

Using CASL Perfusion fMRI to Image Natural Vision

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Introduction The neural substrates underlying the processes of natural scenes in everyday vision remains poorly understood which may be attributed to the much longer time-scales of natural vision than the duration of strictly controlled conditions in optimal BOLD fMRI studies, as well as the complex scenes of multiple objects moving in spatial and temporal dimensions. Recently, Arterial spin labeling (ASL) perfusion fMRI has emerged as an appealing alternative to BOLD fMRI for imaging the longitudinal processes like natural conditions because of its noninvasive quantification of absolute cerebral blood flow (CBF) and long term temporal stability (1-2). The present study used ASL perfusion fMRI to measure the brain activation pattern and explore the functional segregation and specialization during natural vision of freely viewing a cartoon movie by concurrently recording CBF and BOLD contrast images.

Methods Eleven subjects (4 male, age 19-26 years) were scanned on a Siemens 3T Trio scanner while freely watching a comic cartoon movie (Roadrunner "Gee Whiz-z-z-z-z-z-z", Warner Bros, 1956) without sound. An amplitude-modulated continuous ASL technique [12 slices, 6mm thk/1.5mm sp, TR=3s, Labeling time=1.6s, Delay time=0.8s, TE=17ms, FOV=22x22cm², Matrix=64x64] was used for functional scans. Each subject was scanned for 13.5 min (3.5min resting baseline, 6.5min movie viewing, and 3.5min resting baseline). Concurrent perfusion and BOLD data were analyzed by SPM99. For each subject, raw EPI images were corrected for head motion, followed by pair-wise subtraction of label and control acquisitions and conversion to quantitative CBF images based on the single-compartment perfusion model (3). Voxel-wise general linear modeling was conducted on normalized and smoothed CBF and BOLD images for each individual subject and contrast was defined as freely movie viewing minus baseline. Group analysis of random effects were then conducted and areas of significant activation were identified for the false discovery rate (FDR) corrected P value smaller than 0.05 and cluster size larger than 30 voxels (2x2x2 mm³). A separate group of 12 subjects who did not participated fMRI scanning watched the cartoon movie and indicated their ratings of perceived intensity of motion. The mean subjective ratings of motion perception were entered into SPM regression analysis and additional ROI analysis based on literature (4-6) defined middle temporal (MT) regions were performed to explore the associations between the CBF and BOLD activations in MT and the subjective motion perception.

Results Reliable quantitative CBF images were acquired for all subjects (Fig.1 shows a representative subject). Perfusion in all brain regions were visualized with good sensitivity and clear contrast between gray and white matters was observed in the perfusion intensity. Perfusion contrast revealed CBF increases in multiple visual pathway areas and frontal areas during freely movie viewing compared to resting states, while BOLD contrast revealed similar but less and weaker activations in the visual pathway areas and frontal areas (Fig.2). The results from the regression analyses of CBF and BOLD data (Fig.3) and the ROI analysis (Fig.4) consistently showed significant activations in the bilateral MT region correlated with subjects' perception of motion.

Discussion Consistent with earlier studies (2), our results suggested the greater sensitivity of perfusion fMRI than that of BOLD fMRI for imaging prolonged states when the task duration is longer than a few minutes. The present study demonstrates the feasibility and reliability of ASL perfusion fMRI for imaging brain activity during natural situations and supports the view of maintained functional segregation and specialization during natural vision (7).

References

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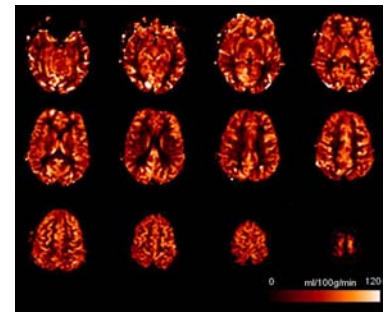


Fig.1. Quantitative CBF images from one representative subject.

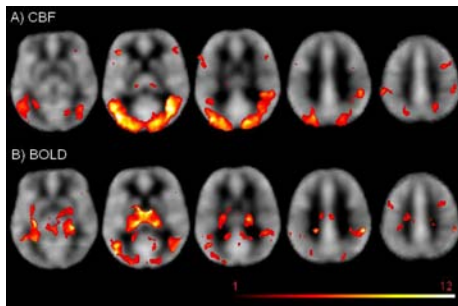


Fig.2. CBF and BOLD activations during freely viewing movie compared to baselines.

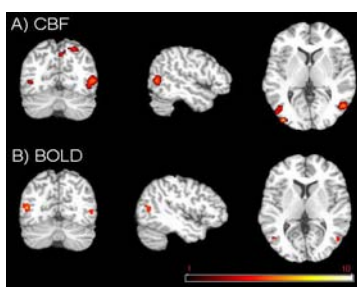


Fig.3. MT activations associated with motion perception.

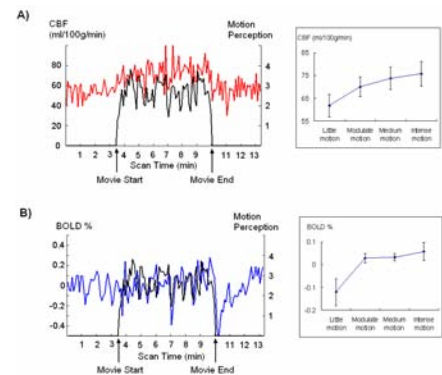


Fig.4. CBF and BOLD time courses in MT correlated with motion perception.