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Employing Image Extraction of the Fusiform Gyrus of Human Brain to Explore Autism

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Abstract: *Autism is an organic process disorder that occurs in the early age of a child defined by troubles with social interaction and communication. It also regards restricted and repetitive behavior. A significant damage occurs in social, occupational and other areas of functioning for these reasons. Today it is a matter of big anxiety. Abnormal inter-regional property of brain at functional level in autistic patients is presented by recent works. In patients with autism the fusiform gyrus (FG) region bearing face processing in controls are hypoactive. To analyze the causes of autism, fusiform gyrusof brain has been studied. For behavior analysis functional magnetic resonance imaging (fMRI) images of fusiform gyrus for control and autistic patients are considered as input images. Three categories of faces such as, familiar faces, stranger faces and accumulation of both familiar and stranger faces are taken. In this work various types of edge detector operators such as Sobel, Roberts, Prewitt are investigated to find edge map of fMRI image. Also anew edge detector operator has been proposed. The aim of this research is to show a new edge detector operator to find better edge map from others operators offMRI images. Extraction of the activation area is done by using thresholding in fusiform gyrus. The values of activation areas for both control and autistic individuals are measured by using the binarization methods after segmentation process. These values are compared with graphical representationfor both control and autistic individuals. In the end, it has been discovered that fusiform gyrus regions are less active in patients with autism than in control. Obtained results are extremely adequate to be encouraged.*

Keywords:*autism, autistic spectrum disorders (ASD), fusiform gyrus, functional magnetic resonance imaging (fMRI).*

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I. Introduction

Autism is a lifetime biological process impairment that impact how people comprehend the world and interact with others. People who have facing autism can see, hear and feel the world dissimilarly to other people. They have reduced social communication ability and limited or iterative behavior or interest. Even so, the most axiomatic signs of autism tend to come out between 2 and 3 years of age. Autism is a component of spectrum disorders defined by a triad of symptoms, regarding insufficiency in all aspects of social reciprocality; practical communication lack and language delays; and a miscellanea of behavioral problems, such asclosed interests, sensory sensitivities and repetitive conducts[1].Autism spectrum disorder (ASD) is a neurological and biological process disorder[2]. It starts early in childhood and lasts throughout a person's life. It impacts how a person acts with others, communicates, and learns. It also adds asperger syndrome and pervasive developmental disorders. Till the causes of ASD are unknown and research advises that genes and environment such as exposures to viruses or toxins during pregnancy are hypothesized to contribute both play crucial roles. However, the genuine reason of autism presence is not well implied yet[3]. It has a powerful genetic basis. In spite of the fact that, the genetics of autism aredecomposable and it is ill-defined either ASD is expressed more by infrequent mutations, or by uncommon combinations of common genetic variants[4]. An Autistic person understands atmosphere and human behavior both uniquely. But they react in an abnormal manner to input stimuli which generates problematic human engagement, limited interests and inability in the environmental generalization[5]. Normal human's social functioning processes of faces allows people to determine individuals and enables them with the capacity to interpret the mental state of others[6]. Functional magnetic resonance imaging (fMRI) studies recognized that the fusiform gyrus is systematically active when normal humans view faces[7]. In the case of autistic people, they can perform face perception tasks but there is powerful evidence that the fusiform gyrus with other cortical regions bearing face processing in controls, is hypoactive[8].It has been determined that the failure of making straight eye contact may justify the determined hypo-activation of the fusiform gyrus in face representation tasks in autism[9]. This critical assessment will generally directs on face representation deficits in autism. It also labels current literature on abnormalities in the fusiform face area and the amygdala. Early abnormality in development in the amygdala can grow later social perceptual deficits in face identity and facial expression perception. The fusiform gyrus incurs input from the visual cortex and supplies the major input into an extended system lies in of cortical regions and sub-cortical regions such as amygdala indicating that the altered function of the fusiform gyrus in patients with autism. Three categories of faces such as, familiar faces, stranger faces and combination of familiar and stranger faces are considered for examine of fusiform gyrus from fMRI images. The proposed approach has been implemented in Matlab. For the input image the fMRI images aretaken. Different edge detection operators are used for detecting the edge of these images and calculate the value of activation area in fusiform gyrus of brain for control and autistic individuals. The results obtained from segmentation is taken as input for binarization operation and compared to the control based on the calculated value of activation area of fusiform gyrus of brain.

