Graph Theory Analysis of ASD Brains
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Introduction and Hypothesis:

For our final project, we decided to use Graph Theory to analyze the functional connectivity of the brains of individuals with Autism Spectrum Disorder (ASD). ASD is a developmental disorder that is characterized as deficits in social behaviors and communication, combined with restricted interests and repetitive behaviors. In recent years, Autism researchers have been using Graph Theory to analyze the brain connectivity of individuals with Autism. Using MRI data, researchers find correlations in the activity of predefined brain regions and create connectivity matrices based off of these correlations (for a more detailed description of the graph construction from MRI data, see the study by Rubinov and Sporns (2009) here: http://www.sciencedirect.com/science/article/pii/S105381190901074X).

We used data from an Autism connectivity study from UCLA that published the connectivity matrices of 42 individuals with Autism as well as 37 control individuals. We hypothesized that the ASD brains would be different from typically developing brains. Specifically, we expect to see decreased clustering coefficient and decreased hub strength in the ASD brains.

Link to dataset: http://umcd.humanconnectomeproject.org/umcd/default/index (Study Name: UCLA_Autism fMRI, entries 1584 to 1662)

Results

1. Average average clustering coefficient for individuals with Autism Spectrum Disorder:

    0.5717559106854493

2. Average average clustering coefficient for typical development:

    0.5910671224615659

3. Top 20 brain regions with highest average betweenness centrality for Autism Spectrum Disorder:

Region	Index	Average BC
Right Occipital Pole	(11)	437.92857142857144
*Right Thalamus	(117)	436.1904761904762
Left Inferior Temporal Gyrus temporooccipital part	(93)	429.5238095238095
*Right Thalamus	(157)	429.1904761904762
*Brain-Stem	(102)	427.8095238095238
Left Thalamus	(195)	422.2142857142857
Left Inferior Temporal Gyrus anterior division	(257)	421.45238095238096

Left Planum Temporale	(91)	420.0
Right Occipital Fusiform Gyrus	(5)	418.42857142857144
*Right Occipital Pole	(0)	417.0
*Right Inferior Temporal Gyrus posterior division	(81)	416.8095238095238
Left Superior Frontal Gyrus	(188)	416.5
Right Parahippocampal Gyrus posterior division	(248)	415.8809523809524
Left Inferior Temporal Gyrus temporooccipital part	(43)	414.0
Left Temporal Fusiform Cortex posterior division	(70)	412.26190476190476
Right Frontal Orbital Cortex	(189)	412.04761904761904
Right Temporal Fusiform Cortex posterior division	(62)	411.54761904761904
Right VI	(82)	410.35714285714283
Left Frontal Pole	(230)	409.4761904761905
Left Middle Temporal Gyrus posterior division	(224)	409.45238095238096

Top 20 brain regions with highest average betweenness centrality for typical development:

Region	Index	Average BC
*Right Thalamus	(157)	460.3783783783784
Left Caudate	(167)	447.27027027027026
Left Putamen	(152)	439.72972972972974
*Right Inferior Temporal Gyrus posterior division	(81)	439.3243243243243
Right Pallidum	(146)	438.8918918918919
Right Occipital Pole	(1)	435.97297297297297
Right Occipital Pole	(11)	433.3783783783784
Left VI	(113)	430.4054054054054
Left Planum Temporale	(100)	429.5405405405405
*Right Thalamus	(117)	428.1081081081081
Right Putamen	(139)	426.2162162162162
*Right Occipital Pole	(0)	421.86486486486484
Left Precentral Gyrus	(66)	421.3783783783784
Right Middle Temporal Gyrus temporooccipital	(210)	421.02702702702703
Right Superior Temporal Gyrus posterior division	(220)	420.8378378378378
Right Thalamus	(122)	419.9189189189189
Left Frontal Pole	(155)	417.8378378378378
*Brain-Stem	(102)	417.2432432432432
Left Cingulate Gyrus posterior division	(98)	416.56756756756755
Right Frontal Medial Cortex	(231)	415.9189189189189

