Universitat Pompeu Fabra Barcelona

# Master in Brain and Cognition

| Subject name: Introduction to Computational Neuroscience | |
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| **ECTS: 3** | **Type: Compulsory** |
| **Term:** | **Third term** |
| **Language(s)** | **English** |

**Description:**

- **Requirements:** none
- **Contents**

Broadly speaking, the use of computational models and theoretical analysis are tools necessary for understanding brain function, such as the process of perception and other cognitive functions. This course presents the basic elements for modelling the dynamics of the synapses, neurons, and the cortical circuits. This framework of computational neuroscience seeks to integrate different levels of research on the brain processes and to study the relationships between them.

Specific content:

- The most relevant neurophysiological and neuropsychological factors for mathematical modelling will be reviewed. Spiking neurons: ion channels, the Nernst equation, passive electrical properties of the neurons. Hodgkin-Huxley. AHP, potassium-dependent channels.
- The mathematical foundations of the synapses and the properties of the nerve cells XXX Synapse dynamics: dynamic networks, encoding, middle lobe techniques XXX.
- Some basic networks used by the brain, which are home to areas of the cortex related to attention, memory, learning and decision-making processes, will be described. Cortical networks: visual perception of attention. Short term memory (working memory). Change, rules, associations, decision-making process tasks.
- Plasticity / learning. The role of molecular and cellular events will be highlighted in order to create hypotheses about cognitive development based on neurobiological mechanisms and therefore, be able to evaluate cognitive aspects such as plasticity and learning.

The course teaches how the different experimental measures at different levels of neuroscience (microscopic: records of one or more neurones; mesoscopic: EEG, fMRI, LFP and macroscopic: behaviour) can be integrated and predicted using the computational model. Students can learn about realistic neural network simulation techniques through practical projects.

| **Learning outcomes** | Reflect on the principles and methods of cognitive neuroscience research to promote critical thinking.<br>Debate a scientific issue, identifying possible methodological errors, ethical considerations and offering alternative solutions.<br>Learn how to model the dynamics of neural networks using simulation techniques.<br>Accurately examine statistical data in the context computational neuroscience and cognition. |
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| **Training activities** | • Whole-class sessions<br>• In-person tutorial sessions<br>• Regulated work placement<br>• Group work<br>• Individual work |

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
|---|---|---|
| Whole-class sessions | 21 | 100% |
| In-person tutorial sessions | 3 | 100% |
| Regulated work placement | 3 | 100% |
| Group work | 7 | 0% |
| Individual work | 41 | 0% |
| **Total** | 75 | |

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|---|---|
| **Teaching methodology** | • Lectures<br>• Seminars involving discussion on pre-assigned readings<br>• Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data<br>• Remote activities dedicated to resolving practical exercises based on data provided by the teachers<br>• In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet<br>• Remote activities for reading articles<br>• Presentations of topics by students<br>• Individual work |
| **Assessment methods** | • Final exam<br>• Individual or group exercises<br>• Class participation and attendance |

| Assessment method | Minimum weighting | Maximum weighting |
|---|---|---|
| Final exam | 30% | 60% |
| Individual or group exercises / class attendance and participation | 20% | 40% |
| **Total** | 50% | 100% |

| **Subject name: Cognitive Neuroscience of Language** | |
|---|---|
| **ECTS: 3** | **Type: Compulsory** |
| **Term:** | **First term** |
| **Language(s)** | **English** |

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|---|---|
| **Description:**<br>• **Requirements:** none<br>• **Contents**<br>- Approach to models of perception and language production from both cognitive and neuroscience perspectives.<br>- How language is represented and processed in the brain, paying special attention to the temporal aspects of language processing.<br>- Bilingualism: how the brain houses two languages. Focussed on issues related not only to the representation of linguistic content, but also on those related to cognitive and brain processes involved in the control of attention of the two languages.<br>- Language impairment in neurodegenerative diseases. Issues related to how diseases such as Alzheimer's or Parkinson's can provide relevant information about language in monolingual and bilingual speakers will be addressed.<br>- Critical analysis of experimental data reporting on language processing models. Evidence from experimental psychology, from cognitive neuroscience and cognitive neuropsychology. | |
| **Learning outcomes** | Raise and solve an issue in the context of scientific research on cognition and language Analyse how the brain reflects the difference in language processing in a monolingual and bilingual environments.<br>Adequately interpret, analyse and describe a scientific article (bibliographic sources, methodology, results, conclusions and relevant contribution to the scientific field) related to brain processing and cognition.<br>Describe the design of an experimental model tailored to a relevant scientific objective and of interest for research. |
| **Training activities** | • Whole-class sessions<br>• In-person tutorial sessions<br>• Regulated work placement<br>• Group work<br>• Individual work |