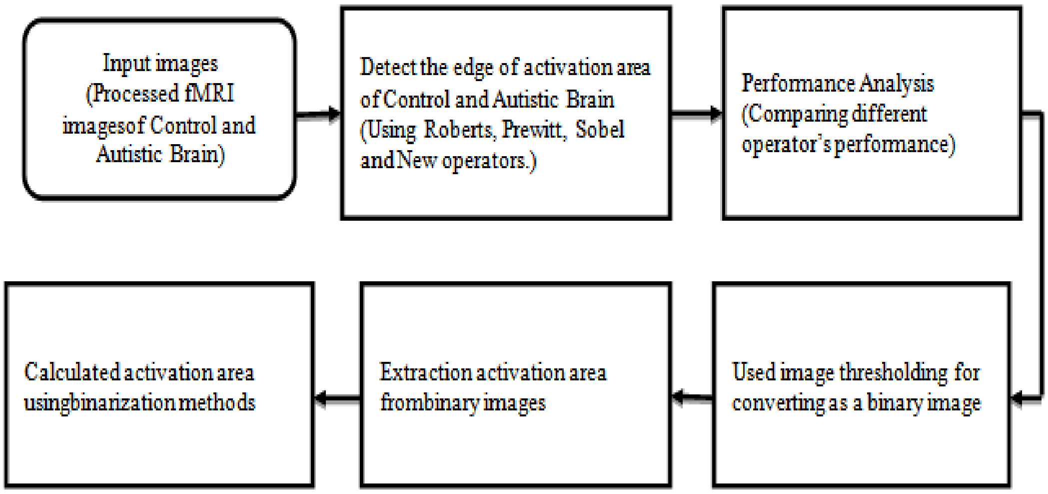


Figure 1: Block diagram of working procedure

The **fusiform gyrus**is a wide cigar-shaped gyrus that spreadss across the basal surface of the temporal and occipital lobes of the cerebral hemispheres. It is also known as the (discontinuous) **temporo-occipital gyrus,** is specialized for facial recognition[10]. It is placed in Brodmann Area 37. Other sources have the fusiform gyrus above the occipitotemporalgyrus and underneath the parahippocampalgyrus. There is still some conflicts over the functionalities of this area, but there is relative consensus on the following:

- dealing with color information
- recognizing face and body
- word and number recognition
- within-category identification

Prosopagnosia, or face blindness disorder is related to the fusiform gyrus. Exploration of fusiform gyrus has also viewed that, the area within the fusiform gyrus, is heavily associated with face perception but only to any generic within-category recognition which is shown to be one of the functions of the fusiform gyrus[11]. It has also been connected in the perception of emotions in facial stimuli[12]. K. Pierce et al. [13] researched with fusiform gyrus and they revealed normal fusiform gyrus activity in children with autism when viewing a familiar and stranger faces.They found abnormalities in autism for face processing.Figure 2 shows the fMRI of fusiform gyrus of brain for the control and autistic individuals which clearly indicates the differences among them (Consider three types of faces of fMRI for control and autistic individuals - all faces, familiar faces and stranger faces)[13].

