

# Closed-loop emotion regulation

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## **Abstract:**

The ability to regulate one's internal affective states and response to perceived emotions is an important aspect of personal well-being. Abnormalities in these emotion regulation mechanisms have been associated with a variety of psychiatric disorders. Real-time fMRI neurofeedback training of emotional brain centers such as the amygdala has been suggested as a training method to improve emotion regulation capabilities. These earlier studies used a symbolic representation of the feedback signal, such as a thermometer icon. Here we explore a conceptually new use of neurofeedback by providing closed-loop brain training using feedback stimuli that inherently recruit the brain regions to be trained, i.e., they are related to the function of the trained brain area. Specifically, we show how participants gain control over the amygdala by using emotional stimuli as a feedback signal, the valence of which will be determined based on ongoing activity in the amygdala. Such closed-loop feedback is more motivating, increases the patient's sense of agency, and increases face validity by virtue of the fact that training is specific to the emotional cues that are related to the disorder. Closing the loop also allows for applying feedback loops derived from control theory models in order to shape brain dynamics. This new approach might facilitate modulation of the amygdala response to emotional stimuli in order to improve emotion regulation in health and disease.