The Human Connectome: Linking Brain Network Features to Healthy and Pathological Information Processing

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http://www.dynamic-connectome.org

http://neuroinformatics.ncl.ac.uk/

@ConnectomeLab

Clinical Neuroinformatics in the UK

UK Biobank (Imaging project with 100k subjects aged 40-65)

13309

Dementias Platform UK

Imaging platforms: FSL and SPM

National Mental Health Informatics network

UK Special Interest Groups in Neuroinformatics

BNA British Neuroscience Association

SIG Neuroinformatics

https://www.bna.org.uk/members/sigs/neuroinformatics/

Experimental and Computational Researchers

incf UK Node

SIG Human Neuroinformatics

http://neuroinformatics.org.uk/

Developers

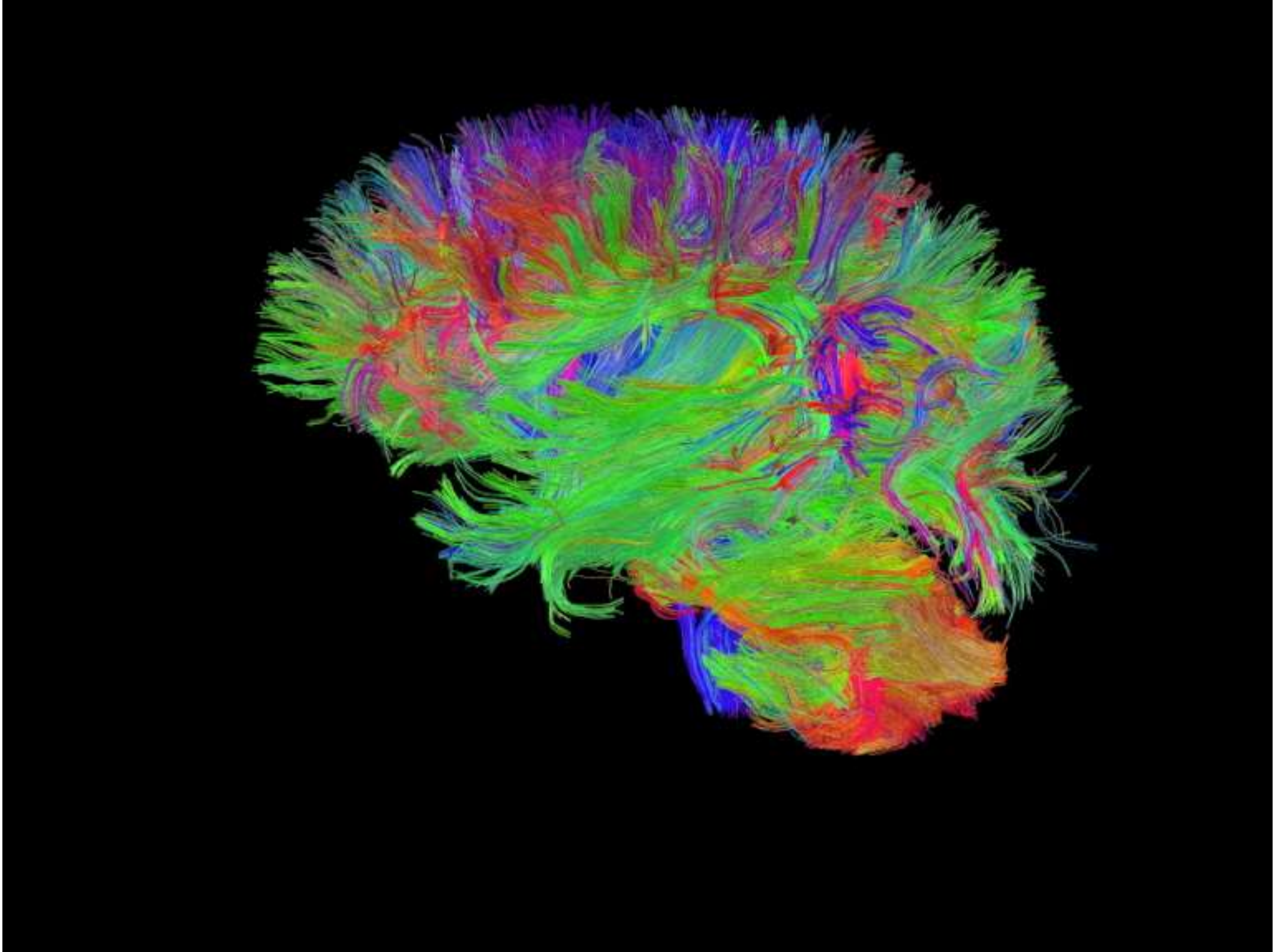
computer models to inform diagnosis and treatment of brain disorders

