Neural correlates of risk/reward decision making in the medial prefrontal cortex and basolateral amygdala

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Introduction

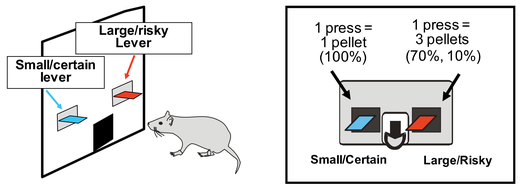
The basolateral amygdala (BLA) and medial prefrontal cortex (mPFC) are two reciprocally connected regions that contribute differently to risk/reward decision making, with the BLA supporting reward value representation, and the mPFC monitoring changes in reward contingencies to modify decision biases (1). Moreover, mPFC-dependent modifications in decision biases are enacted via mPFC descending pathways to the BLA (2). However, it is not clear how neurons in the mPFC and BLA encode information regarding choice behavior and outcomes during decision making.

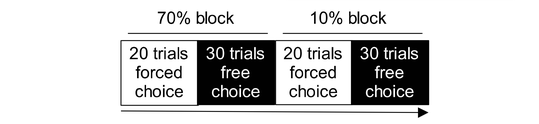
Here, we examined firing of mPFC and BLA neurons during key task events (e.g. pre-choice, after rewarded/non-rewarded choice outcomes) in a probabilistic discounting task.

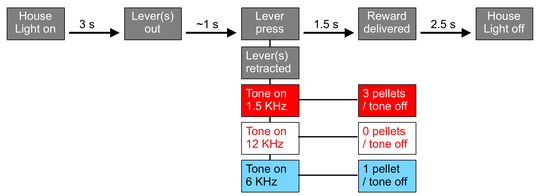
To this end, we recorded multi-unit activity simultaneously from both regions using multi-tetrode arrays during performance of a task where rats chose between a small/certain reward and a large/risky reward, with risky reward probabilities changing over blocks of free-choice trials from 70% to 10%.

Methods

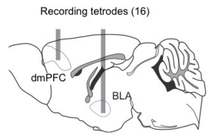
Probabilistic discounting: well-trained rats chose between levers that delivered a small/certain (1 sugar pellet) or a large/ uncertain (3 sugar pellet) reward (the odds of which decreased from 70% to 10%).







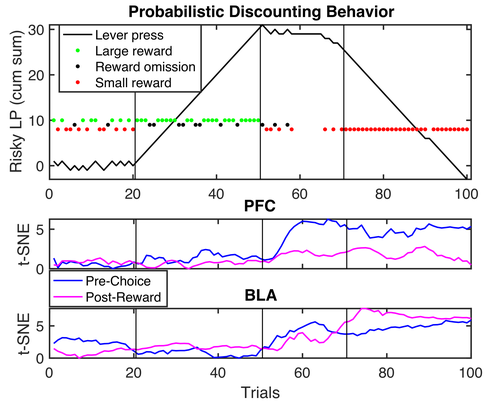
Tetrode implantation: Animals were unilaterally implanted with 8 tetrodes in the BLA, and 8 electrodes in the mPFC, for freely moving in vivo recording.
At the termination of the experiment, recording sites were marked with electrolytic lesions and their location verified histologically.

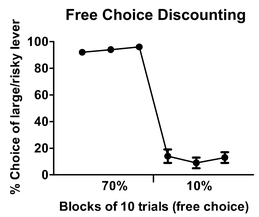


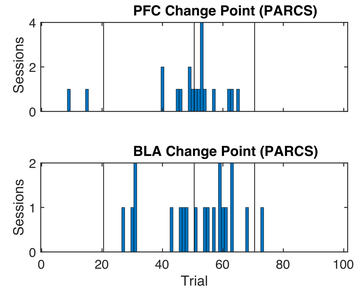
References

(1) Orsini CA, Moorman DE, Young JW, Setlow B, Floresco SB. Neural mechanisms regulating different forms of risk-related decision-making: Insights from animal models. *Neuroscience & Biobehavioral Reviews* 58: 147-167, 2015.
(2) St. Onge JR, Stopper CM, Zahm DS, Floresco SB. Separate Prefrontal-Subcortical Circuits Mediate Different Components of Risk-Based Decision Making. *Journal of Neuroscience* 32: 2886-2899, 2012.

Change of risky reward probability and changes in neuronal population activity

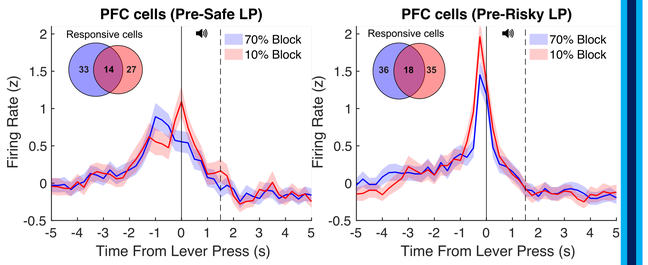






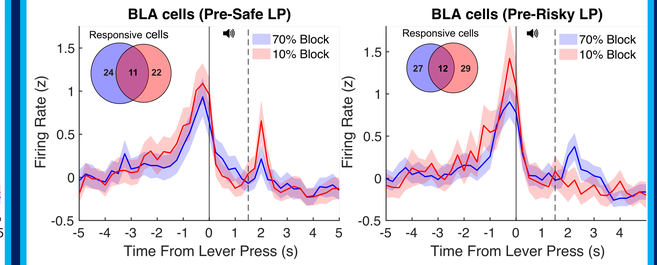
- Over the course of a probabilistic discounting session, the major abrupt transition, or change point, in PFC activity happens around the switch from high to low odds of large reward, primarily in the 10% odds forced choice block.

