Syllabus

NESC 3505: Neural Data Science

Cross-Listed as PSYO 3505

Fall 2025-26

Mondays: 14:35 pm - 16:25 pm September 2 – December 3, 2025 Location: Killam Library 4106

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Instructor

Saisha Rankaduwa (saisha@dal.ca)

Teaching Assistants   Can Souzer (sozuer@dal.ca) | Max Mascini (mascini.max@dal.ca)

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Dalhousie University acknowledges that we are in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People and pays respect to the Indigenous knowledges held by the Mi'kmaq People, and to the wisdom of their Elders past and present. The Mi'kmaq People signed Peace and Friendship Treaties with the Crown, and section 35 of the Constitution Act, 1982 recognizes and affirms Aboriginal and Treaty rights. We are all Treaty people. Dalhousie University also acknowledges the histories, contributions, and legacies of African Nova Scotians, who have been here for over 400 years.

Course Description

An introduction to data management, manipulation, visualization, and analysis for neuroscience. Students will learn scientific programming in Python, and use this to work with example data from areas such as cognitive-behavioural research, single-cell recording, EEG, and structural and functional MRI. Basic signal processing techniques including filtering will be covered.

Prerequisites

PSYO 2000, **PSYO 2501**, and **NESC 2470**, with a minimum grade of B in PSYO 2501. Grades of B+ or better in all three classes are recommended. **No prior programming experience is required**.

Background and Rationale

Most areas of neuroscience research and development rely on increasingly large and complex data sets. Discovery and application in neuroscience thus relies on the ability to manage these large data sets, and extract meaning from them. In other words, neuroscience now relies heavily on **data science**, which has been variously defined as "... an umbrella term to describe the entire complex and multistep processes used to extract value from data." (Wing, 2019) and the ability to "bring structure to large quantities of formless data and make analysis possible" (Davenport & Patil, 2012, p.73).

In neuroscience, data science is an increasingly necessary skill. Data from techniques like single-cell recordings, local field potentials, EEG, and fMRI is complex and multidimensional. Being able to understand, manipulate, and visualize the structure of these complex datasets is a necessary skill for performing the research. On top of this, it is increasingly clear that very large data sets - often built collaboratively by many labs - are required to make reliable inferences about neuroscientific processes. Making inferences also depends on computational models - ways of identifying and representing patterns in the data. While some of these will be familiar from statistics class, a wide range of statistical and machine learning models are now widely used in neuroscience.

While data science and statistics are overlapping fields, statistics is generally focused on the specific task of testing hypotheses based on data. Data science more broadly includes the storage, manipulation, visualization, filtering, and preparation of data that is typically required prior to statistical analysis. Data science does also encompass statistics, as well as machine learning; whereas statistics generally involves deriving conclusions from existing data, machine learning involves making predictions from a data set that will generalize to other data. Since statistics is covered in other courses in the neuroscience and psychology curricula, this course focuses instead on the other "front-end" aspects of data science described above. Other areas of data science, including "back-end"

data science (engineering, hardware, databases) and software development, will not be covered.

Central to data science is the ability to use scientific programming languages, such as Python, Matlab, and R. This ability includes a strong understanding of the fundamentals of at least one programming language, and the ability to extend one's knowledge through continuous learning and problem-solving. This course teaches Python, a mature and widely-used language in neuroscience and data science more broadly. However, much of the fundamentals of scientific programming and data science are common to all languages. Thus, having learned Python, you will be better prepared to learn new languages in the future, as necessary.

Another important facet of data science is that it is a **team endeavour**. On the one hand, it is founded on open, shared software developed by widely distributed teams of contributors. On the other hand, the practice of data science typically involves teams of individuals with complementary skillsets, both due to the size and complexity of many projects. In science, these teams often comprise students and faculty members in collaborating labs distributed around the world. This class prepares you for such collaboration by developing and coaching your teamwork skills, as well as teaching you how to use software platforms that support such collaboration.

