

# Network Curvature as a Hallmark of Brain Structural Connectivity

## SUPPLEMENTARY NOTES

### Supplementary Note 1

Nodes (cortical areas) with high curvature, strength and betweenness centrality from the high resolution (998 x 998) connectivity matrices from Hagmann et al. 2008 (PLoS Biology). The tables below list the top 25% of nodes appearing in 3 (or more) participants out of 5, with the highest curvature, strength and centrality. Cortical areas **only** found by curvature are highlighted in red.

Node Curvature	
High resolution matrices (Hagmann et al. 2008)	
Left Hemisphere	Right Hemisphere
Lateral orbito-frontal	
<b>Pars orbitalis</b>	<b>Pars orbitalis</b>
Pars triangularis	Pars triangularis
<b>Pars opercularis</b>	<b>Pars opercularis</b>
<b>Rostral middle-frontal</b>	<b>Rostral middle-frontal</b>
Superior frontal	Superior frontal
Caudal middle-frontal	Caudal middle-frontal
Precentral	Precentral
	Isthmus cingulate
Rostral anterior cingulate	
Caudal anterior cingulate	
Posterior cingulate	
Postcentral	
Superior parietal	Superior parietal
Inferior parietal	Inferior parietal
Precuneus	Precuneus
Cuneus	
Pericalcarine	
Lateral occipital	Lateral occipital
	Fusiform
<b>Lingual</b>	
Inferior temporal	<b>Inferior temporal</b>
Superior temporal	Superior temporal
	Transverse temporal

Node Betweenness Centrality	
High resolution matrices (Hagmann et al. 2008)	
Left Hemisphere	Right Hemisphere
Lateral orbito-frontal	Lateral orbito-frontal
Medial orbito-frontal	
Pars triangularis	Pars triangularis
Superior frontal	Superior frontal
Caudal middle-frontal	Caudal middle-frontal
Precentral	Precentral
Caudal anterior cingulate	Caudal anterior cingulate
Posterior cingulate	Posterior cingulate
Isthmus cingulate	
Postcentral	
Superior parietal	Superior parietal
Inferior parietal	
Precuneus	Precuneus
Cuneus	Cuneus
Pericalcarine	Pericalcarine
Lateral occipital	Lateral occipital
Superior temporal	
	Supra-marginal
	Inferior temporal
	Middle temporal
	Banks of sup. temporal sulcus

<b>Node Strength</b>	
High resolution matrices (Hagmann et al 2008)	
<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
Medial orbito-frontal	
Superior frontal	Superior frontal
Precentral	Precentral
	Paracentral
	Caudal anterior cingulate
Posterior cingulate	Posterior cingulate
Isthmus cingulate	Isthmus cingulate
Postcentral	Postcentral
Superior parietal	Superior parietal
Inferior parietal	Inferior parietal
Precuneus	Precuneus
Cuneus	Cuneus
Pericalcarine	Pericalcarine
Lateral occipital	Lateral occipital
Inferior temporal	
Middle temporal	Middle temporal
Banks of sup. temporal sulcus	Banks of sup. temporal sulcus
	Superior temporal
	Transverse temporal

## Supplementary Note 2

Nodes (cortical/sub-cortical areas) with high curvature, strength and betweenness centrality from the lower resolution (116 x 116) connectivity matrices generated from the MGH-USC HCP Consortium DSI datasets. The tables below list the top 25% of nodes appearing in 18 (or more) participants out of 33, with the highest curvature, strength and centrality. Cortical areas **only** found by curvature are highlighted in red.

Node Curvature Lower resolution matrices (MGH-USC HCP)	
Left Hemisphere	Right Hemisphere
Precentral	Precentral
Superior frontal	Superior frontal
Middle frontal	Middle frontal
<b>Pars opercularis</b>	<b>Pars opercularis</b>
Pars triangularis	Pars triangularis
	Supplementary motor area
Medial frontal	Medial frontal
<b>Heschl's gyrus</b>	<b>Heschl's gyrus</b>
	Hippocampus
	Lingual
	Caudate
	Putamen
Pallidum	

Node Betweenness Centrality Lower resolution matrices (MGH-USC HCP)	
Left Hemisphere	Right Hemisphere
Superior frontal	Superior frontal
Middle frontal	Middle frontal
Pars triangularis	Pars triangularis
Supplementary motor area	
Medial frontal	Medial frontal
	Fusiform
Cerebellum	Cerebellum

