

Diagnosis of ADHD using Brain Imaging Technique: A Survey

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Abstract: Attention Deficit Hyperactive Disorder (ADHD) is a complex, neuro-biological behavioral impairment that alters a person's functioning and impinges on all aspects of his immediate and often greater environment. In this paper, the overview of ADHD and the structural and functional Brain Imaging techniques to identify the abnormalities are discussed. Brain scans have revealed that the reduced volumes of four regions in the brain: the corpus callosum, the basal ganglia, the frontal lobes and the cerebellar vermis will explain many typical ADHD symptoms. Image processing techniques like Atlas Based Segmentation, Genetic Algorithm, Adaptive Threshold Algorithm, Watershed Algorithm, 3D Region Growing, K-Means Clustering Algorithm, Elastic Matching Technique, Graph Cut Techniques, Fuzzy Expectation Maximization (EM) Algorithm, Voxel-Based Morphometry to find the differences in brain area volume and thickness are analyzed. The results of the study reveal that a ADHD is neurological disorder and an alarm or warning to be extended to the neurologist to detect this disorder with an automatic diagnostic tool.

Keywords: Attention Deficit Hyperactivity Disorder, Brain Imaging Techniques, Brain Damages, Brain Structure

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common childhood disorders and can continue through the teenage years and adulthood. Symptoms of ADHD were Inattention, complexity of controlling behavior, and hyperactivity (over-activity). A study of the Attention Deficit Hyperactivity Disorder (ADHD) is a genetically influenced by a brain disorder which has been undertaken using a three armed approach such as

- Brain Injuries
- Brain Damage
- Brain Abnormalities

A. Brain Injuries

An individual who suffer traumatic brain injuries and the associated symptoms occur after birth here these injuries have directed to ADHD A person who have activities such as maternal smoking, maternal alcohol consumption, fetal hypoxia (lack of oxygen), and alcohol during their pregnancy, disclosure to toxins, zinc absence and also is related to genetic basis. These activities lead to problem such as cognitive, behavioral, physical disabilities and memory problems.

B. Brain Damage

In other words head injuries often origin for concentrate brain damage those brain damages were directly linked to ADHD. A brain damage reason, such as accidents, Physical violence, blows to the head, etc. These reasons cause ADHD symptoms such as Sleep disorders, Shortened attention span, Inability to understand concepts, Lacking mental, physical alertness and activity etc.

C. Brain Abnormalities

An individual suffered in brain abnormalities happen by before birth, such as Problems in utero, Physical injuries, swollen blood vessels in the brain, cerebral palsy, etc. The brains of boys and girls with ADHD were 3% to 4% smaller than the brains of normal children. These brain regions are

complicated in impulse control, motor activity concentration, inhibition, and which are all arrest region for ADHD children.

2. ADHD Brain Structure

This division contains the fine points about the brain structure of ADHD and Healthy subjects. Attention-deficit/hyperactivity disorder (ADHD) is a common Neuro developmental disorder, predictable affect approximately 5% of children worldwide. The brains of boys and girls with ADHD were 3% to 4% smaller than the brains of children without ADHD. Children with more ADHD symptoms had smaller frontal lobes, temporal gray matter, caudate nucleus, and cerebellum. These brain regions are involved in concentration, impulse control, inhibition, and motor activity, which are all problem areas for children with ADHD. They are discussed in more detail below. The courses on brain development in children with and without ADHD were similar. This area shows that Specific areas of the brain are affected by ADHD. The human brain system is shown in fig. [1]. The cerebral cortex, frontal lobes, cortex, limbic system, and reticular activating system are all involved.

a) Cerebral Cortex

The surface of the cerebrum is called the cerebral cortex or "gray matter." The cerebral cortex is divided into the right and Left cerebral hemispheres. The two Hemispheres are Connected

by a thick band of nerve fibers called the corpus callosum, which allows them to communicate and share information. Each hemisphere is divided into lobes: frontal, temporal, parietal, and occipital lobes. Abnormalities in neural Function among children with ADHD, including blunted activation in right Hemisphere dorso lateral prefrontal cortex (PFC), striatum, and thalamus during inhibition and attention tasks; reduced inferior parietal cortex, precuneus, and superior temporal cortex activation during attention tasks; and hypo activation in the left hemisphere frontal-parietal-cerebella circuits during timing

