Graph theoretical investigation of memory and attention networks in the brain

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Introduction

- Memory in adults and children relies on a distributed network of regions in the brain, including the hippocampus[1, 2].
- Recent research has suggested that prefrontal regions, included within the frontoparietal attention network, are also important for the development of memory[3].
- *Interactive specialization*[4] suggests that brain and cognitive development occurs through increased integration and segregation of brain networks.
- The present study uses graph theoretical analysis to:
  - Investigate *integration* and *segregation* of the episodic memory and frontoparietal networks in children and adults.
  - Investigate associations between *integration* and *segregation* and *memory performance* in children.

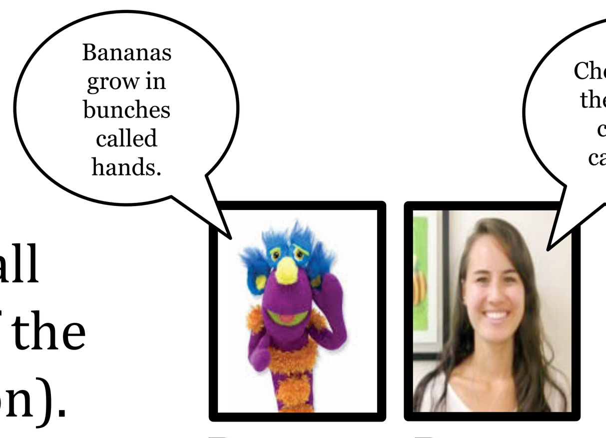
Methods

Participants

- 137 children aged 4-8 years (M= 6.50, SD = 1.48 years) and 30 adults (M=24.5, SD =5.3 years) are included the study.

Behavioral Data

- Children completed a Source Memory Task[5] where they had to recall facts and the source of the facts (puppet vs. person).

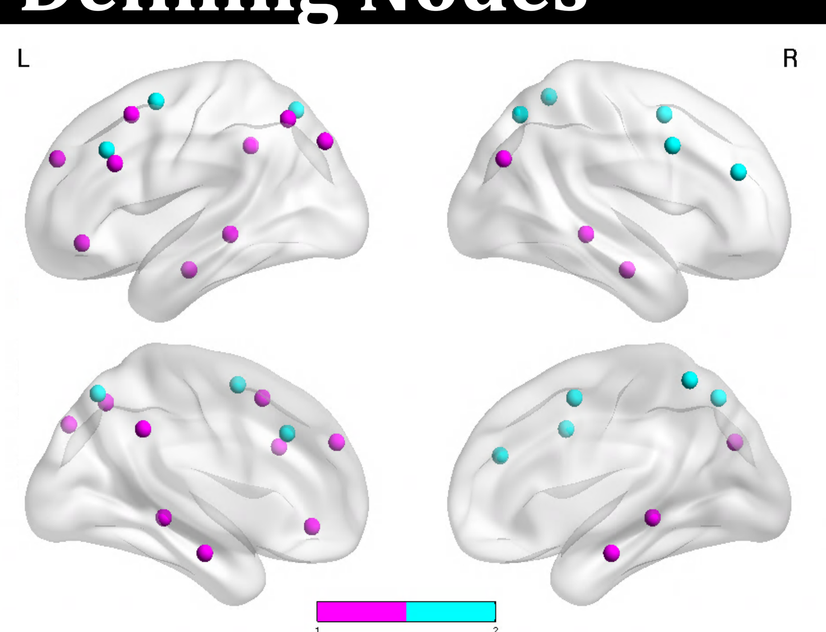


MRI Data

- T1-weighted high resolution (1mm^3) anatomical images were acquired from a Siemens 3T scanner with a 32-channel coil using a standard structural scan sequence.
- Task-free functional data was collected via a 7 min fMRI scan during which participants viewed *Inscapes*, a video of abstract shapes[6].

Methods: Defining Nodes

- Episodic memory and frontoparietal nodes were defined on an MNI child template using peak coordinates from meta-analyses in *Neurosynth*.

