

ICA-Based Analysis of Resting-State fMRI in Major Depressive Disorder

Introductory presentation

Speaker: Katharina Breininger, B.Sc.

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Pattern Recognition Lab (CS 5)

Supervisors: Klaus Sembritzki, M.Sc., Dr.-Ing. Andreas Maier



FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

TECHNISCHE FAKULTÄT

Outline

- Introduction
- Physiological basis of (resting-state) functional MRI
- Extraction of resting-state networks
- Outlook





Introduction



Introduction

- Major Depressive Disorder (MDD)
- Symptoms include [1]:
 - Depressed mood
 - Diminished interest or pleasure
 - Insomnia
 - Suicidal ideation
- One of the main causes of burden of disease [2], approx. 4 Mio. people affected in Germany [3]

Why fMRI for depression?



- Clinical aspects:
 - Aid diagnosis
 - Choice of ideal treatment
 - Monitor treatment response
- „Objective“ measure
- Research on underlying disease mechanisms

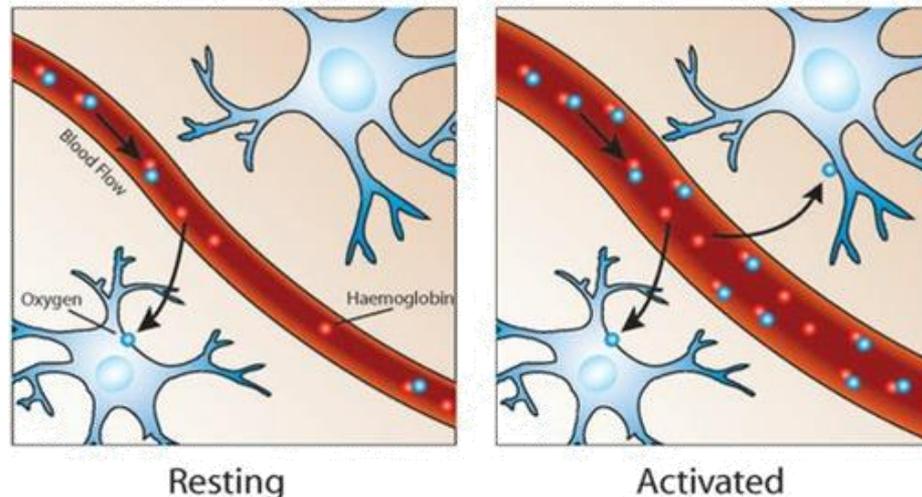


Physiological basis of (resting-state) functional MRI

Physiological basis of functional MRI

Contrast is based on blood oxygen level-dependent (BOLD) effect:

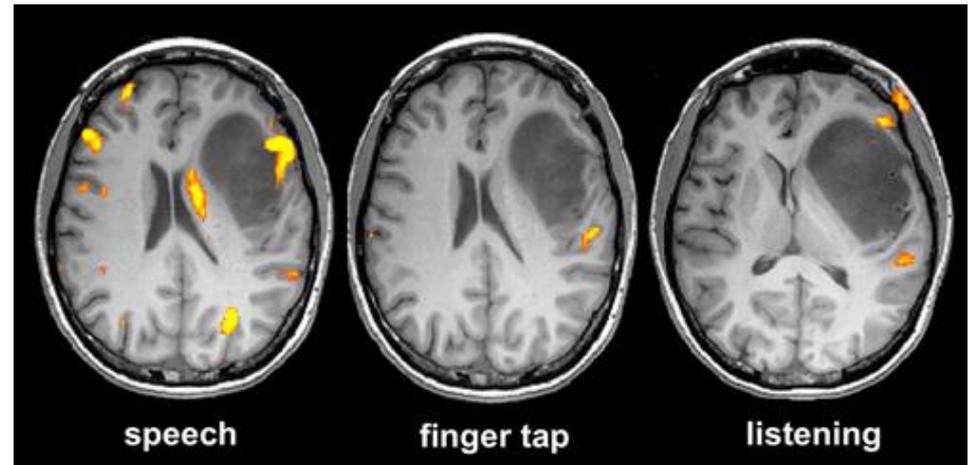
- Deoxygenated haemoglobin is paramagnetic \rightarrow decreases MRI signal
- Locally increased cerebral blood flow during neural activity (haemodynamic response)
- Increases percentage of oxygenated haemoglobin \rightarrow increase in MRI signal



