Long-term Quality Assurance of fMRI and MRS on a 3.0T clinical scanner

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Purpose/Introduction: Functional MRI (fMRI) and Magnetic Resonance Spectroscopy (MRS) are being increasingly used in clinical protocols [1]. Subsequently, it is crucial to develop a routine quality assurance protocol (QA) of both techniques [2]. This work describes a long-term variability study, as a part of the QA of fMRI and MRS on our institution clinical 3.0 T MR scanner.
Subjects and Methods: QA scans were performed over a period of 12 months (Feb 2011-Feb 2012) on a GE HDxt 3.0T MR scanner using an 8-channel array brain coil. An MRS phantom, mimicking healthy brain metabolite concentrations, was placed at the scanner isocentre 15 minutes prior to each QA adquisition. Phantom temperature together with humidity and temperature of the scanner and the hardware rooms were recorded.
The acquisition protocol consisted of a fMRI using an GRE-EPI pulse sequence with a TR=2506ms, TE=40ms, flip angle=60, slice thickness=3mm, matrix-size=64x64 and 35 slices. The MRS data was acquired using a PRESS pulse sequence with a nominal voxel-size=20x20x20 mm, TE=35ms and a total of 128 scan averages.
fMRI and MRS data were analysed with a Matlab developed Image Temporal-Stability Tool [Fig.1] and the LCModel software [Fig.2][3] respectively. Signal-to-Noise Ratio (SNR) and Signal Fluctuation to Noise Ratio (SFNR) were measured for fMRI data. While for MRS, the Creatine (Cre), Phospho-Coline (PCh), Lactate (Lac), Mio-Inositol (mI) and N-Acetyl-Aspartate (NAA) concentrations were computed.
Signal-stability was analised following previous published methods [1,2]. A warning rule (Shewhart chart [1]) for SNR and SFNR was set to values exceeding the mean±two standard deviations.

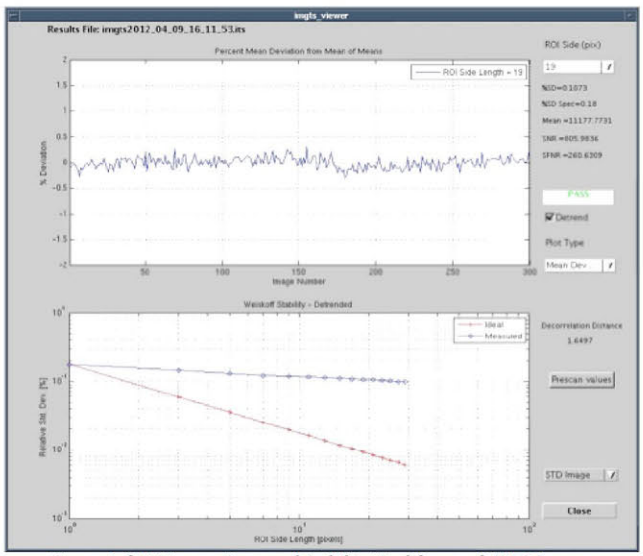

Figure 1. fMRI Image Temporal Stability Tool for one fMRI QC scans

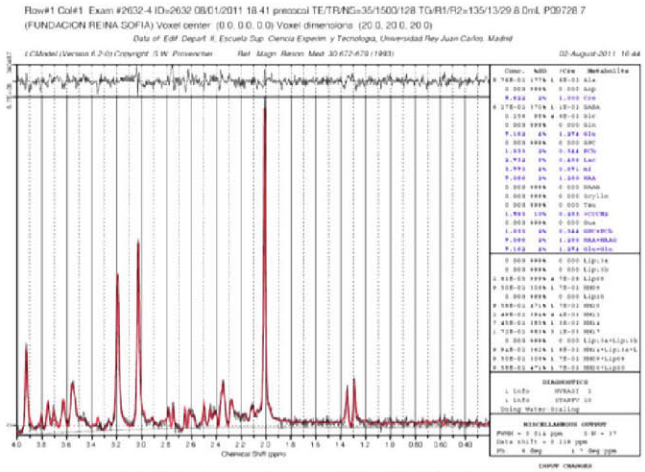
Figure 2. LCModel outcome for one of the MRS phantom acquisitions

Results: SNR and SFNR reached warning values (>mean ± 2 standard deviations) in about 3% and 7% of the repeated measures, respectively. No statistical significant correlation with the registered parameters (scanner-room temperature, technical-room temperature, humidity, percentage of helium volume or helium pressure) [Fig.3] during the fMRI QA study. The Weiskoff stability chart for a fMRI scan [Fig.1-low] also shows that the quality levels are acceptable as the relative fluctuation levels (plotted as %Relative Standard Deviation) follow a decreasing logarithmic line as the ROI increases.
Similarly, Fig.4 demonstrates no statistical significant correlation between metabolite concentrations and these recorded parameters.

PEARSON CORRELATION						
	Temp_Room	Temp_Tec_Room	Humidity	Helium	Helium_Pressure	Temp_Phantom
SNR	-0,1244	-0,0241	-0,0058	0,1010	0,0503	0,0343
SFNR	-0,0725	0,0097	0,0044	-0,0911	-0,1056	0,0506

Figure 3. Pearson Correlation of SNR and SFNR

PEARSON CORRELATION											
	Cre	PCh	PCh/Cre	Lac	Lac/Cre	mI	mI/Cre	NAA	NAA/Cre	GPC+PCh	GPC+PCh/Cre
Temp_Room	0,140	0,139	0,062	0,139	-0,039	0,140	0,015	0,140	0,140	0,139	0,091
Temp_Tec_Room	-0,010	-0,011	-0,002	-0,010	-0,103	-0,010	0,040	-0,009	-0,009	-0,011	-0,035
Humidity	-0,060	-0,060	-0,018	-0,060	-0,004	-0,060	-0,001	-0,061	-0,061	-0,060	-0,054
Helium	-0,018	-0,018	0,048	-0,018	-0,018	-0,018	0,016	-0,018	-0,018	-0,018	0,060
Helium_Pressure	-0,062	-0,062	-0,022	-0,062	0,004	-0,062	0,039	-0,062	-0,062	-0,062	-0,022
Temp_Phantom	-0,009	-0,009	0,025	-0,010	-0,034	-0,008	-0,041	-0,008	-0,009	-0,009	0,060
Hz	0,031	0,031	0,060	0,031	-0,122	0,031	0,114	0,031	0,031	0,031	0,012

Figure 4. Pearson Correlation of Metabolites and Variables

Discussion/Conclusion: Although some data points reached the stablished SNR and SFNR warning values, the results presented here are well within the normal published criteria [1] and no further instrument evaluation was required.

References:

[1] Simmons A. et al.; 1999; MRM 41:1274-1278.
[2] Garcia-Alvarez R. et al.; IPEM; London; July 2003.
[3] Provencher S.W.; MRM 30:672-679; 1993.