NHS CHAIN Technology

SIG Computational Neurology

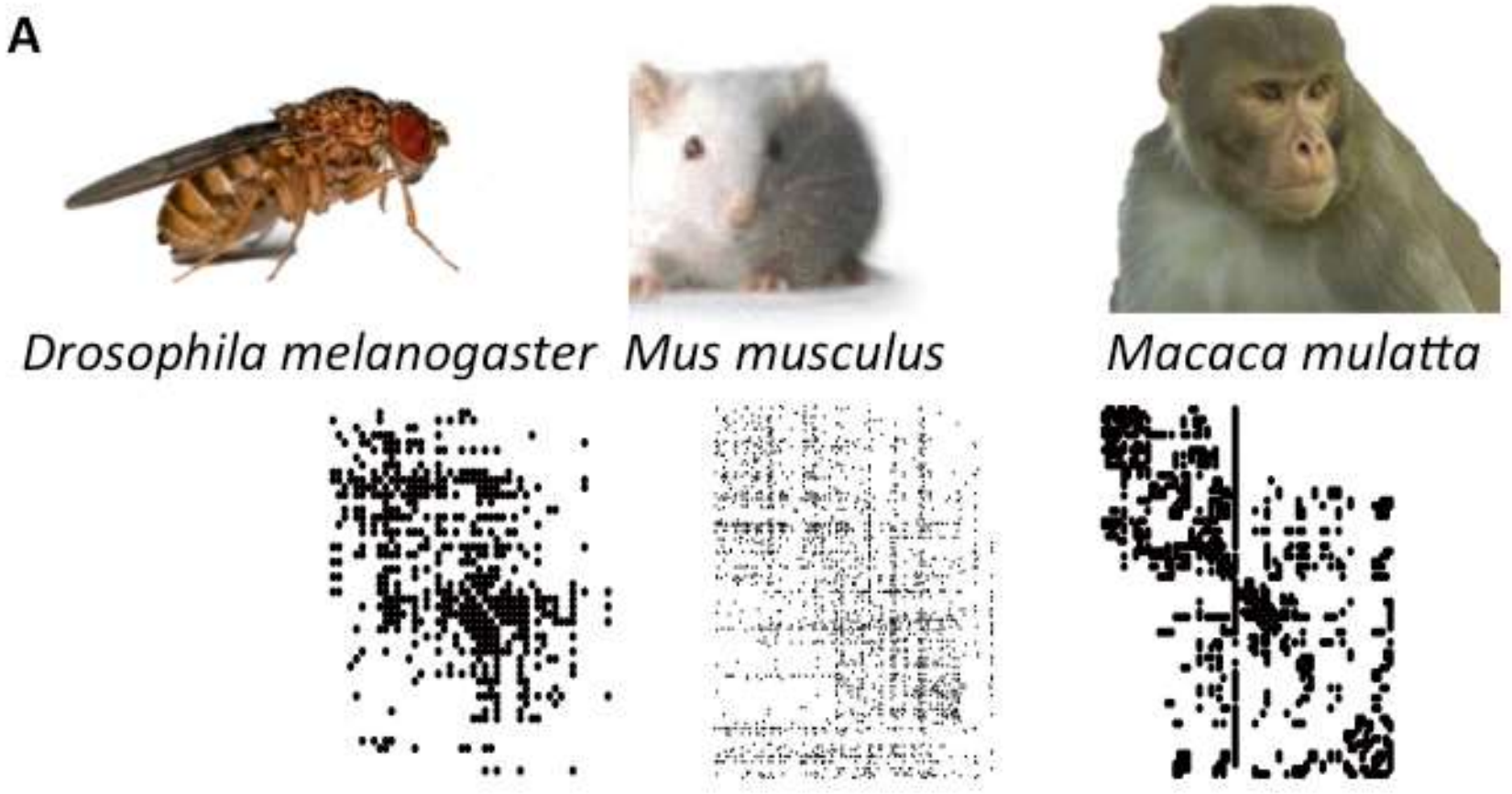
http://www.chain-network.org.uk/

Clinicians



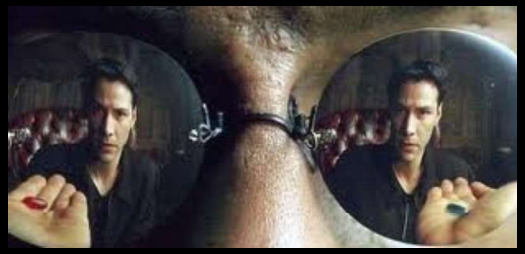
Common connectome features

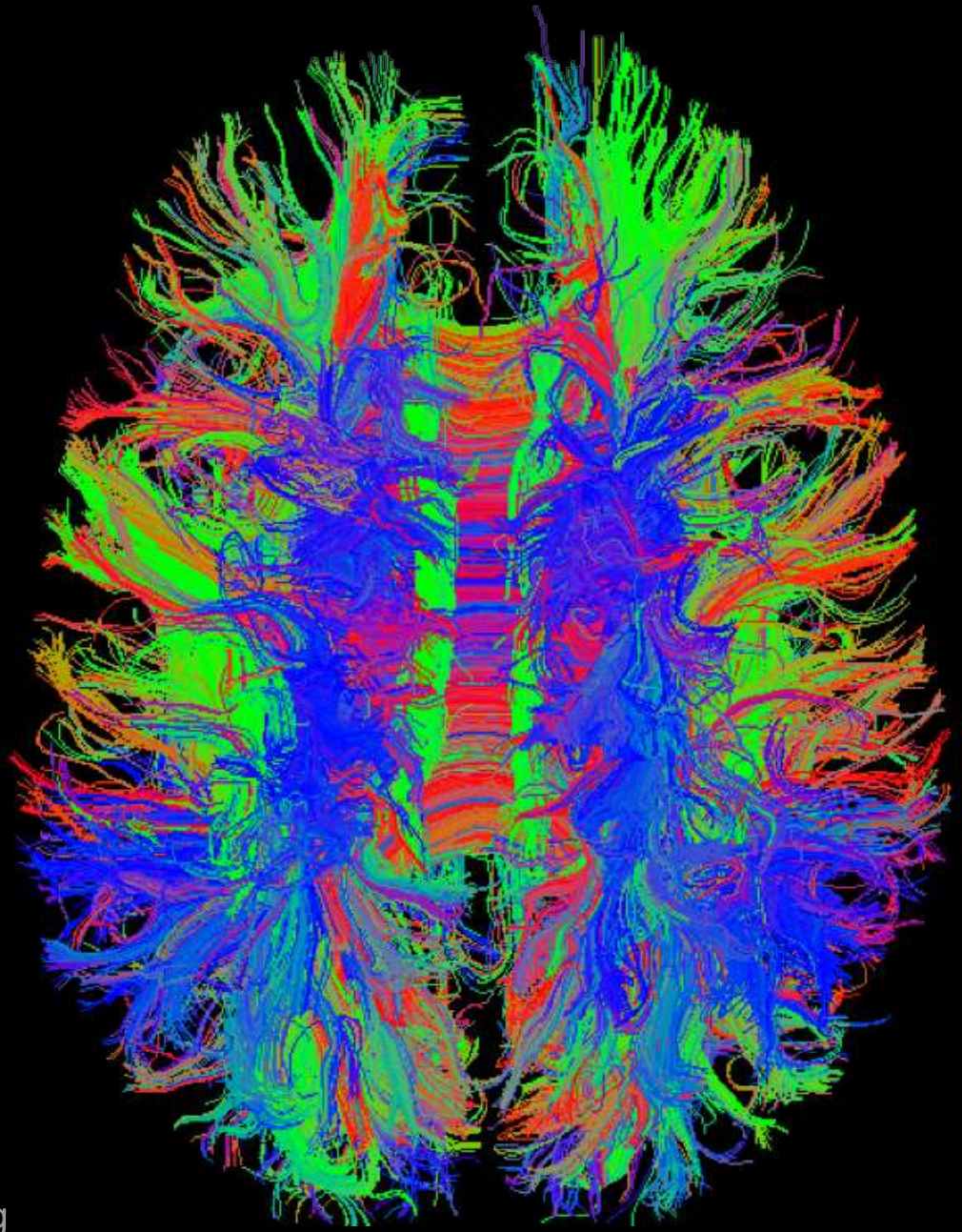
Brain connectivity in Drosophila melanogaster

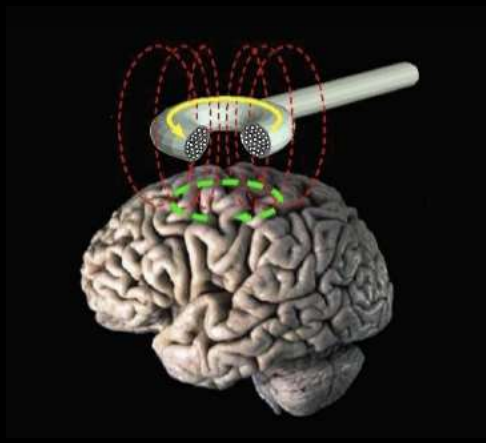


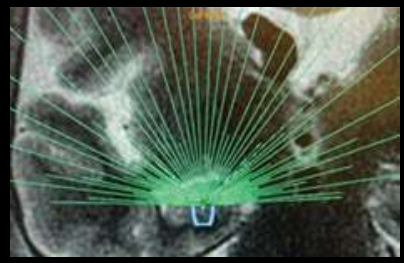
Kaiser (2015) *Current Biology*

Develop computational tools to inform diagnosis and treatment of network disorders









