Sex differences in positive and negative operant conditioning

Are sex differences present on the first day of training?

Background

Reward Training

Chowdhury et al., 2019

Avoidance Training

- Operant conditioning
  - Increase/decrease behavioral response
  - Due to reinforcement/punishment

- Reinforcement learning
  - Positive
  - Negative

- Sex differences in learning acquisition and expression
  - F > M negative reinforcement/fear learning (Chowdhury et al., 2019, Day et al., 2016, Dalla & Shors, 2009)
 - F = M positive reinforcement (Chowdhury et al., 2019)

Are there sex differences in performance on the first day of training?

Here we will measure performance (percent of correct trials) and reaction times on the first day of positive reinforcement operant training ('Appetitive') and negative reinforcement operant training ('Aversive') in female and male rats

Methods

- Sprague Dawley rats
  - (n=8; female n=4, male n=4)
- Pair housed, free fed, reverse light cycle
- Trained on 'appetitive' condition
  - High/Low tone cue signifies one lever (left/right) when pressed will be rewarded
- Moved to 'aversive' condition
 - Opposite cue signifies opposite lever when pressed will prevent/stop footshock
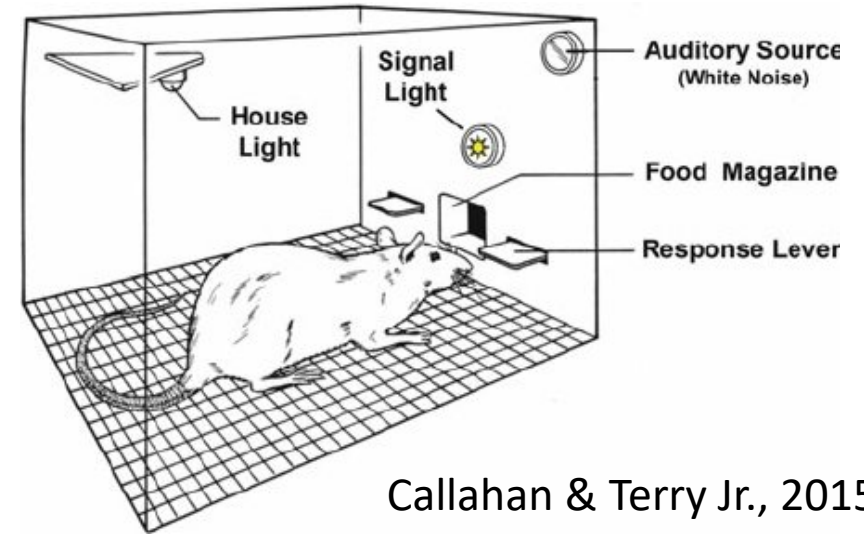
Callahan & Terry Jr., 2015