The skills learned in this class will benefit students working in a wide variety of areas of neuroscience. As well, the class will provide an introductory foundation in data science that can be applied to a wide range of areas of research and application, in academia, industry, and government.

References:

Davenport, T. H., & Patil, D. J. (2012). Data scientist. *Harvard Business Review*, 90(5), 70-76.

Irizarry, R. A. (2020). The role of academia in data science education. *Harvard Data Science Review*, 2(1). https://doi.org/10.1162/99608f92.dd363929

Wing, J. M. (2019). The data life cycle. *Harvard Data Science Review*. https://doi.org/10.1162/99608f92.e26845b4

Learning Objectives

Hard Skills

- Extract meaning from data, but also articulate the limitations of the conclusions you can draw from it
- Write functional and efficient code in Python to perform basic data science tasks

- Use AI coding assistants to generate Python code to perform basic data science tasks
- Critically evaluate, test, and debug code generated by AI coding assistants
- Use online tools for version control, collaborative software development, and project management
- Read and write data files in common formats such as CSV and Excel
- Organize and manipulate data structures such as lists, arrays, and data frames
- Work with continuous, discrete, and factorial data
- Visualize data in a variety of graphical formats
- Perform exploratory data analysis using graphical and basic statistical operations
- Perform basic signal processing on data, such as filtering in temporal and spatial dimensions
- Build and run data processing pipelines on various types of neuroscientific data, including single unit recordings, time series, and 2D/3D/4D images
- Understand basic concepts and common tools used in machine learning, including deep neural networks
- Extend your skills using online resources

Soft Skills

- Demonstrate a professional work ethic
- Be effective and productive in a hybrid in-person/remote working environment
- Work collaboratively, effectively, and productively in a distributed team
- Manage projects: manage time and human resources effectively to achieve specific objectives on a stated timeline
- Peer-review the work of other team members
- Teach others skills and solutions you discover, and communicate your approach to discovering these
- Articulate your strengths and weaknesses as a data scientist working in a team, and identify ways to improve your abilities
- Demonstrate skills you have developed using a portfolio of work, to potential supervisors/employers
- Use, and communicate the value of, open and reproducible code and data

Course Format

This course involves weekly in-person tutorial sessions, with the expectation that students will spend considerable time out of class working through online tutorials. The course consists of the following components: - Freely-accessible online **textbook** - Asynchronous **online lessons** that follow the textbook, along with files you can download to code along with the lessons - Weekly **in-person lab** sessions. Attendance is expected. In some labs the instructor and/or TA

will review material, such as introducing an assignment and discuss approaches to completing it. Some labs will be open work time where the instructor and TA are available for consultation.

Online Lectures and Tutorials

This course employs a "flipped classroom" model. The primary course material is the online textbook, with video walkthroughs of the textbook lessons on the course YouTube channel. These largely involve writing code. **This course requires that you put in significant hours per week outside of class: you should budget 8 h/week for coursework, including the 2 h/week lab time.**

Getting Help

One of the course learning objectives is to "Extend your skills using online resources", and the course is based on the learning theory of connectivism. You are encouraged and supported in taking a *lifelong learning* approach to solving problems in this course. Many of the evaluations expect you to engage in this; by design, you will not find all the answers in the textbook.

That said, learning can sometimes go a lot faster when you ask questions. We encourage you to ask questions of your peers in the class, and of the teaching team — in that order. Peer teaching is built into the class through collaboration tools, demos, and team projects. This is the way real, functional teams operate — supporting each other to achieve more.

The course Brightspace site is where you should direct all your questions (after making your own attempts to research and solve your problem). This can include posting questions in the messaging forums, or joining live check-ins to ask questions.

There are no formal instructor or TA office hours for this course. If you wish to speak with the instructor or TA, just contact them in a timely manner (note that rapid replies cannot be guaranteed) and ask to schedule a meeting and we will set something up at a mutually-agreeable time.

