Virtual Brain Twins in EBRAINS

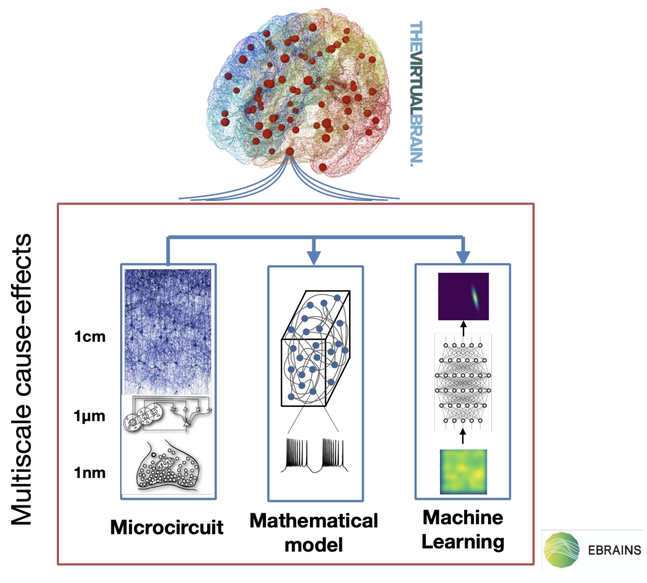
JIRSA Viktor*[1], HASHEMI Meysam[1], WANG Huifang[1], WOODMAN Marmaduke[1], TRIEBKORN Paul[1], DOLLOMAJA Borana[1], RUNFOLA Claudio[1], DEPANNEMAECKER Damien[1], BREYTON Martin[1 2], SORRENTINO Pierpaolo[1], KLIJN Wouter[3], PETKOSKI Spase[1]

[1] Aix Marseille Univ, INSERM, INS, Inst Neurosci Syst, UMR 1006, Marseille, France
*e-mail-address of corresponding author(s) viktor.jirsa@univ-amu.fr
[2] AP-HM, Marseille, France
[3] Simulation & Data Lab Neuroscience, Jülich Supercomputing Centre, Institute for Advanced Simulation, JARA, Forschungszentrum Jülich GmbH, Jülich, Germany

Virtual Brain Twin workflow : from computer to bedside

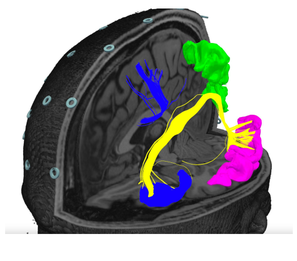
Patient-specific recordings constrain the personalized virtual brain twin. We use machine learning methods to further parametrize the patient's twin for specific conditions, with the goal of aiding clinical diagnosis and predicting best interventions, such as medication, surgery, and stimulation. In particular, one workflow (right) is the computationally demanding multiscale cause-effect simulations with the second workflow integrating patient specific data into a iteratively improved personalized virtual twin towards a system that can support clinicians with guidance in decision making for individual patients on which medication to take, how to adjust the dosage, when to change medications, when to suggest other factors in life such as physical activity.

Multiscale estimation of cause-effect using high-performance computation, mean field theory, and AI



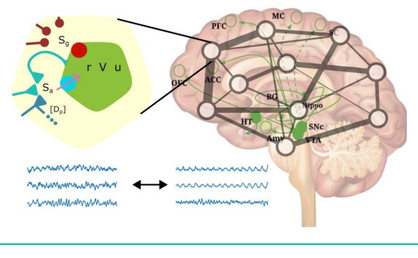
Three ways to Identify how mechanisms traverse across scales and express themselves mathematically in The Virtual Brain (TVB)

Personalized Virtual Brain Twin



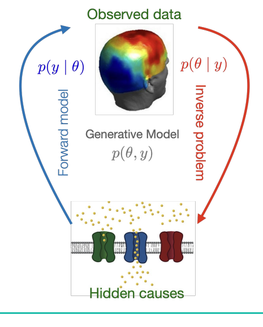
The virtual brain twin (VBT) is a personalization of a general model produced on HPC using a subject's anatomical data including T1- and diffusion weighted Magnetic Resonance Imaging (MRI).

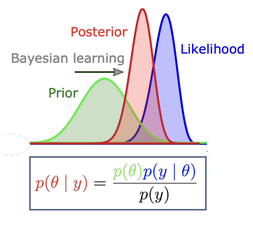
Neuromodulators drive the brain dynamics & entry points for pharmacological interventions



Besides the white matter connectivity each brain node is equipped with a model of neural activity that also captures the effect of neuromodulators (such as dopamine).

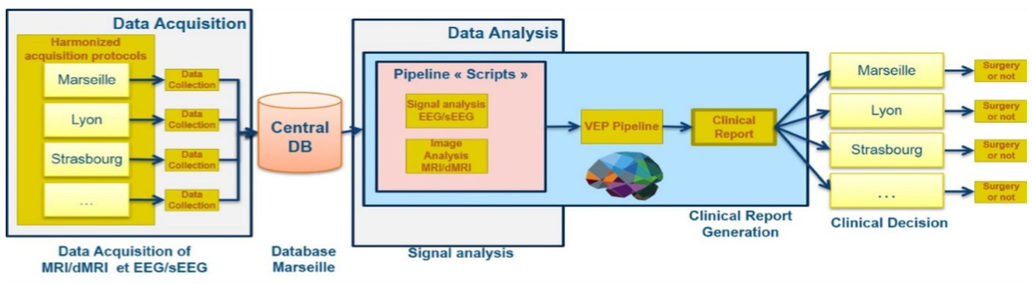
Identification of mechanisms with Bayesian statistics





