Event related fMRI of primary- and higher cognitive cerebral function using Pulsed Arterial Spin Labeling Perfusion

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Introduction

In the field of functional neuroimaging the use of blood oxygen level-dependent (BOLD) fMRI has been extremely successful. There is evidence of a coupling between neuronal activation, metabolism, and blood flow which is still not fully understood. This could pose a limitation for this fMRI method especially in the clinical field where factors influencing the coupling may be altered. One possible way to overcome this shortcoming is the use of event-related cerebral blood flow (CBF) Perfusion fMRI experiments. Several studies demonstrated the feasibility of event-related Perfusion fMRI experiments using Arterial Spin Labeling (ASL) [1-4]. In these studies one single trial type was used in separate runs to reconstruct the hemodynamic response function (HRF). In the present pilot study we investigated four different trial types within the same run. The following hypothesis was formulated: i) Is it possible to localize the activation evoked by each trial type separately? ii) Is it possible to reconstruct the HRF of all trial types within the same run? If these hypotheses hold, then event related CBF fMRI offers several advantages as compared to block design experiments; i.e. intermixing of trials of different types and the option to categorize each trial according to the behaviour of the subjects. The later is of importance when comparing controls with patients group.

Methods

Four subjects were measured with pulsed ASL (PASL) [5,6]. The stimulus material, displayed through a MR-compatible LCD goggle system, consisted in three trial types presented in randomized order: A) full-field 8Hz checkerboard, B) apparent radial moving dots at 4Hz and C) picture of human faces (in black&white). All Stimuli lasted 3 sec followed by 6 sec fixation cross. A "null event" was added to allow for a randomized inter stimulus interval. MR scanning was on a 3.0T Siemens Trio system, using the 12-channely array head coil as receiver and body coil as transmitter. The whole study included a structural 3D MRI (3D Turbo-flash). A pulsed ASL (PASL) sequence was a modified FAIR technique, as described previously [7]. A gradient-echo EPI sequence was used for image acquisition (FOV=23cm, 64x64matrix, TR/TE=2500/11ms, 12 slices of 6mm thickness with 1.5mm gap, GRAPPA 2, 640 volumes, scan time 26.40 min). PASL image series were first co-registered and smoothed with a 10 mm Gaussian-Kernel, and then pair-wise subtracted. CBF was quantified as described elsewhere [8]. All voxels with $p<0.01$ (uncorrected) were considered as putative region of interest and used for the subsequent HRF reconstruction. The general linear model was used to estimate the finite impulse response (FIR) associated with each of the 3 trial type.

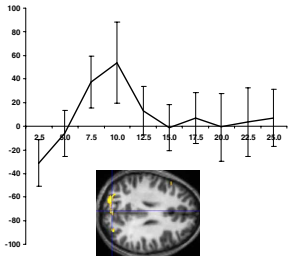

Fig. 1. Yellow: activated area due to Checkerboard paradigm with Peristimulus time (z=26).

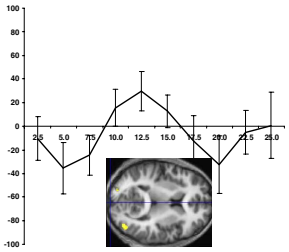

Fig. 2. Yellow: activated area due to Motion paradigm with Peristimulus time (z=11).

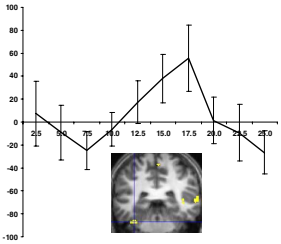

Fig. 3. Yellow: activated area due to Face processing with Peristimulus time (y=-39).

Results and Discussion

The localization of brain activity evoked by the stimulus condition A, B and C was found to be at the expected cortical regions: i.e. early visual cortex for condition A (Fig1), MT/V5 for condition B (Fig 2) and right fusiform gyrus for condition C (Fig 3). The reconstruction of the HRF for each stimulus condition shows an expected temporal pattern. These results demonstrate that it is possible to deconvolve the response function from a time series that contains the information of more than two stimuli. Furthermore, the results also show that it is possible to correctly localize the cerebral activation evoked by primary stimuli (i.e. checkerboard) as well as for higher cognitive stimuli (i.e. face processing). Event related fMRI with PASL comprising different stimulus modalities is feasible.

References [1] Liu HL et al. *Magn Reson.Med.* **42**: 1011-1013; 1999. [2] Liu HL et al. *Magn Reson.Med.* **43**: 768-772; 2000. [3] Yang Y et al. *Neuroimage.* **12**: 287-297; 2000. [4] Liu TT et al. *Neuroimage.* **16**: 269-282; 2002. [5] Detre JA et al. *Magn Reson.Med.* **23**: 37-45; 1992. [6] Wang J et al. *Magn Reson.Med.* **49**: 796-802; 2003. [7] Wang J et al. *J.Magn Reson.Imaging* **18**: 404-413; 2003. [8] Federspiel A et al. *J.Neural Transm.* **113**: 1403-1415; 2006.