Universität Bremen

Faculty 02:
Biology/Chemistry

Summersemester 24

Module Guide

for the study of

Neurosciences

Master of Science

valid in connection with the examination regulations MPO 2023

Generated: April 8, 2024

Index by areas of study

1) Compulsory modules - new (63 CP)

In the first semester, three modules provide fundamental knowledge which covers basic principles and concepts in neuroscience, information processing from cells to networks, and theoretical concepts for describing, analyzing and understanding neural systems. The contents of the lectures are deepened through practical exercises and seminars. The broad spectrum of the courses also serves to bring first-year students from different subject disciplines and countries of origin to a common level of knowledge.

In the first week of the second semester, you get familiar with complementary skills like good scientific practice, scientific writing, presentation skills, critical science, data organization and -handling, and media skills.

In the course of the fourth semester, complementary skills will be brought to flower during a Mind Conference at the Hanse-Wissenschaftskolleg Delmenhorst or in Bremen – show your latest scientific results as a poster or in a talk, get into contact with Alumni, discuss your career options with PI's from different departments and get into contact with partners from the industry.

a) Research Training - new (33 CP)

b) Fundamental courses - new (30 CP)

2) Compulsory elective modules Specialization - new (3 CP)

At the end of the first semester, you choose an in-depth module (*Lab Animal Sciences or Advanced Programming: Data Analysis & Modeling*) according to your interests and abilities. This module prepares you for specializing in either experimental or computational neuroscience, and is a prerequisite for some elective modules.

Ambitious students can even take both courses if there is sufficient teaching capacity.

3) Elective modules Advanced Studies - new (27 CP)

The basics acquired in the first semester are taken to an advanced level and applied in practical training.

You decide for the first time on your individual preferences.

Advanced Studies will emphasize the development of scientific meta skills more than former courses. You choose three courses from a wide range of topics between basic research and application, offered by the participating departments. There you learn and test advanced research methods. Each of the modules is only offered once per summer semester.

4) Master thesis - new (27 CP)

In the 4th semester, a master's thesis is written in one of the participating departments or abroad.

5) Supplementary Courses

Module 02-BIO-MA-MN-F1: Concepts and Principles of Neuroscience
Concepts and Principles of Neuroscience

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules - new • Compulsory modules - new / Fundamental courses - new	none

Learning content:

Lecture Functional Neuroanatomy

- Principal organization of vertebrate brains
- Understanding of cellular components of the brain
- Relationship between structure and function of brains
- Basics of comparative anatomy of vertebrates
- Transmitter systems in Mammals
- Learning and Memory
- Motor System
- Sensory Systems

Laboratory Functional Neuroanatomy

- Microscopic analysis of sections of vertebrate brains
- Experience with stereotaxic atlas
- brain areas and function in the human brain

Seminar Functional Neuroanatomy

- Introduction to up-to-date neuroscientific literature
- State of the art methods in Neuroscience

Lecture Cellular and Molecular Neuroscience

- Basic principles of neurobiochemistry (energy metabolism, transmitter synthesis as well as mechanisms of transmitter degradation)
- Signal transmission at chemical synapses (including second messenger systems)
- Categorization and function of transmitter receptors and transporters; functional neuroanatomy of transmitter systems of mammals
- Basics of neuropharmacology (blood-brain barrier, pharmacological kinetics as well as pharmacological dynamics)
- Mode of action of relevant psychotropic drugs.
- Function of neurotrophic factors, neuromodulators and peptides.

Seminar Clinical Neuroscience:

- Theoretical models and functional neuroanatomy of different cognitive domains (attention, visual perception, executive functions, memory, etc.)
- Neuropsychological disorders and syndromes
- Neuropsychological tests and diagnostic tools
- Neuropsychological Rehabilitation
- Hands-on Training Clinical Neuroscience:
- Application, analysis and discussion of neuropsychological tests
- Discussion of case reports

Learning outcomes / competencies / targeted competencies:
Students

- understand the basic principles of Neuroanatomy
- know basic principles in Neuroscience
- can apply anatomical terms and are able to assign brain areas on brain sections and in brain models
- are familiar with the structure of the brain and its function
- understand the functional principles of natural neuronal networks
- have in-depth knowledge of principles of brain chemistry
- understand the significance of brain modulatory systems in clinical disorders and relevant pharmacological therapies
- can classify and distinguish different neuropsychological syndromes.
- can apply and evaluate neuropsychological tests in different settings.
- understand different approaches of neuropsychological rehabilitation.

Calculation of student workload:
126 h Preparation / follow-up work
105 h SWS / presence time / working hours
39 h Exam preparation

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Prof. Dr. Olivia Masseck
Frequency:	**Duration:**
winter semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Modulprüfung Concepts and Principles of Neuroscience

Type of examination: module exam

Form of examination:	**The examination is ungraded?**
Written examination	no

Number of graded components / ungraded components / prerequisites of the examination:
1 / - / -

Language(s) of instruction:
Englisch

Module courses

Course: Functional Neuroanatomy

Frequency:	**Are there parallel courses?**
winter semester, yearly	no

Contact hours: 3,5	**University teacher:** Prof. Dr. Olivia Masseck
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Modulprüfung Concepts and Principles of Neuroscience

Course: Cellular and Molecular Neurosciences	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 2	**University teacher:** Prof. Dr. Michael Koch
Language(s) of instruction: Englisch	
Teaching method(s): Lecture	**Associated module examination:** Modulprüfung Concepts and Principles of Neuroscience

Course: Clinical Neuroscience	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 2	**University teacher:** Dr. Margarethe Korsch
Language(s) of instruction: Englisch	
Teaching method(s): Seminar	**Associated module examination:** Modulprüfung Concepts and Principles of Neuroscience

Module 02-BIO-MA-MN-F2: Information Processing in the Brain - from Synapses to Networks

Information Processing in the Brain – from Synapses to Networks

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules - new • Compulsory modules - new / Fundamental courses - new	Basic physics understanding of mechanics, electro-dynamics and nuclear physics is recommended. Understanding of the basics biology of neurons (resting potential, action potentials, synaptic transmission) is highly recommended.

