Neural basis of cognitive-emotional interaction

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In everyday life, the same sensory stimulus can produce markedly different emotional responses depending upon the situation. The flexibility that allows us to adaptively express a differential reaction to externally identical but contextually distinct stimuli is an essential premise for a healthy emotional life, and its impairment underpins a wealth of psychopathological conditions such as anxiety and mood disorders. Converging lines of evidence suggest that this versatility in affective behavior involves an interplay between the prefrontal cortex (PFC), a cognitive cortical region, and the amygdala, a structure that elaborates emotional responses. However, the neurophysiological mechanisms instantiating this interaction are still unknown. The PFC is known to implement executive functions, providing cognitive neural signals that encode and maintain information related to rules, goals, and contexts that can be used to guide flexible goal-directed behavior. By contrast, the amygdala has not been shown to represent cognitive information; instead, many studies emphasize its role in learning and representing the relationship between sensory stimuli and looming reinforcement so as to coordinate behavioral and physiological expressions of emotional state.

Our study shows that in fact the amygdala provides neural signals representing abstract cognitive information about contexts that is qualitatively similar to signals provided by PFC. Subjects performed a task whereby the same visual stimulus could lead to different reinforcement depending upon the context in which the stimulus appeared. Subjects grasped the rules dictated by each context, exhibiting switch-like behavior upon transitions from one context to another. Neural signals in amygdala, and two parts of the PFC interconnected with the amygdala – orbitofrontal and anterior cingulate cortices – represented all task-relevant parameters needed to perform the task, including the visual stimuli, context, and expected reinforcement. Failure to accurately perform the task was correlated with changes in how the amygdala represented this cognitive information. Cognitive and emotional processes therefore do not appear to be cleanly divided between PFC and the amygdala. Indeed, rather than simply coordinating emotional responses, the amygdala appears to sit at the nexus of cognitive and emotional interactions during the guidance of flexible behavior.