NeuroAI: Intelligence, Brains, and Machines - Seminar Syllabus

CS8803 - NeuroAI: Intelligence, Brains, and Machines

Course Prefix and Number: CS8803
Course Title: NeuroAI: Intelligence, Brains, and Machines
Credit Hours: 1
Semester and Academic Year: Fall 2026
Format: Seminar

Instructor Information

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General Course Information

Course Description

NeuroAI: Intelligence, Brains, and Machines is a 1-unit seminar for students of artificial intelligence who want a foundation in neuroscience, cognitive neuroscience, neurotechnology, and consciousness studies. The course examines how biological systems compute, learn, represent, remember, attend, act, use language, and support conscious experience. Rather than treating the brain as a vague inspiration for artificial neural networks, the seminar asks what AI students should understand about neurons, circuits, learning, memory, attention, executive control, language, brain-computer interfaces, synthetic biological intelligence, and neuroethics.

The course uses a layered learning model. A compact computational cognitive neuroscience textbook provides the shared foundation. A small number of carefully selected papers expose students to major research conversations in NeuroAI, neurotechnology, artificial consciousness, and neuroethics. AI-assisted reading workflows, including NotebookLM audio overviews, are used to help students engage difficult interdisciplinary material critically and efficiently.

Because this is a 1-unit seminar, the course emphasizes conceptual fluency, critical reading, discussion, and synthesis rather than intensive programming, mathematical derivation, or full computational neuroscience training.

Course Learning Outcomes

Upon successful completion of this seminar, students should be able to:

1. **Describe** core neuroscience and cognitive neuroscience concepts relevant to AI, including neurons, networks, learning, memory, attention, reinforcement learning, executive function, language, and consciousness.
2. **Explain at a high level** how selected biological mechanisms have influenced, or may inform, artificial intelligence research.
3. **Compare** selected features of biological and artificial intelligence systems, including representation, learning, generalization, memory, and control.
4. **Interpret and discuss** foundational NeuroAI readings with appropriate attention to both the original sources and AI-assisted study materials.
5. **Identify** major emerging areas in NeuroAI, including neural decoding, brain-computer interfaces, foundation models for neuroscience, synthetic biological intelligence, artificial consciousness, and neuroethics.
6. **Develop a short synthesis** connecting one neuroscience concept to a current or future direction in AI.

Required Course Materials

Required course materials may include selected textbook chapters, research papers, videos, NotebookLM audio overviews, guest speaker materials, and course-provided resources published in Canvas.

Required Textbook

O'Reilly, R. C., Munakata, Y., Frank, M. J., Hazy, T. E., and Contributors. *Computational Cognitive Neuroscience*, 5th Edition. Open-source textbook. 2024.
Available at: https://compcogneuro.org/book or https://book.compcogneuro.org/

Students will complete a conceptual pass through the textbook across the semester. The emphasis is on conceptual understanding rather than mastery of every mathematical derivation, appendix, or simulation detail.

Required Anchor Papers

The following papers form the required research-paper spine of the course. Additional optional readings may be assigned in Canvas.

1. Hassabis, D., Kumaran, D., Summerfield, C., and Botvinick, M. *Neuroscience-Inspired Artificial Intelligence*. Neuron, 2017.
https://www.sciencedirect.com/science/article/pii/S0896627317305093