Identification of the most likely model parameters (linked to multiscale mechanisms) for the biomarkers

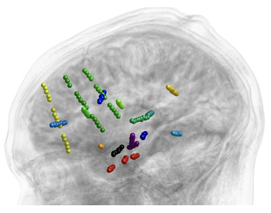
Virtual Brain Twins in clinical trial: improving surgical outcome for drug resistant epilepsy

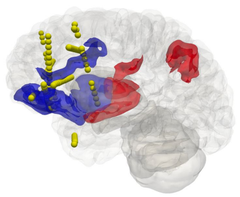


EPINOV Clinical Trial (2019-2023) : randomized parallel-group study trial
Sponsor : Assistance publique - Hôpitaux de Marseille
Coordinator : Fabrice Bartolomei
Scientific Director : Viktor. Jirsa

Objective : evaluate the role of personalized Virtual Epileptic Patient (VEP) brain models for surgery

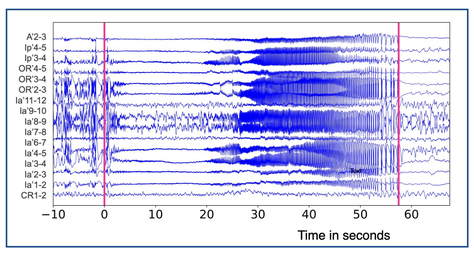
13 French clinical centers
356 prospective patients
310 patients randomized (VEP and 154 control)
160 VEP reports sent (133 VEP and 27 control)
178 surgeries performed (93 VEP and 85 control)

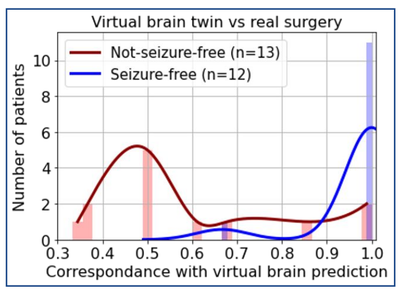




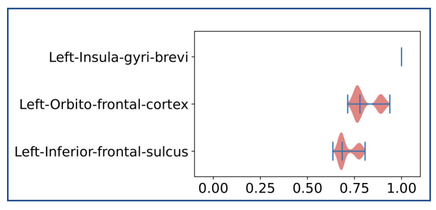
Blue: Clinical Hypothesis for Epileptogenic Zone
Red : Additional epileptogenic zone
29% of all cases fall in the red epileptogenic zone areas and are not accessible via SEEG

SEEG time series during seizure



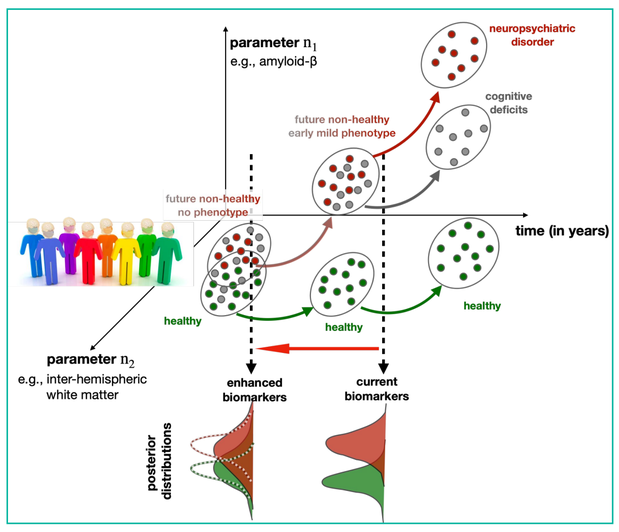


Most surgical failures when TVB finds the clinical hypothesis to be incomplete



Estimated epileptogenic zone network with high excitability values

Virtual Brain Twins and inference predict individual aging, cognitive performance and brain health



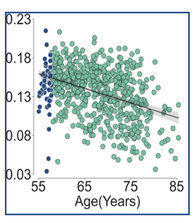
The use of VBT accelerates diagnostics by separating indistinguishable parameter distributions and making pathophysiological causes identifiable.

Significant benefits of diagnostic acceleration by earlier access to pharmacological and non-pharmacological treatments.

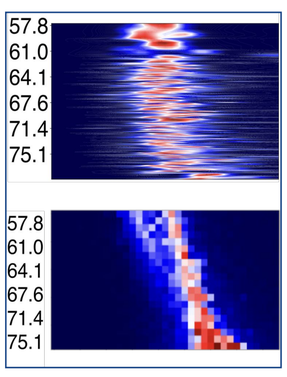
brain health trajectories

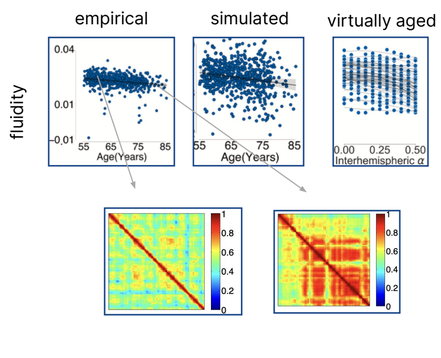
Healthy aging example

Interhemispheric connectivity decline (proxy for age - related decline)



Fitted fluidity





Website

To learn more about the Virtual Brain Twin for personalized treatment of Psychiatric Disorders project, please visit the website virtualbraintwin.eu.

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