Master's program

Interdiciplinary Neuroscience

Course Manual

To the examination regulations 2023

October 2024

Compulsory Modules

	Name of module
INS IN 1	Introduction to Neuroscience 1
INS IN 2	Introduction to Neuroscience 2
INS BM	Basic Methods in Neuroscience
INS MN	Methods in Neuroscience
INS CC	Current Concepts in Neuroscience
INS MA	Master thesis

Elective modules with optional courses

INS A: Elective Module Basic Neuroscience

	Optional courses in elective A: Basic Neuroscience	**Person in charge**
INS A-0	External elective course “Basic Neuroscience”	Head of Master’s program
INS A-7	Neurobiology of the Nematode *Caenorhabditis elegans*	Prof. Alexander Gottschalk
INS A-9	Multi-electrode recordings of the dopamine system	Prof. Jochen Roeper
INS A-10	Neurophysiology and Behaviour	Prof. Bernd Grünewald
INS A-12	The Neuro-Vascular Interface	PD Dr. Stefan Liebner
INS A-14	Genetics and Epigenetics of Neurogenesis and Gliogenesis	Prof. Dorothea Schulte
INS A-15	Recording neuronal activity in freely behaving animals	Dr. Torfi Sigurdsson
INS A-17	Auditory Function and Dysfunction: Behavior and Physiology	PD Dr. Bernhard Gaese
INS A-18	Information Processing in the Central Auditory System	PD Dr. Bernhard Gaese
INS A-19	Neuronal basis of acoustic communication in mammals	Dr. Julio Hechavarria
INS A-21	Cellular, molecular and systemic Neurobiology in mouse and zebrafish	Prof. Amparo Acker-Palmer
INS A-23	Cellular and molecular mechanisms in neurovascular disorders	Prof. Jasmin Hefendehl
INS A-24	Deciphering brain activity during natural behaviour in real time	Dr. Martha Havenith, Dr. Marieke Schölvinck
INS A-25	Neuroscience of Navigation and Self-Motion	Dr. Jean Laurens

INS A-26	Analysis of Social Networks	Dr. Alison Barker
INA A-27	Instinctive Behaviour Circuits	Dr. Vanessa Stempel

INS B: Elective Module Clinical Neuroscience

	Optional courses in elective B: Clinical Neuroscience	**Person in charge**
INS B-0	External elective course “Clinical Neuroscience”	Head of Master’s program
INS B-4	Plasticity in Hippocampus – Morphology, Physiology, and Clinical Relevance	Prof. Thomas Deller
INS B-6	Experimental Brain Tumor Therapy	Prof. Donat Kögel
INS B-8	Clinical Neuroimaging	Prof. Stefan Weidauer
INS B-9	Clinical Auditory Neuroscience	Prof. Uwe Baumann
INS B-10	Experimental and Translational Psychiatry	Prof. David Slattery
INS B-11	Neurobiological human cell models	Dr. Denise Haslinger
INS B-12	Neuroimaging Biomarkers in Psychiatry	Prof. Christine Ecker
INS B-13	Translational Neuro-Oncology Research	Dr. Ann-Christin Hau
INS B-14	Computational Translational Psychiatry	Prof. Andreas Chiocchetti

INS C: Elective Module Cognitive and Computational Neuroscience

	Optional courses in elective C: Cognitive and Computational Neuroscience	**Person in charge**
INS C-0	External elective course „Cognitive and Computational Neuroscience“	Head of Master’s program
INS C-1	Modern non-invasive Methods in Human Cognition research	Prof. Jochen Kaiser
INS C-4	Virtual Hippocampus - Introduction to Computational Neuroscience	Prof. Peter Jedlicka
INS C-7	Cognitive Neuroscience – Higher Cognitive Functions	Prof. Christian Fiebach
INS C-8	Systems Neuroscience – Sensorimotor and Cognitive Networks	PD Dr. Christian Kell
INS C-10	Computational Neuroanatomy – quantitative analysis and modelling	Dr. Hermann Cuntz

INS C-11	Computational Modeling of Neuronal Plasticity	Prof. Jochen Triesch
INS C-15	Developmental and Cognitive Neuroscience	Prof. Yee-Lee Shing
INS C-16	Cognitive and perceptual processes in the human brain	Prof. Rosanne Rademaker

INS D: Elective Module Applied Neuroscience

	Optional courses in elective D: Applied Neuroscience	**Person in charge**
INS D-0	External elective course „Applied Neuroscience“	Head of Master’s program
INS D-1	Behavioral Biology in Zoos	Prof. Paul Dierkes
INS D-2	Attention analysis of students’ media use via eye-tracking	Dr. Maruschka Weber

INS WP: Free choice studies

INS WP	Free-choice studies	Head of Master’s program

Compulsory Modules:

INS IN 1 **Introduction to Neuroscience 1**	**Einführung in die Neurowissenschaften 1**	**Compulsory module**	**8 CP = 240 h**		**8 CP**
			Contact study **7 SWH / 105 h**	**Self study** **135 h**	

Content

Introductory session (WS)
Introducing neurobiology research in Frankfurt. Presenting the Master’s program
Lecture Selected topics in Neuroscience I (WS)
Content: Cellular, molecular and physiological background to the function of nerve and glia cells. Mechanisms of signal transduction. Plasticity, learning, memory, sensory systems, motor control, nervous system function, basis of cognition, development of the nervous system, rhythmic control of nerve function and anatomy of the human brain, good scientific practice
Seminar related to the lecture Selected topics in Neuroscience I (WS)
The students will assess research papers relevant to the lectures
Colloquium (WS, SS)
Participation in 7 neuroscience-oriented colloquia in the institutes
Weekend seminar (WS)
Presenting and discussing research projects within the Master’s programme; thematisation of ethical and legally relevant aspects in the neurosciences

Learning results / Competence objectives

The students have a broad interdisciplinary basic knowledge of the neurosciences and their possible applications. They are familiar with neuroscientific research concepts and are able to link different subfields and paradigms of neuroscience. They will be able to critically assess scientific research papers in the form of an oral presentation. They have knowledge of the guidelines for good scientific practice.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of module (program / department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	In the winter semester, colloquia also in the summer semester
Duration	2 Semesters
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	Proof of participation (regular and active participation) for all events, (except lectures)
Study achievements	1 seminar talk (30 minutes) in the seminar to the lecture series "Selected Topics in Neuroscience I"
Teaching forms	Lecture, seminar, colloquia
Tuition language	English
Module exam	**Form / duration/ content(if applicable)**
Module final exam consisting of:	Written exam for the lecture "Selected Topics of Neuroscience I" (duration: 90 minutes)

Introduction to Neuroscience 1	Form of teaching	SWH	CP	Semester			
				1	2	3	4
Lecture Selected topics in Neuroscience I	V	3	4	X			
Seminar to the lecture Selected topics in Neuroscience I	S	1	2	X			
Introductory session	V	1	0.5	X			
Colloquia	Ko	0.5	0.5	X			
Weekend seminar	S	0,5	1	X			

	Sum		7	8				

INS IN 2 **Introduction to Neuroscience 2**	**Einführung in die Neurowissenschaften 2**	**Compulsory module**	**5 CP = 150 h**		**5 CP**
			Contact study **3 SWH / 45 h**	**Self study** **105 h**	

Content

Lecture Selected topics in Neuroscience II (SS)
The lecture delves into specific aspects of experimental neurology, pathology and diagnostics including non-invasive studies of the human brain, degenerative diseases of the nervous system and medical psychology, as well as methodological developments such as optogenetics.
Seminar to the Lecture Selected topics in Neuroscience II (SS)
The students will assess research papers relevant to the lectures

Learning results / Competence objectives

The students have a broad interdisciplinary basic knowledge of the neurosciences and their possible applications. They are familiar with neuroscientific research concepts and are able to link different subfields and paradigms of neuroscience. They will be able to critically assess scientific research papers in the form of an oral presentation.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of module (program / department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	In the Summer semester
Duration	1 Semester
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	Proof of participation (regular and active participation) for the seminar
Study achievements	1 seminar talk (30 minutes) in the seminar to the lecture series "Selected Topics in Neuroscience II"
Teaching forms	Lecture, seminar
Tuition language	English
Module exam **Module final exam consisting of:**	**Form / duration/ content(if applicable)** Written exam for the lecture "Selected Topics of Neuroscience II" (duration: 90 minutes)

	Introduction to Neuroscience 2	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Lecture Selected topics in Neuroscience II	V	2	3		X		
	Seminar to the lecture Selected topics in Neuroscience II	S	1	2		X		
	Sum		3	5				

INS BM **Basic Methods in Neuroscience**	**Basismethoden der Neurowissenschaften**	**Compulsory module**	**13 CP = 390 h**		**13 CP**
			Contact study 11 SWH / 165 h	**Self study 225 h**	

Content

The module focusses on the following areas:

(1) Methods of cell biology, molecular biology and genetics: Imparting of knowledge on practical and theoretical basics for working with chemical solutions, physical-chemical features of proteins and their isolation, subcellular fractioning and centrifugation, preparation of cell cultures, immune-histology and microscopy and the basic principles of molecular genetics and genomics.

(2) Anatomy of the central nervous system: Using slices, plastic models and stored data-sets the structure and the development of the human brain and spinal cord are shown, including the autonomous nervous system and the cerebral blood supply. Furthermore imaging methods like MRI and fMRI are introduced. Also the evaluation of brains and animal model organisms are discussed.