Learning content:

Lecture Neuronal Networks and Signals

- Principles of Neuronal networks
- Communication and collective phenomena in neuronal networks
- Introduction to neuronal signals
- Understanding the origin of neuronal signals
- Different kinds of neuronal signals
- How to measure neuronal signals in man and mouse
- Interpretation and analysis of neuronal signals
- State of the art methods to investigate neuronal networks, such as Calcium Imaging

Laboratory Neuronal Networks & Signals

- Experience with data analysis of neuronal network data
- Get familiar with different forms of neuronal signals

Lecture Structural & Functional Imaging

- Purpose and principal background of medical imaging in general
- Basic principles of medical imaging modalities:

1. Physical principle
2. technical components
3. field of applications

- Imaging modalities include:

1. ultrasound
2. nuclear imaging (positron emission tomography, single photon emission computed tomography)
3. x-ray and x-ray computed tomography
4. magnetic-resonance tomography (and spectroscopy)

Cognitive Neurophysiology

- Relation between reality, sensory stimuli and perception
- Parallel processing and functional anatomy of the visual system
- Neuronal encoding and representation of sensory information
- Neuronal mechanisms and collective network dynamics underlying cognitive processes
- Methods for investigating neuronal information processing in behaving animals

Learning outcomes / competencies / targeted competencies:
Students

- understand the basic principles of neuronal networks
- have fundamental knowledge of biosginals
- can apply their knowledge of biosignals to measure them in animals and humans
- understand the functional principles of natural neuronal networks.
- have in-depth knowledge of principles of biosignals
- understand the significance of brain modulatory systems in neuronal networks
- know how medical imaging modalities work and what the capabilities of each modality is.
- are able to decide on the appropriate imaging modality for given scenarios
- understand the image content of medical images
- understand the relation between the physical processes of the environment, resulting activation of sensory cells and the active generation of percepts
- have in-depth knowledge of the functionally relevant structure of the visual system and can explain characteristic response properties of its neurons
- can explain how important cognitive capabilities like perception or attention arise from neuronal network structure and dynamics
- understand the role of recording/stimulation in behaving animals and can explain how a specific experimental and task design relates to a research question

Calculation of student workload:
86 h Preparation / follow-up work
100 h Exam preparation
84 h SWS / presence time / working hours

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Prof. Dr. Sami Hassan
Frequency:	**Duration:**
winter semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
SoSe 24 / -	9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Information Processing in the Brain - from Synapses to Networks

Type of examination: combination exam

Form of examination:	**The examination is ungraded?**
See free text	no

Number of graded components / ungraded components / prerequisites of the examination:
1 / 2 / -

Language(s) of instruction: Englisch
Description: PL 1 (graded component): Written examination; SL 1 (ungraded component): Portfolio, consisting of exercises; SL 2 (ungraded component): Portfolio, consisting of exercises

Module courses

Course: Neuronal Networks and Signals	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 3	**University teacher:** Prof. Dr. Sami Hassan
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Laboratory class	**Associated module examination:** Kombinationsprüfung Information Processing in the Brain - from Synapses to Networks

Course: Structural and Functional Imaging	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 2	**University teacher:** Prof. Dr. rer. nat. Matthias Günther
Language(s) of instruction: Englisch	
Teaching method(s): Lecture	**Associated module examination:** Kombinationsprüfung Information Processing in the Brain - from Synapses to Networks

Course: Cognitive Neurophysiology	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 1	**University teacher:** Prof. Dr. Andreas Kreiter
Language(s) of instruction: Englisch	
Teaching method(s): Lecture	**Associated module examination:** Kombinationsprüfung Information Processing in the Brain - from Synapses to Networks

Module 01-PHY-MA-MN-F3: Theoretical Neuroscience and Methods
Theoretical Neuroscience and Methods

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory modules - new • Compulsory modules - new / Fundamental courses - new	Fundamental knowledge about basic mathematical concepts (equation solving, functions, differential and integral calculus, linear algebra, probability calculus, complex numbers) is recommended.

Learning content:
The module comprises three courses which provide students with the basic tools necessary for analyzing neural data, for investigating the dynamics of neural systems, as well as for quantitatively describing information processing and computation in neural networks.
The courses are designed such that skills acquired in Programming can be directly applied to exercises in Theoretical Neuroscience as well as in Statistics & Data Analysis, and vice versa.

Preparatory seminar:

Equation solving, functions, complex numbers
Differential and integral calculus
Linear algebra
Probability calculus

Programming:
Intro: the philosophy of programming and coding
Variables: precision, range, types (numeric, string, Boolean), scope, casting
Elementary operations: declarations, assignments, mathematical/logical computations, special math functions, random numbers and distributions, permutations
Program control: conditional and repeated execution (if, while, for, …)
Structuring: functions, input & output arguments, modularization techniques, classes (basics)
Systematic programming: guidelines, examples, debugging, understanding error reports, testing code integrity
Advanced data types: tuples, lists, dictionaries, sets, list comprehension
Basic data import/export: binary versus text formats, machine representation, file open/read/write/close, file parsing
Interoperability and data sharing (i.e. pandas), export/import to/from R/Matlab/text, translation to and from Matlab code
Arrays and array operations (numpy): creation and initialization, single element and subarray access, augmentation, element-by-element and vector/matrix operations, reshaping/rearranging/tiling, log scaling
Plots and graphs (matplotlib): single plots, multiple plots/graphs, changing plot appearance, 2D- and 3D-visualization, export to storage and printer

Theoretical Neuroscience (in brackets: mathematical concepts introduced)
Neurons (differential equations, steady-state solutions): neuroelectronics, ion channels, resting potential, Hodgkin-Huxley-model, leaky integrate-and-fire model, adaptation
Neural interactions (partial DEQs): cable equations, synaptic transmission and short-term dynamics, learning and plasticity (Hebbian, Window Function), shunting inhibition, divisive normalization
Spikes (delta-distributions, convolutions): spike trains, rates, rate estimators, spike statistics
Stimulus-response characteristics & receptive fields (linear encoding and decoding): linear-nonlinear Poisson model, generalized linear model, spike-triggered average, reverse correlations, tuning curves
Feedforward networks and computation (linear algebra, gradient descent): simple and ML-Perceptron, classification, learning, introduction to deep networks
Recurrent networks (linear stability analysis): spike-based and rate-based/mean-field, collective phenomena: synchronization, spatial pattern formation, associative memory

Statistics & Data Analysis:
Descriptive statistics: discrete and continuous probability distributions (normal, Poisson, Bernoulli), mean, variance, kurtosis and higher moments autocorrelation, cross-correlation, covariance
Probability calculus: Bayes formula and Bayesian estimation, risk, likelihood ratio, objective functions, ML/MAP estimation, receiver operator characteristics, discrimination, classification
Statistical tests (non-parametric/parametric) and models: Wilcoxon, Friedman, Kolmogorov-Smirnov, t-test, ANOVA (basic, multivariate and factorial), surrogate data and bootstrap procedures, regression and statistical modeling
Data analysis: Signal acquisition and sampling, filtering, spectral analysis (Fourier, Wavelet)

Learning outcomes / competencies / targeted competencies:
Preparatory Seminar:

- Students understand mathematical notation and can interpret expression and equations
- Students are able to apply appropriate tools and rules to solve basic mathematical problems in calculus, linear algebra, and probability calculus

Programming:

- Students are able to partition complex tasks into a set of given elementary operations
- Students can translate these operations into a working (Python) program code
- Students are able to debug and test program code on their own
- Students can write programs for solving problems in neural data analysis or for performing simulations of neural (network) models
- Students are able to import/export data for file sharing
- Students are capable to visualize data and computation results in a form suitable for scientific texts.

