The role of neuroimaging beyond T1-weighted MRI in the diagnosis and prediction of neuropsychiatric disorders

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Overview

1. Background: Defining the scope of the lecture.
2. State-of-the-art: How is neuroimaging beyond T1-weighted MRI currently being used with respect to neuropsychiatric disorders.
3. The future: Challenges and opportunities in using neuroimaging for predicting neuropsychiatric disorders moving forward.

Background

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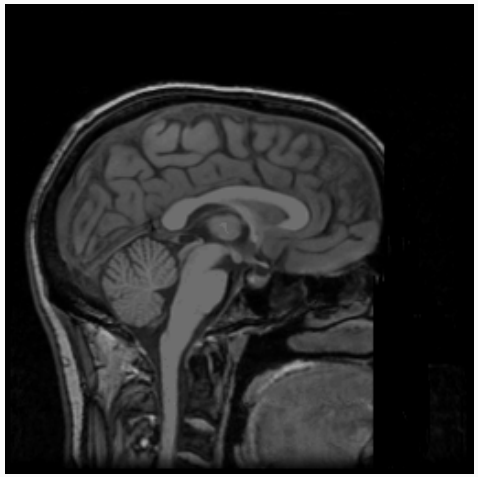

Bert from FreeSurfer 7.3

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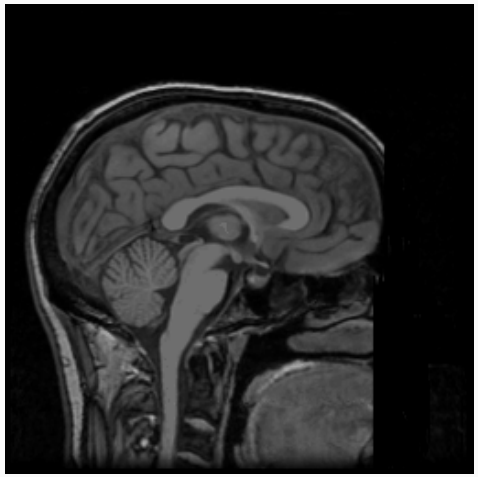

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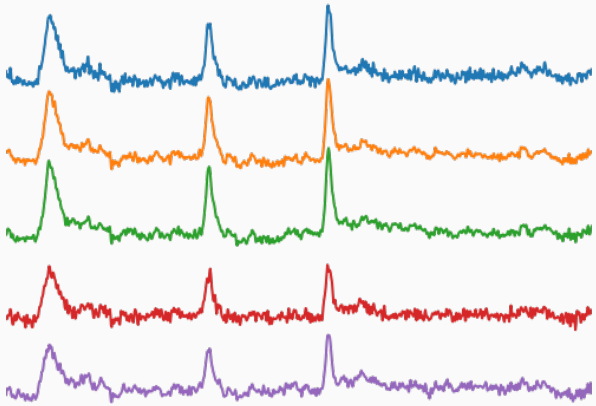

Sample from the MNE library

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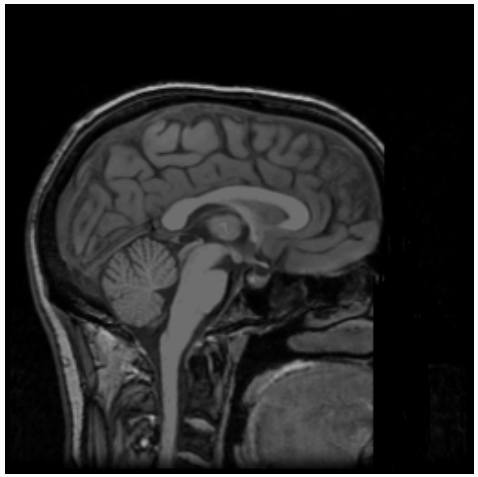

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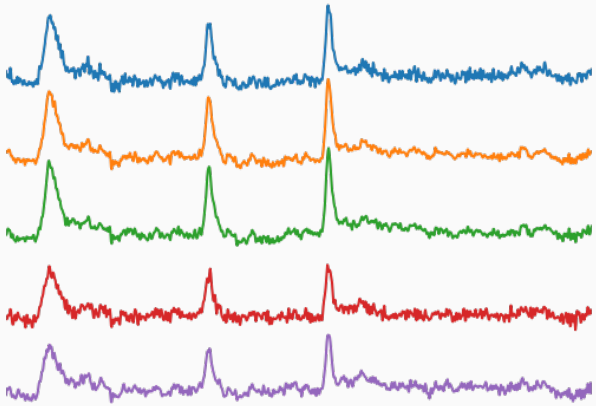

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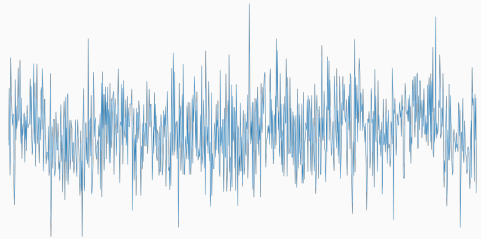

Sample from Tremlay et al., 2016

Tremblay, R., Lee, S., & Rudy, B. (2016). GABAergic interneurons in the neocortex: from cellular properties to circuits. Neuron, 91(2), 260-292

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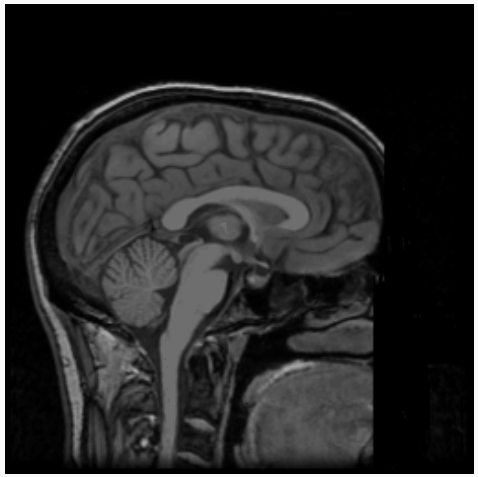

