Analyzing the Development and the Functionality of Dyslexic and Autistic Brains by Investigating the Relationship between the Micro Structures and Macro Structures

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Abstract. The minicolumnar hypothesis argues in favor that minicolumns, not individual neurons, represent the basic unit in the brain circuitry. Recent studies have shown increased number of minicolumns in autism and decreased number of them in dyslexia. This study aims at linking the pathological findings, represented by the minicolumnar distrurbance, to MRI findings. This is motivated by the persistence necessity to find noninvasive methods to analyze diseases. Moreover, the work investigates an MRI evidence that supports the minicolumnar hypothesis.

1 Introduction

Autism and dyslexia are two of the most complicated brain developmental disorders that affect the ability of the children to learn and engage with the surrounding society. The explanation of the way that the autisic brain develops and functions is an open question that needs investigation. Functional anatomy suggests that anatomical differences among the difference groups must have functional implications that would help scientists to understand how the brain works and to give reasonable justification of malfunction in certain groups. The major objective of this study is to relate pathological microstructures (Minicolumns) with MRI Macrostructures (we will focus on corpus callosum) to understand how the development of the brain is affected by this relation.

2 Hypothesis

Recent studies have shown that dyslexia and autism are on opposite tails of the normal distribution of the width of minicolumns. In other words, normal individuals have minicolumns with Guassian width distribution. Autistic individuals have increased number of smaller minicolumns and dyslexic children have decreased number of larger minicolumns[1]. We hypothesize that the difference of the number of miniclumns will have an immediate impact of the communications between the two hemispheres as follows; In autism, we expect that the minicolumns will play an essential role in the communication between the two hemispheres and that the autistic brain will lean towards intrahemispheric connections through the minicolumns instead of the longer interhemisphic connection through the corpus callosum. On the contrary, the dyslexic brain will favor the interhemispheric connections over the intrahemispheric connections. More precisely, we expect the number of commisural fibers in autism to be less than its corresponding in normal controls. And in dyslexic patients, we expect it to be larger than in normal controls. To best of our knowledge, there is no estimate for these commisural fibers in autism or dyslexia, we propose to use the cross sectional area of the corpus callosum to reflect the density of the commisural fibers. Since there exist volume differences among the different groups[2, 3], the corss sectional area of the corpus callosum will be normalized with respect to the total brain volume.

3 Data Set and Methods

The data set consists of 16 dyslexic right handed male subjects and 14 controls matched for the same gender, age, IQ, handedness and education. i.e. all the subjects are physically healthy and have the same psychiatric conditions. The images were acquired with the same 1.5 T MRI scanner using a 3D spoiled gradient recall acquisition in the steady state (time to echo, 5 milliseconds and time to repeat, 24 milliseconds; flip angle, 45; repetition, 1; FOV, 24 cm^2). Contiguous axial slices, 1.5 mm thickness were obtained and the voxel resolution was $0.9375 \times 0.9375 \times 1.5$ mm.

The graph cut based active contour model in [4] is used to segment the brain tissue. Then, connected component analysis is applied to the midsagital slice. The midsagital slice contains mainly two major components; the brain stem and the corpus callosum. The corpus callosum is extracted by selecting all the pixels that correspond to the second mode in the requency histogram of the connected components. The cross sectional area of the corpus callosum and the total intracrantial volume are calculated for each subject in the data set. Statistical analysis is performed on the ratio (R) between the corpus callosum cross sectional area and the total brain volume. The statistical t-test is applied to investigate whether there is a significance difference between the different groups.

4 Preliminary Results and Discussion

The results of the statistical tests showed that the ratio in the dyslexic group is significantly larger than its corresponding in the normal control cases. This findings supports our hypothesis that the dyslexic brain lean towards connecting the hemispheres through the longer interhemispheric connections through the white matter rather than the intrahemispheric connections through the minicolumns which is a logical consequence of the decreased number of minicolumns in dyslexic brains. We are currently performing the same analysis on the autistic subjects. If we can prove the duality of the MRI findings, then we can conclude the validity of our hypothesis.

The major relation of our study with the early development of the brain is that abnormal postnatal retractive events happening during the maturation of the corpus callosum and other long cortico-cortical projections could account for the natural history of some autistic patients that manifest normal development followed by loss of skills and onset of symptomatology. Experience with hemispherectomies suggests that this time frame may be the first 4 years of life. During this period of time the hemispheres are equipotential with regards to linguistic abilities and a postnatal reorganization of its long corticocortical projections establishes cerebral dominance.

References

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