Theoretical Neurosciences:
Students are able to select/to use tools from mathematics, physics and information theory to…

- …describe dynamical processes in neural systems
- …construct simple models of neurons and elementary feedforward/recurrent networks
- …analyze neural signals and deduce stimulus-response properties

Statistics and Data Analysis:

- Students are able to compute with probabilities, and to perform statistical inference on data
- Students can select appropriate statistical tests and apply them to neural data sets
- Students understand the fundamentals of neural signal acquisition, and can apply basic pre-processing techniques on neural data (averaging, filtering, correlation, spectral decomposition)

Calculation of student workload:
98 h SWS / presence time / working hours
98 h Preparation / follow-up work
74 h Exam preparation

Are there optional courses in the modules?
no

Language(s) of instruction: English	**Responsible for the module:** Dr. Udo Alexander Ernst
Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Theoretical Neuroscience and Methods

Type of examination: combination exam

Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / 3 / -	
Language(s) of instruction: Englisch	
Description: PL 1 (graded component): Written examination; SL1 (ungraded component): Portfolio, consisting of exercises; SL2 (ungraded component): Portfolio, consisting of exercises; SL3 (ungraded component): Portfolio, consisting of exercises	

Module courses

Course: Programming	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 2	**University teacher:** Dr. Udo Alexander Ernst
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Laboratory class	**Associated module examination:** Kombinationsprüfung Theoretical Neuroscience and Methods

Course: Theoretical Neurosciences	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 2	**University teacher:** Dr. Udo Alexander Ernst
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Laboratory class	**Associated module examination:** Kombinationsprüfung Theoretical Neuroscience and Methods

Course: Statistics and Data Analysis	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 2	**University teacher:** Prof. Dr. Thorsten Fehr
Language(s) of instruction: Englisch	

Teaching method(s): Lecture Laboratory class	**Associated module examination:** Kombinationsprüfung Theoretical Neuroscience and Methods

Course: Preparatory Seminar	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 1	**University teacher:** Dr. Udo Alexander Ernst
Language(s) of instruction: Englisch	
Teaching method(s): Seminar	**Associated module examination:** Kombinationsprüfung Theoretical Neuroscience and Methods

Module 02-BIO-MA-MN-CS: Complementary Skills
Complementary Skills

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules - new • Compulsory modules - new / Fundamental courses - new	none

Learning content:
Scientific Writing

Good scientific practice

Norms of Science

Critical Science

Planning of experiments

Data organization and handling

Media competence & public outreach

How to give a scientific talk

Leadership

Presentation skills

Learning outcomes / competencies / targeted competencies:
Students

understand norms of science

have fundamental knowledge of data organization and handling and can properly document results and data sets

can apply their knowledge of scientific writing

have in-depth knowledge of good scientific practice

can apply their knowledge of presentations skills to present at scientific conferences and in public

have fundamental knowledge of how to plan experiments

can deal with different media

Calculation of student workload:
42 h SWS / presence time / working hours
8 h Exam preparation
40 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Prof. Dr. Olivia Masseck
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]

The module is valid since / The module is valid until:	Credit points / Workload:
WiSe 23/24 / -	3 / 90 hours

This module is ungraded!

Module examinations

Module examination: Modulprüfung Complementary Skills

Type of examination: module exam

Form of examination:	The examination is ungraded?
See free text	yes

Number of graded components / ungraded components / prerequisites of the examination:
- / 1 / -

Language(s) of instruction:
Englisch

Description:
Oral group presentation

Module courses

Course: Complementary Skills

Frequency:	Are there parallel courses?
summer semester, yearly	no
Contact hours:	**University teacher:**
3	Prof. Dr. Olivia Masseck

Language(s) of instruction:
Englisch

Teaching method(s):	Associated module examination:
Lecture Laboratory class	Modulprüfung Complementary Skills

Associated module courses

Complementary Skills (Laboratory class)

Module 02-BIO-MA-MN-LAB1: Lab Project 1
Lab Project 1

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules - new • Compulsory modules - new / Research Training - new	Prior completion of modules F1, F2 and F3 is recommended. Prior completion of module S1 (Advances Programming: Data Analysis & Modeling) is highly recommended for projects in data analysis and/or modeling. To ensure lab animal safety, projects in experimental Neurosciences can only be chosen if competence in safe handling of lab animals has been certified (by completion of module MN-S2 (Laboratory Animal Science)).

Learning content:
Students will be trained in an advanced lab project on scientific objectives and work techniques in a laboratory (clinics etc.), in Bremen, elsewhere in Germany or abroad.

1. The students can select their preferred working group and topic with the help of a mentor.
2. Students will get involved in all phases of an experimental/theoretical research project: Development of working hypotheses, experimental design, method selection, experimental and/or theoretical work, analysis of the data/numerical results.
   This part includes **compulsory elective choices (Wahlpflicht, WP) of 7-9 weeks duration:**

   WP1: Students undertake the practical work integrated in a research group at the University of Bremen

   WP2: Students undertake the practical work as internship students integrated in an external national or international research group
3. Students will write a research report and present and discuss the outcome of their project results in a seminar.

Learning outcomes / competencies / targeted competencies:
Students…

- are able to work on a research topic with relative independence
- can propose suitable paradigms (experiments, models, …) for investigating a specific research question
- can acquire, analyse, statistically evaluate, and interpret data on an advanced level…
- …and/or can develop, implement, and simulate models on an advanced level
- can summarize the results of their project in a scientific report and oral presentation

Calculation of student workload:
70 h Exam preparation
98 h SWS / presence time / working hours
282 h Preparation / follow-up work

Are there optional courses in the modules?
yes
The module includes compulsory elective choices (Wahlpflicht, WP) of 7-9 weeks duration (see learning content)
WP1: Students undertake the practical work integrated in a research group at the University of Bremen
WP2: Students undertake the practical work integrated as internship students in an external national or international research group

Language(s) of instruction: English	**Responsible for the module:** Dr. Udo Alexander Ernst
Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 15 / 450 hours

Module examinations

Module examination: Modulprüfung Lab Project 1	
Type of examination: module exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: 1 PL: Presentation and written assignment	

Module courses

Course: Lab Project 1	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 7	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Seminar Self-study unit	**Associated module examination:** Modulprüfung Lab Project 1

Module 02-BIO-MA-MN-LAB2: Lab Project 2
Lab Project 2

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules - new • Compulsory modules - new / Research Training - new	Prior completion of modules F1, F2 and F3 is recommended. Prior completion of module S1 (Advances Programming: Data Analysis & Modeling) is highly recommended for projects in data analysis and/or modelling. To ensure lab animal safety, projects in experimental Neurosciences can only be chosen if competence in safe handling of lab animals has been certified (by completion of module MN-S2 (Laboratory Animal Science)).

Learning content:
Students will be trained in an advanced lab project on scientific objectives and work techniques in a laboratory (clinics etc.), in Bremen, elsewhere in Germany or abroad.

1. The students can select their preferred working group and topic with the help of a mentor.
2. Students will get involved in all phases of an experimental/theoretical research project: Development of working hypotheses, experimental design, method selection, experimental and/or theoretical work, analysis of the data/numerical results.
   This part includes **compulsory elective choices (Wahlpflicht, WP) of 7-9 weeks duration:**

   WP1: Students undertake the practical work integrated in a research group at the University of Bremen

   WP2: Students undertake the practical work as internship students integrated in an external national or international research group
3. Students will write a research report and present and discuss the outcome of their project results in a seminar.

