RUHR-UNIVERSITÄT BOCHUM

RUB

THE FATE OF THE **MEMORY TRACE**

EUROPEAN CAMPUS OF EXCELLENCE
SUMMER SCHOOL IN NEUROSCIENCE AT RUB

European Campus Excellence

Stiftung Mercator

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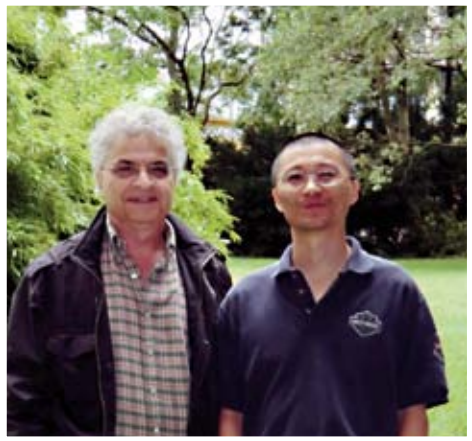
PUNIT SHAH:
»Even more so than learning about memory, I have learned about German culture and other people's cultures.«

ILONA LIPP:
»I really enjoyed the international food evening. The food and the social event were both really good!«

AMIE DOIDGE:
»I really liked the in situ hybridization practical because I have never done anything like that before, so I learned a lot. That practical was really good.«

ALESSANDRO TREVES:
»I greatly enjoyed the new people I met and their diversity, students and lecturers alike; and when receiving, back here in Tel Aviv, goodbye messages from some of the students from Iran, I actually felt the power of science at bridging across political boundaries.«

TIM SCHRÖDER:
»The lectures were even better than expected!«



YADIN DUDAI:
»It is rare indeed to encounter such an impressive group of top international students, getting the opportunity to get acquainted with the most recent developments in memory research in an enticing and encouraging atmosphere. Full marks to the organizers!«

HOWARD EICHENBAUM:
»Superb students, very involved, curious, driven to learn. A wonderful group with whom to share my knowledge.«

»RUHR UNIVERSITY WAS PROUD OF HOSTING THIS EVENT«

Dear Reader,

Excellence in research is a prerequisite for excellence in teaching, as research and teaching form a unity at universities. The Ruhr University Bochum (RUB) follows the universitas principle: Being a community of the learned and the learning is at the heart of our mission. Having been chosen as the site of the first "European Campus of Excellence in Neuroscience" thus was a great honor and also pleasure for us all. We thank in particular Stiftung Mercator for creating and for funding this unique format which brings together the best of talent: highly gifted students from all over Europe and preeminent researchers from all over the world who worked and learned together for several weeks in most intensive, flexible and innovative ways.

Neurosciences at Ruhr University have a long tradition and are one of the most diversified and cross-disciplinary of our research profile areas, ranging from the molecular level all the way to the structural, functional, cognitive and even clinical aspects of nervous systems and brain function. The Research Department Neuroscience, the Mercator Research Group "Structure of Memory", the new Collaborative Research Center "Integration and Representation of Sensory Processes" funded by the German Science Foundation (DFG), the new DFG-funded Research Focus Group "Extinction Learning" and the "International Graduate School of Neuroscience (IGSN)" – a pioneer in European Neuroscience graduate education, are witness of the dynamics and power of Neurosciences at Ruhr University. Thus, the Campus of Excellence was embedded in rich, diverse, high-class science.

This volume shares with you, dear reader, the excitement of this venue and lets you participate in the results that have been obtained and the many activities that took place during the Campus of Excellence. Ruhr University was proud of hosting the event – it proved a seamless fit to the International Research Campus RUB – a finalist in the German Excellence Initiative.

Elmar Weiler
(Rector of the RUB)

»LET IDEAS TAKE FLIGHT«

Dear Reader,

On behalf of Stiftung Mercator, it is with great pleasure that I welcome you to learn more about this year's Summer School "The Fate of the Memory Trace" in this booklet.

Stiftung Mercator is one of Germany's largest foundations. It initiates and funds projects that promote better educational opportunities in schools and universities. In the spirit of Gerhard Mercator, it supports initiatives that embody the idea of open-mindedness and tolerance through intercultural encounters, encouraging the sharing of knowledge and culture. The foundation provides a platform for new ideas to enable people – regardless of their national, cultural or social background – to develop their personality, to play their part in the community and to make the most of the opportunities available to them. In this way it wants to let ideas take flight. Stiftung Mercator takes an entrepreneurial, international and professional approach to its work. It has a particular affinity with the Ruhr area, the home of its founding family.

The influence of science and humanities on almost every sphere of human life is constantly increasing, as are people's expectations regarding scientists and scholars. This is why we promote sciences and academia in two specific ways. First, we are committed to the targets defined in our interdisciplinary clusters – the prevention of dangerous climate change, stronger integration, and education in arts – and seek to achieve these by promoting academic projects, as well. Second, we define three structural areas of academic focus: support for the institutional development of universities and higher-education system, improvement of the quality of teaching and higher-education courses, and development of promising "exploratory" fields of research.

We have supported this Summer School as the first of hopefully many more international Summer Schools to come within the framework of the "European Campus of Excellence". As stated before, Stiftung Mercator wants to improve the quality of teaching and to support international mobility – as part of the Bologna reform. For three weeks, international students had the privilege to learn from internationally renowned scientists together with fellow students from European universities, in very small study groups. And they learned from each other – what an intense, culturally diverse experience. Within a short space of time, they gained "international mobility" – in the middle of the so-called Ruhrgebiet! This is where Stiftung Mercator has its roots. On behalf of the foundation, I would like to thank Professor Roth and Professor Güntürkün and their dedicated teams for their initiative to plan this Summer School. I wish both the participants and the readers more exciting Summer Schools to come – in and outside the campus of Ruhr University Bochum.