Source: <http://www.fmrib.ox.ac.uk/research/education>

The brain during resting state

- fMRI usually used for task-based designs: Which areas of the brain are responsible for a given task?
- Analysis based on model of the expected response
- Resting as a baseline condition
- **But the brain never “rests”**



Source: http://www.mayfieldclinic.com/PE-fMRI_DTI.htm

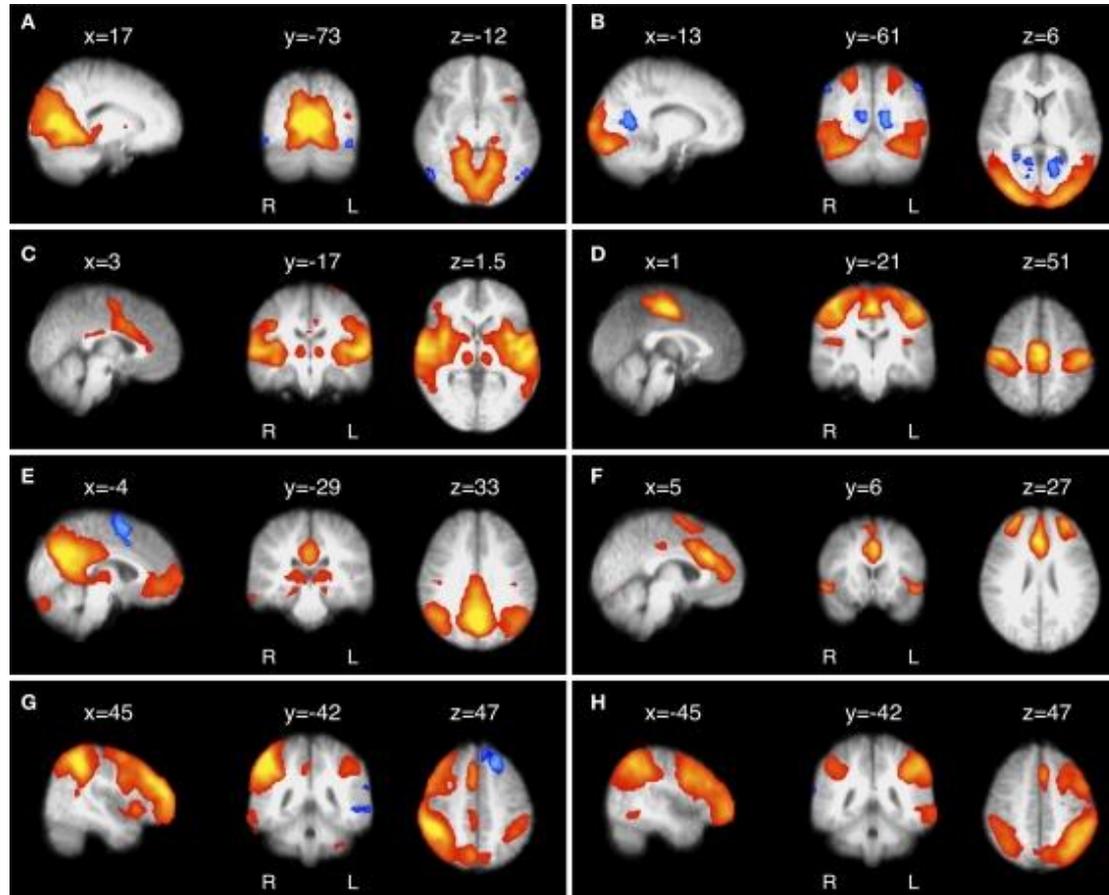


The brain during resting state

- Biswal et al. [4] observed spontaneous low-frequency signal fluctuations (0.01 – 0.8 Hz) during rest:
 - Not random, but structured
 - Multiple temporally correlated regions in the brain that fluctuate in activity, highly consistent between sessions and subjects [5]
 - Resting state networks
 - Measured rs-fMRI signal is a mixture of those networks (+noise)
- Acquisition: Take a sequence of fMRI images over ~5-10 min during „wakeful“ rest



Resting state networks



Consistently identified networks across individuals [6].