Learning outcomes / competencies / targeted competencies:
Students…

- are able to work on a research topic with relative independence
- can propose suitable paradigms (experiments, models, …) for investigating a specific research question
- can acquire, analyse, statistically evaluate, and interpret data on an advanced level…
- …and/or can develop, implement, and simulate models on an advanced level
- can summarize the results of their project in a scientific report and oral presentation

Calculation of student workload:
98 h SWS / presence time / working hours
70 h Exam preparation
282 h Preparation / follow-up work

Are there optional courses in the modules?
yes
The module includes compulsory elective choices (Wahlpflicht, WP) of 7-9 weeks duration (see learning content)

WP1: Students undertake the practical work integrated in a research group at the University of Bremen

WP2: Students undertake the practical work integrated as internship students in an external national or international research group

Language(s) of instruction: English	**Responsible for the module:** Dr. Udo Alexander Ernst
Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 15 / 450 hours

Module examinations

Module examination: Modulprüfung Lab Project 2	
Type of examination: module exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: 1 PL: Presentation and written assignment	

Module courses

Course: Lab Project 2	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 7	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Seminar Self-study unit	**Associated module examination:** Modulprüfung Lab Project 2

Module 01-PHY-MA-MN-MICO: Mind Conference
Mind Conference

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Compulsory modules - new • Compulsory modules - new / Research Training - new	none

Learning content:
The „Mind Conference“ will be jointly organized with the Master Program Neuroscience from the University of Oldenburg and will take place at the Hanse-Wissenschaftskolleg (HWK) in Delmenhorst. The conference is an opportunity for getting into contact with other students from cohorts of previous years who will present their master thesis or lab projects in poster form. In addition, the event serves as a forum for PIs in Bremen and Oldenburg for presenting their research in short presentations and outlining possibilities for doing a lab project or master thesis in their groups. Students will be advised to inform themselves about research in Bremen and Oldenburg before the conference, and to actively contact PI’s and other students to obtain more information about their topic(s) of interest. They will also actively organize the event under the supervision of the PI’s in the M.Sc. Neurosciences (participant registration, program scheduling, announcement, catering, setup and cleanup).

Learning outcomes / competencies / targeted competencies:
- Students understand the basic principles of how to organize and to structure scientific events such as conferences and workshops.
- Students know the workings of a scientific conference from hands-on experience and can establish contacts to fellow students (networking).
- Students have a comprehensive overview on research topics in Bremen and Oldenburg, and are able to make an informed selection of their lab project(s) and master thesis.

Calculation of student workload:
10 h Exam preparation
42 h SWS / presence time / working hours
38 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Dr. Udo Alexander Ernst
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	3 / 90 hours

This module is ungraded!

Module examinations

Module examination: Modulprüfung Mind Conference	
Type of examination: module exam	
Form of examination: See free text	**The examination is ungraded?** yes
Number of graded components / ungraded components / prerequisites of the examination: - / 1 / -	
Language(s) of instruction: Englisch	
Description: Project report (as documentation of conference organization and participation)	

Module courses

Course: Mind Conference	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 3	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Seminar Self-study unit	**Associated module examination:** Modulprüfung Mind Conference
Associated module courses **Mind Conference** (Seminar)	

Module 01-PHY-MA-MN-S1: Advanced Programming: Data Analysis and Modeling
Advanced Programming: Data Analysis and Modeling

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory elective modules Specialization - new	Fundamental knowledge about programming in Python is recommended.

Learning content:
This module is a two-week specialization course in Computational Neuroscience and is required for participating in selected modules in the Advanced Studies. The course covers hands-on training in elementary and advanced tools for programming, data analysis, modeling, numerical simulation, symbolic computation. The topics and their formal background will be introduced in short lectures which also put these concepts into a neuroscientific context. These are followed by closely supervised exercises in the computer lab. The course focuses on Python tools (e.g. numpy, sympy, pandas, numba), but will provide information about similar tools for Matlab/Octave and highlight options for interoperability wherever possible.

Programming Tools and Concepts:

- Fundamentals of digital logics, good practice for coding, parallelization and optimization, systematic debugging, object-oriented programming, symbolic computation.

Data Analysis:

- Data preprocessing, filters (lowpass, hipass, bandpass) and filter theory, spectral analysis (Fourier, Wavelet, Hilbert transform), reduction of dimensionality (PCA, ICA), elementary decoding/classification (ROC, k-NN, SVM).

Numerical Mathematics:

- Integration and differentiation, automatic differentiation, finding extremal values and zero crossings, gradient descent techniques, integration of differential equations (linear, non-linear, partial, systems of DEQs; Euler, Runge-Kutta, adaptive schemes).

Modelling and Simulation:

- Simulating simple and complex neurons, feedforward networks, recurrent networks (global and structured couplings), quantifying and visualizing network behavior

Learning outcomes / competencies / targeted competencies:
Students can write structured and efficient programming code.
Students are able to systematically debug their code and to test the integrity of their algorithms.
Students understand the basic mathematical background of standard data analysis and modelling tools.
Students are able to organize and to preprocess large-dimensional data sets appropriately.
Students can combine methods for decoding and dimensionality reduction to perform exploratory investigations of large multivariate data sets.
Students are able to set up models of feedforward and recurrent networks, equip the network nodes with different neuron types, and simulate the dynamics of the network.
Students can implement basic optimization schemes by performing gradient descent on appropriately defined objective functions.

Calculation of student workload: 38 h Preparation / follow-up work 42 h SWS / presence time / working hours 10 h Exam preparation

Are there optional courses in the modules? no

Language(s) of instruction: English	**Responsible for the module:** Dr. Udo Alexander Ernst
Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 3 / 90 hours

This module is ungraded!

Module examinations

Module examination: Kombinationsprüfung Advanced Programming: Data Analysis and Modeling	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** yes
Number of graded components / ungraded components / prerequisites of the examination: - / 2 / -	
Language(s) of instruction: Englisch	
Description: SL 1 (ungraded component): Portfolio (solutions to exercises) and SL2: oral presentation (of one of the exercises)	

Module courses

Course: Data Analysis and Modeling	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 3	**University teacher:** David Rotermund Dr. Udo Alexander Ernst
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Laboratory class	**Associated module examination:** Kombinationsprüfung Advanced Programming: Data Analysis and Modeling

Module 02-BIO-MA-MN-S2: Laboratory Animal Science
Laboratory Animal Science

Assignment to areas of study:	Content-related prior knowledge or skills:
• Compulsory elective modules Specialization - new	Basic knowledge of animal physiology is recommended.

