

# Module description

Master of Science in the subject Neuroscience  
(Examination regulations version 2021)

**Second Semester:**

**Module 3: Advanced Topics in Neuroscience**

**Module 4: Elective Subjects**

## **Module 3: Advanced Topics in Neuroscience**

Name of module	Number of module
Advanced Topics in Neuroscience	09LE03MO-NA-2021
<b>course</b>	
Advanced Topics in Neuroscience	
Event type	Number
seminar	09LE03S-NA-T1
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	3.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Workload	90 h

<b>Content</b>
Recent research findings in neuroscience including current neuroscience research taking place at the University of Freiburg. The module takes places twice per week. On one appointment, students present recent research findings from the neuroscientific literature while on the other appointment neuroscientists from Freiburg present their own research.
<b>Qualification</b>
<p>The student</p> <ul style="list-style-type: none"> <li>■ can summarize several recent research findings in neuroscience including current neuroscientific research taking place at the University of Freiburg.</li> <li>■ has the competence to extract the important findings from a research publication and present them in a meaningful and well-structured scientific presentation in English</li> </ul>
<b>Examination achievement</b>
none
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>■ Regular participation</li> <li>■ Presentation of a neuroscience research topic (30 min plus discussion)</li> </ul>
<b>Compulsory requirement</b>

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## **Module 4: Elective Subjects**

Name of module	Number of module
Elective Subjects (Focus Area 1: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
Elective Subjects (Focus Area 2: Computational Neuroscience)	09LE03MO-NE-2-2021
Elective Subjects (Focus Area 3: Neurotechnology)	09LE03MO-NE-3-2021
Responsible	
Neural Circuits and Behavior: Prof. Ilka Diester, Prof. Andrew Straw (Faculty of Biology)	
Computational Neuroscience: Prof. Stefan Rotter (Faculty of Biology)	
Neurotechnology: Prof. Thomas Stieglitz (Faculty of Engineering)	

ECTS-Points	27
Recommended semester	2
Pflicht/Wahlpflicht (P/WP)	Core elective
Workload	750 h
Frequency	Only in the summer term

Compulsory requirement
None
Content
<p>For the “Elective Subjects” the student chooses one focus area from the following list:</p> <ul style="list-style-type: none"> <li>▪ Neural Circuits and Behavior (coordinators: Prof. Diester, Prof. Straw)</li> <li>▪ Computational Neuroscience (coordinator: Prof. Rotter)</li> <li>▪ Neurotechnology (coordinator: Prof. Stieglitz)</li> </ul> <p>Each focus area consists of mandatory and elective (i.e. optional) modules. The student must choose a sufficient number of elective modules such that mandatory and elective modules together are worth at least 27 ECTS. For further questions regarding the focus areas, please contact the coordinator of the focus area, the program coordinator Dr. Ahrens or Prof. Mehring.</p>
Qualification
<ul style="list-style-type: none"> <li>▪ The students have acquired in-depth knowledge in a research area of the neurosciences which each student chooses individually from the following available areas: <ul style="list-style-type: none"> <li>(1) Neural Circuits and Behavior</li> <li>(2) Computational Neuroscience</li> <li>(3) Neurotechnology.</li> </ul> </li> <li>▪ The students are able to critically evaluate and discuss important findings and scientific publications from the chosen area</li> <li>▪ The students can apply area specific experimental and/or theoretical research methods</li> </ul>
Examination achievement (Prüfungsleistung, PL)
<p>Each focus area has two graded assessments (“Prüfungsleistung”, PL). The type and scope of the assessments are defined in the module descriptions and are announced to the students at the beginning of each course. To do a PL, it may be required to successfully complete coursework in advance, e.g. you may need to successfully complete some exercises during the course before you can do an exam.</p>
Course achievement (Studienleistung, SL)
<p>Specific criteria that need to be met to pass a “Studienleistung” are explained in the module description and announced by the lecturer at the beginning of the term. Examples of such</p>

“Studienleistung” are a report, a presentation or a written/oral exam, all of which are not graded, i.e. they can only be “passed” or “failed”. Sometimes you will receive a grade for a “Studienleistung” but this grade is only for your information to give you further feedback on your performance.

#### Examination weight

Each focus area has two graded assessments (“Prüfungsleistungen”, PL). All other courses will not be graded but may contain ungraded assessments (“Studienleistungen”, SLs). The overall grade of the module “Elective Subjects” will be calculated as the weighted sum of both PLs as follows:

Module grade =  $w1 \cdot \text{grade PL1} + w2 \cdot \text{grade PL2}$

$w1 = \text{ECTS PL1} / (\text{ECTS PL1} + \text{ECTS PL2})$

$w2 = \text{ECTS PL2} / (\text{ECTS PL1} + \text{ECTS PL2})$

#### Recommendation

Please note:

Several modules are taught not only to MSc Neuroscience students but at the same time to students from other degree programs (e.g. M.Sc. Biology, M.Sc. Computer Science, M.Sc. Applied Physics etc.). The same module may have different assessments depending on the degree program of the student. For example, while a report may be an SL for M.Sc. Neuroscience students (and therefore can only be “passed” or “failed”) it may be a PL (and therefore be graded) for a student from the M.Sc. Computer Science.

A few of the elective modules take place during winter term (as indicated by ‘WS’ behind the module name). In this case the participation takes places during the 3rd semester while students carry out their research project. It is usually not a problem to take part in a teaching module in parallel to a research project, however, this should be agreed by the supervisor of the research project. Please also note that research projects can already be started before the 3rd semester, e.g. in summer.

Some focus areas and modules have limitations with regard to the number of participants. In the case of too many applicants for a focus area or a module, students will be selected according to a procedure outlined in the M.Sc. Neuroscience examination regulations. Students which unfortunately cannot be registered for their first choice will be given the opportunity to choose other elective modules with sufficient number of places.

## Focus Area 1:

### Neural Circuits and Behavior

All students in this Focus Area attend the exercise “Methods in Neurobiology” as their first graded assessment (PL 1) and choose another course as their second graded assessment (PL 2; either “Cognitive Neuroscience”, “Developmental Neuroscience”, “Neurobiology in Genetic Model Organisms” or “Neuroscience – Optophysiology”).

Additionally, you can either choose one more of these 9 ECTS courses as an ungraded assessment (SL). In this case, you need to make sure to choose courses that don’t overlap in time.

If you decide to take only one of these 9 ECTS courses, you need to take all three additional courses.

Please note that at least parts of the courses being offered at the Faculty of Biology need to be done on-site. If this should not be possible due to the pandemic, some courses may not be offered. Moreover, the number of places may be reduced for hygiene reasons.

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Methods in Neurobiology	9	m	PL
<i>Students choose either one or two of these courses:</i>			
A. Developmental Neuroscience	9	e	PL/SL
A. Neurobiology in Genetic Model Organisms	9		
A. Neuroscience – Optophysiology	9		
B. Cognitive Neuroscience	9		
<i>If students choose only one course from the above list, they need to take these additional courses:</i>			
Neuroprosthetics	3	e	SL
Signal Processing and Analysis in Brain Signals	3		
Working in Science	3		

**Example 1:**

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Methods in Neurobiology	9	m	PL 1
<i>Students choose either one or two of these courses:</i>			
A. Developmental Neuroscience	9	e	SL
A. Neurobiology in Genetic Model Organisms	9		
A. Neuroscience – Optophysiology	9		
B. Cognitive Neuroscience	9		PL 2
<i>If students choose only one course from the above list, they need to take these additional courses:</i>			
Neuroprosthetics	3	e	SL
Signal Processing and Analysis in Brain Signals	3		
Working in Science	3		
<b>Total ECTS</b>	<b>27</b>		

**Example 2:**

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Methods in Neurobiology	9	m	PL 1
<i>Students choose either one or two of these courses:</i>			
A. Developmental Neuroscience	9	e	
A. Neurobiology in Genetic Model Organisms	9		PL 2
A. Neuroscience – Optophysiology	9		
B. Cognitive Neuroscience	9		
<i>If students choose only one course from the above list, they need to take these additional courses:</i>			
Neuroprosthetics	3	e	SL
Signal Processing and Analysis in Brain Signals	3		SL
Working in Science	3		SL
<b>Total ECTS</b>	<b>27</b>		



The table below contains more detailed information about the specific parts of the courses (some contain e.g. a lecture and an exercise or seminar) and the Professors in charge.  
Detailed information on the content of each course can be found in the module descriptions below.

Course	Event type	Number
<b>Methods in Neurobiology</b> Prof. Dierk Reiff <i>Faculty of Biology</i>	Exercise	09LE03Ü-SP1-05_0002
<b>Cognitive Neuroscience</b> Dr. Sven Heinrich, Dr. Nicole Roßkothen-Kuhl <i>Faculty of Biology</i> <ul style="list-style-type: none"> <li>Major Concepts in Cognitive Neurosciences</li> <li>Methods in Cognitive Neurosciences</li> <li>Selected Topics in Neurosciences</li> </ul>	Lecture Exercise Seminar	09LE03V-WM-05_0001 09LE03Ü-WM-05_0002 09LE03S-WM-05_0003
<b>Developmental Neuroscience</b> Prof. Wolfgang Driever <i>Faculty of Biology</i> <ul style="list-style-type: none"> <li>Development of the Nervous System</li> <li>Methods in Developmental Neurobiology</li> <li>Establishing the Nervous System</li> </ul>	Lecture Exercise Seminar	09LE03V-WM-07_0001 09LE03Ü-WM-07_0002 09LE03S-WM-07_0003
<b>Neurobiology in Genetic Model Organisms</b> Prof. Dierk Reiff <i>Faculty of Biology</i> <ul style="list-style-type: none"> <li>Neural Circuits guiding behavior in Drosophila</li> <li>Quantitative behavior and functional dissection of neural circuitries in Drosophila</li> <li>Neural Circuits and Behavior</li> </ul>	Lecture Exercise Seminar	09LE03V-WM-13_0001 09LE03Ü-WM-13_0002 09LE03S-WM-13_0003
<b>Neuroscience – Optophysiology</b> Prof. Ilka Diester <i>Faculty of Biology</i> <ul style="list-style-type: none"> <li>Optogenetics for Neuroscience</li> <li>Optophysiology</li> </ul>	Lecture Exercise	09LE03V-WM-31_0001 09LE03Ü-WM-31_0002
<b>Neuroprosthetics</b> Prof. Ulrich Hofmann <i>Faculty of Engineering</i>	Seminar	04LE50V-5318
<b>Signal Processing and Analysis in Brain Signals</b> Prof. Thomas Stieglitz <i>Faculty of Engineering</i>	Lecture	11LE50V-5312
<b>Working in Science</b> Prof. Carsten Mehring <i>Faculty of Biology</i>	Seminar	09LE03S-NE-5-T12

## Focus Area 2:

### Computational Neuroscience

In the Focus Area “Computational Neuroscience”, you choose two PL out of the three mandatory courses (“Models of Neurons and Networks”, “Biological Learning, Control and Decision Making” and “The Neural Code: Quantitative Analysis of Neural Activity”) and take the third one as SL. More SL are chosen from the list of additional courses.

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Models of Neurons and Networks	6	m	PL/SL
Biological Learning, Control and Decision Making	6	m	PL/SL
The Neural Code: Quantitative Analysis of Neural Activity	6	m	PL/SL
<i>Students choose from these additional courses:</i>			
Current Topics in Computational Neuroscience	3	e	SL
Machine learning (WS)	6	e	SL
Neuroprosthetics	3	e	SL
Numerical Optimal Control in Science and Engineering	6	e	SL
Signal Processing and Analysis in Brain Signals	3	e	SL
Simulation of Biological Neuronal Networks	3	e	SL
Statistical Pattern Recognition	6	e	SL
Working in Science	3	e	SL

**Example 1:**

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Models of Neurons and Networks	6	m	PL 1
Biological Learning, Control and Decision Making	6	m	SL
The Neural Code: Quantitative Analysis of Neural Activity	6	m	PL 2
<i>Students choose from these additional courses:</i>			
Current Topics in Computational Neuroscience	3	e	SL
Machine learning (WS)	6	e	SL
Neuroprosthetics	3	e	SL
Numerical Optimal Control in Science and Engineering	6	e	SL
Signal Processing and Analysis in Brain Signals	3	e	SL
Simulation of Biological Neuronal Networks	3	e	SL
Statistical Pattern Recognition	6	e	SL
Working in Science	3	e	SL
<b>Total ECTS</b>	<b>27</b>		

**Example 2:**

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Models of Neurons and Networks	6	m	SL
Biological Learning, Control and Decision Making	6	m	PL 1
The Neural Code: Quantitative Analysis of Neural Activity	6	m	PL 2
<i>Students choose from these additional courses:</i>			
Current Topics in Computational Neuroscience	3	e	SL
Machine learning (WS)	6	e	SL
Neuroprosthetics	3	e	SL
Numerical Optimal Control in Science and Engineering	6	e	SL
Signal Processing and Analysis in Brain Signals	3	e	SL
Simulation of Biological Neuronal Networks	3	e	SL
Statistical Pattern Recognition	6	e	SL
Working in Science	3	e	SL
<b>Total ECTS</b>	<b>27</b>		

The table below contains more detailed information about the specific parts of the courses (some contain e.g. a lecture and an exercise or seminar) and the Professors in charge. Detailed information on the content of each course can be found in the module descriptions below.

