

Uncovering a visuospatial network at rest.

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Introduction

The posterior cingulate cortex (PCC) is a crucial region for visuospatial memory and is one of the main connector hubs in the brain, playing a pivotal role in the coordination of information flow [1]. With fMRI, the PCC can be reliably activated using the Roland Hometown Walking Task (RHWT) [2], [3]. Other sites are also routinely activated during RHWT, namely those within bilateral parahippocampal gyrus (PH), middle occipital gyrus (MOG), BA29/30 (PCC), precuneus (BA7) and middle frontal gyrus (BA6). This is referred to as a “visuospatial” network (VSN) [2] and is very useful for pre-surgical mapping given its widespread activation profile. However, eliciting the VSN depends on the subject’s participation which can be difficult in patient populations. Our goal was thus two-fold: (1) To investigate whether resting-state (RS) fMRI can be used to recover the VSN and (2) identify which of the 5 bilateral sites acts as the main connector hub.

Methods

We recorded fMRI data while participants (N = 18) performed the Roland’s imagery task (Task-fMRI, 5 min 30 sec) and rested quietly (RS-fMRI, 3 min) using a standard acquisition protocol [4]. Post-processing (slice timing and motion correction, spatial and temporal filtering, detrending) were performed using AFNI [5] and FSL [6]. Next, using the Task-fMRI dataset, we isolated 5 bilateral activation clusters (10 in total) in each subject (PH, PCC, MOG, BA7, and BA6) as seen in Fig. 1. These sites then acted as seed regions to compute temporal correlations with all other voxels of the brain in the RS-fMRI data by the means of a novel in-house real-time interactive 3D tool (Fig. 2). The resulting correlation values were converted to Z-scores and only those exceeding a value of 2 ($p < 0.05$) were considered. These correlation maps were then co-registered to the ICBM template [7] and overlaid on the mean task-activation map. Significant voxels within or nearby a task-cluster (size > 35 voxels, distance < 3 mm) were marked as “co-activated” and then modeled using a graph approach. Nodes of the graph corresponded to the 10 sites and their edges (FC) were proportional to the number of subjects showing a link

between two regions. A sensitivity metric expressing the recovery rate (r) was then derived for each pair of nodes (left/right) which consists in the sum of co-activated sites over the total number of possible activations (9 sites x 18 subjects x 2 bilateral sides).

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Results

Temporal correlations of all the nodes provided qualitatively significant RS-networks (RSNs), which comprised the desired RHWT sub-regions. The PCC showed the highest efferent activations ($r = 61\%$) by mostly being involved in the recovery of the MOG, BA7 and PH ($r = 76\%$, 64% and 58% respectively). Overall, bilateral activations showed the strongest presence intra-subject (L-PCC \leftrightarrow R-PCC: $83\% \leftrightarrow 94\%$, L-MOG \leftrightarrow R-MOG: $83\% \leftrightarrow 72\%$, L-PH \leftrightarrow R-PH: $78\% \leftrightarrow 72\%$, L-BA7 \leftrightarrow R-BA7: $83\% \leftrightarrow 83\%$, L-BA6 \leftrightarrow R-BA6: $72\% \leftrightarrow 89\%$).

Conclusions

Our experiment showed that the Roland's network can be found at rest, when combining multiple sub-parts of well-known underlying RSNs. Our results are in great coherence with the authors of [1], who demonstrated that the PCC is a crucial node which acts as a central hub. Our findings also suggest that when using a seed-based approach to recover a specific site at rest, choosing the contra lateral region yields best results. If not available, then the closest functionally / anatomically regions should be favored, and finally, linked regions located at a larger distance. Taken together, we believe that these findings will help identifying sub-regional networks, especially combined with other modalities such as Task-fMRI and High Angular Resolution Diffusion Imaging (HARDI) techniques.

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Figure 2

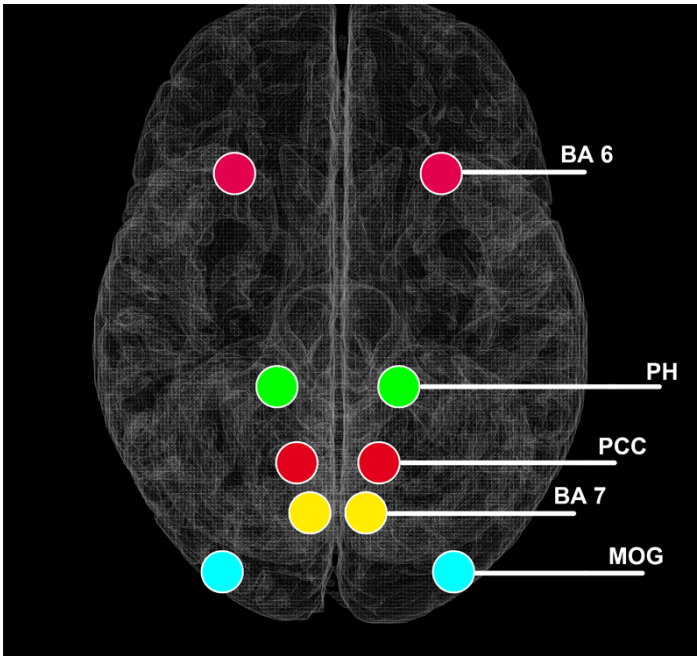


Figure 1