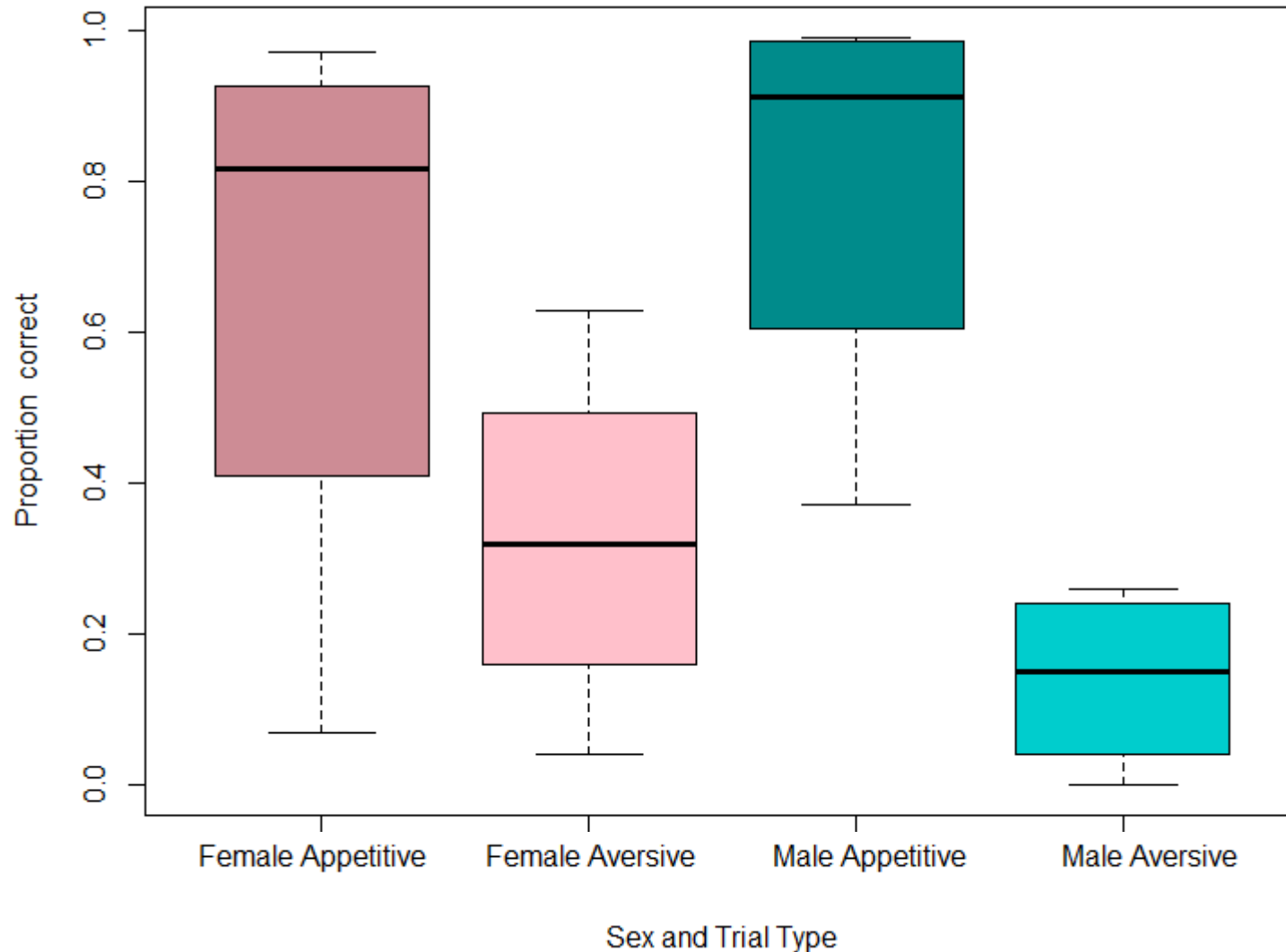Independent variables: Training condition and sex
Dependent variables: Proportion of correct trials and reaction times
Nuisance variables: Freezing/bolting behavior, estrous cycle, reward/punishment sensitivity