Course	Event type	Number
<b>Models of Neurons and Networks</b> Prof. Stefan Rotter <i>Faculty of Biology</i>	Exercise	09LE03Ü-NE-2-T1.1
<b>Biological Learning, Control and Decision Making</b> Prof. Carsten Mehring <i>Faculty of Biology</i>	Exercise	09LE03Ü-NE-2-T1.2
<b>The Neural Code: Quantitative Analysis of Neural Activity</b> Prof. Christian Leibold <i>Faculty of Biology</i>	Exercise	09LE03Ü-NE-2-T1.3
<b>Current Topics in Computational Neuroscience</b> Prof. Stefan Rotter, Prof. Carsten Mehring, Prof. Christian Leibold <i>Faculty of Biology</i>	Seminar	09LE03S-NE-2-T11
<b>Machine Learning (WS)</b> Prof. Josif Grabocka <i>Faculty of Engineering</i>	Lecture + Exercise	11LE13V-1153 11LE13Ü-1153
<b>Neuroprosthetics</b> Prof. Ulrich Hofmann <i>Faculty of Engineering</i>	Seminar	04LE50V-5318
<b>Numerical Optimal Control in Science and Engineering</b> Prof. Moritz Diehl <i>Faculty of Engineering</i>	Lecture + Exercise	11LE50V-5249 11LE50Ü-5249
<b>Signal Processing and Analysis in Brain Signals</b> Prof. Thomas Stieglitz <i>Faculty of Engineering</i>	Lecture	11LE50V-5312
<b>Simulation of Biological Neuronal Networks</b> Prof. Stefan Rotter <i>Faculty of Biology</i>	Exercise	09LE03Ü-NE-2-T2
<b>Statistical Pattern Recognition</b> Prof. Thomas Brox <i>Faculty of Engineering</i>	Lecture + Exercise	11LE13V-1114 11LE13Ü-1114
<b>Working in Science</b> Prof. Carsten Mehring <i>Faculty of Biology</i>	Seminar	09LE03S-NE-5-T12

## Focus Area 3:

### Neurotechnology

In the Focus Area “Neurotechnology”, all students take “Biomedical Microsystems” as their first and “Neuroprosthetics” as their second PL. Additional SL can be chosen from the list below. Please note that some courses are taking place in winter term.

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Biomedical Microsystems	5	m	PL
Neuroprosthetics	3	m	PL
Biomedical Instrumentation I	3	m	SL
<i>Students choose from these additional courses:</i>			
Cognitive Neuroscience	9	e	SL
Machine Learning (WS)	6	e	SL
Numerical Optimal Control in Science and Engineering	6	e	SL
Fundamentals of electrical stimulation (WS)	3	e	SL
Implant manufacturing technologies (WS)	3	e	SL
Signal Processing and Analysis in Brain Signals	3	e	SL
Working in Science	3	e	SL

## Example 1

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Biomedical Microsystems	5	m	PL 1
Neuroprosthetics	3	m	PL 2
Biomedical Instrumentation I	3	m	SL
<i>Students choose from these additional courses:</i>			
Cognitive Neuroscience	9	e	SL
Machine Learning (WS)	6	e	SL
Numerical Optimal Control in Science and Engineering	6	e	SL
Fundamentals of electrical stimulation (WS)	3	e	SL
Implant manufacturing technologies (WS)	3	e	SL
Signal Processing and Analysis in Brain Signals	3	e	SL
Working in Science	3	e	SL
<b>Total ECTS</b>	<b>29</b>		

## Example 2

<i>All students in this focus area attend:</i>	ECTS	mandatory/ elective	SL/PL
Biomedical Microsystems	5	m	PL 1
Neuroprosthetics	3	m	PL 2
Biomedical Instrumentation I	3	m	SL
<i>Students choose from these additional courses:</i>			
Cognitive Neuroscience	9	e	SL
Machine Learning (WS)	6	e	SL
Numerical Optimal Control in Science and Engineering	6	e	SL
Fundamentals of electrical stimulation (WS)	3	e	SL
Implant manufacturing technologies (WS)	3	e	SL
Signal Processing and Analysis in Brain Signals	3	e	SL
Working in Science	3	e	SL
<b>Total ECTS</b>	<b>29</b>		

The table below contains more detailed information about the specific parts of the courses (some contain e.g. a lecture and an exercise or seminar) and the Professors in charge. Detailed information on the content of each course can be found in the module descriptions below.

Course	Event type	Number
<b>Biomedical Instrumentation I</b> Prof. Thomas Stieglitz <i>Faculty of Engineering</i>	Lecture + Exercise	11LE50V-5301 11LE50Ü-5301
<b>Biomedical Microsystems</b> Prof. Thomas Stieglitz <i>Faculty of Engineering</i>	Lecture + Exercise	11LE50V-7900 11LE50Ü-7900
<b>Neuroprosthetics</b> Prof. Ulrich Hofmann <i>Faculty of Engineering</i>	Seminar	04LE50V-5318
<b>Cognitive Neuroscience</b> Dr. Sven Heinrich, Dr. Nicole Roßkothen-Kuhl <i>Faculty of Biology</i> <ul style="list-style-type: none"> <li>Major Concepts in Cognitive Neurosciences</li> <li>Methods in Cognitive Neurosciences</li> <li>Selected Topics in Neurosciences</li> </ul>	Lecture Exercise Seminar	09LE03V-WM-05_0001 09LE03Ü-WM-05_0002 09LE03S-WM-05_0003
<b>Machine Learning (WS)</b> Prof. Josif Grabocka <i>Faculty of Engineering</i>	Lecture + Exercise	11LE13V-1153 11LE13Ü-1153
<b>Numerical Optimal Control in Science and Engineering</b> Prof. Moritz Diehl <i>Faculty of Engineering</i>	Lecture + Exercise	11LE50V-5249 11LE50Ü-5249
<b>Fundamentals of electrical stimulation (WS)</b> Prof. Thomas Stieglitz <i>Faculty of Engineering</i>	Lecture	11LE50V-5306
<b>Implant manufacturing technologies (WS)</b> Prof. Thomas Stieglitz <i>Faculty of Engineering</i>	Lecture + Exercise	11LE50V-5313 11LE50Ü-5313
<b>Signal Processing and Analysis in Brain Signals</b> Prof. Thomas Stieglitz <i>Faculty of Engineering</i>	Lecture	11LE50V-5312
<b>Working in Science</b> Prof. Carsten Mehring <i>Faculty of Biology</i>	Seminar	09LE03S-NE-5-T12

## **Detailed Module Descriptions**

### **Focus Area 1: Neural Circuits and Behavior**



Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Methods in Neurobiology	
Event type	Number
exercise course	09LE03Ü-SP1-05_0002
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	9.0
Hours of week	7.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	110 Stunden
Independent study	160 Stunden
Workload	270 Stunden

<b>Content</b>
Three different 'hands on' courses are offered that provide students with the opportunity to perform small neuroscience research projects. An additional course covers the simulation of biophysically inspired neuron models. Each course will be accompanied by group discussions and interactive presentations of theoretical and practical aspects. Students write a lab report on performed research.
<b>Qualification</b>
<p>Students</p> <ul style="list-style-type: none"> <li>■ can design, perform and document experiments in different fields of neuroscience research, from early visual processing (ERG) to navigation behaviour in different insect species, from EEG &amp; EMG recordings in humans to the control of muscles, movement and basic neuroprosthetic devices.</li> <li>■ are able to perform computer-controlled physiological recording experiments, quantitative measurements of movement and behaviour.</li> <li>■ are able to analyse and interpret recorded data.</li> <li>■ can relate their experiments to important theoretical concepts.</li> <li>■ can present, evaluate and discuss the results from own experiments and integrate them into the state of art in the research field.</li> <li>■ can explain both the usefulness and limitations of research on model organisms and humans.</li> </ul>
<b>Examination achievement</b>
<ul style="list-style-type: none"> <li>■ Evaluation of lab report</li> </ul>
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>■ Active participation in all courses</li> <li>■ Written lab report</li> </ul>

Literature
Course scripts for experimental work, preparatory literature like original articles and reviews will be provided during the course.
Compulsory requirement
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Teaching method
Experimental work by the students performed in small groups using electrophysiological, behavioral and computational techniques, supported by tutors. Practical demonstration of key techniques. Use of computer and Python software. Interactive presentations using blackboard and powerpoint / PDF, discussion as a group.
Target group
<ul style="list-style-type: none"><li>■ M.Sc. Biology</li><li>■ M.Sc. Neuroscience</li><li>■ M.Sc. Bioinformatics &amp; Systems Biology</li><li>■ Diplom Biology</li><li>■ Joint Master in Neuroscience</li></ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Major Concepts in Cognitive Neurosciences	
Event type	Number
lecture course	09LE03V-WM-05_0001
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	4.3
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	
Language	english
Attendance	60 Stunden
Independent study	30 Stunden
Workload	90 Stunden

<b>Content</b>
<p>Topics of the lectures given by various teachers are intentions, methods, and results of diverse fields of research that together contribute to our understanding of the relationship between cognition and the structure and physiology of brains.</p> <p>Topics contain:</p> <ul style="list-style-type: none"> <li>■ Brain evolution</li> <li>■ Cognitive Psychology</li> <li>■ Neuroplasticity</li> <li>■ Perception</li> <li>■ Brain-machine interfaces</li> <li>■ Imaging methods</li> <li>■ Animal cognition</li> <li>■ Clinical neuroscience</li> <li>■ Neurophilosophy</li> </ul>
<b>Qualification</b>
<ul style="list-style-type: none"> <li>■ Students can name major stages of human brain evolution.</li> <li>■ They can explain and differentiate several levels of neuroplasticity.</li> <li>■ They can name major benefits and limits of computational concepts for understanding cognitive functions.</li> <li>■ They identify similarities and differences between human and animal cognition.</li> <li>■ They can give examples of logical complications faced by the cognitive neurosciences.</li> </ul>
<b>Examination achievement</b>
none
<b>Course achievement</b>
none

Literature
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"><li>■ Tim Shallice, Richard P. Cooper: The organization of mind. Oxford Univ. Press 2011</li><li>■ Kenneth M. Heilman, Edward Valenstein (Eds.): Clinical neuropsychology. 4th ed., Oxford Univ. Press 2003.</li></ul>
Compulsory requirement
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Teaching method
Lectures will be given as Power-Point presentation, including multimedia elements, backed by slide handouts. Intermitting discussions will be encouraged and coached.
Target group
<ul style="list-style-type: none"><li>■ M.Sc. Biology</li><li>■ M.Sc. Bioinformatics &amp; Systems Biology</li><li>■ M.Sc. Neuroscience</li><li>■ Diploma Biology</li></ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Methods in Cognitive Neurosciences	
Event type	Number
exercise course	09LE03Ü-WM-05_0002
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	2.0
Hours of week	0.5
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	6 Stunden
Independent study	54 Stunden
Workload	60 Stunden

<b>Content</b>
<ul style="list-style-type: none"> <li>demonstration of key methods in the cognitive neurosciences</li> <li>participation in experiments as subjects.</li> </ul>
<b>Qualification</b>
<p>The students can:</p> <ul style="list-style-type: none"> <li>identify major components and regions of human brain anatomy.</li> <li>explain EEG recordings, name the necessary equipment for it, and assess its fields of application.</li> <li>explain the principles of an MRI measurement and identify reasonable fields of application.</li> <li>plan and conduct experiments in teams, respect competencies of others and contribute their own skills constructively.</li> </ul>
<b>Examination achievement</b>
keine
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>100% active participation in 2 of 3 practical courses</li> <li>writing a lab report each about the experimental procedures done or seen.</li> </ul>
<b>Literature</b>
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"> <li>Lennart Heimer: The human brain and spinal cord. 2nd ed., Springer Verlag, New York 1994.</li> </ul>
<b>Compulsory requirement</b>
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Teaching method
Students will be given hands-on experience of key-methods used in the cognitive neurosciences.
Target group
<ul style="list-style-type: none"><li>■ M.Sc. Biology</li><li>■ M.Sc. Bioinformatics &amp; Systems Biology</li><li>■ Diploma Biology</li></ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Selected Topics in Cognitive Neurosciences	
Event type	Number
seminar	09LE03S-WM-05_0003
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	4.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	30 Stunden
Independent study	90 Stunden
Workload	120 Stunden

<b>Content</b>
<ul style="list-style-type: none"> <li>■ Two seminar blocks will be held for students to learn and discuss original papers about the cognitive neurosciences in general and about brain and language specifically.</li> <li>■ The students will learn how to read and evaluate original research reports.</li> <li>■ They will understand how to structure and present complex issues of current research.</li> <li>■ They will participate in scientific discussions and learn how to deal with controversies</li> </ul>
<b>Qualification</b>
Students present and discuss specific scientific terms and concepts, observing the fundamental distinction between data and their interpretation.
<b>Examination achievement</b>
keine
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>■ 100% active participation in two seminar blocks</li> <li>■ Two seminar presentations of data and concepts contained in original literature</li> </ul>
<b>Literature</b>
To be distribute during the preparatory session.
<b>Compulsory requirement</b>
s. Modulebene
<b>Teaching method</b>
Seminars will be given by each student as media-supported Power-Point presentations.

