Computational Psychology and Artificial Intelligence

LMH Summer Programmes are provided by Lady Margaret Hall, a college in the University of Oxford

Course:	Computational Psychology and Artificial Intelligence
Available:	Programme Session 3: 11th August 2025 to 29th August 2025
Lectures:	18 Hours
Seminars:	12 Hours
Tutorials:	3 Hours
Independent Study:	Approximately 120 Hours
Recommended Credit:	15 CATS / 7.5 ECTS / 4 US Credits

About this Course:	How does the brain process information, make decisions, and learn? Computational Psychologists seek to answer these questions by using algorithms and mathematical models to simulate and analyse the mechanisms behind mental processes. The field has been highly influential on Artificial Intelligence research and development, as data scientists attempt to convincingly recreate human thought, speech, and behaviour in machines, a challenge Alan Turing called the 'Imitation Game'. Introducing Computational Psychology, Computational Neuroscience, and Artificial Intelligence, this course offers a fascinating insight into these exciting and forward-looking interconnected fields of research. The course begins with an introduction to Computational Psychology, exploring the ways in which process-based computational models may be used to represent the working of the human brain, employing algorithms to simulate aspects of cognition and predict behaviour. We shall then turn to how such models correlate with neurobiology, the actual network of cells and signals which constitutes the brain, investigating neuron models, how neural networks perform computations, and neuropsychological theories of learning. Finally, we shall look at the ways in which computational approaches to psychology and neuroscience have influenced, and been influenced by, developments in Artificial Intelligence. We will discuss the physical symbol systems hypothesis and human and artificial cognitive architectures, before considering future developments in computational psychology and artificial intelligence, such as the possibility of machine consciousness and Artificial General Intelligence. From analysing models of mental processes to exploring machine intelligence, join an LMH Summer Programme and discover this important and evolving field of research.

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Course Overview:	Week 1: Introduction to Computation Psychology
	• Computational Theory of Mind
	• Mathematical Modelling and Notation
	• Computational Models of Cognition
	• Symbolic Models
	• Neural Networks
	• Probability Theory and Bayesian Inference
	• Simulation, Parameter Estimation, and Model Comparison
	Week 1 offers an introduction to Computational Psychology, beginning with the history of the field, and an overview of the Computational Theory of Mind. Students will then be equipped with the basics of mathematical notation for computational modelling, before exploring the role of cognitive models in psychological research. With a particular focus on the processes of decision-making, the course will cover symbolic models, neural networks, and probability theory.
	
	Week 2: Computational Psychology and Neuroscience
	• Biological Neuron Models
	  ○ Hodgkin-Huxley Model
	  ○ Integrate-and-Fire Models
	• Neurons, Synapses, and Neural Circuits
	• Synaptic Plasticity and Models of Learning and Memory
	• Modelling Neurological Disorders
	Week 2 considers how computational methods are applied to the complex biology of the brain, seeking to map the electrical and chemical processes of neurons, synapses, and neural circuits. We shall introduce biological neuron models, including the Hodgkin-Huxley model and integrate-and-fire models, before looking at synaptic plasticity and considering Hebbian learning. Finally, we shall introduce the ways in which modelling of neurological disorders may lead to treatment development and novel therapeutics.
	
	Week 3: Psychology and Artificial Intelligence
	• Introduction to Artificial Intelligence and Machine Learning
	• Symbolic AI and GOFAI
	• The Physical Symbol Systems Hypothesis
	• Cognitive Architectures
	• The Future of Artificial Intelligence and Machine Learning
	Week 3 introduces Artificial Intelligence and Machine Learning and their links to Psychology. We shall begin by introducing the basics of AI, giving a brief overview of the history of the discipline, and its main terminology and methodologies. We explore Symbolic AI, GOFAI, the Physical Symbol Systems Hypothesis before looking at Cognitive Architectures and the similarities and differences between human and artificial cognition. We end by looking to future developments in Artificial Intelligence, such as the possibility of machine consciousness and Artificial General Intelligence, and considering the impact of such developments on our understanding of the human brain.