Bernhard Lorentz
(President of Stiftung Mercator)

»AN IMPORTANT PART OF THE EUROPEAN INTEGRATION PROCESS«

Dear Reader,

An important part of the European integration process is to promote highly talented young students in equal ways and to create networks for collaboration. Unfortunately, besides some initiatives between Germany, Great Britain and Switzerland, such networks do not exist in most academic disciplines. This situation can be changed by bringing together the best students from European countries including Turkey and Israel by offering them disciplinary and transdisciplinary courses.

Exactly this is the aim of the initiative "European Campus of Excellence – ECE". Starting in 2011, it offers students at late bachelor and early master level courses lasting two to three weeks on topics within the major academic disciplines of European universities. The lecturers are carefully chosen as excellent international representatives of their disciplines. ECE courses are financed and supported by major European foundations such as the German foundations Stiftung Mercator (Essen) and VolkswagenStiftung (Hannover), the Portugese Kalouste Gulbenkian foundation (Lisboa), the Italian foundation Compagnia di San Paolo (Turin) and the German Max Planck Society.

The first four ECE courses took place in summer 2011, among them the course "The Fate of the Memory Trace" at the Ruhr University Bochum. Additional five courses will be carried out in 2012, and several more courses are already planned for 2014. This appears to be a good start for a young initiative.

Gerhard Roth
(Head of Coordination Office ECE)

»MANY PEOPLE CONTRIBUTED TO THIS SUMMER SCHOOL«

Dear Reader,

From 4th to 23rd of September 2011 we had the great pleasure of hosting the first "European Campus of Excellence" in Neuroscience at the Ruhr University Bochum. Over a period of three weeks thirty truly gifted students from all over Europe visited Bochum to deepen their knowledge in memory research.

The agenda of the three weeks followed the inner logic of "The Fate of the Memory Trace": Week 1 was dedicated to acquisition and consolidation of memories; week 2 dealt with the retrieval of memories and the memory systems; the final week was devoted to all aspects of extinction and forgetting of memory traces. The students attended lectures by experts from the RUB and abroad in the mornings and put the newly acquired information into use during practical lab exercises in the afternoons. In the evenings, further leading scientists held key note lectures on state of the art research.

Many people contributed to the planning and realization of this summer school. First of all, I would like to thank Stifung Mercator for the very generous funding. The specialist organizers Sen Cheng, Magdalena Sauvage, and Oliver Wolf did an amazing job conceptualizing the program. Besides them many more RUB colleagues did their best to make this first ECE at the Ruhr University a huge success.

I also want to thank the scientists from all over the world who shared their knowledge and exciting research results with us. Most of all, I want to thank the ECE students who are incredibly brilliant and critical young minds whom to work and discuss science with was definitely worth hosting this summer school. Together we created a lasting memory of three intensive and stimulating weeks that I will cherish always.

The present volume is a compilation of many of those ECE memories proving that our research is not only relevant to understanding human behavior but can also be a lot of fun for students, scholars and laymen. Enjoy!

Onur Güntürkün
(Chair of the RUB-Department of Biopsychology and host of the ECE)

MEMORY TRACERS

Thirty students from universities all over Europe participated in the summer school. They arrived in Bochum with different expectations and motivations.

NORA OEHLER (GERMANY)
UNIVERSITY OF KONSTANZ, GERMANY

»I look forward to meeting everyone in Bochum and I hope we'll have a great time together.«

MONIKA SCHÖNAUER (GERMANY)
LUDWIG-MAXIMILIANS-UNIVERSITY MUNICH, GERMANY

»I am very much looking forward to the biological part of the summer school.«

ÖMER FARUK ÖZTÜRK (TURKEY)
ISTANBUL UNIVERSITY, TURKEY

»Get ready for three great weeks: we will learn, share and enjoy much more than we expect.«

ANDREINA PAULI (SWITZERLAND)
UNIVERSITY OF BERN, SWITZERLAND

»I am sure, we will have amazing discussions about our 'Neuroworld'.«

OFFIR LAUFER (ISRAEL)
WEIZMANN INSTITUTE OF SCIENCE, ISRAEL

»By taking part in the ECE summer school, I hoped to enrich myself academically as well as socially.«

MARIE-THERES MEEMKEN (GERMANY)
CARL-VON-OSSIETZKY-UNIVERSITY OF OLDENBURG, GERMANY

»I am very excited to hear some interesting talks as well as meeting people who are interested in neuroscience as well.«

ECE KOCAGONCU (TURKEY)
ISTANBUL UNIVERSITY, TURKEY

»I'm really excited about the practicals, and lectures.«

KATHERINE COLE (UNITED KINGDOM)
UNIVERSITY OF ABERDEEN, U.K.

»I came to this summer school, because my PhD is in a very specialist area and I want to get broader knowledge.«

MICAH EDELSON (ISRAEL)
WEIZMANN INSTITUTE OF SCIENCE, ISRAEL

»One of my expectations is to get a first-hand feeling of how research is done in other labs.«

OLIVER BARNSTEDT (GERMANY)
JACOBS UNIVERSITY BREMEN, GERMANY

»I'm really looking forward to getting in touch with the participants and learning from their experiences and interests.«

VIVIANA HAASE (GERMANY)
UNIVERSITY OF MARBURG, GERMANY

»I'm looking forward to three weeks with a lot of input and a lot of fun with people from different countries.«

PUNIT SHAH (UNITED KINGDOM)
UNIVERSITY OF SURREY, U.K.

»The summer school will be a great opportunity for me to dramatically expand my knowledge of memory.«

ALEXANDRA BIEBER (GERMANY)
JUSTUS-LIEBIG-UNIVERSITY GIESSEN, GERMANY

»I am absolutely sure that it will be an informative and very funny time.«

MINA SHAHI (IRAN)
UNIVERSITY OF OSNABRÜCK, GERMANY

»When I heard that I could come, I was so excited!«

CHARLOTTE FALKENBERG (GERMANY)
CHRISTIAN-ALBRECHT-UNIVERSITY OF KIEL, GERMANY

»From the first moment I heard about the course, I've wished to take part.«

DIRK WULFF (GERMANY)
UNIVERSITY OF BASEL, SWITZERLAND

»I was probably most interested in the social aspect of this whole event.«

CATHERINE BOIS (SWEDEN)
DURHAM UNIVERSITY, U.K.