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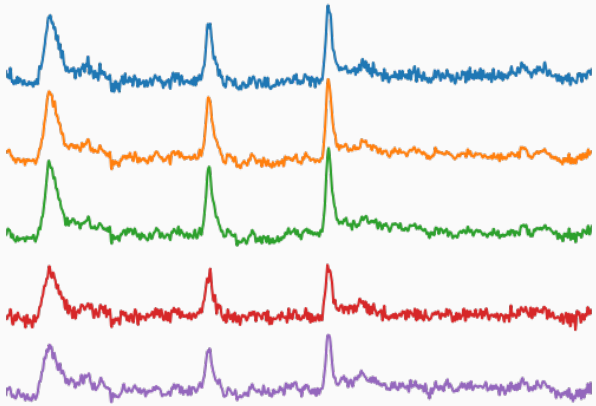

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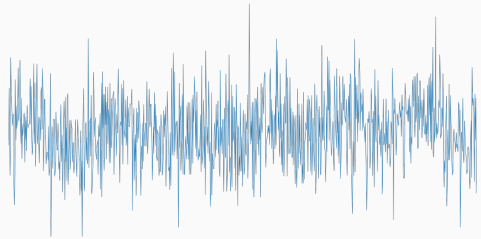

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Meta Quest Pro

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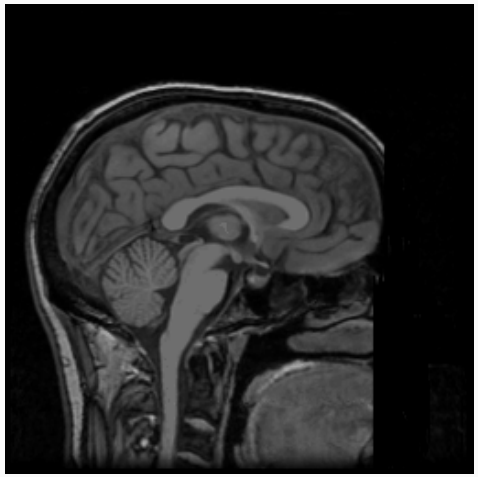

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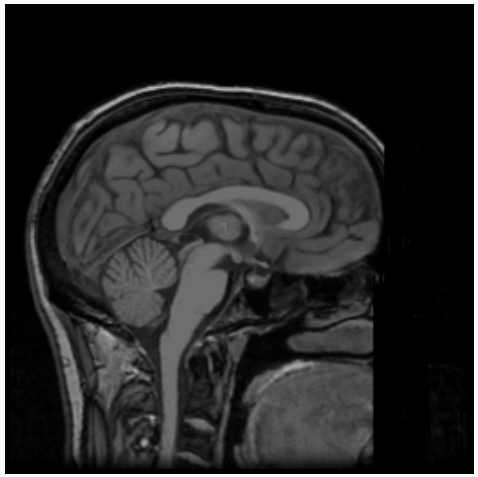

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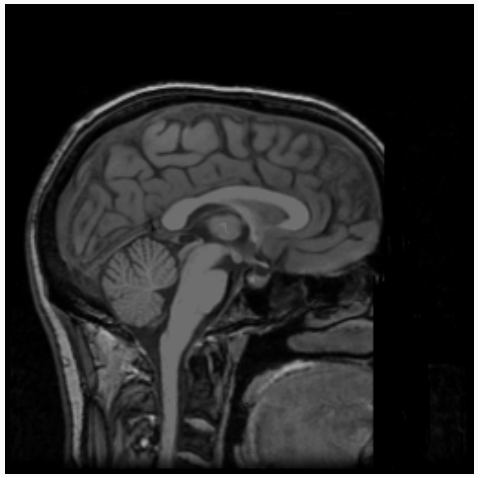

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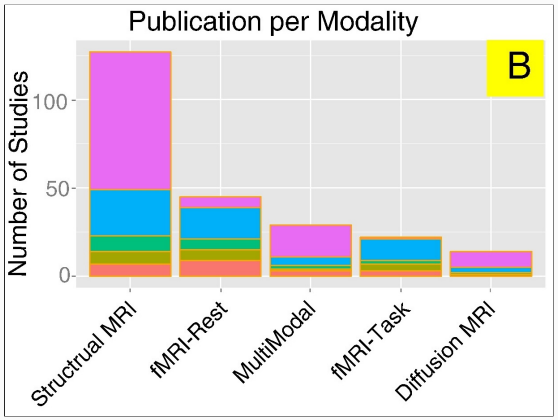

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Arbabshirani, M. R., Plis, S., Sui, J., & Calhoun, V. D. (2017). Single subject prediction of brain disorders inneuroimaging: Promises

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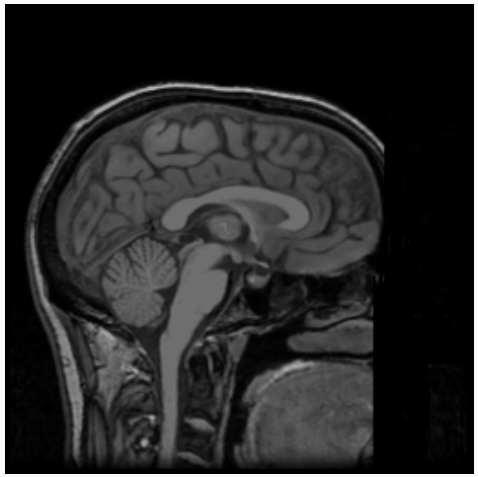

