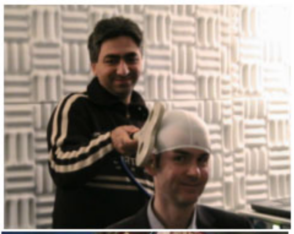
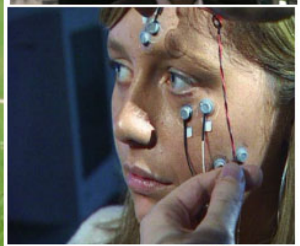
Handbook

Integrated Graduate Program

Cognitive Systems and Processes (COSYP)





21. April 2010

Contents

1 Introduction to COSYP **2**

1.1 Concept . . . 2

1.2 Degrees . . . 2

1.2.1 Doctor of Philosophy (PhD) . . . 2

1.2.2 Master of Science (MSc) . . . 3

1.3 Target Audience . . . 3

2 Study Plan **4**

2.1 Study Plan for the Qualification Phase . . . 4

2.2 Study Plan for the Master Phase . . . 5

2.3 Successful Completion of the Qualification Phase . . . 6

2.4 PhD Phase . . . 7

3 Available Courses **9**

3.1 Involved Faculty . . . 9

3.2 Regular Lectures . . . 9

3.3 Infrastructure for Lab Projects . . . 16

3.3.1 Robotics Laboratory . . . 16

3.3.2 Eye Tracking Laboratory . . . 16

3.3.3 Emotion Physiology Lab . . . 18

3.3.4 Transcranial Magnetic Stimulation (TMS) Laboratory . . . 19

3.3.5 Sensory Motor Laboratory . . . 19

1 Introduction to COSYP

1.1 Concept

The integrated transdisciplinary PhD program "Cognitive Systems and Processes", short COSYP, is linked to the Research Center with the same name at Jacobs University. It has the main aim

to study the generic **processes** *in cognition as basis for artificial* **systems**

This aim is linked to two core scientific endeavors, namely

- the transdisciplinary understanding of cognition
  - as one of the most fundamental basic research questions
  - which can only be tackled in a collaborative effort of researchers working in different disciplines
- and the quest for building artificial intelligent systems
  - to constructively understand principles of natural systems
  - and to enable novel applications, namely machines operating on complex missions in challenging environments without permanent human supervision

The COSYP graduate program is strongly transdisciplinary and it offers a research-oriented education by faculty from

- Computer Science and Electrical Engineering, especially robotics, automation, and machine learning
- Psychology, especially cognitive and social psychology
- Neuroscience, especially computational neuroscience and neurobiology

1.2 Degrees

The COSYP graduate program offers three different tracks, namely an **integrated graduate program**, a **PhD**, and a **Master** track. Hence both, students with a Master or a Bachelor degree may apply. Students who have a MSc engage in 3 years of regular PhD studies. Students with a BSc first need to go through a qualification phase for 3 semesters where they take a set of courses - which is chosen together with their supervisors according to the student's interests and research plans. A Master degree can be obtained in the 4th semester after the qualification phase.

1.2.1 Doctor of Philosophy (PhD)

Students with an excellent record of achievement in their Bachelor's or Master's studies may apply to pursue a PhD degree at Jacobs University.

Students joining the COSYP's Integrated Graduate track with a BSc degree are required to complete successfully three semesters of formal courses and a qualifying examination before progressing to the PhD dissertation phase.

Students who have already achieved a Master's degree and have demonstrated an aptitude to research may, subject to the discretion of the Dean, progress immediately after matriculation to the completion of a PhD dissertation. In total, the completion of a PhD degree takes three years in this case.

Upon graduation, Jacobs University Bremen awards the *Doctor of Philosophy (PhD)*. Depending on the area of specialization of the dissertation, the PhD is awarded in *Computer Science*, *Psychology*, or *Neuroscience*.

Doctoral students of Jacobs University receive a PhD. They may, however, choose to carry the German "Dr." in front of their name. In order to do so no further formal acts are necessary.

