# Neuro RoadMap

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Whether you're a curious student, a dedicated researcher, or someone simply interested in exploring the intricate workings of the human mind, this document is designed to provide you with a roadmap through the various realms of neuroscience, computational neuroscience, and psychology.

Neuroscience, the study of the nervous system and the brain, delves into understanding how these intricate networks shape our thoughts, behaviors, and experiences. From the firing of individual neurons to complex brain circuits responsible for decision-making and emotions, neuroscience tells us about the biological underpinnings of the mind.

Computational neuroscience takes this exploration a step further by leveraging mathematical models and computer simulations to unravel the mysteries of brain function. By bridging the gap between biology and computer science, computational neuroscience offers unique insights into how neural networks process information, learn, and adapt.

Psychology, on the other hand, focuses on the study of human behavior and mental processes. From cognitive psychology exploring thought patterns and memory to social psychology examining interpersonal relationships and group dynamics, psychology encompasses a broad spectrum of disciplines aimed at understanding what makes us tick.

## Let's Begin!

## Let's Talk Neuro:

If you're unsure where to begin exploring the field of neuroscience, we highly recommend checking out the Crash Course into Neuroscience video series. It offers an engaging introduction to various aspects of neuroscience, helping you discover what aspects of the field pique your interest.

For a quick and informative dive into neuroscience, the 2-Minute Neuroscience video series has you covered! Explore a variety of topics, from fundamental concepts like neurons to more advanced discussions on topics like long-term potentiation and neuronal firing patterns.

Now, if you want to stay updated with the newest findings of the field check out this website: NeuroscienceNews.

You can also check out this brilliant website, which is an authoritative source of information about the brain and nervous system: BrainFacts.

This is the most comprehensive tool for open neuroscience resources in the world. If it exists on the internet, it's probably indexed here: Neuroscience Information Framework. Search for ANY kind of neuroscience data, atlas or software!

## Computational Neuroscience

Computational neuroscience means one of two things:

- Analysis of neuroscientific data: For example, analysis of MRI/fMRI imaging data, invasive intracranial electrode recordings from a mouse running in a maze or performing a task, calcium-sensitive fluorescent

dye imaging data, human EEG data, computer-vision analysis of post-mortem histology stains, statistical modeling of such data, and much more!

- Simulation of neural systems: Examples: simulating (aka "modeling") many compartments of a single neuron, large networks of model neurons with simple individual behavior, dynamical systems analysis of simplified neurons, neural "mass" models where only groups of neurons (not individual cells) are modeled, and so much more!

### Coding in Neuroscience:

The Neural Data Science online textbook designed for students and researchers in neuroscience and cognitive psychology, eager to harness the power of Python for data analysis! But wait, it's not just for those in the field - if you're a computer science student looking to apply your skills to neuroscience, you're in the right place too.

No prior knowledge of Python? No problem! This book starts from scratch, assuming no programming background whatsoever. However, if you're already familiar with Python, feel free to skip ahead to Chapter 4 and dive straight into the neuroscience applications.

### Intro To Comp Neuro:

One of the best Computational Neuroscience courses on the internet is Neuromatch Academy's Introduction To Computational Neuroscience Course.

The Neuro Video Series is a collection of 12 videos that covers basic neuroscience concepts and methods. The best part? You can watch them in any order you like, so pick and choose what suits your needs.

The prereq refresher videos are asynchronous, allowing you to go through the material at your own pace. Dive into Python coding with a simple neural model, then brush up on linear algebra, calculus, and probability & statistics - all tailored for the comp neuro course!

Once you're ready, jump into the proper course!

Start with Intro to Modeling, where you'll learn to ask questions about the brain using models - whether it's what, how, or why. Then, explore Machine Learning for fitting models to data and uncovering insights. Next up, Dynamical Systems will delve into building biologically plausible neuron models and networks. Finally, wrap up with Stochastic Processes, where you'll learn about Bayesian inference, optimal control, and reinforcement learning, before diving into the crucial topic of causality.

This course will help get you started with Computational Neuroscience, and will equip you with the skills required for executing relevant projects in the field!

Here are some alternatives, in case you didn't like the course above:

- Fleur Zeldenrust's Computational Neuroscience Resources
- INCF's Computational Neuroscience Resources
- Neuroscience for Machine Learners (You can also learn about Neuromorphic Computing through this course)

Spiking Neural Networks:

- Cosyne's SNNs: This is a cool website that talks about SNN's, and can help you understand and build a model on SNN's
- SNN Simulator: This website can be used to visualize SNNs and can help understand the math and the biology behind these networks.