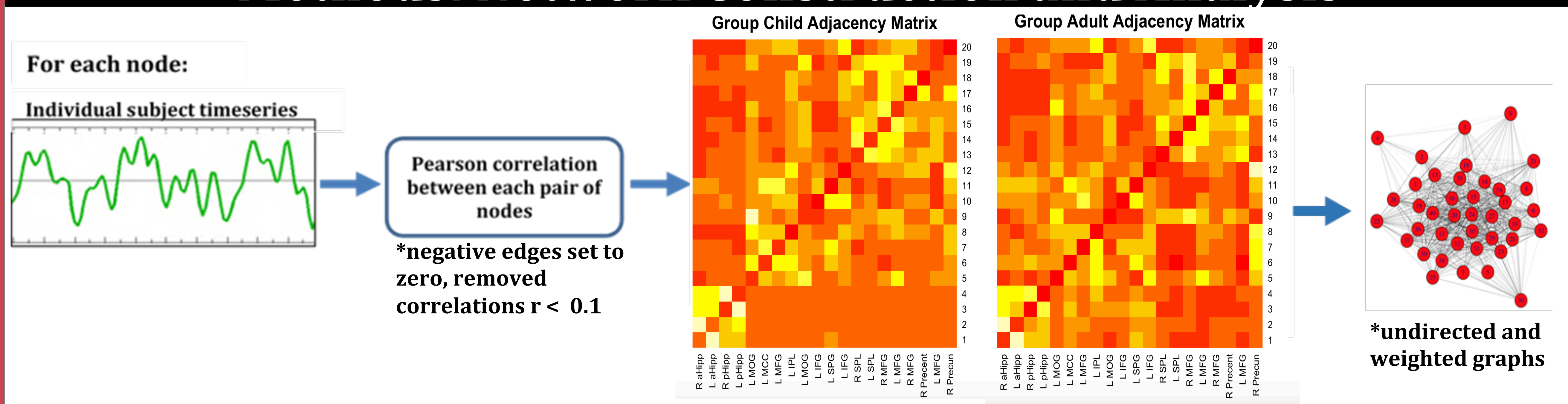


- Regions were defined using a 5mm sphere.

Node	MNI Coordinates			
	x	y	x	Community
L Anterior Hippocampus	-24	-14	-20	EMN
R Anterior Hippocampus	24	14	20	EMN
L Posterior Hippocampus	-26	-34	-4	EMN
R Posterior Hippocampus	26	-34	-4	EMN
L Middle Occipital Gyrus	-32	-80	38	EMN
L Middle Cingulate Cortex	-8	-44	36	EMN
L Middle Frontal Gyrus	-38	14	50	EMN
L Inferior Parietal Lobule	-38	-62	48	EMN
R Middle Occipital Gyrus	42	-74	30	EMN
L Inferior Frontal Gyrus (orbitalis)	-38	38	-8	EMN
L Superior Frontal Gyrus	-16	50	30	EMN
L Inferior Frontal Gyrus (triangularis)	-48	22	28	EMN
R Superior Parietal Lobule	18	-66	50	FPN
L Superior Parietal Lobule	-14	-66	52	FPN
R Middle Frontal Gyrus	26	4	50	FPN
L Middle Frontal Gyrus	-28	2	56	FPN
R Middle Frontal Gyrus	44	40	24	FPN
R Precentral Gyrus	46	8	36	FPN
L Middle Frontal Gyrus	-44	26	34	FPN
R Precuneus	4	-52	58	FPN

Note: L = Left; R = Right; EM = Episodic Memory Network; FPN=Frontoparietal Network

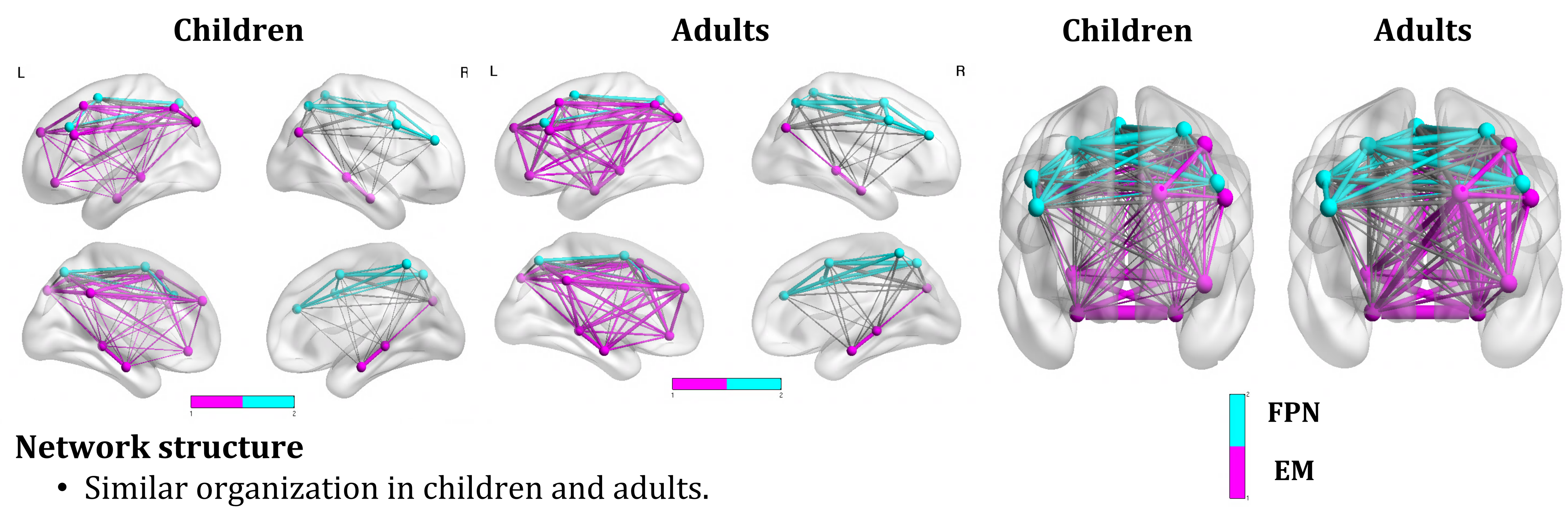
Methods: Network Construction and Analysis



