Resting brain networks revealed by independent component analysis of cerebral blood flow

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Introduction Resting fMRI data have revealed a number of reproducible networks with temporally correlated signal changes representing various cognitive functions, including the default mode network (DMN), sensorimotor network, visual network, attention network, and auditory network (1-2). Most resting-state fMRI is based on BOLD contrast, which measures brain function through susceptibility effects of deoxyhemoglobin. Arterial spin labeling (ASL) perfusion MRI provides a direct measure of cerebral blood flow (CBF) (3), and has noise properties that are well suited to detecting low frequency fluctuations that dominate resting state connectivity effects (4). However, few studies to date have examined CBF connectivity using ASL. Here we assessed resting brain function in a large sample of ASL CBF time series data using independent component analysis (ICA).

Methods Data from 149 healthy adults (age 20-52 years) scanned in a Siemens 3T Trio scanner at rest for 4-6 minutes (30-45 CBF volumes) using a pseudo-continuous ASL sequence were analyzed. A sub-group of subjects (n=81) also had a standard resting-state BOLD scan for 7 minutes (210 volumes). Functional image processing was carried out with SPM and the Grocer toolbox (5). CBF time series were reconstructed and entered into the Gift toolbox for group-ICA. Four ICA analyses were performed on the CBF dataset, including the whole group (CBF-149), two randomly split sub-groups (CBF-74 & CBF-75), and the BOLD sub-group (CBF-81). Twenty independent components (IC) were extracted from each of the CBF analyses. The same ICA analysis was performed on the BOLD time series (BOLD-81) and 25 ICs were extracted.

Results ICA analysis of the BOLD data clearly identified 11 resting-state networks (Fig.1 right), including the DMN (RSN1), the left and right attention networks (RSN2 & 3), the primary and second visual networks (RSN4 & 5), the auditory network (RSN6), the ventral and dorsal medial prefrontal networks (RSN7 & 8), two limbic networks (RSN9 & 10), and the sensorimotor network (RSN11). The four ICA analyses of CBF dataset replicated all of the BOLD networks except for the sensorimotor network, which may due to the reduced coverage of ASL imaging on the top of the brain.

Conclusions The CBF-based ICA results replicated most BOLD resting-state networks that have been consistently reported in the literature (1-2), despite the reduced number of CBF time points analyzed. These findings suggest that BOLD signal fluctuation is mainly driven by CBF changes, and that CBF may be more sensitive than BOLD contrast for detecting resting brain networks.

References

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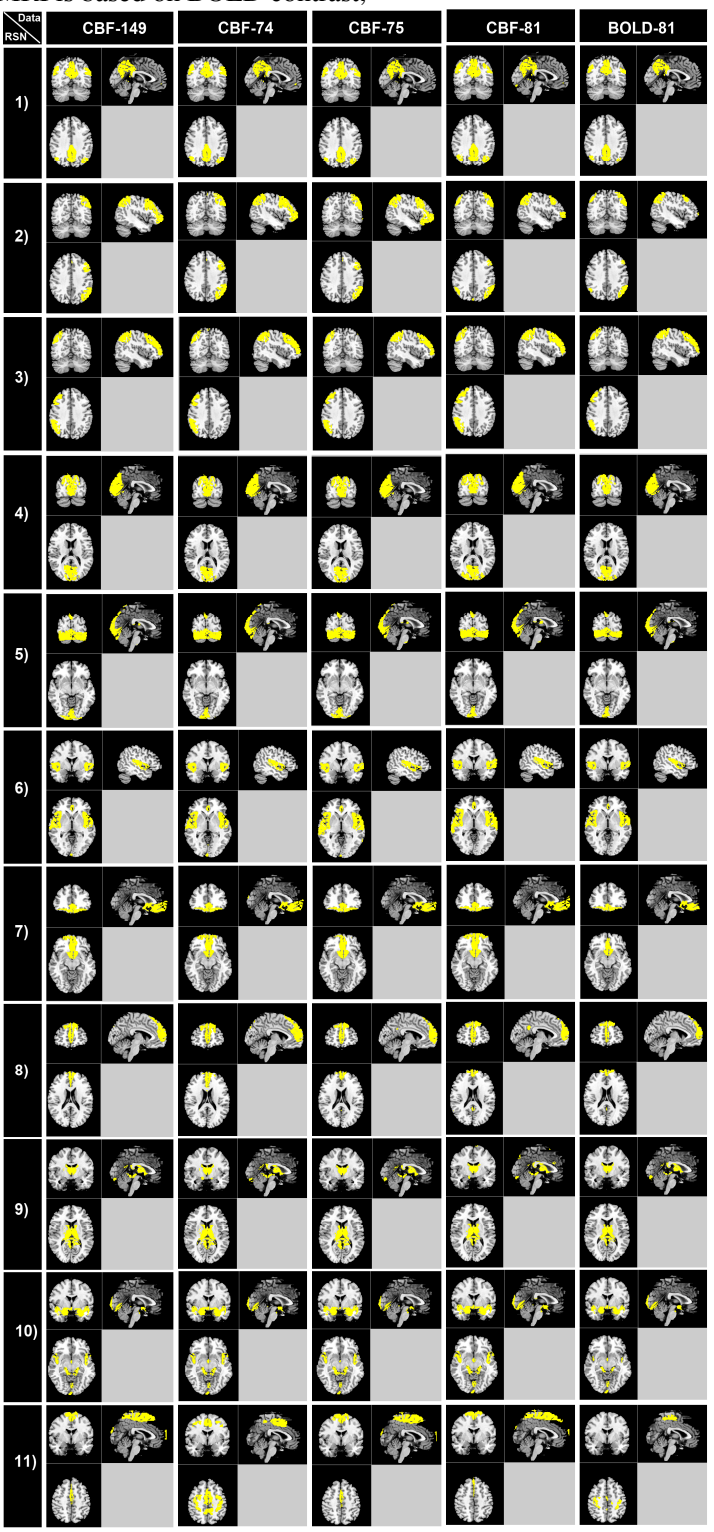

Fig. 1 CBF and BOLD resting state networks (RSNs)