Acute stress rapidly increases energy metabolism in prefrontal and frontal cortex

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The physiological reaction to environmental stress implies changes in energy metabolism, brain function and gene expression, that prepare the body for physical activity (fight-or-flight response) in the short-term response. However, when the stressful event is prolonged or overwhelming, maladaptive mechanisms could occur, thus increasing the risk to develop stress-related pathologies, including neuropsychiatric disorders (McEwen et al., 2015). Bioenergetic fluctuations, induced by stress at neuronal level, actively regulate synaptic transmission and play a key role in stress adaptation and behavior.

In previous studies, we have shown that acute foot shock (FS)-stress induces a fast and long-lasting increase of depolarization evoked glutamate release from prefrontal and frontal cortex (PFC/FC) purified synaptic terminals in superfusion (Musazzi et al., 2016), together with rapid and sustained structural remodeling of excitatory neurons (Treccani et al., 2014; Nava et al., 2016).

Main aim of the present study was to evaluate brain metabolic and behavioral consequences of acute FS-stress. We employed [18F]FDG-Positron Emission Tomography (PET) technique on FS-stressed rats to measure changes in brain areas metabolic activity. FS-stress induced a relative redistribution of glucose metabolism in the brain: [18F]FDG uptake was relatively increased in dorso-rostral (including cortical and subcortical regions), while decreased in ventro-caudal areas.

In line with in vivo [18F]-FDG PET results, in vitro 2-Deoxy [3H] glucose uptake, as well as hexokinase specific activity, were significantly enhanced in PFC/FC synaptosomes from FS-stressed rats compared to controls. Moreover, FS-stress increased both the number and size of mitochondria at excitatory PFC presynaptic terminals, in line with the potentiation of glutamate transmission previously reported. Finally, working memory performance, assessed by the T-maze delayed alternation task, was improved soon after stress, but impaired 24 h later.

Taken together, these results suggest that acute FS-stress induces a fast metabolic and functional activation of PFC/FC, with long-lasting morphological and behavioral effects.

McEwen et al. (2016). Neuropsychopharmacology. 41:3-23.

Musazzi et al. Mol Psychiatry. 2016 in press.

Nava et al. (2017). Cereb Cortex. 27:694-705.

Treccani et al. (2014). Mol Psychiatry. 19:433-43.