

Second International Calcium Channel Conference - Placencia, Belize
March 28 – April 2, 2010

Observational fear learning by empathy involves affective pain system and $\text{Ca}_v1.2 \text{ Ca}^{2+}$ channels in the anterior cingulate cortex

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Fear can be acquired via empathy through social observation of others suffering from aversive stimuli. We show here that a mouse (observer) develop freezing behavior by observing another (demonstrator) receiving repetitive foot shocks. Observers displayed higher fear responses when demonstrators were socially related to themselves, such as siblings or mating partners. Inactivation of anterior cingulate cortex (ACC), and parafascicular or mediodorsal thalamic nuclei, which comprise medial pain system representing pain affection, significantly impaired this observational fear learning, whereas inactivation of sensory thalamic nuclei had no effect on this learning. The ACC neuronal activities were increased and synchronized with those of the lateral amygdala at theta rhythm frequency during this learning. Furthermore, an ACC-limited deletion of $\text{Ca}_v1.2 \text{ Ca}^{2+}$ channels in mice impaired observational fear learning as well as reduced behavioral pain responses. These results demonstrate the involvement of the affective pain system and $\text{Ca}_v1.2$ in the ACC in observational social fear by empathy.