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
|---|---|---|
| Whole-class sessions | 21 | 100% |
| In-person tutorial sessions | 3 | 100% |
| Regulated work placement | 3 | 100% |
| Group work | 7 | 0% |
| Individual work | 41 | 0% |
| **Total** | 75 | |

| | |
|---|---|
| **Teaching methodology** | • Lectures<br>• Seminars involving discussion on pre-assigned readings<br>• Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data<br>• Remote activities dedicated to resolving practical exercises based on data provided by the teachers<br>• In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet<br>• Remote activities for reading articles<br>• Presentations of topics by students<br>• Individual work |
| **Assessment methods** | • Final exam<br>• Individual or group exercises<br>• Class participation and attendance |

| Assessment method | Minimum weighting | Maximum weighting |
|---|---|---|
| Final exam | 30% | 60% |
| Individual or group exercises / class attendance and participation | 20% | 40% |
| **Total** | 50% | 100% |

| **Subject name: Cognitive Neuroscience of Perception and Attention** | |
|---|---|
| **ECTS: 3** | **Type: Compulsory** |
| **Term:** | **First term** |
| **Language(s)** | **English** |

**Description:**

- **Requirements:** none
- **Contents**

Block 1 Cognitive and neural processes involved in perception: approach to basic methodological concepts about brain processes.

Block 2 Multisensory aspects of perceptual functions:

- Perception of space and time through multiple senses. The traditional psycho-physical approach to the perception of multisensory events based on results derived from spatial and time perception. Inter-sensory conflict, inter-modal synergy and inter-modal correspondence will be discussed.

Tactile remapping and representation of the body scheme. Different types of body representation considered in literature and their multisensory nature are explained. Evidence will be presented from human psychophysics, neuroimaging and brain stimulation.

- Speech as a multisensory phenomenon (hearing the lips and reading sounds). Speech will be considered as an audiovisual phenomenon, providing empirical evidence from human behaviour, the phenomenon of development and neuroimaging.

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| Some theoretical models will also be discussed.<br>Block 3 Perceptual mechanisms: development, plasticity, sensory substitution. This topic is divided into two sessions. In the first, the main physiological manifestations of plasticity based on evidence from animal research (cellular and surgical) and on psychophysical and neuroimaging evidence in healthy humans and humans with sensory divergence will be developed. The second session will cover the concepts of sensory substitution and the phenomenon of kinaesthesia.<br>- Mechanism and models of multisensory integration. This unit will be divided into two sessions in which will cover the most widely known mechanisms for explaining perceptual integration at different levels of analysis (neural, approach systems and computational frameworks). The Fuzzy Logic Modal (FLM) as an approach to audiovisual perception of speech; the Optimal Interaction Model (based on the Maximum Likelihood Estimation) from the Bayesian perspective; the Superadditive Principle in physiology, psychophysics and neuroimaging; Oscillatory Dynamics as a mechanism for sensory integration; FeedForward vs Feedback for multisensory integration.<br>Block 4 Consciousness from the perspective of cognitive neuroscience: neural correlates of consciousness and neural determinants of free will. Two sessions which will address the classic problems of consciousness, its main challenges and the responses proposed by cognitive neuroscience. These will be divided into a session on the correlates of perceptual consciousness (correlational and causal evidence) and another session on free will and its possible neural location.<br>Block 5 Laboratory demonstrations: a number of demonstrations will be observed in the ongoing experiments laboratory which will illustrate the main techniques of EEG/EEG recording, TMS application and binocular rivalry. | | |
| **Learning outcomes** | Clearly communicate the knowledge acquired and the reasons behind it related to cognitive neuroscience in order to collaborate in the dissemination of the results.<br><br>Assess the design of an accurate experimental methodology in line with the most relevant current contributions.<br><br>Recognise the typical perception characteristics of multisensory events.<br><br>Reflect on the degree of accuracy of an experimental model used to study different aspects of perception and attention. | |
| **Training activities** | • Whole-class sessions<br>• In-person tutorial sessions<br>• Regulated work placement<br>• Group work<br>• Individual work | |