1.2.2 Master of Science (MSc)

Within the COSYP graduate program, a Master of Science (MSc) can be awarded.

The MSc program at Jacobs University Bremen takes two years equivalent to four semesters. The first three semesters, i.e., 1.5 years of study, of the MSc degree are identical to the qualification phase of the integrated Graduate studies for students with a BSc degree. These three semesters include regular course work, i.e., lectures and seminars, and the opportunity to engage in scientific work.

Provided a sufficiently high level of achievement in first three semesters, the student is permitted to complete a Master's thesis during semester four. Upon graduation, Jacobs University Bremen awards the "Master of Science in Cognitive Systems'".

1.3 Target Audience

The target audience of the COSYP Graduate Program are

- students who have completed their BSc in Computer Science, Psychology, Neuroscience, or related areas and who want to
  - acquire knowledge in COSYP areas that are outside their original field of study,
  - deepen their knowledge in their main field of previous studies, and
  - engage in interdisciplinary research leading to a PhD
- graduate students who have completed their Master's degree and would like to continue their graduate education in an interdisciplinary research environment.

The goal of the 1.5 years of the qualification phase for Integrated Graduate students starting with a BSc degree is to qualify them to carry out independent research. The students who have successfully completed the qualification phase, respectively who enter with a MSc degree are expected to do research. Consequently, the qualification phase offers a structured educational program, whereas the final PhD phase can be seen as a stage on which the student defines, and executes, his/her own research in a professional collaboration with a chosen supervisor, respectively several supervisors to foster the interdisciplinary collaborations within COSYP.

2 Study Plan

2.1 Study Plan for the Qualification Phase

Sem.	Description	Credits	Sem. Total	Running Total
1	5 Lectures/Labs/Seminars	$5 \cdot 5 = 25$	25	25
1	1 Transdisciplinary COSYP Colloquium	$1 \cdot 5 = 5$	30	30
2	5 Lectures/Labs/Seminars	$5 \cdot 5 = 25$	25	55
2	1 Transdisciplinary COSYP Colloquium	$1 \cdot 5 = 5$	30	60
3	1 Lecture/Lab/Seminar	$1 \cdot 5 = 5$	5	65
3	1 Transdisciplinary COSYP Colloquium	$1 \cdot 5 = 5$	10	70
3	Research Proposal	$1 \cdot 20 = 20$	30	90
3	*Qualifying Exam*			

Figure 1: The structure of the 3 semester qualification phase for Integrated Graduate students.

The qualification phase for Integrated Graduate students entering the program with a BSc takes 3 semester during which 90 ECTS credits must be earned. The study plan for the qualification phase is shown in figure 2. Given the interdisciplinary backgrounds of the students and the program, the courses the students can attend are chosen with their supervisor according to their individual research interests and plans, which they have to state when applying to the program.

First of all, course credits can be obtained by successfully attending lectures and seminars that are chosen from existing course offers at Jacobs from following disciplines:

- Integrated Social and Cognitive Psychology (BA)
- Biology/Neuroscience (BSc)
- Computer Science (BSc)
- Electrical Engineering and Computer Science (BSc)
- Smart Systems (MSc.)

A selection of suitable courses is listed in section 3. The ECTS credits awarded to the student for taking a course are always in accordance with the official number of credits for this course. This means that if a course has officially less, respectively more than 5 credits then the student is required to take more, respectively less courses compared to the above study plan to get an overall total of at least 90 credits.

The students are expected to engage in hands on research during the qualification phase in addition to the attendance of standard lectures. This is done by attending seminars, which may be carried out as literature study oriented *Independent Study Courses (ISC)*, and in lab courses. The lab courses can be project based and involve practical experiments using the facilities available in the COSYP Research Center (see also section 3). In both cases of research courses, i.e., seminars and lab projects, the students are expected to work under faculty guidance but in an independent manner. Lab projects are expected to be quite work intensive and they are typically worth 10 ECTS credits. A colloquium where the students regularly present results from their research oriented work to the whole COSYP faculty is mandatory for all students.

