The Effect of Varying Reward Treatments on Performance and Learning Acquisition in Mice

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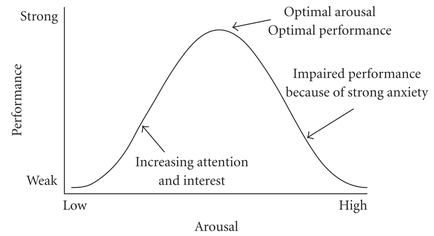
ABSTRACT

An animal's ability to learn and perform perceptual tasks is highly variable, depending on factors such as reward type. Using a more favorable reward is expected to positively influence motivation and performance. The present study examined the effects of using a highly palatable caloric reward in lieu of standard water reward. It was hypothesized that a high caloric reward solution would facilitate a faster learning rate on an auditory discrimination task. By examining the effects of alternative reward treatments on performance in an auditory discrimination task, we can determine optimal treatment conditions in which mice learn most efficiently. These results could further elucidate the relationship between caloric intake, nutrition and arousal.

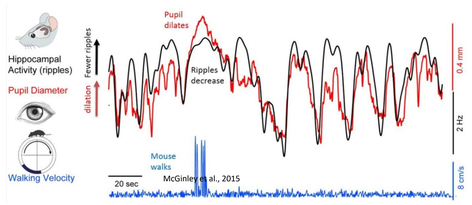
BACKGROUND

- Intermediate levels of arousal are the optimal state for performance of detection tasks, which is measured directly using pupillometry.

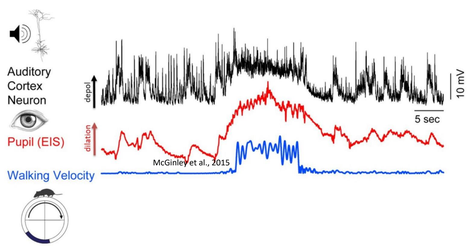


Yerkes and Dodson, Hebbian - Diamond DM, et al., 2007

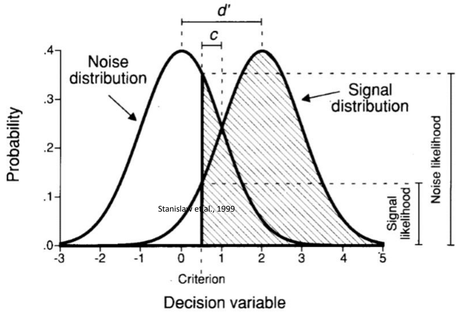
- Pupil diameter, whisker motion and snout motion are external metrics of brain state.



- The arousal level, indexed by walking activities and pupillometry, is highly correlated with the membrane potential of cortical neurons.



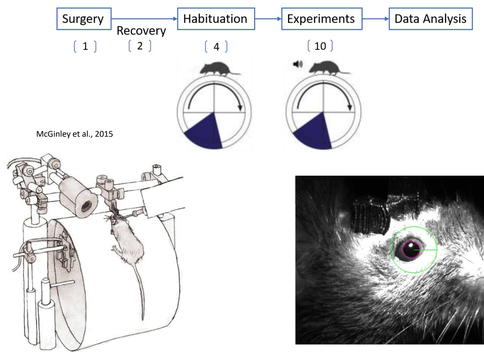
- Performance in an auditory discrimination task is a valid indication of learning acquisition.



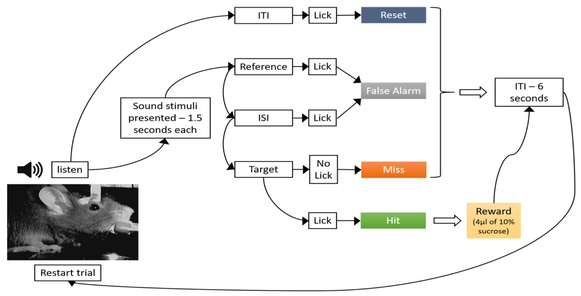
QUESTION: *How do varying reward treatments affect overall learning acquisition and performance on an auditory discrimination task?*

MATERIALS & METHODS

- Water-restricted mice were subjected to one of two reward treatment conditions upon correct licking behaviors during a target interval.
- Four surgically head-posted mice were habituated and put on water restriction prior to behavior sessions. we recorded the animal's performance while simultaneously monitored the pupil dilations.

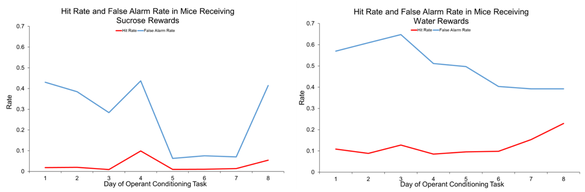


- Mice were trained in a "tone-in-noise" detection task with 10% sucrose solution reward for correct licks and a time out (resetting ITI) for incorrect licks.