Training schematic

Modified from Capuzzo & Floresco, 2020
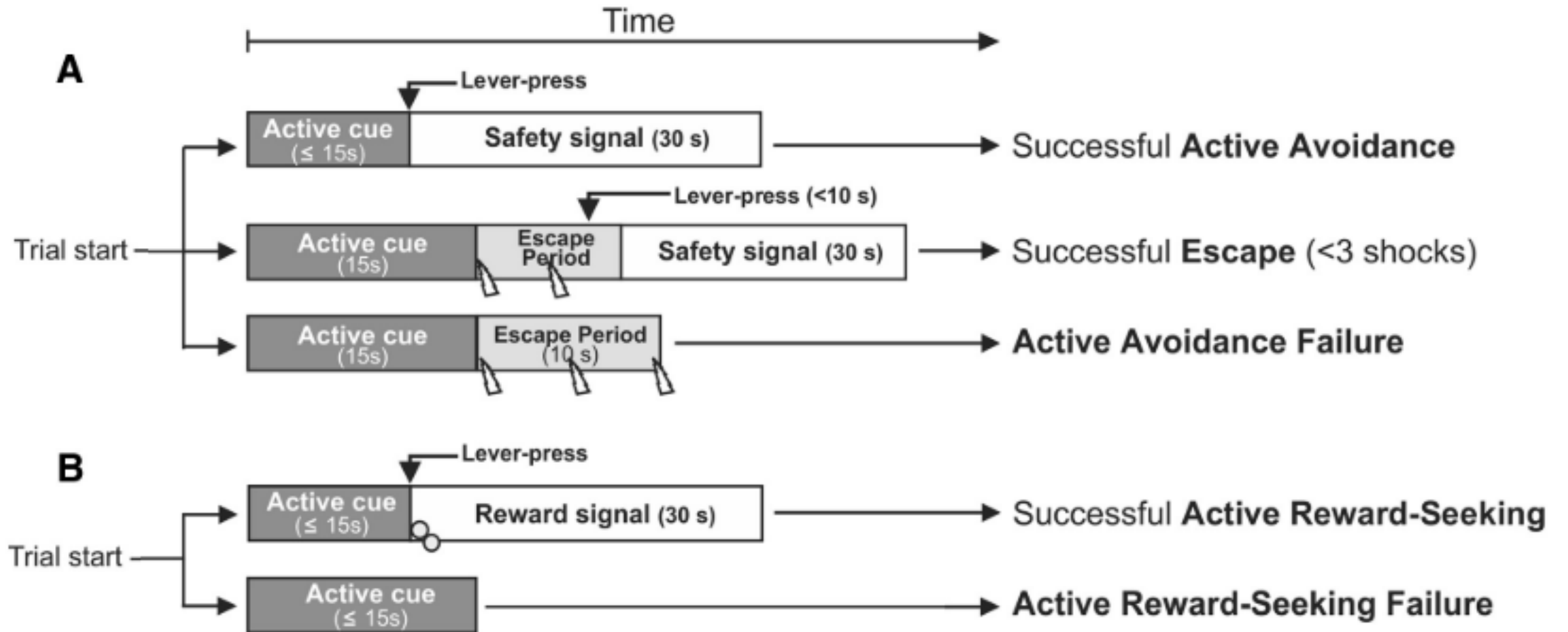
Proportion correct trials – Day 1

Female Appetitive
Mean: 0.6675000
SD: 0.4084422
Median: 0.8150000
IQR: 0.3225000

Male Appetitive
Mean: 0.7950000
SD: 0.2914904
Median: 0.9100000
IQR: 0.2600000

Female Aversive
Mean: 0.3262695
SD: 0.2415835
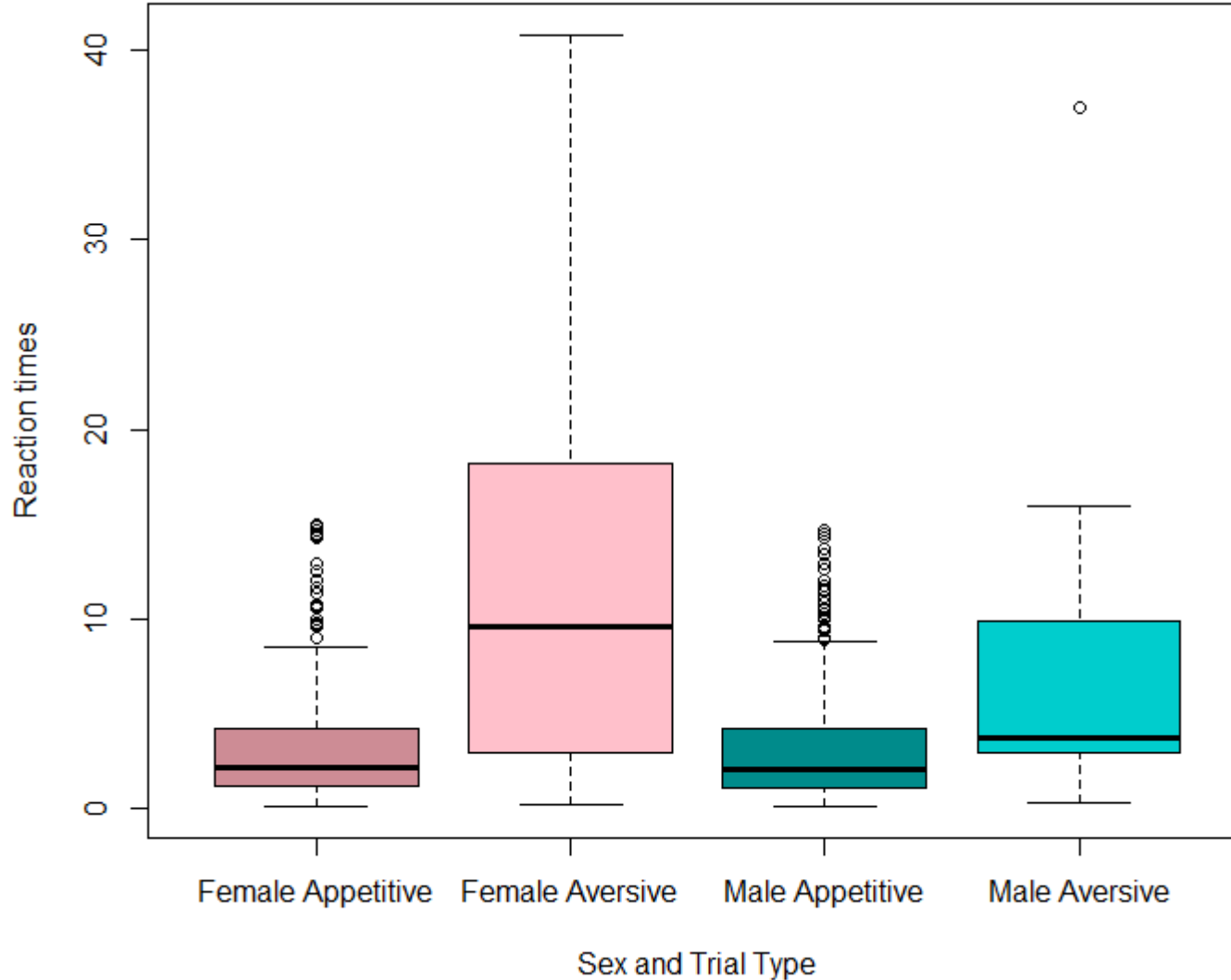Median: 0.3185714
IQR: 0.2044327