Components

- Diagnosis for individual patients including aetiology (developmental origin) and disease subtype
- Identification of potential treatment targets
- Model for effects and side effects of treatment

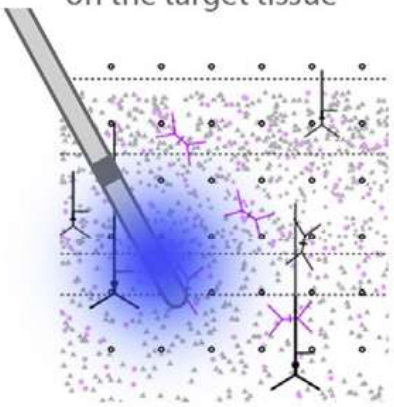
Finite element headmodels

Magnetic resonance imaging (MRI)

-Position of the brain structures
-Morphology of the folded cortex
-White matter connectivity

Stimulation modality model

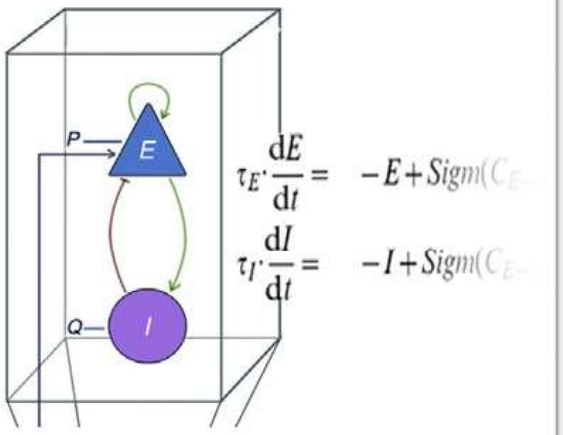
Simulating the effect of the stimulus on the target tissue



-Molecular mechanisms
-Electromagnetic field effects

Mechanistic model

Simulating brain dynamics



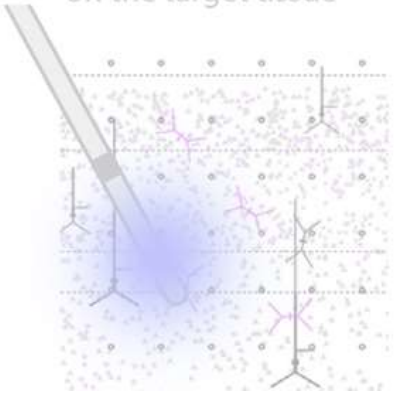
-Neuronal models
-Neural population models

Wang, Hutchings, Kaiser, Prog. Brain Res., 2015

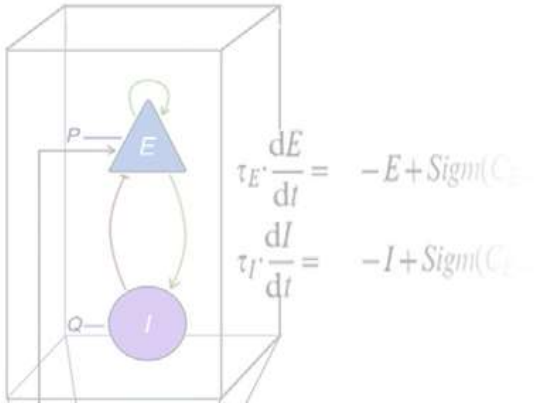
Diagnosis including disease causes

Magnetic resonance imaging (MRI)