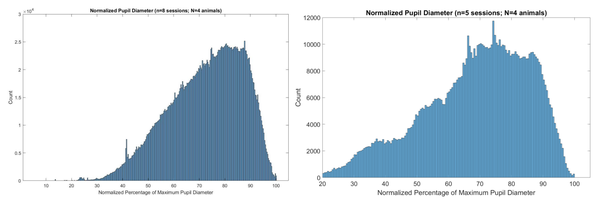


RESULTS

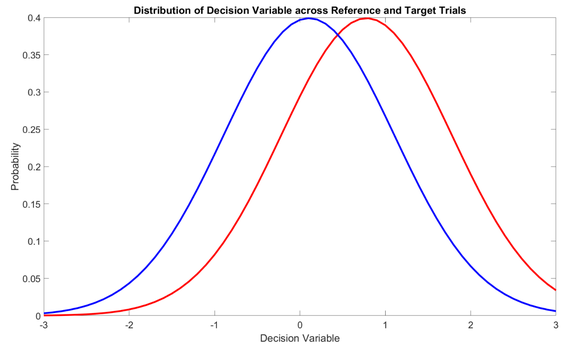
- Both reward treatments (sucrose and water) result in improved performance on auditory discrimination task over time.



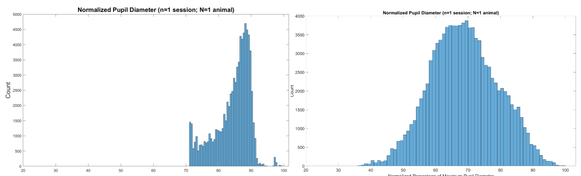
- Population histogram of normalized pupil diameter in sucrose (top) and water (bottom) mice exhibits a rightward shift, indicating a hyperarousal state during first 5-8 sessions of operant conditioning.



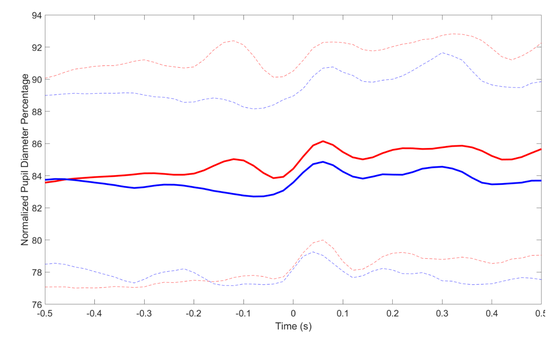
- The d' value of a mouse receiving sucrose reward (2.0208) indicates that sucrose can serve as an effective reward and the animal can statistically differentiate a target stimulus from reference stimuli.



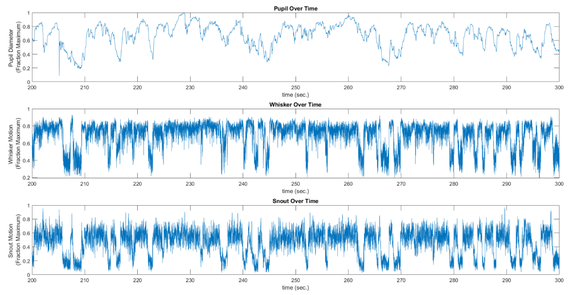
- Pupil histogram of an individual mouse receiving sucrose reward exhibits a rightward skew, indicating a state of hyperarousal. Pupil histogram stabilizes as the mouse receives more training on the auditory discrimination task.



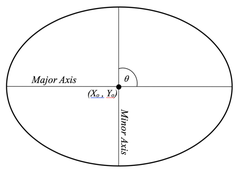
- Normalized pupil diameter increased after sound stimulus distribution.

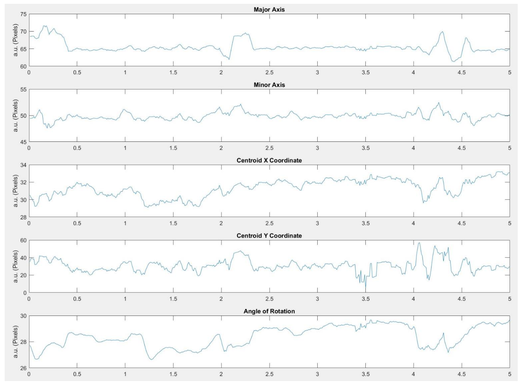


- Plot of pupil, whisker, and snout over time shows correlations between the three variables with arousal as the animal is performing the auditory discrimination task.



- Analyzing multiple ellipse parameters allows for a more comprehensive analysis of pupil dilation and constriction.





CONCLUSIONS

- While the present study determined that a 10% sucrose solution has the capacity to act as a reward stimulus due to its positive reinforcement properties, further experiments and larger sample sizes are required to fully quantify the efficacy of sucrose solution compared to traditional fluid rewards.

FUTURE DIRECTIONS

- Investigate the differences between two different concentrations of sucrose solution (10% vs. 20%) in terms of promoting learning acquisition and optimal performance
- Investigate the effect of VR2 reinforcement schedule on behavior (shown to prevent extinction)
- Analyze the effects of using a nutrient-rich, low calorie reward treatment
  - Esbilac Goat's Milk
- Observe the effects of varying reward treatments during early learning acquisition
  - Analyzing performance during initial learning period

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