»I am really excited to come to Germany, I reckon we will have an amazing time.«

AGNESE ZAZIO (ITALY)
UNIVERSITY OF PADUA, ITALY

»I am really looking forward to spending three weeks of intense work on a topic that is quite new for me.«

ANNE PETZOLD (GERMANY)
OTTO VON GUERICKE UNIVERSITY MAGDEBURG, GERMANY

»My research topic is a huge one and I hope to narrow it down in the course of the ECE.«

TANNY PHILLIPS (U.S.A)
UNIVERSITY OF BASEL, SWITZERLAND

»I'm very much looking forward to learning with and from all of the other participants at this workshop!«

ANDREA MERSEBURG (GERMANY)
UNIVERSITY OF HAMBURG, GERMANY

»I'm so looking forward to Bochum and to meeting everyone and to learning many, many exciting things from great scientists!«

MARTA CASTELLANO (SPAIN)
UNIVERSITY OF OSNABRÜCK, GERMANY

»My interest in the summer school is to discover how a memory trace emerges.«

TIM SCHRÖDER (GERMANY)
EBERHARD KARLS UNIVERSITY TÜBINGEN, GERMANY

»I am looking forward to have an interesting and fun time in Bochum!«

ILONA LIPP (AUSTRIA)
KARL-FRANZENS UNIVERSITY GRAZ, AUSTRIA

»I read so many papers. I'm kind of excited to get to know and listen to the experts who did all that incredible research.«

AMIE DOIDGE (UNITED KINGDOM)
CARDIFF UNIVERSITY, U.K.

»I came here to meet people from all over Europe who are also interested in neuroscience.«

EKIN KECECIOGLU (TURKEY)
MIDDLE EAST TECHNICAL UNIVERSITY ANKARA, TURKEY

»The ECE gives us the opportunity to come together with other young neuroscientists, share our ideas and acquire new perspectives on the field.«

CHRISTIAN PARET (GERMANY)
UNIVERSITY OF HAMBURG, GERMANY

»I am really looking forward to the third week, because extinction is one of my favorite topics.«

AYA BEN-YAKOV (ISRAEL)
WEIZMANN INSTITUTE OF SCIENCE, ISRAEL

»I'm looking forward to meeting everyone! Since Israel is a bit farther away, we don't get many chances to meet students from so many countries.«

DANIELA SCHWAB (AUSTRIA)
KARL-FRANZENS UNIVERSITY GRAZ, AUSTRIA

»I am very keen to find out more about 'the fate of the memory trace' in Bochum.«

TOBIAS RUFF (GERMANY)
UNIVERSITY OF ERLANGEN-NÜRNBERG, GERMANY

»I am already very much looking forward to the ECE Summer School and to meeting everyone in Bochum in September.«

OVER 1000 GALAXIES IN OUR HEAD

The beginning of the memory trace

One hundred billion nerve cells can be found in the adult human brain, a figure almost beyond imagination. Still more difficult to visualize are the one hundred trillion connections, the so-called synapses, between the cells. For comparison, this number equals the amount of stars in 1500 Milky Way galaxies (online news source CNET, Elizabeth Armstrong Moore). Such an organ is bound to have the ability to do amazing things.

Memory is only one of the cognitive abilities that fascinate today's neuroscientists, the others including consciousness, imagination, social skills, decision-making, and many more. Researchers seek to understand how changes in the nerve cells (neurons) lead to the acquisition of new information and how certain physiological states or disorders impair learning. As Tanny Phillips reports in "Getting lost in your own brain", sleep can have quite an impact on forming memory traces.

New research tools, like brain imaging techniques, have led to a deeper understanding of the memory processes in the brain. Some of these modern tools seem quite unusual at first. Amie Doidge, for instance, introduces virtual realities for the investigation of a certain kind of memory, i.e., spatial memory ("Computer games: The latest tool in science"). As explained in detail by Ladina Greuter, we do not possess only one memory system. Rather, we use different resources to remember various kinds of information that we encounter and learn in our daily life. In "A successful distraction", she also shows that, although researchers have been investigating memory for decades, results of new studies can still be quite astonishing.

Spatial memory can also be explored on the level of single cells. Tim Schröder outlines in "Ask the sea horse for the way" that a certain part of the brain, the hippocampus, possesses specialized neurons called place cells. The activity of these cells apparently creates a map in the brain, which helps to navigate the environment.

The Summer School Diary

Our first week in Bochum

Weeks before the first ECE summer school in neuroscience started, the 30 participants from different European universities already got to know each other. In the blog "The fate of the memory trace", they wrote about their motivations to come to Bochum, their research interests, their hobbies, and a lot more. The students continued to exchange their experiences in the blog, ranging from how they made neural networks remember, to getting in touch with the industrial history of the Ruhr area.

Arrival in Bochum: The summer school begins

Clap your hands for the summer school: Marta Castellano

The participants listen raptly to György Buszáki´s key-note speech

Getting ready for the course: Shared breakfast

In the morning lectures and evening key-note speeches, renowned neuroscientists from around the world taught the students all there is to know about the acquisition and consolidation of new memory traces. In the afternoon practicals organized by Sen Cheng, the students learned how to program a neural network.