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
|---|---|---|
| Whole-class sessions | 21 | 100% |
| In-person tutorial sessions | 3 | 100% |

| | | | |
|---|---|---|---|
| | Regulated work placement | 3 | 100% |
| | Group work | 7 | 0% |
| | Individual work | 41 | 0% |
| | **Total** | 75 | |

**Teaching methodology**

- Lectures
- Seminars involving discussion on pre-assigned readings
- Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data
- Remote activities dedicated to resolving practical exercises based on data provided by the teachers
- In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet
- Remote activities for reading articles
- Presentations of topics by students
- Individual work

**Assessment methods**

- Final exam
- Individual or group exercises
- Class participation and attendance

| Assessment method | Minimum weighting | Maximum weighting |
|---|---|---|
| Final exam | 30% | 60% |
| Individual or group exercises / class attendance and participation | 20% | 40% |
| **Total** | 50% | 100% |

**Subject name: Social Cognitive Neuroscience**

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| **ECTS: 3** | **Type: Compulsory** |
| **Term:** | **Second term** |
| **Language(s)** | **English** |

**Description:**

- **Requirements:** none
- **Contents**

**1. Approach to Social Neuroscience**

Evolutionary bases of the social brain
Evolution of social cognition
Social neuroscience: a neuropsychological perspective

**2. Empathy and emotions: theoretical and methodological bases**

Neurobiology of social bond and attachment
Social neuroscience of evaluative motivation
Social processing and non-social rewards in the human brain
Emotion, awareness and social attitudes
The interface between emotion and attention: neural, evolutionary and clinical factors

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| The neuroscience of personality traits<br>Recognition of emotions<br>Regulating emotions: neural bases<br>**3. Understanding, interaction and representation of others**<br>The mirror neurones system and social cognition<br>The mirror neurones system and imitation<br>Social neuroscience of empathy<br>Altruism<br>Neural basis of the response to social rejection<br>Neural systems for maintaining intrapersonal and interpersonal self-esteem<br>Social regulation of emotions<br>**4. Understanding and representation of social groups**<br>The neurobiology of social behaviour in primates<br>Neural representation of the social hierarchy<br>Group processes: social dominance<br>Mechanisms for regulating intergroup responses<br>Influence of culture and genes on brain function: Cultural neuroscience<br>**5. Identity from the perspective of cognition**<br>Unconscious action biases<br>Prefrontal cortex and social behaviour directed at objects<br>Neural bases of self-regulating behaviour<br>The nature of social cognition<br>The formation of impressions<br>Electrophysiological basis of social categorisation processes<br>Consequences of social processing deficits: executive functions, social skills and theory of the mind of patients with ventral frontal injuries.<br>**6. Moral reasoning and antisocial behaviour**<br>Neuroscience of moral cognition and emotions<br>Embodiment and social cognition<br>Socio-emotional functioning in adolescence<br>The perception of social isolation and its implications for health<br>Stress, social support, negative emotions and health<br>Antisocial personality disorders<br>Psychopathy and alexithymia from the perspective of social and cognitive neuroscience<br>**7. Speech and communication: theoretical and methodological bases**<br>Neural bases of the human voice<br>From emotion to concept: the importance of melody<br>Social mechanisms in early language acquisition<br>Language and communication<br>**8. Development of social cognition**<br>Brain development in childhood and adolescence<br>Neural basis of social behaviour on the autism spectrum and developmental disorders<br>Asperger's Syndrome<br>The social brain in adolescence<br>Relevance of social neuroscience in education |

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| **Learning outcomes** | Assess the quality of a scientific question in achieving its objectives.<br>Consolidate understanding on the relationship between cognitive theories of empathy, emotions, social interaction, identity, moral reasoning, communication, speech and their development. |

