Quantitative Magnetic Resonance Imaging to Measure Brain Microstructure in ASD

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Develop and apply advanced brain imaging techniques to:

• Determine changes in the brain specific to autism and linked to symptoms and outcomes

• Identify brain-based biomarkers that inform on causes of autism, neural mechanisms involved, aid in early diagnosis, preventive interventions, and treatment
Magnetic Resonance Imaging

Brain Camera

Brain Image
Magnetic Resonance Imaging
Magnetic Resonance Imaging in ASD

Participant 1

Participant 2
Magnetic Resonance Imaging
Magnetic Resonance Imaging

Anatomy / Brain Structure

Function

Microstructure
Diffusion Tensor Imaging

- Probes tissue microstructure by investigating how water molecules diffuse throughout the brain.
- Diffusion Tensor Imaging (DTI): provides quantitative measures sensitive to underlying white matter microstructure.

- Fractional Anisotropy (FA)
- Mean Diffusivity (MD)
- Radial Diffusivity (RD)
- Axial Diffusivity (AD)
White Matter Matters

Gray Matter = ‘Processing Centers’ or ‘Information Hubs’
White Matter = ‘Brain Wiring’ or ‘Information Highways’
White Matter Matters in ASD

Travers et al., 2015
White Matter Matters in ASD

Dean et al., In Prep
White Matter Variation Across ASD

- Widespread heterogeneity across individual white matter regions
- Individual differences depend on white matter region

Dean et al., NeuroImage Clinical, 2017
• Combining multiple white matter measures together provides greater sensitivity for identifying ASD individuals than just looking at single brain regions.

Dean et al., NeuroImage Clinical, 2017
Diffusion Tensor Imaging

Fibre Organization
- Increasing FA
- Increasing AD
- Decreasing RD

Myelin Formation
- Increasing FA
- Increasing AD
- Decreasing RD

Myelin Remodeling
- Increasing RD

Astrocyte Changes
- Decreasing FA
- Decreasing AD

Fractional Anisotropy (FA)

Mean Diffusivity (MD)

Radial Diffusivity (RD)

Axial Diffusivity (AD)

Non-specific!
Improved measurement and characterization of white matter is important for understanding processes underlying neural diversity in ASD.

Neurite Orientation Dispersion and Density Imaging (NODDI)
- Unique measures shown associated with microstructure,
- Have not been extensively examined in ASD populations

FICVF  ODI  v_{ISO}
Lower FICVF (i.e. lower neurite density) bilateral thalamus

Dean et al., In Prep
Microstructural Imaging in ASD

Dean et al., In Prep
Microstructural Imaging in ASD

$\text{r} = -0.41$

$p = 0.004$

Dean et al., In Prep
Microstructural Imaging in ASD

Higher ODI (i.e. greater dispersion) in corpus callosum and thalamus

Lower ODI (i.e. less dispersion) in internal capsules and right superior longitudinal fasciculus

Dean et al., In Prep
Summary

• White matter microstructure plays important role in neurobiology of ASD

• Despite group level differences between ASD individuals and typically developing controls, widespread individual variation exists within the brain.

• Emerging microstructural imaging techniques, like NODDI (and others), provide new approaches for studying white matter and may inform processes underlying microstructural diversity in ASD
Future Directions: Looking For Answers In Early Brain Development
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- Early brain development plays critical role in later brain development and development of behavior and cognition.
Future Directions: Looking For Answers In Early Brain Development

Brain Growth in Children

- Do not know how the neurodevelopmental trajectory of ASD during early life.

- Can microstructural imaging provide new information about ASD neurodevelopment
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