Target group
<ul style="list-style-type: none"><li>■ M.Sc. Biology</li><li>■ M.Sc. Bioinformatics &amp; Systems Biology</li><li>■ Diploma Biology</li></ul>





Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Development of the Nervous System	
Event type	Number
lecture course	09LE03V-WM-07_0001
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	1.5
Hours of week	1.5
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	
Language	english
Attendance	18 Stunden
Independent study	27 Stunden
Workload	45 Stunden

<b>Content</b>
<p>The lecture series presents the distinct phases of nervous system development starting from neural induction during gastrulation until formation of functional axonal connections and synapses between neurons. Examples for molecular mechanisms (transcriptional regulation, signaling pathways) that contribute to these developmental processes will be presented in order to enable a mechanistic understanding of developmental control. In addition, important techniques and methods for analysis of nervous system development will be presented.</p> <p>Topics of the lectures:</p> <ul style="list-style-type: none"> <li>■ Neuron and Glia</li> <li>■ Neural Crest Introduction into neural development</li> <li>■ Neural Induction</li> <li>■ Neurulation</li> <li>■ Anteroposterior Patterning in the Neural Plate; Regional Organizing Centers</li> <li>■ Hindbrain Segmentation</li> <li>■ Dorsoventral Patterning in the Nervous System</li> <li>■ Axon Guidance systems molecular mechanisms</li> <li>■ Axon Guidance spatial mechanisms and topographic representations</li> <li>■ Neurotrophic Factors and Neuronal Cell Death</li> <li>■ Synaptogenesis and Remodeling</li> <li>■ and Peripheral Nervous System</li> <li>■ Neurogenesis</li> <li>■ Neuronal Differentiation</li> <li>■ Sensory Organ Development</li> <li>■ Neural Stem Cells</li> <li>■ From Development to Behaviour: Ontogeny of visually mediated eye movements</li> <li>■ Optogenetic techniques to study circuit development and function</li> <li>■ 2-photon microscopy and optical techniques</li> </ul>

Qualification
<p>The students are able to:</p> <ul style="list-style-type: none"> <li>■ structure the fundamental phases of development of the nervous system from neural induction to formation of functional neuronal connections</li> <li>■ explain molecular mechanisms of neural development (transcriptional control, signaling mechanisms) using examples</li> <li>■ present how neural cells are induced from pluripotent early embryonic cells by the signaling systems active in gastrulation</li> <li>■ derive the fundamental morphogenetic processes during neurulation based on the participating signaling centers and the specific cell behavior</li> <li>■ explain the organisation of the vertebrate brain and spinal cord based on the anteroposterior and dorso-ventral patterning mechanisms that establish this organisation</li> <li>■ explain the causal role that transcription factors and signals act in pattern formation have during region specific neuronal differentiation</li> <li>■ argue how Delta-Notch signaling control neurogenesis</li> <li>■ explain the roles of neural stem cells and their stem cell niches in neural development and regeneration</li> <li>■ develop how distinct molecular mechanisms contribute to formation of functional connections in axonogenesis and synaptogenesis</li> <li>■ explain the formation of functional neuronal circuits in the embryo for simple behavioral paradigms (optomotor response, swim behavior of fishes)</li> <li>■ explain important classical and modern techniques for the experimental analysis of the distinct phases of neural development</li> </ul>
Examination achievement
none
Course achievement
none
Literature
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"> <li>■ Sanes et al., Development of the Nervous System (2012, 3rd. Ed. chapt. 1-7)</li> <li>■ Price et. al. Building Brains (2011, chapt.1-12)</li> <li>■ Kandel et al. Principles of Neural Sciences (2012, 5th Ed. Part VIII)</li> </ul>
Compulsory requirement
s. Modulebene
Teaching method
<p>Lectures using PowerPoint or Keynote presentations  Handouts of lecture slides as b&amp;w prints and als color PDFs on Illias server.  Up-to-date scientific reviews for each topic provided on Illias server  Development of schemes using chalk / board  Discussion of concepts and open questions</p>
Recommendation
lecture materials will be made available on Illias

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Methods in Developmental Neurobiology	
Event type	Number
exercise course	09LE03Ü-WM-07_0002
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	6.0
Hours of week	6.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	90 Stunden
Independent study	90 Stunden
Workload	180 Stunden

<b>Content</b>
<p>The practical classes present classical experimental embryology techniques as well as modern molecular genetics, signaling research, and microscopy techniques applied to the development of the nervous system using vertebrate model organisms.</p> <p>The trained techniques include:</p> <ul style="list-style-type: none"> <li>■ life imaging using transmitted light, epifluorescence and confocal microscopy</li> <li>■ analysis of genetic mutants</li> <li>■ transgenic animal model systems</li> <li>■ embryo culture</li> <li>■ gene expression analysis and immunohistology</li> <li>■ overexpression of genes using mRNA microinjection or conditional gene expression systems</li> <li>■ pharmacological manipulation of signaling pathways</li> <li>■ analysis of motor behavior development</li> <li>■ analysis of sense organ development</li> <li>■ analysis of axonogenesis</li> </ul>
<b>Qualification</b>
<p>The students are able to:</p> <ul style="list-style-type: none"> <li>■ operate transmitted light, epifluorescence and confocal microscopes and generate scientifically meaningful digital image data</li> <li>■ apply specific experimental or genetic methods for in vivo fluorescent labelling of defined neuronal populations.</li> <li>■ use time lapse analysis to investigate mechanisms and temporal progress of specific processes in neural development</li> <li>■ identify essential anatomical structures in the nervous system of the vertebrate embryo</li> <li>■ accomplish microinjections at the one-cell stage of embryos</li> <li>■ apply gene expression analysis and immunohistology to study development of the nervous system.</li> <li>■ evaluate different genetic techniques for the manipulation of signaling pathways and transcriptional control and apply appropriate techniques in experiments</li> </ul>

<ul style="list-style-type: none"> <li>■ evaluate and apply pharmacological techniques for signaling pathway manipulation</li> <li>■ utilize open source software to analyze digital immunofluorescence image data</li> <li>■ statistically evaluate data for significance.</li> <li>■ plan and conduct experiments in teams, respect competencies of others and contribute their own skills constructively.</li> </ul>
Examination achievement
none
Course achievement
<ul style="list-style-type: none"> <li>■ at least 80% active participation practical classes.</li> <li>■ preparation of scientific standard lab reports of laboratory projects</li> </ul>
Literature
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"> <li>■ Sanes et al., Development of the Nervous System (2012, 3rd. Ed. chapt. 1-7)</li> <li>■ Price et. al. Building Brains (2011, chapt. 1-12)</li> <li>■ Kandel et al. Principles of Neural Sciences (2012, 5th Ed. Part VIII)</li> </ul>
Compulsory requirement
s. Modulebene
Teaching method
Instructions for practical work by faculty. Students perform experiments independently in teams of two or small groups with support by teaching staff.

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Establishing the Nervous System	
Event type	Number
seminar	09LE03S-WM-07_0003
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	1.5
Hours of week	1.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	12 Stunden
Independent study	33 Stunden
Workload	45 Stunden

<b>Content</b>
Each student presents a primary research scientific publication from the field of developmental neurosciences. The research paper will be discussed in the plenum by all participants of the seminar.
<b>Qualification</b>
The students are able to: <ul style="list-style-type: none"> <li>■ recognize the important findings in a research publication and present them in a meaningful way using PowerPoint slides</li> <li>■ critically evaluate the techniques, analysis methods and conclusions of a research publication</li> <li>■ relate the findings of a primary research publication to the scientific context in this closer field of research</li> <li>■ prepare and present a well structured scientific presentation.</li> </ul>
<b>Examination achievement</b>
none
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>■ at least 80% active participation in seminar classes.</li> <li>■ preparation and presentation of a scientific seminar reporting a primary research publication from the field of developmental neurosciences.</li> </ul>
<b>Literature</b>
The following literature is recommended for independent preparation and follow-up of the course contents: <ul style="list-style-type: none"> <li>■ Sanes et al., Development of the Nervous System (2012, 3rd. Ed. chapt.1-7)</li> <li>■ Price et. al. Building Brains (2011, chapt.1-12)</li> <li>■ Kandel et al. Principles of Neural Sciences (2012, 5th Ed. Part VIII)</li> </ul>
<b>Compulsory requirement</b>
s. Modulebene

Teaching method
Discussion of the independently prepared seminar presentation before and after the seminar with the supervising faculty member Students will be guided to contribute actively to the critical discussion of the publication in the plenum.

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Neural circuits guiding behavior in <i>Drosophila</i>	
Event type	Number
lecture course	09LE03V-WM-13_0001
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	2.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	
Language	english
Attendance	30 Stunden
Independent study	30 Stunden
Workload	60 Stunden

<b>Content</b>
<p>The lecture covers the basic neuronal mechanisms underlying vision, visually guided behavior, and variable hot topics in current fly-research. There is a focus on the question how flies use sensory information to guide their behavior. State-of-the-art genetic methods for functional neuroanatomy and neuro-/optogenetics for the functional dissection of the nervous system are presented.</p> <ul style="list-style-type: none"> <li>■ Vision in <i>Drosophila</i> (including a comparison with vertebrate vision)</li> <li>■ Neuroanatomy of the sensory systems</li> <li>■ Neural mechanisms underlying visually guided and other responses in flies</li> <li>■ Tools for the genetic interference with neuronal function: Optogenetics, thermogenetics and other important neurogenetic approaches.</li> <li>■ Genetic tools for functional neuroanatomy</li> <li>■ Design of experiments for the establishment of a causal relationship between identified neurons, neuronal processing and behavior</li> <li>■ Quantitative analysis of behavior in wild type and mutant animals</li> <li>■ Statistics and data analysis</li> </ul> <p>All sections will be presented and discussed at a 'medium-to-advanced level'.</p>
<b>Qualification</b>
<p>The students can</p> <ul style="list-style-type: none"> <li>■ describe the basic concepts of how sensory information is transduced and integrated in a neuronal network</li> <li>■ explain the basic neuronal mechanisms underlying olfaction and vision in vertebrates, flies and worms.</li> <li>■ explain the basic encoding of visual and other sensory information by the nervous system and know how this information is used to guide behavior in flies.</li> <li>■ use genetic techniques for the identification of the function of genes and proteins in neurons.</li> <li>■ design neurogenetic experiments in the introduced systems to disclose basic rules of information processing in neural networks.</li> <li>■ design complex behavioral experiments and use appropriate equipment and technology.</li> </ul>

<ul style="list-style-type: none"> <li>■ make use of the great potential of recent opto- and neurogenetic tools for the functional dissection of the brain.</li> <li>■ explain the basic functional properties and working principle of the most prominent neuro- and optogenetic actuators of neural activity.</li> </ul>
Examination achievement
none
Course achievement
none
Literature
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"> <li>■ Principles of Neural Science (4th ed. Kandel, Schwartz, Jessel), Chapter 1-3 (Brain, Nerve Cells, Genes &amp; Behavior), Chapter 26-29 (Vision), Chapter 32 (Smell &amp; Taste) and other chapters.</li> <li>■ Further Literature will be provided during the course.</li> </ul>
Compulsory requirement
s. Modulebene
Teaching method
<ul style="list-style-type: none"> <li>■ Power-Point presentations</li> <li>■ Comprehensive video material</li> <li>■ Interactive Black Board</li> <li>■ Hand-Outs</li> <li>■ Open discussion rounds</li> <li>■ 'Flipped classroom'</li> </ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Quantitative behavior and functional dissection of neural circuitries in Drosophila	
Event type	Number
exercise course	09LE03Ü-WM-13_0002
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	6.0
Hours of week	5.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	75 Stunden
Independent study	105 Stunden
Workload	180 Stunden

<b>Content</b>
<p>Based on the facts and theory covered by the lecture this course provides students with the opportunity to perform hands-on behavioral experiments guided by expert-instructors. Flies are used as genetically amenable model organisms to establish causal relationships between identified neurons and behavior as described above.</p> <ul style="list-style-type: none"> <li>■ Optogenetic actuators like Channelrhodopsin are used to dissect sensory information processing, motor control and behavior in flies. State-of-the-art experimental techniques and equipment are used to control the activity of genetically targeted neurons by light in behaving animals.</li> <li>■ Combined genetic and functional anatomical studies are performed to disclose underlying neurons and circuitries. Mutant animals may be analyzed to demonstrate that certain genes and proteins are required for animal behavior. The students will learn to use information on functional neuronal anatomy to design their experiments.</li> <li>■ Drosophila and a selection of neuro-/optogenetic tools are used to investigate information processing and the neuronal control of behavior. Populations of genetically identified neurons are activated / inactivated by heat, light, or using other techniques. In parallel movement of the fly is monitored and on-line technology is used to analyze the recorded data.</li> <li>■ Discussion of theory and experiment.</li> <li>■ Theory meets practical use of neuro-/optogenetic tools in behaving animals.</li> <li>■ Hands-on experience and insights into the daily life in the lab (experimental neurobiology &amp; behavior).</li> </ul>
<b>Qualification</b>
<p>The students</p> <ul style="list-style-type: none"> <li>■ can explain the basic concepts of how the nervous system controls behavior</li> <li>■ can use or develop neurogenetic strategies for experimental investigation.</li> <li>■ are able to design and perform combined neuro- /optogenetic and behavioral experiments in flies.</li> <li>■ are able to quantify and statistically analyze experimental data and to design appropriate control experiments.</li> <li>■ are capable of discussing complex problems, of developing goal-oriented strategies and of solving problems in teams.</li> </ul>