- **Metrics of interest**: metrics were used to assess integration and segregation at network and node level (R/L anterior/posterior hippocampus)

	Network Level	Node Level
Integration	Global efficiency (E_{glob})	Within-module degree (Z)
Segregation	Modularity (Q)	Participation coefficient (P)

Results



Network structure

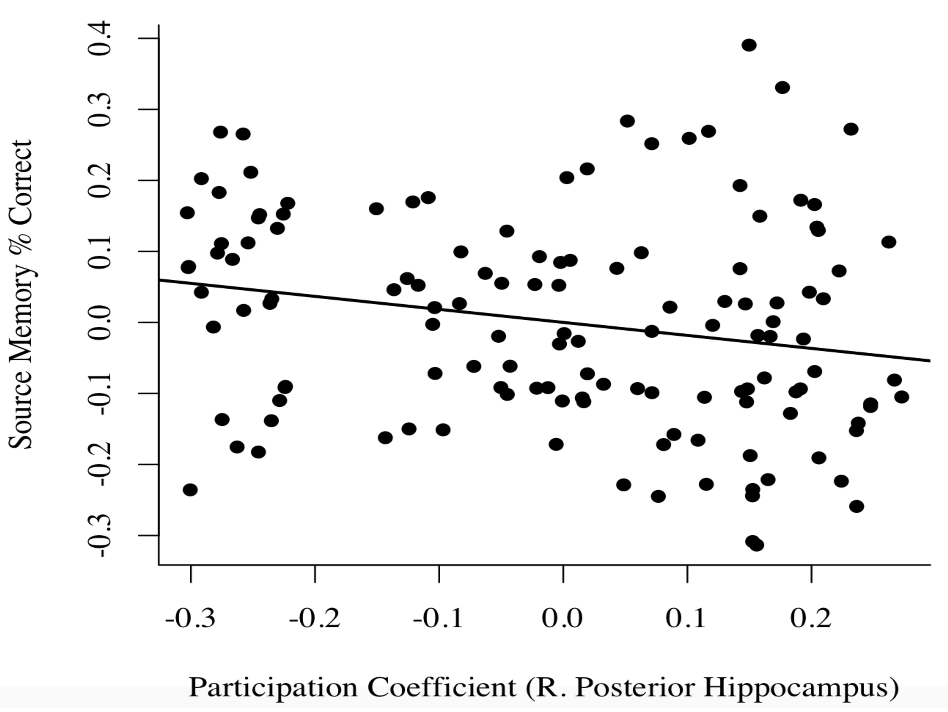
- Similar organization in children and adults.
- Strength of associations is stronger in adults.

Network level integration & segregation

- Global efficiency is significantly higher in adults (M= 0.16, SD=0.02) than in children (M=0.13, SD=0.02, $t(165)$ = 7.85, p <.001).
- Modularity does not significantly differ between adults (M= 0.07, SD=0.06) and children (M= 0.06, SD=0.07, $t(165)$=0.97, p = .33).

Node level integration & segregation

- Neither within-module degree nor participation coefficient differs with age in children.
- Participation coefficient associated with right posterior hippocampus is negatively associated with source memory performance (B = -.19, SE = 0.07, p =.01) after controlling for effects due to age and IQ.
- No association between within-module degree and memory performance.



Discussion

Results suggest:

- Similar network structure in children and adults.
- Increased integration, but not segregation, of the episodic memory network and the frontoparietal attention network in adults compared to children.
- Individual differences in segregation of the hippocampus from the frontoparietal network is related to performance on a source memory task in children.
  - This supports prior research that suggests kids who rely on regions within the episodic memory network perform better on memory tasks than kids who don't rely on such regions[7].

References

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