(3) Electrophysiology: In lectures and seminars/discussions the basics of membrane potentials, action potentials, forwarding of potentials, synaptic morphology/geometry/function are dealt with. Important methods for recognition and analysis of single neurons (extracellular, intracellular, patch-clamp) and neural networks activity are discussed. Both electrical and optical techniques of neural stimulation are presented.

(4) MATLAB-programming and statistics: Basics of programming of neural data recordings and analysis with MATLAB are discussed. A focus lies on practical programming exercises. Basic statistical methods are introduced, discussed and realised in MATLAB.

(5) Legal and ethical aspects of animal experimentation, genetic manipulations, biological safety and proper scientific conduct are imparted.

Learning results / Competence objectives

Within this module the students learn to discuss intensely and independently theoretical as well as practical contents of the study. They attain practical competence in cellular and molecular lab techniques, cell culture techniques and programming of neuro-biological questions in MATLAB. When having finished the module they have basic knowledge on neurogenetics. They have fundamental knowledge on human brain anatomy as well as animal models, can identify important cerebral structures and interpret histological preparations adequately. They possess basic knowledge regarding neural potentials and synaptic mechanisms and can assess potentialities and limitations of electro-physiological technologies. They can apply adequate statistical methods in assessing significance and comparison of neural records. They will attain competence regarding rules of good scientific practice, and to keep the directives regarding genetic works, bioassay practices, and animal welfare.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of module (program / department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	In the winter semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	Regular participation in all events (except lectures)
Study achievements	Successful completion of study achievements ("pass") in the form of tests/exercises following each of the focus areas listed under "Content" or a portfolio across all focus areas.

Teaching forms	Lecture, seminar, exercises
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	none

		Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Basic Methods in Neuroscience	V, S, Üb	11	13	X			
	Methods of cell biology, molecular biology and genetics	V, S, Üb						
	Anatomy of the central nervous system	V, S, Üb						
	Electrophysiology	V, S, Üb						
	MATLAB programming and statistics	V, Üb						
	Legal and ethical aspects of animal experimentation	V, Üb						
	Sum		11	13				

INS MN Methods in Neuroscience	**Vertiefung neurowissenschaftlicher Arbeitstechniken**	**Compulsory module**	**15 CP = 450 h**		**15 CP**
			Contact study 15 SWH/ 225 h	**Self study 225 h**	

Content

The module is a practical on “Deepening scientific research techniques”. The aim is to teach the students as much as possible about the most important experimental techniques recommended for the specialised topics of their Master’s project so that their thesis work can be completed successfully in the time available.

Learning results / Competence objectives

After completing the module, the students will be familiar with the basic techniques that apply directly to a Master’s project in their chosen topic. They will be able to efficiently find information about methods from publications and the Internet and evaluate the feasibility of experimental designs. They will be competent in criticizing methods and assessing artefacts.

Requirements for participating

Successful completion of the modules “Introduction to Neuroscience I”, “Introduction to Neuroscience II” and “Basic Methods in Neuroscience” as well as at least 2 out of the 3 elective modules.

Helpful previous knowledge

none

Assignment of module (program / department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	Representatives of elective modules
Semester-related proofs	
Proof of participation	
Study achievements	Protocol (10–30 pages)
Teaching forms	Practical
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	none

Methods in Neuroscience	Form of teaching	SWH	CP	Semester			
				1	2	3	4
Practical	P	15	15			X	

INS CC **Current Concepts in Neuroscience**	**Forschungskonzepte in den Neurowissenschaften**	**Compulsory module**	**16 CP = 480 h** **Contact study 16 SWH / 245 h** / **Self study 235 h**	**16 CP**

Content

The module comprises a project work and a seminar with the aim of providing students with the essential theoretical basis for developing a research concept in a neurobiological subfield. After familiarization with current literature work, students will identify critical open questions and develop research strategies to address them. During the seminar, the different research directions of the Master's program will be presented and discussed in the form of scientific posters.

Learning results / Competence objectives

Upon completion of the module, students are familiar with the development of scientific research concepts and are able to integrate them into a third-party funding proposal. The students have developed judgment regarding the relevance and realism of different and also contradictory theories and research concepts. The students acquire extended competences regarding rules of good scientific practice and ethical aspects of neuroscience. They are able to design, present and discuss a scientific poster.

Requirements for participating

Successful completion of the modules “Introduction to Neuroscience I”, “Introduction to Neuroscience II” and “Basic Methods in Neuroscience” as well as at least 2 out of the 3 elective modules.

Helpful previous knowledge

none

Assignment of module (program / department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester block course over 6 weeks)
Person in charge	Representatives of elective modules
Semester-related proofs	
Proof of participation	
Study achievements	Written research concept (10–20 pages), 1 seminar talk (20 minutes), Production/presentation of 1-2 scientific posters
Teaching forms	Project, seminar
Tuition language	English
Module exam **Module final exam consisting of:**	**Form / duration / content (if applicable)** none

Current Concepts in Neuroscience	Form of teaching	SWH	CP	Semester 1	2	3	4
Projectwork	Proj	15	15			X	
Weekend seminar	S	1	1			X	
Sum		16	16				

INS MA Masterthesis	Masterarbeit	Compulsory module	30 CP = 900 h		30 CP
			Contact study 30 SWH / 450 h	Self study 450 h	

Content

As part of the Master’s degree, the student works on a problem from the field of neuroscience comprehensively and in depth according to scientific methods. The work can be experimental, empirical or analytic. The results must be written up in a Master’s thesis in the style of a scientific paper. The quality of the work will be assessed based on the written thesis by the supervisor and a second referee

Learning results / Competence objectives

After successful completion of the Master's thesis, students are able to identify, delimit and explain a research-related scientific problem in a subfield of neuroscience. They will be able to analyze, evaluate or solve it using specialized knowledge and scientific methods. They are able to critically analyze relevant contributions to research and assess their relevance to their own research question. They are able to appropriately present and critically evaluate the results within a given period of time using scientific standards, and to recognize and assess central lines of development in the relevant subfield.

Requirements for participating

Proof of at least 79 CP

Helpful previous knowledge

none

Assignment of module (program / department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester
Person in charge	Representatives of elective modules
Semester-related proofs	none
Proof of participation	
Study achievements	
Teaching forms	
Tuition language	English
Module exam **Module final exam consisting of:**	**Form / duration / content (if applicable)** Graded written work in the form of a Master’s thesis (40–90 Seiten) the grade is double weighted against the grades of all other modules.

Masterthesis	Form of teaching	SWH	CP	Semester			
				1	2	3	4
Masterarbeit		30	30				X

Optional courses in elective A: Basic Neuroscience

INS A-0 External elective course “Basic Neuroscience”	Externe Wahlpflichtver-anstaltung„ „Neurowissen-schaftliche Grundlagen-forschung“	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

This elective course teaches basic methods and techniques in the field of basic neuroscience research. Students work on their own current projects under supervision.
The elective course can be offered by departments of Goethe University, by other universities in Germany and abroad as well as by non-university research institutions.

Learning results / Competence objectives

The students have knowledge in conducting neurobiological experiments in the field of basic research. They are able to work on scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Depending on provider
Duration	Depending on provider
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	Regular participation
Study achievements	The regulations of the provider of the elective course are applied. If the provider does not request any study proofs, a working report must be written,and talks have to be given on both, results of own experiments (20 minutes) and topical literature (20 minutes).
Teaching forms	Practical, seminar
Tuition language	Depending on provider
Module exam **Module final exam consisting of:**	**Form / duration / content (if applicable)** The regulations of the provider of the elective course are applied. If grading is not scheduled by the provider, the module completion exam shows a graded protocol (10-30 pages).

External elective course “Basic Neuroscience”	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS A-7 Neurobiology of the Nematode *Caenorhabditis elegans*	**Neurobiologie des Nematoden *Caenorhabditis elegans***	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

This course teaches basic methods for studying the nervous system of Caenorhabditis elegans. More general molecular biology methods will be used, genetic methods (crosses, genotyping) as well as simple behavioral assays, without and with the influence of specific agonists for ligand-gated ion channels (nicotinic acetylcholine receptors, GABAA receptors), which are used for general characterization of the function of the neuromuscular synapse. In addition, cell biological methods for expression analysis of transgenes (GFP fusion proteins) or endogenous proteins (via specific antibodies) depending on the genetic background, are part of the standard repertoire of the laboratory. More specific methods used are exogenous stimulation of neurons in C. elegans by light mediated by the transgene expressed photo-activated cation channel channelrhodopsin-2, and electrophysiological recordings from C. elegans muscle cells.