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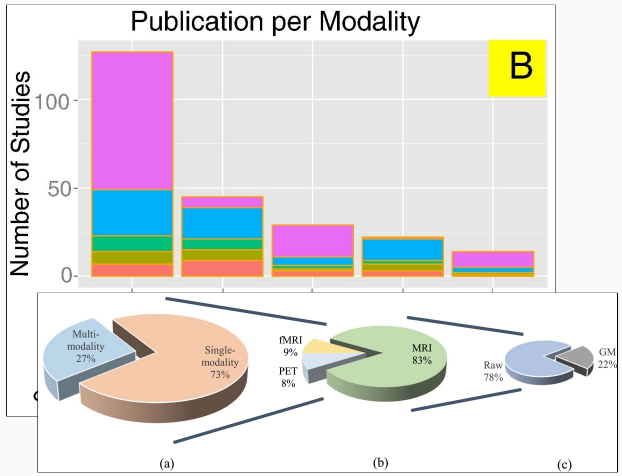

Ebrahimighahnavieh et al., 2020

Ebrahimighahnavieh, M. A., Luo, S., & Chiong, R. (2020). Deep learning to detect Alzheimer's disease from neuroimaging: A systematic literature review. Computer methods and programs in biomedicine, 187, 105242

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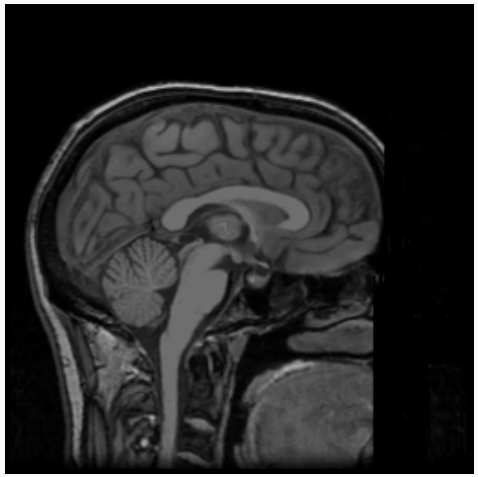

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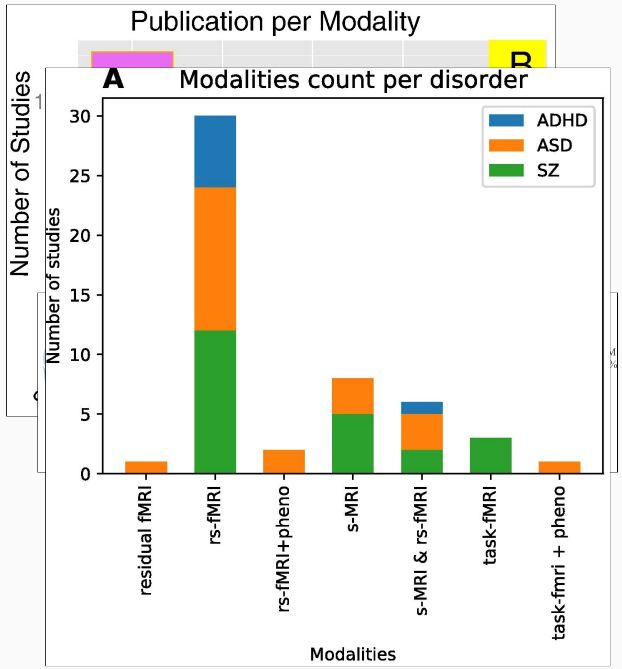

Quaak et al., 2020

Quaak, M., van de Mortel, L., Thomas, R. M., & van Wingen, G. (2021). Deep learning applications for the classification of psychiatric disorders using neuroimaging data: systematic review and meta-analysis. NeuroImage: Clinical, 30, 102584

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Alzheimer's disease and other causes of dementia

Multiple Sclerosis

Parkinson's Disease

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Multiple Sclerosis

Parkinson's Disease

Bipolar Disorder

Schizophrenia

Depressive disorders

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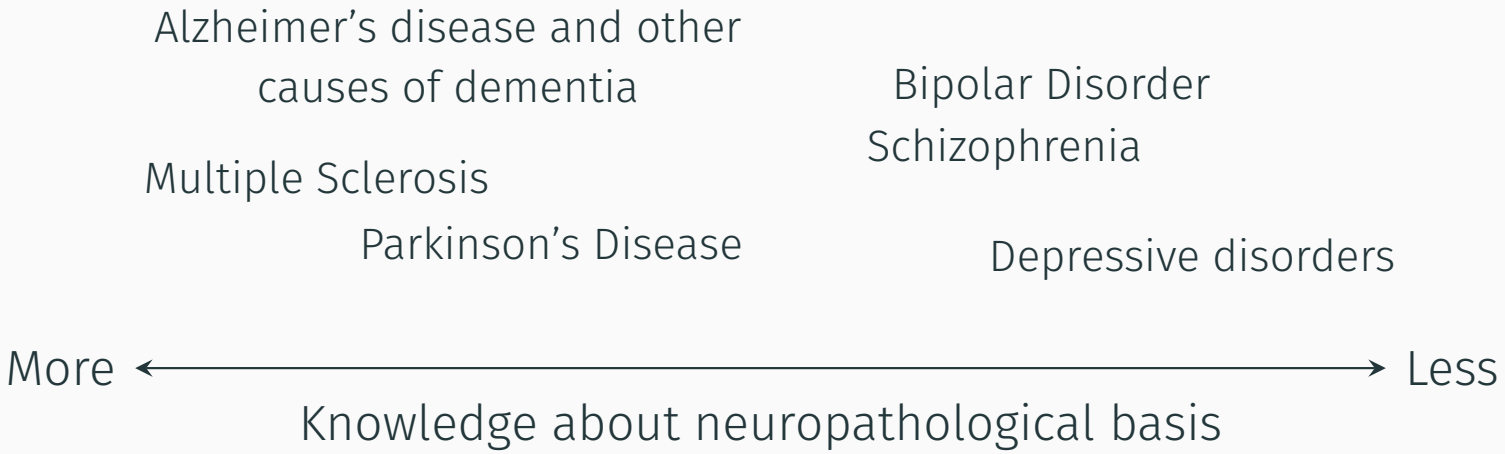

