Diagnostic classification of autism using particle swarm optimization for fMRI feature selection

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Introduction:

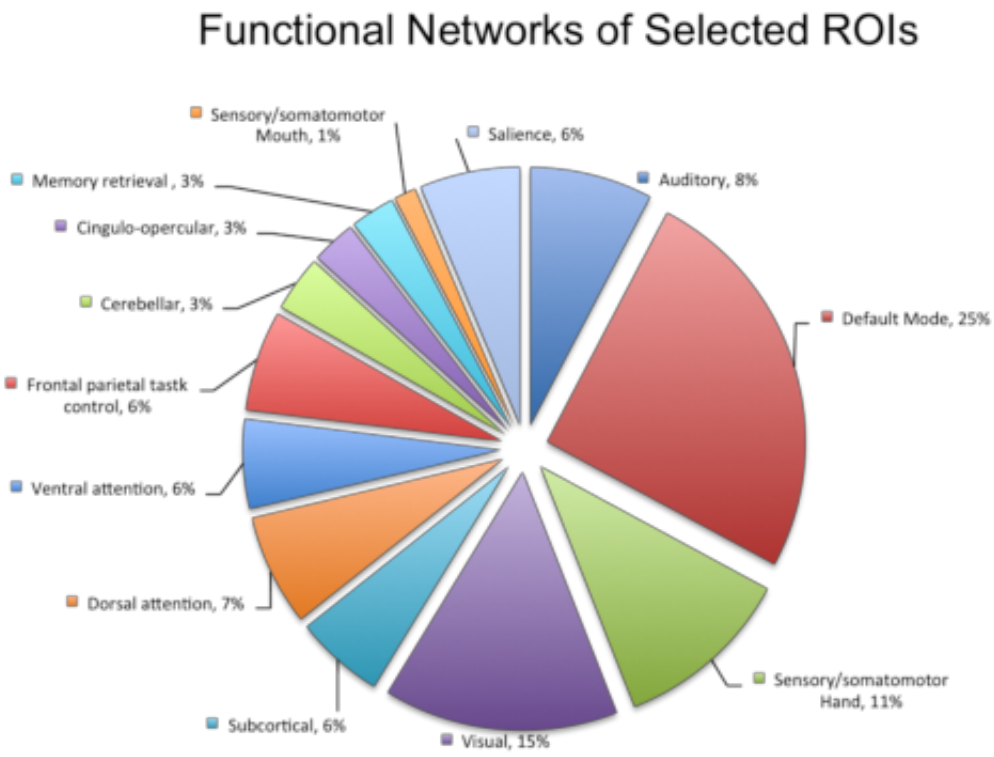
Autism spectrum disorder (ASD) is a developmental disorder characterized by sociocommunicative impairment. Mounting evidence suggests aberrant connectivity in ASD involving multiple brain networks. Accurate diagnostic classification of functional connectivity MRI (fcMRI) data from ASD vs. typically developing (TD) brain is a promising tool for the identification of complex biomarkers. Despite strong evidence of aberrant connectivity, most attempts to classify ASD from TD using fMRI data still perform just above chance. In the present study, we performed feature selection using particle swarm optimization (PSO) algorithm for improved classification performance of a support vector machine (SVM) on ASD and TD fcMRI data.

Methods:

Resting state fMRI data were collected for 6 minutes from 27 ASD and 25 typically developing (TD) children and adolescents, matched on age, sex, IQ, and head motion. FMRI data were motion and field map corrected, aligned to high-resolution anatomicals, standardized to the MNI152 template, and blurred to a 6mm global full-width-at-half-maximum. Six rigid-body motion parameters and signal from white matter were modeled as nuisance regressors. Time points (and their neighbors) with motion >1.5mm were censored; data sets with <5 minutes remaining were excluded.
PSO is a bio-inspired, stochastic optimization algorithm useful for searching high-dimensional problem spaces. Its implementation here was based on Wang et al. (2007). We chose 264 regions of interest (ROIs) defined by meta-analysis in Power et al (2011), using 10-mm spheres to extract an average signal from each. For all possible pairs of ROIs, a feature was defined as the functional connectivity (signal correlation) between them. Twenty particles were initially randomized throughout the search space, where each particle's position denoted a set of selected features (connections). The fitness of a particle was defined as the percentage of participants accurately classified using SVM with leave-one-out cross-validation. Based on the fitness score, each particle's position was updated to be more similar to the particle's individual best performance and to the globally best-performing particle, while maintaining randomness in its movement, as to continue exploring the search space. This process was repeated for 70 iterations, and the highest-performing particle was then further analyzed.

Results:

The highest-performing particle selected 78 features (connections) and scored 88% classification accuracy. The 78 features included both overconnected (ASD>TD) and underconnected ROI pairs. Selected connections had an average Euclidean distance of 82.5 mm and were primarily inter-network (93%), as opposed to intra-network (8%). Of the ROIs included in these informative connections, 27% were in the default mode network (DMN) and 16% in the visual network.



Conclusions:

Using PSO, SVM reached an 88% accuracy classifying fMRI data from ASD vs. TD participants. Selected most informative features were overall consistent with the literature, implicating primarily long-distance connectivity, in particular of DMN and visual regions. Informative connections were characterized by mixtures of over- and underconnectivity, suggesting that fcMRI biomarkers may be found in aberrant (but not necessarily reduced) connectivity in ASD.

Disorders of the Nervous System:

Autism

Power J.D., (2011), 'Functional Network Organization of the Human Brain', Neuron, vol. 72, pp. 665-789.

Wang X., (2007), 'Feature Selection Based on Rough Sets and Particle Swarm Optimization', Pattern Recognition Letters, vol. 28, pp. 459-471.