ANTS course schedule overview

Dates: 8-12 August 2022
Learn: 9:00 to 12:00
LUNCH: 12:00 to 13:30
Learn: 13:30 to 18:00

What to bring to class:
I strongly encourage you to take notes on paper with a pen/pencil. A lot of empirical educational research has shown that learning, comprehension, and retention are better when taking notes by hand. **Lecture slides will not be made available.**
If at all possible, please use a computer that has MATLAB installed.

Where to download course materials:
MATLAB code and data files are organized per-day.
Code might be updated during the course; I'll let you know if you need to re-download any files.

Big-picture overview of major course topics:

Monday
- [*note: starts at 10.30!*] Introduction to EEG/LFP analyses
- Sine waves, Gaussian tapers, noise, stationarity
- Simulating data to evaluate analysis methods

Tuesday
- Fourier transform, part I (basic mechanics and implementation)
- Fourier transform, part II (frequency resolution, zero-padding, etc.)

Wednesday
- Complex Morlet wavelets, convolution theorem
- Getting power and phase results from wavelet convolution
- Parameters and their effects on TF results. Baseline normalization.

Thursday
- Other time-frequency methods: filter-Hilbert, STFFT, multitaper. Resting-state data
- Phase-based connectivity, Laplacian spatial reference

Friday
- Statistics: permutation testing and multiple comparisons
- Within-subjects and group-level statistics

ANTS course schedule details

NOTE: Details and links may be updated daily

Monday

Topics:

- Introduction to the course
- Neuroscience as source separation
- Why and how to simulate data for methods evaluation

Themes:

- The brain is really complex and it does a lot of things simultaneously. Neuroscience can be conceptualized as an attempt to separate the mixed sources.
- We can understand reality only by measuring it, but our measurement tools (physical and analytic) are imperfect and the data are noisy. Simulating data not only builds skills in data analysis, it also tells us how much we can trust analysis methods.

Code goals:

- Become familiar with the eeglab EEG data structure.
- Understand the concepts of signal, noise, ongoing, transient, broadband, wideband, narrowband.
- Be familiar with the two empirical datasets we'll use this week.

Videos and code work:
The table below shows the workflow. Start with the first row: Watch the videos then go through the corresponding code file. Then move to the next row (videos→code), etc. The duration shows the approximate amount of time recommended to spend on each row (videos+code).

Monday			
Topic	**Videos**	**Code file**	**Duration (min)**
Simulate EEG data	19, 26, 27, 28, 29, 30	**fund_1**	**120**
EEG, V1 datasets	31	**prac_1**	**30**

Tuesday

Topics:

- The math underlying the Fourier transform (complex numbers, dot product, Euler's formula)
- The mechanism of the Fourier transform and its inverse
- Stationarity
- Spectral analysis

Themes:

- Spectral analysis is a method of source separation for features that are mixed in time but differ in frequency.
- Nonstationarities are necessary for brain function, but present challenges for data analysis.
- "Signal" and "noise" can be difficult to distinguish.
- All analyses involve parameters and choices; some are easy to pick while others are more ambiguous.

Code goals:

- Code the Fourier transform from scratch.
- Extract scaled amplitude and power from Fourier coefficients
- Analyze resting-state EEG data
- Compute power spectra in time windows from task-related data

Videos and code work:
The table below shows the workflow. Start with the first row: Watch the videos then go through the corresponding code file. Then move to the next row (videos→code), etc. The duration shows the approximate amount of time recommended to spend on each row (videos+code).

Tuesday			
Topic	**Videos**	**Code file**	**Duration (min)**
Fourier fundamentals	51, 53, 54, 56, 58, 60	**fund_1**	**100**
The Fourier transform	62, 65, 66, 67, 72, 74	**fund_2**	**135**
Non-stationarities	77	**fund_3**	**30**
Resting-state	80	**prac_1**	**25**
Averaging spectra		**prac_2**	**10**

Wednesday

Topics:
- Math of wavelets
- Math and mechanics of convolution (time and frequency domains)
- Extracting and averaging phase values
- Baseline normalization

Themes:
- Time-frequency analysis combines temporal and spectral source separation.
- TF analysis involves a trade-off between temporal and spectral precision.
- Trade-off between individual results and group-level consistency. Smoothing is a good thing.
- TF analyses *increase* data dimensionality, which increases the importance of hypotheses.
- All analyses involve parameters and choices; some are easy to pick while others are more ambiguous.