Excerpts of the blog can be found throughout the chapters of this publication. Andreina Pauli, Christian Paret, Ilona Lipp, Micah Edelson, Oliver Barnstedt, Catherine Bois, and Viviana Haase wrote about their first week in Bochum. The full diary and a lot more information about the summer school, including the program, can be found at: http://eceneuroscience.blogs.rub.de/

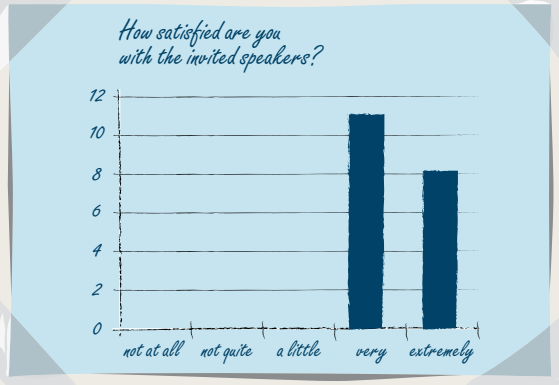
Andrew Mayes: Listening to recognition memory theories

Daniela Schiller: The brain structure „amygdala" and memory processes

Arriving in Bochum – Love at second sight

3. September 2011

After a preparation period full of excitement and expectations about the practicals and lectures, the ECE summer school started. […] As many prejudices about the Ruhrpott predicted, the city seemed very industrial and gray. Despite those bad first impressions, we got a warm welcome by the ECE organizers who accompanied us to our dorms close to the Ruhr University. The next morning, we met up at the Uni Center to have breakfast in the sun together. It was a great atmosphere; everybody was eager to get to know each other and tried hard to remember all the new names. […] We planned many activities for the following weeks, like playing soccer and beach volleyball, or going for a run in the woods […]. After that lovely first weekend, many of us probably now agree with Herbert Grönemeyer's song "Bochum": "Tief im Westen, wo die Sonne verstaubt, ist es besser, viel besser als man glaubt" (Deep in the West, where the sun struggles through smoke and steam, life is much better than one thinks).



Summer school prelude

4. September 2011

After arriving in Bochum, all of us 30 ECE participants were excitedly looking forward to the beginning of the Opening Event. […] I think we all got immediately caught by the ceremonial atmosphere when arriving at the reception. For most of us this was the first time we met our hosts Onur Güntürkün and Emily who was known to everyone by supplying us with helpful information about the upcoming stay in Bochum in advance. With a glass of champagne in hand, we made our way to the tables. […]

Professors Gerhard Roth and Onur Güntürkün spoke to us about the short but nonetheless successful history of the European Campus of Excellence and how they managed to organize this first ECE summer school in a remarkable short time, from the initial idea to the actual course. […] In an exciting talk, Ray Dolan presented some of his cutting-edge research on different types of memory systems and their neural substrates in the brain. At 8 p.m. the buffet was opened and we enjoyed conversations, drinks and getting to know each other.

Enjoying the lecture: Mina Shahi and Marta Castellano

ANDREW MAYES:
»I was very impressed not just by the standard of the students, but by their enthusiasm and, most of all, by the acuteness of their questions. They revealed to me that the questioners had thought deeply about the conceptual issues and concerns about these were driving what they asked. This comment related not just to a few of the students but to many of them, who asked deep and carefully thought through questions.«

IN HER OWN WORDS
ALEXANDRA BIEBER

»I am totally fascinated by the brain and its functions. Now, at the end of my master's thesis, my interest is at the highest point.«

Who is afraid of a computational model?

8. September 2011

Here is a scenario that all students probably can relate to at one time or another; you are sitting in class surrounded by frightened faces, all staring at the projector screen filled with formidable functions. You think back at the progression of the events in the last hour and try to pinpoint the exact time in which it all went wrong. A feeling of despair may creep over you and you resign to go back to your comfort zone and leave mathematics for the more gifted minds.

However, this is not how it has to be! In today's practical on modeling we learned, step by step, how to program a model for neuronal learning called the Hopfield network model. […] Creating such models has proved especially useful for us and has provided a unique opportunity to experience real modeling and become exposed to this level of scientific analysis.

IN HER OWN WORDS
DANIELA SCHWAB

»I am very impressed by the summer school. I've liked every day so far and I am looking forward to the next days.«

That's what the summer school is all about: The brain

A summer school is more than just studying: Daniela Schwab, Katherine Cole, and Ilona Lipp

How we made the computer remember: Applying the Hopfield model

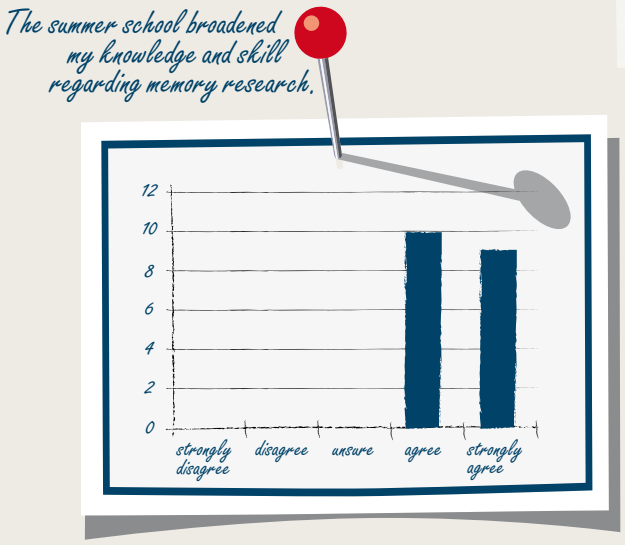
8. September 2011

The Hopfield model is a model for associative memory. […] This means that the brain does not store entire memories in one place. Rather, parts of individual memories are spread across relatively large areas of the brain. On Thursday, we used the computer program Matlab to demonstrate the Hopfield model by constructing a simple computational neural network. […]

So in the end, the networks we created were able to successfully regenerate the original pictures (memories) that we had stored in them. The Hopfield model is of course a very simplified model about how memory might be represented in the brain. However, by implementing the Hopfield model in a computer program, we were able to understand how a relatively simple computational model could replicate human memory processes.

