

LAN course schedule overview

Dates: 21-25 August 2023

Daily schedule:

Lecture: 9:00 to 10:00
Group: 10:00 to 12:00
LUNCH: 12:00 to 13:00
Lecture: 13:00 to 14:00
Group: 14:00 to 15:30
Break: 15:30 to 16:00
Project: 16:00 to 17:30
Closing: 17:30 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.**

Please bring a laptop that has MATLAB installed, or have a login to matlab.mathworks.com.

Where to download course materials:

MATLAB code and data files are organized per-day. They're all available here:

Discord server direct link:

Udemy course direct link:

Big-picture overview of major course topics:

BEFORE THE COURSE STARTS

- Linear algebra blitz! In the Udemy course (Section 4, videos 13-28)

Monday

- Course intro
- Spectral source separation (time series filtering)
- Simulating data to evaluate analysis methods
- **Project: Use AI to help you simulate and analyze data**

Tuesday

- Covariance and correlation matrices
- General linear models (least-squares, inverse)
- Regression for brain-brain and brain-behavior correlations
- **Project: Regression for connectivity**

Wednesday

- Principal components analysis
- State-space trajectories and clustering
- **Project: Visualizing and characterizing state-space trajectories**

Thursday

- Generalized eigendecomposition (GED) applications
- Linear discriminant analysis
- **Project: multivariate spectral scanning + single-trial regression**

Friday

- Independent components analysis, spatial filters comparisons
- Overfitting and inferential statistics
- **Project: source reconstruction accuracy by channel count**

LAN course schedule: Monday 21 August

Philosophical themes (concepts to ponder during the day):

- 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.
- The power (and limitations) of using simulated data to understand analysis methods.

AI-assistance themes:

- LLM are getting really good. Embrace them and use them to your advantage.
- You take final responsibility, even if ChatGPT helped you.
- ChatGPT can help you generate, translate, debug, and understand code.

Concrete goals (by the end of the day, you will...):

- Become familiar with the datasets used in this course.
- Implement the Gaussian filter-Hilbert method for time-frequency analysis.
- Simulate EEG data using source dipole models.

Project description:

Part 1: Create an EEG dataset with the following features. Explain what you want to ChatGPT, and have it code as much as possible. Make sure to check its work!

- 100 trials; 3 seconds at 750 Hz (-1 to +2 sec).
- One dipole generates an oscillatory burst centered at 500 ms.
- Frequency of burst increases from 10 to 20 Hz linearly as a function of trial number.
- Check the results by plotting channel data.

Part 2: Get ChatGPT to write code to compute and plot the power time series extracted from each trial, then averaged across trials, from channel 7 (v1 data).

Work overview

Morning lecture: Introductions, course organization and overview, spectral source separation

Group: EEGLab data format, empirical datasets, spectral source separation

Lecture: DL and generative AI, source simulations with dipoles

Group: source simulations, project work

Closing: What you see is what you see.

Videos and code work:

Start with the first row: Watch the videos (if listed) then go through the corresponding code file. Then move to the next row (videos→code), etc.

Monday		
Topic	Videos	Code file
Sources and separation	8, 9	
Spectral decomp.		fund_1, fund_2
EEG, V1 datasets	12	prac_1, prac_2
Simulate EEG data	29	fund_3, fund_4, prac_3

LAN course schedule: Tuesday 22 August

Philosophical themes (concepts to ponder during the day):

- Nonstationarities are necessary for brain function, but are challenging for data analysis.
- “Signal” and “noise” can be difficult to distinguish.
- A surprising amount of information is embedded in linear interactions

AI-assistance themes:

- ChatGPT can improve your code, and can explain other people’s code.

Concrete goals (by the end of the day, you will...):

- Understand confidence intervals and bootstrapping
- Examine dynamics of task-related covariance properties
- Transform covariance to correlation matrices
- Implement regression using your own code and built-in functions

Project description:

Part 1: Use regression to study connectivity across space and frequency. Extract TF power from one channel, and store the results for each trial. Pick a TF window to use as the “seed.” Regress power from that window across all other TF points. Use confidence intervals (via bootstrapping) to evaluate and plot statistical significance.

Part 2: Give sections of your code to ChatGPT and ask for feedback or improvement.

Part 3: Explain the analysis and results to ChatGPT and ask for an hypothesis that match the analysis and results.