### Brain Computer Interface:

- If you're interested in the interaction between the brain and computers, you can check out this course by UCSD: Introduction To Modern Brain Computer Interface Design. It is an online course on Brain-Computer Interface (BCI) design with a focus on modern methods.The course includes basics of EEG, BCI, signal processing, machine learning, and also contains tutorials on using BCILAB and the lab streaming layer software.

### Building a brain from scratch:

The 'How to Build a Brain from Scratch?' course explores the quest for a unified theory of learning and inference in biological brains! Join us as we delve into the interdisciplinary realms of psychology, neuroscience, machine learning, and artificial intelligence.

This course kicks things off by pondering fundamental questions about the purpose and functioning of brains. Then, through a series of engaging lectures, it explores parallel computational approaches in machine learning/AI and psychology/ neuroscience, covering topics like reinforcement learning, deep learning, and Bayesian methods.

Throughout the course, you compare computational and representational approaches to interpreting neuroscience data, discussing the feasibility and scalability of current machine learning methods. You also examine how artificial agents emulate high-level cognitive functions and their relationship with mammalian brain mechanisms.

## Psychology and the Brain

Psychology encompasses a wide range of topics, from understanding emotions and behaviors to unraveling the complexities of memory and cognition. And at the heart of it all lies the brain, the command center of our thoughts, feelings, and actions.

It explores intriguing concepts such as perception, consciousness, and the neural basis of decision-making.You can explore and uncover how your brain shapes your experiences and shapes who we are as individuals.

### Biases

Have you ever wondered why you make certain choices, even when they might not seem like the best option in hindsight? The answer may lie in cognitive biases. Biases in psychology are like hidden traps in our thinking, leading to systematic errors in judgment and decision-making. They sneak in due to our cognitive limits, social surroundings, and emotional reactions. By understanding biases, we can investigate their underlying mechanisms, develop models to explain their effects, and explore interventions to mitigate their impact. This Cognitive Biases page lists out the interesting biases, and explains them with some great examples.

### How to design a good experiment?

Imagine yourself lost in a dense forest, searching for a hidden temple. Without a map or any idea of where to look, the journey becomes a frustrating exercise in randomness. A strong hypothesis in psychology acts like a detailed GPS, guiding your research through the uncharted territory of human behavior. It tells you where to focus your efforts, what patterns to expect, and ultimately, increases your chances of making a significant

discovery.The following links can help you understand the basics behind experimental design, as well as how to arrive at a hypothesis:

- Paradigm Design
- Ten simple rules for the computational modeling of behavioral data
- How to write a good hypothesis
- Developing a hypothesis

## EEG

Ever wondered how an EEG can unveil the mysteries of your brain activity? Imagine your brain as a bustling city, alive with electrical chatter. EEG technology acts like a set of microphones strategically placed throughout the city. These microphones, unlike their audio counterparts, pick up the subtle electrical hum of brain activity – not words or music, but the symphony of communication between your neurons. By analyzing these tiny electrical signals, EEG offers a window into the inner workings of your mind.

As these signals are amplified, they appear as a graph on a computer screen or a printout. Your healthcare provider acts as the investigator, interpreting these readings to uncover any abnormalities or patterns in your brain activity.

When it comes to the analysis of EEG data, you might easily feel overwhelmed by the huge variety of pre-processing steps, all of which require informed decisions with regard to the expected effects on the data. Don't worry, we've got you covered! Explore these links below to navigate through the preprocessing journey step by step:

- UpsideDownLabs  Practical Tutorials for EEG
- Neuroelectrics: EEG preprocessing
- Medium: EEG preprocessing
- Overview of MEG/EEG analysis with MNE-Python: This tutorial covers the basic EEG/MEG pipeline for event-related analysis: loading data, epoching, averaging, plotting, and estimating cortical activity from sensor data.

## Fin.

As we conclude this guide, it's important to recognize that your journey is far from over—it's merely the starting point! The human brain, with its intricate connections and limitless possibilities, presents an infinite realm for exploration and creativity. If you've reached this stage, you're primed to embark on more advanced ventures. Now is the moment to seek out new project inspirations and delve deeper into your interests.

Happy learning!

Any doubts? Shoot 'em up on discord

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