

Multimodal evidence of a rostro-caudal and ventro-dorsal organization in the dorsal premotor cortex

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Introduction:

Different methods for in-vivo characterization have resulted in different maps of the human dorsal premotor cortex (PMd): Task-based

functional studies suggested a rostro-caudal gradient corresponding to a cognitive-motor gradient [1,2] and mapping based on resting-state functional connectivity (RSFC) likewise suggested a subdivision along the rostro-caudal axis [3]. In contrast, mapping based on structural connectivity as assessed by probabilistic diffusion tractography (PDT) provided evidence that the dorsal part of the precentral gyrus (PG) is organized along a ventro-dorsal axis [4]. However, there is currently no multimodal mapping of a broadly defined PMd. The present study used a multimodal approach to (1) identify a robust topographical organization of the right PMd by using connectivity-based parcellation (CBP) applied to a meta-analytic approach of task-related coactivation data (i.e. meta-analytic connectivity modeling, MACM[5,6]), and (2) examine whether the thus obtained parcellation pattern would be reproduced by CBP based on two other connectivity modalities: unconstrained functional (as reflected by RSFC) and structural as measured by PDT based on diffusion-weighted imaging (DWI).

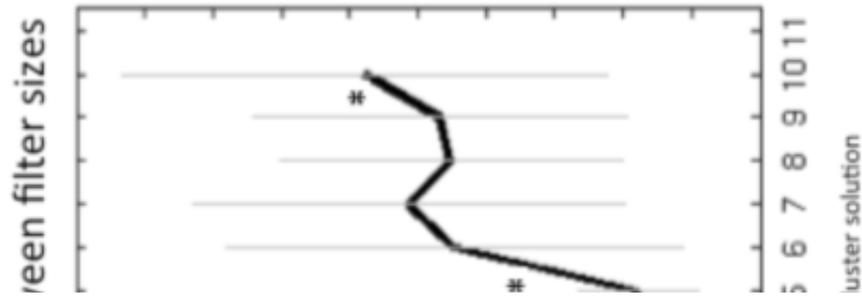
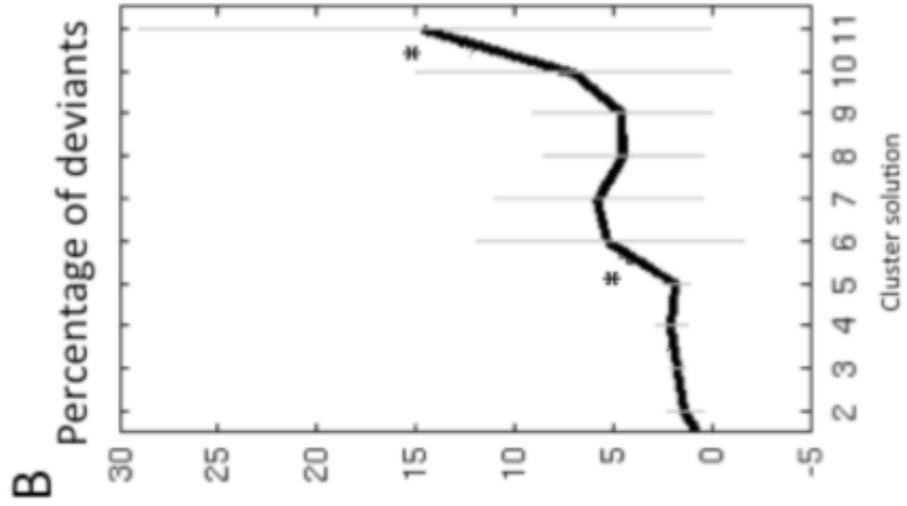
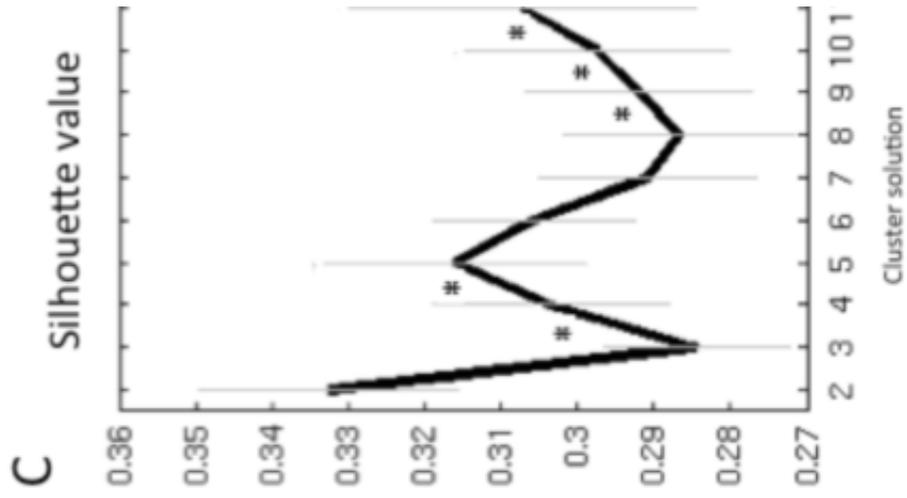
Methods:

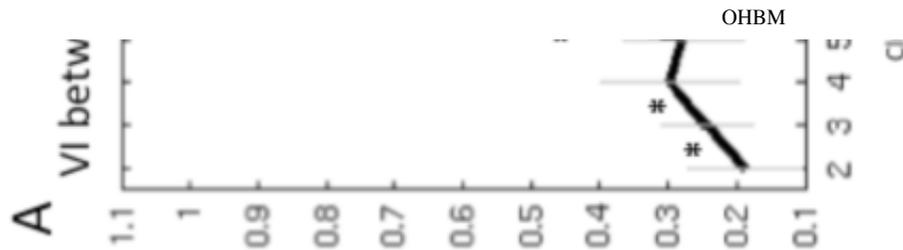
A volume of interest (VOI) was defined by merging PMd activation sites from several meta-analyses serving as robust functional localizers of the PMd while excluding primary sensorimotor areas. MACM-CBP [6] was performed using Brainmap database. RSFC-CBP and PDT-CBP were performed on distinct datasets to ensure independent parcellation [7]. RSFC-CBP was computed on RS data of 124 healthy subjects (age: 39.5 ± 11.5 yrs., 66 males) from the 1000BRAINS project [8]. The voxels' time series (TS) were first cleaned from confounding effects using PCA denoising and global signal regression. RSFC was then computed by Pearson correlations between the TS of the VOI voxels and those of the rest of the brain. PDT-CBP [9] was performed on DWI data of 20 healthy subjects (age: $18.5 \pm .76$, 10 males) using FSL. Several cluster solutions (k solutions) were examined with k-means for MACM- and RSFC-CBP and spectral clustering for PDT-CBP. The choice of the k solution was driven by task-based functional data (MACM) based on three criteria: variation of information, percentage of deviants, and silhouette value[6].

Results:

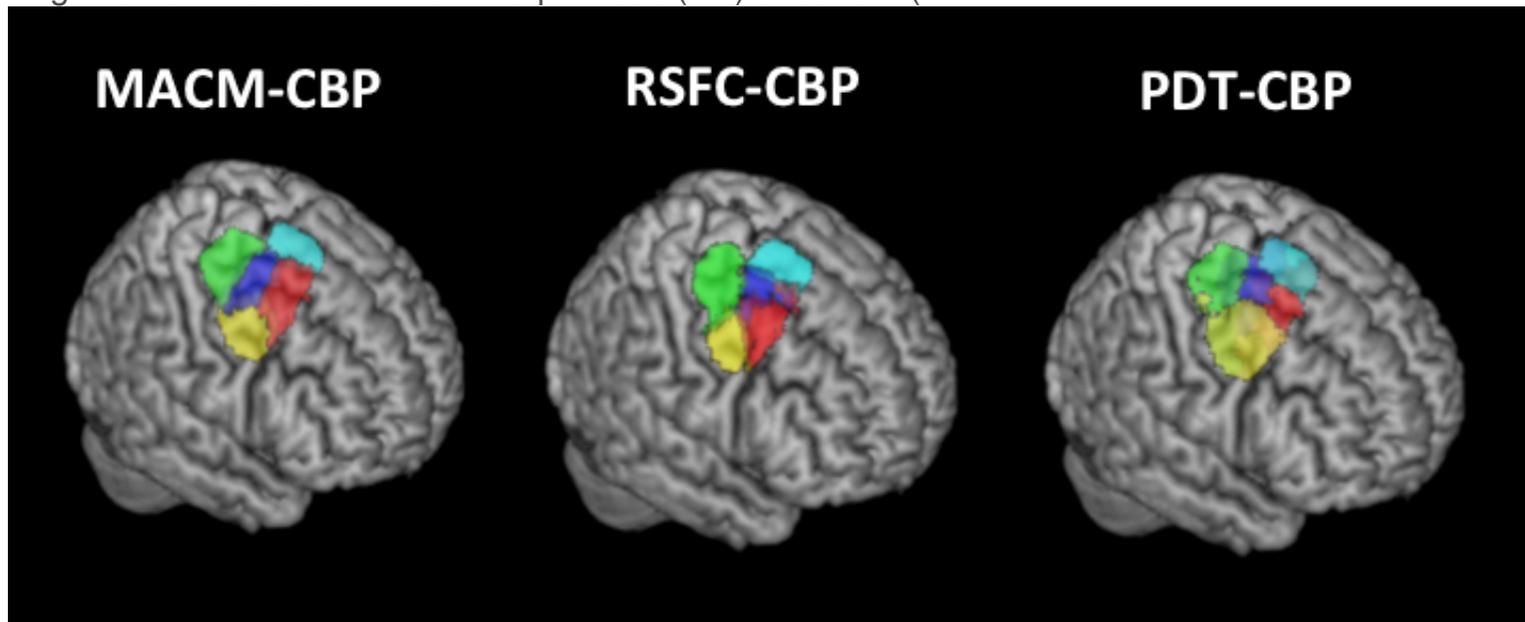
The selected criteria jointly identified the 5-cluster (5k) solution as optimal across the range of functional studies from Brainmap database (Figure 1). Examination of stability across subjects following PDT-CBP further suggested that $k=5$ may be considered a local optimum within $2 \leq k \leq 6$. This solution revealed a similar pattern of topographical organization across modalities (Figure 2) with a subdivision along both rostro-caudal and ventro-dorsal axes, including a rostral cluster lying mainly anteriorly to the PG, a central one at the intersection of the precentral sulcus and the superior frontal gyrus, a caudal one in the posterior part of the PG, a ventral one adjacent to ventral PM, and a dorsal one adjacent to the inter-hemispheric premotor areas.







·Figure 1. MACM-CBP: cluster solution criteria. (A) Variation of Information (VI) between filter sizes across the 10 cluster solutions; *Significant increase in VI from the previous (k-1) to current (



·Figure 2. Rendering of the 5k solution yielded by different CBP modalities in the right PMd.

Conclusions:

For the first time our study revealed that the PMd could be divided along two axes: rostro-caudal and ventro-dorsal. This is consistent with previous functional [2] and microstructure studies [10] in humans and non-human primates suggesting a rostro-caudal distinction and with a previous PDT-CBP of the (dorsal) precentral gyrus [4] showing that it could be subdivided in the ventro-dorsal direction.

Importantly, this topographical organization was found in the independent analysis of three different connectivity aspects: task functional, unconstrained functional and structural, each based on different datasets. In sum, different modalities consistently show that the PMd can be subdivided into 5 subregions organized along both rostro-caudal and ventro-dorsal axes, comprehensively integrating patterns previously revealed by different methods.

Imaging Methods:

Multi-Modal Imaging ²

Modeling and Analysis Methods:

fMRI Connectivity and Network Modeling
Segmentation and Parcellation ¹

Neuroanatomy:

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Keywords:

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SPM
FSL

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