Coffee time: Taking a break from the lectures

Fascination memory research: Rapt attention in the morning lecture



Socializing after work: Agnese Zazio

ANDREA MERSEBURG:
»I very much enjoy the social life here so far. There is always something going on!«

Lecture breaks: Time for networking

A lot of new information: Morning lectures

Connecting the dots of memory

9. September 2011

After a long day of listening to lectures, discussing the researchers' results and theories, plenty of coffee and three hours of practical work in the lab or behind the computer, it is about time to relax and leave science aside. Or is it? Certainly not if you are trying to understand how the most complex structure in the universe can capture our everyday experiences. […] Hugo Spiers demonstrated in his key-note speech how the brain structure hippocampus actually helps us find our way around to the next café or bus stop by retrieving stored memories of space. With this knowledge "stored" in our brains, we mindfully navigated back home to finally have a nibble, a chat and a good, memory-consolidating sleep.

The most beautiful coal mine in the world

11. September 2011

On the Sunday of our first full weekend spent in Germany, two field trips were planned for us. In the morning, we awakened our senses in an exhibition full of thought-provoking exhibits, such as optical illusions and "seeing with our feet". After getting caught in the rain, we finally made it to the main event of the day: Zeche Zollverein. […]

Awakening the senses: The students participate in a special guided tour at the exhibition Phänomania at Zeche Zollverein

Colorful experience: Tobias Ruff and Oliver Barnstedt at the exhibition Phänomania

Nora Oehler and Andreina Pauli explore the exhibition Phänomania

It has been listed as a World Heritage Site since 2001 and some parts of the complex have even been referred to as the "most beautiful coal mine in the world" (European Route of Industrial Heritage). However, the guided tour really demonstrated the true nature of the industry; although it had been a main source of income for many people, the working conditions were harsh, often resulting in severe disabilities.

However, as a contemporary visitor to the site, it was fascinating to see all the tools, shafts and even the coal that constituted the mine itself when it was in use. We really enjoyed this field trip, because it illustrated the industrial history of the Ruhr area, giving us a real feel for the area in which we are living for these three weeks.

Personal feedback week 1

11. September 2011

I just wanted to summarize the essentials I learned in Week 1:

I. Ray Dolans' advice for researchers: "1. Have something to say, 2. Say it, 3. Stop once it's said."

II. Sleep is very important. More sleep is even better. […]

MORNING LECTURES

Raymond Dolan, University College London, U.K.
» Decision-making in the human brain
» Advice for students

Yadin Dudai, Weizmann Institute of Science, Israel
» Basic concepts in memory research: Processes, mechanisms, and levels of analysis
» The phases of memory
» Molecular devices of plasticity: Encoding and consolidation
» Molecular devices of plasticity: Persistence, activation and fidelity
» Introduction to memory systems

Jan Born, University of Lübeck, Germany
» Sleep-dependent memory consolidation: Psychological conditions
» Sleep-dependent memory consolidation: Neurophysiological mechanisms
» Active system consolidation during sleep; spatial representation in the brain

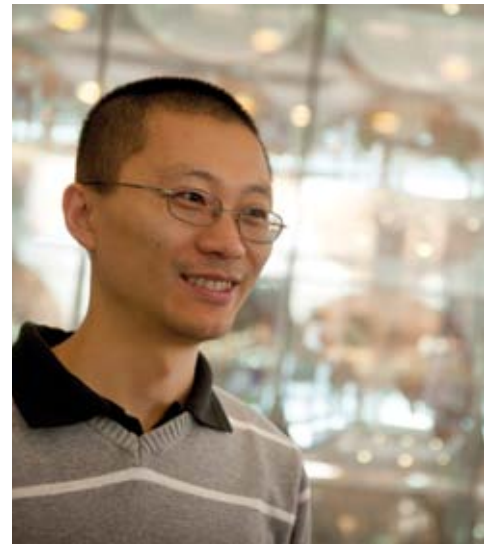
Sen Cheng, Ruhr University Bochum, Germany
» Mathematical models of learning and memory
» Reactivation: A neural mechanism for consolidation?

KEY-NOTE SPEECHES

Denise Manahan-Vaughan, Ruhr University Bochum, Germany
» Understanding the relationship between synaptic plasticity and learning

Emrah Düzel, Otto von Guericke University Magdeburg, Germany
» Regulation of encoding and consolidation in episodic memory: insights from human imaging studies

Hugo Spiers, University College London, U.K.
» The neural basis of spatial memory



SEN CHENG
ORGANIZER OF THE FIRST SUMMER SCHOOL WEEK

»The ECE summer school was a great success. I learned a lot – and I'm one of the co-organizers! My personal favorite were the interactions with the highly motivated and capable students and with the world-class lecturers.«

A SUCCESSFUL DISTRACTION – *OUR MEMORY'S PARADOX*

PEOPLE WITH MEMORY DEFICITS REMEMBER BETTER AFTER DISTRACTION

Have you ever asked yourself what would happen if you lost your memory? You would lose yourself, not just your memories – all the things you have seen, learnt and experienced would be gone, and your life would look like a white, blank page of paper. A frightening thought; but let me reassure you: It is very unlikely that this would happen, because there are three kinds of memories each of which is stored in a different part of the brain.

First, there is semantic memory, which is the memory for facts. Semantic memories are strengthened by repetition and use: When we memorize foreign language vocabulary, the more often we repeat the words, the better we get. Episodic memory, on the other hand, is made up of all the unique experiences we have gathered in our life. The third kind is procedural memory, which represents all the skills achieved in life, e.g., knowing how to ride a bike. These three kinds of memory are represented in different parts of the brain. Thus, people with global amnesia, who have impaired episodic and semantic memory, may still be able to play the piano, meaning that their procedural memory is intact.

The hippocampus, a brain structure in the temporal lobe, seems to be important for the episodic and the semantic memory. Studies have shown that this brain region is, for instance, active when people recognize pictures which they have seen before. Similar studies were also carried out with older people. Some of them performed well on the task, i.e. recognized many pictures, while others exhibited memory impairments. Interestingly, the brains of older people with good memory abilities looked functionally and structurally similar to a younger brain. In contrast, researchers found structural aberrations in the brains of older people with memory impairments, for instance in the hippocampus.