Learning content:

Lectures:

- Legislative requirements for conducting animal experiments
- General aspects of biology and keeping of most widely used laboratory animal species
- Planning and assembly of animal experiments, biometry, and statistical analysis
- Abiotic and biotic standardization of animal experiments
- Substance administration and sample drawing
- Analgesia and anesthesia
- Surgical procedures, surgical instruments, and hygiene
- Chemical fixation of tissue and perfusion
- Methods of humane killing in accordance with animal protection law

Practical Work:

- Handling and behavior of rodents, acquisition of fundamental physiological and behavioral data, ethograms, recognition test and elevated plus maze test.
- Substance administration in rat and mice
- Humane killing and dissection of rodents
- Induction and surveillance of anesthesia and drawing of blood samples
- Intra-abdominal surgery of a rat (splenectomy)
- Suturing of muscle and skin tissue
- Perfusion of a rat and dissection of the brain
- Visit of and introduction to rodent and non-human primate husbandries,

Learning outcomes / competencies / targeted competencies:

Students have a detailed understanding of the manifold of aspects to be considered when preparing and performing an animal experiment and they have acquired corresponding theoretical and practical skills:

Students…

- know about the legal requirements to perform an animal experiment
- are able to acquire basic behavioral and physiological data
- can handle rodents, apply substances, and draw samples
- can induce and and control anesthesia, including pre-, peri-, and postoperative care and analgesia, on a basic level
- can use standard surgical instruments and can apply surgical techniques
- are able to apply different suturing techniques
- know the legal requirements for humane killing of laboratory animals and can apply this knowledge
- can perform perfusion, tissue fixation and dissection on a basic level

Calculation of student workload: 20 h Preparation / follow-up work 42 h SWS / presence time / working hours 28 h Exam preparation

Are there optional courses in the modules? no

Language(s) of instruction: English	**Responsible for the module:** Dr. Detlef Wegener
Frequency: winter semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung Laboratory Animal Science	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 2 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1 (graded component, 75%): Project report and PL2 (graded component, 25%): oral examination (single, during course)	

Module courses

Course: Laboratory Animal Science	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours: 3	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Laboratory Animal Science

Module 02-BIO-MA-MN-BP: Behavioral Pharmacology
Behavioral Pharmacology

Assignment to areas of study:	Content-related prior knowledge or skills:
• Elective modules Advanced Studies - new	Lectures and seminars from 1st semester are highly recommended. There is a PVL (prerequisite for the examination) in this module which has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2).

Learning content:
- Basic techniques in animal behavioral pharmacology (systemic drug infusions and behavioral tests) including animal handling
- Stereotaxic surgery in rodents including appropriate anesthesia techniques and postoperative animal care. Microinfusions of drugs into the brain
- Planning and design of behavioral experiments, statistical analysis of behavioral data
- Histology and microscopy of brain sections
- Presentation and discussion of data in written and oral form

Learning outcomes / competencies / targeted competencies:
- Students can explain theoretical approaches on rodent behavioral pharmacology and carry out respective experiments.
- Students have basic knowledge about selected brain transmitter systems in terms of physiology, chemical neuroanatomy and pharmacology
- Students can develop scientific hypotheses and find experimental solutions for testing them
- Students can statistically analyse scientific data, interpret and discuss them

Calculation of student workload:
112 h SWS / presence time / working hours
44 h Exam preparation
114 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:	Responsible for the module:
English	Prof. Dr. Michael Koch
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Behavioral Pharmacology

Type of examination: module exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / 1	
Language(s) of instruction: Englisch	
Description: PL (graded component): Project report and PVL: The PVL is a project report and has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2).	

Module courses

Course: Behavioral Pharmacology	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 8	**University teacher:** Prof. Dr. Michael Koch
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Behavioral Pharmacology
Associated module courses **Behavioral Pharmacology** (Laboratory class)	

Module 02-BIO-MA-MN-NE: Neuro- and Electrophysiology
Neuro- and Electrophysiology

Assignment to areas of study:	Content-related prior knowledge or skills:
• Elective modules Advanced Studies - new	There is a PVL (prerequisite for the examination) in this module which has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2). .

Learning content:

- Basics of electrical engineering and measurement technology for neuroscientists
- Building a measuring chain for microelectrode recordings
- Stereotactic surgery and recording
- Planning a neurophysiological recording experiment
- Performing neuronal single- and multi-unit recordings in the mammalian cortex
- Generation and testing of neurobiological hypotheses
- Quantitative, computer-based data analysis of neurophysiological and behavioral data
- Reporting and presentation of neurophysiological results

Learning outcomes / competencies / targeted competencies:

Students

- have a fundamental understanding of electrical engineering and measurement technology aspects required in electrophysiological experiments
- are capable to build up an electrophysiological measurement chain for microelectrode recordings
- can use stereotactic atlases for planning stereotactic recording experiments
- can plan and organize all aspects of an electrophysiological recording experiment to test specific neurobiolocal hypotheses
- are able to perform microelectrode recordings in the mammalian cortex including surgery and anesthesia
- know fundamental methods for analyzing single- and multi-channel electrophysiological data for hypothesis testing and are able to perform them by using and developing data analysis scripts
- can explain the neurobiology of sensory systems

Calculation of student workload:

144 h Preparation / follow-up work
112 h SWS / presence time / working hours
14 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:	Responsible for the module:
English	Prof. Dr. Andreas Kreiter
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]

The module is valid since / The module is valid until:	Credit points / Workload:
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Neuro- and Electrophysiology	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 2 / - / 1	
Language(s) of instruction: Englisch	
Description: PL 1 (graded component, 50%): protocol and PL2 (graded component, 50%): oral presentation and PVL: The PVL is a project report and has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2).	

Module courses

Course: Neuro- and Electrophysiology	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 8	**University teacher:** Dr. Detlef Wegener Prof. Dr. Andreas Kreiter
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Neuro- and Electrophysiology
Associated module courses **Neuro- and Electrophysiology** (Laboratory class)	

Module 02-BIO-MA-MN-ONM: Optogenetics and Neuroscience Methods
Optogenetics and Neuroscience Methods

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	There is a PVL (prerequisite for the examination) in this module which has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2).

Learning content:

- Molecular Biology techniques to design and construct optogenetic tools
- Cell culture techniques to express and analyze proteins
- Microscopy techniques
- Design and performance of tracer and optogenetic experiments
- Stereotactic surgery
- Immunohistochemical stainings and analysis
- Experimental design and investigation of different behaviors, such as anxiety, decision making
- Formation and testing of hypotheses
- Basics and good scientific practice of scientific writing and oral presentations

Learning outcomes / competencies / targeted competencies:

Students…

- have fundamental knowledge of basic techniques for the development of optogenetic tools
- can apply their knowledge to plan, perform and analyze optogenetic experiments
- understand brain anatomy and neurotransmitter systems
- can form and test hypotheses
- are able to deal with experimental data in a critical and qualified way

Calculation of student workload:

112 h SWS / presence time / working hours
14 h Exam preparation
144 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:	**Responsible for the module:**
English	Prof. Dr. Olivia Masseck
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Optogenetics and Neuroscience Methods	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 2 / - / 1	
Language(s) of instruction: Englisch	
Description: PL 1 (graded copmponent, 75%): Protocol (of laboratory work) and PL2 (graded component, 25%): oral presentation and PVL: The PVL is a project report and has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2)	

Module courses

Course: Optogenetics and Neuroscience Methods	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 8	**University teacher:** Prof. Dr. Olivia Masseck
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Optogenetics and Neuroscience Methods
Associated module courses **Optogenetics and Neuroscience Methods** (Laboratory class)	

Module 02-BIO-MA-MN-NN: Neuronal Networks
Neuronal Networks

Assignment to areas of study:	Content-related prior knowledge or skills:
• Elective modules Advanced Studies - new	There is a PVL (prerequisite for the examination) in this module which has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2).

