Automated classification of SLE and APL patients and normal controls using fMRI and DTI features

A. Vo[1], A. M. Ulug[1,2], E. Kozora[3,4], G. Ramon[5], J. Vega[5], R. D. Zimmerman[6], D. Erkan[5], and M. D. Lockshin[5]

[1]The Feinstein Institute for Medical Research, Manhasset, New York, United States, [2]Department of Radiology, Albert Einstein School of Medicine, Bronx, New York, United States, [3]National Jewish Health, Denver, Colorado, United States, [4]University of Colorado Medical Center, Denver, Colorado, United States, [5]Hospital for Special Surgery, New York, New York, United States, [6]Weill Medical College of Cornell University, New York, New York, United States

Introduction

Most patients with systemic lupus erythematosus (SLE) have cognitive dysfunction suggesting but clinically important central nervous system involvement [1]. Antiphospholipid syndrome is another autoimmune disorder defined as the presence of arterial or venous thromboses and/or pregnancy morbidity with persistent antiphospholipid antibodies (APL). Diffusion tensor imaging (DTI) and fMRI have been used to study the SLE and APL patients [2-7]. The purpose of this study is to use both fMRI and DTI features to automatically classify SLEs, APLs and normal controls.

Subjects and Methods

Twenty SLE patients, ten APL patients and ten normal controls were studied. We acquired the MR images with a 3T clinical scanner. A 3D volumetric image set, diffusion tensor images including 5 b0 and 33 diffusion weighted images and functional MR images were acquired. The b-value in the DWIs was 800 s/mm^2. The DTI protocol included 60 slices of 2.6 mm thickness, FOV 240 mm, image matrix of 128x128 zero filled to 256x256 and 15 sec TR. After DTI data acquisition, fractional anisotropy (FA) maps were reconstructed and registered to a standard MNI template using FSL software. The fMRI protocol included FOV of 240 mm, 5mm slice thickness, imaging matrix of 64x64, pulse angle of 70 degrees and TR of 2 sec. Four fMRI paradigms, finger tapping, word generation, rhyming and N-back were used in our experiment. SPM is used to determine activation maps in each paradigm. SPM is then used to determine volumes (VOI) with significant group differences. The FA maps were also registered to the MNI template and the significant group differences were determined with SPM. Once a VOI is determined, the data from each paradigm is measured and considered as a "feature." The forward feature selection procedure [8] and kmean clustering were then used to select features of importance and discriminant analysis classifier [9] was used to classify subjects according to their group. Feature vectors are normalized to have a zero mean and unit variance before classification step.

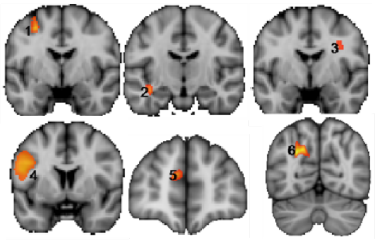

Figure 1: Six selected significant features.

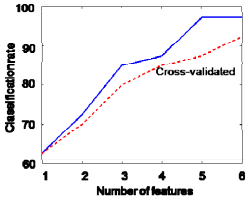

Figure 2: Classification rate of 3 groups versus number of features.

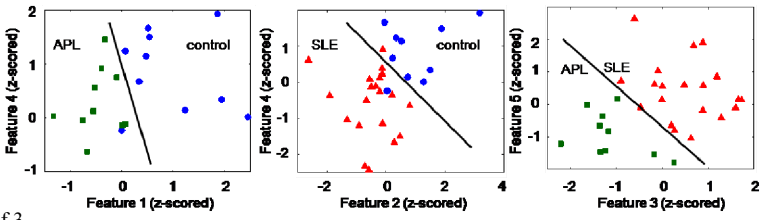

Figure 3: Two groups classified by two significant features only.

Results

After analyzing fMRI and DTI images, we obtained 56 volumes of interest (VOIs) and 280 features from activation and group difference maps of finger tapping, word generation rhyming and NBack as well as FA maps. We found six significant features (Fig. 1), which include two features from word generation activation map (1,2), one from rhyming (3), one from N-back (4) and two from FA group difference (5,6) using the forward feature selection and kmean clustering method. Classification rates of 40 subjects from three groups versus numbers of features were shown in Fig. 2. In cross validation each subject was classified by the functions derived from all subjects other than that subject (leave one out method). We also showed scatter plots of two groups in Fig. 3 using two significant features.

Discussion/Conclusions

Six features that are found, are in Broca (1, 4), hippocampus (2), prefrontal cortex BA8 (3), BA10 (5), and superior parietal lobe (6) (Figure 1). These results suggest that these six regions are important in the disease processes of APL and SLE. With these 6 features, 39 of 40 subjects were correctly classified into three groups. When we use subjects from two groups only, we were able to separate two groups with accuracy more than 93% with using only 2 features. The rhyming activation map in BA8 (3) and FA values in BA10 (5) played a key role to discriminate SLE and APL subjects. The word generation maps in Broca (1), hippocampus (2) and NBack map in Broca (4) are the most significant VOIs to recognize APLs and SLEs from normal control subjects.

Acknowledgments

This study was supported in part by Kirkland Foundation.

References

1) Sibbitt WL, *et al*. Arthritis&Rheumatism 42, 2026 (1999). 2) Zhang L, *et al*. MRI 25, 399-405 (2007). 3) Ulug AM, *et al*. in ESMRMB 2009 p.314. 4) DiFrancesco MW, *et al*. Arthritis & Rheumatism 56, 4151(2007). 5) Fitzgibbon BM, *et al.* Rheumatology 47, 50 (2008). 6) Rocca MA, *et al.* Neuroimage 30, 478(2006). 7) Ulug AM, *et al*. in ISMRM 2010 p.4466. 8) Kohavia,R. *et al*. Artificial Intelligence, 97, 273 (1997). 9) Krzanowski,W.J. Principles of Multivariate Analysis, (1988).