Learning results / Competence objectives

Students have knowledge of standard methods for the analysis of an invertebrate nervous system, genetic methods for crossbreeding, and cell biological and molecular biological methods. They will be able to address scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSC Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4-6- weeks)
Person in charge	Prof. Alexander Gottschalk
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments; Practical: 1 work report (if the final module exam is a written exam).
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10–30 pages) or written exam (45 mintes)

Neurobiology of the Nematode *Caenorhabditis elegans*	Form of teaching	SWH	CP	Semester			
				1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS A-9 **New title and content coming soon**	**Kognition in Mausmodellen für psychische Störungen: Schwerpunkt auf dopaminergen Systemen**	**Elective course**	**11 CP = 330 h** **Contact study 11 SWH / 165 h** / **Self study 165 h**	**11 CP**

Content

The practical covers basic in vivo electrophysiological techniques of the dopaminergic midbrain system and neuronal imaging of dopamine dynamics in the striatum with fiber photometry during behavioural tasks in mice. The students work on their own projects under supervision and present their results in the form of a seminar talk. In a further seminar talk they present an original piece of research from the field of basal ganglia neurophysiology and pathophysiology (e.g. Parkinsos's disease, schizophrenia, drug addiction). The main focuses are measuring and evaluating neuronal activity and its behavioral and dopamine release correlates. This also includes using statistical evaluation methods. The students learn about the associated stochastic background and how to use the relevant software or how to implement data analysis in Matlab, which involves interdisciplinary cooperation with the BSc/MSc courses in mathematics.

Learning results / Competence objectives

Students will have knowledge to perform electrophysiological, behavioral, and fiber photometric experiments to measure and analyze the electrical activity of dopaminergic neurons and changes in fluorescence that reflect dopamine dynamics in vivo. They can combine in vivo techniques with neuroanatomical and immunohistological analyses. They have knowledge of basic computational modeling of neuronal activity and stochastic description and statistical analysis of recorded time-sequence data. They have an understanding of the molecular pathophysiological relationship between major diseases of the dopaminergic system and the corresponding mouse models, with particular emphasis on schizophrenia.

Requirements for participating

none

Helpful previous knowledge

Matlab knowledge

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Dr. Natascha Diamantopoulou/ Prof. Jochen Roeper/ Prof. Gaby Schneider
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Cognition in mouse models of mental disorders: focus on dopaminergic systems	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS A-10 Neurophysiology and Behaviour	Neurophysiologie und Verhalten	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The practical investigates the neurophysiological basis of behaviour control. The students work on their own project on a theme defined together beforehand. The techniques that are taught include: cell physiology (patchclamp conductance, intracellular conductance, calcium imaging, cell culture); neuroanatomy (staining methods, brain preparation, confocal laser microscopy, fluorescence microscopy); behavioural experiments (behaviour pharmacology, extracellular conductance, learning and memory, social behaviour). Insects (honey bees, drosophila) are used as model organisms. The principle areas are: how ion channels and transmitter receptors work, neuromodulation, learning behaviour, olfactory memory formation, and social behaviour of bees. The students present their results in the form of a seminar talk and poster. In a further seminar talk they learn how to critically assess analytic physiological and behavioural research papers. These presentations are held in English and the students receive comprehensive feedback about the content and style of the presentation. They become familiar with writing a scientific publication by producing a protocol in the form of a paper.

Learning results / Competence objectives

The students can plan, carry out and evaluate neurobiological experiments. They have knowledge in the measurement of ionic currents and perform behavioral observations and behavioral quantifications. They are familiar with neuroanatomical methods. They are familiar with approaches to scientific questions and literature work and prepare scientific papers and presentations.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Bernd Grünewald
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Neurophysiology and Behaviour	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10		X		
	Seminar	S	1	1				
	Sum		11	11				

INS A-12 The Neuro-Vascular Interface	Die neuro-vasculäre Schnittstelle	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The course provides basic theoretical and experimental knowledge of the cerebrovascular system in embryonic development and under pathological conditions. The research focus is the development and maintenance of the blood-brain barrier (BBB), and its importance for neuronal function. Students will participate in current experiments in the laboratory setting that will contribute to the understanding of the molecular mechanisms of BBB formation. This work may include the following: basic work with transgenic mouse models (various reporter mouse lines for detection of the Wnt signaling pathway, as well as conditional/inducible "gain-" and "loss-of-function" lines), processing of brain tissue for in situ hybridization and immunohistochemistry, Isolation of cortex microcapillaries from mice, transfection and infection techniques of cells, immunofluorescence, confocal and live-cell microscopy, biochemical techniques such as protein gel electrophoresis, western blot and immunoprecipitation.

Learning results / Competence objectives

Students know basic techniques of cellular and molecular neurobiology. By the end of the course, they will have gained experience with transgenic mice and/or cells in vitro, and they will have learned how to process brain tissue from mice according to subsequent methods. Students operate in an international environment and are able to communicate and write scientifically in English.

Requirements for participating

None

Helpful previous knowledge

None

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Dr. Stefan Liebner
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	The Neuro-Vascular Interface	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10		X		
	Seminar	S	1	1				
	Sum		11	11				

INS A-14 Genetics and Epigenetics of Neurogenesis and Gliogenesis	Genetik und Epigenetik der Neurogenese und Gliogenese	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The topic of this practical is the control of neuron and glia production by genetic and epigenetic processes. We study this in healthy organisms and in different disease states, with a focus on glial, brain tumors and childhood neurodevelopmental disorders. Depending on the ongoing projects at the time of the course, the course will teach the following skills: bioinformatic analyses of existing genome-wide datasets (ChIP-seq, RNA-seq), culturing and differentiation of cell lines and stem cells (adult neural stem cells, mouse ES cells), qPCR, CRISPR/Cas-based methods for genome modification, retro- and lentiviral gene transfer, immunohistochemistry and microscopy, basic biochemical methods.
Students work as full members of the research group, with supervision, on their own small projects.

Learning results / Competence objectives

Students have hands-on experience with basic as well as some advanced molecular¬genetic methods. They have solid knowledge of the regulation of gene expression, different epigenetic modifications on chromatin (e.g. histone modifications, DNA methylation) and stem cell biology. Students will have gained experience in developing and conducting their own research project.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Dorothea Schulte
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Genetics and Epigenetics of Neurogenesis and Gliogenesis	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS A-15 Recording neuronal activity in freely behaving animals	**Ableitungen der neuronalen Aktivität in sich frei bewegenden Tieren**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

During this event, participants will learn methods for studying neuronal activity in freely moving animals. This will focus on one of two methods (depending on the experiments running in the lab during the time window of the course): extracellular recordings using fixed implanted electrodes or calcium imaging using a miniaturized microscope. Participants will learn to perform behavioral tests in mice, how measurement probes are implanted in the mouse brain using stereotactic surgery, both the theory behind the measurement methods and their use for recording neural activity during behavioral tasks; methods for analyzing neural signals related to mouse behavior; and histological methods to confirm the placement of the measurement probes. The collected and analyzed data will be presented at the end of the practicum.

Learning results / Competence objectives

Students will have learned animal behavioral training, basic knowledge of techniques for recording and analyzing the neural activity of freely moving animals, and they will be able to address scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Dr. Torfi Sigurdsson
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Recording neuronal activity in freely behaving animals	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar		1	1				
Sum		11	11				

INS A-17 Auditory Function and Dysfunction: Behavior and Physiology	Gestörte Wahrnehmung beim Hören: Verhaltens-untersuchungen und Physiologie	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

This course teaches methods for determining auditory function and hearing loss in laboratory rodents. Exemplary of working with animal models, the methods will be used to study the effects of pharmaceuticals and other therapeutic approaches to sensory processing damage such as tinnitus or hearing loss. Emphasis is placed on characterizing these disorders as accurately as possible through behavioral testing. For this purpose, all the necessary steps for carrying out a project are taught: Planning the study, handling animals, determining experimental variables, pharmacological treatment of animals, and data analysis. In parallel to the behavioral tests, basic electrophysiological techniques are taught to determine physiological changes in hearing. Participants will work on their own project under supervision and the results will be presented in a seminar lecture. Important content of the course are: Measurement and analysis of behavioral data, efficient execution of experiments in hearing physiology and statistical evaluation. This will finally lead to a summary of the results in the form of a possible publication. At the end, the individual projects will be presented and discussed in a seminar lecture. In addition, original papers in the field of cognition and hearing will be discussed in a seminar.

Learning results / Competence objectives

The students are able to perform quantitative behavioral tests (handling of animals, analysis of behavioral data, statistical evaluation) and physiological experiments with electrophysiological measurements in minimally invasive preparations. Students have basic knowledge of computer-assisted data analysis, signal processing and the graphical representation of experimental data. They will be able to formulate scientific questions from the current literature and assess the possibilities and limitations of animal models for disturbed brain functions.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	PD Dr. Bernhard Gaese
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Auditory Function and Dysfunction: Behavior and Physiology	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS A-18 Information Processing in the Central Auditory System	Informationsverarbeitung im Zentralen Hörsystem	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

This course teaches the methods used to study the activity of neurons in processing sensory information, using hearing as an example. Emphasis is placed on the electrophysiology of single neurons in laboratory rodents, both awake and under anesthesia. The activity of neurons is recorded with the aim of understanding acoustically triggered behavior. Cognitive influences (e.g. attention, context dependence) are controlled and taken into account. The participants work on their own project under supervision, the results are presented in a seminar lecture. Important contents are the recording and analysis of neuronal activity with different methods of in-vivo electrophysiology. The subsequent analysis includes modern signal processing techniques, efficient data management of large data sets and statistical analysis. This finally leads to a summary of the results in the form of a possible publication. At the end, the individual projects are presented and discussed in a seminar presentation. In addition, original work in the field of cognition and hearing will be discussed in a seminar.