<table>
<tr><td></td><td>Learn about and apply innovative technical methodology in the study of cognition.<br>Know how coherently explain the results of a scientific experiment and know how to respond to questions from other participants.</td></tr>
<tr><td>Training activities</td><td>
<ul>
<li>Whole-class sessions</li>
<li>In-person tutorial sessions</li>
<li>Regulated work placement</li>
<li>Group work</li>
<li>Individual work</li>
</ul>
<table>
<tr><th>TYPE OF ACTIVITY</th><th>HOURS</th><th>IN PERSON?</th></tr>
<tr><td>Whole-class sessions</td><td>21</td><td>100%</td></tr>
<tr><td>In-person tutorial sessions</td><td>3</td><td>100%</td></tr>
<tr><td>Regulated work placement</td><td>3</td><td>100%</td></tr>
<tr><td>Group work</td><td>7</td><td>0%</td></tr>
<tr><td>Individual work</td><td>41</td><td>0%</td></tr>
<tr><td>Total</td><td>75</td><td></td></tr>
</table>
</td></tr>
<tr><td>Teaching methodology</td><td>
<ul>
<li>Lectures</li>
<li>Seminars involving discussion on pre-assigned readings</li>
<li>Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data</li>
<li>Remote activities dedicated to resolving practical exercises based on data provided by the teachers</li>
<li>In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet</li>
<li>Remote activities for reading articles</li>
<li>Presentations of topics by students</li>
<li>Individual work</li>
</ul>
</td></tr>
<tr><td>Assessment methods</td><td>
<ul>
<li>Final exam</li>
<li>Individual or group exercises</li>
<li>Class participation and attendance</li>
</ul>
<table>
<tr><th>Assessment method</th><th>Minimum weighting</th><th>Maximum weighting</th></tr>
<tr><td>Final exam</td><td>30%</td><td>60%</td></tr>
<tr><td>Individual or group exercises / class attendance and participation</td><td>20%</td><td>40%</td></tr>
<tr><td>Total</td><td>50%</td><td>100%</td></tr>
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| Subject name: Comparative Cognition | |
|---|---|
| **ECTS: 3** | **Type: Compulsory** |
| **Term:** | **First term** |
| **Language(s)** | **English** |

**Description:**

- **Requirements:** none
- **Contents**

This course aims to present and review the different current aspects of the study of cognitive neuroscience from a comparative point of view in a comprehensive manner. Over the course of the subject, different conceptual and methodological issues will be addressed that frame the work with other types. The following lines of work and discussion will be followed:

- Research techniques of research in cognitive science with animals. Current development and comparison with humans. Behavioural experimental procedures. Observational models. Comparative cognitive neuroscience. Extrapolation of experimental models in humans to other species: the case of the familiarisation procedure.
- Learning mechanisms. Specificity and generality across domains and species. Models of classical and conditioned learning. Cognitive specialisation Language as a special case study. Discussion of human-only cognitive faculties.
- Animal models: psychological processes. Hypothesis testing from a comparative approach. Evolutionary discussions and implications. Adaptation versus exaptation. The role of experience in the development of cognitive skills. Cognitive modelling from comparative data.
- Ethical considerations. Lines that guide the use of animal models. 3 Rs principle (reduce, refine, replace) Similarity principle.

Presentations by the teachers on the different topics will be complemented by active participation by the students based on readings and discussions of practical examples of each of the ideas presented.

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| **Learning outcomes** | Debate a scientific issue, identifying possible methodological errors, ethical considerations and offering alternative solutions.<br>Propose a suitable methodological solution for the analysed population, using initiative and creativity.<br>Identify and develop methodological tools related cognitive science which are appropriate for the starting hypothesis.<br>Demonstrate the ability to link the results of an experimental animal model to human brain function. |
| **Training activities** | • Whole-class sessions<br>• In-person tutorial sessions<br>• Regulated work placement<br>• Group work |

| | |
|---|---|
| | • Individual work |

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
|---|---|---|
| Whole-class sessions | 21 | 100% |
| In-person tutorial sessions | 3 | 100% |
| Regulated work placement | 3 | 100% |
| Group work | 7 | 0% |
| Individual work | 41 | 0% |
| **Total** | 75 | |

**Teaching methodology**

- Lectures
- Seminars involving discussion on pre-assigned readings
- Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data
- Remote activities dedicated to resolving practical exercises based on data provided by the teachers
- In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet
- Remote activities for reading articles
- Presentations of topics by students
- Individual work

**Assessment methods**

| Assessment method | Minimum weighting | Maximum weighting |
|---|---|---|
| Final exam | 30% | 60% |
| Individual or group exercises / class attendance and participation | 20% | 40% |
| **Total** | 50% | 100% |

| **Subject name: Early Human Cognition** | |
|---|---|
| **ECTS: 3** | **Type: Compulsory** |
| **Term:** | **First term** |
| **Language(s)** | **English** |

**Description:**

- **Requirements:** none
- **Contents**

- Historical and philosophical foundations of the theories of cognition
- Early childhood concepts, representations and learning. The notion of structure. Modular and non-modular processes. Representations and why behaviourism does not work.
- Between reflexes and knowledge: reorientation in space, identification of objects, numbers.
- Between innatism and learning: the initial state of language and its development. The language of words and gestures.
- Systems of learning words and rules.