In the same laboratory, a recognition task for pictures of landscapes was conducted with patients suffering from sclerosis in the hippocampus that caused impairment in the function of this brain region. These patients recognized fewer landscape pictures than healthy participants. However, the performance of the patients improved when another stimulus was introduced into the task: In between two landscape pictures, the researchers presented a picture of a face that had no relevance for the task. Interestingly, this distractor did not impair the performance of the patients, but rather increased their recognition skills significantly. With the distractor, the patients performed nearly as good as the healthy participants. This astonishing finding will allow new insights into the brain mechanisms of remembering and may lead to a new theory of memory.

INTERVIEW
WITH MINA SHAHI

»AS A CHILD, I WANTED TO BE A BRAIN SURGEON.«

Have you always been interested in neuroscience?

»I remember that I have been really interested in how the brain works since I was a kid. Or maybe not how the brain works, but I wanted to be a brain surgeon. For my Bachelor degree, I studied computer science. Afterwards, I wanted to pursue something more related to the brain. I wanted to study psychology, but I didn't see that much mathematics in there. So I thought I will open up a new field that combines psychology and mathematics. When I was searching through the fields, I saw neuroscience, and thought: This is really cool.«

Do you have any special expectations of the summer school?

»Not really, because this is the first time that I participate in a summer school, so I was OK with everything. I really like it!«

What do you think about Bochum?

»I heard that it is not a really interesting city, but I don't see it like that! I think it's good.«

Is there anything in the program you are looking forward to most?

»Actually, I didn't study the program too much, because I thought I wouldn't be able to come here. Suddenly, they told me that they have a free slot and that I could come. I was so excited! I didn't know anything, I just packed and came! Maybe if I would have known from the beginning that I could participate, I would have had more expectations. But I didn't, so now everything makes me happy!«

GETTING LOST IN YOUR OWN BRAIN

WHY LACK OF SLEEP SABOTAGES THE MEMORY SYSTEM

Everyone loves a good night's sleep, but too often we choose to sacrifice sleep for our careers, relationships, and leisure time. What many of us do not realize is that forgoing sleep for an extra few hours of work will likely hurt rather than help our performance in class and at work.

Research by neuropsychologist Jan Born suggests that forgoing sleep is a bad idea. In one study, scientists gave participants a keyboard containing six keys and a display with images corresponding to each key. The researchers told the participants that whenever they saw a specific key light up on the display, they should press the matching key on their keyboard as quickly as possible. The participants did not know that there was a hidden pattern behind the order that keys were displayed, but they were able to improve their speed over time in the task by learning the pattern. Interestingly, almost no one could say out loud what the specific sequence was, suggesting that participants were learning the sequence without knowing it.

The next day, the researchers found that participants who got only three hours of sleep were still mostly unable to explain the pattern behind the sequence. However, the group that got eight hours of sleep was able to tell the experimenter what the key sequence from the day before was. This suggests that sleep helps us convert unconscious knowledge to something we can consciously access. You could even conclude from this research that getting a good night's sleep will help you communicate with others better.

Another study gives evidence for the idea that sleep actively improves memories that are more important than others. Participants in this study memorized several pieces of information and then were either told that they would or would not need the information later on. The next day, all participants were asked to remember the information from the previous day. The researchers found that sleep especially benefited those people who believed they would need the information again. This suggests that during sleep, our brain selectively acts to organize memories we will need later and pays less attention to memories we do not think we will need.

So what do these studies tell us about how sleep works to improve our ability to remember information? Jan Born suggests that one of the primary purposes of sleep is to reorganize the information (e.g.; names, appointments, creative ideas) that we have acquired during the day in a way that makes them easier to remember later. To illustrate, imagine that your brain is a large, organized kitchen pantry that stores all of your memories. In the pantry, a can of pasta sauce might represent your doctor's phone number, and a jar of olives might represent your partner's birthday. Throughout each day, you obtain lots of new items (memories) but because you are busy you do not have time to put the new items in the right place, you throw them into a disorganized pile.

During sleep, your brain actively organizes your pantry of memories so you can easily find specific memories later when you need them. Just like you would put all your pasta sauces in one place, your brain tries to keep similar memories next to each other. Sleep is like our own free personal cleaner who keeps everything organized and ready for you to find when you need something later. However, if you do not give your organizer time to work, your mind becomes a disorganized mess of memories that is very difficult to access effectively. This means that a student without sleep will spend too much time during an exam trying to find that one fact she tried to memorize the night before, while a student with sleep will be able to quickly access it from its appropriate place.

So the next time that you think about skipping on sleep, remember that you are cheating yourself out of your free memory organizer. If you do, you may find yourself lost in your pantry of memories and accidently grab your doctor's phone number instead of your partner's birthday.

INTERVIEW
WITH JAN BORN

»I WAS ASTONISHED.«

What do you think about the summer school?

»Very nice! But it is good that you're asking the question now, because in the beginning, I may have said it was a bit stressful. It is hard to figure out the best way to prepare the lectures, because the students have a heterogeneous background. However, I think it is good to group the students in this way.«

What do you think about the students?

»I was astonished. Some of the questions really surprised me – some were very sophisticated, and others questioned very basic issues. That was good for me! Because some people asked questions I would never have asked myself, and that gives me new input! I also noticed that some students really thought everything through, they did not just take things for granted.«

What advice would you give to the students?

»This is difficult. I do not actually want to do that. It's not that I am the "teacher" and they are the "pupils" and that I can pass on worldly wisdom. I already have my own take on science, but they are still very open-minded. This is great! They ask questions from different perspectives, which gives them many possibilities to come up with new theories. Maybe this could be my advice: They should be aware that the perspectives they acquire now will shape their way of thinking as scientists in future.«

COMPUTER GAMES: THE LATEST TOOL IN SCIENCE

THE USE OF VIRTUAL REALITY SCENES FOR INVESTIGATING SPATIAL MEMORY

For years scientists have been grappling with how people are able to learn about their physical environment. To answer this seemingly basic question, researchers have used a variety of tools, including non-human animals, complicated equations, and expensive brain-imaging systems. More recently, neuroscientists at UCL, London have enjoyed great success by turning to an unlikely source: computer games.