Students finishing with a MSc degree after two years of studies devote the 4th semester to writing the Master's thesis based on the research proposal made in the 3rd semester (see Section 2.2). They are required to have earned 120 ECTS credits for the MSc degree.

Students progressing to PhD research must pass a qualifying exam at the end of the 3rd semester. This is based on the Research Proposal, as a rule.

2.2 Study Plan for the Master Phase

Students who are interested in pursuing a master degree within the COSYP program must demonstrate their interest in the different areas of the program by attending according lectures. Concretely, students with a background in either Computer Science, Neuroscience, or Psychology - as indicated through their previous BSc degree - must also have attended suited lectures from the other disciplines to be eligible for a COSYP MSc degree. A minimum of 3 lectures or 15 credits from the areas that are not the main fields of the students is required for pursuing an MSc degree.

Available suited lectures within the three COSYP areas include the following:

- Computer Science
  - Autonomous Systems
  - Advanced Robotics
  - Advanced Machine Learning
  - Algorithmical and Statistical Modelling
  - Speech Signal Processing
  - Advanced Random Processes (Kalman Filters, Hidden Markov Models, ...)
- Neuroscience
  - Systems Neuroscience
  - Computational Neuroscience
  - Methods in Neuroscience
- Psychology
  - Sensation and Perception
  - Decision Making

– Introduction to Cognitive Psychology

– Learning and Memory

The recommended study plan for students pursuing an COSYP MSc is shown in the following table. The main area of the student is denoted with "home discipline (HD)" and the other two areas as "interdisciplinary complements (IC)". The label "(HD/IC)" means that these courses can be either from the home discipline or the interdisciplinary complements.

Sem.	Description	Credits	Sem. Total	Running Total
1	3 Lectures/Labs/Seminars (HD/IC)	$3 \cdot 5 = 15$	15	15
1	2 Lectures (IC)	$2 \cdot 5 = 10$	25	25
1	1 Transdisciplinary COSYP Colloquium	$1 \cdot 5 = 5$	30	30
2	4 Lectures/Labs/Seminars (HD/IC)	$4 \cdot 5 = 20$	20	50
2	1 Lecture (IC)	$1 \cdot 5 = 5$	25	55
2	1 Transdisciplinary COSYP Colloquium	$1 \cdot 5 = 5$	30	60
3	1 Lecture/Lab/Seminar (HD/IC)	$1 \cdot 5 = 5$	5	65
3	1 Transdisciplinary COSYP Colloquium	$1 \cdot 5 = 5$	10	70
3	Research Proposal	$1 \cdot 20 = 20$	30	90
3	*Qualifying Exam*			
4	Master thesis	$1 \cdot 30 = 30$	30	120

Figure 2: The structure of the 3 semester qualification phase for Integrated PhD students.

2.3 Successful Completion of the Qualification Phase

The following list summarizes the guidelines for successful completion of the qualification phase for Integrated Graduate and Master students. All specified credits are minimum requirements.

- 90 ECTS credits are needed to successfully complete the qualification phase of the Integrated Graduateprogram. These credits have to be earned as follows:
  – 15 credits from attending the colloquium.
  – 55 credits from attending courses in form of lectures, seminars, and lab projects.
  – 20 credits for the research proposal.
- At least 20 ECTS credits must be earned in every semester, with an average grade of at least 3.0 or better, otherwise the student will be placed on academic probation by the registrar. Any graduate student whose GPA in any given semester is worse than 4.33 will be automatically suspended.
- 120 ECTS credits are needed to receive a MSc. In addition to the above listed requirements, following additional ones apply:
  – A thesis for which 30 credits are awarded must be written in the 4th semester.

- Master's thesis credits are awarded only if the grade is better than 4.0. In case the thesis does not fulfill this requirement, the examination committee may grant the right to resubmit it within three months.