<table>
<tr><td colspan="2">The concept of critical period. Development of concepts and case studies: “another mind”, beauty, socialisation. Moral reactions.<br>- Numeric and logical reasoning in childhood: reasoning and decision-making. Cognitive modules and rationality. Development of probability and logical reasoning. The course programme will be systematically updated and modified in accordance with the latest discoveries in the area of human cognition to ensure that students will be aware of the most recent developments in the discipline.</td></tr>
<tr><td>Learning outcomes</td><td>Critically analyse the relevant scientific literature of a field of study.<br>Identify the relevant evolutionary milestones in human cognitive development to predict experimental results.<br>Propose a suitable methodological solution for the analysed population, using initiative and creativity.<br>Identify and develop experimental research hypotheses.</td></tr>
<tr><td>Training activities</td><td>
<ul><li>Whole-class sessions</li><li>Individual work</li></ul>
<table>
<tr><td>TYPE OF ACTIVITY</td><td>HOURS</td><td>IN PERSON?</td></tr>
<tr><td>Whole-class sessions</td><td>25</td><td>100%</td></tr>
<tr><td>Individual work</td><td>50</td><td>0%</td></tr>
<tr><td>Total</td><td>75</td><td></td></tr>
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</td></tr>
<tr><td>Teaching methodology</td><td>
<ul><li>Lectures</li><li>Seminars involving discussion on pre-assigned readings</li><li>Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data</li><li>Remote activities dedicated to resolving practical exercises based on data provided by the teachers</li><li>Remote activities for reading articles</li><li>Individual work</li></ul>
</td></tr>
<tr><td>Assessment methods</td><td>
<ul><li>Final exam</li><li>Individual exercises</li><li>Class participation and attendance</li></ul>
<table>
<tr><td>Assessment method</td><td>Minimum weighting</td><td>Maximum weighting</td></tr>
<tr><td>Final exam</td><td>30%</td><td>60%</td></tr>
<tr><td>Individual exercises / class attendance and participation</td><td>20%</td><td>40%</td></tr>
<tr><td>Total</td><td>50%</td><td>100%</td></tr>
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</td></tr>
</table>

| Subject name: The Physiological Basis of Visual Perception | |
|---|---|
| **ECTS: 3** | **Type: Compulsory** |
| **Term:** | **Second term** |
| **Language(s)** | **English** |

**Description:**

- **Requirements:** none
- **Contents**

All information is received by the senses; therefore, the first step of the nervous system is to transform the physical energy into electrical energy. The visual perceptual process begins in the retina and is transmitted to the cortex. Two great pathways of the "what" and the "where" stand out, pathways in which visual perception changes will also be observed.

- From the retina to the cortex: microscopic anatomy of the retinal-cortical pathway; structure of the retina (rods and blind spot); retinal ganglion cells (associated physiology and calculations); magnocellular and parvocellular pathways; detection of brightness and colour contrast.

- Retinotopic organisation: functional specialisation of the extra-striate cortex; differential characteristics of the electrophysiological responses of neurons in V1, V2, V4 and V5/MT (medial temporal lobe); direct and feedback connectivity; hierarchical organisation, parallel processing pathways and the binding problem.

- Functional specialisation of colour and movement: colour, parvocellular pathway and the V4 and V8 areas, electrophysiology and brain imaging of selective neurons for colour and of the associated cortical areas (V4 in primates and V8 in humans); equiluminance; cerebral achromatopsia and patients who are "cortically colour blind"; the conjunction of chromatic information with other visual information. Motion, motion perception and the V5/MT area; V5/MT neural characteristics; speed adjustment and speed sensitivity; columnar adjustment, the contrast effect and its relationship with the magnocellular pathway; Motion After Effect (MAE); Zihl's patient, "motion blind"; study of the role of feedback through transcranial magnetic stimulation (TMS).

- Segmentation, occlusion and illusory contours. Scene segmentation (visual occlusion, figure/background segregation and edge identification); illusory contours (IC) as a case study of the segmentation task; physiological responses of ICs in V2 (in primates and LOC (in humans); computational studies on segmentation based on contours or regions; interaction between the flow of stimulus-driven or feedback-driven information.

- Object recognition: Visual agnosia; partial and invariant recognition of the form; study of methods based on images, extraction of characteristics and template comparison; specialised modules, facial and character recognition; innate and/or acquired specialisation; internal representations and action.

