Syllabus

NEUR 592 | BIOL 691 | BINF 739

Our Brain is a Time Machine: The Physics, Psychology, and Neuroscience of Time

Spring Semester 2025

Weekly schedule: Starting on **January 21, 2025**, each week runs from Monday (12:01 am) to Sunday (11:59 pm).
Instructor: Frank Krueger, Ph.D.
Department: School of Systems Biology
Phone: 703-993-4358
Email: FKrueger@gmu.edu (preferred)
Office Hours: By appointment via Zoom

Course Description

Our Brain is a Time Machine: The Physics, Psychology, and Neuroscience of Time is an **asynchronous online course** that explores the fascinating relationship between the brain and the concept of time. Students will investigate how the brain perceives, processes, and manipulates time, drawing insights from philosophy, psychology, neuroscience, and physics. Through reading assignments about topics, watching videos and reflecting on neuroscience methods, defining key concepts, testing their knowledge about brain anatomy, and sharing and discussing their knowledge with classmates, students will gain a deeper understanding of the neural mechanisms that shape our experience of time, from the ticking of the clock to the flow of memories.

The course is divided into four parts:

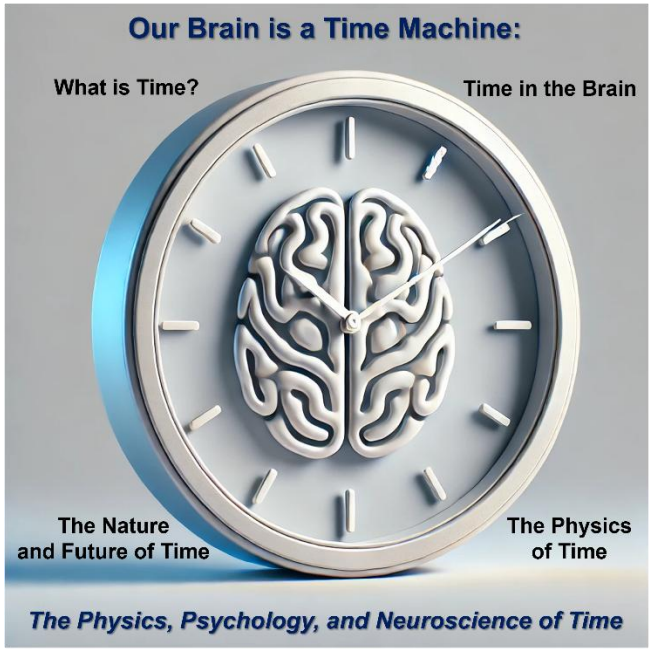
- **Part 1 (What is Time?)** examines different philosophical perspectives on the nature of time, explores how psychological factors influence our subjective experience of time, and investigates how different cultures conceptualize time.
- **Part 2 (Time in the Brain)** delves into the neuroscience of time, exploring biological clocks, neural mechanisms for timing movements, and the role of the brain in forming and retrieving memories related to time.
- **Part 3 (The Physics of Time)** examines the world of physics to understand classical mechanics, Einstein's theory of relativity, and the intriguing possibilities (and paradoxes) of time travel.
- **Part 4 (The Nature and Future of Time)** explores the arrow of time, the relationship between time and consciousness, how altered states affect time perception, and the impact of technology on our experience of time.

Learning Outcomes

By the end of this course, students will be able to:

1. Understand how the brain constructs and interacts with the concept of time by integrating perspectives from psychology, philosophy, and neuroscience, and
2. Evaluate the advantages and disadvantages of various neuroscientific methods (anatomical, genetic, neurophysiological, pharmacological, endocrinological, and neurocomputational) in studying animal and human time perception.

Concept map



Prerequisites

Completion or concurrent enrollment in all other required general education courses or permission of the instructor. This course is essential for anyone interested in this rapidly developing interdisciplinary field. Reading, research, and collaboration with the class are major components of the course.