2.4 PhD Phase

The three-year PhD phase is devoted to focused research within the research group of an academic supervisor, respectively multiple advisors whenever possible to foster interdisciplinary research within COSYP. This phase is entered after successful completion of the qualification phase by an Integrated Graduate student or by a student who enters with an already completed MSc. In both cases, it is required that the student has found a COSYP faculty member who is willing to supervise the student. Students who enter the PhD phase from the qualification phase typically choose their supervisor after the 2nd semester, i.e., before writing the research proposal, whereas students who enter with a MSc by a direct application choose the supervisor during the application/acceptance process.

BSc Sem.	MSc Sem.	Title	Activity
1-3	-	*qualification phase for Integrated PhD*	
4	1	PhD definition	development of a thesis proposal; public defense of thesis proposal at end of semester
5	2	PhD research	e.g., experiment design, detailed implementation specification
6	3	PhD research	e.g., running experiments, implementation phase
7	4	PhD research	evaluation and refinement phase; written progress assessment by the thesis committee at end of semester
8	5	PhD research	thesis preparation, publications
9	6	thesis and defense	write-up of the PhD thesis; public defense

Figure 3: The structure of an example final phase of the PhD. The semesters differ depending on whether the student entered with a BSc or an MSc.

Figure 3 shows an overview of a typical PhD phase. For Integrated PhD students who have successfully completed the qualification phase and found a supervisor, this typically corresponds to their fourth semester. In the first semester of this phase, the student works out a thesis proposal in collaboration with the academic supervisor(s). This proposal must

- demonstrate that the student masters the professional terminology in the research domain and has the requisite background knowledge,
- identify and motivate a relevant and feasible research question,
- connect the question to the state of the art by a focused and illustrative literature overview,
- lay out a design for planned experiments, theoretical investigations or implementations, including a schedule,
- and describe criteria for evaluating the eventual success of the project.

At the end of the first semester, a doctoral thesis committee is constituted and the proposal is defended in a public presentation.

After (and if) the thesis proposal is successfully defended, in the remaining time the proposed research is carried out. It is only natural that the originally stated objectives are refined or even re-defined in this process. Progress is monitored by presentations within group-seminars, which are mandatory for the PhD students, and of course on a day-by-day basis in close interaction with the supervisor.

The last semester is devoted to writing up the thesis document. At the end of the program, the findings are presented to the graduate program and the university in a public PhD thesis defense. The thesis committee judges the presentation in the thesis defense together with the content and form of the thesis to determine whether to accept or reject the thesis. The PhD thesis is not graded with respect to the Jacobs University grading system but may be awarded with an honour's predicate.

Given the interdisciplinary nature of COSYP, PhD students are encouraged but not required to enlist in courses to broaden and deepen their knowledge in the different underlying fields.

Teaching experience is part of graduate education. All graduate students are encouraged to work in undergraduate courses as teaching assistants (TAs). This involves among other activities giving tutorials, grading exercise sheets, and supervising lab or undergraduate project work. According to their experience, PhD students may also work out exercise sheets or define undergraduate projects and offer seminars. TA work is paid according to the general Jacobs University policies.

3 Available Courses

3.1 Involved Faculty

The following faculty members from Jacobs University are involved in the program:

- Andreas Birk (Robotics)
- Mathias Bode (Signal Processing)
- Adele Diederich (Cognitive Psychology, Mathematical Psychology)
- Ben Godde (Systemic Neuroscience)
- Claus Hilgetag (Computational Systems Neuroscience)
- Herbert Jaeger (Machine Learning)
- Arvid Kappas (Emotions Research)
- Andreas Nüchter (Automation)
- Bettina Olk (Cognitive Psychology, Neuropsychology)
- Peter Schupp (Theoretical and Mathematical Physics)
- Claudia Voelcker-Rehage (Human Movement Science)

3.2 Regular Lectures

As mentioned before, course credits can be obtained by successfully attending lectures that are chosen from existing lecture offers at Jacobs from primarily following disciplines: Integrated Social and Cognitive Psychology (BA), Biology/Neuroscience (BSc), Computer Science (BSc), Electrical Engineering and Computer Science (BSc), Communications, Systems and Electronics (MSc), and Smart Systems (MSc).

