Valid Detection of Autism Spectrum Disorder in Male Children with Structural and Functional MRI Data Using Machine Learning Classification

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Introduction

- Autism Spectrum Disorders (**ASD**) - set of **neurodevelopmental** disorders that can vary in severity
- Classified using **DSM-5** criteria

Characterization:
- ASD is characterized by **deficits** in social communication and interaction, as well as **restrictive** and **repetitive** behaviors and interests

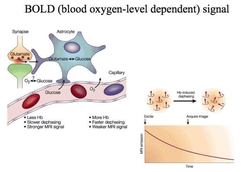
Development:
- Exact manner of **development** for ASD **unknown**
  - Evidence points towards **genetic liability**
    - 1 in 37 boys
    - 1 in 151 girls

Research:
- Machine learning techniques for the detection of ASD are being research as a result of advances in neuroimaging

Literature Review

Females with ASD:
- Vary in **neural** and **behavioral** characteristi**cs**
- **High IQ** females with ASD **develop coping strategies** and may be under diagnosed
- Females may display **different types** of restrictive or repetitive behaviors
- For this study, subjects will only be male

Magnetic Resonance Imaging:
- Utilizes magnetic field gradients and radio waves
- Structural MRIs (**sMRI**) scan **anatomy**
- Functional MRIs (**fMRI**) scan **metabolic function** and **activity**
- Recent studies used **pattern classification** techniques to analyze sMRI and fMRI data **independently**
- **Machine learning** is used to highlight brain structures and **functional connectivity** (FC) network signals associated with ASD



Gap in Research

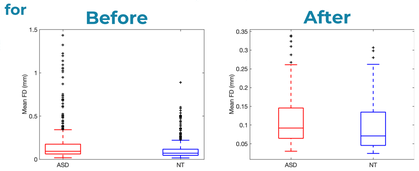
There is a lack of **valid automated detection** for ASD in male children

Goal of Research

Create a **machine learning technique** to **detect ASD** in Male Children

Methodology

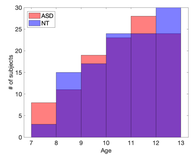
Subjects:
- **1112 subjects** taken from the Autism Brain Imaging Data Exchange (ABIDE I) Database
- 539 subjects had ASD and 573 were neurotypical (NT) controls
- Applied **filtering for**
  - Male children
  - 6.5 - 13 years old
  - Low motion



Reasoning:
- Male children
  - Differences in **development** and **characteristics** lead to differences in **neural psychopathol**ogy in ASD
  - Majority of ASD subjects are male
- 6.5 - 13 years old
  - **Age** affects FC measurements
  - FC measurements change aro**und adulthood**
  - Younger age at detection is mo**st helpful for intervention** treatment

Subject Demographics:
- **Age**, full scale intelligence quotient (**FIQ**), and **ADOS** scores were **analyzed**
- **Distribution** of these data were graphed using box plots and histograms
- Maximize age and FIQ **matching** between NT and ASD groups
- Important to **identify outliers** for data integrity

Final Filtering:
- After filtering to find subjects with
  - No **outlying** FIQ and ADOS figures
  - **Low** functional **motion**
  - **Passing** structural **ratings** for motion
- Left with 226 subjects
  - 113 ASD
  - 113 NT



Functional and Structural MRI Data Processing:
- **fMRIs** from ABIDE I database **available preprocessed** from the Preprocessed Connectomes Project
- These preprocessed data is **adapted** for machine learning
  - Motion **correction**
  - Intensity **normalization**
  - Nuisance **signal removal**
- Whole-brain **connectomes** used as **biomarker inputs**

- Preprocessed sMRI **data** from ABIDE I database made available through the Preprocessed Connectomes Project
- Intensity normalization
- Skull stripping
- Basic biomarkers taken from structural data
  - Biomarkers use to identify ASD
    - Cortical **thickness**
    - Cortical **surface area**

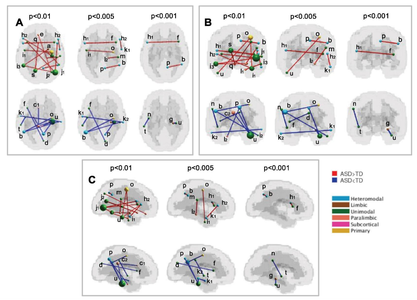
Machine Learning Classification:
- Linear kernel Support Vector Machine (L-SVM) **classification** completed on the **structural and functional inputs** for each brain network
- Integrated predictive model for set of both FC measures and structural biomarkers are used to **classify** each subject as ASD or neurotypical
- Model will also be capable of predicting **ADOS** scores

- Final predictive model
  - Conducted **cross validation** test
    - Shows model's ability to diagnose ASD on **unfamiliar** data
  - Dataset is **split** into training and testing data
  - The predictive model is trained using a **portion** of ABIDE I dataset and tested using data that it was **not trained on**
    - Next iteration, model **trained** with previous testing data and **tested** with training data, etc

Hypothesized Results

Validity:
- Run **statistical analysis** tests with predictive model to show significance of findings

Accuracy:
- Predictive model will be capable of detecting ASD with over **90% accuracy**
- Predictive capabilities are improved upon compared to previous studies due to the **combination** of **fMRI** and **sMRI**
- Previous study to combine fMRI and sMRI did not **refine** subject set to match data and still found >85% accuracy
- Brain regions previously **identified** as **disrupted** in ASD subjects consistently **contributed greatest alterations** in FC measurement



Discussion

Clinical Application:
- Algorithm could be used in **public hospitals** to detect ASD at a **young age**

Early Intervention:
- **Increase success rate** of treatment to **help assimilate** children with ASD **into** a **school** environment

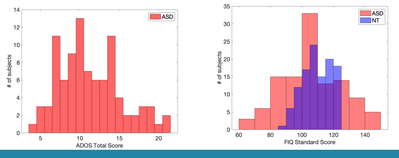
Severity:
- Predicts **ADOS** scores and **detection** of **brain regions** most **heavily impacted** by ASD

Limitations

Subjects:
- The **sample size** is relatively **small**. A **homogeneous** dataset would preform better.

Demographic:
- The ASD subjects had a **larger spread** of FIQ scores.

Site Variation
- Different sites held sMRIs and fMRIs with different site **parameters** and **scanning protocols**.



Conclusion

Gap in Research:
- **Lack** of **valid detection** of ASD in male children
- Aimed to create a **machine learning technique** to **detect ASD** in Male Children
- Utilized **publicly available** data from the ABIDE I database
  - **Filtered** for subjects that require **early detection**
- **Trained** machine learning **algorithm** on 226 subjects with **final accuracy** of ~ **90%**

Future Research

- With a larger **dataset** of younger ASD and neurotypical subjects, using sites with **similar scanning protocol** and **reduced FIQ and age ranges**, this method of differentiation between individuals with ASD and TC may **become valid at an even younger age**
- **Explicit testing** of algorithm **against alternative datasets** to **generalize ability** of detection
- **Application** of detection algorithm **for female subjects**
- Test **alternative** Machine Learning **methods** such as Deep Learning and Neural Networks

Acknowledgements

- The ABIDE Dataset
- The Preprocessed Connectomes Project
- My mentor, Mr. Jeffrey Eilbott
- My family
- My Science Research teacher, Ms. Gillian Rinaldo
- My Science Research Peers

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