Emotional Attention: Circuits Linking Amygdala, Limbic Cortices and the Thalamic Reticular Nucleus

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Emotion, once considered an irrational process, is now understood to contribute critically to the ability to engage in flexible, adaptive behaviors in response to changing contingencies. A key aspect of emotion's adaptive role is its relationship with attentional processes. Emotionally salient events capture attention and trigger appropriate responses. But in order to achieve goals, it is also necessary to flexibly control the degree to which a salient stimulus can disrupt behavioral plans. Recent studies have shown that pathways linking posterior orbitofrontal cortex (pOFC), the amygdala and the inhibitory thalamic reticular nucleus (TRN) may serve as a basis for emotion-related "top-down" and "bottom up" modulation of attentional resources [1]. The TRN receives unreciprocated pathways from the cortex and has bidirectional connections with the thalamus, which in turn has two-way communication with the cortex. This circuitry suggests that the TRN is a key node in the brain's attentional system.

Two structures associated with emotional processing send robust projections to TRN: the pOFC and the amygdala, which also interact strongly with each other, forming a tripartite circuit that serves the adaptive interaction of emotion and attention. The pOFC-amygdala-TRN interaction may allow the system to switch between "bottom-up" attention from the amygdala to any salient stimulus, and "top-down" attention from pOFC to stimuli that are relevant to goals and strategies. The amygdala forms large and efficient synapses onto TRN neurons, so it can send rapid, coarse-grained signals that direct attention to stimuli that are essential for survival [2]. The cortical circuits centered on pOFC, on the other hand, may involve slower and more fine-grained representations appropriate for flexible, intelligent behavior. Projections from pOFC to the amygdala may modulate the threshold for salience detection, so that as a behavioral plan unfolds the system is not derailed by distracters. In a rich environment that includes both positive and aversive stimuli, it may be necessary to suppress fear responses in order to take risks, such as needed during foraging. Concurrently, pOFC projections to TRN may direct attention to goal-related stimuli, or alternatively, to more refined representations that help discriminate and evaluate aversive stimuli. The projections from the amygdala to pOFC may serve the opposite function -- taking control of the TRN attentional network in the event of extreme risk, such as the presence of a predator.

The pOFC and the amygdala thus may be key nodes in a circuit that maintains a balance between caution and risk-taking behavior, directing attentional resources in context-sensitive ways. Dysfunctions in this circuit may be related to a spectrum of pathologies ranging from phobias and stress disorders to abnormal suppression of risk avoidance and fear. Phobias and stress may be caused by an imbalance in favor of "bottom-up" signals from the amygdala that are coarse, rapid, and prone to over-generalization. At the other extreme, excessive risk-taking and lack of fear, seen in social disorders such as psychopathy, may be related to an imbalance favoring "top-down" signals that suppress the course grained amygdalar signals. Here we present the elements of a computational approach to model how the pOFC-amygdala-TRN circuit can serve as a basis for salience dependent attentional modulation in adaptive and maladaptive behavior.

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