■ can plan and conduct experiments in teams, respect competencies of others and contribute their own skills constructively.
Examination achievement
none
Course achievement
<ul style="list-style-type: none"> <li>■ Active participation on all days.</li> <li>■ Students are obligated to present (ppt) their experiments and results.</li> <li>■ Diligent record keeping (lab-book).</li> <li>■ Writing of a report), assessed by course instructor.</li> </ul>
Literature
Literature will be provided about two weeks prior the official beginning of the module.
Compulsory requirement
s. Modulebene
Teaching method
<ul style="list-style-type: none"> <li>■ Hands on, this is a practical course!</li> <li>■ Small teams of 2-3 students will be assisted by expert course instructors . Close interactions between students, teams, and instructors characterize this course.</li> <li>■ Black board and round-table discussions are used to debate questions, ideas, problems and results.</li> <li>■ Power-Point presentations will be used if inevitable.</li> </ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Neural circuits and behavior	
Event type	Number
seminar	09LE03S-WM-13_0003
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	1.0
Hours of week	0.5
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	7,5 Stunden
Independent study	22,5 Stunden
Workload	30 Stunden

<b>Content</b>
Each student will prepare and present a research article on behavioral neuroscience to the members of the course and instructors (in English, using Power-Point or comparable). Science and style of presentation will be discussed by the whole team.
<b>Qualification</b>
<p>The students can:</p> <ul style="list-style-type: none"> <li>■ analyze a research article written in English.</li> <li>■ compile its content and present it in English to a small audience using PowerPoint.</li> <li>■ perform a critical evaluation of published work and demonstrate that published articles and information are not sacrosanct.</li> <li>■ discuss a scientific article and answer questions in front of an audience.</li> </ul>
<b>Examination achievement</b>
none
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>■ Each student will present (ppt) a recent research article in English.</li> <li>■ Active participation in all seminar sessions</li> </ul>
<b>Literature</b>
Students can choose articles or articles will be provided.
<b>Compulsory requirement</b>
s. Modulebene

Teaching method
<ul style="list-style-type: none"><li>■ PowerPoint presentations including videos</li><li>■ Handouts and original research publications</li><li>■ Discussion of data and style of presentation</li></ul>



Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Optogenetics for Neuroscience	
Event type	Number
lecture course	09LE03V-WM-31_0001
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	1.0
Hours of week	1.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	
Language	english
Attendance	15 Stunden
Independent study	15 Stunden

<b>Content</b>
<p>The lecture covers optogenetic aspects of neuroscience. Specifically, the following topics are addressed</p> <ul style="list-style-type: none"> <li>■ translation, transcription, genetic constructs</li> <li>■ Cloning strategies</li> <li>■ Delivery of opsins</li> <li>■ Cell type specificity and circuit targeting</li> <li>■ Combined optogenetic stimulation, neural recordings and behavior</li> <li>■ Putative clinical applications</li> <li>■ Calcium imaging via Two-Photon microscopy</li> <li>■ Opsin variants and Opsin development</li> <li>■ Non-opsin tools</li> <li>■ Two photon imaging combined with optogenetic stimulation</li> <li>■ optogenetic applications</li> </ul>
<b>Qualification</b>
<p>The students</p> <ul style="list-style-type: none"> <li>■ can understand and summarize the contents of the lectures and answer detailed questions regarding these</li> <li>■ can use this acquired knowledge and insights to read, understand and critically discuss scientific publications in the neurosciences</li> </ul>
<b>Examination achievement</b>
none
<b>Course achievement</b>
none
<b>Literature</b>
The following literature is recommended for independent preparation and follow-up of the course contents:

- Optogenetics: A Roadmap. Springer Protocols, Springer. Volume 133, ISBN 978-1-4939-7415-3
- Course script, primary literature and academic reviews as provided at the beginning of the course

#### Compulsory requirement

s. Modulebene

#### Teaching method

The course will be taught in the form of

- Interactive presentations

The following media will be used:

- PowerPoint presentations

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Optophysiology	
Event type	Number
exercise course	09LE03Ü-WM-31_0002
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	8.0
Hours of week	8.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	120 Stunden
Independent study	120 Stunden

<b>Content</b>
<p>The course covers cloning and histological aspects as well as electrophysiological and optogenetic aspects of neuroscience. Neuronal activity is assed in cell cultures of cortical neurons to teach 2-Photon Calcium imaging and analyzing the activity and properties of individual neurons and networks. Extracellular recordings with optogenetic stimulations are provided from adult rats, which will be analyzed. Histology is performed on brain slices from adult rats. The course is an intense exercise using advanced techniques of neurophysiological and optogenetic research, emphasizing independent use of high-tech equipment and critical analysis and interpretation of own research data.</p> <p>Specifically, participants will perform</p> <ul style="list-style-type: none"> <li>■ Molecular cloning (restriction enzyme cloning and Gibson assembly)</li> <li>■ Transient transfection of mammalian cells in culture</li> <li>■ Histology</li> <li>■ Calcium imaging via Two-Photon microscopy</li> <li>■ Measure fundamental properties of neurons and networks,</li> <li>■ Conduct antibody staining and fluorescence microscopy to assess opsin expression,</li> <li>■ Visualize activity dynamics in neuronal cultures,</li> <li>■ Analyses of the recorded neural data.</li> </ul> <p>The results obtained will be presented in the style of a conference workshop among the participants</p>
<b>Qualification</b>
<p>The students</p> <ul style="list-style-type: none"> <li>■ understand the basics behind molecular cloning, are aware of the various cloning techniques available to them and are able to perform restriction based cloning and Gibson assembly</li> <li>■ are able to prepare and document immunocytochemical stains of brain slices</li> <li>■ can name neuronal subtypes in the cortex, cortical layers, fiber tracts and their connectivity and explain their functions, respectively</li> <li>■ can record and analyze electrical activity in individual neurons and networks with tools used in current research</li> </ul>

<ul style="list-style-type: none"> <li>■ are able to assess the electrophysiological properties of individual neurons, synaptic properties and network dynamics with the corresponding experimental paradigms and techniques</li> <li>■ can stimulate neurons and neural tissue for different paradigms</li> <li>■ are able to present in speech and writing the concepts, implementations and interpretation of electrophysiological experiments in scientific style using own data</li> <li>■ are able to critically assess electrophysiological experiments</li> <li>■ are able to connect neurobiological concepts and signal with methods for their quantitative analysis.</li> <li>■ can modify algorithms in a standard scripting language to analyze neural data</li> </ul> <p>can use this acquired knowledge, insights and skills to read, understand and critically discuss scientific publications in the experimental neurosciences</p>
<b>Examination achievement</b>
none
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>■ Preparation for the practical parts using the course script</li> <li>■ Active participation in the practical parts incl. written lab reports</li> <li>■ Active participation in the interactive colloquia and seminar presentations</li> <li>■ Active participation in all course days (100%)</li> </ul>
<b>Literature</b>
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"> <li>■ Optogenetics: A Roadmap. Springer Protocols, Springer. Volume 133, ISBN 978-1-4939-7415-3</li> <li>■ Course script, primary literature and academic reviews as provided at the beginning of the course</li> </ul>
<b>Compulsory requirement</b>
s. Modulebene
<b>Teaching method</b>
<p>The course will be taught in the form of</p> <ul style="list-style-type: none"> <li>■ Interactive presentations</li> <li>■ Individual work on imaging and histological setups</li> <li>■ individual work on molecular cloning and transient transfection</li> <li>■ group work</li> <li>■ lab visits to research laboratories</li> <li>■ tutoring during practical sessions and data analysis</li> <li>■ seminar presentations</li> <li>■ colloquia</li> </ul> <p>The following media will be used:</p> <ul style="list-style-type: none"> <li>■ scripts for practical sessions</li> <li>■ electrophysiological research equipment</li> <li>■ lab equipment for histology</li> <li>■ PowerPoint presentations</li> <li>■ several software toolboxes for data analysis and visualization</li> <li>■ data from neurophysiological recordings</li> </ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Neuroprothetik / Neuroprosthetics - Seminar	
Event type	Number
seminar	04LE50V-5318
<b>Faculty</b>	
Technische Fakultät Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	3.0
Recommended semester	4
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	39 hours
Independent study	51 hours
Workload	90 hours

<b>Content</b>
<p>Introductory lessons contain:</p> <ul style="list-style-type: none"> <li>■ Basic concepts of neuroscience</li> <li>■ Interfacing the nervous system</li> <li>■ Modelling approaches for CNS applications</li> <li>■ Neuroethical aspects</li> </ul> <p>Student covered topics will contain:</p> <ul style="list-style-type: none"> <li>■ Cochlea Implant - Deafness</li> <li>■ Retina Implant - Blindness</li> <li>■ Deep Brain Stimulation - Parkinson's Disease</li> <li>■ Spinal Cord Stimulation - Chronic Pain Syndrome</li> <li>■ Vagal Nerve Stimulation - Epilepsy</li> <li>■ Functional Electrical Stimulation - Drop Foot Syndrome</li> <li>■ Human Machine Interfacing - BCI and BMI</li> <li>■ Foreign Body Reaction</li> </ul>
<b>Examination achievement</b>
Written documentation and oral presentation. The module grade is based on the written documentation (50%) and the oral presentation (50%).
<b>Course achievement</b>
None
<b>Literature</b>
<ul style="list-style-type: none"> <li>■ Farina, D., Jensen, W., Akay, M., Eds. (2013). INTRODUCTION TO NEURAL ENGINEERING FOR MOTOR REHABILITATION, IEEE</li> </ul>

- Dagnelie, G., Ed. (2011). Visual Prosthetics: Physiology, Bioengineering, Rehabilitation: Physiology, Bioengineering and Rehabilitation, Springer
- DiLorenzo, D. J. and J. D. Bronzino, Eds. (2008). Neuroengineering Boca Raton, CRC Press
- Akay, M. (2007). Handbook of Neural Engineering, IEEE Press, Wiley
- Dornhege, G., et al., Eds. (2007). Toward Brain-Computer Interfacing. Neural Information Processing Series. Cambridge, MA, MIT Press
- Horch, K. W. and G. S. Dhillon (2004). Neuroprosthetics - Theory and Practice. Singapore-London, World Scientific Publishing

Compulsory requirement

None

Recommended requirement

High level knowledge in mathematics and natural sciences

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Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Signalverarbeitung und Analyse von Gehirnsignalen / Signal processing and analysis in brain signals - Lecture	
Event type	Number
lecture course	11LE50V-5312
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	26 hours
Independent study	64 hours
Workload	90 hours

Content
<p>The course starts with an introduction to the basic principles of the measurement of neurophysiological signals mainly EEG and MEG. Despite a basic technical introduction of the measurement systems an overview about physiological and pathological patterns and rhythms in brain signal is given. Pattern recognition in the diagnostics of patients suffering from epilepsy is one core topic of the module. Long term recordings of EEG in epilepsy diagnostic create a high demand for automatic EEG analysis procedures. Three different types of events are at the moment in the focus for automatic detection strategies.</p> <p>a) Epileptic seizures, which are the core syndrome of the disease. Automatic detection may facilitate the review of long term recordings tremendously.</p> <p>b) Short high amplitude peaks in EEG and MEG called spikes contribute to the diagnoses of epilepsy and give information related to the localization of the seizure onset region in focal epilepsy.</p> <p>c) Oscillatory activity in the frequency range between 80 Hz and 600 Hz gives according to recent result probably more specific information about the seizure origin area than spikes.</p> <p>Signal processing and pattern recognition strategies are presented and how they can be applied to the patterns of interest in epilepsy diagnostic.</p> <p>In detail following strategies will be presented:</p> <p>a) Heuristics</p> <p>b) Template matching</p> <p>c) Wavelet transformation</p> <p>d) Hilbert transformation</p> <p>e) Background and target modelling</p> <p>f) Artificial neural networks</p>

A second focus of the module is related to the localization of generators of neuronal activity based on EEG and MEG measurements.

The introduction starts with the presentation of the Maxwell equations and the common simplifications as they are applied in EEG and MEG source localization. Localization includes two basic components, the forward simulation and an inverse parameter estimation procedure. Concepts of the following forward models representing the physical properties of the head are presented:

- a) Spherical model
- b) Boundary element model
- c) Finite element model

Main types of focal and distributed inverse models will form the contents of the inverse part of the source localization procedure.

Exemplary application examples will show the complete processing chain from measurements and image acquisition to localization results.