Learning results / Competence objectives

Students will have experience in performing physiological experiments (handling animals, surgical techniques, recording and analyzing electrophysiological activity of single cells). They can supplement physiological techniques with neuroanatomical and histological staining techniques. They have basic knowledge of behavioral experiment control, computerized data management, signal processing, data analysis, and graphical presentation. They overview the importance of cognitive influences in the processing of sensory information as the basis of behavior and can formulate scientific questions from the current literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	PD Dr. Bernhard Gaese
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Information Processing in the Central Auditory System	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS A-19 Neuronal Basis of Acoustic Communication in Mammals	Neuronale Grundlagen akustischer Kommunikation bei Säugetieren	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

To understand acoustic communication, it is essential to understand both the mechanisms of sound generation and the neural basis of auditory perception. Accordingly, the practical is based on the broadcaster-receiver approach and is divided into two parts. In the first part, the generation of communication calls in two mammalian species (gerbil, bat) is investigated. Using bioacoustic methods, a vocal alphabet for bats and gerbils will be defined. In the second part, the "receiver" properties of neurons in the auditory cortex of the gerbil will be investigated with the main goal of understanding how behaviorally relevant sound stimuli are processed. At the beginning of each of the two parts of the practical, the theoretical knowledge necessary for the experiments will be provided in the form of lectures and discussions. An introduction to statistics and Matlab relevant to the practical will also be given. The results are to be summarized in the form of a scientific paper and presented in the form of a seminar talk.

Learning results / Competence objectives

(1) Understanding of basic concepts of bioacoustics, sound propagation, and acoustic measurement techniques using various microphone systems and analog-to-digital converters.
(2) Measurement and analysis of important parameters of sound events (frequency, duration, intensity).
(3) Learning of surgical techniques for cortical measurement data collection
(4) Understanding important concepts in neuroscience, e.g..: Action potential, local field potential, receptive field, cortex topography, "spike clustering", neuronal oscillations.
(5) Test hypotheses using basal statistical tests (normal distribution tests, parametric and non-parametric t-tests, analysis of variance (ANOVA)).

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 5 weeks)
Person in charge	Dr. Julio Hechavarria
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Neuronal Basis of Acoustic Communication in Mammals	Form of teaching	SWH	CP	Semester 1	2	3	4
	Practical	P	10	10		X		
	Seminar	S	1	1				
	Sum		11	11				

INS A-21 Cellular, molecular and systemic neurobiology in mouse and zebrafish	Zelluläre, molekulare und systemische Neurobiologie in Maus und Zebrafisch	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

The practical provides basic theoretical and experimental knowledge in the field of cellular, molecular and systemic neurobiology in mouse and zebrafish. Students work on their own projects under supervision and present the results in the form of a lecture. In another lecture they present an original paper from the thematic area of their projects. They learn how to write a scientific paper by designing a protocol of results accordingly.
The practical is divided into two units. The first part includes the following work: Basic techniques of mouse genetics, processing of brain tissue for immunohistochemistry, basics of working with neuronal cell cultures including generation of primary neuronal,astrocytic or endothelial cell cultures, immuofluorescence microscopy, confocal microscopy and biochemical techniques including protein gel electrophoresis and western blot. In the second part of the practical, students are introduced to basic genetic techniques used in zebrafish research. This includes learning molecular biology and histology methods, using various microscopes, manipulating zebrafish embryos, and performing simple behavioral tests.

Learning results / Competence objectives

Students will have experience in basic techniques of cellular, molecular and systemic neurobiology. They can independently perform sterile work on cultured cells, independent work on fluorescence microscope and stereomicroscope, basic zebrafish work such as handling embryos and genetic techniques, and computational analysis of laboratory data and image files. Students will operate in an international environment and will be able to present and communicate their results in English.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	Prof. Amparo Acker-Palmer, Dr. Bettina Kirchmaier
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Cellular, molecular and systemic neurobiology in mouse and zebrafish	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS A-23 **Cellular and molecular mechanisms in neurovascular disorders**	**Zelluläre und molekulare Mechanismen neurovaskulärer Erkrankungen**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

The practical course provides basic theoretical and experimental knowledge in the field of neurodegenerative and vascular diseases. The practical course includes cellular and molecular aspects addressed in the model organism mouse. These include the following work: Basic techniques of mouse genetics and experimental OR methods, processing of brain tissue for immunohistochemistry, basics of working with primary cell cultures, immunofluorescence microscopy, confocal microscopy, and biochemical techniques. Primary cell culture experiments are used to analyze techniques such as phagocytosis efficiency of different cell types. Immunohistochemistry is used to analyze cell specific markers in different disease states. Microscopy allows us to record the cellular and systemic events. The data obtained will be further analyzed by the students, thus teaching them how to use image processing and analysis software. In addition, students will have the opportunity to observe surgical methods such as experimental stroke surgery and in vivo 2-photon microscopy.

Learning results / Competence objectives

Students will be familiar with the basic techniques used in the study of neurodegenerative diseases, among others. The different methods allow to ask targeted questions. Accordingly, the students can assess the advantages and disadvantages of different model systems. The students operate in an international environment and are able to present and communicate their results in English.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Jasmin Hefendehl
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments and on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Cellular and molecular mechanisms in neurovascular disorders	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS A-24 **Deciphering brain activity during natural behaviour in real time**	**Dekodierung von Hirnaktivität während des natürlichen Verhaltens in Echtzeit**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

People often can't multitask - but their brains can! Cognitive processes such as learning and attention are often represented simultaneously in the same brain areas. Previous studies have focused predominantly on how each of these processes affects neuronal activity in isolation. In contrast, in our lab we are investigating how neurons simultaneously represent such cognitive processes and whether these are evolutionarily conserved or vary between species. To this end, we are conducting parallel experiments in monkeys and mice. These animals are trained to perform naturalistic foraging tasks in a virtual environment, while we record the activity of large neuronal populations in their visual system. Different tasks will be offered depending on when the practical begins, including mouse/monkey behavioral training, Matlab/Python programming, psychophysics in humans, virtual reality (VR) experiments, and in vivo electrophysiology.

Learning results / Competence objectives

Students will be familiar with all the techniques required for in vivo electrophysiology: handling animals (mice and/or monkeys), training the animals to perform a natural task in a virtual environment, surgeries to implant electrodes, and electrophysiological recordings from these electrodes as the animals perform their task. In addition, students are able to perform VR psychophysics on human subjects, and are given their own data analysis project to learn Matlab/Python programming. Students are in an international environment and are able to present and communicate their results in English.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4-6 weeks)
Person in charge	Dr. Martha Havenith / Dr Marieke Schölvinck
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments and on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Deciphering brain activity during natural behaviour in real time	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X	X		
Seminar	S	1	1				
Sum		11	11				

INS A-25 Neuroscience of Navigation and Self-Motion	**Neurowissenschaftliche Grundlagen der Navigation und Eigenbewegung**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

We interact with the world by moving and navigating through it whenever we walk into our kitchen or explore a new shopping mall; and whenever we drive a car or climb a mountain path. The research group is studying the circuits in the brain responsible for sensing how our bodies move, controlling balance, and navigating the world. Neural derivations are performed on small, squirrel-sized monkeys called marmosets in experiments where they can sit on moving platforms or move freely in natural cages. We are a computational laboratory, and develop models of self-motion perception based in particular on the Bayesian formalism. Students learn the techniques of extracellular recordings and neural data analysis, motion and navigation science, and theoretical and systems neuroscience, and can then conduct an in-depth research project in one of the lab's topics: Navigation (head-directional cell system), intrinsic motion (vestibular system), cerebellar physiology, Bayesian modeling.

Learning results / Competence objectives

Students are familiar with systems neuroscience techniques: chronic implant design and operation; neural spiking data and LFP analysis; 3D motion tracking and analysis, robotic platform programming. They have also become familiar with one of the scientific areas of the lab: navigation, self-motion sensing, cerebellar physiology, Bayesian modeling. Students are in an international environment and are able to present and communicate their results in English.

Requirements for participating

none

Helpful previous knowledge

Basic knowledge of Matlab programming.
Lab projects are typically focused on motion science, data analysis, and modeling, so a basic knowledge of algebra and statistics is helpful.

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Dr. Jean Laurens
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments and on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Neuroscience of Navigation and Self-Motion	Form of teaching	SWH	CP	Semester 1	2	3	4
	Practical	P	10	10	X	X		
	Seminar	S	1	1				
	Sum		11	11				

INS A-26 **Analysis of Social Networks**	**Analyse von sozialen Netzwerken**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study **11 SWH / 165 h**	**Self-study** **165 h**	

Content

This practical will provide an introduction into bioacoustics, neuroethology, and machine learning. Participants will have the opportunity to be involved in projects studying the interaction between vocal communication and cooperation, using the naked mole-rat as a model species. Students will have the opportunity to collect and analyze vocalization data using programs in Python and R and to develop machine learning tools for characterizing acoustic features of different vocalization types. Additionally, students will have the opportunity to participate in behavioral studies of naked mole-rats in a wide range of cooperative assays.

Learning results / Competence objectives

Students will be able to use Python modules to analyze bioacoustics and neuronal data, as well as design and perform basic behavioral tests.