Course Materials

All necessary materials (including the textbook) will be provided online. **You must have access to a computer** running a recent version of a Mac, Windows, or Linux operating system. It may be possible to complete this course, including programming assignments, using an iPad, Android device, or Chromebook, but this has not been verified. It is not a good idea to expect to be able to complete the course using only a mobile device (phone or tablet).

You must also have access to internet service of sufficient quality to stream

videos and maintain a live connection to remote servers. If you are unable to access the internet at home, you can use the internet at Dalhousie, or at a public library or other public space. If you are unable to access the internet at all, please contact the instructor to discuss options.

Beyond these basic requirements, this course emphasizes (and will teach you about) openly accessible resources including the software that runs the course, open access to the course materials, and the use of external resources that are available for free. No physical textbook is required. This course will rely on Open Educational Resources — materials that are freely accessible and openly licensed — including online tutorials, videos, and books. A wide variety of educational materials (free and paid) for data science are available, and this course teaches an approach to lifelong learning and exploration by which you will be able to find and critically evaluate the information necessary to perform desired tasks.

Assessment and Evaluation

Due dates for all assessment and evaluation components will be posted on the course Brightspace area.

You can expect that grading of the evaluations will be quite strict. For all evaluations, **late work will be penalized 2% per hour**, with the clock starting the minute after the deadline has elapsed. **Requests for extensions will only be considered prior to the due date**.

Assignments

These are coding assignments that you will complete, based on neuroscience data. There is an assignment due approximately every second week, except weeks when projects are due. The first assignment is mandatory for everyone, and it's important because it will teach you how to access course materials and use the tools required for the rest of the course. All of the other assignments are mandatory, however — if and only if you submit *all* of the assignments — the grade on the assignment you did worst on will be dropped (see table below).

Projects

There are 2 team-based projects to complete. These projects are directly based on the class assignments, but integrate across multiple classes and assignments, as well as requiring you to extend and apply what you have learned, to new contexts.

Dealing with unequal contributions Submitting a peer assessment itself is worth only a few points towards your final grade. However, it is also an opportunity for teams to identify individuals who did not contribute substantially to the project work. The peer assessment asks each team member to estimate

the proportion of work done on the project by each team member. If any team member is identified by a majority of other team members as having done substantially less then their fair share of the work ("substantially less" being less than half as much work as others), the average contribution rating of all team members (other than the student in question) will be used to reduce the student's grade on the team project.

For example, imagine a team of 4 members: A, B, C, and D. Team member D slacks off and does little to none of the work, and members A, B, and C rate D's contribution as 0, 2, and 4% of the project respectively — for an average of 2% (where equal work would have been 25% each). Let's say the team's project receives a grade of 80/100 points. In this case, team member D's grade on the project would be 2/25 or 8% of the points awarded for the project, i.e., 0.08 * 80 = 6.4 points.

Please note that this is a "worst case" scenario, although it has happened in the past. We much prefer it if issues are identified before things get this bad. Teams should first try to contact the team member who seems to be doing less work, and discuss the issue with them to try to find a resolution. Secondly, *before the project deadline*, teams should contact the instructor to discuss the problem.

If you are on a team and are having trouble completing your fair share of the work, likewise please first discuss this with your team members, and if you can't resolve it that way, please contact the instructor to discuss — ideally well before the project deadline. The purpose of this mechanism is to prevent students from "freeloading" on the work of others, but it is *not* meant to penalize people who are experiencing genuine struggles of any kind. The instructor is eager to support students who are struggling in any way.

Quiz

Because the course meetings are on Mondays, but the term starts on a Tuesday, we have scheduled an online quiz for the end of week 1. The quiz will be on the first two textbook chapters, which provide background information on the course and are important for your doing well throughout the term.

Project Peer Assessments

You will be asked to submit structured peer reviews following each of the two team projects. This will be done using a rubric with five components: participation, preparation, communication, collaboration, and academic quality. Your grade will be the average of the ratings assigned to you by your team members. **Late peer assessments will be penalized 2% per hour**, with the clock starting the minute after the deadline has elapsed.

