Big Data & Machine Learning Personalize Neuropsychiatric Disorders–Ready for Clinical Translation?

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Symposium

Numbers of imaging studies exploded in the last decades. They investigated cognitive processes in normal development and numerous diseases. Recently, ambitious machine-learning approaches have been introduced that are promised to revolutionize analysis strategies (Nature Neuroscience 2017; 20, 365-377). On the other hand, severe limitations have been discussed such as “deep trouble(s) for deep learning” (Nature 2019, 574, 163-166). Here, we will discuss the potentials and limitations of such machine learning techniques for personalized approaches in health and disease occurring in the human brain.

Neuroimaging findings revealed the mechanisms of neuropsychiatric disorders. Accordingly, the DSM-5 suggested incorporating biomarkers in diagnosis of neuropsychiatric diseases. Although large amounts of imaging data have been accumulated to date, a decisive step has still to be done: Translating group studies’ results into individualized regimens. Early prediction of diagnosis and therapy are in particular relevant for neuropsychiatric disorders. Diseases shall be diagnosed as early as possible to predict their course and enable disease-specific treatment.

The symposium will span from health to disease and focus on predicting normal aging, diagnosis and treatment in neuropsychiatric disorders with cutting-edge pattern recognition algorithms in neuroimaging big data. The first part of the symposium will focus onto healthy aging and neurodegenerative diseases. Ioanna Skampardoni & Christos Davatzikos will discuss how machine learning can revolutionize the understanding of healthy brain aging and the most abundant dementia syndrome Alzheimer’s disease and its prestages. Matthias Schroeter will show how pattern classification in multimodal imaging data combined with meta-analyses can be used to predict subtypes of frontotemporal lobar degeneration and treatment response in Parkinsonian’s disease. The second part of the symposium will extend the view to psychiatric disorders such as schizophrenia and mood disorders. Here, Nikolaos Koutsouleris will show what neuroimaging data can contribute to identification and prediction of treatment response in depression and schizophrenia. Finally, Choong-Wan Woo will review machine learning studies already published in the literature and discuss good practices in developing neuroimaging biomarkers based on machine learning models.

Objective

Pattern recognition algorithms / machine learning can pave the way to individualized diagnosis and treatment regimens in the framework of personalized medicine
Biomarkers for disease classification might be incorporated in new classification systems
Validity has still to be proven by successful translation into clinical routine

Target Audience

The symposium is of general interest for researchers and clinicians investigating neuropsychiatric diseases, and who are interested in understanding and applying machine learning techniques in neuroscience.

Presentations

Brain Aging Charts: Large-Scale Imaging Harmonization and Analytics Using Machine Learning

This talk by Ioanna Skampardoni & Christos Davatzikos will review work investigating patterns of brain aging obtained from over 20,000 MRIs pooled and harmonized across over a dozen studies. We will also discuss the value of machine learning for deriving personalized biomarkers that predict future cognitive decline and progression to mild cognitive impairment and Alzheimer's disease.

Presenter

Ioanna Skampardoni, National Technical University of Athens ATHENS, Attiki
Greece

Decoding the Neurodegenerative Mind with Pattern Recognition in MRI & Meta-Analyses

This talk will show how pattern classification in multimodal imaging data combined with meta-analyses can be used to predict the second most frequent dementia syndrome, frontotemporal lobar degeneration and its subtypes. Moreover, it will discuss how machine learning in imaging data can predict treatment response in Parkinsonian's disease and how meta-analyses can substantially improve the application of such approaches.

Presenter

Matthias Schroeter, Max Planck Institute for Human Cognitive and Brain Sciences
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Comparative Neuroscience: Understanding Psychosis from the Perspective of Affective and Neurodegenerative Disorders

This talk will focus on (1) the use of supervised machine learning to learn MRI-based signatures for disorders

hypothesized to partly overlap with psychosis and (2) the use of these signatures to study the cross-sectional (diagnostic) and longitudinal (prognostic) heterogeneity of the psychosis spectrum. The talk will combine data of patients in early stages of psychotic and affective diseases (PRONIA sample; www.pronia.eu) with data of patients with the behavioural variant of fronto-temporal dementia (German FTLD consortium; http://www.ftld.de/), thus exemplifying methods of age calibration needed to compare conditions separated by ~40 of age using machine learning.

Presenter

Nikolaos Koutsouleris, Ludwig-Maximilian University Munich, AK
Germany

Good Practices in Developing Neuroimaging Biomarkers Based on Machine Learning Models

Machine learning is a powerful tool for creating predictive models of brain structures and functions, and therefore its uses have become widespread in neuroscience, particularly in translational neuroimaging. However, the machine-learning algorithm in itself will not be enough to develop clinically useful tools and will have to be used judiciously to enable a quantum leap forward in developing translational applications. In this talk, I will review the state of translational neuroimaging studies to provide a few concrete recommendations on good practices in developing neuroimaging-based biomarkers. They include (i) conducting sensitivity and specificity tests against multiple test cases, (ii) including independent datasets for testing generalizability, (iii) developing neuroimaging biomarkers that have clinical utility, (iv) demonstrating that the biomarkers are based on relevant neurobiological signal, not artifacts or confounds, (v) providing novel (or useful) information about neuroscience, (vi) characterizing the boundary conditions of your biomarker, and finally (vii) naming it to keep the process of annotating and interpreting the model open-ended. These recommendations, by integrating ideas from machine learning, 'big data,' replicability, and open science, will be able to bring translational goals within reach.

Presenter

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