Work overview

Morning lecture: Linear algebra review of key points, bootstrapping

Group: Covariance, correlation, confidence intervals

Lecture: GLM/regression, ChatGPT for code feedback/explanation

Group: Brain-brain and brain-behavior regression with confidence intervals

Closing: Reflections, is math real?

Videos and code work:

The table below shows the workflow. Start with the first row: Watch the videos (if listed) then go through the corresponding code file. Then move to the next row (videos→code), etc.

Tuesday		
Topic	Videos	Code file
Bootstrapping		fund_1, fund_2
Covariance	30, 31	prac_1
Covariance matrices	35	prac_2, prac_3
Cleaning covmats		prac_4
Regression		fund_3, fund_4
Regression		prac_5

LAN course schedule: Wednesday 23 August

Philosophical themes (concepts to ponder during the day):

- “Effective” dimensionality is often much lower than “numerical” dimensionality.
- Averages are snapshots; real data are exhibit continuous trajectories.
- All analyses involve parameters and choices; some are easy to pick while others are more uncertain and ambiguous.

AI-assistance themes:

- ChatGPT can translate code into a Methods section.
- ChatGPT can make your Methods section clearer.

Concrete goals (by the end of the day, you will...):

- Implement a PCA on your own and using `pca()`
- Project data to a smaller number of dimensions.
- Compute and visualize subspace trajectories.

Project description:

Part 1:

- Compute and plot the state-space trajectory in the V1 data.
- Use bootstrapping to confirm the significance of the top two components.
- Compute and plot trajectory speed.

Part 2: Put code into ChatGPT and have it write a methods section.

Work overview

Morning lecture: PCA principles and applications, ChatGPT for Methods sections

Group: PCA by own-code and by function.

Lecture: Dealing with the curses of complexity and dimensionality in neuroscience

Group: More on PCA, state-space trajectories; project work

Closing: Reflections; models and their limitations

Videos and code work:

Special note for this table: The first row is code that you (should have) worked through before the class started. You might want to go through them quickly as a refresher.

Wednesday		
Topic	Videos	Code file
LA review (pre-class work)		fund_1, fund_2
Source separation	10, 11	fund_3
V1 eigenvalues		prac_1
PCA	41, 44, 45	fund_4
PCA in data		prac_2, prac_3, prac_4
State space	52	prac_5

LAN course schedule: Thursday 24 August

Philosophical themes (concepts to ponder during the day):

- Linear separation methods can work inexplicably well.
- Covariance matrices contain lots of minable information.
- Toolboxes won't take you to the frontiers of science

AI-assistance themes:

- ChatGPT can write (or at least draft) your Results section.
- ChatGPT can help you brainstorm analyses to try.

Concrete goals (by the end of the day, you will...):

- Source separation via GED
- Simulate ground-truth EEG data for methods validation
- Understand and implement LDA (linear discriminant analysis)

Project description:

Perform GED spectral scanning on `sampleEEGdata`. Compute single-trial power in each spatial filter using the formula $\mathbf{v}'\mathbf{S}\mathbf{v}$, where \mathbf{v} is the GED vector and \mathbf{S} is the single-trial covariance. Compute power in a prestim and poststim window. Regress those two IVs on RT. Plot the standardized betas coefficients as a function of frequency.

- Describe your results in a bullet-point list.
- Have ChatGPT transform that list into a results section.
- Then have ChatGPT generate hypotheses for which the analyses are appropriate and the results confirm.

Work overview

Morning lecture: Source separation via GED, ChatGPT to write Results sections

Group: GED theory and applications

Lecture: LDA; feature selection for GED

Group: LDA in simulated and real data; project

Closing: Reflections; the unreasonable success of linearity

Videos and code work:

Special notes for this table: Code file `prac_4` is important for the project 😊. You can go through the answers file if you're running short on time. You can just run the `ANS` file for `prac_5` (or skip it altogether).

Thursday		
Topic	Videos	Code file
GED 1	60	<code>fund_1</code>
GED 2	62	<code>prac_1, prac_2</code>
Regularization	63, 76	<code>fund_2</code>
GED 3 (content not code)	67, 68	<code>prac_3, prac_4</code>
Linear discriminant analysis		<code>prac_5</code>

LAN course schedule: Friday 25 August

Philosophical themes (concepts to ponder during the day):

- 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]

AI-assistance themes:

- ChatGPT can be your tutor when Mike X Cohen isn't around (not dead, just busy).
- ChatGPT doesn't know everything (or anything) and can give incorrect explanations.