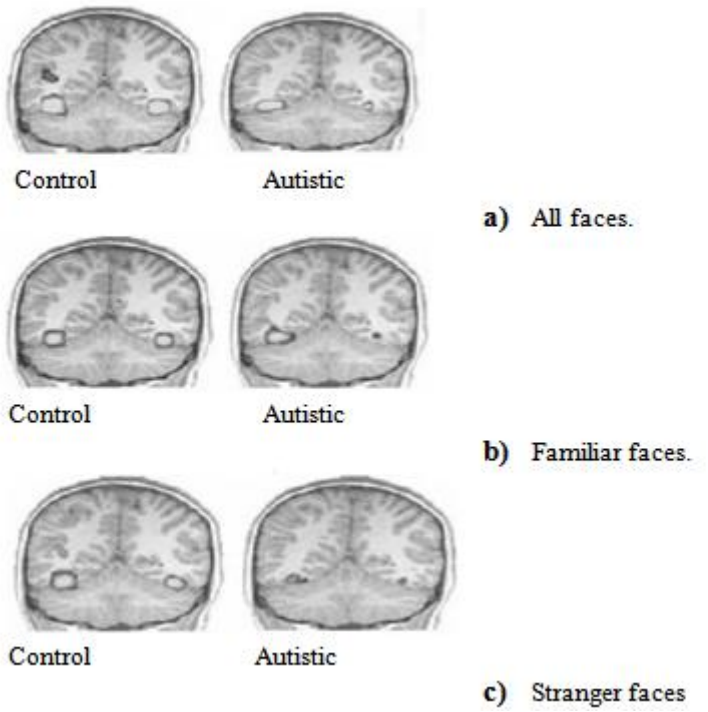


Figure 2: fMRI offusiform gyrus both of control and autistic for a) all faces, b) familiar faces and c) stranger faces.

II. Material And Methods

In carrying out the work processed fMRI images of the fusiform gyrus of brain for control and autistic individuals are taken as input. Three categories of faces that are familiar faces, stranger faces and combination of both familiar and stranger faces are considered of fusiform gyrusfrom fMRI.Detect the edge of activation area in fusiform gyrus of input images using Roberts, Prewitt,Sobel and new operators.

Roberts Operator

The Roberts operator is given by the equations:

$G_x = W_9 - W_5$

$G_y = W_8 - W_6$

-1	0
0	1

0	-1
1	0

(a) (b)

Figure 3: (a) Roberts Mask for Horizontal Direction(b) Roberts Mask for Vertical Direction

Prewitt Operator

Consider the arrangement of pixels:

W_1	W_2	W_3
W_4	W_5	W_6
W_7	W_8	W_9

The Prewitt's operator is given by the equations:

$G_x = (W_7+W_8+W_9) - (W_1+W_2+W_3)$

$G_Y = (W_3+W_6+W_9) - (W_1+W_4+W_7)$

-1	-1	-1
0	0	0
1	1	1

-1	0	1
-1	0	1
-1	0	1

(a) **(b)**

Figure 4: (a) Prewitt Mask for Horizontal Direction (b) Prewitt Mask for Vertical Direction

Sobel Operator

The Sobel operator is given by the equations:

$G_x = (W_7+2W_8+W_9) - (W_1+2W_2+W_3)$

$G_Y = (W_3+2W_6+W_9) - (W_1+2W_4+W_7)$

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

(a) (b)

Figure 5: (a) Sobel Mask for Horizontal Direction (b) Sobel Mask for Vertical Direction

New Operator

The new operator is given by the equations:

$G_x= (W_7+3W_8+W_9) - (W_1+3W_2+W_3)$

$G_Y = (W_3+3W_6+W_9) - (W_1+3W_4+W_7)$

The new mask is given below:

-1	-3	-1
0	0	0
1	3	1

-1	0	1
-3	0	3
-1	0	1

(a) (b)

Figure 6: (a) New Mask for Horizontal Direction (b) New Mask for Vertical Direction

Image thresholding isused for converting as a binary image. Extract the activation area from binary imagre. After extraction, the values of activation area for both control and autistic individuals are calculated using the binarization method. That is the image having only two values either black or white (0 or 1). Here 256x256 jpeg image is a maximum image size. The binary image can be represented as a summation of total number of white and black pixels. Area of an image is the total number of the pixels present in the area which can be calculated in the length units by multiplying the number of pixels with the dimension of one pixel:

Image, I = Σ 255w=0Σ 255H=0[f(0) + f(1)]

f (0) = white pixel (digit 0)

f (l) = black pixel (digit 1)

Pixels = Width (W) X Height (H)= 256 X 256

No_ of_ white pixel P = Σ 255w=0Σ 255H=0[f(0)]

Where, P = number of white pixels (width*height)

Finally, the calculated activation values are used for comparing to show as the graphical representation for both control and autistic. The proposed work is implemented byMatlab.