- Visual attention: neural bases of visual search processes; single-cell primate records; functional neuroimaging studies; evoked potentials studies

- Binocular rivalry and ambiguous figures: fusion, rivalry and suppression; binocular perception of depth, stereoscopic vision; theoretical approach to figure-background relationships and their reversibility (ambiguous figures).

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| **Learning outcomes** | Develop creative ideas in an experimental context about cognitive neuroscience to generate viable research proposals. |

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| | Interpret and use statistical data accurately based on the results of a scientific experiment in cognitive neuroscience to provide quality experimental research.<br>Acquire the knowledge necessary to record and analyse data using the main electrophysiological techniques used in visual perception .<br>Know how to coherently explain the results of a scientific experiment and know how to respond to questions from other participants. |
| **Training activities** | • Whole-class sessions<br>• In-person tutorial sessions<br>• Regulated work placement<br>• Group work<br>• Individual work |

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
|---|---|---|
| Whole-class sessions | 21 | 100% |
| In-person tutorial sessions | 3 | 100% |
| Regulated work placement | 3 | 100% |
| Group work | 7 | 0% |
| Individual work | 41 | 0% |
| **Total** | 75 | |

| | |
|---|---|
| **Teaching methodology** | • Lectures<br>• Seminars involving discussion on pre-assigned readings<br>• Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data<br>• Remote activities dedicated to resolving practical exercises based on data provided by the teachers<br>• In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet<br>• Remote activities for reading articles<br>• Presentations of topics by students<br>• Individual work |
| **Assessment methods** | • Final exam<br>• Individual or group exercises<br>• Class participation and attendance |

| Assessment method | Minimum weighting | Maximum weighting |
|---|---|---|
| Final exam | 30% | 60% |
| Individual or group exercises | 20% | 40% |

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|---|---|---|---|
| | / class attendance and participation | | |
| | **Total** | 50% | 100% |

| **Subject name: Data Analysis for Cognitive Neuroscience** | |
|---|---|
| **ECTS: 2.5** | **Type: Compulsory** |
| **Term:** | **First term** |
| **Language(s)** | **English** |

**Description:**

- **Requirements: none**
- **Contents**

New experimental techniques applied in the field of cognitive neuroscience have led to a progressive increase in technology use in the data analysis process. Specialised packages are available for the most standardised analyses, but for pioneering analyses or for unique experimental designs direct use of lower-level programming techniques is necessary. The programming platform most used in the context of cognitive neuroscience is Matlab, although recently Python programming is also suggested as another platform for neuroscience analysis and modelling. The general aim of this course is to provide students with the tools they need to get started in the direct programming of their analysis codes, with a broad view of the possible applications of different types of data, from neurophysiology to behaviour or neuroimaging. The course is designed as a course-workshop where the students will work directly on data sets with their computers through guided exercises or smaller, less structured projects. The specific content that will be taught on this course are:

- Specific programming in experimental research
- Use of programmes for experimental data analysis, such as Matlab or Python
- Mathematical methods for the univariate and multivariate statistical analysis of the results of neurophysiological, behavioural and neuroimaging records

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| **Learning outcomes** | Propose appropriate methodological solutions for data analysis.<br>Learn to programme analysis codes.<br>Properly interpret data records derived from the different technologies applied to cognitive science. |
| **Training activities** | • Whole-class sessions<br>• In-person tutorial sessions<br>• Regulated work placement<br>• Group work<br>• Individual work |

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
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|---|---|---|---|
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| | Whole-class sessions | 18 | 100% |
| | In-person tutorial sessions | 3 | 100% |
| | Regulated work placement | 3 | 100% |
| | Group work | 4 | 0% |
| | Individual work | 35 | 0% |
| | **Total** | 63 | |
| **Teaching methodology** | • Lectures<br>• Seminars involving discussion on pre-assigned readings<br>• Computer exercises to consolidate understanding about the concepts explained in the classes and seminars by applying real data<br>• Remote activities dedicated to resolving practical exercises based on data provided by the teacher(s)<br>• In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet<br>• Remote activities for reading articles<br>• Presentations of topics by students<br>• Individual work | | |
| **Assessment methods** | • Final exam<br>• Individual or group exercises<br>• Class participation and attendance | | |
| | **Assessment method** | **Minimum weighting** | **Maximum weighting** |
| | Final exam | 30% | 60% |
| | Individual or group exercises / class attendance and participation | 20% | 40% |
| | **Total** | 50% | 100% |

| **Subject name: Neuroimaging Methods** | |
|---|---|
| **ECTS: 2.5** | **Type: Compulsory** |
| **Term:** | **First term** |
| **Language(s)** | **English** |
| **Description:**<br>• **Requirements:** None<br>• **Contents**<br>The purpose of this course is to introduce the different functional neuroimaging methods used to study the brain. | |