Male Aversive
Mean: 0.1396078
SD: 0.1213673
Median: 0.1492157
IQR: 0.1711765

Median reaction time on correct trials – Day 1

Female Appetitive
Mean: 3.335387
SD: 3.260607
Median: 2.191
IQR: 3.100

Male Appetitive
Mean: 3.333421
SD: 3.229265
Median: 2.045
IQR: 3.103

Female Aversive
Mean: 11.652593
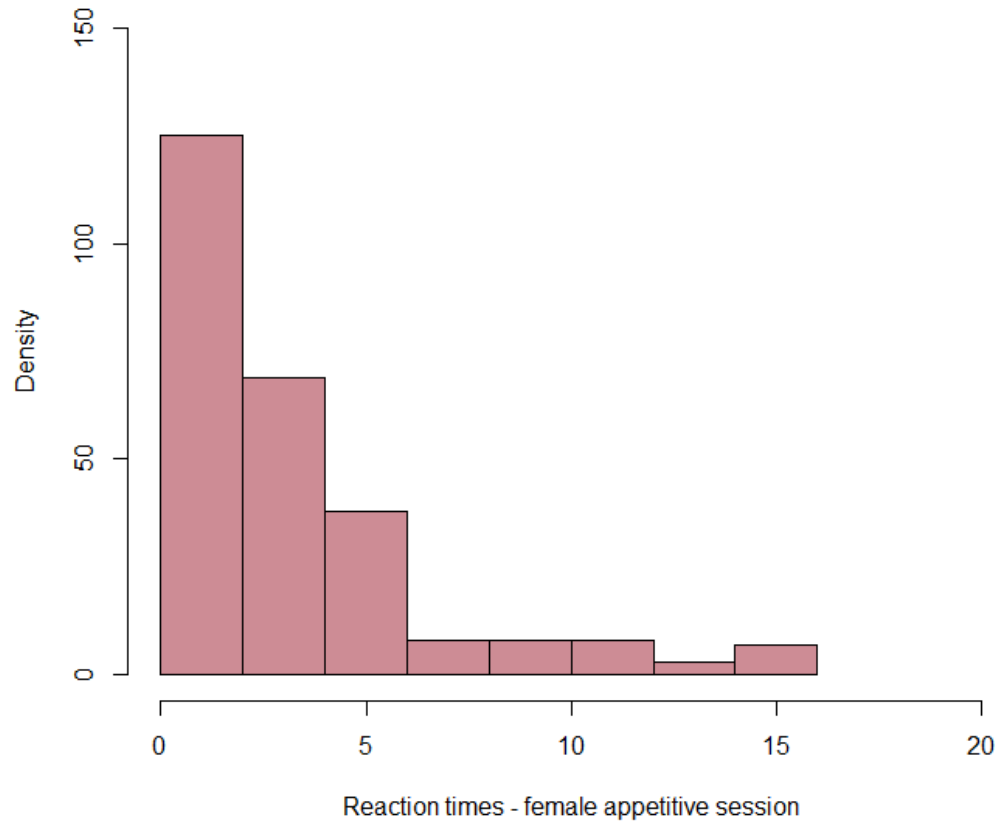SD: 9.819249
Median: 9.612
IQR: 15.267