III. Resultand Discussion

In carrying out the work fMRI images of the control and autism are taken as input and the corresponding images are produced by edge detection methods (Roberts, Prewitt, Sobel and new operators). Then using new operator, the edge detected images apply for thresholding and these produced images are consider for extraction activation area. After extraction the activation areas of fusiform gyrus are calculated using binarization operation. The images of the input and produced output for the control and the autistic individuals are shown separately.

Figure 2 shows the input images of the fusiform gyrus of brain both of control and autistic for all faces, familiar faces and stranger faces.

Roberts Operator

Using Roberts operator to detect the edge surrounding of the fusiform gyrus area of brain for the control and the autistic. Figure 7 shows the processed images of the control and autistic for all, familiar and stranger faces.

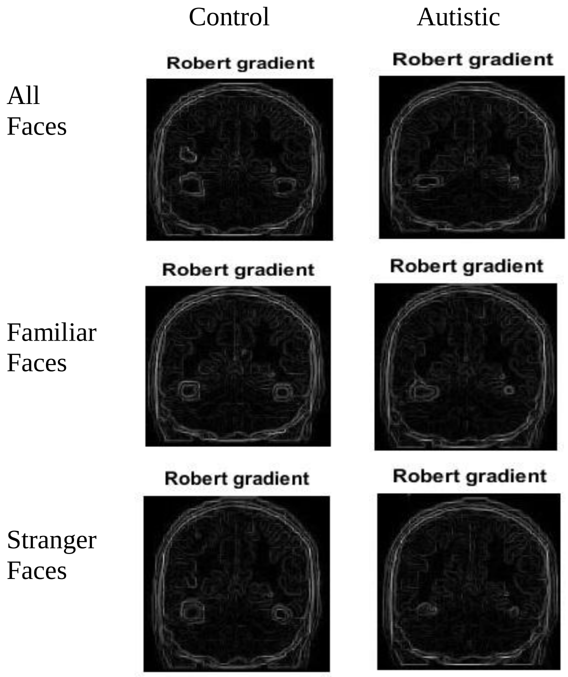


Figure 7: Processed images of the fusiform gyrus using Roberts operator of control and autistic for all faces, familiar faces and stranger faces.

Prewitt Operator

Using Prewitt operator to detect surrounding edge of the fusiform gyrus area of brain for the control and the autistic. Figure 8 shows the processed images of the control and autistic for all, familiar and stranger faces.

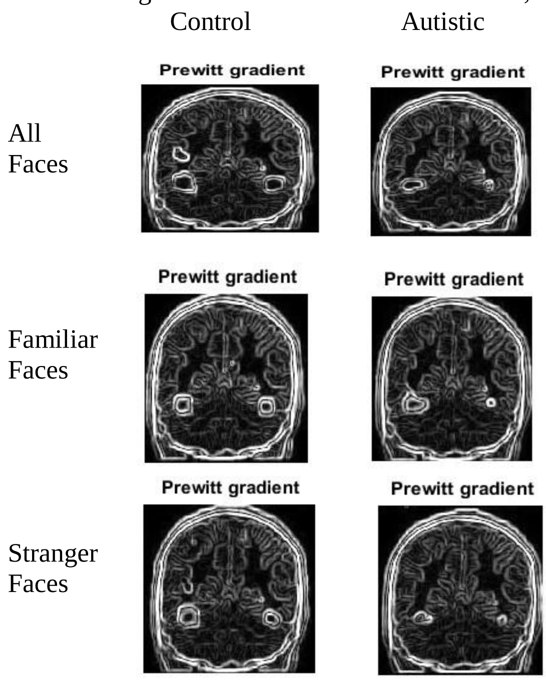


Figure 8: Processed images of the fusiform gyrus using Prewitt operator of control and autistic for all faces, familiar faces and stranger faces.

