

A Move from Measurement of Brain Metabolism to Monitoring of Dynamic Brain Function: Advancement towards Better Understanding of Brain Behavior

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Received: January 13, 2019; **Published:** March 04, 2019

Background

Studying brain behavior is a complicated process and the choice of a technique to do that depends on the nature of brain function to be observed. What makes brain-behavior relationship studies complicated lies in the fact that the brain is not distinctively sectioned into specific parts for independent control of human behavior. For this reason, several methods have been explored in the understanding of brain function; examples of some of these techniques include electroencephalography (EEG) [1], computerized axial tomography (CAT) [2], positron emission tomography (PET) [3] and functional magnetic resonance imaging (fMRI) [4]. Magnetic resonance spectroscopy (MRS) [5] and functional MRS (fMRS) [6] have also been extensively used in brain studies due to their noninvasiveness and ability to measure subtle brain chemical changes from which brain function can be inferred. Indeed, fMRS represents a revolution towards a better understanding of brain function in neuroscience and psychology.

Measurement of brain metabolism as a means of probing brain function

MRS [5,7] noninvasively measures up to eight quantifiable (in concentration units) neurochemicals within neurons and glial cells; these neurochemicals provide vital information about brain function, and they include N-acetyl aspartate (NAA), myo-inositol (mI), choline (Cho), creatine (Cr), glutamate (Glu), glutamine (Gln), gamma-aminobutyric acid (GABA) and lactate (Lac). Even brain water content can also be measured noninvasively by the MRS technique [8,9].

NAA is a marker of the density, health status and function of neurons [7], mI is a marker of glial cell health [10], Cho represents cell membrane turnover or myelination [11], Cr is a marker of energetic status of brain cells [12], Glu and Gln are respectively excitatory and inhibitory neurotransmitters [11,13], GABA is produced from Glu and also acts as an inhibitory neurotransmitter [7,14], Lac is a marker of anaerobic metabolism [14] and water serves as the medium in which most biochemical reactions occur. Thus, brain behavior associated with changes in any of these neurochemicals can be inferred from MRS study of the brain.

MRS has therefore been used to measure brain metabolism in human disease conditions such as stroke [15], multiple sclerosis [16], brain tumours [17], Alzheimer's disease [18], dementia [19], schizophrenia [20], bipolar disorders [21] and major depression [22].

Understanding brain function by monitoring dynamic brain metabolism

By exploiting the blood oxygenation level dependent (BOLD) contrast mechanism during MRS of the brain, the data acquisition process can be modified to capture neurochemical changes associated with neuronal response to a controlled external stimulus [23]. The BOLD effect arises when an external stimulus causes neural activity to increase above baseline physiological state. This change in physiological

state is associated with changes in cerebral blood flow, cerebral blood volume and the cerebral metabolic rate of oxygen consumption [24]. Consequently, the flow of oxygenated blood to the region of activity increases, an effect detected as the BOLD signal spreading from the activation site [25] to the vessels and tissue near the vessels.

Most fMRS studies use a visual stimulus which varies at a frequency of 8 Hz to induce a maximum stimulation in the visual cortex of the brain [26]. Thus, the BOLD effect is observed in this region of the brain in a dynamic way; that is, neurochemical changes associated with the activation pattern can be monitored in order to evaluate tissue health and function in this area of the brain. It is also possible to use motor activation to make a similar observation in the motor region of the brain. However, this has to be done with care in order not to contaminate the fMRS signal with motion artefacts since MRS is inherently sensitive to motion of the patient during data acquisition.

The future of dynamic brain metabolism studies

Functional MRS (fMRS) is a relatively new technique of studying brain function. Therefore, fMRS studies so far have focused on optimization of the technique and establishing thresholds of neurochemical changes that can reveal *in vivo* information with good precision [27]. It is therefore possible to optimize specific stimuli for fMRS data acquisition and establish a multicenter dataset specifying standard, expected levels of change (in percentage units) in the neurochemicals, for the respective stimuli within the corresponding brain regions they cause neuronal activation. When this is accomplished, fMRS will be an excellent technique to complement the already existing techniques in elucidating brain function and its associated behavior.

Conflict of Interest

The author has no conflict of interest to declare.

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Volume 8 Issue 3 March 2019

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