Requirements for participating

none

Helpful previous knowledge:

Proficiency in Python, knowledge of Matlab and R

Assignment of course (program/department)	Interdisciplinary Neuroscience / faculty 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 semester (block course over 4 weeks)
Person in charge	Dr. Alison Barker
Semester-related proofs	
Proof of participation	Regular participation
Study achievements	Seminar: 1 seminar talk (20 minutes) on experimental results, 1 seminar talk (20 minutes) on current publications
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: Graded protocol (10-30 pages)

	Analysis of Social Networks	Teaching forms	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10		X		
	Seminar	S	1	1				
	Sum		11	11				

INS A-27 Instinctive Behaviour Circuits	**Schaltkreise des Instinktverhaltens**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self-study 165 h**	

Content

The goal of the internship is to provide an introduction into the mechanistic study of instinctive behaviours using modern systems neuroscience techniques, such as *in vivo* neural activity recordings and manipulation experiments in ethologically-relevant behavioural tasks in mice, as well as molecular, cellular and circuit-level analyses *in vitro*. We focus our analysis on evolutionarily conserved circuits in the rodent midbrain that are critically involved in the initiation and execution of instinctive behaviours, such as escape from predators and hunting of crickets. Depending on the projects in progress at the time of the module, the course will give an introduction to the following methods: recordings, manipulations and analysis of instinctive behaviours, stereotaxic surgeries, patch-clamp recordings *in vitro*, immunohistochemical analyses. Students work as full members of the research group, with supervision, on their own small projects embedded within a group member's research focus.

Learning results / Competence objectives

Students will gain practical and theoretical experience with basic as well as advanced methods from neuroethology and systems neuroscience, including behavioural experiments, neurophysiological methods such as patch clamp recordings, stereotactic injections, neuronal manipulations *in vivo* and *in vitro*, and immunohistochemical analyses. Students gain experience in developing and conducting their own research question, programming in Python and will be exposed to work with laboratory animals (Mus musculus).

Requirements for participating

none

Helpful previous knowledge:

Basic knowledge of Python (or another programming language), willingness to work with lab mice.

Assignment of course (program/department)	Interdisciplinary Neuroscience / faculty 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 semester (block course over 4-6 weeks)
Person in charge	Dr. Vanessa Stempel
Semester-related proofs	
Proof of participation	Regular participation
Study achievements	Seminar: 1 seminar talk (20 min) on experimental results, 1 seminar talk (20 min) on current publications
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: Graded protocol (10-30 pages)

Instinctive Behaviour Circuits	Teaching forms	SWH	CP	Semester			
				1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

Optional courses in elective B: Clinical Neuroscience

INS B-0 External elective course “Clinical Neuroscience”	Externe Wahlpflicht-veranstaltung „Klinische Neurowissenschaften“	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

The elective course teaches basic methods and techniques in the field of clinical neuroscience. Students work on their own projects under supervision.
The elective course can be offered by departments of Goethe University, by other universities in Germany and abroad as well as by non-university research institutions.

Learning results / Competence objectives

The students have knowledge in conducting neuroscientific investigations in the field of clinical research. They are able to work on scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Depending on provider
Duration	Depending on provider
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	regular participation
Study achievements	The regulations of the provider of the elective course are applied. If the provider does not request any study proofs, a working report must be written,and talks have to be given on both, results of own experiments (20 minutes) and topical literature (20 minutes).
Teaching forms	Practical, seminar
Tuition language	Depending on provider
Module exam **Module final exam consisting of:**	**Form / duration / content (if applicable)** The regulations of the provider of the elective course are applied. If grading is not scheduled by the provider, the module completion exam shows a graded protocol (10-30 pages).

External elective course “Clinical Neuroscience”	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS B-4 **Plasticity in Hippocampus – Morphology, Physiology, and Clinical Relevance**	**Plastizität im Hippocampus – Morphologie, Physiologie und klinische Relevanz**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

Practical and seminar provide an interdisciplinary overview of plastic changes in the hippocampus. The course will focus on questions concerning morphological and physiological changes of hippocampal neurons after CNS damage or neuronal overexcitation, cellular network dynamics and molecular mechanisms of hippocampal plasticity and homeostasis. The organotypic slice culture model of the hippocampus is used to scientifically investigate the underlying molecular and cell biological processes. The goal is to learn various techniques to study hippocampal plasticity, including optogenetic and pharmacological manipulation of cellular activity, live cell imaging, immunocytochemistry, patch clamp, and methods in molecular biology. Students will learn appropriate techniques in the context of their own project, perform their own experiments under instruction, and present their results in a seminar. The weekly seminars will train students to work with scientific publications, multiple models and methods and discuss the translation of results to clinical applications in the field of neurological diseases using examples and original papers.

Learning results / Competence objectives

The students have knowledge in the basics of electrophysiological and anatomical work, in the preparation of organotypic section cultures and in confocal microscopy. They are able to work on scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

Experience working experimentally in a "wet lab".

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4-6 weeks)
Person in charge	Dr. Tijana Radic, Dr. Tassilo Jungenitz, Prof. Thomas Deller
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature, 1 work report (if the final module exam is a written exam)
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of	Practical: graded protocol (10-30 pages) oder written exam (45 minutes)

	Plasticity in Hippocampus – Morphology, Physiology, and Clinical Relevance	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10		X		
	Seminar	S	1	1				
	Sum		11	11				

INS B-6 Experimental Brain Tumor Therapy	Experimentelle Therapie von Hirntumoren	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

In the practical course, experiments are performed using the following methodological approaches: Cultivation of brain tumor cells (adherent culture and tumor spheroids), application of different cancer drugs in vitro, determination of cell death and cell viability, assays for monitoring autophagy and the autophagic flux, FACS techniques, visualization of proteins by immunofluorescence microscopy and by western blot;

Learning results / Competence objectives

Students will acquire experience in current cell biological and molecular biological techniques in experimental neuroscience. They will obtain knowledge on data analysis and interpretation, and on mechanistic aspects of drug-induced tumor cell killing. They will also learn how to address scientific questions in the context of relevant literature.

Requirements for participating

none

Helpful previous knowledge

basic knowledge in cell culturing

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Donat Kögel
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Brain Damage and Neuroprotection	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10		X		
	Seminar	S	1	1				
	Sum		11	11				

INS B-8 Clinical Neuroimaging	Klinisches Neuroimaging	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The practical course introduces the basics of image analysis, image interpretation and the preparation of findings in examinations of the CNS (cerebral and spinal) with imaging procedures in neuroradiology. The following procedures are used: magnetic resonance imaging (MRI) of the head and spine, computed tomography (CT) of the skull and spine, digital cerebral and spinal subtraction angiography (DSA), as well as introduction to the basics of interventional neuroradiological procedures.

In addition, the practical course teaches theoretical / physical principles of the individual examination modalities in neuroradiology with emphasis on magnetic resonance imaging. The following will be covered: physical principles of MRI / image formation, sequences and sequence parameters of MRI, diffusion and perfusion weighted MRI imaging, tractography (fiber tracking), functional MRI (fMRI), nuclear spin spectroscopic examinations (MR spectroscopy).

Depending on the project, (co-) authorship in a publication may also be possible and encouraged.

Learning results / Competence objectives

The students have knowledge of neuroanatomy (cerebral/spinal) as well as of the cranial skeleton and the spine and basic knowledge of the relevant neurological diseases. They also have basic knowledge of the indication of neuroradiological examinations, image formation and image interpretation as well as the assignment to individual typical clinical pictures.

They are able to deal with scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

Basic knowledge of German language

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4-6 weeks)
Person in charge	Prof. Weidauer, Prof. Hattingen, Dr. Polkowski
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Clinical Neuroimaging	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS B-9 Clinical Auditory Neuroscience	**Klinische Auditorische Neurowissenschaften**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

The practical provides knowledge of the most important objective and subjective audiometric measurement techniques for the differential diagnosis of hearing disorders. Sound and speech audiometry as well as the application of otoacoustic emissions, impedance audiometry, and different techniques of brainstem audiometry (BERA, CERA, ASSR, MMN) are used. The treatment of hearing impairment with implantable hearing aids and cochlear implants is demonstrated in practical use. The use of intraoperative electrophysiological conduction techniques will be demonstrated.

An own current project is determined within the scope of the course, which is to be worked on by the students under guidance. The results are to be presented in a lecture. Another lecture is scheduled to present original work in the field of electrophysiological stimulation/derivation of auditory potentials. Main topics are: Psychoacoustic measurements of auditory perception during electrical stimulation by cochlear implants, investigation of new rejection techniques for frequency-specific diagnosis of hearing disorders, creation of software protocols for data acquisition and stimulus generation.

Learning results / Competence objectives

The students are able to perform psychoacoustic experiments and measurement of acoustically evoked potentials, and have basic knowledge of audiometry as well as basic knowledge of the function of hearing implants. They are able to work on scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Uwe Baumann
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Clinical Auditory Neuroscience	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10	X			
	Seminar	S	1	1				
	Sum		11	11				

INS B-10 Experimental and Translational Psychiatry	Experimentelle und translationale Psychiatrie	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The goal of this practical is to introduce students to a range of experimental techniques for the study of psychiatric disorders. In doing so, they will be able to participate in a wide range of translational projects. These include cell culture techniques for functional evaluation of candidate genes previously identified in large cohorts and behavioral analysis of mice that have been pharmacologically treated or genetically modified (e.g., viral gene transfer, gene knockout). Following such experiments, a series of immunohistochemical and histological characterizations will be performed. In addition, there is an opportunity to gain insight into neural imaging techniques (e.g., functional magnetic resonance imaging, electroencephalography, and magnetoencephalography) for detecting abnormalities of neural processing and coordination in psychiatric disorders.