Male Aversive
Mean: 6.885207
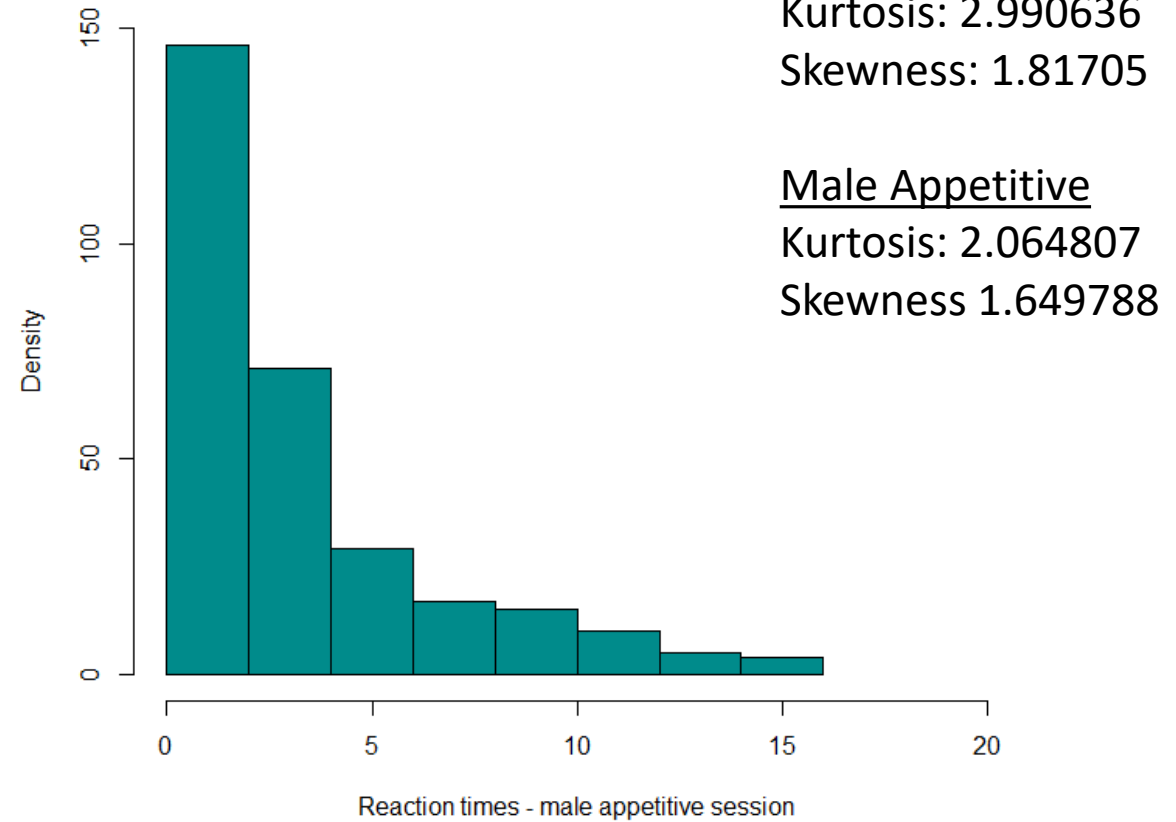SD: 7.330201
Median: 3.740
IQR: 6.945