PFC cells responsive prior to forced choice safe lever press



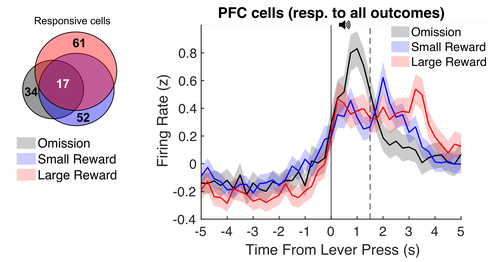
- PFC pre-Safe LP responsive cells show higher activity before LP forced choice during the lower large-reward probabilities.
- PFC pre-Risky LP responsive cells show higher activity before LP forced choice during the lower large-reward probabilities block.

BLA cells responsive prior to forced choice risky lever press



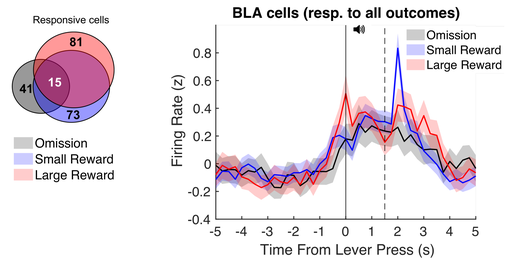
- BLA pre-Safe LP responsive cells show similar activity before forced choice, but show increased activity at small reward delivery during lower large-reward probabilities.
- BLA pre-Risky LP responsive cells show similar activity at time of forced choice, but show increased activity after reward delivery during higher large-reward probabilities.

PFC cells responsive to reward outcomes



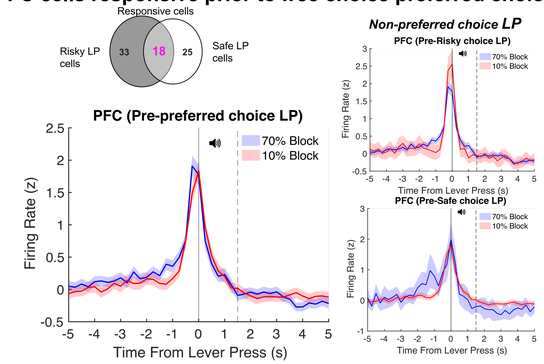
- PFC cells responsive to all outcomes post-lever press, show peak responding at different time points, with omission peaking during omission tone-cue, and response to small reward and large reward at the termination of their delivery.

BLA cells responsive to reward outcomes



- BLA cells responsive to all outcomes all show prolonged elevated response over the tone cue period and the reward delivery, with a phasic response to the small reward delivery.

PFC cells responsive prior to free choice preferred choices



- PFC cells responsive to the preferred choice (risky at 70%, and safe at 10%), during **both** free choice blocks, show slightly lower responding at the 10% block.
- Same PFC cells show higher risky choice responding when it is not the preferred choice (10% block), whereas they show stronger responding early in their approach prior to safe-choice when it is not the preferred choice (70% block).

Summary & Conclusion

- As large reward probabilities change from high to low, well trained animals show abrupt changes in choice behavior during free choice blocks. However, choice point analysis suggests that neuronal activity patterns in the PFC and BLA have shown abrupt changes before the low odds free choice block has begun, most frequently during the preceding forced choice block.
- During forced choice blocks, safe choice PFC cells show increased responding prior to lever pressing during low odds of large reward relative to higher odds, as well as risky choice responsive cells, consistent with transition in activity between high and low probability blocks. As reward odds of pressing the safe lever remain the same, this suggests that this change is due to changes in reward odds at the risky lever, i.e. devaluation of the risky lever.
- BLA pre-forced choice responsive neurons show similar activity prior to risky and safe lever pressing during high and low odds periods, but show increased activity following reward delivery after risky lever pressing during high odds, and after safe lever pressing during low odds, tracking the optimal reward outcome.
- With regards to outcome PFC cells sensitive to all three outcomes, show a distinct phasic response to each outcome, whereas BLA cells responsive to all outcomes show a long phasic response over the tone cue and reward delivery period, with a phasic response to the small reward delivery.
- During free choice blocks, we found that PFC cells that are responsive during the rats preferred choice, during both free choice blocks, show slightly lower responding when large reward odds were low. Same cells show higher risky choice responding when it is not the preferred choice (10% block), but stronger early early response prior to safe lever when it is not the preferred choice (70% block).

Together these data suggest that both the PFC and BLA show a marked change in activity with changes in reward probabilities during probabilistic discounting, and are sensitive to different reward outcomes.