Node Strength Lower resolution matrices (MGH-USC HCP)	
Left Hemisphere	Right Hemisphere
Precentral	Precentral
Superior frontal	Superior frontal
Middle frontal	Middle frontal
Pars triangularis	Pars triangularis
Supplementary motor area	Supplementary motor area
Medial frontal	Medial frontal
	Fusiform
Superior parietal	Superior parietal
Pallidum	Pallidum
Cerebellum	Cerebellum

### **Supplementary Note 3**

Nodes (cortical/sub-cortical areas) with significant change (uncorrected  $p$  value < 0.05 for exploratory results) between age 8-9 (6 subjects) and 65-75 (5 subjects) as detected by curvature, strength and betweenness centrality using lower resolution (116 x 116) connectivity matrices generated with data from the WU-Minn HCP Consortium Lifespan Pilot project.

<b>Node Curvature (WU-Minn HCP Lifespan)</b>	
<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
Supplementary motor area	Supplementary motor area
Pallidum	Pallidum
Parahippocampal	Parahippocampal
Precuneus	Precuneus
Paracentral Lobule	Paracentral Lobule
Thalamus	Thalamus
Cerebellum	Cerebellum
Heschl's gyrus	Caudate
Superior temporal gyrus	Rectus
Middle temporal pole	Pars triangularis
Hippocampus	

<b>Node Strength (WU-Minn HCP Lifespan)</b>	
<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
Supplementary motor area	Supplementary motor area
Pallidum	Pallidum
Anterior cingulate gyrus	Rectus
Fusiform	Mid-cingulate area
Putamen	Medial frontal gyrus
Middle temporal pole	Postcentral
	Caudate
	Supra-marginal
	Thalamus
	Cerebellum
	Precentral
	Pars orbitalis
	Rolandic operculum

#### **Supplementary Note 4**

Nodes (cortical/sub-cortical areas) with significant difference (uncorrected  $p$  value < 0.05 for exploratory results) between 51 individuals with Autism Spectrum Disorders and 43 typically developing subjects, as detected by curvature, strength and betweenness centrality using connectivity matrices (264x264) from Rudie et al. 2013 (Neuroimage: Clinical).

<b>Node Curvature (Rudie et al. 2013)</b>	
<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
Juxtapositional lobule	Inferior temporal gyrus (temporo-occipital)
	Temporal occipital fusiform cortex
	Parahippocampal gyrus (posterior)
	Cuneus cortex
	Supra-marginal gyrus (posterior)
	Insular cortex
	Frontal orbital cortex
	Frontal pole

<b>Node Strength (Rudie et al. 2013)</b>	
<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
Thalamus	Thalamus
Precentral gyrus	Precentral gyrus
Superior parietal lobule	Superior parietal lobule
Superior frontal gyrus	Putamen
	Middle temporal gyrus (posterior)
Cingulate gyrus (anterior)	Angular gyrus
Temporal pole	Occipital pole
Postcentral gyrus	Juxtapositional lobule
	Crus-II
Cingulate gyrus (posterior)	Precuneus cortex
Occipital fusiform gyrus	Precuneus cortex
Central opercular cortex	
Middle temporal gyrus (anterior)	
Insular cortex	

<b>Betweenness Centrality (Rudie et al. 2013)</b>	
<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
Paracingulate gyrus	Juxtapositional lobule cortex
Thalamus	Lateral occipital cortex (superior)
Precuneus cortex	Parahippocampal gyrus (posterior)
Intracalcarine cortex	Lateral occipital cortex (inferior)
Occipital pole	
Occipital fusiform gyrus	
Superior parietal lobule	
Middle frontal gyrus	
Precentral gyrus	
Central opercular cortex	

<b>Clustering Coefficient (Rudie et al. 2013)</b>	
<b>Left Hemisphere</b>	<b>Right Hemisphere</b>
Cingulate gyrus (anterior)	Precentral gyrus
Postcentral gyrus	Precentral gyrus
Cuneus cortex	Lateral occipital cortex (superior)
Lingual gyrus	Precuneus cortex
Parahippocampal gyrus (anterior)	Precuneus cortex
Occipital fusiform gyrus	Temporal occipital fusiform
Superior parietal lobule	Middle temporal gyrus (posterior)
Insular cortex	Middle temporal gyrus (posterior)
Precentral gyrus	
Frontal pole	
Central opercular cortex	
Planum temporale	