#### Examination achievement

Oral exam (30 minutes)

#### Course achievement

None

#### Compulsory requirement

None

#### Recommended requirement

None

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neural Circuits and Behavior)	09LE03MO-NE-1-2021
<b>course</b>	
Working in Science	
Event type	Number
seminar	09LE03S-NE-5-T12
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	22 h
Independent study	68 h
Workload	90 h

<b>Content</b>
<p>The seminar discusses the foundations, methods, current practices and implications of science. Among the topics are</p> <ul style="list-style-type: none"> <li>■ Falsification, Karl Popper</li> <li>■ Research paradigms, Thomas Kuhn; research programs, Imre Lakatos</li> <li>■ Anything goes!, Paul Feyerabend</li> <li>■ New experimentalism, Deborah Mayo</li> <li>■ Pseudoscience and the demarcation problem</li> <li>■ Scientific publishing</li> <li>■ Science communication</li> <li>■ Science and its influence on politics</li> <li>■ Scientific misconduct</li> <li>■ The future of neuroscience</li> </ul> <p>Further topics related to the overall topic of the seminar can be added, and/or topics can be modified based on the interests of the students taking part in this seminar. This will be decided during the first seminar session.</p>
<b>Qualification</b>
<p>The students acquire the competence to</p> <ul style="list-style-type: none"> <li>■ summarize and critically reflect on the foundations, methods, current practices and implications of science</li> <li>■ draw a broader framework of science and connect it to their own area of specialisation.</li> </ul>
<b>Examination achievement</b>
None

Course achievement
<ul style="list-style-type: none"><li>■ Oral presentation of a seminar topic</li><li>■ Active participation in the seminar</li></ul>
Compulsory requirement

↑

## **Detailed Module Descriptions**

### **Focus Area 2: Computational Neuroscience**

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Models of Neurons and Networks	
Event type	Number
exercise course	09LE03Ü-NE-2-T1.1
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	6.0
Hours of week	6.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	84 h
Independent study	96 h
Workload	180 h

<b>Content</b>
<p>Building on prior knowledge in neurobiology and quantitative methods acquired during the entry level modules, the lecture series "Models of Neurons and Networks" covers important concepts and tools in computational neuroscience. This includes mathematical foundations</p> <ul style="list-style-type: none"> <li>■ Mathematical concepts and methods:</li> <li>■ Basic probability and statistics</li> <li>■ Linear and nonlinear dynamical systems</li> <li>■ Phase plane methods</li> <li>■ Continuous stochastic processes and point processes</li> <li>■ Graphs and networks, random graphs</li> </ul> <p>as well as specific models of biological neurons and networks</p> <ul style="list-style-type: none"> <li>■ Mathematical concepts and methods:</li> <li>■ Hodgkin-Huxley theory of the action potential</li> <li>■ Stochastic theory of ionic channels</li> <li>■ Synaptic integration and spike generation</li> <li>■ Correlations in recurrent networks and populations</li> <li>■ Dynamics of spiking networks and population dynamics</li> <li>■ Primary visual cortex and processing of visual information</li> <li>■ Models of plasticity, growth and maturation</li> </ul>
<b>Qualification</b>
<p>The interactive course is comprised of classical lectures (PDF slides) and interactive formats (black-board/whiteboard). Weekly homework assignments are designed to encourage independent work. In all parts active participation by the students is essential.</p> <p>The students acquire the competence to</p> <ul style="list-style-type: none"> <li>■ link biological phenomena arising in network neuroscience with mathematical models using theory,</li> <li>■ computer simulations and advanced model-based data analysis;</li> </ul>



<ul style="list-style-type: none"> <li>■ understand the fundamental tradeoff between biological detail and mathematical abstraction and evaluate its consequences;</li> <li>■ explain the steps necessary to develop and validate models of a biological neuron, or a biological neuronal network, or a more abstract model of behavior;</li> <li>■ appreciate and explain the gain in understanding biological mechanisms arising from the study of mathematical models of neuronal systems;</li> <li>■ critically discuss the limits of mathematical modeling, numerical methods and statistics in computational neuroscience.</li> </ul>
<b>Examination achievement</b>
Written exam (70 minutes duration)
<b>Course achievement</b>
Sufficient participation in the weekly homework assignments (50% of the total achievable score)
<b>Compulsory requirement</b>
None
<b>Recommended requirement</b>
Basic knowledge in the biological foundations of and quantitative methods in neuroscience. Working knowledge in numerical simulation techniques, e.g. elective course "Simulation of Biological Neuronal Networks".
<b>Teaching method</b>
Interactive lecture, plenary discussion triggered by the lecturer, joint discussion of simple examples at the blackboard triggered by students.

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Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Biological Learning, Control and Decision Making	
Event type	Number
exercise course	09LE03Ü-NE-2-T1.2
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	6.0
Hours of week	6.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	60 h
Independent study	120 h
Workload	180 h

<b>Content</b>
<p>Building on prior knowledge in neurobiology and mathematical methods acquired during the modules in the first semester, this course covers the computational neuroscience of biological learning, control and decision making. Topics include:</p> <ul style="list-style-type: none"> <li>■ Biological movement control</li> <li>■ Sensorimotor learning and motor adaptation</li> <li>■ Reinforcement learning in neuroscience</li> <li>■ Bayesian models in action and perception</li> </ul> <p>The course consists of interactive lectures and exercises. Supervision will be provided for the exercises and the solutions to the exercises will be discussed in the course.</p>
<b>Qualification</b>
<p>The students acquire the competence to</p> <ul style="list-style-type: none"> <li>■ summarize models of biological learning, control and decision making</li> <li>■ link mathematical models with biological phenomena arising in systems neuroscience, using theory and computer simulations</li> <li>■ understand the fundamental tradeoff between biological detail and mathematical abstraction and evaluate its consequences</li> <li>■ explain the steps necessary to develop and validate models of behaviour their underlying neural mechanisms</li> <li>■ explain the gain in understanding biological mechanisms arising from the study of mathematical models and critically discuss the limits of mathematical modeling</li> </ul>
<b>Examination achievement</b>
Written exam (70 minutes duration)

Course achievement
None
Compulsory requirement
None
Recommended requirement
Basic knowledge in the biological foundations of and quantitative methods in neuroscience.
Teaching method
Lecture, supervised exercises, discussion

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
The Neural Code: Quantitative Analysis of Neural Activity	
Event type	Number
exercise course	09LE03Ü-NE-2-T1.3
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	6.0
Hours of week	5.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	75 h
Independent study	105 h
Workload	180 h

<b>Content</b>
<ul style="list-style-type: none"> <li>■ Spike trains as point processes (PSTHs, Poisson Processes, Renewal Processes, Correlations)</li> <li>■ Tuning curves and likelihoods, probabilistic decoding, Cramer Rao bound and Fisher Information</li> <li>■ Model identification (Reverse Correlation and Spike triggered Averages, Generalized Linear Models)</li> <li>■ Learning and Regression</li> <li>■ Perceptrons and patterns</li> <li>■ Support Vector Machines and kernel trick</li> <li>■ Information (binary patterns, Gaussian Channel and applications)</li> <li>■ Dimensionality Reduction (PCA, SVD, ICA, NMF, Isomap, t-SNE)</li> </ul>
<b>Qualification</b>
<p>Lecture:</p> <p>The students can</p> <ul style="list-style-type: none"> <li>■ answer detailed questions about the lecture contents</li> <li>■ explain the mathematical foundations of the introduced analysis concepts</li> <li>■ apply the analysis concepts to standard neuroscience problems</li> <li>■ generalize the presented methods to new problem variants</li> <li>■ explain the limitations of the presented analysis methods</li> </ul> <p>Exercise class:</p> <p>The students can</p> <ul style="list-style-type: none"> <li>■ implement the analysis concepts from the lecture in python.</li> <li>■ reproduce mathematical derivations and proofs shown in the lecture</li> <li>■ apply the analysis concepts to small data sets</li> </ul>
<b>Examination achievement</b>
Written exam (70 minutes duration)

<b>Course achievement</b>
<p>Lecture:</p> <ul style="list-style-type: none"> <li>■ Attendance of the lecture is voluntary, but highly recommended.</li> </ul> <p>Exercise class:</p> <ul style="list-style-type: none"> <li>■ Regular participation in exercises (no absence permitted)</li> <li>■ Independent self-studies during waiting times in the exercises</li> <li>■ Successful completion of exercises</li> </ul>
<b>Literature</b>
<ul style="list-style-type: none"> <li>■ Spikes; Bialek, de Ruyter van Steveninck, Rieke, Garland</li> <li>■ Introduction to Theoretical Neurobiology I; Tuckwell</li> <li>■ Information Theory, Inference and Learning Algorithms; McKay</li> <li>■ Advanced Data Analysis in Neuroscience: Integrating Statistical and Computational Models; Durstewitz</li> <li>■ Pattern Recognition &amp; Machine Learning; Bishop</li> </ul>
<b>Compulsory requirement</b>
None
<b>Recommended requirement</b>
Quantitative Methods, undergraduate degree in Computer Science, Mathematics, Physics, or related
<b>Teaching method</b>
<p>Lecture:</p> <ul style="list-style-type: none"> <li>■ Presentation of lecture notes</li> </ul> <p>Exercise class:</p> <ul style="list-style-type: none"> <li>■ Discussion of homework in tutorials</li> <li>■ Homework problems require both programming (Python) and mathematical analysis</li> </ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Maschinelles Lernen / Machine Learning - Lecture	
Event type	Number
lecture course	11LE13V-1153
<b>Organizer</b>	
Institut für Informatik, Professur für Maschinelles Lernen	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	6.0
Hours of week	3.0
Recommended semester	2
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	45
Independent study	120
Workload	180 Stunden

<b>Content</b>
Characterization of supervised, unsupervised and reinforcement learning, concept learning, decision trees, neural networks, probabilistic methods, committee techniques, reinforcement learning.
<b>Learning target</b>
<p>This course provides you with a good theoretical understanding and practical experience about the basic concepts of machine learning. You shall be enabled to implement a number of basic algorithms, understand advantages and drawbacks of single methods and know typical application domains thereof. Furthermore, you should be able to use (Python) software libraries in order to work on novel data analysis problems.</p> <p>The course will prepare you to dive deeper into advanced methods of ML, e.g. deep learning, recurrent networks, reinforcement learning, hyperparameter optimization, and into specific application domains such as image analysis, brain signal analysis, robot learning, bioinformatics etc., for which specialized courses are available.</p>
<b>Examination achievement</b>
Oral examination with a duration of 35 minutes
<b>Course achievement</b>
see exercise
<b>Literature</b>
<p>Duda, Hart and Stork: Pattern Classification          Christopher Bishop: Pattern Recognition and Machine Learning          Hastie, Tibshirani and Friedman: The Elements of Statistical Learning</p>

Mitchell: Machine Learning  
 Murphy: Machine Learning – a Probabilistic Perspective  
 Criminisi et. al: Decision Forests for Computer Vision and Medical Image Analysis  
 Schölkopf & Smola: Learning with Kernels  
 Goodfellow, Bengio and Courville: Deep Learning  
 Michael Nielsen: Neural Networks and Deep Learning

In addition, literature for every section of the course is announced during these sections.

#### Compulsory requirement

keine | none

#### Recommended requirement

We have to rely on a solid background in basic math, specifically linear algebra (an eigenvalue decomposition, matrix operations, covariance matrices etc. should be very familiar concepts), calculus and probability theory.

We use the Python programming language for most of our assignments. If you do not yet have Python experience, you must ramp up at least basic knowledge thereof.

We recommend basic knowledge of optimization and of the scikit-learn Python library.

#### Teaching method

##### For in-class lectures:

Despite the large lecture rooms, a teacher-centered style shall be enriched as much as possible by measures like:

- interactive question and answer rounds
- discussions in sub-groups, reporting to the large group
- cross-teaching
- problem-oriented teaching e.g. via data analysis competition
- repetition of important concepts in slightly altered contexts.

##### For virtual lectures:

- flipped classroom teaching with videos provided
- Q&A sessions to discuss the videos' content
- Cross-teaching via Ilias forum
- problem-oriented teaching e.g. via data analysis competition
- repetition of important concepts in slightly altered contexts.

#### Target group

Advanced BSc., MSc. students and PhD students



Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Maschinelles Lernen / Machine Learning - Exercises	
Event type	Number
exercise course	11LE13Ü-1153
<b>Organizer</b>	
Institut für Informatik, Professur für Maschinelles Lernen	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	.
Hours of week	1.0
Recommended semester	2
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	15

<b>Content</b>
The exercises are intended to give students a better understanding of the most important techniques they learn during lectures. They are expected to implement some selected methods to gain experience in practical applications.
<b>Examination achievement</b>
see Lecture
<b>Course achievement</b>
Passing an oral or written examination.
<b>Compulsory requirement</b>
none
<b>Recommended requirement</b>
none

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Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Simulation of Biological Neuronal Networks	
Event type	Number
exercise course	09LE03Ü-NE-2-T2
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	3.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	45 h
Independent study	45 h
Workload	90 h

<b>Content</b>
This course covers the fundamentals of simulating networks of single-compartment spiking neuron models. We start from the concept of a point neuron and then introduce more complex topics such as phenomenological models of synaptic plasticity, connectivity patterns and network dynamics.
<b>Qualification</b>
<p>The course is based on introductory lectures using slides (provided for download) and whiteboard in the computer pool. The task is to individually implement NEST programs, starting with simple tasks and later executing small project. The intense interaction with tutors enhances the learning experience.</p> <p>The students acquire the competence to</p> <ul style="list-style-type: none"> <li>■ link mathematical models with biological phenomena arising in systems neuroscience, both using theory and computer simulations;</li> <li>■ implement and simulate simple neuronal network models using modern tools and methods of scientific programming (based on Python and NEST);</li> <li>■ implement simple programs for data analysis and apply them to simulated data;</li> <li>■ appreciate and explain the gain in understanding biological mechanisms arising from the study of mathematical models of neuronal systems and their simulation on a computer;</li> <li>■ critically discuss the limits of mathematical modeling and numerical methods in computational neuroscience.</li> </ul>
<b>Examination achievement</b>
None
<b>Course achievement</b>
Regular attendance, active participation and self-guided study; successful completion (50% correct) of all assignments and/or projects.