At the end of the course, students are expected to have in-depth knowledge of the analysis techniques and methods related to the methods used for the functional understanding of the human brain.
- Specific experimental knowledge comprising different neuroimaging methodologies to investigate how information is processed in the brain.
- Description of the imaging, mathematical and statistical methods for the analysis of sample results from neuroimaging records, for example, electrophysiological methods (EEG, ERPs, fMRI, etc.), non-invasive electrophysical methods adapted for research with children and transcranial magnetic stimulation (TMS) in adults.
Specific content:
- MRI neuroimaging methods, fMRI techniques and methods: general foundations of image processing (physiology, research methods in experimental designs and statistical methods for data analysis).
- MEG and EEG methods and physiology: estimation of structural parameters (the creation of functional brain images, blood flow, electrical acquisition in animals).
- Transcranial Magnetic Stimulation (TMS) methods and physiology: alterations of functional and dysfunctional networks
- Optical topography or functional near-infrared spectroscopy (NIRS) and their applications in scientific research
- Applications of neuroimaging: memory, pain, senses and emotions

**Learning outcomes**

Demonstrate knowledge of the main data collection and recording techniques in the context of cognitive neuroscience with the purpose of conducting rigorous data analysis.

Interpret and use statistical data accurately based on the results of a scientific experiment in cognitive neuroscience to provide quality experimental research.

Learn about the potential of new technologies applied in cognitive science to develop future research.

**Training activities**

- Whole-class sessions
- In-person tutorial sessions
- Regulated work placement
- Group work
- Individual work

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
|---|---|---|
| Whole-class sessions | 18 | 100% |
| In-person tutorial sessions | 3 | 100% |
| Regulated work placement | 3 | 100% |
| Group work | 4 | 0% |

| | | | |
|---|---|---|---|
| | Individual work | 35 | 0% |
| | **Total** | 63 | |
| | | | |

| | |
|---|---|
| **Teaching methodology** | • Lectures<br>• Seminars involving discussion on pre-assigned readings<br>• Practical exercises in laboratories to consolidate understanding about the concepts explained in the classes and seminars by applying real data<br>• Remote activities dedicated to resolving practical exercises based on data provided by the teachers<br>• In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet<br>• Remote activities for reading articles<br>• Presentations of topics by students<br>• Individual work |
| **Assessment methods** | • Final exam<br>• Individual or group exercises<br>• Class participation and attendance |

| | **Assessment method** | **Minimum weighting** | **Maximum weighting** |
|---|---|---|---|
| | Final exam | 30% | 60% |
| | Individual or group exercises / class attendance and participation | 20% | 40% |
| | **Total** | 50% | 100% |
| | | | |

| **Subject name: Seminar** | |
|---|---|
| **ECTS: 7** | **Type: Compulsory** |
| **Term:** | **Entire course (first, second and third term)** |
| **Language(s)** | **English** |

**Description:**

- **Requirements:** none
- **Contents**

This seminar is designed to help students consolidate their learning by meeting with their teachers every week to build upon their knowledge. Doubts, questions and reflections on experimental logic can be expressed and answers can be reached through the group's joint knowledge. The general structure is as follows:

- Selection of a topic that corresponds to the preparation and motivation of the group. These are subjects related to the content that they have worked on in their subjects and in their ongoing research projects.

- Presentation of experimental articles (one or two per session), explained by experts (master's teachers or guests) or by the students (master's or doctorate).

Special emphasis is placed on analysing the methodological characteristics of the article, the adequacy of the sample and the data recording.

- Time for questions about experimental quality, methodological design and analysis of results. Discussion generated from the group debate led by a session mediator (a different person each week).
- Answers provided for student questions and doubts about the design of their research projects (TFM): structure, content, ethical considerations. And scientific input.