Key Texts:	Busemeyer, J.R., Wang, Z., Townsend, J.T., and Eidels, A. (eds.), *The Oxford Handbook of Computational and Mathematical Psychology*, Oxford, 2015. Lewandowsky, S., and Farrell, S., *Computational Modeling in Cognition: Principles and Practice*, Los Angeles CA, 2011.

Learning Outcomes:	By the end of this course, you will: • Understand how computational models are used to simulate mental processes and cognitive functions. • Be able to demonstrate understanding of the relationship between mathematical models of cognition and the biology of the brain, including neurons, synapses, and circuits. • Be able to evaluate critically the strengths and limitations of computational models in explaining psychological phenomena. • Be able to demonstrate awareness of the influence of Computational Psychology on Artificial Intelligence research. • Be able to demonstrate awareness of ethical concerns around current and potential research at the intersections of Psychology and Artificial Intelligence.
Admissions Requirements:	LMH Summer Programmes are designed for students who want to gain and develop knowledge in their chosen subject area. LMH Summer Programmes are intensive courses of study aimed at undergraduates who have completed one, two, or three years of their degree, or entry level postgraduate students. We will consider each applicant's academic ability and expect successful applicants to have a minimum grade point average equivalent to 2:1 level on the British grading scale. For example, this would mean at least a 3.2 GPA on the 4.0 grading scale in the United States, and 80% in China. **This course would suit students who are interested in the scientific study of mental processes and their analysis through computational methods.** **Basic knowledge of calculus, linear algebra, and probability theory is required.** **Some prior study of Cognitive Psychology is beneficial but not essential.** **Prior study of Computer Science, Programming, Artificial Intelligence, or Machine Learning is not required.** To participate fully in the programme all students will need to have proficiency in English. English language requirements for students who are not native English speakers: • TOEFL iBT score of 98 • IELTS score of 7.0 (no less than 6.5 in each component) • Duolingo English Test score of 125 (no less than 115 in each section) • Cambridge English Scale score of 185 If the language of instruction in your home institution is English you do not need to provide evidence of your English proficiency.
Teaching Methods:	Core syllabus material will be covered in lectures. Students attend four lectures each week and each lecture lasts 90 minutes. Seminars in smaller groups offer students space to discuss and debate, to dig deeper into difficult concepts, and to explore their own ideas. Student contribution to seminars is vital, and tutors will ensure everyone takes part in discussions. Seminars last 1 hour and students will take part in four seminars each week. Independent study is a crucial part of an LMH Summer Programme and of the Oxford teaching model. Tutors will recommend important reading to do between lectures and seminars that will enable students to come to class equipped to understand the information presented and prepared to take part in discussion and debate. Each week students will have an assignment of independent work to complete and submit in advance of the tutorial. There is an appropriate amount of

	space in the timetable to complete the necessary reading, preparation, and assignments. Students should expect to do around 40 hours of independent study each week. The final class each week is a tutorial, a very small class typically including only 2-4 students and central to the teaching methods used by the University of Oxford and on LMH Summer Programmes. Guided by their tutor, students will receive feedback on their assignments and be challenged to defend, justify, or even rethink their work and ideas. These rigorous academic discussions help develop and facilitate learning in a way that cannot be done with lectures and seminars alone.
Assessment:	On a three-week LMH Summer Programme students produce one piece of assessed work every week, which is submitted to the tutor and then discussed in a tutorial. At the end of each week students will receive a percentage grade for their submitted work. Each week's work counts for a third of the final percentage grade, so the final grade is an average of the mark received for each piece of work. Students who stay for six or nine weeks will receive a separate grade for each 3-week course.
Academic Credit:	Lady Margaret Hall will provide a transcript of students' assessed work, and can send this directly to your home institution if required. LMH Summer Programmes are designed to be eligible for academic credit, and we will communicate with home institution to facilitate this as needed. As a guide, we recommend the award of 15 CATS / 7.5 ECTS / 4 US Credits for each 3-week course.