Simple 'spatial' tasks, such as remembering where you parked your car, involve a breathtakingly complicated array of brain processes. The importance of this navigation is highlighted by the devastating effects of disease that impair spatial memory. Alzheimer's Disease, for instance, is epitomized by extreme deficits in recalling simple spatial information, for instance where your house is located. It is therefore important to understand how the brain learns about its spatial environment, as this will ultimately allow us to comprehend the complicated causes of diseases such as Alzheimer's.

A breakthrough came in the early 1990s when Eleanor Maguire, a young researcher in London, decided to investigate what happens when individuals learn vast amounts of spatial information over a short period of time. Her inspiration came from trainee London taxi drivers, who are required to pass an exam on "the knowledge", which tests their ability to recall street-names and routes around the capital's labyrinth of back-streets, alleys and one-way systems. Maguire and her colleagues found that, whilst learning this wealth of spatial information, an extraordinary change occurs in the anatomy of a taxi-driver's brain. An area of tissue known as the hippocampus, located deep towards the center of the brain, changes shape. Maguire suggested that the complicated maps learnt by the taxi-drivers are stored in this small area.

Some may say that this finding was sufficient, in conjunction with previous research, to provide concrete evidence for the role of the hippocampus in spatial memory. However, such findings do not provide any information about how the hippocampus might be involved in this process. Plus, the previous method of investigation only provided a static measure of the brain. Hence, scientists brought out the computer games to provide a dynamic environment in which to investigate potential mechanisms by which people navigate.

It has been proposed that there were two pieces of information people could use to navigate their environment: Euclidean distance (distance to the goal "as the crow flies") and egocentric direction (the angle between your current position and the goal destination). As people move through their environment these pieces of information are constantly updating. To dissociate which brain regions could be associated with processing this information, researchers modified a popular computer game of a map of London covering a staggering 50 km^2 of the city. Participants (once again taxi drivers) had to navigate between start and goal destinations using a console controller while brain activity was recorded using functional magnetic resonance imaging (fMRI).

After fMRI scanning, participants watched a replay of their journey and commented on why they made the spatial decisions they did. The findings indicated that the hippocampus was only active when participants were given new goal destinations, i.e., when the drivers had to work out how to get from their current position to the goal destination at the beginning of a new journey. This suggests that the hippocampus could be involved in coordinating the information for spatial planning, but that other brain regions process the specific information (i.e., the Euclidean distance and egocentric direction).

Now we are starting to get a better picture about what is happening during the retrieval of spatial memory for navigation. While further investigations are continuing to determine the precise mechanisms of spatial memory, it is safe to say that these results successfully demonstrate the utility of computer games to the advancement of science (an excuse children might want to bear in mind the next time they are told to get off the computer).

ASK THE SEA HORSE FOR THE WAY

SCIENTISTS DISCOVERED A MENTAL MAP IN THE BRAIN

The ability to find our way is an essential part of our lives. Without remembering how to get to work, to school, to the kitchen, or anywhere else, a normal life would not be possible. Without some kind of map of our environment, we would get lost immediately. Luckily, our brain has the tools to understand and memorize the world around us.

In the 16th century, the anatomist Aranzi described a brain structure that – inspired by its shape – he called hippocampus, which is Latin for sea horse. Since it was first described, the hippocampus has been linked to several cognitive functions, such as olfactory perception or memory. Moreover, it helps us to compute maps of the environment we are in. This was first shown in the 1970s by a group of researchers from London. In their experiments, rats were moving around in an arena and engaging in different activities. The scientists found neurons which increased their activity whenever the animals were in a specific location in the arena. Since then, many properties of these neurons, called place cells, have been discovered.

When a rat enters a new environment, for example a room it has not been in before, it does not have any predetermined place cells for this specific room – the animal does not have a final mental map. While it is moving around and exploring, some neurons in the hippocampus suddenly start to react to the animal being in one part of the arena. When the environment changes, for instance when new objects and landmarks are added to it, the place cells seem to change their response accordingly. However, until now, the exact code with which the place cells in the hippocampus represent the outside world has remained a mystery.

Early research assumed that the strength of the cells' activity is the important information. But according to other studies, it might as well be that a phenomenon called phase precession explains how the maps of our environment are represented: As soon as mammals are active, for example when moving around and exploring a new environment, large groups of hippocampal neurons generate rhythmic activity, termed theta oscillations. Depending on how far away the animal is from the preferred location of a place cell, this cell fires at a different point in time within this rhythm. By analyzing at which time a group of place cells was active with relation to the theta rhythm, scientists are able to reconstruct the position of an animal. But whether the brain uses the same information to infer the location in the environment is still unclear.

In addition to simple place cells, there seems to be a whole set of neurons with different functions that help us find our way. In tasks in which rats have to decide between different routes in a maze, special place cells seem to incorporate information about the animals' intended movements as well. That is, they are active for example only in a certain place when the animal will turn left, but not if it will turn right. In some brain structures in the vicinity of the hippocampus, more complex representations of space can also be found. The entorhinal cortex is one of the brain areas that provides input to the hippocampus. Here, researchers found so-called grid cells. These cells seem to divide the environment into grids of different sizes. Whenever we are in a location that lies on these grids, the cells react.

Place and grid cells can be observed not only in animals. In patients with otherwise not treatable epilepsy, brain surgery is performed. To find the focus of epileptic seizures, the activity of different brain areas is recorded directly. When such patients navigated through a virtual environment, scientists found neurons that behaved in a similar way to the place cells in animals. Despite the fact that we know which part of the brain helps us create a mental map of the world around us, there are still many open questions left. In addition to the question of how the information is represented, we do not even know which information is used. In contrast to experiments in virtual reality, the real world offers many clues about where we are. We can see the environment around us, but we could also use different modalities to determine where we are: the sound of cars on a particularly busy street or the smell of a specific factory or flower. Figuring out the exact mechanisms remains a goal for future research.