Appetitive session reaction time distributions – Day 1

Female Appetitive
Kurtosis: 2.990636
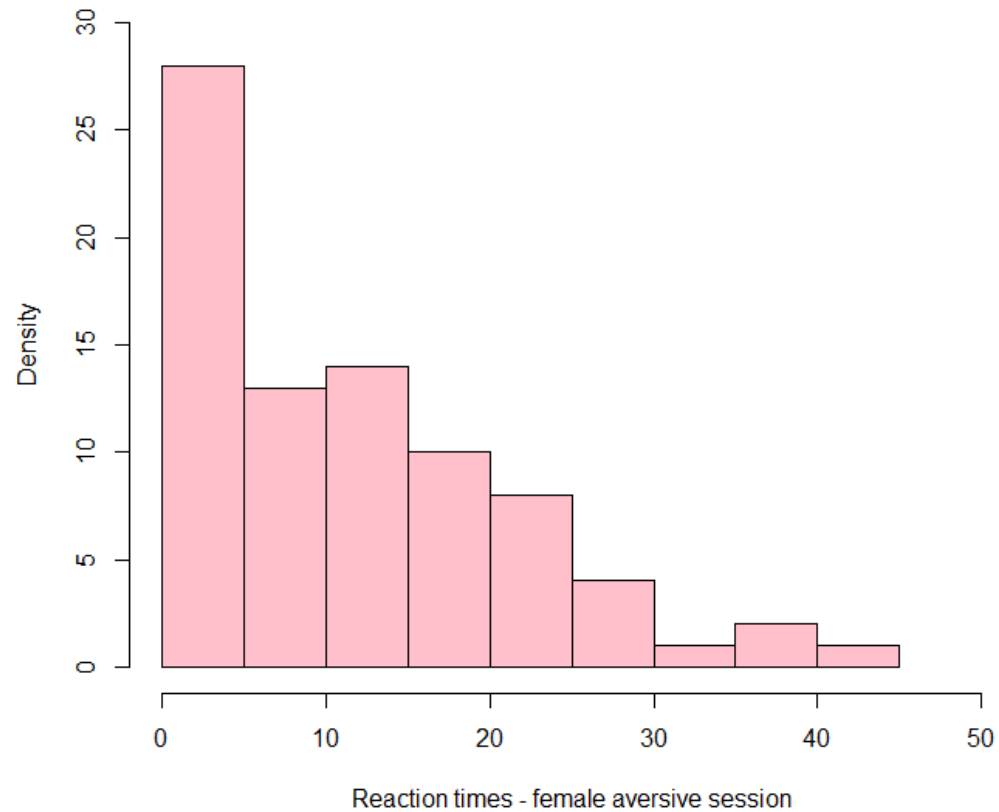Skewness: 1.81705