2. Marblestone, A. H., Wayne, G., and Kording, K. P. *Toward an Integration of Deep Learning and Neuroscience*. Frontiers in Computational Neuroscience, 2016.
https://www.frontiersin.org/journals/computational-neuroscience/articles/10.3389/fncom.2016.00094/full
3. *The emergence of NeuroAI: bridging neuroscience and artificial intelligence*. Nature Reviews Neuroscience, 2025.
https://www.nature.com/articles/s41583-025-00954-x
4. Lake, B. M., Ullman, T. D., Tenenbaum, J. B., and Gershman, S. J. *Building Machines That Learn and Think Like People*. 2016/2017.
https://arxiv.org/abs/1604.00289
5. Richards, B. A., et al. *A deep learning framework for neuroscience*. Nature Neuroscience, 2019.
https://www.nature.com/articles/s41593-019-0520-2
6. *The state of clinical trials of implantable brain-computer interfaces*. Nature Reviews Bioengineering, 2024.
https://www.nature.com/articles/s44222-024-00239-5
7. Seth, A. K., and Bayne, T. *Theories of consciousness*. Nature Reviews Neuroscience, 2022.
https://www.nature.com/articles/s41583-022-00587-4
8. Butlin, P., et al. *Consciousness in Artificial Intelligence: Insights from the Science of Consciousness*. 2023.
https://arxiv.org/abs/2308.08708
9. Yuste, R., et al. *Four ethical priorities for neurotechnologies and AI*. Nature, 2017.
https://www.nature.com/articles/551159a

Optional Online Content

1. Computational Cognitive Neuroscience Book (Open Source: https://book.compcogneuro.org/
2. Computational Cognitive Neuroscience (Randall O'Reilly) Playlist: https://www.youtube.com/playlist?list=PLu02O8xRZn7xtNx03Rlq6xMRdYcQgEpar
3. Neuromatch NeuroAI Course: https://neuroai.neuromatch.io
4. Neuromathc Academy YouTube Playlist: https://www.youtube.com/@neuromatchacademy/playlists

Optional / Student-Choice Frontier Papers and Case Studies

Because this seminar is intended primarily for students of artificial intelligence and computer science, the course will include selected current readings and case studies that show where NeuroAI is moving now. These topics are intended to create excitement about the possibilities of the field while connecting the neuroscience foundation to active research in AI, machine learning, representation learning, neural decoding, hardware, and embodied agents.

Five CS-Facing Frontier Areas

1. **Brain foundation models**: Large-scale models trained on neural activity, MRI, EEG, fMRI, or multi-subject neural data.
2. **Neural decoding and brain-to-language systems**: AI systems that translate brain activity into words, captions, speech, semantic representations, or other interpretable outputs.
3. **Brain-model alignment and representation comparison**: Using AI models to understand brains, and using brains to evaluate, interpret, or constrain AI models.
4. **Neuromorphic / connectome-based AI**: Biological wiring diagrams, sparse event-driven computation, graph-like neural architectures, and brain-like hardware.
5. **Embodied / agentic NeuroAI**: Using neuroscience to think about agents that perceive, remember, act, learn, adapt, and interact with the physical world.

These papers and case studies are provided as possible sources for student-led discussion, final reflection, optional exploration, or future study. **Students are not expected to read all of them**.The ideal cadence is to read 1 paper from this list per month, based on individual interest.

1. **Brain foundation models**
   Foundation model of neural activity predicts response to new individuals and new stimuli. Nature, 2025.
   This paper applies the foundation-model paradigm to neural activity, using large-scale recordings from mouse visual cortex to predict neuronal responses to natural video stimuli.
   Seminar question: What would it mean to have a foundation model of a brain area?
   https://www.nature.com/articles/s41586-025-08829-y
2. **AI foundation models transforming neuroscience**
   From prediction to understanding: Will AI foundation models transform neuroscience? Neuron, 2025.
   This discussion piece asks whether foundation models will merely predict neural activity or help explain mechanisms of cognition and brain function. It is useful for distinguishing predictive performance from scientific understanding.
   Seminar question: Is predicting the brain the same as understanding the brain?
   https://www.cell.com/neuron/fulltext/S0896-6273(25)00752-4
3. **Non-invasive language decoding**
   Towards decoding individual words from non-invasive brain recordings. Nature Communications, 2025.
   This paper introduces a deep learning pipeline for decoding individual words from EEG and MEG signals and connects deep learning, NLP, signal processing, neural decoding, and neuroethics.
   Seminar question: Are we approaching practical brain-to-language interfaces without implants?
   https://www.nature.com/articles/s41467-025-65499-0
4. **Mind captioning / semantic neural decoding**
   Mind captioning: Evolving descriptive text of mental content from human brain activity. Science Advances, 2025.
   This paper serves as a high-interest case study in semantic neural decoding. It raises questions about

