

Distinct contributions of the amygdala and prefrontal cortex in the regulation of fear.

Jeffrey C. Erlich¹, Carlos Brody¹, and Joseph E. LeDoux²

¹Princeton University, ²New York University

The lateral nucleus of the amygdala (LA) and the medial prefrontal cortex (mPFC) seem to play opposing roles in the regulation of fear: activity in the LA covaries positively with fear expression and activity in the mPFC covaries negatively with fear expression [1]. Based on the putative roles of these structures, we hypothesized that the LA would signal the onset of fear and the mPFC would signal the offset of fear. Rats lick at 6-8 Hz, thus conditioned lick suppression allows for the measure of the onset and offset of fear at a temporal resolution of ~100 ms, an order of magnitude faster than freezing, which is the most common measure of fear expression. By combining this measure of fear expression with single unit recording from awake rats, we could analyze neural and behavior activity at millisecond timescales.

We found that neural activity in the LA and mPFC was not simply negatively correlated. Rather, neurons in the LA seemed to use an adaptive code to trigger the onset and offset of fear: activity ramped up before the onset of fear and ramped down before the offset of fear, with essentially no activity during sustained behavior. In the mPFC we found ‘*up*’ neurons that covaried positively with fear and also ‘*down*’ neurons that covaried negatively with fear. The timing of changes in neural activity in relation to the onset and offset of lick suppression was consistent with the notion that the LA drives fear and the mPFC inhibits fear.

The existence of ‘*up*’ and ‘*down*’ neurons in mPFC is reminiscent of other reports of prefrontal activity. An elegant explanation for this type of redundant encoding is that these two populations can instantiate an attractor network via mutual inhibition, which subserves working memory and decision-making [2]. We are currently investigating whether the ‘*up*’ and ‘*down*’ neurons might encode a working memory of fear in the mPFC.

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References

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