Simulating the effect of the stimulus on the target tissue



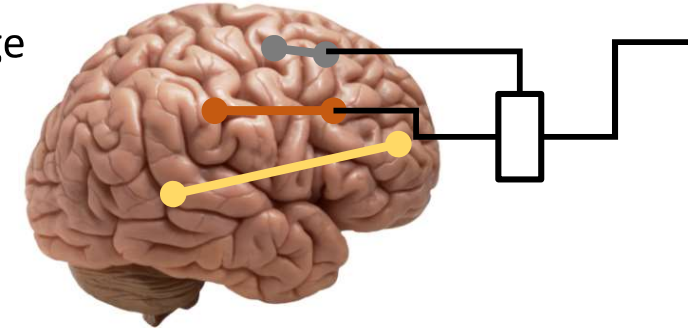
Simulating brain dynamics



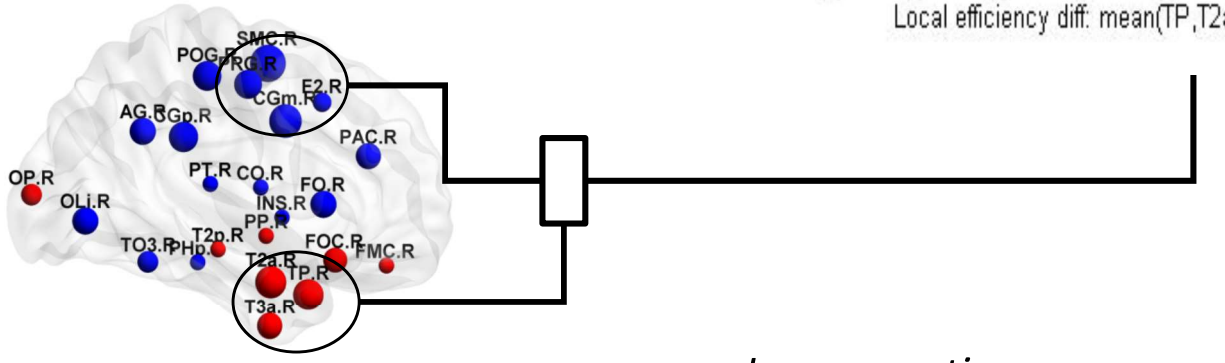
Predicting subtypes of dementia

Correlation with clinical measures and group differentiation

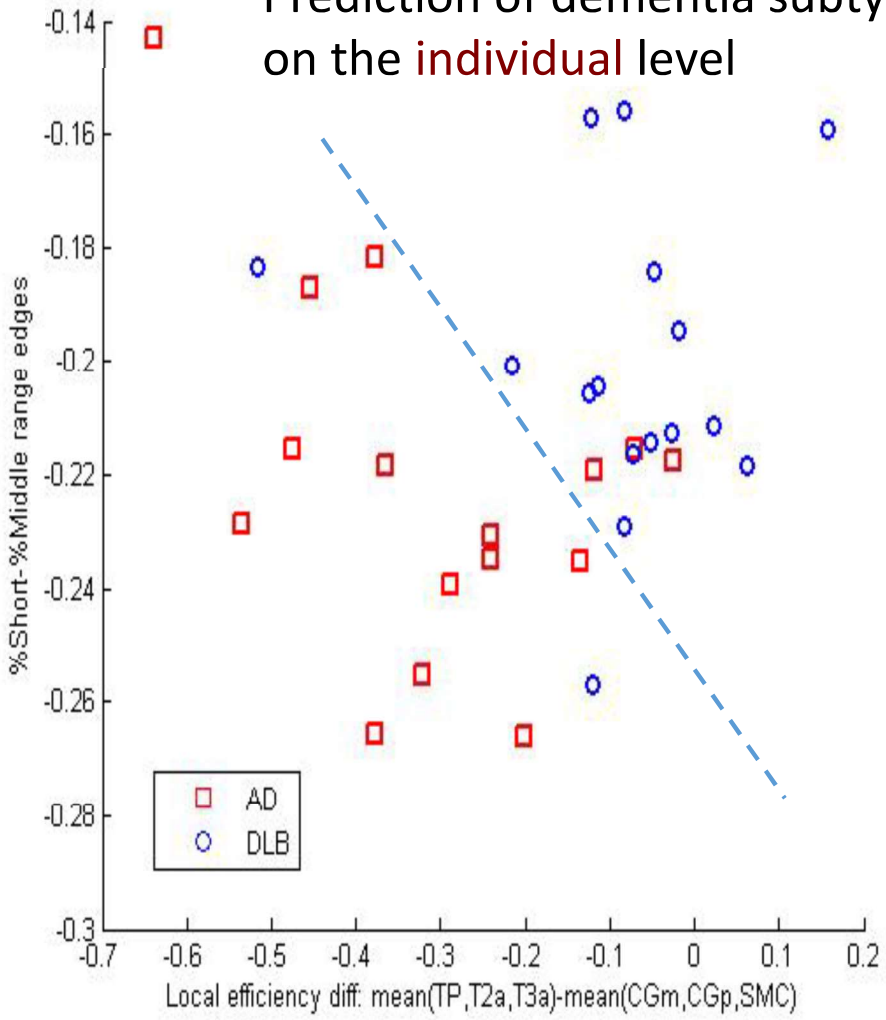
Short-Middle range connections



Local Efficiency



Prediction of dementia subtype on the individual level

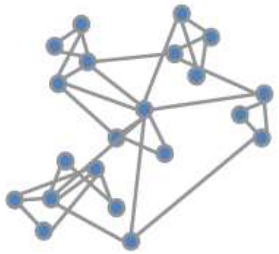
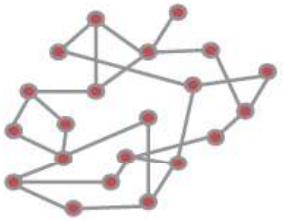
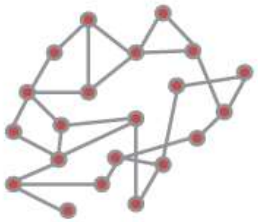


