Social fear learning and the underlying neuronal circuits in the central amygdala

In its simplest form empathy can be characterized as the capacity to be affected by and/or to share the emotional state of another being (emotional contagion). An animal can socially learn about potentially harmful stimuli either by observing a conspecific in danger or by interacting with a conspecific, which had experienced danger. These two ways of learning presumably involve different neuronal circuits within the amygdala, a brain structure crucial for fear learning and memory. We have compared activation of the amygdala in two rat models of emotional contagion: observational fear learning (direct danger) and social transfer of emotions (indirect danger). We observed different behaviors (passive vs. exploratory, respectively) in the observer rats and activation of different neuronal circuits, with behavioral and neuronal changes mirroring those of the demonstrators. To elucidate the role of neuronal circuits activated by interaction with a fearful partner, we used optogenetics. Activating central amygdala (CeA) ”social fear” neurons involved during social transfer of fear we showed that they enhance exploratory behavior of the familiar environment but inhibit social interaction and ultrasonic communication. Their activation in the novel environment resulted in increased anxiety reflected by shortened exploration of anxiogenic stimuli. On the other hand, activation of neurons involved in observational fear learning led to inhibition of any exploratory behaviors in the novel environment. Thus, by activation of CeA neurons involved in social interaction with a fearful partner we were able to reproduce active and passive fear observed during the interaction. We also showed a population of the CeA neurons that was activated by socially transferred active fear but not by passive fear. To further characterize subpopulation of the CeA neurons activated by active socially transmitted fear we identified their anterograde and retrograde projections by functional mapping methods. Especially dense anterograde projections have been found in the periaqueductal gray (PAG) and dorsal raphe nuclei (DRN); the structures implicated in fear and anxiety. Taken together, out results show that the neuronal circuits within the CeA control active and passive socially transmitted fear and that these circuits involve at least partially different groups of neurons.