Evaluation of GABA Detection Sensitivity Gains Achieved with an 8-Channel Phased-Array Head Coil at 3.0 T in the Human Dorsolateral Prefrontal Cortex Using the J-editing Technique

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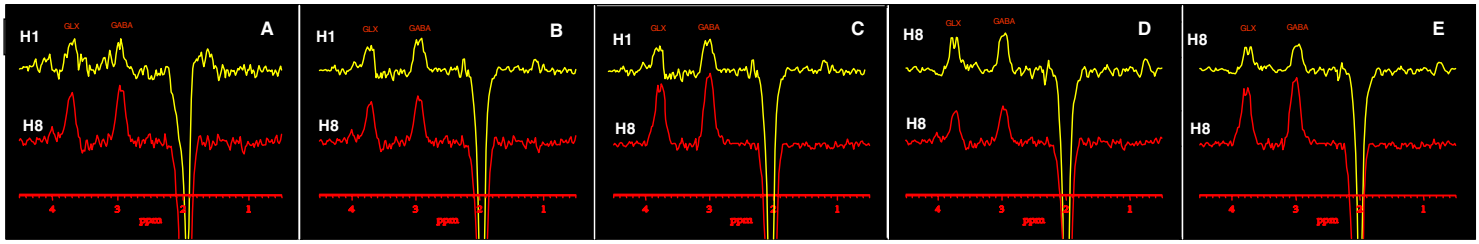
Introduction. Dysregulation of the inhibitory amino acid neurotransmitter system of γ-aminobutyric acid (GABA) has been implicated in the pathophysiology of most neuropsychiatric and many neurological disorders, including schizophrenia, major depressive disorder, generalized anxiety disorder, substance abuse and epilepsy. There is, therefore, great interest in studying the function of this neurotransmitter in *vivo*. However, detection of brain GABA by ^{1}H MRS – the only technique that can currently measure this amino acid *in vivo* -- presents formidable challenges. First, the strongly-coupled GABA multiplets in the 1.9-3.7 ppm range are overlapped by the much stronger resonances of NAA, total Creatine, macromolecules, and glutamate and glutamine. And second, the concentration of GABA in brain is estimated to be only of the order 0.5-1.0 mM, i.e., at the lower limit of detectability by ^{1}H MRS at commonly available field strengths. Though the challenges associated with spectral overlap for GABA detection can now be overcome using a variety of "editing" techniques, the low brain GABA concentration remains a challenge that requires use of relatively large voxels, at the expense of partial volume effects and spectral purity. Recently, van der Veen and Shen [1] demonstrated that use of the J-editing difference technique with a phased-array head coil at 3.0 T can significantly enhance GABA detection sensitivity for a voxel in the human dorsolateral prefrontal cortex (DLPFC). In this study, we evaluated the tradeoffs for the GABA detection sensitivity gains achieved with an 8-channel phased-array coil at 3.0 T between voxel size and scan time that can be made without sacrificing spectral quality.

Methods. All the *in vivo* human brain GABA editing spectra were recorded on a 3.0 T GE "EXCITE" MR system using the J-edited spin echo difference technique [2] with either a standard single-channel quadrature head coil or with an 8-channel phased-array coil, both supplied with the instrument. The data were obtained from a single voxel that was localized in the left DLPFC of healthy human subjects. Detection sensitivity was assessed as a function of voxel size and/or scan time. Using the results of [1] as a guide, we set a scan time of 26 min as the maximum practical total scan time. The scans consisted of a modified standard PRESS sequence [3] in which a frequency-selective 180^o refocusing rf pulse was interleaved with a standard non-selective 180^o refocusing pulse, such that J-modulation of the GABA C^{4}H resonance at 3.0 ppm was inhibited and allowed on alternate scans. Subtracting the two spectra yielded the difference spectra containing the edited GABA C^{4}H resonance at 3.0 ppm and, as a by-product, the Glu+Gln ("Glx") peak at 3.7 ppm, which is co-edited, though with very poor efficiency. The 8-channel phased-array coil data were combined into a single regular FID using a "C" program that implemented a previously reported time-domain algorithm [4]; voxel water signal was used to derive relative array coil sensitivities.

Results and Discussion. The GABA data obtained with the single-channel head coil and with the 8-channel phased-array head coil were compared as shown in Panels below: (1) Panels A-C compare single- (H1) and 8-channel (H8) coil data recorded by varying voxel size only; and (2) Panels D and E compare data obtained with the 8-channel coil for different voxel sizes and scan times. Using the standard



quadrature single-channel head coil to record the edited GABA spectra from a 9.7-cc voxel in 26 min yielded very poor quality data (Panel A, top). In order to obtain useable GABA spectra with a single channel coil in 26 min, it was necessary to double the voxel size to 19.5 cc (Panel B, top), which unavoidably resulted in the inclusion of significant white matter within the DLPFC volume-of-interest. By comparison, using the 8-channel head coil, we were able to obtain excellent quality GABA spectra in 26 min from a 9.7-cc voxel (Panel A, bottom), allowing sampling of a mainly gray-matter VOI. It is also interesting to note that the spectrum from the smaller phased-array coil voxel is even slightly better than a spectrum obtained in the same scan time but from a two-fold larger voxel size with the single-channel head coil (compare top and bottom traces in Panel B). Comparing two spectra obtained from a 19.5-cc voxel in 26 min with the single-channel (Panel C, top) and with the 8-channel (Panel C, bottom) coils shows a more than a factor of two SNR enhancement in the 8-channel GABA spectrum. In Panel D, 8-channel GABA spectra obtained from a 19.5-cc voxel in 13 min (top) and from a 9.7-cc voxel in 26 min (bottom) are compared and found to have nearly similar SNR, indicating that the sensitivity enhancement achieved with the 8-channel coil is sufficient to allow either scan time or voxel size to be decreased by a factor of about two, without a significant penalty in SNR. For completeness, 8-channel spectra obtained from a 19.5 cc voxel in 13 min (Panel E, top) and in 26 min (Panel E, bottom) show the well-established square-root dependence of SNR on scan time

Conclusion. This study confirms that significant sensitivity gains for *in vivo* GABA detection can be achieved by using a phased-array coil. These high SNR gains are undoubtedly made possible by the proximity of the DLPFC voxel to the individual coils of the phased array. Gains for deeper lying structures are likely to be less than those achieved for the DLPFC, for which sufficient sensitivity has been achieved to allow either the voxel size or scan time to be decreased by a factor of two without paying a significant penalty in data quality. The decreased voxel size is important for minimizing partial volume effects or tissue heterogeneity within the voxel of interest.

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