On the feasibility and specificity of simultaneous EEG and ASL MRI at 3T

Elise Bannier[1,2], Marsel Mano[2,3], Robert Stroemer[4], Isabelle Corouge[2], Lorraine Perronnet[2,3], Jussi T. Lindgren[3], Anatole Lecuyer[3], and Christian Barillot[2]

[1]Radiology, University Hospital of Rennes, Rennes, France, [2]Unité VISAGES U746 INSERM-INRIA, IRISA UMR CNRS 6074, University of Rennes, Rennes, France, [3]Unité HYBRID INRIA, IRISA UMR CNRS 6074, Rennes, France, [4]Brainproducts GmbH, Gilching, Germany

Purpose Brain functional imaging can be performed using several approaches, including EEG, BOLD and ASL MRI. To date, only a few studies have addressed the issue of connecting EEG signal to ASL perfusion[1-3]. ASL imaging relies on control and label RF pulses, generating alternate gradient patterns as well as higher SAR. The aim of this study was to assess ASL-EEG at 3T in terms of safety as well as EEG and MR signal quality[4,5].

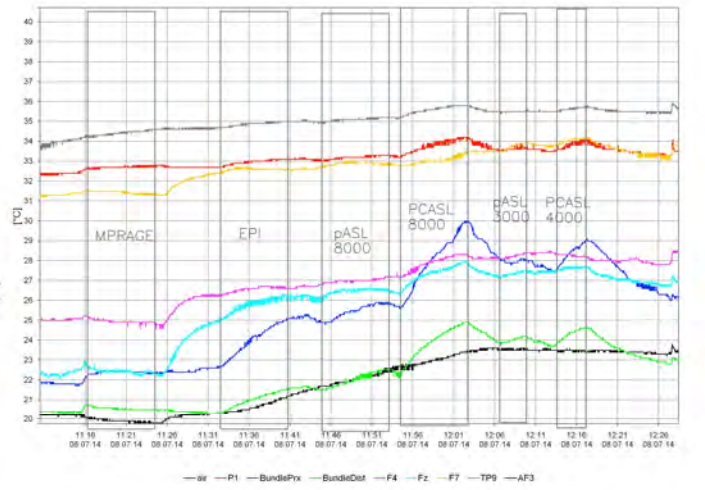
Methods MR imaging was performed on a 3T Verio MR scanner with a 64-ch MR compatible EEG device in 3 healthy volunteers. The imaging protocol consisted of 3D T1 MPRAGE, BOLD EPI, long TR as well as 3s TR PASL PICORE Q2TIPS and 4s TR pCASL 2D EPI, repeated without EEG. Temperature measurements were performed using GaAs probes with a 0.1°C resolution and ±0.8°C precision[4]. Ventilation was turned off in the bore just after the 3D MPRAGE not to bias EPI temperature measurements. Nine sensors were placed on the electrodes (P1, F4, Fz, F7, TP9, AF3) as well as on the connecting cables between cap (proximal sensor position) and EEG amplifier (distal sensor position). EEG data processing was performed using the Vision Analyzer2 software. MRI data processing was performed using Matlab/SPM8.

Results Protocol parameters, SAR values and temperature measurements are shown in Table 1 and Figure 1.

Start time	Sequence	Duration (min)	TR (ms)	Slices	Dynamics	Flip Angle (°)	SAR (W/kg)
11:25:19	3D MPRAGE	08:08	1900	176	1	9	0.046
11:33:14	ep2d_bold	08:06	3210	32	150	90	0.046
11:45:50	PASL	08:10	8000	14	61	90 + L/C	0.036
11:55:39	pCASL	08:08	8000	19	60	90 + L/C	0.105
12:08:35	PASL	03:08	3000	14	61	90 + L/C	0.118
12:15:19	pCASL	04:12	4000	19	60	90 + L/C	0.192

Table 1: Sequence parameters and SAR values

Figure 1: Temperature curves for the sequences detailed in Table 1 (Note that temperatures were not corrected for different starting values due to their position on the head and equipment)



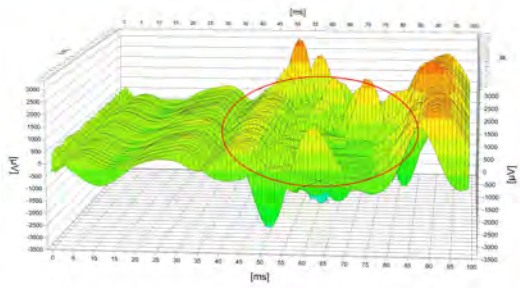


Figure 2: Stacked plot of the raw imaging artifact in one EEG channel during Q2TIPS pulse. The red circle marks data during the pulse where no stable artifact model for the average artifact subtraction can be obtained.

Standard PASL and pCASL acquisitions generated a 2.5-fold and 4-fold SAR increase for PASL and pCASL respectively as compared to a standard BOLD EPI sequence. This corresponded to up to 4°C temperature increase on the bundle, yet not exceeding 36°C. Following gradient correction of the EEG signal by AAS (average artifact subtraction) residual artifacts were observed for PASL-EEG 1260 to 1360ms after start of the volume acquisition. Such phenomenon was not observed in EEG data acquired during BOLD or pCASL. This correction imperfection affects about 1% of the data (~100ms), namely where the Q2TIPS pulse is played. A 20% loss in SNR was observed when compared to acquisitions performed without EEG.

Discussion and Conclusion This experiment shows that ASL EEG can be safely performed using the parameters presented above. However, residual gradient artifacts in the PASL-EEG data have to be considered. Further research is needed to understand the artifact variability and to develop an appropriate correction strategy.

References [1] Rao et al, ISMRM 2005, [2] Detre et al, Curr Opinion in Neurology 2009, [3] Mullinger et al, Neuroimage 2014 94 p263, [4] Nöth et al, JMRI 2011, [5] Ihalainen et al, MAGMA 2014