* Indicates hub in both ASD group and TD group

Figure 1

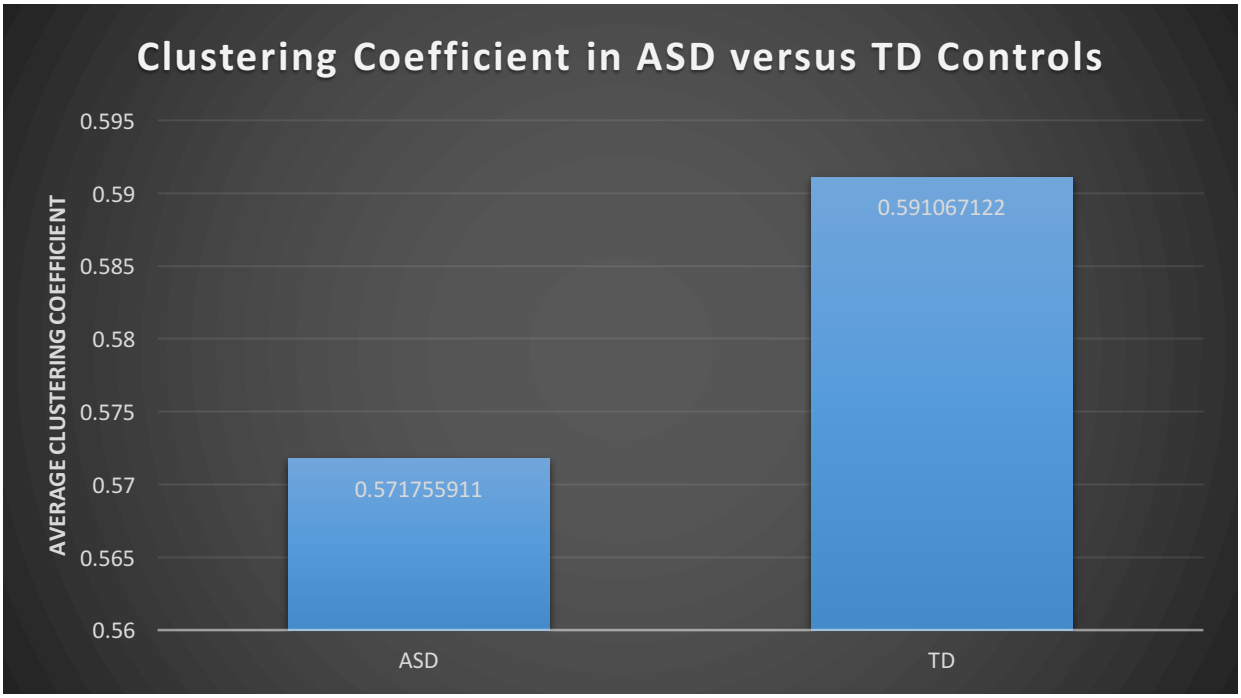

Clustering Coefficient in ASD versus TD Controls
AVERAGE CLUSTERING COEFFICIENT
0.595
0.59
0.585
0.58
0.575
0.57
0.565
0.56
0.571755911
0.591067122
ASD
TD