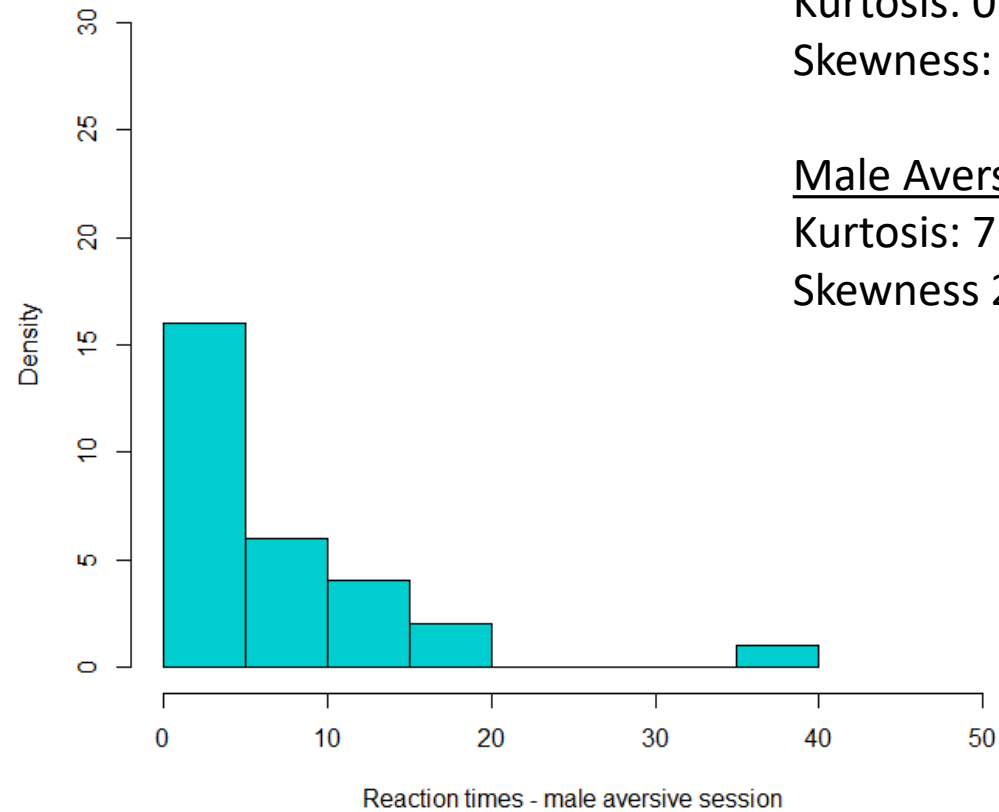**Male Appetitive**
Kurtosis: 2.064807
Skewness 1.649788

Aversive session reaction time distributions – Day 1

Female Aversive
Kurtosis: 0.1426324
Skewness: 0.8962176

Male Aversive
Kurtosis: 7.072644
Skewness 2.412677

Top performers – current training

- Animals are still training
- All have successfully and quickly learned the appetitive task
  - Mean sessions to completion (female =3.5 , male =4.25)
- Only 2/8 have learned aversive (1 female, 1 male)
  - Sessions to completion (female = 9, male = 6)

Did the animals who learned the aversive task more quickly perform better on training day 1 than other animals?

Female appetitive z-score: 0.201987   Male appetitive z-score: 0.154379

Female aversive z-score: -1.181592   Male aversive z-score: 0.9919652

Conclusions

Percent correct

      Males performed slightly better (~10%) on day 1 of appetitive training

      Females performed slightly better (~20%) on day 1 of aversive training

Reaction time

      Both sexes performed similarly on day 1 of appetitive training (~3 seconds)

      Females took longer than males (by ~6 seconds) to respond on day 1 of aversive training

Top performing animals

      Both had similar z-scored performance on day 1 of appetitive training

      Male top performer did almost 1 sd **better** than the mean of all males on day 1 of aversive training

      Female top performer did > 1 sd **worse** than the mean of all females on day 1 of aversive training

At group level: F > M on aversive day 1, M > F on day 1 appetitive

At individual level: Performance on Day 1 does not predict time to reach criterion

Citations

- Callahan PM, Terry A V. (2015) Attention. In, pp 161–189 Available at: http://link.springer.com/10.1007/978-3-319-16522-6_5.

- Capuzzo G, Floresco SB (2020) Prelimbic and Infralimbic Prefrontal Regulation of Active and Inhibitory Avoidance and Reward-Seeking. J Neurosci 40:4773–4787 Available at: http://www.jneurosci.org/lookup/doi/10.1523/JNEUROSCI.0414-20.2020.

- Chowdhury TG, Wallin-Miller KG, Rear AA, Park J, Diaz V, Simon NW, Moghaddam B (2019) Sex differences in reward- and punishment-guided actions. Cogn Affect Behav Neurosci 19:1404–1417 Available at: http://link.springer.com/10.3758/s13415-019-00736-w.

- Dalla C, Shors TJ (2009) Sex differences in learning processes of classical and operant conditioning. Physiol Behav 97:229–238 Available at: http://dx.doi.org/10.1016/j.physbeh.2009.02.035.

- Day HLL, Reed MM, Stevenson CW (2016) Sex differences in discriminating between cues predicting threat and safety. Neurobiol Learn Mem 133:196–203 Available at: http://dx.doi.org/10.1016/j.nlm.2016.07.014.