Course Materials

This course utilizes a curated selection of weekly readings, including overview articles, research papers, and occasional book chapters, to provide a comprehensive and engaging exploration of the topic. This approach ensures exposure to the most relevant and up-to-date research. All readings will be available online.

Course Logistics

This course will use a distance learning format; the primary meeting space will be on Canvas 9.1, and we will use other means of keeping in touch, such as email, telephone, and Zoom. This is a rigorous course: you will accomplish the following activities in a typical week:

- reading about 35-50 pages, reflecting on the content, and discussing the material with your classmates,
- completing online activities and responding to weekly requirements and
- working on assignments completed in Canvas according to the assignment schedule.

Although the delivery method differs, it should take the same time as a full-semester course. You should **expect to spend approximately 9 hours on coursework each week** (this includes the time you would have spent in a classroom). It is critical to keep up with weekly requirements. It is critical to keep up with weekly requirements. Each week, I will provide an announcement via email and a learning module in our Canvas course to specify required activities and assignments.

Canvas (Available on January 21, 2025)

We will use Canvas for the course. Additional guidance on individual assignments and discussion questions will be posted there. All assignments will be submitted through Canvas for grading. Please visit our Canvas site regularly.

Access Canvas by following these steps:

1. Go to http://mymason.gmu.edu.
2. Login using your NETID and password,
3. Click on the 'Courses" tab.
4. Click on 'Neurobiology of Decision-Making (Spring 2025 Special Topics in Neuroscience: NEUR-592-DL1, BINF-739-DL2, BIOL-691-DL1)' under the 'Course List' heading.

Instructor-Student Communication

I will respond to your emails within 24 hours from Monday (9 a.m.) through Friday (6 p.m.). If I am away from email for more than two days, I will post an announcement in the Canvas course folder.

Before sending an email with questions, please check the following (available on your Canvas course menu) **unless the email is personal**:

1. Syllabus.
2. Ask the Professor (Feel free to respond to other students in the Help forum if you know the answer.).
3. Canvas Tutorials on how to use Canvas features.
4. Canvas Q&A (resources specific to Mason).
5. Technology Requirements.

Mason EMAIL

- Mason requires that you use your Mason email for all courses. I will send messages to your Mason email, and you are responsible for making sure you have access to these messages.
- You may forward your Mason email to other accounts but always use your Mason email when communicating with me to allow verification of your identity.
- You are required to check your Mason email account regularly and to keep your mailbox maintained so that messages are not rejected for being over quota.
- When you email me, you can expect a response within 24 hours (*Monday through Friday*). If I am away from email for more than two days, I will send an announcement to the class.
- When you email me, include **Our Brain is a Time Machine** at the beginning of the subject heading to alert me that I have received a message from one of my online students.

Participation

Netiquette For Online Discussions

Our discussion should be collaborative, not combative; you create a learning environment, sharing information and learning from one another. Respectful communication is essential to your success in this course and as a professional. Please re-read your responses carefully before you post them so others will not take them out of context or use them as personal attacks. Be positive to others and diplomatic with your words, and I will try my best to do the same. Be careful when using sarcasm and humor. Without face-to-face communication, your joke may be viewed as criticism. Experience shows that even an innocent remark in the online environment can be easily misconstrued.

Netiquette prepared by Charlene Douglas, Associate Professor, College of Health & Human Services, GMU.

Technology Requirements

Technology requirements for the course are:

- Internet connection (DSL, LAN, or cable connection desirable);
- Supported Web browser (e.g., Internet Explorer, Chrome, Safari) to use Adobe Connect for Live Class Sessions and
- MS Office 365 ProPlus is free via the Microsoft Student Advantage Program (Access is tied to your @masonlive.gmu.edu email address).

Student Responsibilities

Mason Email

Students are responsible for the content of university communications sent to their George Mason University email account and are required to activate their account and check it regularly. For accessibility and privacy, the university, school, and program will send communications to students solely through their Mason email account—students should respond accordingly.