81% Sensitivity
87% Specificity
0.88 AUC

In preparation

Connectome topology not always sufficient as biomarker

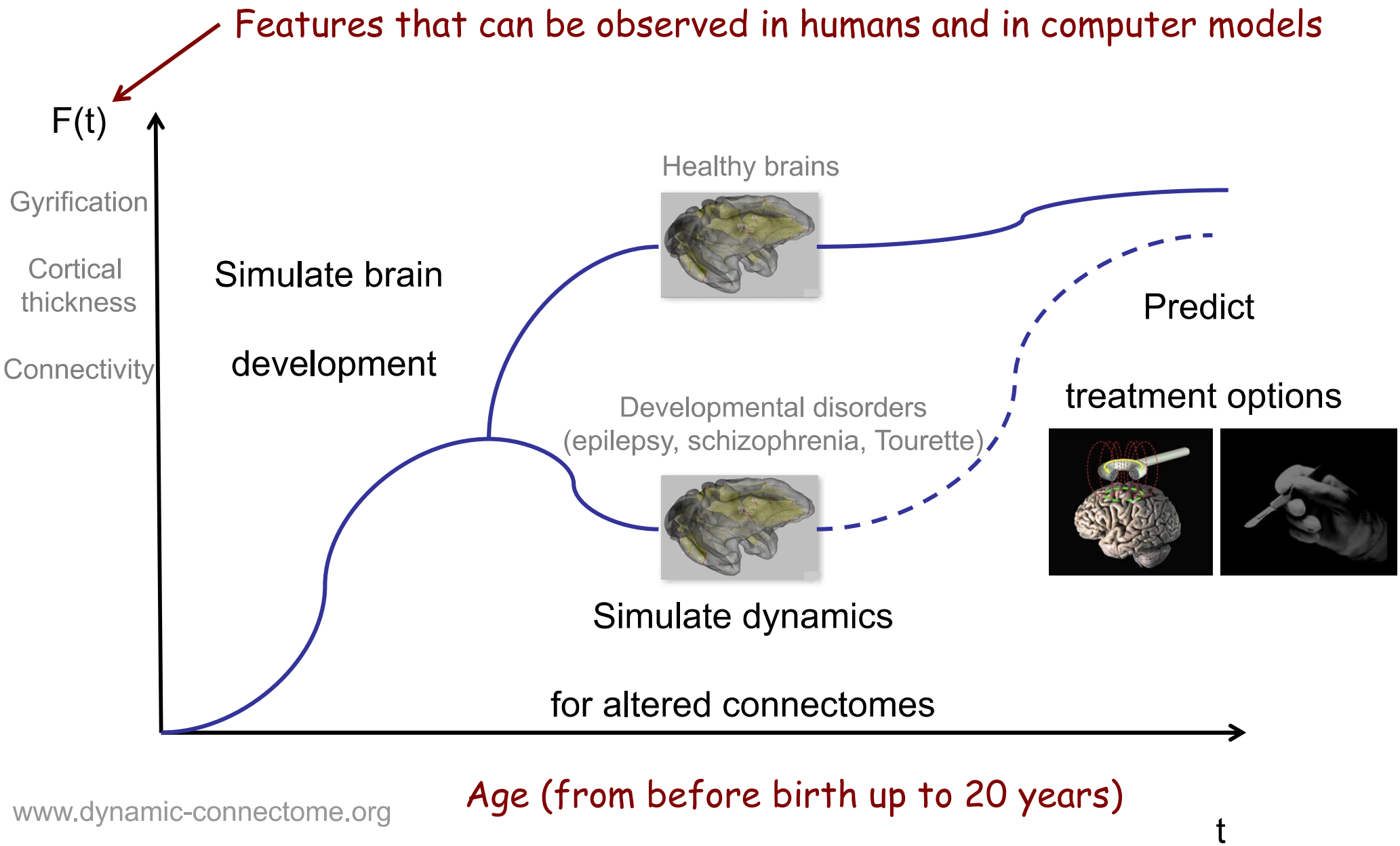
Brains are non-linear systems: small system changes can have large effects on system behaviour

Connectome	Consequence	Classification
	Seizure	Epilepsy
	Hallucinations	Schizophrenia
	Seizure	Epilepsy