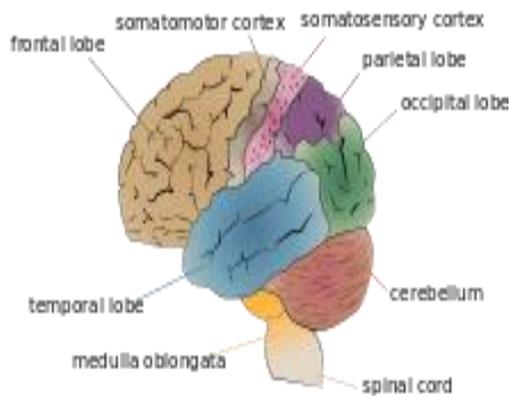


Figure 1: Human Brain

Attention-deficit/hyperactivity disorder is also associated with a typical neural structure, including the smaller volume of the PFC and basal ganglia and reductions in cortical thickness across prefrontal, parietal, and temporal cortex.

b) Frontal Lobe

This area is involved in concentration, the ability to make sound decisions, learn, and remember. The frontal lobe also helps you pay attention to a task and seeing it to Completion. Further, normal frontal lobes play a role in the situation-proper behavior and emotional impulse control. In ADHD Frontal lobe does not function properly, it shows the result in learning disabled.

c) Cortexes

The inhibitory mechanisms of the cortex are sort of like the body's impulse control center. A properly functioning cortex results in a "reining in" of hyperactivity and/or angry outbursts, for example. In ADHD, the inhibitory mechanisms of the cortex do not function properly, resulting in little or no impulse control in certain situations.

d) Limbic System

This is deep in the center and at the base of the brain. It acts as our "watchman," alerting us to alarming or dangerous situations. If the limbic system is not functioning correctly, then normal emotional changes and energy levels may be affected, as well as sleep patterns and stress supervision those with faulty limbic systems may be subject to emotional outbursts or be oversensitive to their environment.

e) Reticular Activating System (RAS)

Located at the back of the head in the brain stem, the RAS is said to control walking and sleeping patterns, and plays a role in the ability to concentrate and focus attention. In the ADHD brain, aspects of the RAS may not be functioning normally. Finally Children with ADHD showed a decrease in total cerebral Volume and total cortical volume of over 7 and 8%, respectively. Brain of ADHD, the cortex achieved peak thickness at an average age of 10.5. In the brains of without ADHD, peak cortex thickness occurred at age 7.5. This three-year delay in the ADHD brain is most well-known in the area of the brain that controls thinking, attention, and planning [19].

3. Brain Imaging Techniques

ADHD researchers are currently investigating that ADHD may be due to alterations in the brain and the way it functions. Experts say that head injuries can cause ADHD-like symptoms in previously unaffected people, perhaps due to frontal lobe damage. Differences in the brain area, volume and thickness are to be analyzed to determine the presence of a relationship between brain development and behavior. Modern technology has given us several ways to learn about the brain:

- Magnetic Resonance Imaging (MRI) and Diffusion Tensor Imaging (DTI) are examples of structural imaging. Structural imaging gives a two- or three-dimensional picture of the brain. However, it does not give any information about the brain activity or how the abnormalities affect the child's functioning.
- Functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG) and Magneto Encephalography (MEG) are examples of functional imaging. Functional imaging gives information about the activity of specific areas of the child's brain while the child is performing certain tasks.

Several recent studies using these techniques have given us information about subtle differences in the brains of people with ADHD. These brain abnormalities probably contribute to the behavior symptoms and cognitive problems of people with ADHD. So far there is no evidence that treatment with stimulant medication causes the brain abnormalities seen in ADHD.