Literature
See <a href="http://www.nest-initiative.org/">http://www.nest-initiative.org/</a> for some general information and an online tutorial on the BNN simulator NEST.
Compulsory requirement
None
Recommended requirement
Basic knowledge in the biological foundations of and quantitative methods in neuroscience
Teaching method
Practical exercises in devising, executing and analyzing numerical simulations of neuronal networks. Introductory lectures to cover the neuroscience background.

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Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Current Topics in Computational Neuroscience	
Event type	Number
course	09LE03S-NE-2-T11
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	15 h
Independent study	75 h
Workload	90 h

<b>Content</b>
<p>In this seminar, current topics in computational neuroscience will be presented and discussed. While the final list of seminar topics is updated each semester and selected before the organization meeting, the following list comprises some topics that have been part of this seminar previously:</p> <ul style="list-style-type: none"> <li>■ Dynamics of spiking neuronal networks</li> <li>■ Models of sensory networks, sensory processing and perception</li> <li>■ Functional and structural plasticity of neurons and networks</li> <li>■ Models of learning and memory</li> <li>■ Models of sleep and memory consolidation</li> <li>■ Models of brain dysfunction and brain diseases</li> <li>■ Models of movement control</li> <li>■ Models of decision making</li> <li>■ Biophysics of single neurons and networks</li> </ul>
<b>Qualification</b>
<p>The students</p> <ul style="list-style-type: none"> <li>■ have advanced knowledge about several recent research findings in the field of computational neuroscience</li> <li>■ have the competence to extract the important findings from a research publication and present them in a meaningful and well-structured scientific presentation in English</li> <li>■ have the competence to give an oral presentation about an advanced research topic from the field of computational neuroscience.</li> </ul>
<b>Examination achievement</b>
None

Course achievement
Active participation in the seminar (including the initial organization meeting). Oral presentation of one of the seminar topics.
Compulsory requirement
Recommended requirement
Participation in all lectures of the focus area Computational Neuroscience
Teaching method
Oral presentation by the student; individual instruction how to present an advanced seminar topic, including feedback after the presentation; guidance how to lead a scientific discussion in front of the group; numerical reproduction of essential research findings

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Neuroprothetik / Neuroprosthetics - Seminar	
Event type	Number
seminar	04LE50V-5318
<b>Faculty</b>	
Technische Fakultät Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	3.0
Recommended semester	4
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	39 hours
Independent study	51 hours
Workload	90 hours

<b>Content</b>
<p>Introductory lessons contain:</p> <ul style="list-style-type: none"> <li>■ Basic concepts of neuroscience</li> <li>■ Interfacing the nervous system</li> <li>■ Modelling approaches for CNS applications</li> <li>■ Neuroethical aspects</li> </ul> <p>Student covered topics will contain:</p> <ul style="list-style-type: none"> <li>■ Cochlea Implant - Deafness</li> <li>■ Retina Implant - Blindness</li> <li>■ Deep Brain Stimulation - Parkinson's Disease</li> <li>■ Spinal Cord Stimulation - Chronic Pain Syndrome</li> <li>■ Vagal Nerve Stimulation - Epilepsy</li> <li>■ Functional Electrical Stimulation - Drop Foot Syndrome</li> <li>■ Human Machine Interfacing - BCI and BMI</li> <li>■ Foreign Body Reaction</li> </ul>
<b>Examination achievement</b>
Written documentation and oral presentation. The module grade is based on the written documentation (50%) and the oral presentation (50%).
<b>Course achievement</b>
None
<b>Literature</b>
<ul style="list-style-type: none"> <li>■ Farina, D., Jensen, W., Akay, M., Eds. (2013). INTRODUCTION TO NEURAL ENGINEERING FOR MOTOR REHABILITATION, IEEE</li> </ul>

- Dagnelie, G., Ed. (2011). Visual Prosthetics: Physiology, Bioengineering, Rehabilitation: Physiology, Bioengineering and Rehabilitation, Springer
- DiLorenzo, D. J. and J. D. Bronzino, Eds. (2008). Neuroengineering Boca Raton, CRC Press
- Akay, M. (2007). Handbook of Neural Engineering, IEEE Press, Wiley
- Dornhege, G., et al., Eds. (2007). Toward Brain-Computer Interfacing. Neural Information Processing Series. Cambridge, MA, MIT Press
- Horch, K. W. and G. S. Dhillon (2004). Neuroprosthetics - Theory and Practice. Singapore-London, World Scientific Publishing

Compulsory requirement

None

Recommended requirement

High level knowledge in mathematics and natural sciences

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Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Numerical Optimal Control in Science and Engineering	
Event type	Number
lecture course	11LE50V-5249
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Systemtheorie, Regelungstechnik und Optimierung	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	6.0
Hours of week	6.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	78 hours
Independent study	102 hours
Workload	180 hours

<b>Content</b>
<ul style="list-style-type: none"> <li>■ Introduction: Dynamic Systems and Optimization</li> <li>■ Rehearsal of Numerical Optimization</li> <li>■ Rehearsal of Parameter Estimation</li> <li>■ Discrete Time Optimal Control</li> <li>■ Dynamic Programming</li> <li>■ Continuous Time Optimal Control</li> <li>■ Numerical Simulation Methods</li> <li>■ Hamilton-Jacobi-Bellmann Equation</li> <li>■ Pontryagin and the Indirect Approach</li> <li>■ Direct Optimal Control</li> <li>■ Differential Algebraic Equations</li> <li>■ Periodic Optimal Control</li> <li>■ Real-Time Optimization for Model Predictive Control</li> </ul>
<b>Examination achievement</b>
Written exam (180 minutes)
<b>Course achievement</b>
see exercise
<b>Literature</b>
<ol style="list-style-type: none"> <li>1. Manuscript "Numerical Optimal Control" by M. Diehl and S. Gros</li> <li>2. Biegler, L.T., Nonlinear Programming, SIAM, 2010</li> </ol>

Compulsory requirement
None
Recommended requirement
Mathematics 1 and 2 for Engineers or basic Linear Algebra and Calculus courses. Numerical Optimization (NUMOPT), Modelling and System Identification (MSI), Systems and Control Bachelor or Master lectures.

↑



Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Numerical Optimal Control in Science and Engineering	
Event type	Number
exercise course	11LE50Ü-5249
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Systemtheorie, Regelungstechnik und Optimierung	
<b>Faculty</b>	
Mathematisches Institut-VB Technische Fakultät	

ECTS-Points	.
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english

<b>Content</b>
Theoretical and computer exercises accompany the lecture to deepen the understanding
<b>Examination achievement</b>
<b>Course achievement</b>
Successful participation/solution of at least 50% of the weekly exercise sheets
<b>Compulsory requirement</b>
None
<b>Recommended requirement</b>
Mathematics 1 and 2 for Engineers or basic Linear Algebra and Calculus courses. Numerical Optimization (NUMOPT), Modelling and System Identification (MSI), Systems and Control Bachelor or Master lectures.

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Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Signalverarbeitung und Analyse von Gehirnsignalen / Signal processing and analysis in brain signals - Lecture	
Event type	Number
lecture course	11LE50V-5312
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	26 hours
Independent study	64 hours
Workload	90 hours

<b>Content</b>
<p>The course starts with an introduction to the basic principles of the measurement of neurophysiological signals mainly EEG and MEG. Despite a basic technical introduction of the measurement systems an overview about physiological and pathological patterns and rhythms in brain signal is given. Pattern recognition in the diagnostics of patients suffering from epilepsy is one core topic of the module. Long term recordings of EEG in epilepsy diagnostic create a high demand for automatic EEG analysis procedures. Three different types of events are at the moment in the focus for automatic detection strategies.</p> <p>a) Epileptic seizures, which are the core syndrome of the disease. Automatic detection may facilitate the review of long term recordings tremendously.</p> <p>b) Short high amplitude peaks in EEG and MEG called spikes contribute to the diagnoses of epilepsy and give information related to the localization of the seizure onset region in focal epilepsy.</p> <p>c) Oscillatory activity in the frequency range between 80 Hz and 600 Hz gives according to recent result probably more specific information about the seizure origin area than spikes.</p> <p>Signal processing and pattern recognition strategies are presented and how they can be applied to the patterns of interest in epilepsy diagnostic.</p> <p>In detail following strategies will be presented:</p> <p>a) Heuristics</p> <p>b) Template matching</p> <p>c) Wavelet transformation</p> <p>d) Hilbert transformation</p> <p>e) Background and target modelling</p> <p>f) Artificial neural networks</p>

A second focus of the module is related to the localization of generators of neuronal activity based on EEG and MEG measurements.

The introduction starts with the presentation of the Maxwell equations and the common simplifications as they are applied in EEG and MEG source localization. Localization includes two basic components, the forward simulation and an inverse parameter estimation procedure. Concepts of the following forward models representing the physical properties of the head are presented:

- a) Spherical model
- b) Boundary element model
- c) Finite element model

Main types of focal and distributed inverse models will form the contents of the inverse part of the source localization procedure.

Exemplary application examples will show the complete processing chain from measurements and image acquisition to localization results.

#### Examination achievement

Oral exam (30 minutes)

#### Course achievement

None

#### Compulsory requirement

None

#### Recommended requirement

None

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Statistische Mustererkennung / Statistical Pattern Recognition - Lecture	
Event type	Number
lecture course	11LE13V-1114
<b>Organizer</b>	
Institut für Informatik, Mustererkennung u. Bildverarbeitung	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	6.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	28 Stunden
Independent study	126 Stunden
Workload	180 Stunden   hours

<b>Content</b>
The course introduces the basic ideas of recognition and learning and reviews the most important terminology of probabilistic methods. Afterwards the most common techniques for classification, regression, and clustering are presented, among them linear regression, Gaussian processes, logistic regression, support vector machines, non-parametric density estimation, and expectation-maximization. Additionally, the course includes dimensionality reduction methods and inference in graphical m
<b>Examination achievement</b>
Klausur / schriftliche Abschlussprüfung (Dauer im Rahmen der Prüfungsordnungsregelung)   Written examination (duration within the framework of the examination regulations)
<b>Course achievement</b>
Siehe Übung   see exercises
<b>Literature</b>
"Pattern Recognition and Machine Learning" by Christopher Bishop
<b>Compulsory requirement</b>
keine   none
<b>Recommended requirement</b>
Fundamental mathematical knowledge, particularly statistic

<b>Recommendation</b>
Usually the course is offered every summer semester; as there might be rare exceptions in some years, it's marked as "irregularly"



Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Statistische Mustererkennung / Statistical Pattern Recognition - Exercises	
Event type	Number
exercise course	11LE13Ü-1114
<b>Organizer</b>	
Institut für Informatik, Mustererkennung u. Bildverarbeitung	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	.
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	26 Stunden

<b>Content</b>
The exercises consist of theoretical assignments and programming assignments, to apply the methods and concepts from the lecture.
<b>Examination achievement</b>
siehe Vorlesung   see lecture
<b>Course achievement</b>
keine   none
<b>Compulsory requirement</b>

↑

Name of module	Number of module
Elective Subjects (Focus Area: Computational Neuroscience)	09LE03MO-NE-2-2021
<b>course</b>	
Working in Science	
Event type	Number
seminar	09LE03S-NE-5-T12
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	22 h
Independent study	68 h
Workload	90 h

<b>Content</b>
<p>The seminar discusses the foundations, methods, current practices and implications of science. Among the topics are</p> <ul style="list-style-type: none"> <li>■ Falsification, Karl Popper</li> <li>■ Research paradigms, Thomas Kuhn; research programs, Imre Lakatos</li> <li>■ Anything goes!, Paul Feyerabend</li> <li>■ New experimentalism, Deborah Mayo</li> <li>■ Pseudoscience and the demarcation problem</li> <li>■ Scientific publishing</li> <li>■ Science communication</li> <li>■ Science and its influence on politics</li> <li>■ Scientific misconduct</li> <li>■ The future of neuroscience</li> </ul> <p>Further topics related to the overall topic of the seminar can be added, and/or topics can be modified based on the interests of the students taking part in this seminar. This will be decided during the first seminar session.</p>
<b>Qualification</b>
<p>The students acquire the competence to</p> <ul style="list-style-type: none"> <li>■ summarize and critically reflect on the foundations, methods, current practices and implications of science</li> <li>■ draw a broader framework of science and connect it to their own area of specialisation.</li> </ul>
<b>Examination achievement</b>
None

Course achievement
<ul style="list-style-type: none"><li>■ Oral presentation of a seminar topic</li><li>■ Active participation in the seminar</li></ul>
Compulsory requirement

↑



**Detailed Module Descriptions**  
**Focus Area 3: Neurotechnology**

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Biomedizinische Messtechnik I / Biomedical Instrumentation I - Lecture	
Event type	Number
lecture course	11LE50V-5301
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	39 hours
Independent study	51 hours
Workload	90 hours

<b>Content</b>
<p>The course introduces different aspects of the recording of bioelectrical signals starting with the nerve and including amplifier design. It presents the most important medical diagnosis methods in the field of bioelectrical signals. In detail, the following topics will be covered:</p> <ul style="list-style-type: none"> <li>■ Origin of bioelectrical signals</li> <li>■ Electrochemistry of electrodes</li> <li>■ Acute and chronic applications of electrodes</li> <li>■ Recording and amplification of bioelectrical signals</li> <li>■ Interference and artefacts</li> <li>■ Bioelectrical signals of peripheral nerves and the muscle</li> <li>■ Electrical signals of the heart (ECG)</li> <li>■ Cardiac pacemakers and implantable defibrillators</li> <li>■ Technical safety of medical devices</li> </ul> <p>Finally, the content of the course and the learning targets will be summarized together with the students to facilitate the preparation of the examination.</p>
<b>Examination achievement</b>
Oral examination (30 minutes)
<b>Course achievement</b>
See exercise
<b>Literature</b>
Actual copies of the slides will be delivered accompanying to the lectures.