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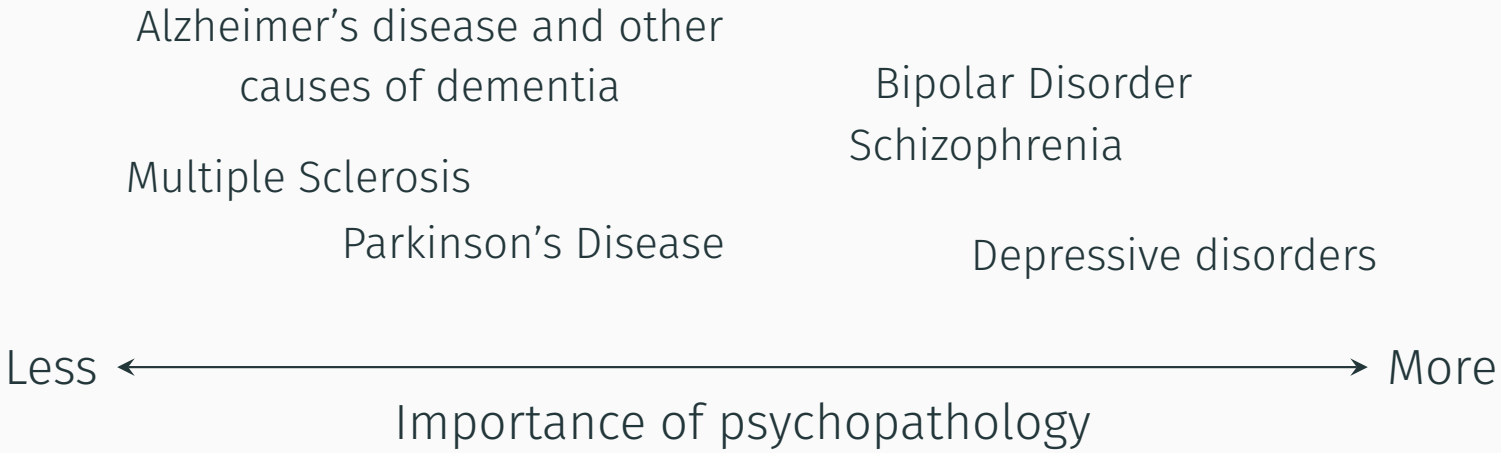

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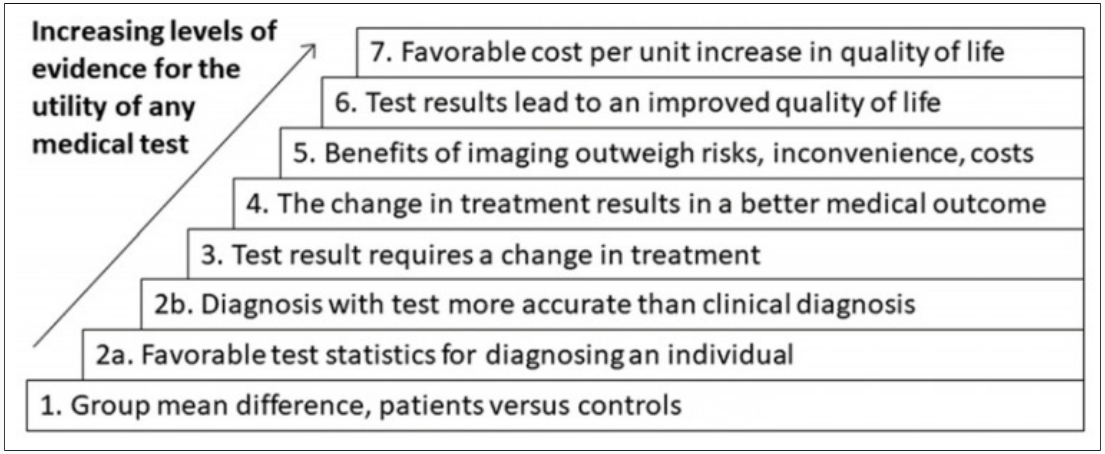

Vogel & Black (2024)

Vogel, A. C., & Black, K. J. (2024). Brain Imaging in Routine Psychiatric Practice. Missouri Medicine, 121(1), 37

The current roles of neuroimaging modalities

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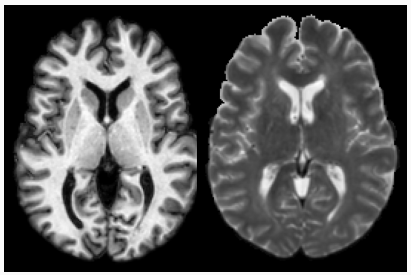
Other structural MRI modalities

T1

Other structural MRI modalities

T1 T2



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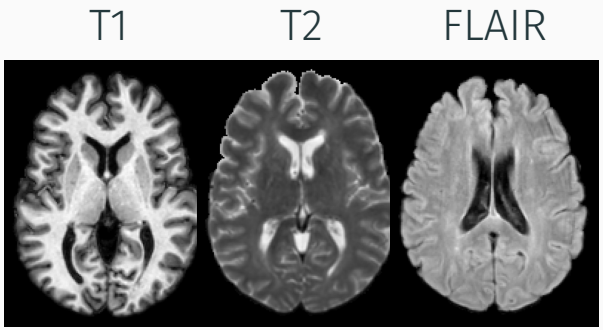

Adapted from Shoeibi et al., 2021

Shoeibi, A., Khodatars, M., Jafari, M., Moridian, P., Rezaei, M., Alizadehsani, R., ... & Acharya, U. R. (2021). Applications of deep learning techniques for automated multiple sclerosis detection using magnetic resonance imaging: A review. Computers in Biology and Medicine, 136, 104697

