Anterior-posterior shift of hippocampus structural covariance across development: a multicohort study

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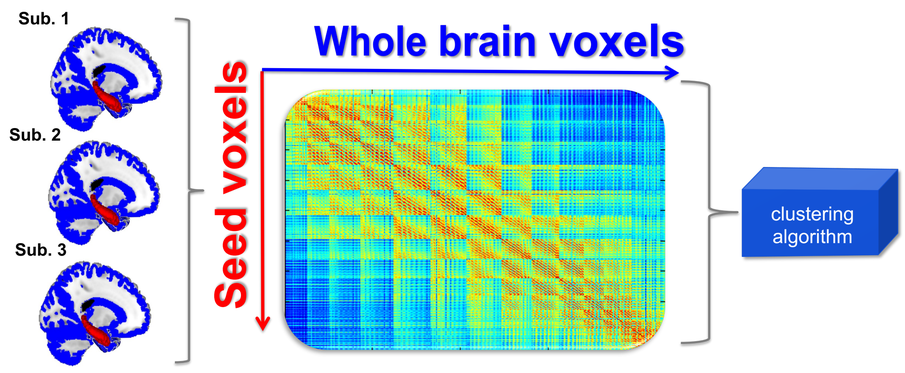
Introduction

- Hippocampal-cortical networks play an important role in neurocognitive development during childhood and adolescence
- Co-maturational processes between the hippocampus and the whole brain are reflected in structural covariance (SC) networks
- We applied a connectivity-based parcellation (CBP) approach to hippocampal-cortical grey matter covariance data to identify a topological organization within the hippocampus across cohorts

Methods

- Hippocampus **VOI**  from SPM Anatomy Toolbox & Harvard-Oxford Atlas
- **SC**: proxy for co-maturation and co-plasticity, Voxel Based Morphometry (VBM) for grey matter probabilities modulated for non-linear transformations only
- SC-CBP performed on structural T1-weighted MRI data in age groups of late childhood (6-10 years, n = 316), early adolescence (11-14 years, n = 328), and middle adolescence (15-18 years, n = 361)

SC-CBP



Clustering:

- k-means for k=2-7, 500 repetitions, 255 iterations

Optimal hippocampal differentiation patterns:

- by assessing stability with split-half cross-validation (10,000 splits) using the adjusted Rand Index (aRI), and silhouette values

Statistics:

- Analysis of Variance (ANOVA) performed on split-half-, bootstrap samples and silhouette values

SC- networks and behavioral profiling:

- Computing voxel-wise GLM analysis for each identified hippocampal subregion to elucidate which SC patterns (uncorrected, T =1) drove the clustering for each age group
- obtained SC networks were then characterized using NeuroSynth decoding for unthresholded maps (considering correlation with meta-analytic maps of r ≥ 0.1)

