Title: Detecting changes in human brain glutamate using 7-Tesla functional magnetic resonance spectroscopy at short versus long echo times

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Structured Abstract:

Introduction: Typically, magnetic resonance spectroscopy sequences attempting to measure glutamate aim to utilize the shortest echo time achievable to reduce the effects of J-coupling and T2 relaxation. However, in 2017, Wong et al. described the optimal echo time for glutamate detection for 7T semi-LASER proton magnetic resonance spectroscopy (1H-MRS) to be in the range of 100 to 125ms, which is almost twice longer than the typical shortest echo achievable with this sequence (Wong et al., ISMRM abstract, 2017). This work aimed to investigate whether one should choose the shortest echo time or the "optimal" echo time when attempting to detect small glutamate concentration changes in a functional MRS paradigm.

Methods: Measurements were acquired on a Siemens MAGNETOM 7-Tesla MRI scanner at the Centre for Functional and Metabolic Mapping at Western Universtiy. Brain glutamate changes were measured using a proton functional magnetic resonance spectroscopy (1H-fMRS) semi-LASER pulse sequence (TR=7500ms, 128 averages) with a 20x20x20 mm3 voxel placed in the dorsal anterior cingulate cortex. This study consisted of fMRS measurements on eight healthy participants. The functional components used during the fMRS acquisition was a color-word Stroop interference task consisting of four periods of four minutes (rest, active, recovery 1, recovery 2). For each of the four periods of both echo times, a single spectrum was produced by averaging 32 transient phase and frequency corrected spectra. Afterwards, these averaged spectra underwent post-processing using combined QUALITY deconvolution and eddy current correction and were then fitted using the Levenberg-Marquardt minimization algorithm to echo time specific prior knowledge templates. Lastly, metabolite quantification was performed using the fitted output spectra.

Results: Using a two-tailed t-test, glutamate concentration estimates at TE=100ms showed significantly lower percent coefficient of variation ($p < 0.05$) as well as significantly lower percent Cramer-Rao lower bounds ($p < 0.001$) than those at TE=60ms. Also, a trend was observed for TE=60ms to produce greater spread in glutamate concentration differences per subject between each subsequent period pairs of the fMRS paradigm.

Discussion: Measurements and analysis of glutamate concentration coefficient of variation and Cramer-Rao lower bounds show TE=100ms to be more optimal for glutamate detection during human brain fMRS than TE=60ms. Also, though only a trend was observed in glutamate concentration differences between each period pairs of the task paradigm, this lack of significance could potentially be due to low sample size. Future works may include increasing sample size to confirm the trend observed that TE=100ms produces more consistent glutamate concentration differences than TE=60ms.