Examining the right dorsal premotor mosaic: a connectivity-based parcellation approach.

Submission Number:

1142

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Introduction:

A wide range of motor and non-motor functions has been assigned to the dorsal premotor cortex (dPM) leading to an inconsistent and vague functional definition1. In addition, the frontal eye field (FEF) has been frequently assigned to the dPM but its location varies across studies. It may be assumed that such inconsistency actually reflects a functional mosaic formed by several distinct modules within this region. The present study therefore aimed to characterize this mosaic within the right dPM (r-dPM) regarding structural, functional, and connectivity aspects by combining coactivation-based parcellation (CBP), resting-state (RSC) and meta-analytic (MACM) connectivity analysis including functional decoding.

Methods:

A volume of interest (VOI) corresponding to the r-dPM was defined based on a series of meta-analytic findings2,3,4,5,6. Whole-brain coactivation patterns for each voxel within this VOI were computed by activation likelihood estimation (ALE) meta-analysis over all experiments in the BrainMap database activating this location. Based on those coactivation patterns, CBP7 was performed using k-means clustering (i.e. non-hierarchical clustering based on an iterative algorithm to divide a VOI into k non-overlapping clusters8), with k varying from 2 to 11. Next, the most stable k clustering solution was determined by means of topological, cluster separation, and information-theoretic criteria. MACM (performed on BrainMap) and RSC modeling (performed on the 132 healthy subjects from the NKI "Rockland" sample) were then combined to examine the derived clusters' brain-wide functional connectivity. Finally, meta-data profiling allowed their functional characterization by using forward and reverse inferences on Behavioral Domain and Paradigm Class associations in BrainMap.

Results:

CBP within the r-dPM identified a five clusters solution (Fig. 1) comprising a rostral (C1), a caudal (C2), a central (C3), a ventral (C4) and a dorsal cluster (C5) as the most stable solution. A conjunction of each cluster's RSC and MACM results relative to the remaining clusters revealed that C1 was specifically connected to the bilateral inferior parietal cortex, lateral and dorsomedial prefrontal cortex (PFC) and precuneus, C2 to bilateral M1, SMA, left cerebellum and right rolandic operculum, C3 to bilateral IPS, while C4 was specifically connected to the right posterior superior temporal sulcus (Fig. 2). In turn, C5 had no specific connectivity profile common to resting state and task processing. The functional characterization furthermore revealed an association of C1 with working memory and attentional tasks, of C2 with tasks related to action execution, of C3 with both action execution and visual attention tasks, of C4 with visual attention tasks and C5 with action execution, in particular hand-related action, music-related and language-related tasks.