Examples include the following lectures:

- Autonomous Systems
- Advanced Robotics
- Advanced Machine Learning
- Algorithmical and Statistical Modelling
- Speech Signal Processing
- Advanced Random Processes (Kalman Filters, Hidden Markov Models, ...)
- Systems Neuroscience
- Computational Neuroscience
- Methods in Neuroscience
- Sensation and Perception

- Decision Making
- Introduction to Cognitive Psychology
- Learning and Memory

320421 – Advanced Robotics

Field: Computer Science
Credit Points: 5

Course contents Robotics is a broad field ranging from low-level mechatronics and signal processing over autonomous capabilities to high-level cooperation protocols of intelligent agents. The advanced robotics course reflects this wide range and covers the engineering as well as the scientific side of robotics. The course links core scientific topics with a hands-on training with the equipment of the robotics group in the related lab course.

320451 – Advanced Machine Learning

Field: Computer Science
Credit Points: 5

Course contents The course offers an introduction into a variety of modern machine learning techniques. Because the field is fed from many disciplines (statistics, artificial intelligence, electrical engineering, mathematical modelling and logics, information theory) and is very diverse and quickly evolving, a comprehensive overview cannot be attempted. Instead, the student is first given an intuitive introduction to the basic concepts and challenges of machine learning (that is, to the "curse of dimensionality" and the "dilemma of bias vs. variance"). Then, in the main part of the course, two to four areas of modern machine learning from the following list are treated in some depth, where the choice is made by the students: (i) linear classifiers and feedforward neural networks, (ii) statistical learning theory and support vector machines, (iii) Hidden Markov models and Observable Operator Models, (iv) recurrent neural networks, (v) clustering algorithms and self-organizing feature maps, (vii) adaptive filters, – and possibly others. A self-contained set of lecture notes will be available.

320xxx – Advanced Automation

Field: Computer Science
Credit Points: 5

Course contents Automation and control are pervasively enabling technologies which are found in almost any modern technical system, in particular in processing, production and transportation systems. Process automation and robots are key components in modern factories.

This course provides an introduction to control systems from a computer science perspective. Application of feedback analysis and design ranges from mechanical, thermal, and electrical to fluid systems, including classical control theory in the frequency and time domains.

Besides coverings methods for system modeling and simulation, the course covers digital control and microprocessor systems, industrial robots and advanced mechatronic technology for product design.

320xxx – Machine Vision

Field: Computer Science
Credit Points: 5

Course contents This course discusses introduces and discusses recent computer vision algorithms. Most of these algorithms developed are proven theoretically sound, presumably with a specific application in mind, but its practical applications and the detailed steps, methodology, and trade-off analysis required to achieve its real-time performance are never fully explored. This course focuses on applications of computer vision methods.

The real-time aspect is critical in many real-world devices or products such as mobile phones, digital still/video/cell-phone cameras, portable media players, personal digital assistants, high-definition television, video surveillance systems, industrial visual inspection systems, medical imaging devices, vision-assisted intelligent robots, spectral imaging systems, and many other embedded image or video processing systems.

300451 – Speech Signal Processing

Field: Computer Science
Credit Points: 5

Course contents Speech signal processing is important in fields like intercom, telephony, VoIP, user authentication, and man-machine interfaces ranging from speech dialing and dictation to human-robot communication. The course treats the signal chain including the generation of speech, distortions due to reverberation, echo and background noise, as well as techniques to recover the original signal. Other important topics are fundamentals of speech compression, speaker identification, and automatic speech recognition including a discussion of feature vectors, vector quantizers, time warping and stochastic word modeling with HMMs.