Magnetic Resonance Imaging (MRI): One study looked at children with and without ADHD over a 10-year period. At various ages, children's brains were scanned using magnetic resonance imaging (MRI). The brains of boys and girls with ADHD were 3% to 4% smaller than the brains of children without ADHD. Children with more severe ADHD symptoms had smaller frontal lobes, temporal gray matter, caudate nucleus, and cerebellum. These brain regions are involved in concentration, impulse control, inhibition, and motor activity, which are all problem areas for children with ADHD. The course of brain development in children with and without ADHD was similar. This suggests that changes in the brain happen early in development [20] [21].

Diffusion Tensor Imaging (DTI): A new technique called Diffusion Tensor Imaging (DTI) lets scientists look at the white matter in children's brains in more detail. White matter consists of axons (nerve fibers) covered by myelin sheaths.

DTI lets us look at the nerve pathways between different areas of the brain. A recent study using DTI found abnormalities in the fiber pathways in the frontal cortex, basal ganglia, brainstem, and cerebellum. These areas are involved in attention, impulsive behavior, inhibition, and motor activity. The findings suggest that specific brain circuits that connect different areas of the brain may be altered in people with ADHD. It is not surprising, therefore, to find that people with ADHD often have problems with regulating attention, behavior, and learning [23][24].

Functional Magnetic Resonance Imaging (fMRI): The children engaged in a test of sustained attention in which they

were shown a set of three numbers and then asked whether subsequent groups of numbers matched the original set. For each participant, fMRI produced a brain activation map that revealed which regions of the brain became activated while the child performed the task. fMRI measure brain activation while children are performing various tasks. These Studies have shown that reductions in brain volume in children with ADHD are associated with poorer performance on tests of attention and inhibition and measures of behavior [22].

Electroencephalography (EEG): The standard Electroencephalograph (EEG) measures brain electrical activity. Tracings are made from electrodes placed around the skull. The resulting paper record is read by a neurologist who will note major abnormalities which suggest conditions such as epilepsy. This technique is too crude to pick up the subtle electrical differences present ADHD [25].

4. Literature Survey

Jaini P.Shah (2014) et.al, proposed “Image Processing Application in The Detection of White Matter Lesions” The author introduces a new algorithm K-means clustering algorithm to overcome the detection of white matter changes obtained along with the CSF (cerebro-spinal fluid). Finally, it shows better and accurate result [4]. Ritu Agrawal (2014) et.al, proposed “Review of Segmentation Methods for Brain Tissue with Magnetic Resonance Images” to segmenting the brain tissues using four different techniques, namely Markov Random Field (MRF), Adaptive fuzzy C - means (ASFCM), Fuzzy Connectedness (FC), Atlas based Re - fuzzy connectedness (Re-FC). The performance of these segmentation techniques has been compared in terms of validation metric as a dice similarity coefficient, overlap ratio and Jaccard coefficient. The comparison of all validation metric shows that adaptive Fuzzy C - means clustering segmentation method give better results in the segmentation of brain tissue [10].

KaushikK.S (2013) et.al, proposed “Segmentation of the White Matter from the Brain FMRI Images” the author used FMRI brain images to segment the white matter using Otsu’s algorithm which is used for reducing the noise and also segmenting the white and gray matter in the brain. Finally, it shows the accurate result for extraction of white matter [5]. Resmi A (2013) et.al, proposed “A novel automatic method

for extraction of glioma tumor, white matter and gray matter from brain magnetic resonance images” the author enforce a novel technique called, an adaptive threshold technique for extracting the gray and white matter from MR Images of the brain. This technique achieves 92% better performance, accurate automatic segmentation method and less computation time [9].

P. Tamije Selvy (2013) et.al, proposed “A Proficient Clustering Technique to Detect CSF Level in MRI Brain Images Using PSO Algorithm” to find the CSF (Cerebro-spinal fluid) level in brain MR Images that consist of many steps: first, the Contrast Limited Adaptive Histogram Equalization (CLAHE) algorithm is used to enhance the low contrast images. Second, FCM (Fuzzy C Means), TVFCM (Total Variation Fuzzy C Means) and ADTVFCM

(Anisotropic Diffusion Total Variation Fuzzy C Means) methods are used to extract the CSF in the brain. The above clustering methods are then optimized using Particle Swarm Optimization (PSO). Finally ADTVFCM - PSO achieves a global optimal solution result compared to other clustering methods and also provides 98% of Accuracy, 92% of Sensitivity and 97% of Specificity [16].