Learning results / Competence objectives

Students will have knowledge of a range of commonly used molecular and behavioral methods for analyzing psychiatric disorders and will be able to design their own experiments using the knowledge thus acquired. In addition, a series of seminars (and optional participation in case presentations) will provide students with basic knowledge regarding these disorders, particularly affective disorders, anxiety disorders, schizophrenia, and attention-deficit/hyperactivity disorder.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	Prof. David Slattery
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Experimental and Translational Psychiatry	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS B-11 Neurobiological human cell models	Neurobiologische humane Zellmodelle	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The goal of this practical is for students to learn the basics of experimental techniques for studying genetic variants in human neural progenitor cells and to be able to apply them independently. These techniques include cell culture methods for culturing and neuronal differentiation, genomic editing of sequences (CRISPR/Cas9 techniques), and fluorescence and luciferase assays for functional analysis. Specifically, techniques for the production of cerebral organoids and iNeurons can be learned.
Following genetic modification of cell lines, a series of immunohistochemical, functional and morphological assays will be applied and evaluated. In addition, insights into the basics of transcriptome and genome analysis can be gained.

Learning results / Competence objectives

The students have knowledge of the current molecular and cell biological methods for the analysis of human neurons and can plan and perform their own experiments with the knowledge thus acquired. At the end, students will have the necessary know-how to use human neural progenitor cells, or human stem cells and their derivatives as an effective model for psychiatric disorders. In addition, in a series of seminars, also in close collaboration with adult psychiatry, students are given the basic knowledge regarding underlying disorders such as autism spectrum disorder, attention deficit/hyperactivity syndrome, or social behavior disorder.

Requirements for participating

none

Helpful previous knowledge

Cell culture experience

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	Dr. Denise Haslinger
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Neurobiological human cell models	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10	X	X		
	Seminar	S	1	1				
	Sum		11	11				

INS B-12 Neuroimaging-Biomarkers in Psychiatry	Neuroimaging Biomarkers in in der Psychiatrie	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The goal of the practical is to provide students with insight into the analysis of magnetic resonance imaging (MRI) data of the human brain. This will include analysis of MRI data from individuals with autism spectrum disorder (ASD) compared to control groups in terms of different anatomical features of the human brain, such as cortex thickness, surface area, or gyrification index. Statistical analyses are performed based on regions of the brain defined based on a brain atlas. Common programs and software for the analysis of MRI data are used.
There is also an opportunity to gain insight into neural imaging techniques and data management. Students will also gain knowledge of how structural MRI data is used to determine differences in neuroanatomy of psychiatric disorders such as ASD.

Learning results / Competence objectives

Students will be able to use common programs and software to analyze MRI data and will have acquired basic knowledge of Autism Spectrum Disorder and other psychiatric disorders as appropriate. They are able to perform their own analyses of a data set in the form of statistical evaluations using R and/or Matlab, visualize and present the results.

Requirements for participating

none

Helpful previous knowledge

Basic knowledge in MatLab and R

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 16
Suitable for other study programs	
Times offered	each semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	Prof. Christine Ecker
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam **Module final exam consisting of:**	**Form / duration / content (if applicable)** Practical: graded protocol (10-30 pages)

	Neuroimaging Biomarkers in Psychiatry	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10	X	X		
	Seminar	S	1	1				
	Sum		11	11				

INS B-13 Translational Neuro-Oncology Research	Translationale Neuro-Onkologie-Forschung	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self-study 165 h	

Content

During this practical, students have the opportunity to be involved in ongoing research projects in the field of translational, neuro-oncological research. This includes both participation in routine laboratory workflows and the development of an independent scientific project within the conceptual orientation of the "Translational Neuro-Oncology" working group.

The routine laboratory processes include the generation of 3D cultures, so-called tumor organoids, based on surgical tissue from patients suffering from brain tumors. These organoids are routinely characterized on several molecular levels to ensure the preservation of the histopathological, (epi-)genetic and transcriptional features of the primary parental tumours. We are also using these tumor organoids as a preclinical model for our exploratory drug profiling workflow to eventually improve personalized medicine approaches and therapeutic options for cancer patients.
Furthermore, we are generating patient-derived orthotopic xenografts (PDOXs) by intracortical implantation of the tumor organoids into immunodeficient mice. These PDOXs enable long-term propagation of patient tumors and are clinically relevant patient avatars for precision oncology studies.
Additionally, we have a strong interest in recapitulating early brain tumor evolution by sequential oncogenic editing of the genome of human induced pluripotent stem cells (hiPSCs). Cerebral organoids, so-called "mini-brains", are used to grow hiPSC-derived brain tumors within a physiologically relevant 3D brain microenvironment. This model allows us to study the impact of specific mutations on tumor metabolism and to test new treatment strategies ex vivo.

Learning results / Competence objectives

After completing the internship, the students have gained theoretical knowledge and hands-on experience in the field of neuro- and cellular molecular biology including basic techniques of cellular model system development and, to a limited extent, of applied molecular biology. The students will be able to describe their purposes and apply them in practice.
Basic techniques include the generation of brain tumor organoids from fresh tumor tissue, the cultivation of human brain tumor cell lines, working with hiPSCs and associated cerebral organoid cultures, and the practical use of various cellular assays. The standard techniques, taught in this internship, include the quantification of invasive cells, the measurement of proliferation behavior, the detection of tumorigenicity via colony formation and survival, as well as live cell imaging of 2D and 3D cell cultures and compound screenings in a medium-throughput manner. Array-based DNA methylation analysis, CRISPR-Cas based (epi)genome modification and the associated basic molecular biological methods and bio-informatic analyzes represent more specialized methods depending on the particular scientific project and are not necessarily always taught in this practical. Students will work on their own scientific project with the help and guidance of experienced scientists. They will be able to independently develop a patient-oriented, translational research hypothesis and how to design experiments to validate it. The students have acquired skills and knowledge in order to deal with advanced topics in cell, molecular and neurobiology as well as related disciplines, and will be able to evolve them independently.

Requirements for participating

None

Helpful previous knowledge:

Experience with sterile cultivation of cell lines is an advantage

Assignment of course (program/department)		MSC Interdisciplinary Neuroscience / FB 15
Suitable for other study programs		
Times offered		Each semester
Duration		1 Semester (block course 6 weeks)
Person in charge		Dr. Ann-Christin Hau
Semester-related proofs		
	Proof of participation	Regular participation
	Study achievements	Seminar: 1 seminar talk (20 minutes) on literature, 1 seminar talk (20 minutes) on the research project
Teaching forms		Practical, seminar
Tuition language		English and/or German
Module exam		**Form / duration / content (if applicable)**

	Module final exam consisting of:				Practical: Graded protocol (10-30 pages)			
	Translational Neuro-Oncology Research	Teaching forms	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10	X	X		
	Seminar	S	1	1				
	Sum		11	11				

INS B-14 Computation translational Psychiatry	Computergestützte translationale Psychiatrie	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

This course will focus on the computational aspects of neuropsychiatric research, mainly on performing large scale data analyses on data from patients including psychiatric diagnoses and traits and genomics. This includes working on high performance computational clusters and data-science environments, applying machine-learning algorithms and using software and algorithms for processing and analysing genetic datasets. Depending on the current demands in the lab copy-number variations, polygenetic (risk) scores and rare genetic variations in large genetic samples will be identified and tested for their association with psychiatric phenotypes will be identified.

Learning results / Competence objectives

The students will be able to autonomously work with code, writing their own analytical pipelines and get a better understanding about machine learning. The participants will work on specified research tasks based on the available datasets. In a series of seminars students will gain a better understanding on the psychiatric phenotypes and the currently ongoing research. Specifically basic knowledge about underlying disorders such as autism spectrum disorder, attention deficit/hyperactivity syndrome, or social behaviour disorder will be achieved.,

Requirements for participating

None; affinity for coding or data is helpful

Helpful previous knowledge

Any programming experience (R, python, C++, Matlab etc)

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 6 weeks)
Person in charge	Prof. Andreas Chiocchetti
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature or algorithm
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages) or programming task (1-30 pages)

	Neurobiological human cell models	Form of teaching	SWH	CP	Semester 1	2	3	4
	Practical	P	10	10	X	X		
	Seminar	S	1	1				
	Sum		11	11				

Optional courses in elective C: Cognitive and Theoretical Neuroscience

INS C-0 External Elective Course “Cognitive and theoretical Neuroscience”	Externe Wahlpflichtveranstaltung „Kognitive und theoretische Neurowissenschaften“	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

The course teaches basic methods and techniques in the field of cognitive or/and theoretical neuroscience. Students work on their own current projects under supervision and present the results in the form of a seminar presentation. The course can be offered by departments of Goethe University, by other universities in Germany and abroad as well as by non-university research institutions.

