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Changes in salivary oxytocin levels, cardiac vagal tone, and functional connectivity in the brain: effects of voluntary breathing regulation

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Motivation and Aim: Breathing is one of the most fundamental and partially controllable physiological behaviors in daily life. Breathing regulation has been identified as a clinical method to temporarily relieve anxiety and depressive symptoms. However, It is still an ongoing debate in the scientific community regarding the functional circuits and voluntary breathing regulation within the brain.

Methods: The study was divided into two core sections: the first section explored changes in functional magnetic resonance imaging (fMRI) time courses during rapid breathing and breath-holding cycles, as well as potential respiratory-related connectivity networks in the brain. The second section recruited two groups of participants – the experimental group underwent respiratory training exercise, and the sham group played piano keyboard games – to examine group differences within resting-state fMRI connectivity networks and on their salivary hormone concentrations.

Results: The first experiment found that there were at least two connectivity networks highly associated with the interactions between breathing regulation and ANS. Notably, the ventral medial prefrontal cortex exhibited fMRI time courses that showed inverse patterns to those observed in the dysgranular structure in the insula cortex, amygdala, and premotor cortex. The second experiment revealed significant increases in salivary oxytocin levels in participants after breathing exercise compared with those playing piano games. Additionally, the experimental group demonstrated significantly weaker inter-hemispheric connectivity in the hippocampus and its associated motor areas as well as weaker connectivity between the hippocampus and the salience network.

Conclusion: This study identified brain connectivity networks associated with breathing regulation and their associations with salivary oxytocin levels. The results are expected to provide a neurophysiological basis and connectivity evidence for the clinical application of respiratory practices in emotion regulation, and for enriching the scientific foundation of psychiatric therapy.

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