→ **need for simulations of dynamics and development**

Kaiser, Frontiers in Human Neuroscience, 2013

Understanding the factors that lead to neurodevelopmental diseases



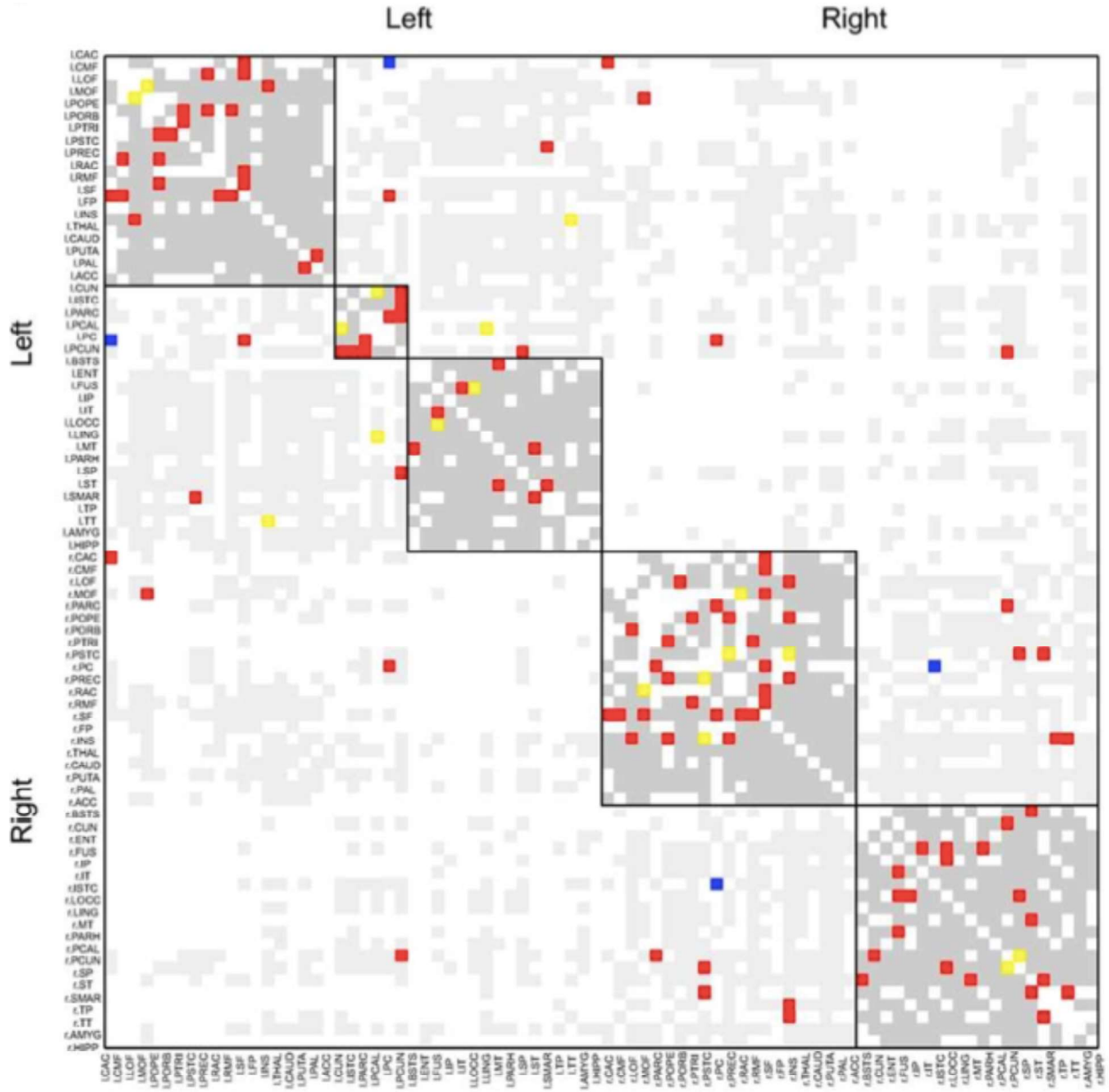
www.dynamic-connectome.org

Reduction of streamlines over time

DTI

121 healthy subjects
age 4-40 years

82 regions:
68 cortical
14 subcortical



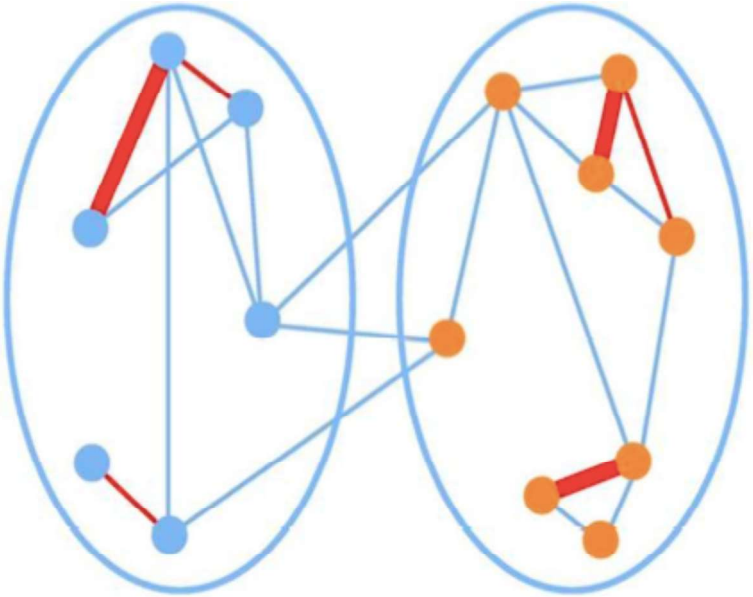
Decreased

Increased

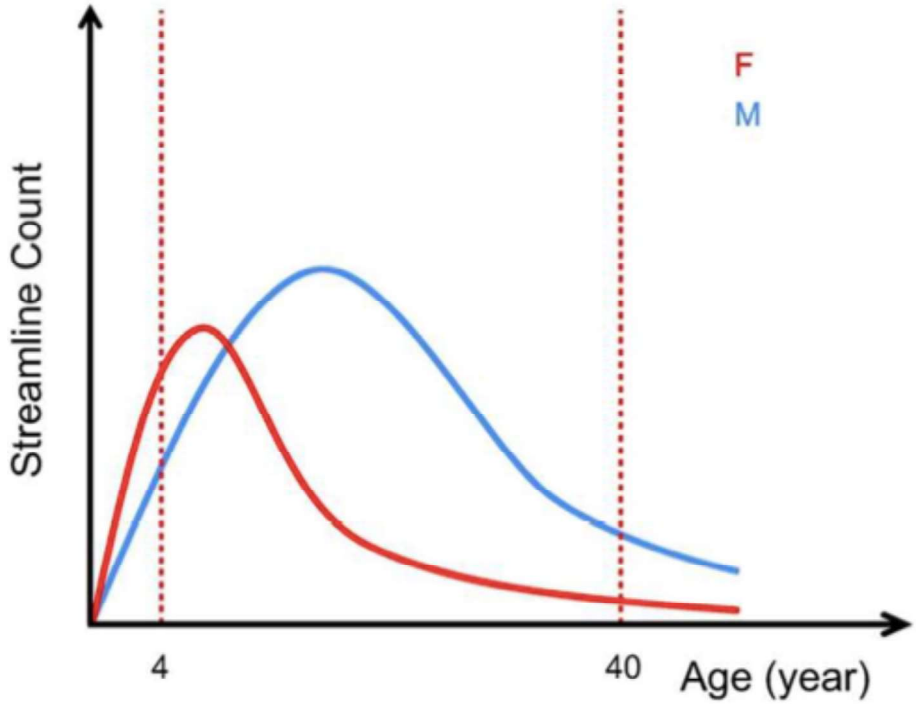
Sex-Specific

Lim et al., *Cerebral Cortex*, 2015

Preferential detachment and gender differences



Preferential loss of streamlines within thick, short-distance, intra-module, and intra-hemisphere fibre tracts



