# Electrophysiological correlates of brain network dynamics over the human lifespan

By

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# Contents

# Acknowledgement

# Abstract

Aim: Apply data science methods to questions in aging Neuroscience
Methods: Supervised and unsupervised methods in different settings
Results: Novel Data Driven insights
Coclusion: ML rocks!

# Figures

# Tables

# List of Abreviations

# Publications and other scientific contributions

# Chapter 1

# Introduction

- ML as the next frontier in science
- Open questions in aging neuroscience
- What can ML tell us?
- Age related changes occur at different scales and are manifestet at several levels.
- There is a wide variety in how this changes occur
- Changes are e.g. neural dedifferentiation and compensatory mechanisms (see Reuter Lorenz et al. 2010) and are noticable brain network level and dynamics
- NOTE: Check what EEG studies said about this...
- The idea is to model these changes with tools from datascience to answer questions in aging neuroscience
- First study is about detecting dedifferentiated and compensatory mechanisms with EEG
- Tools used are DMD and Machine learning
- Main idea: Study classification performance as proxy for age related changes in different motor control tasks
- Expertise as possible way of builing a reserve:
- Higher individuality

- Dynamics of dedifferentiation and how do they relate to fitness
- Basic for targeted interventions
- How much and what (relate to Julia)
- Background of ML
- ML as tool
- novel insights
- Problem: Data is multidimensional and we have often limited data
- Solution: Use DMD to reduce Complexity and "model" evolution of signal
- Dynamic Mode Decompsition
- DMD extracts coupled spatio-temporal modes and is able to kind of model the evolution of the signal
- Backgrouund + Papers
- Mathematical Formulation
- What can ML tell us?
- ML applied in aging Neuroscience
- Formulating Aims and goals
- Formulation expectred outcomes

# Chapter 2

# Theoretical Background

## 2.1 Age related reorganization of the brain

Age related reorganization processes are detectable at the whole body. This is underpinned by multiple interacting biological systems operating on several spatial and temporal scales contributing to the complexity of the phenomenon [1]. At the behavioral level these processes are noticeable in changes in cognitive, motor and sensory functioning [QUELLE]. Aging is one of the biggest risk factors for neurodegenerative diseases such as dementia, including Alzheimer's disease, as well as Parkinson's disease making the brain as one of the target systems to study. Patterns of reorganization of the brain are highly individual as they are subject to genetic and environmental influences [QUELLEN]. At the same time, however, overarching, generalizable patterns can be detected [QUELLE]
On a structural level aging has been associated with a reduction in gray matter with an onset early in life

### 2.1.1 Contributing Factors

## 2.2 The brain as a complex Network

The brain is formed by interconnected neurons and neuronal populations representing a complex network. This network forms the basis of the function of central information processing and thus the basis of perception and action. On a global level, this represents the separation and integration of functionally specialized brain areas that change based on the environmental context. - During rest several brain networks have been identified:
- DMN, SMN, DAN etc.

- formed by spatially separated but functionally integrated and connected brain areas - hirarchy
- This network is assumed to be multiscale in nature

## 2.3 Methodological Approaches

### 2.3.1 Network Neuroscience

#### 2.3.1.1 Electrophysiological markers of brain network activity

### 2.3.2 Neural Datascience

#### 2.3.2.1 Dimensionality reduction

#### 2.3.2.2 Machine Learning

# Chapter 3

# Aims and scope

# Chapter 4

# General methodology

# Chapter 5

# Publications

## 5.1 Paper 1

## 5.2 Paper 2

## 5.3 Paper 3

## 5.4 Paper 4

# Chapter 6

# General discussion

# Chapter 7

# Bibliography

# Bibliography

[1] Kathleen M. Mooney, Amy E. Morgan, and Mark T. Mc Auley. Aging and computational systems biology. *WIREs Systems Biology and Medicine*, 8(2):123–139, 2016.

# Chapter 8

# Statutory Declaration