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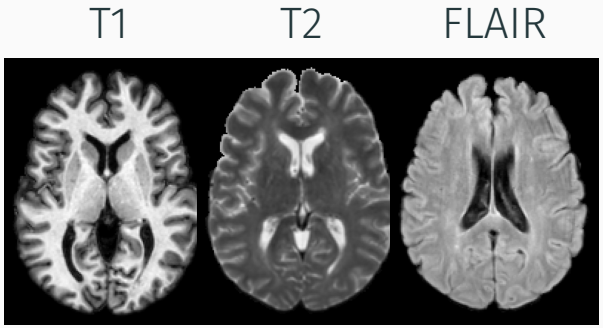

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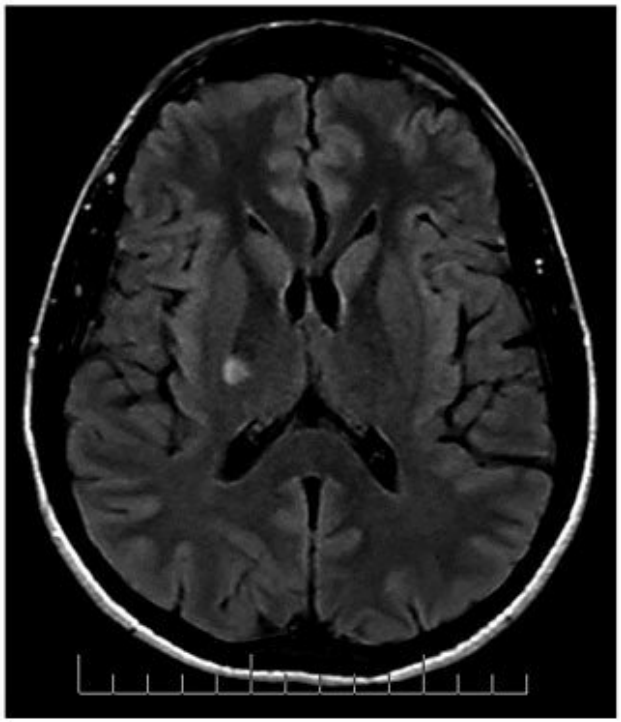

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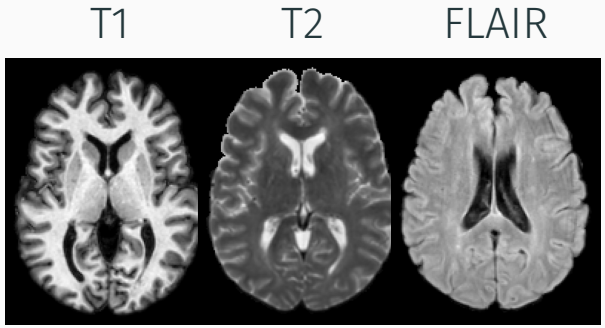

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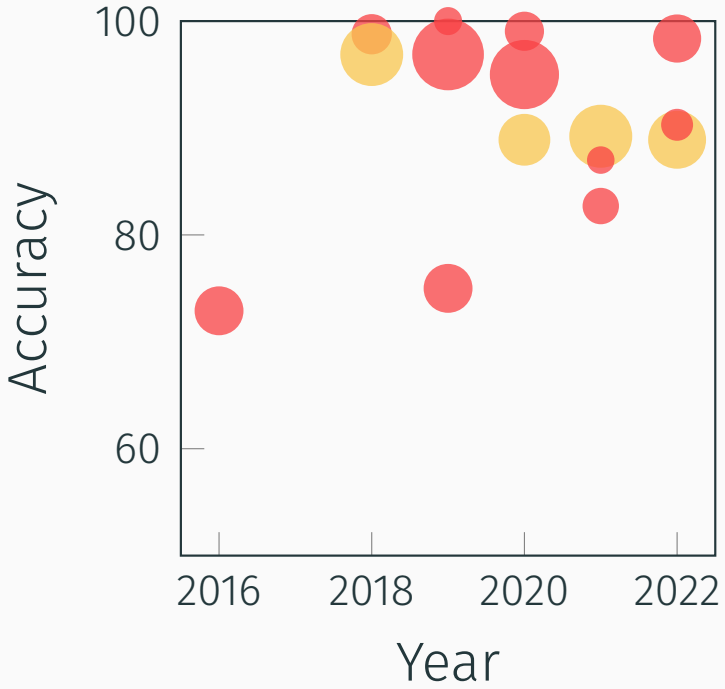

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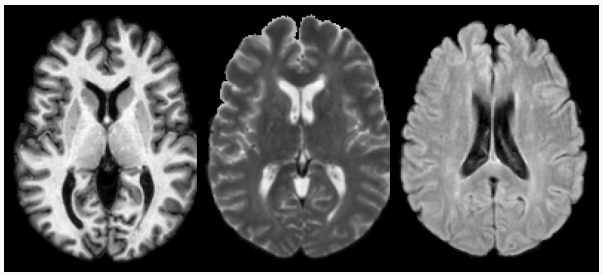

