UCLouvain

wsbim2251

2026

Theoretical Approaches in Neurosciences

3.00 credits	20.0 h + 10.0 h	Q2

Teacher(s)	Lee John ;Missal Marcus (coordinator) ;
Language :	English > French-friendly
Place of the course	Bruxelles Woluwe
Prerequisites	*The prerequisite(s) for this Teaching Unit (Unité d'enseignement – UE) for the programmes/courses that offer this Teaching Unit are specified at the end of this sheet.*
Learning outcomes	
Evaluation methods	Oral or written examination (questions with written development or multiple choices).
Teaching methods	Ex-cathedra lessons, remotely if necessary. Group discussions. Article presentations by students.
Content	**I. Introduction to Theoretical Neuroscience** • **Goal:** What is theoretical neuroscience? Its relationship to experimental neuroscience, mathematics, physics, and computer science. • **Key Topics:** The role of theory (prediction, interpretation, synthesis). Levels of analysis (Marr's three levels: computational, algorithmic, implementation). Causality in Neurosciences. **II. The Neuron as a Computational Unit** • Introduce the fundamental building block and its electrical properties. • **The Hodgkin-Huxley Model** (ionic currents, action potential generation). • **Integrate-and-Fire** models and their variants (e.g., leaky I&F). **III. Neural Encoding and Decoding** • How does the brain represent information? How can we read it out? • Rate coding vs. Temporal coding. **IV. The Bayesian brain hypothesis** • **Predictive Coding** (prediction error). • Free energy principle. **V. Theoretical Approaches to Deep Learning** • Bridging the gap between biological neural networks and Artificial Neural Networks (ANNs). • Comparing ANNs and the brain (e.g., backpropagation vs. local learning rules). • Convolutional Neural Networks (CNNs) as models for the visual cortex. • Recurrent Neural Networks (RNNs) and sequence processing. **VI. Oscillations and Neural Synchronization** • Network rhythms and their functional role. • Synchronization, binding problem. • Coupled Oscillator Models (Kuramoto model). • Different frequency bands (#,#,#) and their hypothesized functions (e.g., # oscillations in attention).
Inline resources	https://moodleucl.uclouvain.be/course/view.php?id=9189
Faculty or entity in charge	SBIM

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Biomedicine	SBIM2M	3	WSBIM2280 AND (WSBIM2112 OR WSBIM2151) AND WSBIM2154 AND WSBIM2155 AND WSBIM2156	🔍
Master [60] in Biomedicine	SBIM2M1	3		🔍