representation, mental content, privacy, and what it means to infer thoughts or perceptual experience from brain activity.
Seminar question: What exactly is being decoded: mental content, semantic representation, brain state, or model-generated interpretation?
https://www.science.org/doi/10.1126/sciadv.adw1464

5. **Brain-model alignment**
   Structure as an inductive bias for brain-model alignment. Nature Machine Intelligence, 2025.
   This article raises a CS-flavored question about whether alignment between artificial and biological systems comes from architecture, training data, task objectives, model structure, or some combination of these factors.
   Seminar question: When an AI model aligns with the brain, what exactly is doing the work?
   https://www.nature.com/articles/s42256-025-01155-y
6. **The complete fly connectome as a computational resource**
   Complete wiring map of an adult fruit fly brain. Nature / FlyWire project, 2024.
   This case study makes the brain visible as a graph, a dataset, and a computational artifact. It can lead into discussions of connectomics, graph neural networks, neuromorphic computing, efficient computation, and embodied behavior.
   Seminar question: What happens when biological brains become computable graphs?
   https://www.nature.com/collections/hgcfafejia
7. **Connectome-based / neuromorphic AI**
   Neuromorphic Simulation of Drosophila Melanogaster Brain Connectome on Loihi 2. Preprint, 2025.
   This frontier case study describes implementing the adult Drosophila connectome on neuromorphic hardware. It connects graph structure, sparse computation, event-driven architectures, hardware acceleration, biological realism, and energy efficiency. Because this is a preprint, it should be treated as frontier material rather than an established anchor paper.
   Seminar question: Could biological wiring diagrams become executable AI architectures?
   https://arxiv.org/abs/2508.16792
8. **Embodied NeuroAI / agentic systems**
   NeuroAI and Beyond: Bridging Between Advances in Neuroscience and Artificial Intelligence. Preprint, 2026.
   This roadmap-style paper connects NeuroAI to the current AI conversation around agents, embodiment, continual learning, brittle systems, sparse event-driven computation, and energy efficiency. Because this is a preprint and roadmap paper, it is best used as a future-directions discussion source.
   Seminar question: What does NeuroAI offer beyond bigger models?
   https://arxiv.org/abs/2604.18637

Required Platforms and Tools

Required platforms and tools may include:

- Canvas
- Ed Discussion or another course discussion platform
- Georgia Tech email
- Google's NotebookLM or an approved alternative for AI-assisted reading activities
- PDF reader, ideally capable of annotation

Students should refer to Canvas for the current list of required and supplemental tools for the term.

AI-Assisted Reading Workflow

For selected paper/PDF-based weeks, students will use an AI-assisted reading workflow. Students will upload the assigned reading into NotebookLM or an approved alternative, generate an approximately 30-minute Audio Overview, and listen to the full AI-generated discussion before class. Students may also use NotebookLM's interactive audio mode to ask follow-up questions, clarify technical concepts, or explore connections to prior course topics.

This activity is intended to support, not replace, scholarly reading. Students are responsible for the assigned source material. Claims made in AI-generated summaries should be checked against the original reading. Weekly reflections may ask students to distinguish between what the original source argues and what the AI-generated discussion emphasized, clarified, omitted, or potentially distorted.

Expected Weekly Workload

This is a 1-unit seminar with an expected workload of approximately 3-4 hours per week.

Activity	Approximate Time
Seminar meeting	Up to 60 minutes
Reading textbook chapter or paper	45-90 minutes
NotebookLM Audio Overview or video/guest preparation	30 minutes
Reflection, discussion preparation, or light synthesis activity	30-60 minutes

Weeks with guest speakers or longer videos may have modified workload expectations.