M.Anitha (2012) et.al, proposed “Automated Detection of White Matter Lesions in MRI Brain Images Using Spatio fuzzy And Spatio-Possibilistic Clustering Models” to find the white matter lesions by analyzing the white matter changes. First the input image was enhanced by a Contrast Stretching technique, then moved to the clustering algorithms which includes Fuzzy c-means Clustering (FCM), Geostatistical Possibilistic Clustering (GPC) and a Geostatistical Fuzzy Clustering Model (GFCM) used for detecting WML automatically. Geostatistical Fuzzy Clustering Model (GFCM) gives 95% accurate result comparing GPC and FCM [1].

Mehdi Jafri and Reza Shafaghi (2012) proposed,” A Hybrid Approach for Automatic Classification of Brain MRI Using Genetic Algorithm and Support Vector Machine” - a hybrid approach for detection of brain tissue in MRI based on Genetic algorithm (GA) and support vector machine (SVM). In the preprocessing stage, noise is removed by using a low pass filter and contrast is enhanced by using the image histogram stretching method. Finally feature selection GA is used for reducing the complexities, and then the SVM classifier used to classify the image into normal or abnormal [8].

E.A.Zanaty (2012) et.al, proposed “Determination of Gray Matter (GM) and White Matter (WM) Volume in Brain Magnetic Resonance Images (MRI)” They enforce hybrid approach such as a combination of three algorithms are fuzzy clustering, seed region growing, and Jaccard similarity coefficient algorithms to determine gray (GM) and white matter tissue (WM) volumes. It gives stable and accurate result. [18].

Bouchaib CHERRADI (2011) et.al, Proposed “Fully Automatic Method for 3D T1-Weighted Brain Magnetic Resonance Images Segmentation” for segmenting the GM, WM and CSF use the following Technique: first step, median filtering used for reducing noise in MR Images of the brain then TMBE (Threshold Morphologic Brain Extraction) method for segmenting the GM, WM and CSF. Next, the gray level histogram analysis used for improving the accuracy, Finally Modified version of Fuzzy C-means Algorithm (MFCM) is used for MRI tissue segmentation. And it shows 70% better result in tissue segmentation [2].

Larry J. Seidman, (2011) et.al, proposed a “Gray Matter Alterations in Adults with Attention-Deficit/Hyperactivity Disorder Identified by Voxel-Based Morphometry” for segmenting the volumes of gray matter, white matter, and cerebro-spinal fluid (CSF) using FSL Brain Extraction segmentation tool to calculate the Normal Brain Volume. ROI (Region of Interest) based Voxel-based thresholding (VBM) method is used to analysis the ADHD brain volumes by assigning the two threshold values for the brain. This value

is used for identifying the increasing and decreasing levels of gray matter. The results show that ADHD adults had smaller gray matter, whereas other parts of the dorsolateral prefrontal cortex and the inferior parietal lobule were larger in ADHD adults [6].

Soodabeh Safa (2011) et al. proposed "New methods in Brain MR Segmentation with Fuzzy EM Algorithm" that implement a Fuzzy Expectation Maximization (FEM) method with K-means is used for grouping the individual pixels/voxels of main tissue in the brain, are Gray matter (GM), White matter (WM), CSF (Cerebro-spinal fluid). The result indicates FEM-K Means has better performance and convergence speed compared to the EM histogram method [15].

Mohammad Shajib Khadem (2010) et al. proposed "MRI Brain image segmentation using graph cuts" The MR image of the human brain can be divided into gray matter, white matter and cerebro-spinal fluid using two algorithms min-cut/max-flow algorithm and normalized cut algorithm. Comparing these two algorithm's performance, finally min-cut/max-flow algorithm shows results that which had less computational time for segmentation [7].

Sasha M. Wolosin, (2010) et al. proposed "Abnormal Cerebral Cortex Structure in Children with ADHD" defining the boundary between gray matter and cerebro-spinal fluid surface, by using a watershed algorithm with deformable surface models and also assigns the threshold value $p < 0.001$ and < 0.005 for analysis volume reduction was Observed throughout the cortex and all four lobes respectively. He gives the sample inputs were 21 children with ADHD and 35 healthy people. Finally the Result Shown that the children with ADHD showed a decrease in cerebral and cortical volume of over 7 and 8%, respectively [14].