Literature:

**German**

1. Schmidt, Robert F., Lang, Florian, Thews, Gerhard (Hrsg.): Physiologie des Menschen, 29. Auflage. Heidelberg: Springer Medizin Verlag, 2005

**English**

1. Bronzino, Joseph D. (Hrsg.): The Biomedical Engineering Handbook, Volume 1 (and 2), Second Edition. Boca Raton: CRC Press 2000 / Heidelberg: Springer-Verlag, 2000
2. Enderle, John, Blanchard, Susan, Bronzino, Joseph (Hrsg.): Introduction to Biomedical Engineering, Second Edition. Burlington, San Diego, London, Elsevier, 2005

Compulsory requirement

None

Recommended requirement

None

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Biomedizinische Messtechnik I / Biomedical Instrumentation I - Exercises	
Event type	Number
exercise course	11LE50Ü-5301
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Institut für Mikrosystemtechnik	

ECTS-Points	.
Hours of week	1.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english

<b>Content</b>
<b>Examination achievement</b>
See lecture
<b>Course achievement</b>
The exercises are considered passed if 50% of maximum points will be achieved in each of the three tests that are written in the exercises with prior notice.
<b>Compulsory requirement</b>

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Neuroprothetik / Neuroprosthetics - Seminar	
Event type	Number
seminar	04LE50V-5318
<b>Faculty</b>	
Technische Fakultät Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	3.0
Recommended semester	4
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	39 hours
Independent study	51 hours
Workload	90 hours

<b>Content</b>
<p>Introductory lessons contain:</p> <ul style="list-style-type: none"> <li>■ Basic concepts of neuroscience</li> <li>■ Interfacing the nervous system</li> <li>■ Modelling approaches for CNS applications</li> <li>■ Neuroethical aspects</li> </ul> <p>Student covered topics will contain:</p> <ul style="list-style-type: none"> <li>■ Cochlea Implant - Deafness</li> <li>■ Retina Implant - Blindness</li> <li>■ Deep Brain Stimulation - Parkinson's Disease</li> <li>■ Spinal Cord Stimulation - Chronic Pain Syndrome</li> <li>■ Vagal Nerve Stimulation - Epilepsy</li> <li>■ Functional Electrical Stimulation - Drop Foot Syndrome</li> <li>■ Human Machine Interfacing - BCI and BMI</li> <li>■ Foreign Body Reaction</li> </ul>
<b>Examination achievement</b>
Written documentation and oral presentation. The module grade is based on the written documentation (50%) and the oral presentation (50%).
<b>Course achievement</b>
None
<b>Literature</b>
<ul style="list-style-type: none"> <li>■ Farina, D., Jensen, W., Akay, M., Eds. (2013). INTRODUCTION TO NEURAL ENGINEERING FOR MOTOR REHABILITATION, IEEE</li> </ul>

- Dagnelie, G., Ed. (2011). Visual Prosthetics: Physiology, Bioengineering, Rehabilitation: Physiology, Bioengineering and Rehabilitation, Springer
- DiLorenzo, D. J. and J. D. Bronzino, Eds. (2008). Neuroengineering Boca Raton, CRC Press
- Akay, M. (2007). Handbook of Neural Engineering, IEEE Press, Wiley
- Dornhege, G., et al., Eds. (2007). Toward Brain-Computer Interfacing. Neural Information Processing Series. Cambridge, MA, MIT Press
- Horch, K. W. and G. S. Dhillon (2004). Neuroprosthetics - Theory and Practice. Singapore-London, World Scientific Publishing

Compulsory requirement

None

Recommended requirement

High level knowledge in mathematics and natural sciences

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Biomedical microsystems	
Event type	Number
lecture course	11LE50V-7900
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Technische Fakultät Institut für Mikrosystemtechnik	

ECTS-Points	.
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	60
Independent study	120
Workload	180 hours

<b>Content</b>
<p>The course presents exemplary applications of microsystems in biomedical engineering, discusses challenges and illustrates solutions to meet the requirements of biocompatibility, biostability and reliability in clinical applications. In detail, the following topic will be covered:</p> <ul style="list-style-type: none"> <li>■ Introduction to Biomedical Microdevices</li> <li>■ Medical Devices: Legal Framework and Classification</li> <li>■ Glaucoma Monitoring Implant</li> <li>■ Neural Implants to Restore Vision</li> <li>■ Neural Implants to Record from the Brain</li> <li>■ Sensors in Cardiac Pacemakers</li> <li>■ Imaging Pills</li> <li>■ Spectroscopic Billirubin Measurement</li> <li>■ Trends for Intelligent Endoprotheses</li> <li>■ Stability and Functionality Implantable MEMS</li> <li>■ Packaging and Housing Concepts</li> <li>■ Data and Energy Transmission in (Micro-)Implants</li> </ul> <p>Finally, the content of the course and the learning targets will be summarized together with the students to facilitate the preparation of the examination.</p>
<b>Examination achievement</b>
Written examination

Course achievement
see exercises
Literature
Actual copies of the slides will be delivered accompanying to the lectures. Literature: ■ G. A. Urban (ed.) BioMEMS. Dordrecht: Springer 2006.
Compulsory requirement
none

↑



Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Biomedical microsystems	
Event type	Number
exercise course	11LE50Ü-7900
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Technische Fakultät Institut für Mikrosystemtechnik	

ECTS-Points	.
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english

<b>Content</b>
<b>Examination achievement</b>
The exercises are considered passed if 50% of maximum points will be achieved from the tests that are written in the exercises with prior notice.
<b>Course achievement</b>
<b>Compulsory requirement</b>
none
<b>Recommended requirement</b>
none

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Major Concepts in Cognitive Neurosciences	
Event type	Number
lecture course	09LE03V-WM-05_0001
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	4.3
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	
Language	english
Attendance	60 Stunden
Independent study	30 Stunden
Workload	90 Stunden

<b>Content</b>
<p>Topics of the lectures given by various teachers are intentions, methods, and results of diverse fields of research that together contribute to our understanding of the relationship between cognition and the structure and physiology of brains.</p> <p>Topics contain:</p> <ul style="list-style-type: none"> <li>■ Brain evolution</li> <li>■ Cognitive Psychology</li> <li>■ Neuroplasticity</li> <li>■ Perception</li> <li>■ Brain-machine interfaces</li> <li>■ Imaging methods</li> <li>■ Animal cognition</li> <li>■ Clinical neuroscience</li> <li>■ Neurophilosophy</li> </ul>
<b>Qualification</b>
<ul style="list-style-type: none"> <li>■ Students can name major stages of human brain evolution.</li> <li>■ They can explain and differentiate several levels of neuroplasticity.</li> <li>■ They can name major benefits and limits of computational concepts for understanding cognitive functions.</li> <li>■ They identify similarities and differences between human and animal cognition.</li> <li>■ They can give examples of logical complications faced by the cognitive neurosciences.</li> </ul>
<b>Examination achievement</b>
none
<b>Course achievement</b>
none

Literature
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"><li>■ Tim Shallice, Richard P. Cooper: The organization of mind. Oxford Univ. Press 2011</li><li>■ Kenneth M. Heilman, Edward Valenstein (Eds.): Clinical neuropsychology. 4th ed., Oxford Univ. Press 2003.</li></ul>
Compulsory requirement
s. Modulebene
Teaching method
Lectures will be given as Power-Point presentation, including multimedia elements, backed by slide handouts. Intermitting discussions will be encouraged and coached.
Target group
<ul style="list-style-type: none"><li>■ M.Sc. Biology</li><li>■ M.Sc. Bioinformatics &amp; Systems Biology</li><li>■ M.Sc. Neuroscience</li><li>■ Diploma Biology</li></ul>

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Methods in Cognitive Neurosciences	
Event type	Number
exercise course	09LE03Ü-WM-05_0002
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	2.0
Hours of week	0.5
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	6 Stunden
Independent study	54 Stunden
Workload	60 Stunden

<b>Content</b>
<ul style="list-style-type: none"> <li>demonstration of key methods in the cognitive neurosciences</li> <li>participation in experiments as subjects.</li> </ul>
<b>Qualification</b>
<p>The students can:</p> <ul style="list-style-type: none"> <li>identify major components and regions of human brain anatomy.</li> <li>explain EEG recordings, name the necessary equipment for it, and assess its fields of application.</li> <li>explain the principles of an MRI measurement and identify reasonable fields of application.</li> <li>plan and conduct experiments in teams, respect competencies of others and contribute their own skills constructively.</li> </ul>
<b>Examination achievement</b>
keine
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>100% active participation in 2 of 3 practical courses</li> <li>writing a lab report each about the experimental procedures done or seen.</li> </ul>
<b>Literature</b>
<p>The following literature is recommended for independent preparation and follow-up of the course contents:</p> <ul style="list-style-type: none"> <li>Lennart Heimer: The human brain and spinal cord. 2nd ed., Springer Verlag, New York 1994.</li> </ul>
<b>Compulsory requirement</b>
s. Modulebene

Teaching method
Students will be given hands-on experience of key-methods used in the cognitive neurosciences.
Target group
<ul style="list-style-type: none"><li>■ M.Sc. Biology</li><li>■ M.Sc. Bioinformatics &amp; Systems Biology</li><li>■ Diploma Biology</li></ul>

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Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Selected Topics in Cognitive Neurosciences	
Event type	Number
seminar	09LE03S-WM-05_0003
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	4.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	30 Stunden
Independent study	90 Stunden
Workload	120 Stunden

<b>Content</b>
<ul style="list-style-type: none"> <li>■ Two seminar blocks will be held for students to learn and discuss original papers about the cognitive neurosciences in general and about brain and language specifically.</li> <li>■ The students will learn how to read and evaluate original research reports.</li> <li>■ They will understand how to structure and present complex issues of current research.</li> <li>■ They will participate in scientific discussions and learn how to deal with controversies</li> </ul>
<b>Qualification</b>
Students present and discuss specific scientific terms and concepts, observing the fundamental distinction between data and their interpretation.
<b>Examination achievement</b>
keine
<b>Course achievement</b>
<ul style="list-style-type: none"> <li>■ 100% active participation in two seminar blocks</li> <li>■ Two seminar presentations of data and concepts contained in original literature</li> </ul>
<b>Literature</b>
To be distribute during the preparatory session.
<b>Compulsory requirement</b>
s. Modulebene
<b>Teaching method</b>
Seminars will be given by each student as media-supported Power-Point presentations.

Target group
<ul style="list-style-type: none"><li>■ M.Sc. Biology</li><li>■ M.Sc. Bioinformatics &amp; Systems Biology</li><li>■ Diploma Biology</li></ul>



Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Grundlagen der Elektrostimulation / Fundamentals of electrical stimulation - Lecture	
Event type	Number
lecture course	11LE50V-5306
<b>Faculty</b>	
Technische Fakultät Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	3
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	30 hours
Independent study	60 hours
Workload	90 hours

<b>Content</b>
<p>The lecture introduces biological-medical as well as physico-technical aspects during electrical stimulation of nerves and muscles. The following topics will be covered:</p> <ul style="list-style-type: none"> <li>■ Overview of the history of electrical stimulation</li> <li>■ Anatomy and physiology of nerves and muscles</li> <li>■ Description of electrical excitation of nerve cells</li> <li>■ Electrical fields and electrochemical processes at electrodes</li> <li>■ Methods of selective nerve stimulation</li> <li>■ Effects of chronic electrical stimulation of nerve and muscle</li> <li>■ Limits of safe electrical stimulation</li> <li>■ System theory and control aspects in neural prosthetics</li> <li>■ Simulation of nerve excitation</li> <li>■ Design of stimulators for electrical stimulation</li> <li>■ Characteristic parameters for different applications in electrical stimulation.</li> </ul> <p>The learning targets and objectives will be summarized at the end of each lecture and a comprehensive summary will take place at the end of the course to repeat the most important objectives and facilitate preparation of the oral examinations.</p>
<b>Examination achievement</b>
Oral exam (30 minutes)
<b>Course achievement</b>
None
<b>Literature</b>
Actual copies of the slides will be delivered accompanying to the lectures.