Grading Policy and Participation Expectations

This seminar is intended to be a low-pressure, intellectually engaging opportunity for students who are interested in exploring NeuroAI. Because the seminar is optional and does not count toward graduation credit, students are generally expected to receive credit for the course as long as they make a good-faith effort to participate.

Participation may include attending seminar sessions, contributing to discussion, engaging with course readings, reflection reports, or AI-assisted study activities, posting in the course forum, responding to prompts, or otherwise demonstrating meaningful engagement with the course community.

Students are not expected to *over-participate*, and participation will not be evaluated based on how frequently a student speaks in class. The goal is steady engagement, not performance. Students may participate in different ways depending on their interests, schedules, and comfort level.

No credit may be awarded in cases where a student does not meaningfully participate in the seminar. If a student has not attended sessions or engaged through the forum or other course activities, the instructional team will determine whether there has been sufficient engagement to warrant course credit.

Students who anticipate difficulty participating consistently are encouraged to communicate with the instructional team so that reasonable ways to remain engaged can be discussed.

Description of Graded Components

- **Reading reflections / AI-assisted reading notes** ask students to identify the central idea of the assigned reading, connect it to AI, and distinguish the source's claims from AI-generated summaries or interpretations.
- **Seminar participation and discussion engagement** evaluate students' preparation, thoughtful participation, respectful engagement, and ability to connect weekly material to prior course themes.
- **Student-led discussion or paper briefing** requires each student or small group to introduce one reading, identify its central contribution, and prepare questions for seminar discussion.
- **Final synthesis memo or lightning presentation** asks students to synthesize one major course theme, such as memory and continual learning, biological constraints on AI, BCI and neural decoding, consciousness and AI, synthetic biological intelligence, or neuroethics.

Course Schedule and Reading List

The following schedule is a proposed 16-week structure. The final schedule, readings, guest speakers, videos, and assignment due dates will be maintained in Canvas.

Note: The schedule may be modified during the term, dependent on student provided feedback and instructor observations.

Week	Topic	Required Reading / Preparation	Suggested Seminar Focus
1	What is NeuroAI?	CCN Ch. 1; Hassabis et al., *Neuroscience-Inspired Artificial Intelligence*	Why AI students should study the brain; natural and artificial intelligence; course framing
2	Why the brain matters for AI	CCN Ch. 1 selected sections, especially computational approach and why the brain matters; Marblestone et al.	Marr's levels; biological constraints; implementation as a source of computational insight
3	Neurons as computational units	CCN Ch. 2	Neurons, spikes, synapses, excitation, inhibition, leak, rate codes, and what artificial neurons abstract away
4	Networks and representation	CCN Ch. 3	Distributed representations, recurrence, attractors, inhibition, activity regulation, and network-level computation
5	Learning in brains and machines	CCN Ch. 4; Lake et al.	Hebbian learning, self-organization, error-driven learning, biological plausibility, human-like learning
6	Brain systems roadmap	CCN Ch. 5; *The emergence of NeuroAI*	Functional anatomy, brain systems, and how NeuroAI links brain mechanisms to AI architectures
7	Perception and attention	CCN Ch. 6; Richards et al.	Vision, attention, DNNs as models of sensory systems, and representational comparison
8	Memory and continual learning	CCN Ch. 7	Hippocampus, pattern separation/completion, consolidation, catastrophic interference, replay, and continual learning
9	Motor control, dopamine, and reinforcement learning	CCN Ch. 8	Basal ganglia, action selection, dopamine, temporal-difference learning, actor-critic parallels
10	Executive function and cognitive control	CCN Ch. 9	PFC, working memory, gating, top-down control, task maintenance, agency, and AI agents