Concrete goals (by the end of the day, you will...):

- Implement permutation testing
- Compute empirical p-values

Project description:

Part 1: Determine how channel count affects GED performance, measured as reconstruction accuracy in simulated noisy data. In a loop, select subsets of channels that are either randomly selected or crafted based on location. Plot accuracy as a function of channel count/montage.

Part 2: Ask ChatGPT to teach you about GED (note: it will probably think GED stands for "general educational development") math, applications, and implementations. Ask follow-up questions that range from high-level overviews (e.g., current and potential applications in medicine) to mathematically detailed questions (e.g., norms of, and relations between, eigenvectors; how to interpret the generalized eigenvalues; statistics theory of uncertainty associated with each eigenvalue).

Work overview

Morning lecture: How to analyze data using spatial filters

Group: ICA, spatial filter comparisons

Lecture: Statistics

Group: Statistics, project work

Closing: Reflections; interpreting different results in the same data; closing remarks

Videos and code work:

Special note for this table: Have the goal to finish prac_1 by lunch. Videos 90-93 were discussed in the post-lunch live lecture. I put them in the table here because the topics are important and complicated (repetition is good for learning 🤔); you might consider watching them at 1.5x or 2x speed as a refresher.

Friday		
Topic	Videos	Code file
ICA	86	fund_1, fund_2
Oscillation distributions		fund_3
Methods comparisons		prac_1
Overfitting	90, 91	fund_4
Statistics	92, 93	prac_2, prac_3

Information about evening social programs

You are here not only to learn, but also to have fun and meet your future friends and colleagues. Every evening has a unique social event. These events are optional, but I hope you'll join for some/all of them.

Sunday 20 August

Description: Opening reception at Hotspot coworking space. Come check out the course location, have a drink and a snack, meet the instructor and your colleagues, and pick up your badge and bag. There will be PING PONG and music and alcohol!!!!

Time: 6pm until 8pm. When you arrive, tell the porter you are part of the "neuroscience workshop" and they will let you through the main gate (or just walk through if the gate is open). The coworking space is one floor up; you can take the elevator or the stairs (stairs are past the elevator on the left/right; you need to press the button "Press to exit"; it will beep and the door will unlock).

Cost: Free

Monday 21 August

Description: Hang out in the Roaba park. We meet at cafe [Modelier Parc](#). It's a nice place with outdoor seating. They have food, snacks, drinks, beers, cocktails, etc. We can also walk to the lake at sunset.

Time: 6.30pm to 9pm.

Cost: What you consume.

Tuesday 22 August

Description: Traditional Romanian dinner! Come find out what the real Romanians eat :) The restaurant is great and there are plenty of veggie/gluten-free options. It's called [Lacrimi si Sfinti](#). Link to [map location](#).

Time: Starts at 6:30pm.

Cost: Free (mostly). Food and bottled water are paid by the summer-school. You pay for any alcohol you drink.

Wednesday 23 August

Description: Local Bucharest band at a local [concert venue](#). You can listen to the band [here](#).

Time: Starts at 8 pm. The venue is about a 15-minute Uber ride from the coworking space.

Cost: Free (mostly). I will buy your tickets **if you fill in [this form](#)**. Dinner/drinks/transportation not included.

Thursday 24 August

Description: Pubquiz! Test how much you really learned in the course 😊. Location is Mark restaurant (next-door to the course location). (Note: *different questions compared to the ANTS course!*)

Time: Starts at 6.30pm.

Cost: Free (mostly)! I will provide food platters. You pay for your alcoholic drinks.

Friday 25 August

Description: Get your certificate and enjoy the last day of the course! The closing ceremony includes Italian dinner and drinks. Afterwards we'll go to a beautiful terrace with alcohol and see what happens... previous sessions have ended up at a dance bar until late.

Time: The closing ceremony starts at 6pm when class ends, and will take place at Hotspot. Dinner will be catered and include things like pizza, salad, and snacks. After dinner will be optional post-dinner drinks at [J'ai Bistro](#), which is an 8-minute walk from Hotspot.

Cost: Closing ceremony at Hotspot is free (including drinks). You pay for your own drinks at J'ai Bistro.