Gradients go to the movies: Macroscale cortical organization during naturalistic viewing

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BACKGROUND

- Applying dimension-reduction techniques has revealed underlying principles of functional organization by identifying functional connectivity (FC) components (i.e., gradients)[1].
- These FC gradients are phylogenetically conserved[1,2] and are now being used to study brain disorders[3,4], and to query state-based differences in FC patterns[5].
- Another rapidly advancing area of research is the use of naturalistic conditions such as movie-watching to study brain function under more ecologically valid conditions[6].
- Here, we ask if the principles of macroscale cortical organization, captured by FC gradients, are the same during movie and rest.

METHODS

Dataset
- Human Connectome Project (HCP) 7T release[7]
- N=95, 58 females, mean age 29.5±3.3

Functional runs
- 7T, TR=1000ms, TE=22.2ms, 1.6mm isotropic voxels
- 4 Rest runs, 15 min each, eyes open
- 4 Movie runs, roughly 15 min each, 4-5 movie clips per run
- Runs within each condition were concatenated

Behavioural data
- Cognitive, emotion and motor domains
- PCA, first component (PC1) of each domain

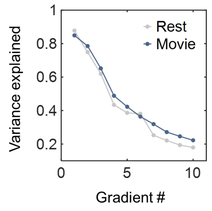
Gradient analyses
- Inputs: group- and individual-level FC matrices (Schaefer-1000 parcellation[8])
- BrainSpace toolbox[9]
- Cosine similarity, diffusion embedding
- Group-level gradients were sign-flipped
- Individual-level gradients were aligned to group template

Prediction of behaviour
- Brain: Rest gradients vs. Movie gradients
- Behaviour: cognitive PC1, emotion PC1 and motor PC1
- Penalized regression
- 10-fold (9 training, 1 testing), siblings constrained to same fold, 100 iterations

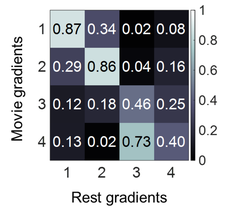
RESULTS

Figure 1. Gradient topography

1A. Variance explained by top gradients



1B. Cross-condition correlations



1C. Gradient scores projected on cortical surface

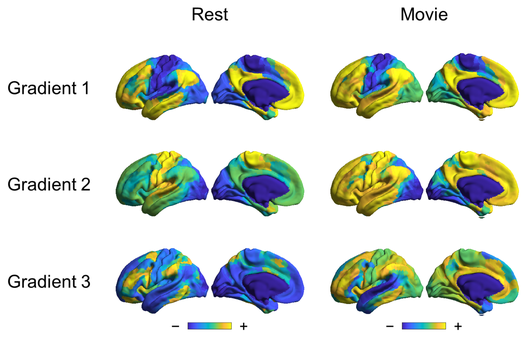
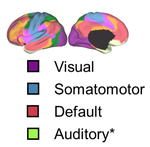
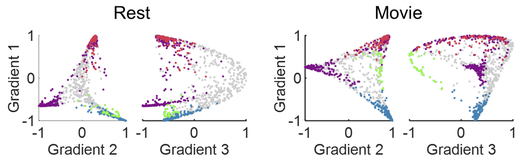


Figure 2. Gradient space

2A. Gradient space color-coded by canonical networks. Scatterplots of top gradients in Rest and Movie color-coded by parcel membership in Yeo networks. Auditory network: overlap of 10% of parcels with the lowest Movie gradient 3 scores and somatomotor network.





2B. Hierarchical gradients. Scatterplots of top 3 gradients in Rest and Movie. Rest gradient 1 captures a unimodal-to-heteromodal functional hierarchy. Top 3 Movie gradients are modality-specific hierarchical gradients. A1, primary auditory; DN, default network; M1, primary motor; S1, primary somatosensory; V1, primary visual.

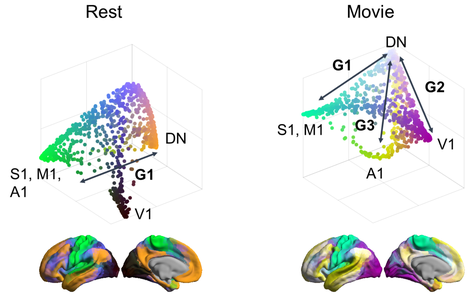
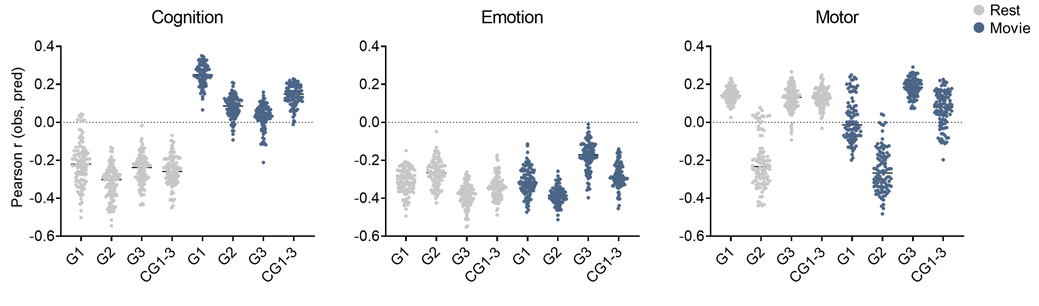


Figure 3. Predictive modelling.

Movie vs. Rest for gradient-based prediction of cognitive, emotion and motor behavioral scores. CG1-3, combined gradients 1-3; G1, gradient 1; G2, gradient 2; G3, gradient 3.



CONCLUSIONS

- Movie-watching data underscore the hierarchical organization of the brain observed in resting state.
- Movie-watching reveals 3 unique modality-specific hierarchical gradients.
- Movie gradients appear to outperform Rest gradients when predicting cognitive scores.
- These modality-specific hierarchical gradients might provide a unique tool for biomarker research in neuropsychiatry.

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