Literature:

- Horsch, K.W., Dhillon, G.S. (Hrsg.): Neuroprosthetics – Theory and Practice. (Series on Bioengineering & Biomedical Engineering – Vol. 2)
- River Edge: World Scientific Computing, 2004

Compulsory requirement

None

Recommended requirement

None

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Technologien der Implantatfertigung / Implant Manufacturing Technologies - Lecture	
Event type	Number
lecture course	11LE50V-5313
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	3
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	45 hours
Independent study	45 hours
Workload	90 hours

<b>Content</b>
<p>In the lecture Implant Manufacturing Technologies, knowledge and methods for the development of electrically active implants such as pacemakers or hearing prostheses (cochlear implants) are taught. Materials, components, systems and legal frameworks are presented. Clinically established (neuro-) implants as well as novel developments, which are still in the research phase, will be presented and critically discussed. The following topics will be covered during the lecture:</p> <ul style="list-style-type: none"> <li>■ Overview of active implants &amp; neuroprostheses in clinical and research settings.</li> <li>■ Definitions and classification of electrically active implants</li> <li>■ Biocompatibility testing and biostability (corrosion and degradation)</li> <li>■ Electrodes</li> <li>■ Design of electrically active implants (components, interfaces)</li> <li>■ Silicone as material for encapsulation</li> <li>■ Materials for hermetically sealed housings</li> <li>■ Connections and joining techniques</li> <li>■ Requirements for implant development and production (risk management, FMEA, production rooms, documentation)</li> <li>■ Thin-film technology in implant development</li> <li>■ Manufacturing of microimplants using the example of a BION</li> </ul> <p>Finally, the learning content will be repeated together with the students in order to facilitate the preparation for the examination.</p>
<b>Examination achievement</b>
Written examination (90 minutes)

Course achievement
None
Compulsory requirement
None
Recommended requirement
None

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Technologien der Implantatfertigung / Implant Manufacturing Technologies - Exercises	
Event type	Number
exercise course	11LE50Ü-5313
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Institut für Mikrosystemtechnik	

ECTS-Points	.
Hours of week	1.0
Recommended semester	3
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english

<b>Content</b>
<b>Examination achievement</b>
See lecture
<b>Course achievement</b>
None
<b>Compulsory requirement</b>

↑

Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Maschinelles Lernen / Machine Learning - Lecture	
Event type	Number
lecture course	11LE13V-1153
<b>Organizer</b>	
Institut für Informatik, Professur für Maschinelles Lernen	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	6.0
Hours of week	3.0
Recommended semester	2
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	45
Independent study	120
Workload	180 Stunden

<b>Content</b>
Characterization of supervised, unsupervised and reinforcement learning, concept learning, decision trees, neural networks, probabilistic methods, committee techniques, reinforcement learning.
<b>Learning target</b>
<p>This course provides you with a good theoretical understanding and practical experience about the basic concepts of machine learning. You shall be enabled to implement a number of basic algorithms, understand advantages and drawbacks of single methods and know typical application domains thereof. Furthermore, you should be able to use (Python) software libraries in order to work on novel data analysis problems.</p> <p>The course will prepare you to dive deeper into advanced methods of ML, e.g. deep learning, recurrent networks, reinforcement learning, hyperparameter optimization, and into specific application domains such as image analysis, brain signal analysis, robot learning, bioinformatics etc., for which specialized courses are available.</p>
<b>Examination achievement</b>
Oral examination with a duration of 35 minutes
<b>Course achievement</b>
see exercise
<b>Literature</b>
<p>Duda, Hart and Stork: Pattern Classification          Christopher Bishop: Pattern Recognition and Machine Learning          Hastie, Tibshirani and Friedman: The Elements of Statistical Learning</p>

Mitchell: Machine Learning  
 Murphy: Machine Learning – a Probabilistic Perspective  
 Criminisi et. al: Decision Forests for Computer Vision and Medical Image Analysis  
 Schölkopf & Smola: Learning with Kernels  
 Goodfellow, Bengio and Courville: Deep Learning  
 Michael Nielsen: Neural Networks and Deep Learning

In addition, literature for every section of the course is announced during these sections.

#### Compulsory requirement

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#### Recommended requirement

We have to rely on a solid background in basic math, specifically linear algebra (an eigenvalue decomposition, matrix operations, covariance matrices etc. should be very familiar concepts), calculus and probability theory.

We use the Python programming language for most of our assignments. If you do not yet have Python experience, you must ramp up at least basic knowledge thereof.

We recommend basic knowledge of optimization and of the scikit-learn Python library.

#### Teaching method

##### For in-class lectures:

Despite the large lecture rooms, a teacher-centered style shall be enriched as much as possible by measures like:

- interactive question and answer rounds
- discussions in sub-groups, reporting to the large group
- cross-teaching
- problem-oriented teaching e.g. via data analysis competition
- repetition of important concepts in slightly altered contexts.

##### For virtual lectures:

- flipped classroom teaching with videos provided
- Q&A sessions to discuss the videos' content
- Cross-teaching via Ilias forum
- problem-oriented teaching e.g. via data analysis competition
- repetition of important concepts in slightly altered contexts.

#### Target group

Advanced BSc., MSc. students and PhD students



Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Maschinelles Lernen / Machine Learning - Exercises	
Event type	Number
exercise course	11LE13Ü-1153
<b>Organizer</b>	
Institut für Informatik, Professur für Maschinelles Lernen	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	.
Hours of week	1.0
Recommended semester	2
Frequency	only in the winter term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	15

<b>Content</b>
The exercises are intended to give students a better understanding of the most important techniques they learn during lectures. They are expected to implement some selected methods to gain experience in practical applications.
<b>Examination achievement</b>
see Lecture
<b>Course achievement</b>
Passing an oral or written examination.
<b>Compulsory requirement</b>
none
<b>Recommended requirement</b>
none

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Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Numerical Optimal Control in Science and Engineering	
Event type	Number
lecture course	11LE50V-5249
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Systemtheorie, Regelungstechnik und Optimierung	
<b>Faculty</b>	
Technische Fakultät	

ECTS-Points	6.0
Hours of week	6.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	78 hours
Independent study	102 hours
Workload	180 hours

<b>Content</b>
<ul style="list-style-type: none"> <li>■ Introduction: Dynamic Systems and Optimization</li> <li>■ Rehearsal of Numerical Optimization</li> <li>■ Rehearsal of Parameter Estimation</li> <li>■ Discrete Time Optimal Control</li> <li>■ Dynamic Programming</li> <li>■ Continuous Time Optimal Control</li> <li>■ Numerical Simulation Methods</li> <li>■ Hamilton-Jacobi-Bellmann Equation</li> <li>■ Pontryagin and the Indirect Approach</li> <li>■ Direct Optimal Control</li> <li>■ Differential Algebraic Equations</li> <li>■ Periodic Optimal Control</li> <li>■ Real-Time Optimization for Model Predictive Control</li> </ul>
<b>Examination achievement</b>
Written exam (180 minutes)
<b>Course achievement</b>
see exercise
<b>Literature</b>
<ol style="list-style-type: none"> <li>1. Manuscript "Numerical Optimal Control" by M. Diehl and S. Gros</li> <li>2. Biegler, L.T., Nonlinear Programming, SIAM, 2010</li> </ol>



Compulsory requirement
None
Recommended requirement
Mathematics 1 and 2 for Engineers or basic Linear Algebra and Calculus courses. Numerical Optimization (NUMOPT), Modelling and System Identification (MSI), Systems and Control Bachelor or Master lectures.

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Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Numerical Optimal Control in Science and Engineering	
Event type	Number
exercise course	11LE50Ü-5249
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Systemtheorie, Regelungstechnik und Optimierung	
<b>Faculty</b>	
Mathematisches Institut-VB Technische Fakultät	

ECTS-Points	.
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english

<b>Content</b>
Theoretical and computer exercises accompany the lecture to deepen the understanding
<b>Examination achievement</b>
<b>Course achievement</b>
Successful participation/solution of at least 50% of the weekly exercise sheets
<b>Compulsory requirement</b>
None
<b>Recommended requirement</b>
Mathematics 1 and 2 for Engineers or basic Linear Algebra and Calculus courses. Numerical Optimization (NUMOPT), Modelling and System Identification (MSI), Systems and Control Bachelor or Master lectures.

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Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Signalverarbeitung und Analyse von Gehirnsignalen / Signal processing and analysis in brain signals - Lecture	
Event type	Number
lecture course	11LE50V-5312
<b>Organizer</b>	
Institut für Mikrosystemtechnik, Biomedizinische Mikrotechnik	
<b>Faculty</b>	
Institut für Mikrosystemtechnik	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	compulsory
Language	english
Attendance	26 hours
Independent study	64 hours
Workload	90 hours

<b>Content</b>
<p>The course starts with an introduction to the basic principles of the measurement of neurophysiological signals mainly EEG and MEG. Despite a basic technical introduction of the measurement systems an overview about physiological and pathological patterns and rhythms in brain signal is given. Pattern recognition in the diagnostics of patients suffering from epilepsy is one core topic of the module. Long term recordings of EEG in epilepsy diagnostic create a high demand for automatic EEG analysis procedures. Three different types of events are at the moment in the focus for automatic detection strategies.</p> <p>a) Epileptic seizures, which are the core syndrome of the disease. Automatic detection may facilitate the review of long term recordings tremendously.</p> <p>b) Short high amplitude peaks in EEG and MEG called spikes contribute to the diagnoses of epilepsy and give information related to the localization of the seizure onset region in focal epilepsy.</p> <p>c) Oscillatory activity in the frequency range between 80 Hz and 600 Hz gives according to recent result probably more specific information about the seizure origin area than spikes.</p> <p>Signal processing and pattern recognition strategies are presented and how they can be applied to the patterns of interest in epilepsy diagnostic.</p> <p>In detail following strategies will be presented:</p> <p>a) Heuristics</p> <p>b) Template matching</p> <p>c) Wavelet transformation</p> <p>d) Hilbert transformation</p> <p>e) Background and target modelling</p> <p>f) Artificial neural networks</p>

A second focus of the module is related to the localization of generators of neuronal activity based on EEG and MEG measurements.

The introduction starts with the presentation of the Maxwell equations and the common simplifications as they are applied in EEG and MEG source localization. Localization includes two basic components, the forward simulation and an inverse parameter estimation procedure. Concepts of the following forward models representing the physical properties of the head are presented:

- a) Spherical model
- b) Boundary element model
- c) Finite element model

Main types of focal and distributed inverse models will form the contents of the inverse part of the source localization procedure.

Exemplary application examples will show the complete processing chain from measurements and image acquisition to localization results.

#### Examination achievement

Oral exam (30 minutes)

#### Course achievement

None

#### Compulsory requirement

None

#### Recommended requirement

None

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Name of module	Number of module
Elective Subjects (Focus Area: Neurotechnology)	09LE03MO-NE-3-2021
<b>course</b>	
Working in Science	
Event type	Number
seminar	09LE03S-NE-5-T12
<b>Faculty</b>	
Fakultät für Biologie	

ECTS-Points	3.0
Hours of week	2.0
Recommended semester	2
Frequency	only in the summer term
Pflicht/Wahlpflicht (P/WP)	core elective
Language	english
Attendance	22 h
Independent study	68 h
Workload	90 h

<b>Content</b>
<p>The seminar discusses the foundations, methods, current practices and implications of science. Among the topics are</p> <ul style="list-style-type: none"> <li>■ Falsification, Karl Popper</li> <li>■ Research paradigms, Thomas Kuhn; research programs, Imre Lakatos</li> <li>■ Anything goes!, Paul Feyerabend</li> <li>■ New experimentalism, Deborah Mayo</li> <li>■ Pseudoscience and the demarcation problem</li> <li>■ Scientific publishing</li> <li>■ Science communication</li> <li>■ Science and its influence on politics</li> <li>■ Scientific misconduct</li> <li>■ The future of neuroscience</li> </ul> <p>Further topics related to the overall topic of the seminar can be added, and/or topics can be modified based on the interests of the students taking part in this seminar. This will be decided during the first seminar session.</p>
<b>Qualification</b>
<p>The students acquire the competence to</p> <ul style="list-style-type: none"> <li>■ summarize and critically reflect on the foundations, methods, current practices and implications of science</li> <li>■ draw a broader framework of science and connect it to their own area of specialisation.</li> </ul>
<b>Examination achievement</b>
None

Course achievement
<ul style="list-style-type: none"><li>■ Oral presentation of a seminar topic</li><li>■ Active participation in the seminar</li></ul>
Compulsory requirement

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