Studies of the human brain neural network: methods and application

by

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ABSTRACT

Magnetic resonance imaging (MRI) provides non-invasive techniques for studying the anatomy and function of the human brain, with such efficiency, that it allows for study of the whole neural network *in vivo*. In this dissertation, multiple MRI methods were used to investigate the impact of maturing in a hypoxic environment on the structure and function of human brain. MRI experiments were conducted on subjects who matured at high altitudes (HA) and recently moved to sea level (SL) and control subjects who had matured at SL. Novel approaches were developed to investigate the neural networks of the two groups. In the anatomical MRI study, HA subjects showed decreased regional gray matter density. In multiple task-based fMRI experiments, HA subjects demonstrated decreased cerebrovascular reactivity reflected in blood oxygen level dependent (BOLD) signal. In resting state fMRI studies, HA subjects demonstrated changed amplitudes of spontaneous activity and local connectivity. Although several of the above studies with traditional fMRI experiment paradigms and analytical approaches seem to indicate that the HA group had neural deficiency (reflected in decreased gray matter density and cerebrovascular reactivity), such conclusion seems contradictory to the non-difference of IQ and academic level of the two groups of subjects. Therefore novel approaches were developed to study the neural network properties. Such analyses indicate compensatory mechanisms in terms of enhanced functional connectivity in the global neural network. Furthermore, a novel approach further revealed changed network architecture. Finally, during the short period of SL relocation (1 to 5 years), various neural parameters of the HA subjects were changing towards the direction of becoming more similar to those of SL residents, indicating considerable neural plasticity. These

studies have the following implications: firstly, they indicated the capacity of neural adaptation to a hypoxic environment, and considerable neural plasticity was observed during short periods of SL relocation; secondly, this example indicated that the novel approaches for studying neural network properties and architecture can provide important new perspectives for understanding human brain function.