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Detection of Local Cortical Asymmetry via Discriminant Power Analysis

Moo K. Chung, Daniel J. Kelley, Kim M. Dalton, Richard J. Davidson
Waisman Laboratory for Brain Imaging and Behvaior,
University of Wisconsin, Madison, WI, United States

Introduction:
We present a discriminant power analysis framework that can be used in localizing the abnormal cortical thickness asymmetry pattern in a clinical group compared with a control group. In our example, we show that a group of high functioning autistic subjects has a cortical thickness asymmetry pattern that differs reliably from controls. Unlike previous literature, our approach does not require any preselected feature vectors and performs the classification at each mesh vertex.

Methods:
Data. Three Tesla T1-weighted MR scans were acquired for n=28 subjects (16 high functioning autistic and 12 control right-handed males). After a sequence of image preprocessing steps, cortical thickness is obtained. The *weighted spherical harmonic representation* (Chung et al., 2007) is used to smooth out both noisy cortical thickness and cortical surfaces, and register surfaces in a unified Hilbert space framework. A cortical asymmetry index of type (L-R)/(L+R) is constructed on the template surface, which is obtained by averaging the weighted spherical harmonic representation. Figure 1 shows the proposed analysis flow.

Logistic model. In almost all two-group comparison settings in brain imaging, the two-sample t-test with the equal variance assumption has been used as a test procedure. This hypothesis driven approach introduces a multiple comparison correction issue.
We use a different approach called the *logistic discriminant analysis* that bypasses the multiple comparison issue and still able to locally detect the regions of abnormal asymmetry pattern in the autistic subjects. Let Y be the clinical status of a subject modeled as a Bernoulli random variable, i.e. Y=1 if the subject is autistic and 0 otherwise. We set up a logistic model that links the probability of clinical status to predictor variables such as age, gender and cortical thickness. The parameters of the model are estimated by maximizing the likelihood function using the Newton-Raphson method.

Discriminant power. Once the parameters are estimated, subjects are classified as autistic if P(Y=1) > P(Y=0) and control otherwise. The classification error rate r, which is the overall probability of misclassifiction, is estimated by the leave-one-out cross-validation scheme. The *discriminant power* (DP) is then given as 1-r and it is displayed in Figure 1 localizing the regions of abnormal asymmetry pattern in autistic subjects.
In order to show that the DP-map can be used as an alterative to the usual P-value map, we determined the statistical significance of DP using Press's Q-statistic (Hair et al., 1998). Figure 2 shows the P-value plot of Press's Q-statistic as a function of DP for various sample sizes (n=10, 28, 100). For n=28, DP=0.85 corresponds to the small P-value of 0.0002.

Results:
The pre- and post- central gyri, inferior frontal gyrus and orbitofrontal cortex show high DP in Figure 1. The red cluster in the inferior midline is where the brain step has been cut off.

Conclusions:
The DP-map can be used to localize the regions of abnormal cortical asymmetry pattern in the autistic group.

References:
Chung, M.K. et al., 2007. IEEE Transactions on Medical Imaging. 26:566-581.
Hair et al., 1998. Multivariate Data Analysis. Prentice hall, Inc.

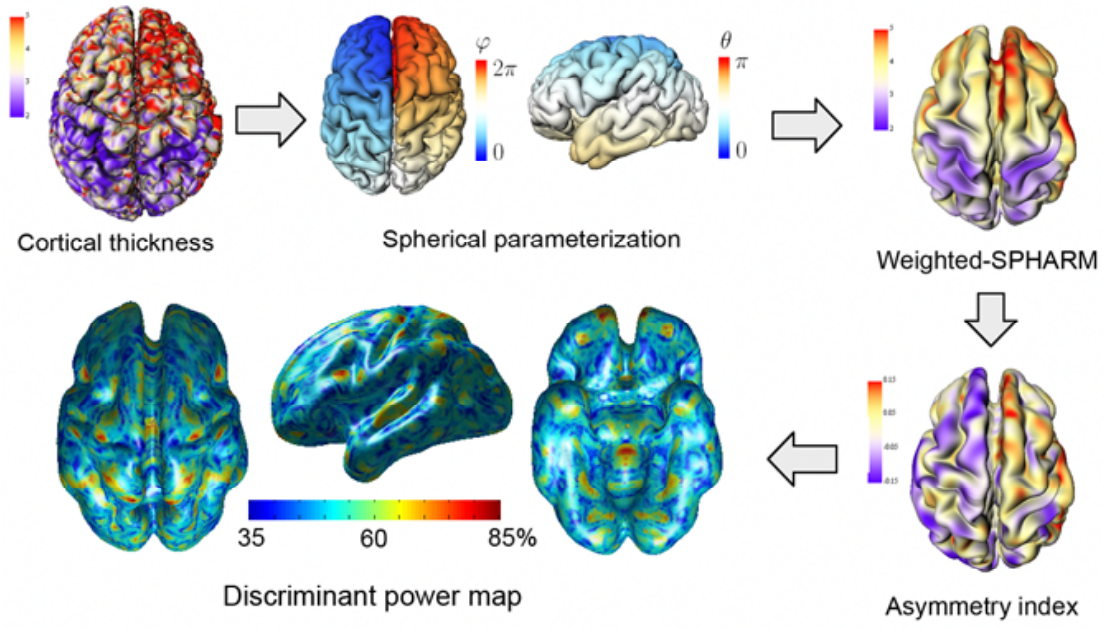

Figure 1.

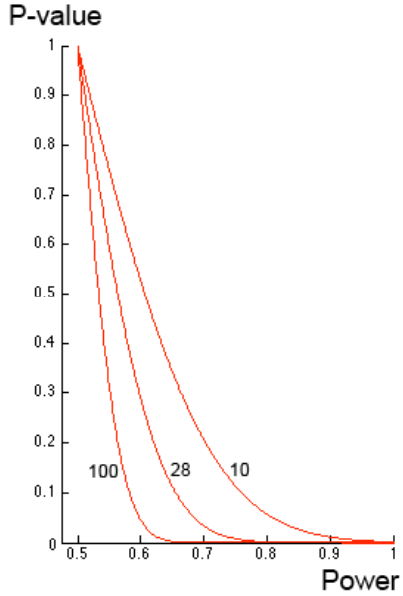

Figure 2.