Figure 2

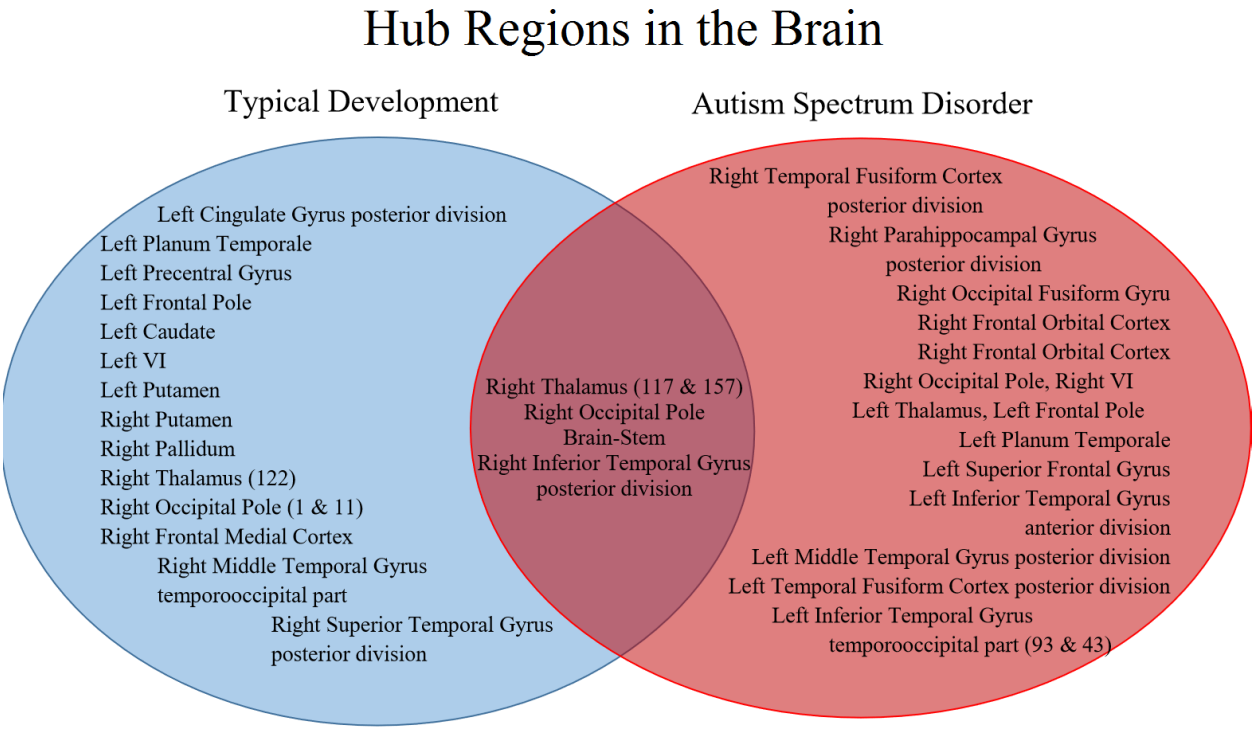
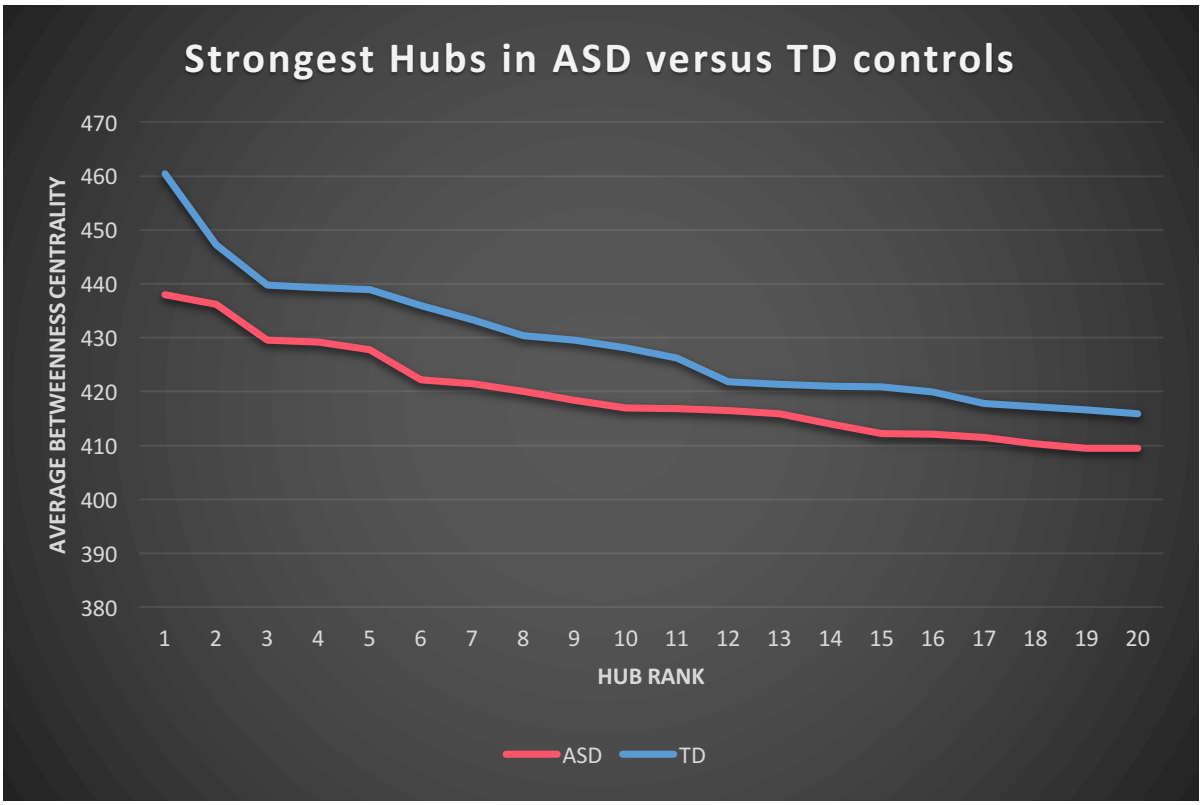

Hub Regions in the Brain
Typical Development
Autism Spectrum Disorder
Left Cingulate Gyrus posterior division
Left Planum Temporale
Left Precentral Gyrus
Left Frontal Pole
Left Caudate
Left VI
Left Putamen
Right Putamen
Right Pallidum
Right Thalamus (122)
Right Occipital Pole (1 & 11)
Right Frontal Medial Cortex
Right Middle Temporal Gyrus temporooccipital part
Right Superior Temporal Gyrus posterior division
Right Thalamus (117 & 157)
Right Occipital Pole
Brain-Stem
Right Inferior Temporal Gyrus posterior division
Right Temporal Fusiform Cortex posterior division
Right Parahippocampal Gyrus posterior division
Right Occipital Fusiform Gyru
Right Frontal Orbital Cortex
Right Frontal Orbital Cortex
Right Occipital Pole, Right VI
Left Thalamus, Left Frontal Pole
Left Planum Temporale
Left Superior Frontal Gyrus
Left Inferior Temporal Gyrus anterior division
Left Middle Temporal Gyrus posterior division
Left Temporal Fusiform Cortex posterior division
Left Inferior Temporal Gyrus temporooccipital part (93 & 43)

Figure 3



Discussion

Overall, our results prove our hypothesis: the ASD group had a lower average clustering coefficient, different hub distribution, and decreased hub strength than the TD group, as shown in figures 1, 2, and 3. Our findings are similar to findings from researchers who have examined this and other data sets of fMRI scans of individuals with Autism (see Links to similar studies). Overall, our findings of decreased clustering coefficient and decreased hub strength indicate that the brains of individuals with Autism have broad-ranging differences in information processing when compared to typically developing individuals.

Links to similar studies:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3777708/#bb0290
http://www.sciencedirect.com/science/article/pii/S2451902216300830