Learning results / Competence objectives

Students gain knowledge in conducting neuroscientific investigations in the field of cognitive neuroscience or/and knowledge in computer-based modeling of neurobiological questions. They are able to address scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Depending on provider
Duration	Depending on provider
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	regular participation
Study achievements	The regulations of the provider of the elective course are applied. If the provider does not request any study proofs, a working report must be written,and talks have to be given on both, results of own experiments (20 minutes) and topical literature (20 minutes).
Teaching forms	Practical, seminar
Tuition language	Depending on provider
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	The regulations of the provider of the elective course are applied. If grading is not scheduled by the provider, the module completion exam shows a graded protocol (10-30 pages).

External elective course “Cognitive and theoretical Neuroscience”	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS C-1 Non-Invasive Methods in Human Cognition Research	Nicht-invasive Methoden der Kognitionsforschung am Menschen	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The practical course teaches basic techniques of non-invasive research of human cognitive functions. This includes behavioral studies or measurements of brain activity using electro/magnetoencephalography (EEG/MEG) or functional magnetic resonance imaging (fMRI). After a theoretical introduction to the methodological principles and the research question, students conduct their own experiments on questions of perception, attention or working memory. They will be made aware of the advantages and disadvantages of the respective research method and learn the basic evaluation steps. The questions to be worked on are based on current projects in the Institute of Medical Psychology.

Learning results / Competence objectives

The students have basic knowledge of the design and implementation of cognitive experiments in humans. They are familiar with behavioral or psychophysiological methods (fMRI, EEG, MEG) and are able to address scientific questions based on relevant literature.

Requirements for participating

none

Helpful previous knowledge

Basic knowledge in cognitive psychology

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Jochen Kaiser
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Non-Invasive Methods in Human Cognition Research	Form of teaching	SWH	CP	Semester 1	2	3	4
	Practical	P	10	10		X		
	Seminar	S	1	1				
	Sum		11	11				

INS C-4 Virtual Hippocampus – Introduction to Computational Neuroscience	Virtueller Hippocampus – Einführung in die Computer-Modellierung neuronaler Systeme	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The practical provides an overview of computational modeling of neural systems with particular emphasis on modeling of hippocampal neurons and networks. The course is an introduction to computational neuroscience, which studies the brain at different levels (from synapses and dendrites to neurons and neural circuits) using computer models. The goal is to learn standard techniques for the formation, management, and use of models that are closely linked to experimental data, especially those involving hippocampal cells with complex anatomical and biophysical properties. Planned computational experiments (in silico) include large-scale network simulations in biophysically realistic and data-driven models of the hippocampus, and single-cell simulations in morphologically reconstructed neurons in the hippocampus. The relevance of computational models to understanding brain function will be discussed using examples from recent research articles.

Learning results / Competence objectives

The students have basic knowledge of compartment and network modeling. They can use NEURON (software for biologically motivated simulations of neurons and networks of neurons, http://www.neuron.yale.edu/neuron) and are able to address scientific questions based on relevant literature.

Requirements for participating

None

Helpful previous knowledge

Programming experience

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Dr. Peter Jedlicka
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages) or programming task (1-30 pages)

Virtual Hippocampus – Introduction to Computational Neuroscience	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS C-7 **Cognitive Neuroscience – Higher Cognitive Functions**	**Höhere kognitive Funktionen**	**Elective course**	**11 CP (insg.) = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

The practical gives an insight into the research of the neuronal basis of higher cognitive performance on the basis of current projects in the area of working memory, language processing, movement perception or executive control, as well as partly also their development in children of primary school age.
Depending on the current research projects, the practical course enables the students to participate in neurocognitive studies (fNIRS, fMRI, EEG, behavioral measurements) as well as in the field of data processing of neurophysiological data. The aim is to learn the theoretical background of the projects as well as the collection, analysis and interpretation of the corresponding data. In doing so, students are encouraged to work independently and to carry out parts of the study themselves.

Learning results / Competence objectives

Students are familiar with cognitive and neurocognitive models as well as experimental psychological methods, and are familiar with the basics of collecting and analyzing neurocognitive data. They are able to address scientific questions based on relevant literature.

Requirements for participating

None

Helpful previous knowledge

Basic knowledge in Matlab, Python oder other programming skills

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Christian Fiebach
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments or on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Cognitive Neuroscience – Higher Cognitive Functions	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS C-8 Systems Neuroscience – Sensorimotor and cognitive networks	**Sensomotorische und kognitionstragende Netzwerke**	**Elective course**	**11 CP (insg.) = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

The pracical introduces students to neural networks (cortical and subcortical) that are important for cognitive and sensorimotor processing. One focus is on the study of hemispheric lateralization, particularly with respect to language processing and motor control of hand movements. Another part of the group is concerned with the translation of the findings into immediate patient care, e.g. using closed-loop control.

Healthy volunteers and patients are studied with respect to their behavioral responses and using electro- and magneto-encephalographic techniques. In addition, electrocorticographic data are collected from patients during brain surgery or stereo-EEG in epilepsy patients.

Students become familiar with the methods used and acquire knowledge of the organizing principles of neuronal networks. Students will be assigned to a current project, will participate in data collection and/or analysis, and will attend weekly seminars.

Learning results / Competence objectives

Students are familiar with the collection and evaluation of data sets from imaging procedures or neurophysiological experiments on healthy control subjects and patients and are able to address scientific questions based on relevant literature.

Requirements for participating

None

Helpful previous knowledge

Programming knowledge in Python and/or Matlab

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (Block course over 4-6 weeks)
Person in charge	PD Dr. Christian Kell
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Systems Neuroscience – Sensorimotor and cognitive networks	Form of teaching	SWH	CP	Semester 1	2	3	4
	Practical	P	10	10	X			
	Seminar	S	1	1				
	Sum		11	11				

INS C-10 Computational neuroanatomy – quantitative analysis and modelling	Neuroanatomische Modellierung	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

Based on neuroanatomical data obtained thanks to state-of-the-art developments in microscopy technology and neurogenetic techniques, models are created with a focus on dendritic and axonal interactions. Image processing techniques and quantitative analysis methods are applied in the computer to digitize anatomical components from the microscopy images. The digital form then allows measured geometric properties to be assigned biophysical principles. For example, time-lapse methods can be used to observe and measure the precise assembly of neurons into circuits during development. The structure of dendrites and axons then allows conclusions to be drawn about the interconnection and functioning of circuits in the nervous system. The laws learned from this are then tested in simple quantitative models. This course on computational neuroanatomy thus bridges the gap between data analysis and the design of a scientific theory using simple computer models.

Learning results / Competence objectives

The participants are able to deal scientifically with biological data using quantitative methods (incl. use of Matlab). Furthermore, they will be able to create simple models that are strongly related to the biological data. The projects will be approaches from current research topics of the group.

Requirements for participating

None

Helpful previous knowledge

Programming skills (e.g. Python, Matlab, Java)

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Dr. Hermann Cuntz
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages) or programming task (1-30 pages)

Computational neuroanatomy – quantitative analysis and modelling	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X			
Seminar	S	1	1				
Sum		11	11				

INS C-11 Computational Modeling of Neuronal Plasticity	Computer-Modellierung neuronaler Plastizität	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The practical provides an introduction to the development and implementation of computational models of neural networks and the modeling of neural plasticity mechanisms. The course is a hands-on introduction to core computational neuroscience methods that use computational models to study the workings of the brain at various levels. Standard neuron models and network architectures are programmed and analyzed by the students themselves. The focus is on the role of plasticity mechanisms, their influence on network dynamics, and their role in learning processes. The possibilities and limitations of computer models for understanding brain function are discussed using examples from the literature.

Learning results / Competence objectives

The students have knowledge in programming computer models of neuron networks, as well as of different plasticity mechanisms and learning processes. They are able to work on a scientific problem against the background of relevant literature.

Requirements for participating

Please consult with the person in charge before applying regarding prior experience

Helpful previous knowledge

Programming skills in at least one programming language (e.g., Python, Matlab, Java).
Background in a quantitative discipline (e.g., physics, mathematics, computer science, or engineering). Basic knowledge of linear algebra, probability, differential equations, numerical methods.

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Prof. Dr. Jochen Triesch
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages) or programming task (1-30 pages)

Computational Modeling of Neuronal Plasticity	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Sum		11	11				

INS C-15 Developmental cognitive neuroscience	Neurokognitive Entwicklung	Elective course	11 CP = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

Our brain is highly plastic and undergoes dynamic changes across the lifespan. These developmental changes are reflected in modifications of cognitive functions, such as learning and memory. In our lab, we are interested in how the human brain and cognitive systems develop throughout the lifespan, particularly in how age-related neurocognitive changes influence the way we learn and extract regularities from the environment and our ability to create memories of unique experiences.
For this, we conduct experiments in which we test participants of different age groups, using cognitive tasks designed to tap into specific processes involved in learning and memory.
Depending on the stage of the experiment that you will work on, you may get experience in programming cognitive tasks, Matlab/Python/R programming, processing of behavioural/neuroimaging data, and/or conducting statistical/computational model analyses.