Sobel Operator

To detect the neural pathway surrounding the fusiform gyrus area, sobel edge detection operator is used for the control and the autistic. Figure 9 shows the processed images of the control and autistic for all, familiar and stranger faces.

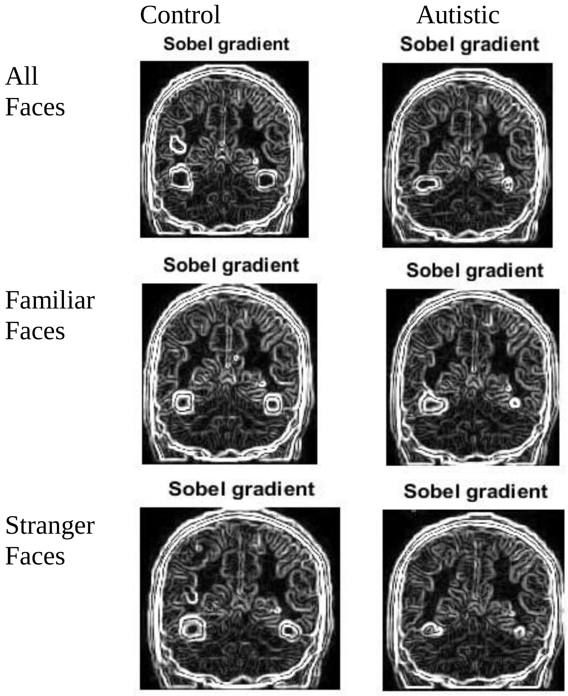


Figure 9: Processed images of the fusiform gyrus using Sobel operator of control and autistic for all faces, familiar faces and stranger faces.

New Operator

New operator is used to detect the edge of fusiform gyrus area and Figure 10 shows the processed images of control and autistic for all faces, familiar faces and stranger faces. Comparing the produced images, it is clearly visualized that the edges for the control are sharply observed which indicates that the neural pathways for the control are more effective surrounding the fusiform gyrus than autistic.

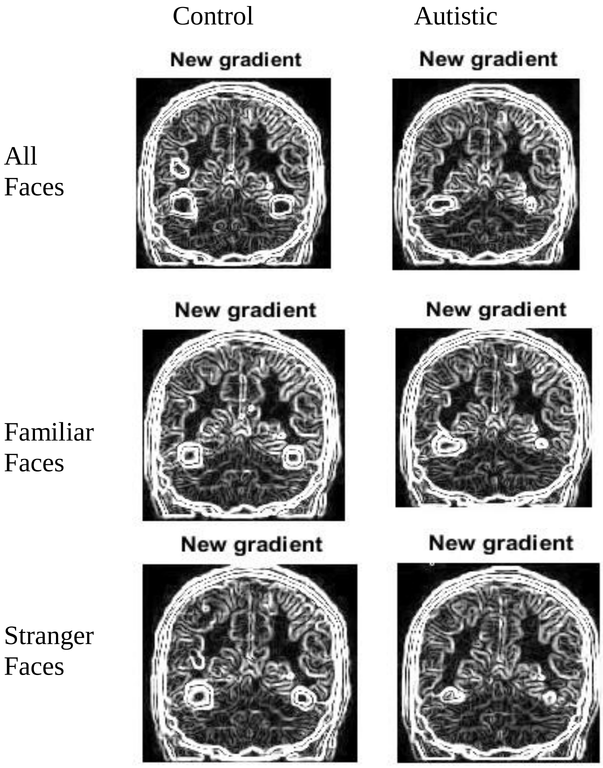


Figure 10: Processed images of the fusiform gyrus using new operator of control and autistic for all faces, familiar faces and stranger faces.

Performance evaluation

Table 1 shows the subjective fidelity scoring scales that used for comparing different operator's performance[14]. The new operator's performance for edge detection in image is evaluated subjectively against the different operators (Sobel, Robert and Prewitt).

