A Study of Lateral Ventricular Asymmetry in Schizophrenia

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Aim

Our aim is to measure differences in the degree of left/right shape asymmetry in the lateral ventricles of the brains of a group of schizophrenic subjects and a group of control subjects. We obtain, in addition to an intuitive qualitative assessment of shape asymmetry, specific quantitative measures of the degree and localisations of asymmetries, and the differences between the patient and control groups.

Introduction

Investigating brain asymmetry may increase understanding of the aetiology of schizophrenia as well as provide more insight into the nature of the disease. Asymmetry has been investgated in volumetric MR studies, and more recently by morphometric analysis [1] gives a recent review. Crow [2] hypothesised that the loss of asymmetry in schizophrenics accounts for some of the symptoms associated with the disease. Recent studies have both supported and contradicted Crow's hypothesis. Although the lateral ventricles are not involved in complex functions in the brain, lateral ventricular enlargement is a consistent feature associated with schizophrenia. As they are a fluid filled structure, changes in their shape and symmetry can give indications of the changes in adjacent structures of functional importance.

We use a three-dimensional point distribution model (PDM) for our asymmetry analysis. A PDM allows a compact parameterised representation of a number of members of a class of shapes (in this case ventricles). Each member of the class (each ventricle) is represented by the same number of points distributed on its surface at *corresponding* locations. The PDM equation is shown in Equation 1. $\mathbf{x}$ is a shape vector giving an instance of the class, $\mathbf{x}_m$ is the mean of all the shape vectors used in building the model, $\mathbf{P}$ is a matrix whose columns are eigenvectors of a covariance matrix obtained from the aligned shape vectors, and $\mathbf{b}$ is a vector of the eigenvalues of the covariance matrix. Once the PDM is constructed, Equation 1 can be inverted and a **b**-vector can be obtained for each ventricle. The **b**-vector is equivalent to the shape vector as a description of shape, but is of much lower dimension. Each eigenvector in **P** represents a *mode of variation* of the PDM

$$\mathbf{x} = \mathbf{x}_m + \mathbf{Pb} \quad \text{- [Equation 1]}$$

We have previously described the method of construction of a PDM of the ventricles and the analysis of shape differences between the lateral ventricles of a group of control subjects and schizophrenics [3]. In that case we sought to maximise the separation between the control and schizophrenic groups. In our current analysis we seek to investigate the differences in the degree of left/right asymmetry within the control and schizophrenic groups. We therefore seek to maximise the separation between left and right ventricles of the same subject in *shape space* (i.e. a space defined by the b-vectors). To obtain the direction of the discriminant vector, we substitute the difference in the means of the two classes being compared (the standard for the Fisher criterion) with the mean difference between left and right pairs of each individual. The scatter matrix of the standard Fisher criterion is replaced with a paired covariance matrix, the covariance matrix of the differences between the left and right pairs for each individual. More details are available in [4].

Methods

The data and the method of construction of the PDM have been described in a previous publicaiton [3], hence only brief details are given here. T2 MR images of 30 controls (age range 14-45 years, 13F, 17M) and 39 age and sex matched schizophrenics (age range 14-45, 9F, 30M) were used in this study. All images were corrected for MR inhomogeniety, the lateral ventricles were segmented with the guidance of a neuroradiologist. The contours of the left lateral ventricles were reflected to give the same pose as those of the right, resulting in an evaluation set of 138 ventricles for this study. PDMs were constructed in the same manner as that described in our earlier study on shape differences [4]. The resulting **b**-vectors of each ventricle were used in the paired linear discriminant analysis.

Results

We used the first thirty elements of each **b**-vector (which accounted for over 95% of the variation in the model) in asymmetry analysis. A discriminant vector was obtained for separation of the left/right pairs for the control group, and the **b**-vectors of the left and right ventricles were projected onto this vector. The same was done for the schizophrenic group, and the results are shown in Figure 1. For the schizophrenic group the difference in the means of the left and right ventricles on the discriminant vector was 7.94 units, whilst for the control group the difference was 2.48. In both cases the differences were statistically significant (p<<10-6). The localisation of asymmetry for both groups is shown in Figure 2(a) and 2(b).

Discussion

Our results show that there is a significant degree of shape asymmetry between the left and right ventricles of both control subjects and schizophrenics. The extent of shape asymmetry is greater in the schizophrenic group than in the control group. This result contradicts theories such as that of Crow that suggest that schizophrenia is associated with decreased brain asymmetry. However, an interesting aspect of our results is the revealation that the nature of asymmetry in both groups is different. For the control group the greatest asymmetries in shape are found at the tip of the temporal horn and lateral aspect of the frontal horns. In the case of schizophrenics the greatest shape differences were in lower part of the main body of the ventricle.

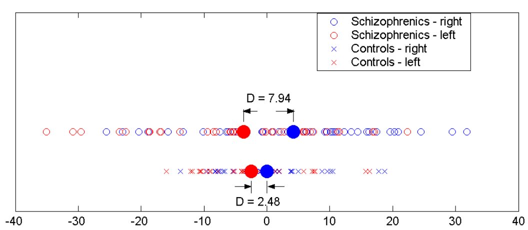

Figure1: Scalar values for projection of b-vectors onto the discriminant Vector for the schizophrenic group (above) and the control group.

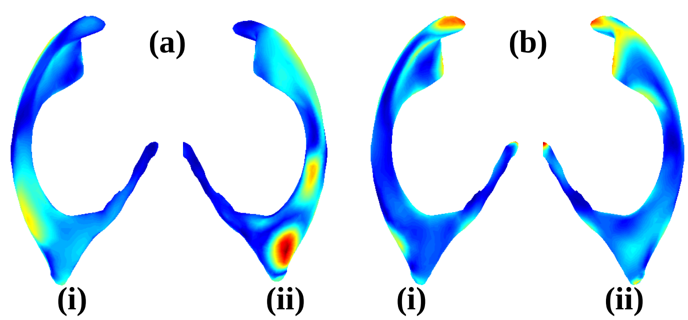

Figure 2: Localised shape differences between left and right means of the schizophrenic (a) and the control (b) groups. In both cases (i) is the view from the lateral aspect and (ii) the view from the medial aspect.

References

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