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Title

# Goals

This article’s primary goal is to report the results of the LEICA pipeline on a schizophrenia dataset and compare these results to other articles published by the TReNDS group. This will serve to reveal the new hire’s skills and deficiencies, which will serve to inform both his future education and the viable work he may perform while in the TReNDS center. The stages of this report will thus take the following:

## Description of the LEICA pipeline

### Purpose

### Reasoning

### Implementation

## Description of results

# ABSTRACT

# introduction

## Brief overview of dFC / dFNC history

### Biswal: resting state FC

### Calhoun: dFC, dFNC

#### Discovery of fluctuations in functional connectivity:

#### Functional connectivity networks (FCNs):

##### Development: Abou-Elseoud et al., 2010; Kiviniemi et al., 2009; Yu et al., 2011a (see introduction of (Yu et al. 2015))

##### Implementation: ﻿Calhoun and Adali, 2012; Calhoun et al., 2001, 2009b; Du and Fan, 2013 (see methods of (Yu et al. 2015))

##### Model order: ﻿Abou-Elseoud et al., 2010; Allen et al., 2011, 2014; Kiviniemi et al., 2009; Smith et al., 2009; Yu et al., 2011a (see methods of (Yu et al. 2015))

##### Argument for FNC over atlas-based connectivity: discussion of (Yu et al. 2015)

##### Evidence that spatial ICs evolve with time: ﻿(Kiviniemi et al., 2011), ﻿(Ma et al., 2014) (discussion of (Yu et al. 2015))

#### Proof of brain networks evolve in time: (Allen et al. 2014)

#### Quantification of dynamic graph properties: see (Yu et al. 2015), especially introduction

##### Parallels with cognitive ﻿ networks identified by meta-analyses (Amft et al., in press; Balsters et al., 2014; Kohn et al., 2014; Rottschy et al., 2012) (see results of (Yu et al. 2015))

## Conception of state or latent space for dFNC

### Recurrent patterns in dFC

#### Discovery:

##### k-means: (Allen et al. 2014)

##### eigenconnectivity: (Leonardi et al. 2013)

##### hierarchical clustering ﻿(Yang et al., 2014)

#### Quantification: Allen et al., 2014; Cribben et al., 2012; Yang et al., 2014 (see introduction of (Yu et al. 2015))

### Possible to define state or latent space using these patterns

#### Suggestion:

##### Instantaneous connectivity made up of linear combination of basis vectors

##### Unclear what to use as basis vectors:

###### Recurrent patterns?

###### Harmonic spectra?

###### Independent components?

###### Machine learning latent space(s)

#### Implementation:

## Use of state / latent spaces in analyzing dFC / dFNC

### Purpose

#### Pattern recognition & group separation:

##### Supervised

##### Unsupervised

#### Trajectory quantification

#### Reducing dimensionality simplifies all both goals:

##### Curse of dimensionality

##### Requires determining most informative axes

##### Allows definition of independent axes

### Allows deployment of novel metrics, e.g. complexity (Shannon entropy rate)

#### Explanation of Shannon entropy & Shannon entropy rate

#### Explanation of need for lower-dimensional orthogonal space

## Schizophrenia

### Phenomenology

### Societal cost

### Current findings in dFC

#### Dysconnectivity (Damaraju et al. 2014); ﻿(Friston and Frith, 1995; Stephan et al., 2006; Volkow et al., 1988; Weinberger et al., 1992)

#### Dynamic properties: ﻿(Jones et al., 2012; Rottschy et al., 2012; Sakoglu et al., 2010; Wee et al., 2013) (see introduction of (Yu et al. 2015))

#### Latent space analysis

##### Early work: Miller et. al. 2016

###### Suggests reduced dynamism in schizophrenia patients

#### Dominant hypotheses

## Role of current study

### How will LEICA method aid in this goal?

#### summarize; already have description in initial article

#### model on description(s) from Figueroa, Lord articles

# Hypotheses

## All relevant information contained in dominant connectivity pattern

# Methods

## Data collection

## Data preprocessing

## Spatial network extraction

## Static functional network connectivity

## Dynamic functional network connectivity (sliding window method)

## Eigendecomposition: motivation and use

### Motivation:

#### Shrinkage of feature (latent) space

#### Isolation of dominant connection pattern

### Implementation:

## Marcênko-Pasteur distribution: motivation and use

### Motivation:

### Implementation:

## Temporal independent component analysis: motivation and use

### Motivation

#### Optimal separation (Lopes-dos-Santos)

#### Temporal independence (Calhoun 2013, Calhoun 2015)

### Implementation (Oja & Hyvärinen 2000)

## Entropy rate: motivation and use

### Motivation:

### Implementation:

## Joint entropy: motivation and use

### Motivation:

### Implementation:

## Regression of entropy vs. clinical scores:

### Motivation:

### Implementation:

#### Joint

#### Component

# Results

## Static functional network connectivity (sFNC)

## Dynamic functional network connectivity (dFNC)

## Joint entropy rate

## Component-level entropy rate

## Entropy rate and clinical scores

### Joint

### Component-level

# Discussion

## Previous findings

### Reduced static connectivity in patients ﻿(Liu et al., 2008; Lynall et al., 2010; Yu et al., 2011a, 2013b).

### Reduced dynamical activity in patients (Miller et al. 2016; Yu et al. 2015)

#### Reduced variance of graph metrics (Yu et al. 2015)

#### Reduced magnitude of graph metrics (Yu et al. 2015); ﻿(Bassett et al., 2012; Liu et al., 2008; Lynall et al., 2010)

#### Temporal rigidity in patients ﻿(Rottschy et al., 2012); seems to contradict LEICA findings (see discussion of Yu et. al. 2015)

### Reduced spectral coupling

# Conclusions

# Future Steps

## Run a dynamical model comparison?

## Compare LEICA components to known RSNs?

## Determine whether groups (subjects?) contain same number of components?

## Determine which components are common across subjects?