Exploring the Mechanisms of Empathy-Like Behaviors in Rats

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Contreras, M.[1], Cruz, K.G.[2] Cummings J.[1], Hatfield A.[3], Fellous J.M.[1]

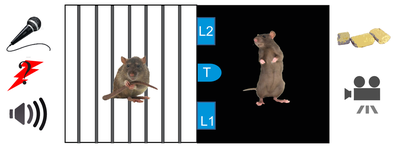
1. Department of Psychology, University of Arizona 2. Brain and Cognitive Sciences, Massachusetts Institute of Technology, MA 3. Undergraduate Research Opportunities Consortium

1. Introduction

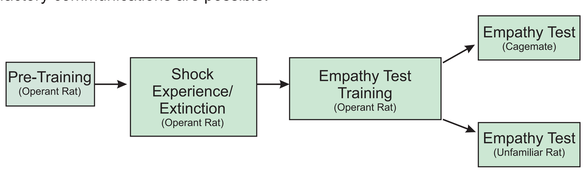
- Empathy: An affective response stemming from the understanding of another individual's emotional state which allows for social stimuli to trigger appropriate pro-social behaviors (1).
- Rodents can show emotional contagion (a basic form of empathy) (2). Rats are capable of sharing states of fear (3) and of acting pro-socially (4).
- We have recently shown that rats were capable of exhibiting empathy-like behavior in an operant model (5).
- Rats produce 22 KHz calls in response to aversive situations. These ultrasonic vocalizations (USVs) are associated with the negative emotional state of the rat (6).
- In humans, oxytocin (OXT) has been implicated in empathy behavior (7). In rats, OXT has been implicated in pro-social behavior (8).
- Neuroimaging studies have shown that observing another's distress elicits activity in the anterior insular cortex (AIC) (9).

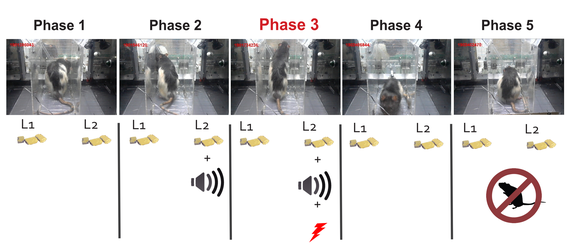
- **We investigated whether empathy-like behaviors in rats were triggered by USV playback, modulated by the OXT system, and correlated with neural activity in the AIC.**

2. Methods



Compartments are divided by a wire mesh through which auditory, visual and olfactory communications are possible.





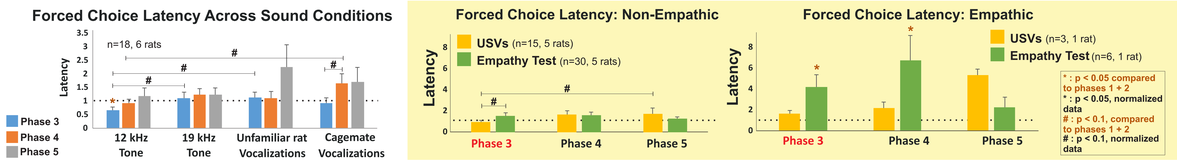
Measurable behaviors during the Empathy Test

Grid Contact — Avoidance — Grooming

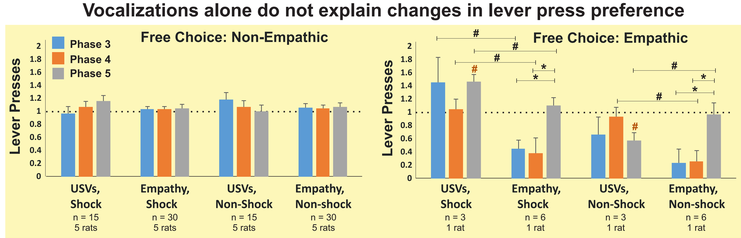
3a. Ultrasonic Vocalizations

Empathy tests, 12 kHz, 19 kHz, Unfamiliar rat vocalizations, Cagemate vocalizations

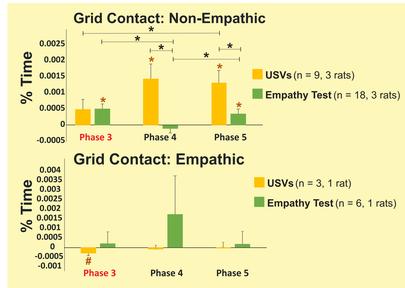
Empathic rats show increased latency to press the shock lever (forced choice) in empathy tests and a similar but smaller increase in latency during USV playback