Results

Optimal differentiation patterns

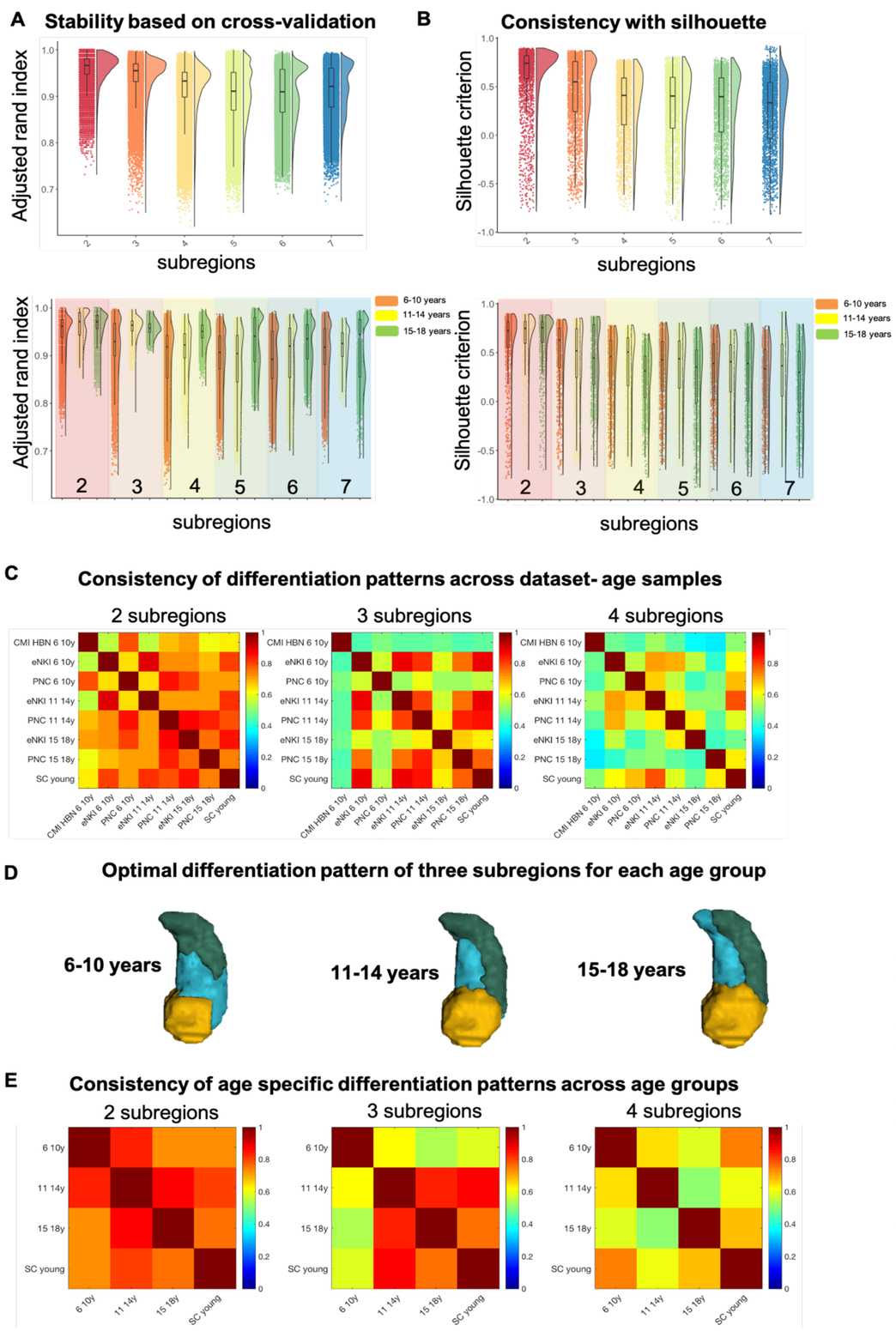


Figure 1. Stability and consistency of differentiation patterns measured with the aRI or the silhouette scores.