<table>
<tr><td>Learning outcomes</td><td>Reflect on the principles and methods of cognitive neuroscience research to promote critical thinking.<br>Adequately interpret, analyse and describe a scientific article (bibliographic sources, methodology, results, conclusions and relevant contribution to the scientific field) related to brain processing and cognition.<br>Publicly exhibit new ideas and solutions to scientific problems, even under the pressure of critical evaluation.<br>Assess the quality of a scientific question in achieving its objectives.<br>Take part in the debates and scientific meetings, demonstrating their performance through achievement of objectives and reaching an optimal level of results.</td></tr>
<tr><td>Training activities</td><td>

- Seminars
- Individual work

| TYPE OF ACTIVITY | HOURS | IN PERSON? |
|---|---|---|
| Seminars | 52 | 100% |
| Individual work | 123 | 0% |
| **Total** | 175 | |

</td></tr>
<tr><td>Teaching methodology</td><td>

- Seminars involving discussion on pre-assigned readings
- Remote activities for reading articles
- Presentations of topics by students
- Individual work

</td></tr>
<tr><td>Assessment methods</td><td>

- Individual or group exercises
- Participation and attendance

| Assessment method | Minimum weighting | Maximum weighting |
|---|---|---|
| Individual or group exercises / | 50% | 100% |

</td></tr>
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| | | | |
|---|---|---|---|
| | class attendance and participation | | |
| | **Total** | 50% | 100% |

<table>
<tr><td colspan="2">Subject name: End of master’s degree research work</td></tr>
<tr><td>ECTS: 27</td><td>Type: Compulsory</td></tr>
<tr><td>Term:</td><td>Entire course (first, second and third term)</td></tr>
<tr><td>Language(s)</td><td>English</td></tr>
<tr><td colspan="2">Description:<br>• Requirements: none<br>• Contents<br>Research project based on the master’s degree themes, resulting in a final master’s degree project which will be presented both in writing and orally.<br>The final master’s degree project will involve a written project of between 30 and 50 pages. It must contain experimental data or experimental research on an original subject. It will be organised like a scientific article which can be published in the main journals in this field (according to the standards of the American Psychological Association). Its quality should be similar to that of a manuscript which could be presented to a journal in this field.</td></tr>
<tr><td>Learning outcomes</td><td>Develop creative ideas in an experimental context about cognitive neuroscience to generate viable research proposals.<br>Clearly communicate the knowledge acquired and the reasons behind it related to cognitive neuroscience in order to collaborate in the dissemination of the results.<br>Interpret and use statistical data accurately based on the results of a scientific experiment in cognitive neuroscience to provide quality experimental research.<br>Assess the design of an accurate experimental methodology in line with the most relevant current contributions.<br>Raise and solve an issue in the context of scientific research about an aspect of cognition.<br>Accurately examine statistical data in the context computational neuroscience and cognition.<br>Critically analyse the relevant scientific literature of a field of study.</td></tr>
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<tr><td></td><td>Write a research project or essay following the standards of excellence required.<br>Propose a suitable methodological solution for the analysed population, using initiative and creativity.<br>Describe the design of an experimental model based on a relevant scientific objective and of interest for research.<br>Identify and develop methodological tools related cognitive science which are appropriate for the starting hypothesis.<br>Assess the quality of a scientific question in achieving its objectives.<br>Identify and develop experimental research hypotheses.<br>Propose appropriate methodological solutions.<br>Learn about and apply innovative technical methodology to develop future research.</td></tr>
<tr><td>Training activities</td><td>• In-person tutorial sessions<br>• Individual work
<table>
<tr><td>TYPE OF ACTIVITY</td><td>HOURS</td><td>IN PERSON?</td></tr>
<tr><td>In-person tutorial sessions</td><td>50</td><td>100%</td></tr>
<tr><td>Individua l work</td><td>624</td><td>0%</td></tr>
<tr><td>Total</td><td>674</td><td></td></tr>
</table></td></tr>
<tr><td>Teaching methodology</td><td>• Seminars involving discussion on pre-assigned readings<br>• In-person and online tutorial sessions in which the students will have access to online resources, such as the UPF intranet<br>• Remote activities for reading articles<br>• Presentations of topics by students<br>• Individual work</td></tr>
<tr><td>Assessment methods</td><td>• Final master’s degree project<br>• Presentation of papers
<table>
<tr><td>Assessment method</td><td>Minimum weighting</td><td>Maximum weighting</td></tr>
<tr><td>Final project</td><td>35%</td><td>70%</td></tr>
<tr><td>Individual work</td><td>15%</td><td>30%</td></tr>
<tr><td>Total</td><td>50%</td><td>100%</td></tr>
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