Table 1: Subjective fidelity scoring scales

Quality	Comparison
A – Very good	+ 3 Very high
B – Good	+2 High
C – Fair	+1 Medium
D – Poor	- 1 Less
E – Bad	- 2 Much less

Table 2 shows the performance for evaluating contrast for all input images of comparing different operators (Sobel, Robert, Prewitt and New). The performance of new operator is better than from all operators to consider table 1 scoring scales.

Table 3 shows the performance for detecting edge map of different operators (Sobel, Robert, Prewitt and New) for all input images. The edge map performance of new operator from all operators is also very good.

Table 4 shows the performance for noise contents of different operators (Sobel, Robert, Prewitt and New) for all input images. The processed images have much less noise contents using new operator from all operators.

It has been shown that the new operator performs better than all these operators under almost all scenarios.

Table 2: Performance for evaluating contrast of different Operators

Operators For Comparison	All faces		Familiar faces		Stranger faces	
	Control	Autism	Control	Autism	Control	Autism
Sobel	B	B	B	B	B	B
Roberts	C	D	C	D	C	D
Prewitt	B	C	B	C	B	C
New	A	A	A	A	A	A

Table 3: Performance for edge map of different operators

Operators For Comparison	All faces		Familiar faces		Stranger faces	
	Control	Autism	Control	Autism	Control	Autism
Sobel	B	B	B	B	B	B
Roberts	C	D	C	D	C	D
Prewitt	B	C	B	C	B	C
New	A	A	A	A	A	A

Table 4: Performance for noise contents of different operators

Operators For Comparison	Contrast		Edge Map		Noise Contents	
	Control	Autism	Control	Autism	Control	Autism
Sobel	-1	-1	-1	-1	-1	-1
Roberts	+1	+2	+1	+2	+2	+1
Prewitt	-1	+1	-1	+1	-1	+1
New	-2	-2	-2	-2	-2	-2

Thresholding

Figure 11 shows the result of thresholding which gives the accurate edge detected images using new operator of the fusiform gyrus of brain for control and autistic for all faces, familiar faces and stranger faces.

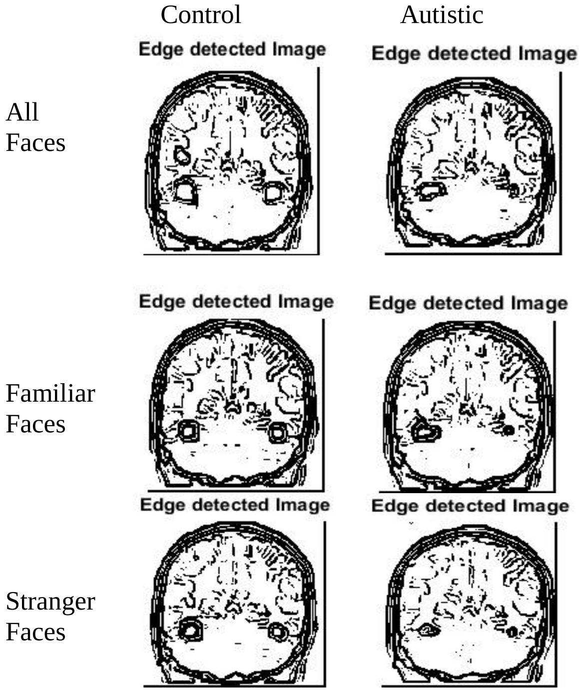


Figure 11: Edge detected images of the fusiform gyrus of brain for control and autistic using thresholding

Calculation activation area of fusiform gyrus

Consider segmented processed images for calculating the area values of activation area fusiform gyrus of brain of control and autistic for all faces, familiar faces and stranger faces.

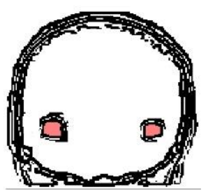
	Control	Autistic
All Faces		

Figure 12: Segmented images of the fusiform gyrus of brain of control and autistic for all faces.