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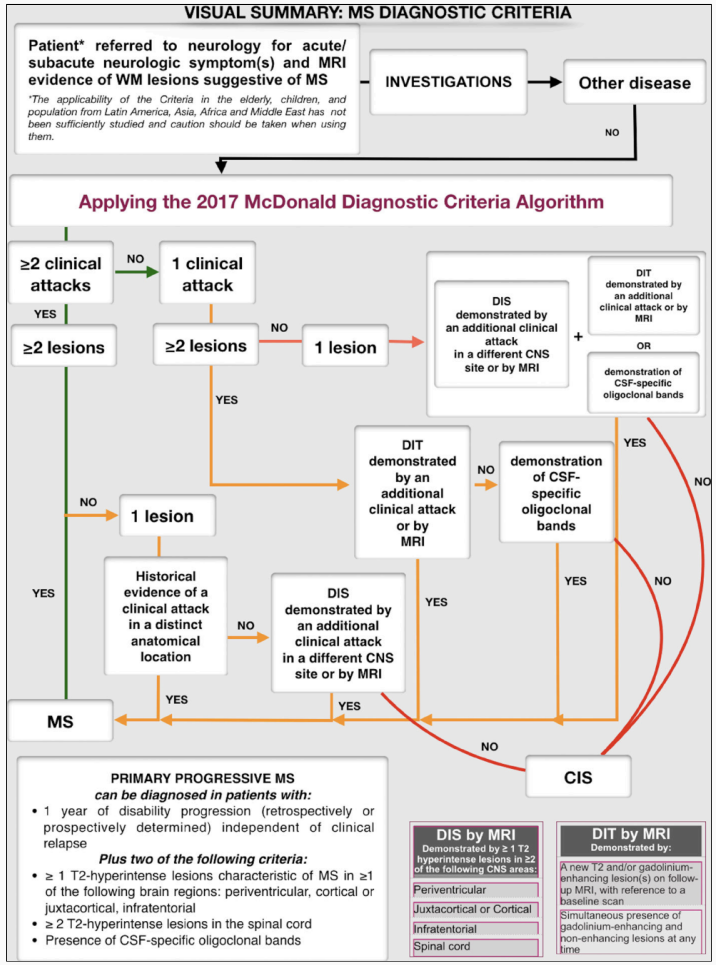
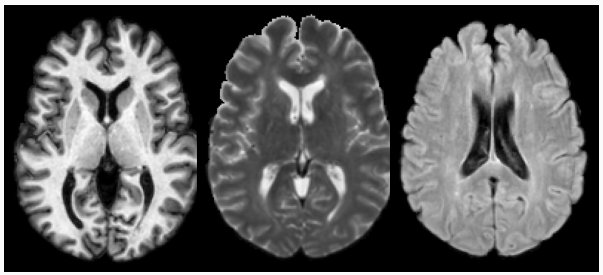


De Angelis et al., 2019

De Angelis, F., Brownlee, W. J., Chard, D. T., & Trip, S. A. (2019). New MS diagnostic criteria in practice. Practical Neurology, 19(1), 64-67

Other structural MRI modalities

T1 T2 FLAIR



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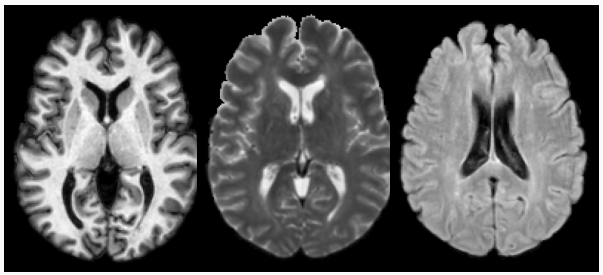
T2 in PD

Other structural MRI modalities

T1 T2 FLAIR



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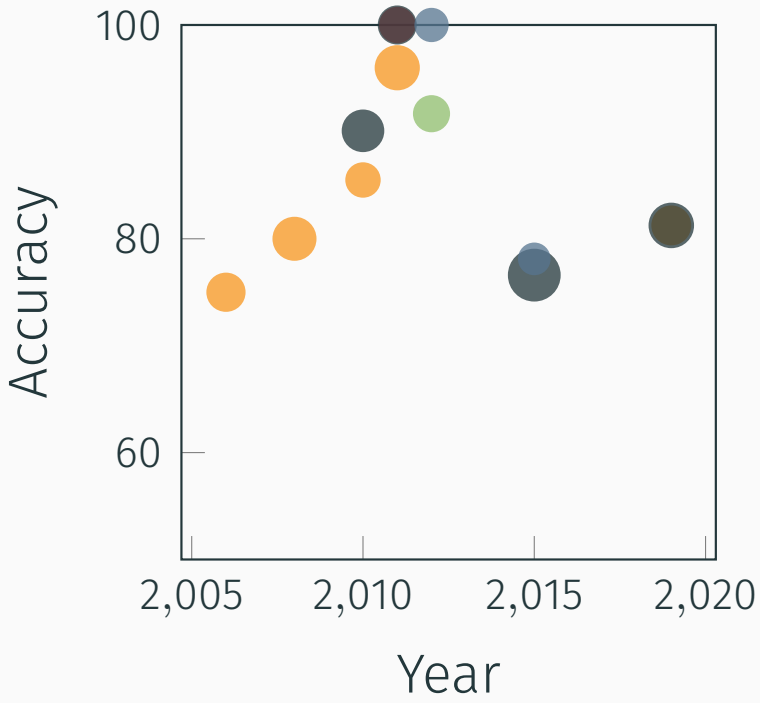
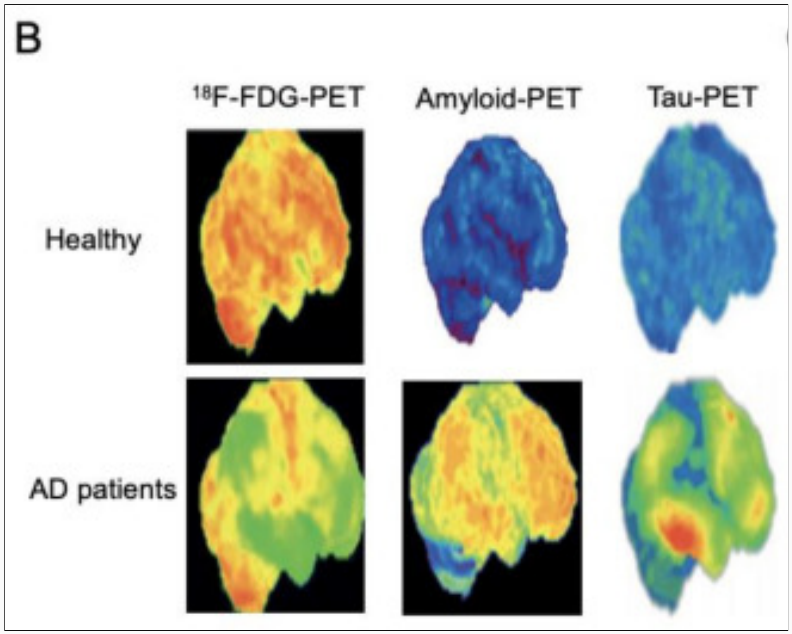
T2 in AD