710101 – Sensation and Perception

Field: Psychology
Credit Points: 5

Course contents Pioneering work on sensation and perception started in the 19th century and through the years, perception has remained a major focus of Psychology. Sensation refers to the process of detecting a stimulus or a stimulus property in the environment. It is the necessary collection of information about the world from which perceptions will be made. Perception refers to the way in which we interpret the information that is gathered by the senses. The process of perception can not be understood while ignoring the known physiology of the sensory systems that underlies the perceptual process. The course covers both physiological explanations for phenomena of perception and more cognitive aspects of the perceptional process, for which a physiological explanation might be available in the future. This lecture covers the following topics:

- Methods of investigation: Phenomenological method; psychophysical methods such as methods of limits, method of constant stimuli, magnitude estimation, and basic ideas of signal detection; psychophysical measures such as absolute threshold, difference threshold, adaptation; Fechner's law, Weber's law, Stevens' power law.
- Visual perception: The visual stimulus, the structure of the eye, neural processing including basic neural circuitry, and information flow and organization in the brain; perception of objects and models of object perception such as the Gestalt approach, feature integration theory (Treisman), recognition-by-component model (Biederman), Marr's computational approach; perception of depth, monocular depth cues, binocular depth cues; perception of color and models of color perception such as trichromatic theory, opponent-process theory; perception of movement, motion sensing systems such as image-retina system, eye-head system, corollary discharge theory; perceptual constancies such as color constancy, size constancy, lightness constancy, shape constancy; and phenomenon such as visual illusions.
- Auditory perception: The sound stimulus, the structure of the ear, neural processing in the cochlea and auditory nerve; the experience of sound (loudness, pitch, timbre); perception of simple tones and complex sound; models such as Bekesy's Place Theory; localization of sound.
- Touch and pain: The cutaneous stimulus; the skin and its different receptor systems; active versus passive touch; pain and pain relief, such as analgesia and endogenous opiates, placebo.
- Smell and taste: The olfactory stimulus, the olfactory system, the taste stimulus, the taste system; pheromones; taste quality; flavor.

710302 – Decision Making

Field: Psychology
Credit Points: 5

Course contents Decision making may be defined as intentional and reflective choice in response of perceived needs. Decision making and decision theory are broad and complex areas of great theoretical interest and practical impact in many fields. Decision making has been studied, e.g., in philosophy, mathematics, statistics, economy, biology, sociology, psychology, marketing, psychiatry, organizational behaviour, political science, anthropology, and many more, for some of these disciplines in more than two centuries. The following topics are covered in this seminar:

- Basic concepts: Utility, preference, uncertainty, prediction and interference (judgment), evaluation, and choice.
- Prescriptive (normative) theories: Subjective expected utility (SEU), prospect theory, sign
- and rank dependent utility; cumulative prospect theory.
- Descriptive theories: Decision making under certainty; random utility models, elimination by aspects (EBA)
- Decision making under risk / uncertainty: Structural models; Hammond's social judgment theory; Brunswik's lens model; Anderson's information integration theory (functional measurement
- process theories contingency model; cost/benefit model (adaptive decision maker; criterion dependent choice model; decision field theory.
- Practical issues: Improving decisions and avoiding decision traps.

710102 – Learning and Memory

Field: Psychology
Credit Points: 5

Course contents The study of memory seeks to understand how information is stored and retrieved, how new information is integrated to existing information, why we forget, and whether or not we can improve memory. The concept of model testing, i.e., stating assumptions and deriving predictions, empirical testing, and possible modification of the model, is introduced. This lecture covers the following topics:

- Sensory memory: Link between perception and memory; iconic memory; echoic memory; experimental paradigms such as partial report.
- Immediate memory: Information to be retained only briefly; experimental procedures for investigating immediate memory such as free and serial recall, Brown-Peterson paradigm; models of immediate memory such as Broadbent's model of primary memory; Atkinson & Shiffrin's Dual Store model; serial position curves and its meaning for testing immediate memory; Sternberg paradigm for memory retrieval from short-term store; Baddeley's working memory model; levels of processing.

