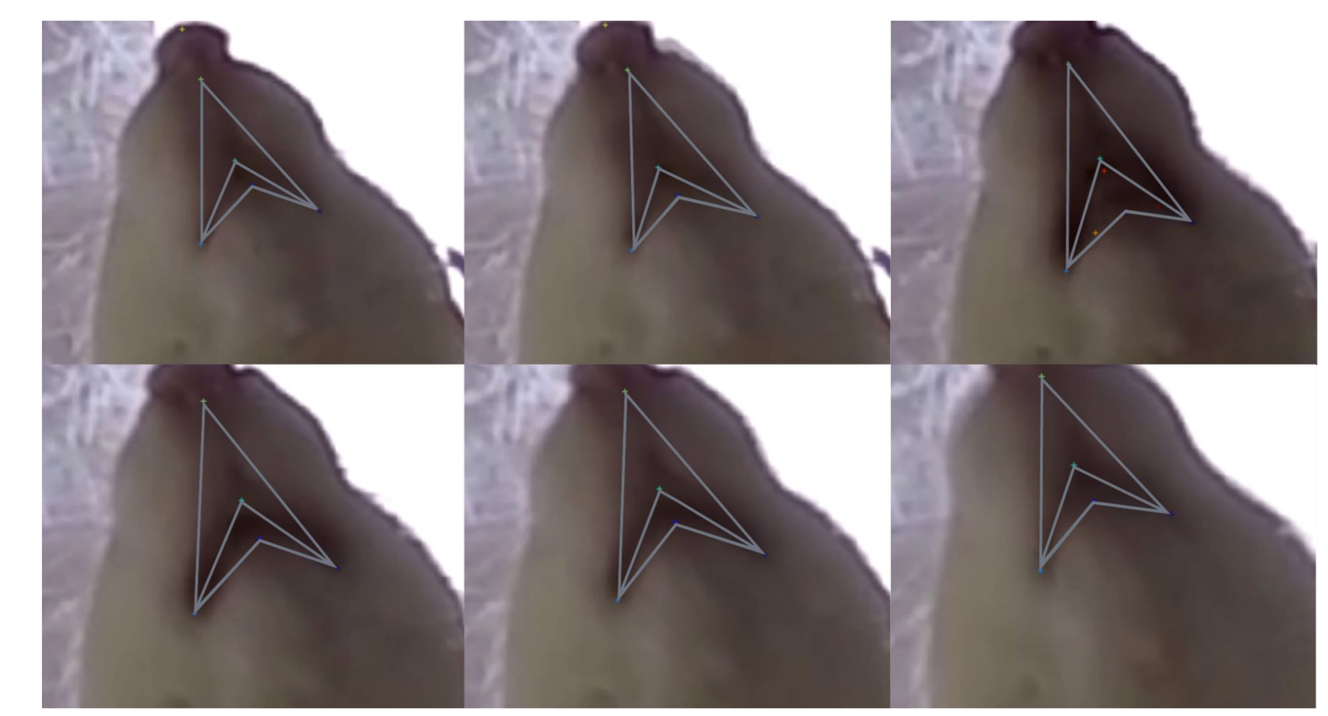
STEP 2: Accuracy Test

Train Error (pixels)	Test Error (pixels)	Significance Threshold (p-cutoff)	Train Error with p-cutoff	Test Error with p-cutoff
2.19	7.47	0.6	2.19	7.31

Features	Total Frames	Total Accurate Frames	Accuracy Percentage
Mouth Movement	348	260	74.7%
Tongue Protrusion	270	206	76.3%
Lateral Tongue Protrusion	314	236	75.2%
Gape	397	251	63.2%
Forelimb Flailing	237	48	20.3%
Head Shake	205	146	71.2%
Chin Rub	520	285	54.8%

DISCUSSION

- Further training run-throughs with a wider breadth of frames will improve the network to reach an accuracy up to 95%.
- Once the network reliably detects the facial features, the output from the network can be used to detect differences in the areas between the rat's mouth, nose, and tongue to discern between an ingestive versus an aversive behavior. A hypothetical example of detecting an aversive taste reactivity (gape) using detected facial features is shown below. In this way, the cyclical ingestive or aversive behaviors recorded in the videos can be tallied.



Ultimately, DeepLabCut and coding can be combined to effectively and efficiently analyze videos of rodents, for oromotor or somatic reactions of interest.

REFERENCES & ACKNOWLEDGMENTS

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3. Berridge, K., Grill, H. J., & Norgren, R. (1981). Relation of consummatory responses and preabsorptive insulin release to palatability and learned taste aversions. Journal of Comparative and Physiological Psychology, 95(3), 363–382.

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