Table 5: Calculated area values of both control and autism for all faces.

For All faces		Area
Control	Left side	219
	Right side	154
Autistic	Left side	102
	Right side	47

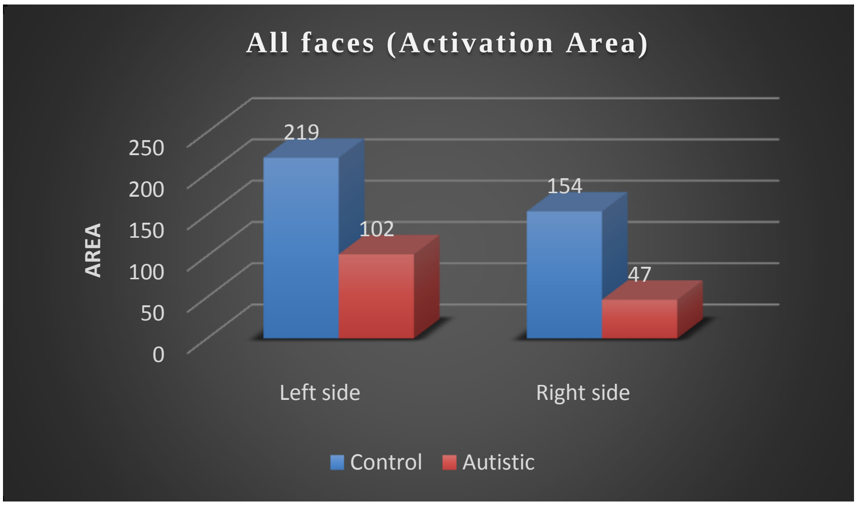


Figure 13: Graphical representation of both control and autistic for allfaces.

Figure 12shows activation area is indicated as pink color for left and right sides of fusiform gyrus of brain both of Control and Autistic for all faces. The values are calculated for indicated area of fusiform gyrus. From table 5 for left side, the values are 219 (in pixels) for Control and 102 (in pixels) for Autistic. For right side, the values are 154 (in pixels) for control and 47 (in pixels) for autistic. From these calculated values, it is observed that the values for left and right sides of Autistic are smaller than Control.The compared results are shown in Figure 13 with graphical representations.

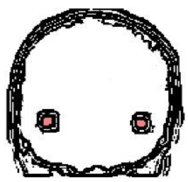
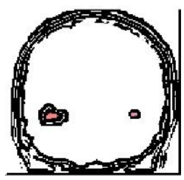
	Control	Autistic
Familiar Faces		

Figure 14: Segmented images of the fusiform gyrus of brain of control and autistic for familiar faces

Table 6: Calculated area values of both control and autism for familiar faces.

For Familiar faces		Area
Control	Left side	107
	Right side	76
Autistic	Left side	92
	Right side	54

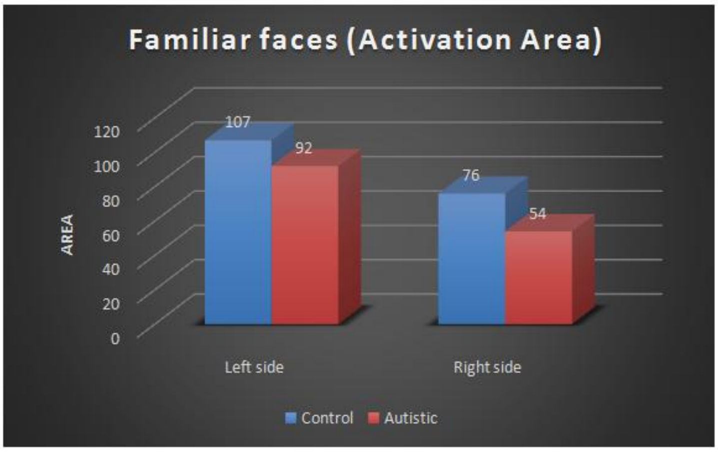


Figure 15: Graphical representation of both control and autistic for stranger faces.