- Generic memory: Information to be retained indefinitely; propositions and concepts; knowledge; models of semantic memory such as Collins & Quillian's hierarchical model; the feature overlap model; Collins & Loftus's spreading activation model including priming.
- Forgetting: The failure to retrieve a memory of a previous experienced event; models of forgetting such as consolidation theory, interference theory; decay versus interference in immediate memory; retroactive interference; proactive interference.
- Implicit memory: Memory without reference to a specific learning episode; Implicit versus explicit memory; indirect versus direct test; implicit learning; experimental dissociations; association priming; models of implicit memory such as activation, multiple memory systems, transfer appropriate processing, bias approach.
- Memory and brain: The neural base of learning and memory; Information processing in and between neurons; synaptic plasticity; postsynaptic potential; classical conditioning; instrumental conditioning; Hebb rule; anatomy; cerebral cortex, methods of investigation such as EEG, ERP, CT, MRI, PET, fMRI.
- Memory deficits: Amnesia and Alzheimer's disease; retrograde and anterograde amnesia; Korsakoff syndrome; methods to assess amnesia; case study; Alzheimer's disease and diagnosis.
- Recognition: Identifying material that has been presented previously; signal detection theory; face recognition.
- Reconstructive processes in memory: Eyewitness memory; flashbulb memory; hypnoses; emotion and memory; context and memory; cognitive interview; implanting memories (false memory).
- Mnemonics: Strategies used to improve memory; levels of processing; PQ4R; method of loci; method of associations; method of key words; number-consonant alphabet.

710111 – Introduction to Cognitive Psychology

Field: Psychology
Credit Points: 5

Course contents This course provides an introduction to cognitive psychology. The goal of cognitive psychology is to understand how the human mind works, in particular how we perceive, attend to, learn and memorize information as well as how we solve problems and make decisions. The course will focus on the historical foundations of cognitive psychology, influential and current theories and models as well as empirical research methods.

As an introductory course, this lecture will review important aspects of cognitive psychological research, which then will be discussed in more detail in 1st, 2nd and 3rd year lectures and seminars.

The lecture includes the following topics:

- History of Cognitive Psychology
- Basic concepts and research methods of Cognitive Psychology
- Perception
- Attention
- Learning and Memory
- Thinking and Problem Solving
- Intelligence
- Language and Knowledge
- Decision Making
- Cognitive Development
- Cognitive Neuroscience and Neuropsychology

500201 – Systems Neuroscience

Field: Neuroscience
Credit Points: 5

Course contents The course provides an outline of structure - function relationships in the mammalian nervous system, in particular at the large-scale systems level. It covers the anatomical organization and physiological mechanisms underlying sensory perception and motor behavior, as well attention, emotion and memory.

500332 – Computational Neuroscience

Field: Neuroscience
Credit Points: 5

Course contents The course will cover methods and knowledge for addressing structure - function relationships at different scales of the nervous system through mathematical analyses and computational modeling. Lectures will review neurobiological concepts and currently available data as well as mathematical approaches for representing neural systems. Complementary lab session will provide an opportunity to become familiar with widely used neural modeling packages and to carry out individual course projects.

3.3 Infrastructure for Lab Projects

As mentioned before in section 2.1, the students are expected to engage in hands on research during the qualification phase in addition to the attendance of standard lectures. This happens in projects for which the COSYP Research Center is particularly well equipped. In addition to standard infrastructure like computers for programming projects or facilities to engage in experiments with volunteers, COSYP features some special labs including the following ones.

3.3.1 Robotics Laboratory

The robotics prototyping lab is equipped for the development of robots and robot components. It has several electronics workbenches, basic facilities for mechanical processing and assembly, as well as several PC workplaces for programming. In addition to various sensors and mechatronic components, the lab features a nice collection of robots including several mobile land robots and autonomous underwater vehicles (AUV).

Figure 4: The Robot Prototyping Lab.

Jacobs University Robotics is also equipped with special testing facilities for mobile robots. They are mainly used for evaluating search and rescue robots, but they provide standardized test elements for a large variety of locomotion, perception and world modeling challenges for mobile robots in general.

3.3.2 Eye Tracking Laboratory

The laboratory consists of specialized and general purpose rooms, among those several rooms with PC workstations, including special software (Superlab, Medialab, Matlab, C++), to be used for behavioral experiments.