Learning content:

- Principles of Neuronal networks
- Introduction to biosignals
- Understanding the origin of biosignals
- Different kinds of biosignals
- How to measure biosignals in man and mouse
- Interpretation and analysis of biosignals
- State of the art methods to investigate neuronal networks, such as Calcium Imaging
- Experience with data analysis of neuronal network data
- Get familiar with different forms of biosignals

Learning outcomes / competencies / targeted competencies:
Students
can understand the basic principles of neuronal networks
have fundamental knowledge of biosignals
can apply their knowledge of biosignals to measure them in man and mouse
can understand the functional principles of natural neuronal networks.
have in depth knowledge of principles of biosignals
understand the significance of brain modulatory systems in neuronal networks

Calculation of student workload:

Are there optional courses in the modules?
no

Language(s) of instruction:	Responsible for the module:
English	Prof. Dr. Sami Hassan
Frequency: summer semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Neuronal Networks

Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / 1 / 1	
Language(s) of instruction: Englisch	
Description: 1 PL (graded component) and 1 SL (ungraded component): to be named by new professor, and PVL: The PVL is a project report and has to be passed before starting the lab work to certify competence in safe handling of lab animals. The PVL consists of the passed project report required in the examination of module Laboratory Animal Science (Module MN-S2).	

Module courses

Course: Neuronal Networks	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours:	**University teacher:** Prof. Dr. Sami Hassan
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Neuronal Networks
Associated module courses **Neuronal Networks** (Laboratory class)	

Module 11-PSY-MA-MN-CPE: Cognitive Psychology and EEG
Cognitive Psychology and EEG

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	none

Learning content:

Seminar:

- Basics of Electroencephalography
- Analysis of Event-related Potentials
- Event-related Potentials and cognitive processing
- Event-related Potentials and clinical psychology
- Reading/Discussion of ERP-studies
- Planning EEG Experiment
- Literature search
- Discussion about research idea / definition of research question
- Preparation of experimental Setup

Practical Work:

- Data acquisition
- Data analysis (behavioral & EEG)
- Presentation of results

Learning outcomes / competencies / targeted competencies:

Students understand the research process in the context of EEG. They are able to plan and conduct an EEG-Study, analyze the data and discuss the results. They can communicate their results in a scientific context.

Calculation of student workload:

156 h Preparation / follow-up work
84 h SWS / presence time / working hours
30 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:	**Responsible for the module:**
English	Dr. Margarethe Korsch
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Cognitive Psychology and EEG

Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 2 / - / -	
Language(s) of instruction: Englisch	
Description: PL1 (graded component, 50%): Projects report and PL2 (graded component, 50%): oral presentation	

Module courses

Course: Cognitive Psychology and EEG	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 6	**University teacher:** Dr. Margarethe Korsch
Language(s) of instruction: Englisch	
Teaching method(s): Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Cognitive Psychology and EEG
Associated module courses **Cognitive Psychology and EEG** (Laboratory class)	

Module 11-PSY-MA-MN-CN: Cognitive Neuroscience
Cognitive Neuroscience

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	Knowledge about basic statistical methods is recommended

Learning content:

Seminar:

- Introduction to structural and functional Neuroimaging (fMRI, CT, SPECT, PET, fNIRS)
- Introduction to Biosignalanalysis (EEG/MEG)
- Experimental design and data analyses in fMRI and EEG
- ERPs, Frequency analyses, source analyses, fMRI-constrained source analysis
- Voxel density and individuality analyses
- Introduction to paper and protocol writing and scientific illustration
- Basic programming and data structuring for analyses
- Handling covariates and psychological testing

Practical work:

- Experimental design programming, optimization and appliance
- EEG-laboratory setup and EEG-data measurement
- MRI-laboratory setup and (f)MRI-data measurement

Learning outcomes / competencies / targeted competencies:

Students can…

- optimize experimental designs for EEG and fMRI studies
- measure and handle EEG- and fMRI-data measurements
- apply advanced EEG- and fMRI-data analyses strategies
- write neuroscientific protocols and papers

Calculation of student workload:

112 h SWS / presence time / working hours
30 h Exam preparation
128 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:	**Responsible for the module:**
English	Prof. Dr. Thorsten Fehr
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Modulprüfung Cognitive Neuroscience	
Type of examination: module exam	
Form of examination: Project report	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	

Module courses

Course: Cognitive Neuroscience	
Frequency: summer semester, yearly	**Are there parallel courses?** yes
Contact hours: 8	**University teacher:** Prof. Dr. Thorsten Fehr
Language(s) of instruction: Englisch	
Teaching method(s): Seminar Laboratory class	**Associated module examination:** Modulprüfung Cognitive Neuroscience

Module 02-BIO-MA-MN-fMRI: Functional MR Imaging
Functional MR Imaging

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	Fundamental knowledge about Matlab and scientific data handling are recommended.

Learning content:

Lectures:

- principles of MR physics
- experimental basics of MR Imaging (RF, magnetic field gradients, multidimensional FT)
- physiological fundamentals brain metabolism
- BOLD effect, modelling
- fMRI data analysis (data preprocessing, general linear model, basic statistical analysis)
- presentation of stimuli (block and event-related design)
- experimental optimization and artefact detection
- introduction into fMRI data analysis with the SPM software (Matlab based)

Practical work:

- safe behaviour in an MR lab
- MR-study: Students develop, conduct and analyse studies on their own-

1. formulate a scientific question / problem / hypothesis
2. develop an appropriate experimental setup (stimulus design, MR-parameters)
3. conduct measurements on volunteers (course participants)
4. analyse the acquired data (SPM, Matlab)

Seminar:

- present study and results to course participants

Learning outcomes / competencies / targeted competencies:
Students are able to design, conduct, analyze, and present an fMRI experiment. They comprehend the appropriate choice of MR and experimental design parameters relevant for the neuroscientific research topic.

Calculation of student workload:
40 h Exam preparation
112 h SWS / presence time / working hours
118 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Dr. Ekkehard Küstermann
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]

The module is valid since / The module is valid until:	Credit points / Workload:
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Functional MR Imaging	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / 1 / -	
Language(s) of instruction: Englisch	
Description: PL (graded component): Written examination and SL (ungraded component): presentation, oral	

Module courses

Course: Functional MR Imaging	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 8	**University teacher:** Dr. Ekkehard Küstermann
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Functional MR Imaging
Associated module courses **Functional MR Imaging** (Laboratory class)	

Module 03-INF-MA-MN-BPR: Brain Pattern Recognition
Brain Pattern Recognition

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	Prior completion of module S1 (Advanced Programming: Data Analysis and Modeling) is highly recommended to ensure that programming skills in Python and basic knowledge in data processing and neural modeling as well as machine learning are available.