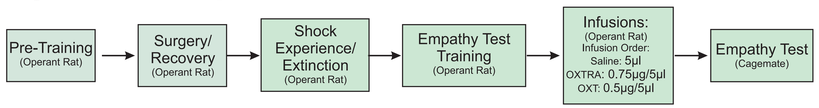
Vocalizations alone do not explain changes in lever press preference

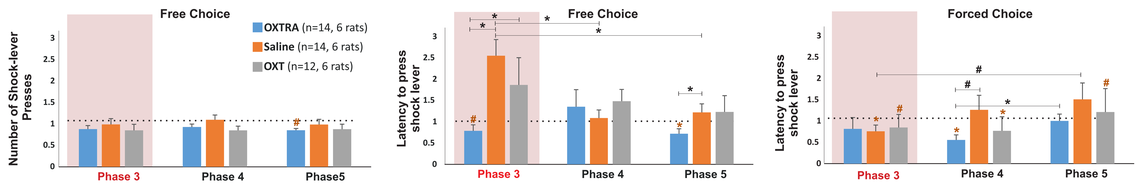


Grid contact occurs mostly during the empathy tests
Non-empathic animals react more to the vocalization

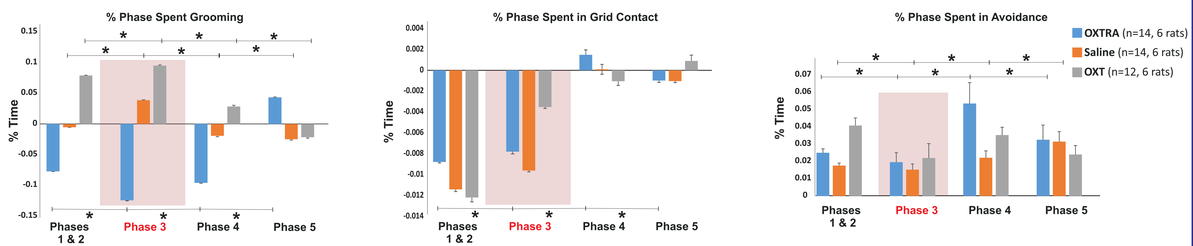


3b. Oxytocin Manipulations



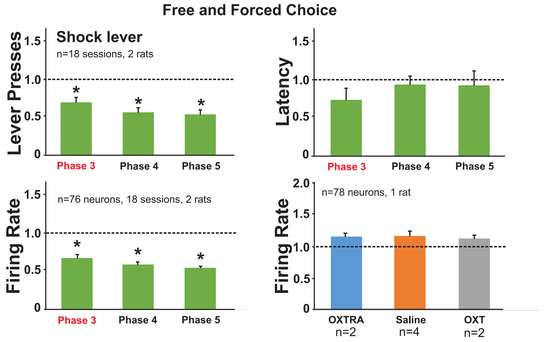


No changes in the number of shock-lever presses. Blocking the OXT receptors decreases the latency to press the shock lever in Phase 3. OXT infusions do not change latency. These effects are only present in the Free Choice condition (Decision making).



Emotional contagion is evident in Phase 3 for the saline condition, and is enhanced by exogenous administration of OXT.

3c. Anterior insular cortex (AIC)



Empathy-like behavior was correlated with a decrease in neural activity in AIC.
In separate experiments, Oxytocin manipulations (icv) did not modify the neural activity of AIC.

4. Conclusions

- USV playback leads to increased attentional behavior, but is not sufficient for empathy-like behavior to occur.
- Non-empathic rats show greater attention to USV playback; empathic rats show a trend toward increased lever press latency.
- Oxytocin increases emotional contagion suggesting a role as a promoter of salience of socio-emotional cues.
- Antagonizing the oxytocin system decreases empathy-like behavior.
- Potential role of anterior insular cortex in empathy-like behavior in rats.

5. Future directions

- Pharmacological manipulation of the Arginine Vasopressin system.
- USV playback experiments before empathy tests to examine how previous exposure to USVs changes empathy-like behavior.
- Search for key brain areas in which oxytocin acts (e.g. amygdala, HPA axis, etc).
- Optogenetic manipulations of anterior insular cortex activity.

6. References

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Contact: mcontreras@email.arizona.edu