N. Senthilal Kumaran (2010) et al. presented, "Hybrid Method for White Matter Separation in Brain Images Using Granular Rough Sets and Fuzzy Thresholding" - A hybrid method for white matter separation of the MRI brain image that consists of three phases. The first phase is to preprocess an image, the second phase is to segment an image using a granular rough set and the third phase is to separate white matter from the segmented image using fuzzy sets. This method was compared with a mean shift algorithm and finally found that hybrid segmentation performs better result [13].

S. Groeschel (2006) et al. proposed "Age-related changes in cerebral white and gray matter structures from infancy to adulthood: a voxel-based morphometry study". They implemented a voxel-based morphometry technique to analysis the gray and white matter in the brain by voxel-by-voxel basis of 3 years aged group childhood. Finally results concluded that white matter was higher than the gray matter [3].

Stewart H. Mostofsky et al (2002) proposed "Smaller Prefrontal and Premotor Volumes in Boys with Attention-Deficit/Hyperactivity Disorder" using Talairach-based approach. In this approach, first the brain tissue is subdivided into sub cortical, brainstem cerebral lobes, and cerebellar regions. Next cerebral lobes were subdivided into four lobes

(frontal, parietal, temporal, and occipital). The frontal lobe was subdivided into the following regions were motoring, promoter, prefrontal, anterior cingulate, and deep white matter, including gyri, sulci. Finally, this approach produces identifiable landmark for the above given region based on the coefficients for tissue segmentation were .99, .99, and .96 for gray matter, white matter, and CSF volumes, respectively. Using these values cerebral brain volumes were compared with a hierarchical approach with a series of two-tailed multiple analyses of variance (MANOVAs). He gives input as groups of 12 boys with ADHD and 12 boys with control. In that the frontal lobes, a reduction was seen in both gray and white matter volumes, in depth of reduction in frontal white matter volume was specific to the left hemisphere; there was a bilateral reduction in frontal gray matter volume but more so in the right hemisphere. Final result shows Boys with ADHD had (on average) 8.3% smaller total cerebral volumes [11].

Simon Warfield (1995) et al. Proposed "Automatic Identification of Gray Matter Structures from MRI to Improve the Segmentation of White Matter Lesions" for identifying the white matter by using 3D region growing and elastic matching technique. First step, 3D region growing and elastic matching technique are used for segmenting the cortex and gray matter. Next step, white matter is segmented by elastic matching technique. Finally 3D region growing and elastic matching technique shows very accurate results on extracting the white matter [12].

Vedran Srhoj-Egekhe et al. proposed "Automatic segmentation of neonatal brain MRI using atlas based segmentation and machine learning approach" to segmenting the MR Images of brain into 8 different tissues, namely cortical grey matter (CoGM), unmyelinated white matter (UWM), brainstem, cerebellum, ventricles, cerebro-spinal fluid in the extra cerebral space (CSF), basal ganglia and thalami, myelinated white matter (MWM) using multi-atlas-based segmentation (MAS) and supervised voxel classification method. Finally multi-atlas-based segmentation (MAS) method took 20 min for clustering the images for per patient [17].

5. Conclusion

This paper provides an overview of the brain imaging studies that investigated the neurobiological substrate of ADHD. The findings suggest that ADHD is an indicator of neurological damage. It widely affects children in the age limit of 2 to 9 and even persists in adulthood. The frontal cortex, an area of the brain appears thinner and matures slower in children with ADHD. The motor cortex, which controls movement grows much faster than normal in a child with ADHD. Persons with ADHD struggle to pay attention or control the impulse to lash out because of the lower brain volume and less gray matter, which in turn leads to major depression. ADHD is redefined as a life span disorder. It can be reliably diagnosed and effectively treated. An alarm/sign of warning is to be extended to the neurologists to learn more about this disorder and hence take preventive measures to overcome this problem.

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