Extraction of resting-state networks



Resting state networks

Extraction of networks can be done in various ways:

- Seed-based correlation analysis – pick a ROI/voxel in the brain and correlate against time course of all other courses [6]
- Independent component analysis (ICA) – see resting state as a blind source separation problem [6]



Resting state networks

- Independent component analysis (ICA):
 - Measured signal is linear mixture of unknown spatial maps
 - Individual or group-wise ICA (concatICA)
 - Assumptions: non-gaussianity and independence of sources

$$X = AS,$$

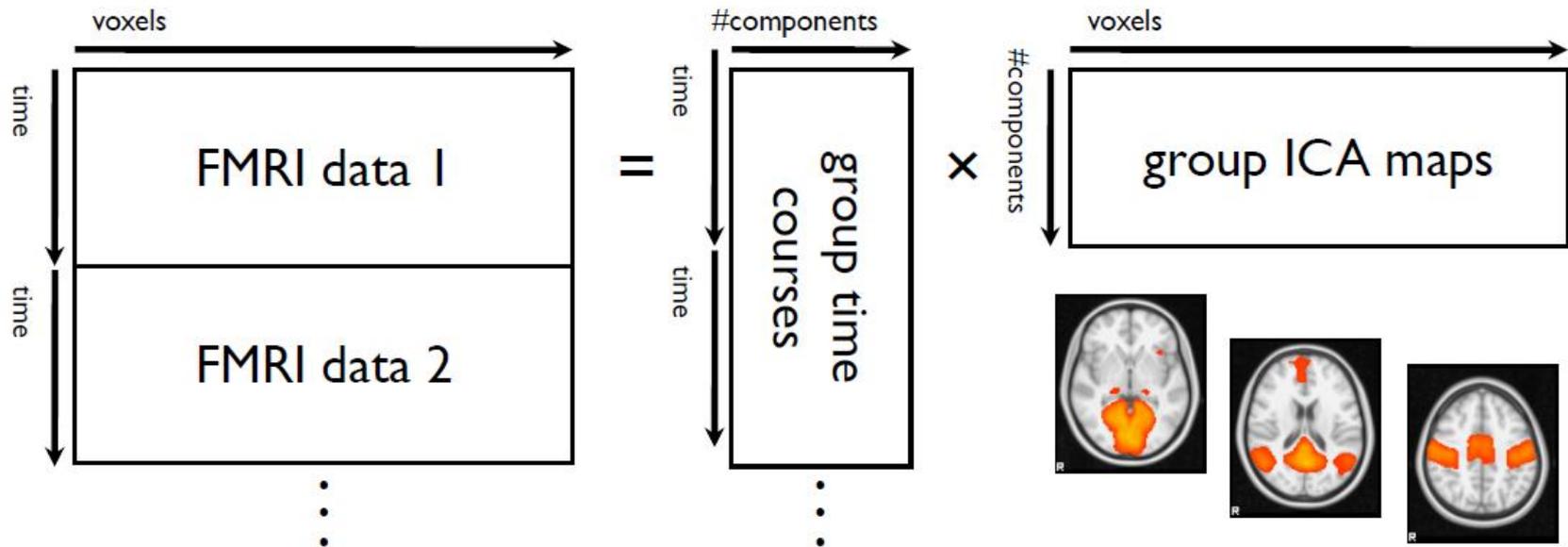
X : observed fMRI data, A : mixing matrix (time courses), S : spatial source maps



ICA-based analysis of resting state data

- Different options for ICA:
 - Single subject ICA (ssICA)
 - Group ICA (gICA)
 - Regression based on previous ICA
- ConcatICA and atlas based methods require back projection/dual regression to obtain subject specific maps from the group maps

ICA-based analysis of resting state data



Principle of temporal concatenation group ICA [7].



ICA-based analysis of resting state data

- Challenges:
 - Association of network components/noise components to resting state networks (ssICA, gICA)
 - Computational/memory requirements for large datasets
 - Atlas data (based on healthy subjects) not sensitive enough?

Outlook





ICA-based analysis of resting state data

- Compare different ICA-based methods
 - Single „Atlas“-based regression of ICA components [8, 9]
 - Dual „Atlas“-based regression of ICA components
 - Temporal concatenation group ICA [9]
- Investigate group differences in extracted networks between healthy controls and individuals affected with MDD
- Tools:
 - fMRI processing pipeline available from Klaus Sembritzki
 - Melodic, FMRIB Software Library, Oxford University [10]
 - Python NumPy, NiPy and SciPy



Thank you!





References

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