Figure 14shows also activation area is indicated as pink color for left and right sides of fusiform gyrus of brain both of control and autistic for familiar faces. The values are calculated for indicated area of fusiform gyrus. From table 6, for left side, the values are 107 (in pixels) for control and 92 (in pixels) for autistic. For right side, the values are 76 (in pixels) for control and 54 (in pixels) for autistic. From the result values, it is observed that the values for left and right sides of autistic are also smaller than control but the difference of values are very close.

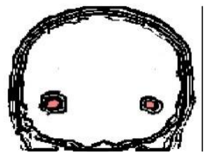
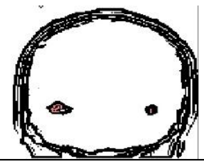
	Control	Autistic
Stranger Faces		

Figure 16: Segmented images of the fusiform gyrus of brain of control and autistic for stranger faces.

Table 7: Calculated values of both control and autism for stranger faces.

For Stranger faces		Area
Control	Left side	126
	Right side	63
Autistic	Left side	65
	Right side	26

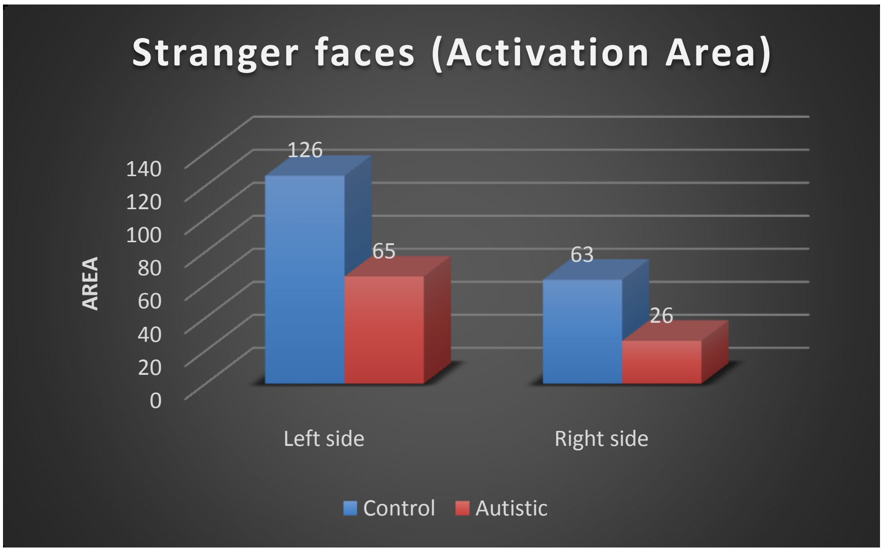


Figure 17: Graphical representation of both control and autistic for stranger faces.

Figure16shows also activation area is indicated as pink color for left and right sides of fusiform gyrus of brain both of control and autistic for all faces. The values are calculated for indicated area of fusiform gyrus. From table 7, for left side, the values are 126 (in pixels) for control and 65 (in pixels) for autistic. For right side, the values are 63 (in pixels) for control and 26 (in pixels) for autistic. From these calculated values, it is observed that the values for left and right sides of autistic are smaller than control.
From the calculating values, it has been observed that the values of activation area for autistic are smaller than control.

IV. Conclusion

By using new operator the edge detection of fusiform gyrus of brain is very clear from different operators (Sobel, Roberts and Prewitt operators). Then applying threshoding, segmentation and binarization operation on fMRI images of control and autistic individuals, it is clearly visualized that there are differences in calculated values of activation area of the fusiform gyrus for three types faces (all faces, familiar faces and stranger faces). From these differences, it has been observed that the activation areas in fusiform gyrus are hypoactive in patient with autism than in control. As the activation area extracted from the fusiform gyrus and its segments is significant, the results of this study could be used to assess the detection human neurological disorders such as autism. It is a simulation model to understand the risk of autistic individuals. To understand more about autism, functional studies of fusiform gyrus and its surroundings are of key interest and molecular level investigations are needed for further detailed study.

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