Diffusion Tensor Imaging (DTI)



Positron Emission Tomograhy (PET)



Functional Magnetic Resonance Imaging (fMRI)

Magnetoencephalography (MEG)

Alzheimer's disease

- Pathological changes are apparent in a variety of neuroimaging modalities, to a level which can support individual diagnostics.
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Method	Sensitivity	Specificity	Accuracy	Pros	Cons	Refs.
MRI	80–95%	55–98%	89–97%	Spatial resolution	Temporal resolution, MR exposure	[36,105–108]
FDG-PET	43–100%	57–100%	50–100%	Clear image	FDG injection	[44,47,57,63,109]
fNIRS	82–94%	72–88%	50–90%	High speed, portability	Spatial resolution	[110,111]
fMRI	84–94%	68–91%	75–93%	Spatial resolution	Not portable/Expose MR	[78,80,112]
EEG	35–88%	82–100%	62–92%	High speed, portability	Spatial resolution	[99,101,103,113,114]

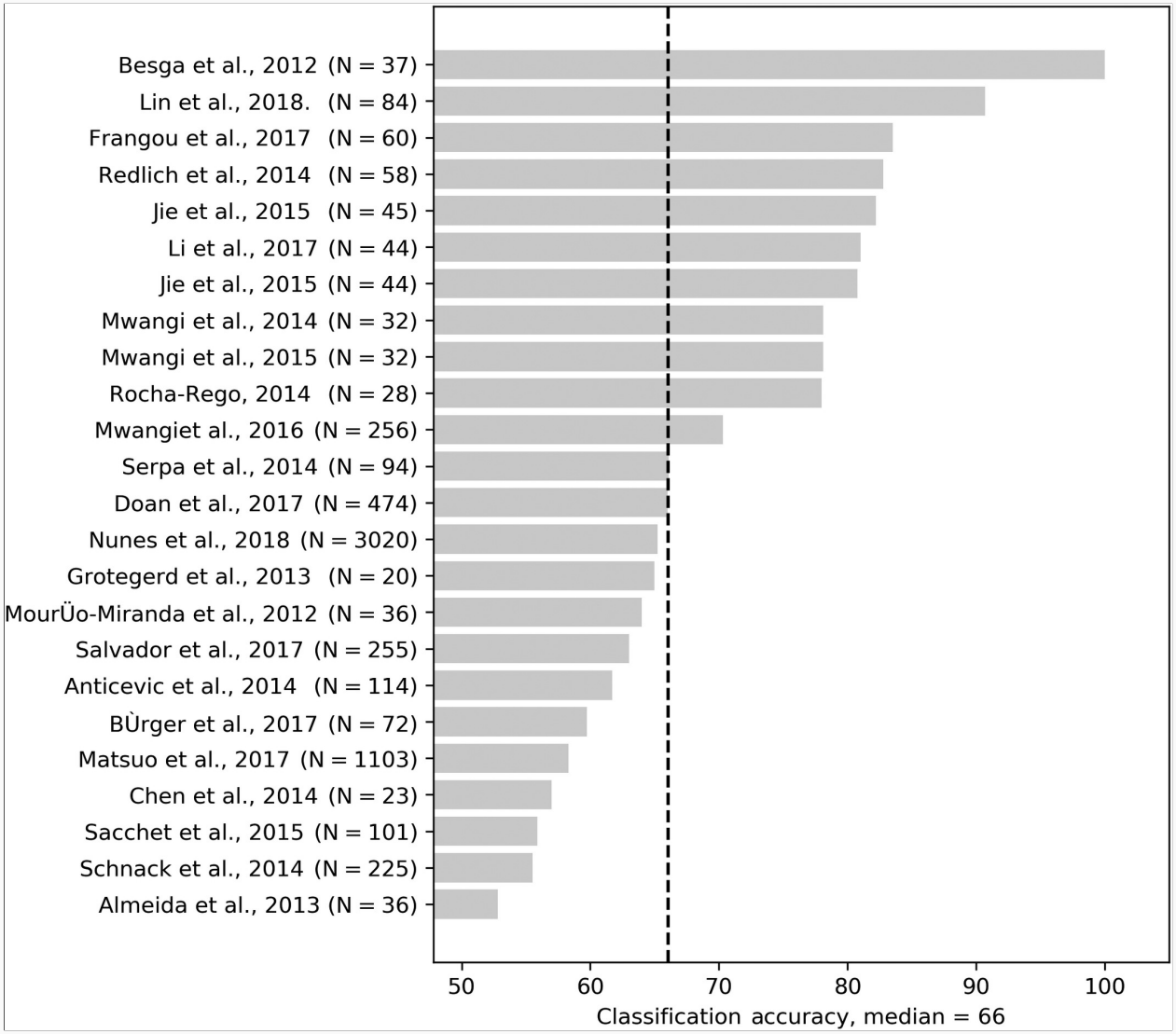
Multiple sclerosis

- Lesions apparent in T2-weighted and FLAIR images are used clinically to support diagnostics.
- DTI reveals group-wise differences also in apparently healthy white matter.
- A stereotypical trajectory that has been observed in patients using fMRI is heightened activation up until a point where it is no longer possible to compensate for structural damage, after which the activation generally resides.