Learning content:

Preparation:

- Recap of programming fundamentals with focus on data processing
- Introduction to important libraries (e.g. for EEG processing and visualization)
- Paper reading on Brain-Computer Interfaces (BCI)

Block Course:

- BCI experiment design
- EEG data recording for BCI
- Signal preprocessing & artifact handling
- Online Machine Learning (ML) for BCI
- Machine Learning evaluation & ML experiment management
- Integration of end-to-End BCI system

Learning outcomes / competencies / targeted competencies:

- Students have an in-depth understanding of all components of state-of-the-art end-to-end BCIs
- Students are able to design and conduct BCI experiments for specific applications and BCI paradigms
- Students are able to implement a pipeline for preprocessing and classification of EEG data
- Students are able to manage different classification setups systematically
- Students know how to interpret the results of an BCI evaluation
- Students are able to create end-to-end BCIs with simple adaptive user interfaces

Calculation of student workload:

154 h Preparation / follow-up work
32 h Exam preparation
84 h SWS / presence time / working hours

Are there optional courses in the modules?

no

Language(s) of instruction:	**Responsible for the module:**
English	Dr. Felix Putze
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Modulprüfung Brain Pattern Recognition	
Type of examination: module exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / - / -	
Language(s) of instruction: Englisch	
Description: Presentation and written assignment (of project)	

Module courses

Course: Brain Pattern Recognition	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 6	**University teacher:** Dr. Felix Putze
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Modulprüfung Brain Pattern Recognition
Associated module courses **Brain Pattern Recognition** (Laboratory class) **Gehirn-Muster-Erkennung** ()	

Module 03-INF-MA-MN-DSM: Digital Systems Modeling
Digital Systems Modeling

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	Prior completion of module MN-S1 (Advanced Programming: Data Analysis and Modeling) is highly recommended to ensure that programming skills in Python and basic knowledge in data processing and neural modelling are available. Knowledge of C/C++ is recommended.

Learning content:

State-of-the-art experimental paradigms and applications in neuroscience require fast analysis of an increasing numbers of neural signals using sophisticated algorithms, and the ability to communicate directly with miniaturized neurotechnology in low-power environments. This module provides the knowledge for using digital circuit logic (Verilog and HLS flow) to create hardware-based implementations of different data analysis algorithms to decrease their execution time, and for establishing closed-loop paradigms for data acquisition and stimulation control.

Lecture:

- Basics of digital logics
- Introduction into Verilog hardware description languages
- Introduction into FPGA architecture and design process
- Fundamentals of C programming language required to learn high-level synthesis (HLS)
- Introduction to HLS design flow and its importance in the hardware-based implementation of various applications.

Practical work and exercises:

- Modeling simple digital logic and hardware blocks in Verilog
- Modeling hardware blocks related to parallel programming in Verilog
- Introduction to HLS tools
- Implementing different parallel programming related applications using HLS

Learning outcomes / competencies / targeted competencies:

At the end of this course students

- know basics and fundamentals of digital system modeling
- have a fundamental background knowledge about FPGA architecture and design process for parallel programming
- are able to use hardware description language like Verilog to model hardware blocks of different applications
- can understand and use HLS design flow to create the hardware-based implementation of various applications

Calculation of student workload:

84 h SWS / presence time / working hours
50 h Exam preparation
136 h Preparation / follow-up work

Are there optional courses in the modules? no

Language(s) of instruction: English	**Responsible for the module:** Prof. Dr. Rolf Drechsler
Frequency: summer semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Digital Systems Modeling	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 2 / - / -	
Language(s) of instruction: Englisch	
Description: PL 1 (graded component, 50%): Portfolio, consisting of exercises and PL2 (graded component, 50%): oral examination	

Module courses

Course: Digital Systems Modeling	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 6	**University teacher:** Dr. Muhammad Hassan
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Digital Systems Modeling
Associated module courses **Digital System Modelling** (Lecture)	

Module 01-PHY-MA-MN-NMA: Network Modeling and Analysis
Network Modeling and Analysis

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	Prior completion of module MN-S1 (Advanced Programming: Data Analysis and Modeling) is highly recommended to ensure that programming skills in Python and basic knowledge in data processing and neural modeling are available. Basic knowledge in statistics, calculus, and linear algebra are recommended.

Learning content:
Students will focus on a specific topic in network modeling and analysis as well as pursue a mini research project following a three-staged process for mimicking real lab research (reading & preparation, setup & simulation/analysis, interpretation & dissemination). They will

(a) select a specific topic of interest and become acquainted with the fundamental concepts and associated mathematical methods (by reading original literature, lectures, and individual supervision),

(b) reproduce key results from the literature by performing a numerical simulation or mathematical analysis of a neural network or computational model, and

(c) summarize their findings in a concise manner, and present them to their fellow students and supervisors in a comprehensive manner.

For their mini-projects, students can select from different topics, like:

(a) Collective dynamics in networks of recurrently coupled neurons (e.g. synchronization and oscillations, feature integration, non-linear dynamics of elementary circuits).

(b) Computation, inference, and classification (e.g. generative models, efficient coding, Bayesian methods, convolutional networks)

Lecture:

- Advanced concepts and methods in Theoretical Neurosciences, with focus on network dynamics and neural computation.
- Seminar:
- Presentation of seminal research articles on the selected topics in mini-projects
- Presentation of results of mini-projects

Seminar:

- Presentation of seminal research articles on the selected topics in mini-projects
- Presentation of results of mini-projects

Laboratories:

- Practical project work on a computer (or analytically), closely supervised by supervisors.

Learning outcomes / competencies / targeted competencies:
Students are able to acquire novel computational/mathematical concepts from research literature, and explain these concepts to other scientists

Students can set up a suitable neural network model for investigating dynamics or computation in brain networks

Students are able to perform numerical simulations of network models on a computer

Students can apply appropriate mathematical tools to analyze network dynamics or quantify information processing

Calculation of student workload:
28 h Exam preparation
112 h SWS / presence time / working hours
130 h Preparation / follow-up work

Are there optional courses in the modules?
no

Language(s) of instruction:	**Responsible for the module:**
English	Dr. Udo Alexander Ernst
Frequency:	**Duration:**
summer semester, yearly	1 semester[s]
The module is valid since / The module is valid until:	**Credit points / Workload:**
WiSe 23/24 / -	9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Network Modeling and Analysis

Type of examination: combination exam

Form of examination:	**The examination is ungraded?**
See free text	no

Number of graded components / ungraded components / prerequisites of the examination:
1 / 1 / -

Language(s) of instruction:
Englisch

Description:
1 PL: Presentation and written assignment (of mini-project and its results) and 1 SL: oral presentation (of the literatiure relevant for the mini-project selected by the student)

Module courses

Course: Network Modeling and Analysis

Frequency:	**Are there parallel courses?**
summer semester, yearly	no

Contact hours: 8	**University teacher:** David Rotermund Dr. Udo Alexander Ernst
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Seminar Laboratory class	**Associated module examination:** Kombinationsprüfung Network Modeling and Analysis
Associated module courses **Network Modeling and Analysis** (Lecture)	

Module 03-INF-MA-MN-FML: Fundamentals of Machine Learning
Fundamentals of Machine Learning

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Elective modules Advanced Studies - new	Prior completion of module MN-S1 (Advanced Programming: Data Analysis and Modeling) is highly recommended to ensure that programming skills in Python and basic knowledge in data processing and neural modeling are available. Basic knowledge in statistics, calculus, and linear algebra are recommended.