Grading

This course follows the [Dalhousie grading scale]().

Evaluations	%
Assignments	
Assignment 1	2.0
Assignments 2-5, 3 best marks @ 15	45.0
Projects	
Project 1	
Written submission	12.0
Class Presentation	12.0
Project 2	
Written submission	12.0
Class Presentation	12.0
Quiz	
Quiz 1	2.0
Peer Assessments	
Project 1 peer assessment	1.5
Project 2 peer assessment	1.5
Total	100.0

Schedule

[Click here to see the schedule]().

Weekly Structure

Synchronous Activities

Each week, there will be one in-person lab session as scheduled in the university timetable. This session will typically include review of the week's learning material, tutorials on course content or on things that we identified as issues (e.g., errors on assignments, questions from students), and the opportunity to ask questions of the teaching team. Some lab sessions will be open work time when you can work on course material with the teaching team on-hand to answer questions as they arise.

Asynchronous Activities

Most of your learning will come from sitting and coding, working through the lessons (ideally following along with the videos), and completing the assignments and projects. These are asynchronous activities so you can work on them on the schedule that best works for you. The course is designed expecting you to complete three lessons per week, along with any assignments. You should aim to

follow the schedule to keep up with the lessons (although of course the beauty of asynchronous learning is the flexibility). For many people, it works best to block off time every day or two to focus on work for this course.

Policies

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate.

Attendance

Attendance of scheduled class meetings is expected, and scheduled class times are the only time when you can get in-person help with the course material. You can message the TAs and instructor outside of this time for help, but response times and availability will be variable.

Academic Freedom

Freedom of speech and of thought are cornerstones of academic institutions such as Dalhousie. Our goal in science is to observe and characterize the world accurately and objectively. However, we must realize that our perceptions of reality are often coloured by our beliefs and assumptions, some of which we may not be aware of. Academic freedom includes not only the freedom to think as you please, but others' freedom to express their beliefs as well. Please do not hesitate to express your ideas, but do so in a way that is respectful of others. This is the only avenue for the free expression and exchange of ideas.

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity. For more details please see: https://www.dal.ca/about/leadership-governance/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia). Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Code of Student Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution. For more information please see https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/student-life-policies/code-of-student-conduct.html

Important Dates in the Academic Year (including add/drop dates)

https://www.dal.ca/study/plan-your-degree/important-dates.html

University Grading Practices

https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/grading-practices-policy.pdf

Missed or Late Academic Requirements due to Student Absence (policy)

https://www.dal.ca/content/dam/www/about/leadership-and-governance/university-policies/student-absence-regulation.pdf

Learning and Support Resources

Advising

General Advising: https://www.dal.ca/campus_life/academic-support/advising.html

Science Program Advisors: https://www.dal.ca/campus_life/academic-support/advising/where-to-go-for-advising.html

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Black Students Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre/current-students.html

Academic supports

Library: https://libraries.dal.ca

Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Studying for Success: https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Copyright Office: https://libraries.dal.ca/services/copyright-office.html

Fair Dealing Guidelines: https://libraries.dal.ca/services/copyright-office/fair-dealing.html

Other supports and services

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness.html

Student Advocacy: https://www.dsu.ca/dsas

Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html

Safety

Biosafety: https://www.dal.ca/dept/safety/programs-services/biosafety.html

Chemical Safety: https://www.dal.ca/dept/safety/programs-services/chemical-safety.html

Radiation Safety: https://www.dal.ca/dept/safety/programs-services/radiation-safety.html

Scent-Free Program: https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html

Recognition

Recognition of Mi'kmaq Territory

Dalhousie University is located in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq. We are all Treaty people. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit the Indigenous Student Centre or contact the programs at elders@dal.ca.

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported,

which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness. For more information please see here.