Code goals:
- Create, parameterize, and visualize complex Morlet wavelets in time and frequency domains.
- Implement convolution in time and frequency domains.
- Create a time-frequency power map!
- Flexibly adjust time-frequency trade-off parameters

Videos and code work:
The table below shows the workflow. Start with the first row: Watch the videos then go through the corresponding code file. Then move to the next row (videos→code), etc. The duration shows the approximate amount of time recommended to spend on each row (videos+code).

Wednesday			
Topic	**Videos**	**Code file**	**Duration (min)**
Wavelets: time and freq	100	**fund_1**	**30**
Convolution	102, 104	**fund_2**	**65**
TF feature extraction	108, 109	**fund_3**	**35**
Power and ITPC maps	113, 114	**fund_4**	**45**
Parameters, baseline	116, 120	**fund_5**	**60**
Downsampling	132	**prac_1**	**20**
Resting-state data		**prac_2**	**15**
Optional	137, 128		

Thursday

Topics:
- Other TF methods (filter-Hilbert, STFFT, multitaper)
- Connectivity interpretations
- Phase clustering vs. phase lag
- Baseline normalization

Themes:
- All roads lead to Rome (there are many ways to do TF analyses)
- Capturing the transient nature of brain dynamics.
- The cultural persistence of data analysis methods.
- The importance of hypotheses

Code goals:
- Implement the filter-Hilbert method
- Compute phase synchronization (ISPC and PLI)
- Data selection
- Visualizing connectivity results

Videos and code work:
The table below shows the workflow. Start with the first row: Watch the videos then go through the corresponding code file. Then move to the next row (videos→code), etc. The duration shows the approximate amount of time recommended to spend on each row (videos+code).

Thursday			
Topic	**Videos**	**Code file**	**Duration (min)**
Filter-Hilbert	124	**fund_1**	**35**
EEG Laplacian	166	**fund_2**	**25**
Phase synch	164	**fund_3**	**30**
ISPC time/trials	173	**fund_4**	**25**
ISPC and PLI	169, 171	**prac_1**	**55**
Connectivity matrices	187	**prac_2**	**40**
Optional	126, 128, 162, 176, 181, 186		

Friday

Topics:
- Statistics
- Permutation-based statistics
- Multiple comparisons and their corrections
- Avoiding circular analysis (“double-dipping”)

Themes:
- Inferential statistics are imperfect quantifications of how much we trust a finding.
- The balance of objectivity and subjectivity in data selection
- Writing your own code is [great/dangerous]; using toolboxes is [great/dangerous]
- How much of EEG research is reproducible?

Code goals:
- Implement permutation testing in simple and TF data
- Compute empirical p-values
- Extract “islands” in thresholded images
- Index and select data from individuals

Videos and code work:
The table below shows the workflow. Start with the first row: Watch the videos then go through the corresponding code file. Then move to the next row (videos→code), etc. The duration shows the approximate amount of time recommended to spend on each row (videos+code).

Friday			
Topic	**Videos**	**Code file**	**Duration (min)**
Permutation testing	200	**fund_1**	**50**
Multiple comparisons	203, 204, 206, 208	**fund_2**	**75**
Perm test in V1 data		**prac_1**	**30**
Group stats	209, 211	**prac_2**	**65**
Optional	198, 199, 210		

ANTS group assignments

You will work in groups in this course. The table below shows group assignments. I've tried to create groups according to mismatching countries of origin.

You don't need to meet or work with your group before the course. I will tell you what you need to know on Monday.

Group number	Last name	Group number	Last name
1		4	
2		5	
3			