Patriot Pass

Once you sign up for your Patriot Pass, your passwords will be synchronized, and you will use your Patriot Pass username and password to log in to the following systems: Canvas, University Libraries, MasonLive, myMason, Patriot Web, Virtual Computing Lab, and WEMS. [See https://password.gmu.edu/index.jsp].

Students with Disabilities

Students with disabilities who seek accommodation in a course must be registered with the George Mason University Office of Disability Services (ODS) and inform their instructor in writing at the beginning of the semester (Office of Disability Services).

Academic Integrity

Students must be responsible for their work, and students and faculty must take on the responsibility of dealing explicitly with violations. The tenet must be the foundation of our university culture (https://oai.gmu.edu/).

Honor Code and Virtual Classroom Conduct

Students must adhere to the guidelines of the George Mason University Honor Code (See Honor Code).

We value critical thinking, and therefore, it is imperative that students read the assigned material (e.g., books and articles) before class with a critical eye. Active thought, quality input, and a conflict-resolution attitude should be your guiding principles.

The principle of academic integrity is taken very seriously, and violations are treated gravely. What does academic integrity mean in this course? Essentially, when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form.

Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind), please ask for guidance and clarification.

Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please contact me.

University Policies

Students must follow university policies (University Policies).

Responsible Use of Computing

Students must follow the university policy for Responsible Use of Computing (http://universitypolicy.gmu.edu/policies/responsible-use-of-computing).

University Calendar

Details regarding the current Academic Calendar (https://registrar.gmu.edu/calendars/).

University Catalog

The current university catalog (University Catalog).

Student Services

Writing Center

The George Mason University Writing Center staff provides a variety of resources and services (e.g., tutoring, workshops, writing guides, handbooks) intended to support students as they work to construct and share knowledge through writing (Writing Center). ESL Help: The program was designed specifically for students whose first language is not English and who feel they might benefit from additional, targeted support throughout the semester (Writing Center).

University Libraries

University Libraries provide resources for distance students (http://library.gmu.edu/for/online).

Counseling and Psychological Services

The George Mason University Counseling and Psychological Services (CAPS) staff consists of professional counseling and clinical psychologists, social workers, and counselors who offer a wide range of services (e.g., individual and group counseling, workshops, and outreach programs) to enhance students' personal experience and academic performance (http://caps.gmu.edu).

Family Educational Rights and Privacy Act (FERPA)

The Family Educational Rights and Privacy Act of 1974 (FERPA), also known as the "Buckley Amendment," is a federal law that protects student educational records and provides students with certain rights (http://registrar.gmu.edu/privacy).

Weekly Schedule

Distance learning courses are dynamic—to ensure we achieve our learning outcomes— we may need to negotiate weekly schedule changes. We will focus on learning, fairness, and reason for any approved changes. Each week's activities —reading assignments about topics, watching videos and reflecting on neuroscience methods (via a blog), defining key concepts (via a glossary), testing your knowledge about brain anatomy (via a quiz), and sharing and discussing your knowledge with classmates (via discussion forum)— **requires approximately 9 hours.**

The table below lists the weekly schedule, major activities, major assignments, points, and due dates for this course. Final grades will be based on the total points earned in the course.

Weeks	Major Topics and Methods	Assignments (graded)	Points	Due Dates (11.59 pm, EST)
Week 1 Tue., January 21 – Sun., January 26	**I. WHAT IS TIME?** *Topic*: Philosophical Perspectives on Time *Method*: Single-Unit Recording	Orientation Quiz Self-Introduction Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 10 5 5 5 5 10	Sun., 1/26 Thu., 1/23 Sun., 1/6
Week 2 Monday, January 27 – Sun., February 2	**I. WHAT IS TIME?** *Topic*: The Psychology of Time *Method*: Electroencephalography (EEG)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 1/30 Sun., 2/2
Week 3 Mon., February 3 – Sun., February 9	**I. WHAT IS TIME?** *Topic*: The Anthropology of Time *Method*: Event-Related Potential (ERP)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 2/6 Sun., 2/9
Week 4 Mon., February 10 – Sun., February 16	**II. TIME IN THE BRAIN** *Topic*: The Neuroscience of Time I - Biological Clocks *Method*: Magnetoencephalography (MEG)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 2/13 Sun., 2/16
Week 5 Mon., February 17 – Sun., February 23	**II. TIME IN THE BRAIN** *Topic*: The Neuroscience of Time II - Timing and the Cerebellum *Method*: Positron Emission Tomography (PET)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 2/20 Sun., 2/23