Week	Topic	Required Reading / Preparation	Suggested Seminar Focus
11	Language, meaning, and LLMs	CCN Ch. 10	Biological language systems, semantics, sentence processing, and LLMs as models of language/cognition
12	Comparing brains and machines	Review CCN Ch. 3, 6, and 10 themes; optional instructor-selected ANN/brain alignment reading	Representational similarity, encoding models, neural decoding, and limits of model-brain comparison
13	Neurotechnology and BCI	*The state of clinical trials of implantable brain-computer interfaces*; optional *Mind captioning*	Neural decoding, implantable BCIs, neuromodulation, human-machine loops, and clinical translation
14	Consciousness and artificial consciousness	Seth and Bayne; Butlin et al.	Theories of consciousness, recurrent processing, global workspace, AI-consciousness indicators and skepticism
15	Frontier directions: foundation models, wetware, and synthetic biological intelligence	Student-choice paper from foundation models, wetware, or synthetic biological intelligence list	Organioids, biohybrid systems, foundation models for neuroscience, and future research directions
16	Ethics, neurodata, and synthesis	Yuste et al.; final synthesis preparation	Mental privacy, neurorights, agency, neurodata, responsible AI use, and student synthesis presentations

Course Policies

Attendance and/or Participation

See Grading Policy and Participation Expectations (above).

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. Review [Georgia Tech’s Honor Code]() and the student [Code of Conduct]().

Any student suspected of cheating or plagiarism on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, [contact the Office of Disability Services] (404-894-2563) as soon as possible to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also open a private post on Ed Discussions (preferred) or e-mail me (alternate) as soon as possible in order to set up a time to discuss your learning needs.

Student-Faculty Expectations Agreement

At Georgia Tech, we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. The [Student-Faculty Expectations] articulate some basic expectations that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Collaboration, Group Work, and Use of Generative AI

This course permits selected use of AI tools for learning support, including NotebookLM audio overviews and interactive questioning, when explicitly assigned or authorized. However, students remain responsible for the original source material and for the integrity of their own submitted work. Students may not submit AI-generated text as their own reflection, analysis, synthesis memo, or discussion preparation unless the assignment explicitly authorizes that use and the student discloses it in the required manner.

Students should be able to explain, defend, and discuss the ideas they submit. Unauthorized collaboration, misrepresentation of AI-generated material, failure to cite or disclose required sources, or submission of work that is not the student's own may be treated as academic misconduct.

Additional Course Information in Canvas

To keep this syllabus relatively stable across terms, detailed operational and term-specific information is maintained in Canvas. Students are responsible for reviewing those materials as applicable. In the rare case of conflicts between this syllabus and Canvas, the content in Canvas shall prevail as the official content.

Canvas materials may include, but are not limited to:

- Course Schedule and Details
- Course Policies
- Reading and NotebookLM Instructions
- Video Lessons, Guest Speaker Materials, and Other Resources

- Assignment instructions and submission requirements
- Discussion lead guidelines
- Final synthesis memo or presentation instructions

These materials provide detailed information such as weekly schedules, readings, assignment instructions, technology expectations, participation expectations, and other course processes.

Campus Resources for Students

Graduate Student Academic and Professional Success Resources:

A list of resources for graduate students is given on the Office of Graduate and Postdoctoral Education website. Specific information for current graduate students includes

- Academic Resources such as the Communications Center, Language Institute, Library, Catalog, Registrar, resources for conducting research, Advocacy and Conflict Resolution resources, and how to manage unexpected situations that may impact your academic performance;
- Student Resources such as Campus Services, Child Care/Family programs, Health & Wellness, Career Services, and the Student Resource Guide; and
- Professional Development such as the programming from the Career Center and other professional development resources and events"

Student Well-Being:

At Georgia Tech, we are concerned about your overall physical, social, and mental well-being. A comprehensive list of wellness related resources has been compiled and maintained by the Office of the Vice President for Student Engagement and Well-being (student-resource-guide (gatech.edu)