Associated SC-networks and their behavioral profiles

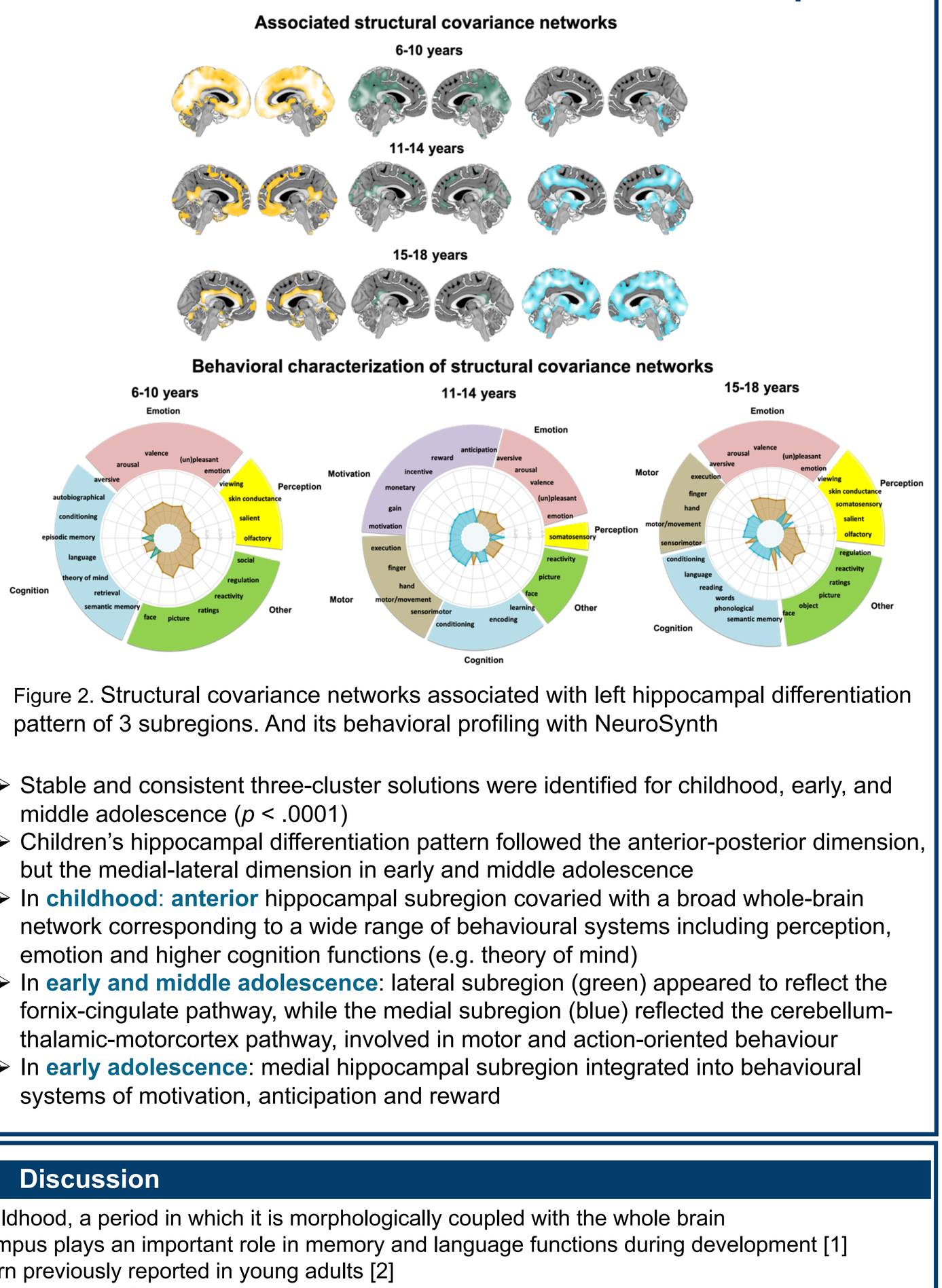


Figure 2. Structural covariance networks associated with left hippocampal differentiation pattern of 3 subregions. And its behavioral profiling with NeuroSynth

- Stable and consistent three-cluster solutions were identified for childhood, early, and middle adolescence ($p < .0001$)
- Children's hippocampal differentiation pattern followed the anterior-posterior dimension, but the medial-lateral dimension in early and middle adolescence
- In **childhood**: **anterior** hippocampal subregion covaried with a broad whole-brain network corresponding to a wide range of behavioural systems including perception, emotion and higher cognition functions (e.g. theory of mind)
- In **early and middle adolescence**: lateral subregion (green) appeared to reflect the fornix-cingulate pathway, while the medial subregion (blue) reflected the cerebellum-thalamic-motorcortex pathway, involved in motor and action-oriented behaviour
- In **early adolescence**: medial hippocampal subregion integrated into behavioural systems of motivation, anticipation and reward

Discussion

- Our findings stress the importance of the anterior hippocampus in late childhood, a period in which it is morphologically coupled with the whole brain
- These results are in line with previous evidence that the anterior hippocampus plays an important role in memory and language functions during development [1]
- The SC-hippocampus in adolescence approaches the hippocampal pattern previously reported in young adults [2]
- The co-plasticity of the medial subregion (~ posterior hippocampus) plays a core role [3] in hippocampus' functional integration in adolescence, being involved in action-oriented and motivational reward system [4,5]

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Acknowledgments: This study was supported by the Deutsche Forschungsgemeinschaft (DFG, GE 2835/1-1, EI 816/4-1), the National Institute of Mental Health (R01-MH074457), the Helmholtz Portfolio Theme 'Supercomputing and Modeling for the Human Brain', and the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 720270 (HBP SGA1) and No. 785907 (HBP SGA2).