Learning content:

Machine learning (ML) is a subdiscipline of artificial intelligence which grew and gained a lot of popularity in the last two decades. This course serves as an introduction to this field with the goal to enable students to solve problems in the field of ML independently. We focus on the most common approaches and their implementation in Python. Therefore, we focus on intuitive understanding down to the realization in code, instead of covering every formal proof or as many methods as possible. There are no weekly exercises, but an accompanying assignment which can be used to train the application of the learned methods to a larger ML task. The content is taught through Living Python Slides.

Covered Topics:

- Machine Learning Basics
- Classification
- Clustering
- Generative Models
- Discriminative Models
- Regression
- Ensemble Methods
- Neural Networks

Learning outcomes / competencies / targeted competencies:

- Students are able to identify practical problems in the field of ML independently
- Students are able to propose solution strategies for problems in the field of ML
- Students understand different algorithms for classification and regression problems and know their advantages and drawbacks
- Students are able to preprocess and visualize data
- Students can evaluate ML algorithms

Calculation of student workload:

84 h SWS / presence time / working hours
144 h Preparation / follow-up work
42 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction: English	**Responsible for the module:** Prof. Dr. Tanja Schultz
Frequency: summer semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 9 / 270 hours

Module examinations

Module examination: Kombinationsprüfung Fundamentals of Machine Learning	
Type of examination: combination exam	
Form of examination: See free text	**The examination is ungraded?** no
Number of graded components / ungraded components / prerequisites of the examination: 1 / 1 / -	
Language(s) of instruction: Englisch	
Description: 1 PL (graded component): written examination and 1 SL (ungraded component): Assignment	

Module courses

Course: Fundamentals of Machine Learning	
Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 6	**University teacher:** Prof. Dr. Tanja Schultz
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Laboratory class	**Associated module examination:** Kombinationsprüfung Fundamentals of Machine Learning
Associated module courses **Fundamentals of Machine Learning** (Laboratory class) **Grundlagen des Maschinellen Lernens** ()	

Module 02-BIO-MA-MN-MAS: Module Master Thesis (including Colloquium)

Module Master Thesis (including Colloquium)

Assignment to areas of study:	**Content-related prior knowledge or skills:**
• Master thesis - new	At least 60 CP from compulsory, elective and compulsory elective modules of the M.Sc. Neurosciences. All compulsory and compulsory elective modules from the first study year have to be passed, as well as one Lab Project (3rd semester).

Learning content:

Students will perform subject-specific research either in the different working groups in Bremen participating in the MSc. Neuroscience programme, elsewhere in Germany or abroad.

The module Master Thesis aims at the training and individual independent performance of a research project under supervision of a senior scientist in the framework of inquiry-based learning. The master thesis project is supervised and conducted under the conditions of the respective department at the University of Bremen and the examination regulations of the respective study programme.

This includes getting familiar with the scientific context (literature) of the proposed topic, working out a well-defined research question, developing a suitable paradigm for investigating that question, **experimental or theoretical work** inside the lab, and analysis and critical assessment of the acquired/generated data and results. Students will actively attend lab seminars, and present aspects of their work such as project outlines and/or progress reports. Finally, students will learn how to write and to defend a Master Thesis which contains a concise description of background, approach, methods, results, and discussion of their research project.

The module includes compulsory elective choices (Wahlpflicht WP) of 24 weeks (or upon request 32 weeks) duration:

WP1: The practical work is conducted in a research group at the University of Bremen

WP2: The practical work is conducted as an internship student integrated in an external national or international research group

Learning outcomes / competencies / targeted competencies:

Students…

- are able to work on a research topic with relative independence
- can develop suitable paradigms (experiments, models, analysis procedures) for investigating a specific research question
- can acquire, analyse, statistically evaluate, and interpret data on an advanced level…
- …and/or can develop, implement, and simulate models on an advanced level
- can summarize the approach, methods, and results of their research project in a Master Thesis
- are able to critically assess novelty and relevance of their research results in the context of previous studies and the state-of-the-art reported in current literature
- can convey the idea and results of their Thesis in an oral presentation to a scientific audience, and defend their insights in a discussion with other scientists

Calculation of student workload:
544 h Preparation / follow-up work
188 h Exam preparation
168 h SWS / presence time / working hours

Are there optional courses in the modules?
yes
The module includes compulsory elective choices (Wahlpflicht WP) of 24 weeks (or upon request 32 weeks) duration:

WP1: The practical work is conducted in a research group at the University of Bremen

WP2: The practical work is conducted as an internship student integrated in an external national or international research group

Language(s) of instruction: English	**Responsible for the module:** Dr. Udo Alexander Ernst
Frequency: summer semester, yearly	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: WiSe 23/24 / -	**Credit points / Workload:** 27 / 810 hours

Module examinations

Module examination: Master Thesis (including Colloiquium)

Type of examination: module exam

Form of examination: See free text	**The examination is ungraded?** no

Number of graded components / ungraded components / prerequisites of the examination:
2 / - / -

Language(s) of instruction:
Englisch

Description:
PL1 (graded component, 75%): Master Thesis and PL2 (graded component, 25%): Colloquium

Module courses

Course: Master Thesis (including Colloquium)

Frequency: summer semester, yearly	**Are there parallel courses?** no
Contact hours: 12	**University teacher:** N. N.

Language(s) of instruction:
Englisch

Teaching method(s):	**Associated module examination:**
Self-study unit	Master Thesis (including Colloiquium)

Module 02-BIO-MA-0-MN: Supplementary Courses in the Master Neurosciences
Supplementary Courses in the Master Neurosciences

Assignment to areas of study: • Supplementary Courses	**Content-related prior knowledge or skills:** none

Learning content:

Learning outcomes / competencies / targeted competencies:

Calculation of student workload:

Are there optional courses in the modules?
no

Language(s) of instruction: English	**Responsible for the module:** N.N.
Frequency: (depending on capacity) winter or summer semester	**Duration:** 1 semester[s]
The module is valid since / The module is valid until: SoSe 24 / -	**Credit points / Workload:** 0 / 0 hours

This module is ungraded!

Module examinations

Module examination: with examination or without examination

Type of examination: module exam

Form of examination: See free text	**The examination is ungraded?** yes

Number of graded components / ungraded components / prerequisites of the examination:
- / 1 / -

Language(s) of instruction:
Englisch

Module courses

Course: Lab Safety and Fire Prevention Workshop (in English)

Frequency: (depending on capacity) winter or summer semester	**Are there parallel courses?** no
Contact hours:	**University teacher:** N. N.

Language(s) of instruction:
Englisch

Teaching method(s): Lecture Tutorial	**Associated module examination:** with examination or without examination
Associated module courses **Lab Safety and Fire Prevention Workshop (in English)** (Lecture)	

Course: First introductory meeting	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours:	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture	**Associated module examination:** with examination or without examination

Course: RefreshIT	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours:	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Lecture Tutorial	**Associated module examination:** with examination or without examination

Course: Supplementary Courses in the Master Neurosciences	
Frequency: winter semester, yearly	**Are there parallel courses?** no
Contact hours:	**University teacher:** N. N.
Language(s) of instruction: Englisch	
Teaching method(s): Tutorial Seminar Field trip	**Associated module examination:** with examination or without examination