Parkinson's disease

- DTI has been shown useful for classifying patient subtypes and correlates with motor and cognitive function in PD patients.
- fMRI has been shown useful for differentiating patient subtypes, supporting the notion of PD subtypes as network models.
- PET imaging can be used to reveal subtypes

Bipolar disorder



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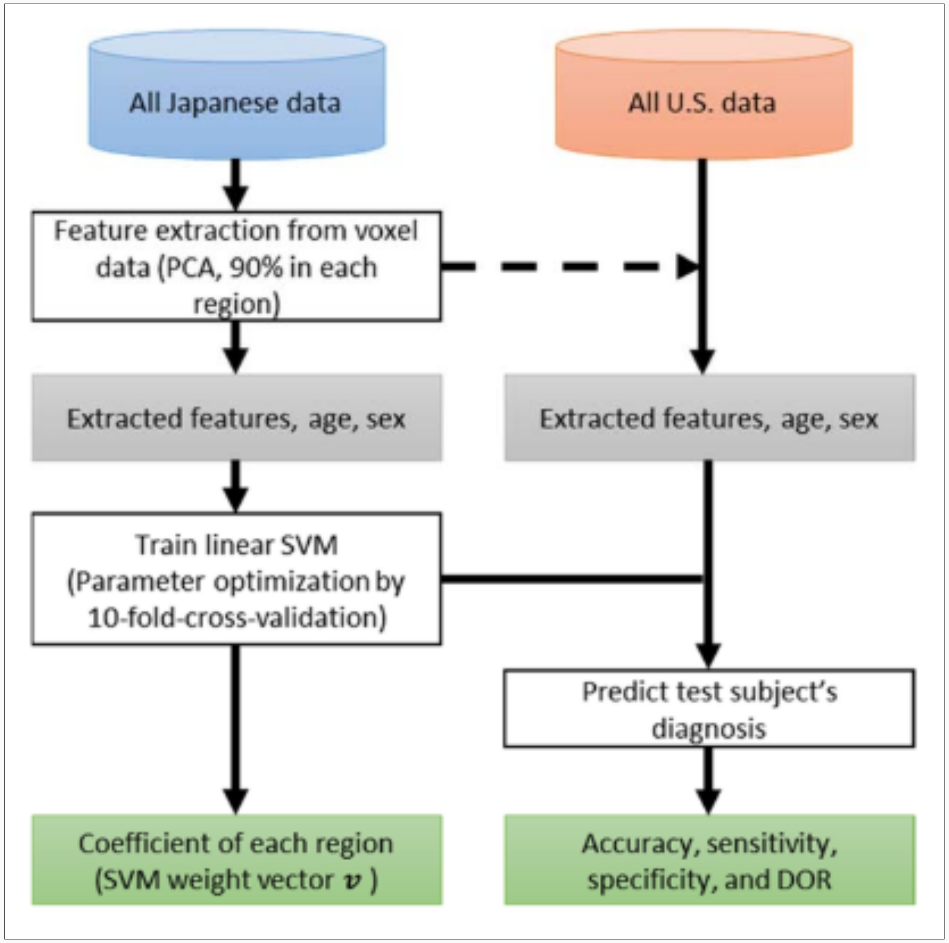

Future opportunities and challenges

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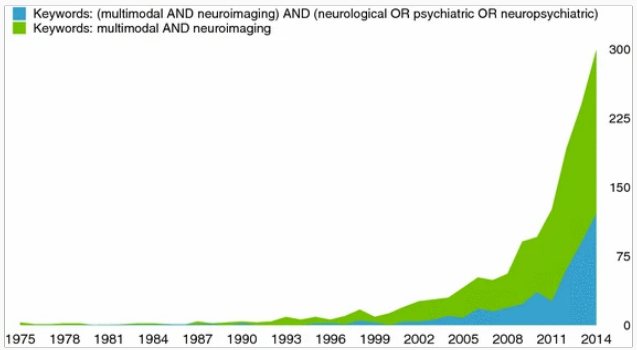
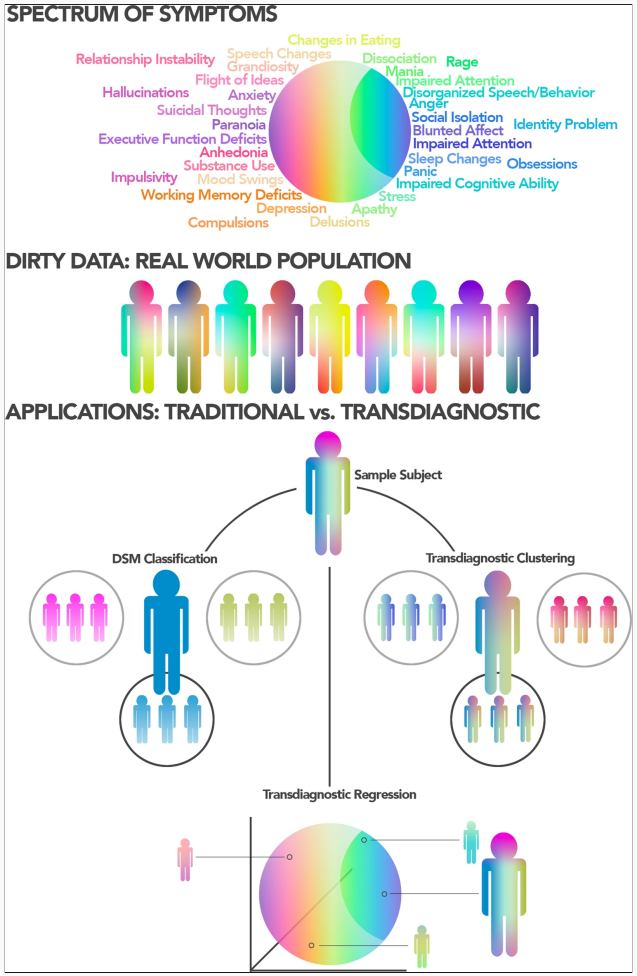
Multimodality and data fusion



The role of prediction



Prediction versus interpretability