Learning results / Competence objectives

Students will be familiar with various techniques used to collect experimental human data: cognitive tasks to collect behavioral data from participants, neuroimaging data while participants are performing tasks, and/or computer modeling of participant data. In addition, students will be able to design and program cognitive tasks, and have learned various methods for data analysis, for which they will use Matlab/Python/R programming. Students have worked in an international environment and are able to present and communicate their results in English.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (Block course over 4 weeks full-day, or 8 weeks half-day)
Person in charge	Prof. Dr. Yee Lee Shing
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments and on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Developmental cognitive neuroscience	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10	X	X		
Seminar	S	1	1				
Sum		11	11				

INS C-16 **Cognitive and perceptual processes in the human brain**	**Kognitive und Wahrnehmungsprozesse im menschlichen Gehirn**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

Our lab studies basic human cognitive processes such as attention and working memory and how these cognitive processes affect our basic perception of the world. Consequently, most of this work uses the human visual system as the basis for such questions because the visual system is well defined and it can be imaged in humans using non-invasive imaging techniques such as fMRI. In this course, students will work with members of the lab to define a research project. Possible research projects could range from designing and programming experiments to collecting behavioral and/or neuroimaging data (EEG or MEG) to using computational techniques to analyze these data. The analysis of fMRI data is also possible.

Learning results / Competence objectives

Students are familiar with the many aspects of cognitive neuroscience research. They have learned about both cognition (e.g., attention, working memory, etc.) and the visual system (e.g., retinotopic organization in cortex, tuning properties of early sensory neurons, etc.) and computational approaches (e.g., multivariate analysis, simulations, etc.). They have experience with all techniques used in the laboratory including fMRI, MEG, psychophysics, data analysis, and computational modeling. Students operate in a close and very international environment, with ample opportunity to perfect both their social and scientific communication skills in English.

Requirements for participating

Helpful previous knowledge

Programming skills (Matlab oder Python)

Assignment of course (program/department)	Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Each semester
Duration	1 Semester (block course over 4 weeks)
Person in charge	Dr. Rosanne Rademaker
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments and on current literature
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

	Cognitive and perceptual processes in the human brain	Form of teaching	SWH	CP	Semester 1	2	3	4
	Practical	P	10	10	X	X		
	Seminar	S	1	1				
	Sum		11	11				

Optional courses in elective D: Applied Aspects of Neuroscience

INS D-0 External Elective Course “Applied Aspects of Neuroscience”	**Externe Wahlpflichtveranstaltung „Angewandte Aspekte in den Neurowissenschaften“**	**Elective course**	**11 CP = 330**		**11 CP**
			Contact study 11 SWH / 165 h	**Self study 165 h**	

Content

This elective course teaches basic methods and techniques in applied areas of neuroscience. Students work on their own projects under supervision and present the results in the form of a seminar presentation. The course can be offered by departments of Goethe University, by other universities in Germany and abroad as well as by non-university research institutions.

Learning results / Competence objectives

Students have knowledge in conducting scientific investigations in the field of applied neuroscience. They are able to work on scientific questions against the background of relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Depending on provider
Duration	Depending on provider
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	regular participation
Study achievements	The regulations of the provider of the elective course are applied. If the provider does not request any study proofs, a working report must be written,and talks have to be given on both, results of own experiments (20 minutes) and topical literature (20 minutes).
Teaching forms	Practical, seminar
Tuition language	Depending on provider
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	The regulations of the provider of the elective course are applied. If grading is not scheduled by the provider, the module completion exam shows a graded protocol (10-30 pages).

	External elective course “Applied Aspects of Neuroscience”	Form of teaching	SWH	CP	Semester			
					1	2	3	4
	Practical	P	10	10	X			
	Seminar	S	1	1				
	Sum		11	11				

INS D-1 Behavioral Biology in Zoos	Verhaltensbiologie in Zoos	Elective course	11 CP (insg.) = 330 h		11 CP
			Contact study 11 SWH / 165 h	Self study 165 h	

Content

The course includes the components seminar, practical & excursion. In the seminar, basic aspects and current topics of zoo biology are taught at the beginning using original papers, which are presented by the students in a lecture and then discussed. The excursions to different zoos and the research practical at the Opel Zoo serve to deepen theoretical foundations. Emphasis is placed on ecological, physiological and ethological research contexts. Other topics include: Historical development of zoos, zoos & species conservation, population biology & breeding programs in zoos, animal husbandry (nutrition, behavior, enrichment, community husbandry), veterinary basics, organization and structural development, enclosure design and planning, educational work in zoos. The methodological approach to the practical course components includes, depending on the chosen content focus, classical and modern methods of behavioral research, laboratory activities (microscopic and physiological examinations), imaging techniques (e.g. thermographic measurements with infrared cameras or video analyses with high-speed cameras).

Learning results / Competence objectives

The students have knowledge in basic contents of zoo biology (behavioral research in zoos, enrichment, animal husbandry, species protection aspects) and in the application of modern imaging techniques (thermography, high-speed cameras). They have methodological knowledge to conduct behavioral studies and are able to address scientific questions against the background of relevant literature.

Requirements for participating

none

Helpful previous knowledge

none

Assignment of course (program/department)	MSc Interdisciplinary Neuroscience / FB15
Suitable for other study programs	
Times offered	in the summer semester
Duration	1 Semester (block course over 5 weeks)
Person in charge	Prof. Paul Dierkes
Semester-related proofs	
Proof of participation	regular participation
Study achievements	Seminar: 1 talk (20 minutes) on the results of own experiments, 1 talk (20 minutes) on current literature
Teaching forms	Seminar, Practical, Excursion
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module final exam consisting of:	Practical: graded protocol (10-30 pages)

Behavioral Biology in Zoos	Form of teaching	SWH	CP	Semester 1	2	3	4
Practical	P	10	10		X		
Seminar	S	1	1				
Exkursion	Ex						
Sum		11	11				

INS-D2 **Attention analysis of students' media use via eye-tracking**	**Eye-tracking** **Verhaltensanalyse von Studierenden beim Umgang mit diversen Lehr-Medien**	**Elective course**	**11 CP = 330 h**		**11 CP**
			Contact study **11 SWH / 165 h**	**Self-study** **165 h**	

Content

The goal of the course is to provide an introduction to the study of attention and cognitive processing during presentation and use of diverse media using modern neuroscience techniques as eye-tracking and retrospective think-alouds (RTA: interviewing subjects for cognitive process data in addition to their eye-tracking data).
Depending on the projects in progress at the time of the module, the course will consist of practical tasks in the following methods: Design of experiments, Recording and analysis of eye-tracking data, Recording and analysis of RTAs, Statistical analysis.
Students will work in the research group under supervision on their own clearly defined projects embedded in the research focus of the group.

Learning results / Competence objectives

Students will have practical and theoretical experience with basic and advanced methods for studying the cognitive and physiological processing of visual information, including eye-tracking, RTAs, and log-data analysis of online searches. Students are familiar with developing, implementation, analyzing, and presenting their own research questions.

Requirements for participating

German language skills for subject interviews as well as analysis of eye-tracking data from German texts.

Helpful previous knowledge:

Willingness to work with subjects (medical students).

Assignment of course (program/department)	Interdisciplinary Neuroscience / faculty 15
Suitable for other courses	
Times offered	Each semester, depending on availability
Duration	1 semester (block course over 4-6 weeks)
Person in charge	Dr. Maruschka Weber
Semester-related proofs	
Proof of participation	Regular participation
Study achievements	Seminar: 1 seminar talk (20 min) on experimental results, 1 seminar talk (20 min) on current publications
Teaching forms	Practical, seminar
Tuition language	English
Module exam	**Form / duration / content (if applicable)**
Module completion exam	Practical: Graded protocol (10-30 pages)

Attention analysis of students' media use via eye-tracking	Teaching forms	SWH	CP	Semester			
				1	2	3	4
Practical	P	10	10	X	X		
Seminar	S	1	1				
Sum		11	11				

INS WP **Free-choice Studies**	**Freies Studium**	**Wahlpflichtmodul**	**11 CP = 330 h**		**11 CP**
			Contact study **11 SWH / 165x h**	**Self study** **165x h**	

Content

See description of the selected module

Courses from all departments of Goethe University can be credited. Courses from the departments of Computer Science and Mathematics (FB12), Biochemistry, Chemistry and Pharmacy (FB14), Biosciences (FB15), Philosophy and Historical Sciences (FB8), Psychology and Sports Sciences (FB5) seem to be particularly suitable. The module can also be from other universities in Germany and abroad. Alternatively, a business or r esearch practical (4-6 weeks) can be carried out in a university or non-university research institution or company.

Learning results / Competence objectives

See description of the selected module

Requirements for participating

none

Helpful previous knowledge

none

Assignment of module (program / department)	Interdisciplinary Neuroscience / FB 15
Suitable for other study programs	
Times offered	Depending on provider
Duration	Depending on provider
Person in charge	Head of study program
Semester-related proofs	
Proof of participation	regular participation
Study achievements	The regulations of the provider of the course are applied. If the provider does not request any study proofs, a working report must be written,and talks have to be given on both, results of own experiments (20 minutes) and topical literature (20 minutes).
Teaching forms	Practical, Übung, Vorlesung, Seminar, Exkursion
Tuition language	Je nach Anbieter
Module exam **Module final exam consisting of:**	**Form / duration / content (if applicable)** The regulations of the provider of the course are applied. If grading is not scheduled by the provider, the module completion exam shows a graded protocol (10-30 pages).

Free-choice studies	Form of teaching	SWH	CP	Semester			
				1	2	3	4
Practical, tutorial, lecture, seminar, excursion	P, Ü, V, S, Ex	11	11	X			
Sum		11	11				