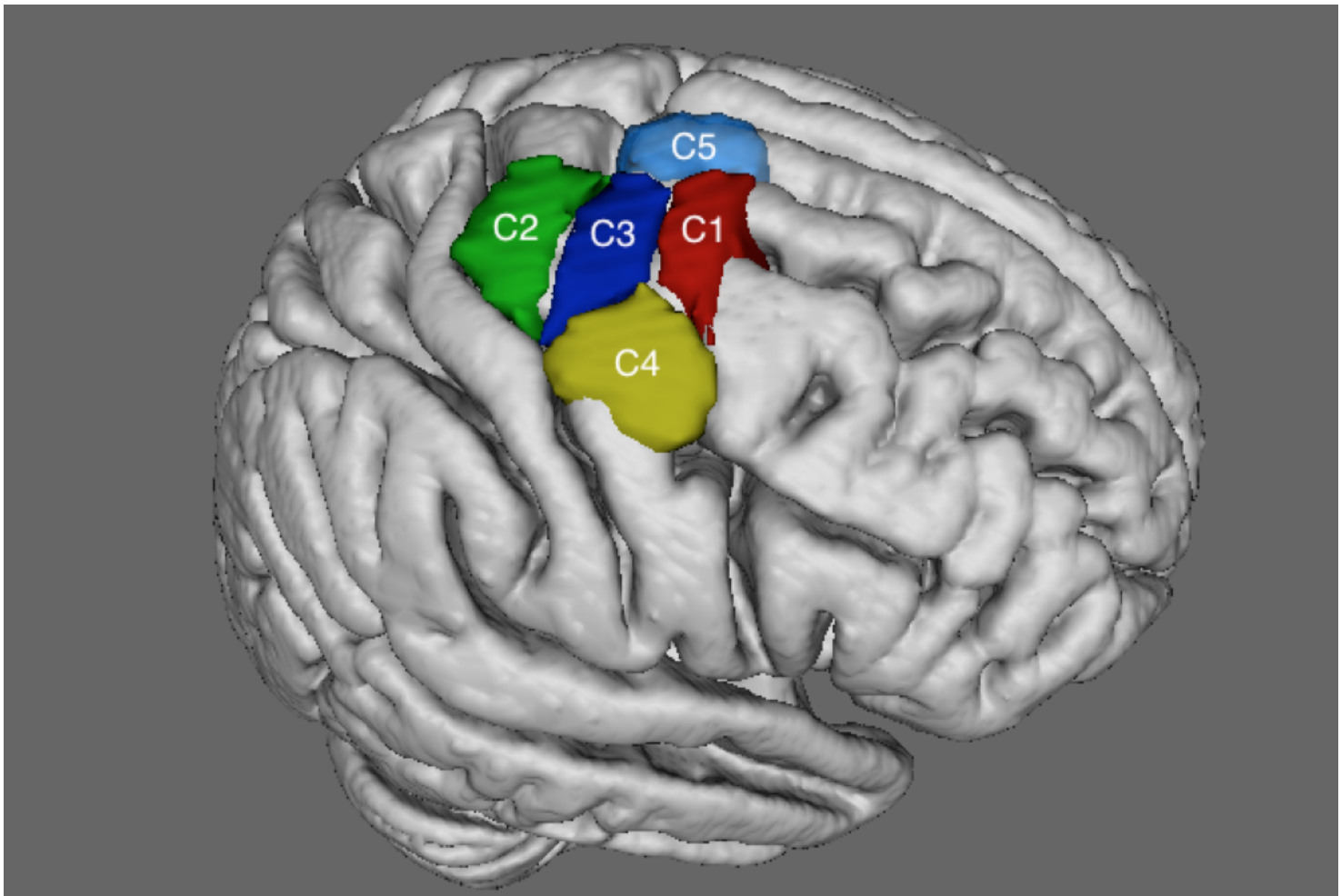
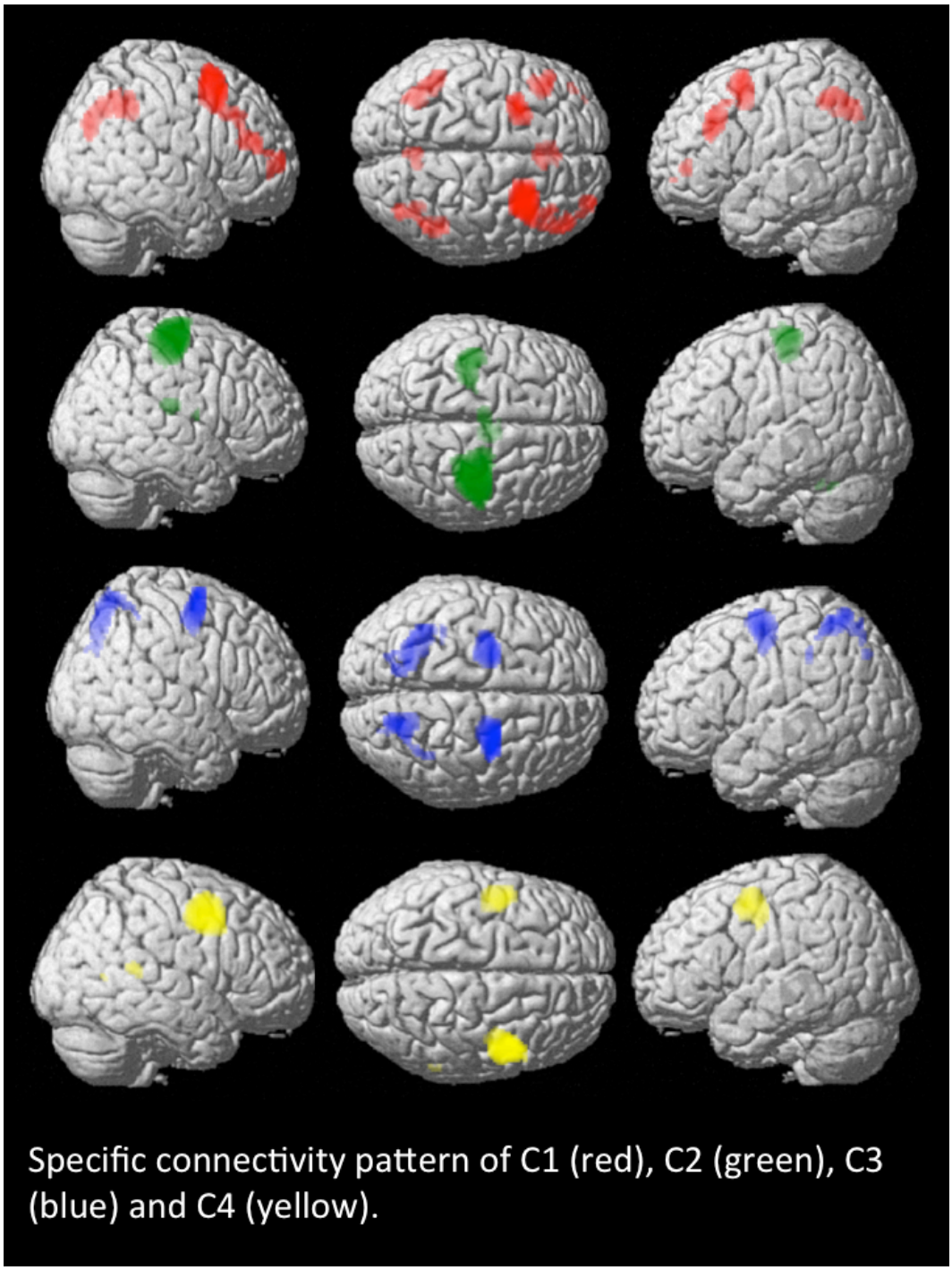