The specialized eye tracking laboratory is equipped with an EyeLink II (SR Research, Canada) eye tracker (see Figure 10), which consists of a headset with three cameras that track the movements of the pupils and the head with a very high temporal (500 Hz, recording every 2 ms) and spatial (typically 0.3 degrees) resolution. The recording of

Figure 5: The Jacobs NIST mobile robot test arenas.

Figure 6: Two eye cameras monitor eye movements. A head camera, hidden inside the bar resting on the forehead, records the location of the head in relation to the environment.

head position is crucial as it allows separating measurements of eye and head movements.

Figure 7: Examples of scanpaths. Yellow arrows indicate moving from one fixation point to the next. Yellow numbers indicate the sequence of fixations and blue numbers indicate the time in ms the participant fixated on the particular spot.

The recorded data contain information regarding the location and duration of fixations and saccades and saccadic reaction times and allow the reconstruction of the scanpath of each participant very accurately (see Figure 7). The eye tracker is equipped with special software for programming and analyzing experimental data.

3.3.3 Emotion Physiology Lab

Figure 8: The lab is a.o. equipped with an EMG for measuring facial muscle activities.

The laboratory is equipped to study parameters linked to emotion, for example

- objective behavioral parameters like
  - reaction times,
  - facial responses

- physiological responses like
  - EMG responses
  - skin conductance
  - respiration
  - heart rate

3.3.4 Transcranial Magnetic Stimulation (TMS) Laboratory

Figure 9: Transcranial Magnetic Stimulation (TMS) in operation.

The laboratory is equipped for TMS studies with

- Visual stimulus generator (VSG 2/5, Cambridge Research Systems Ltd.)
- CRT projector (BARCO) and back-projecting system for stimulus presentation at high temporal resolution
- Magstim Super Rapid (MagStim, Whitland,UK) for rTMS as well as several Magstim200 and Bistim stimulators and coil systems for single- and double-pulse stimulation
- Brainsight frameless stereotaxic camera system (Rogue Research, Montreal, Canada) for identifying brain regions underlying stimulation sites

3.3.5 Sensory Motor Laboratory

The laboratory can be used for sensor/motor-studies. It is equipped a.o. with

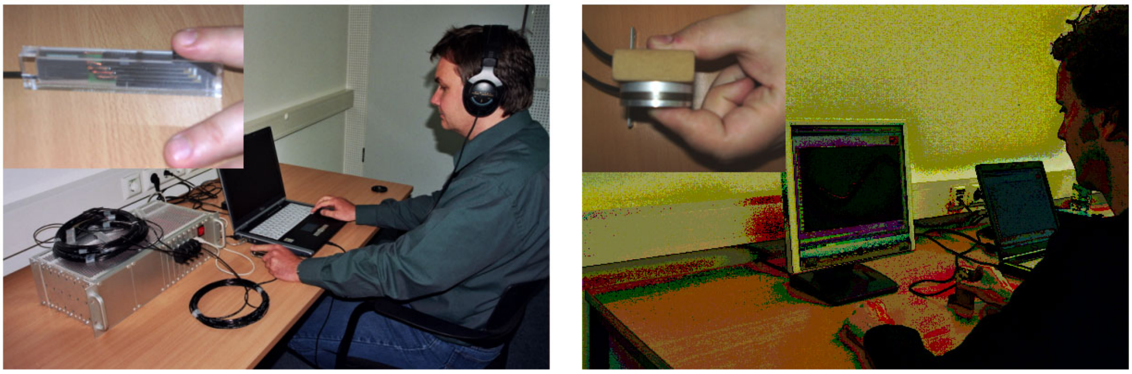


Figure 10: Setup for testing tactile sensitivity (left) and precision grip (right).

- Computerized tests of tactile sensitivity as well as spatial and temporal discrimination performance (using e.g. Braille piezoelements, Johnson-van Boven Domes, von Frey hairs).
- Computerized tests of fine finger forces (precision grip) using six axis force transducers in the micro range