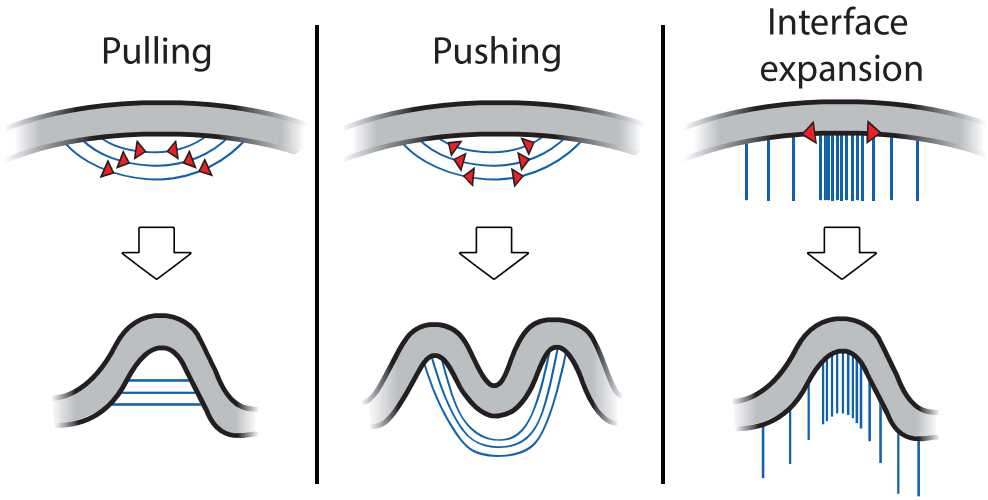
Delayed removal of streamlines in males

Reason why some psychiatric diseases are more common in men?

Lim et al., *Cerebral Cortex*, 2015

Simulating development: From micro- to macro-connectome

Cortical layer formation → formation of gyri/sulci and fibre tracts



Wang et al. *PNAS* 2016

CERN openlab

intel

INNOPOLIS UNIVERSITY

https://biodynamo.web.cern.ch/

Identifying treatment targets

Not necessarily the ones that show changed connectivity

changes might be a consequence of a disease rather than its cause and could even be involved in compensating for disease effects