Figure 1. Co-activation-based parcellation of the right dorsal premotor cortex.



Conclusions:

CBP showed that the r-dPM may be divided into 5 distinct clusters highlighting a cognitive-motor gradient along the rostro-caudal axis according to which the rostral part (C1) is functionally closely interacting with the PFC in supporting high-level cognitive processes whereas the caudal part (C2) is more related to motor regions and functions. Our findings also revealed a highly "eye-related" ventral cluster (C4) which may correspond to the "true" FEF and a dorsal cluster (C5) which is preferentially hand-related and associated with tasks characterized by sequence comprehension. Finally, our analysis revealed a central cluster (C3), which may integrate all aspects in a visuo-motor coordination function. Thus, our findings show that the r-dPM can be separated into functionally meaningful mosaic pieces based on distinct connectivity profiles. Furthermore, the right FEF may not be a homogenous region, as we distinguished one cluster (C3) supporting visuo-motor coordination and a more ventral cluster (C4) supporting eye movements/visual attention orientation per se.

Neuroanatomy:

Anatomy and Function

Reference

1) Rizzolatti, R., et al. (2001). 'The cortical motor system'. Neuron, vol. 31, pp. 889-901.
2) Hardwick, R.M., et al. (2013). 'A quantitative meta-analysis and review of motor learning in the human brain'. NeuroImage, vol. 67, pp. 283-297.
3) Caspers, S., et al. (2010). 'ALE meta-analysis of action observation and imitation in the human brain'. NeuroImage, vol. 50, pp. 1148-1167.
4) Grosbras, MH., et al. (2012). 'Brain regions involved in human movement perception: a quantitative voxel-based meta-analysis'. Human Brain Mapping, vol. 33, pp. 431-454.
5) Langner, R., et al. (2013). 'Sustaining attention to simple tasks: a meta-analytic review of the neural mechanisms of vigilant attention'. Psychological Bulletin, vol. 139, no. 4, pp. 870-900.

6) Rottschy, C., et al. (2012). 'Modelling neural correlates of working memory: a coordinates-based meta-analysis.' NeuroImage, vol. 60, no. 1, pp. 830-846.
7) Eickhoff, S.B., et al. (2010). 'Anatomical and functional connectivity of cytoarchitectonic areas within the human parietal operculum.' The Journal of Neuroscience, vol. 30 no.18, pp. 6409-6421.
8) Hartigan, J.A., et al. (1979). 'A k-means clustering algorithm.' Journal of Applied Statistics, vol. 28, pp. 100-108.