Week 6 Mon., February 24 – Sun., March 2	**II. TIME IN THE BRAIN** *Topic*: Time and Memory *Method*: Magnetic Resonance Imaging (MRI)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 2/ 27 Sun., 3/2
Week 7 Mon., March 3 – Sun., March 9	**II. TIME IN THE BRAIN** *Topic*: Time and Decision-Making *Method*: Functional Magnetic Resonance Imaging (fMRI)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 3/6 Sun., 3/ 9
Spring Break Mon., March 10 – Sun., March 16				
Week 8 Mon., March 17 – Sun., March 23	**III. THE PHYSICS OF TIME** *Topic*: The Physics of Time I - Classical Mechanics *Method*: Resting-State fMRI (RS-fMRI)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 3/ 20 Sun., 3/ 23
Week 9 Mon., March 24 – Sun., March 30	**III. THE PHYSICS OF TIME** *Topic*: The Physics of Time II - Relativity *Method*: Functional Near-Infrared Spectroscopy (fNIRS)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 3/ 27 Sun., 3/ 30
Week 10 Mon., March 31 – Sun., April 6	**III. THE PHYSICS OF TIME** *Topic*: Time Travel - Possibility and Paradoxes *Method*: Transcranial Magnetic Stimulation (TMS)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 4/ 3 Sun., 4/6
Week 11 Mon., April 7 – Sun., April 13	**IV. THE NATURE and FUTURE OF TIME** *Topic*: The Arrow of Time *Method*: Transcranial Direct Current Stimulation (tDCS)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 4/10 Sun., 4/13

Week 12 Mon., April 14 – Sun., April 20	**IV. THE NATURE and FUTURE OF TIME** *Topic*: Time and Consciousness *Method*: Invasive Stimulation Methods in Animals (Microstimulation)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 4/17 Sun., 4/20
Week 13 Mon., April 21 – Sun., April 27	**V. THE NATURE and FUTURE OF TIME** *Topic*: Time in the Altered States of Consciousness *Method*: Invasive Stimulation Methods in Animals (Optogenetics)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection	5 5 5 5 10	Thu., 4/24 Sun., 4/27
Week 14 Mon., April 28 – Sun., May 4	**V. THE NATURE and FUTURE OF TIME** *Topic*: The Future of Time - Technology and Time Perception *Method*: Lesion Studies (Humans)	Topic: Discussion (Part 1) Topic: Glossary Brain: Quiz Topic: Discussion (Part 2) Method: Reflection Course Evaluation	5 5 5 5 10 15	Thu., 5/1 Sun., 5/4
Exam Week Mon., May 5 – Sun., May 11	Research Grant Proposal	Submission: Proposal	150	Sun., 5/11
			Total 600	

Grading Scale (points)

Final grades assigned for this course will be based on the percentage of total points earned and are assigned as shown in the table. Remember that I do not give grades; you earn them.

Letter Grade	Percentage	Points	Performance
A+	98-100%	588-600	Superb Work
A	93-97%	558-582	Excellent Work
A-	90-92%	540-552	Nearly Excellent Work

B+	87-89%	522-534	Very Good Work
B	83-86%	498-516	Good Work
B-	80-82%	480-492	Mostly Good Work
N/A	<80%	<480	Failing Work