USING THE MEMORY TRACE

How functions map onto brain regions

In the early 19th century, some people believed that details in the shape of the skull reveal information about character traits and mental abilities, since they are determined by the shape of the brain. Physicians like Franz Joseph Gall created maps of the skull, assigning certain functions and traits to circumscribed regions. Although the assumptions of these so called phrenologists did not hold true, one aspect of their theory survived.

After decades of brain research, scientists still think that distinct brain areas mediate specific functions, but they do no longer claim there would be a one-to-one mapping. Some abilities are brought about by a network of brain regions and some brain regions seem to carry out more than one task.

Many memory researchers concentrate on the medial temporal lobe of the brain, which is a part of the cortex hidden under the surface. It is not a uniform structure, but consists of several distinct regions, for instance the hippocampus and the amygdala. The hippocampus seems to be a key player in long-term memory, as studies with brain damaged patients have shown. If people suffer from a lesion to the hippocampus, they are left with a severe disturbance of memories for personally experienced events. In extreme cases, they do not remember a single event that ever happened to them.

However, Marta Castellano and Viviana Haase demonstrate in "Looking for stability" and "'Save as' and 'save in'" that the hippocampus does more than that. They look into how this brain region enables the storage of personal events as well as the representation of time and space. Their articles also hint at the fact that there are different kinds of memory systems in the brain. Charlotte Falkenberg, for instance, describes how we can recognize people and objects in two different ways ("A very familiar face, but who is this guy?").

The question of how the hippocampus carries out its functions can also be asked from a different perspective. Ece Kocagoncu explains in "The brain's vocabulary" how the rhythmic activity of nerve cells may provide the fundamental mechanism for memory, decision making, and spatial navigation.

The Summer School Diary

Continuing research and learning in Bochum

The second week of the summer school was dedicated to remembering. Neuroscientists investigate this process on many different scales – ranging from single molecules to the whole organism. The students experienced both worlds. In the magnetic resonance imaging tutorial by Boris Suchan, they explored what is going on in their own brains during remembering, while in the molecular imaging practical organized by Magdalena Sauvage, they took a close look into the cells of the brain.

Colorful results: The molecular imaging analysis

IN HIS OWN WORDS
ÖMER ÖZTÜRK

»I think Bochum is a true university city! The university is big, and the campus is full of students and professors. To me, this is very impressive!«

The following blog excerpts by the students Agnese Zazio, Aya Ben-Yakov, Punit Shah, Katherine Cole, Ömer Öztürk, Dirk Wulff, and supervisor Boris Suchan allow an insight into the practicals of this week. The full diary and a lot more information about the summer school can be found at: http://eceneuroscience.blogs.rub.de/

Experiencing magnetic resonance imaging: Robert Lech prepares Tanny Phillips for a memory experiment

Hey, what is going on in our brain? Let's fMRIze!

13. September 2011

What happens in our brain when we are driving a car? Which areas are activated when we are tasting a new flavor? […]

These questions have needed to be answered since the 18th century, when Franz Joseph Gall suggested that different areas of the brain might be responsible for different mental functions. Today, Professor Boris Suchan has shown us the principles of a brain imaging technique which enables us to understand more about that: it is called functional Magnetic Resonance Imaging (fMRI). […]

It works like a scanner by means of which we can visualize the internal structures of our body, like those of our brain. […] We can't wait to have a close look at the fMRI scanner and to see how it works!

Hands-on studies: Robert Lech teaches the participants how to use the magnetic resonance scanner

IN HIS OWN WORDS
DIRK WULFF

»The lectures are exceptional!«

Investigating memory on the microscopic level: Molecular imaging

A sneak peek into our brains

13. September 2011

During the ECE, we had the opportunity to get a glimpse of our own brain activity during performance of a memory task. […]

Six volunteers entered the fMRI scanner and we scanned their brains while they tried to recollect pictures they had seen a few days earlier. Fully equipped with state-of-the-art goggles, headphones and a response device, we sent them into a huge magnet that creates a magnetic field 300000 times stronger than that of the Earth. While they lay inside the scanner, we watched as the machine created a high-resolution structural image of their brains. The volunteers then viewed a series of pictures through special goggles while the scanner recorded changes in their brain activity over time. It is quite amazing that scientists are now able to view localized brain activity in humans with such precision using a non-invasive method. […]

What would have been considered science fiction a little over twenty years ago is now common scientific practice.

What's going on in your brain during recollection? We will see on Saturday . . .

14. September 2011

Ok, most of the scanning is done. […] The third group will have their scanning session at the end of the week and then… we will start the analysis. It is not magic, but sometimes tricky and time and coffee-consuming. We are prepared. That means we have enough coffee! […] Everybody will get a CD with all analysis programs that are mentioned and explained in the manual. So hopefully, the fMRI participants gave their best and we will see some nice activations, at least in the vicinity of the medial temporal lobe ;-) […]

ECE: After a hard day's work, it's time for some fun

fMRI data analysis: Creating the pretty pictures we see in articles

17. September 2011

Do: Locate yourself close to a coffee machine. Don't: Expect to leave in under four hours.
[…] With the data gathered, we navigated the minefield of functional neuroimaging analysis via SPM (Statistical Parametric Mapping) […]

We were taught step by step how and why each step is crucial and Professor Suchan quickly dispelled any misconceptions that this process was as simple as it is often made to look. However, our persistence paid off and we were left with a distinct feeling of self satisfaction at 8 pm on a Saturday night, complete with a set of pretty pictures. Given the costs involved in MRI, rarely does one get such an invaluable opportunity to acquire and process fMRI data during a tutorial. Despite all that has been and will be great about the ECE, this will undoubtedly be one of the most useful experiences we will take home with us.

Checking the fMRI data: Robert Lech and Marie-Theres Meemken

Visualizing the brain

13. September 2011

The brain is a fascinating structure which houses around 100 billion neurons or brain cells in humans. Have you ever wondered how we can visualize these cells and how they are all arranged within the brain? In today's practical we found out how this is possible. The first step is to section or cut the brain into very thin sections, about 8 micrometers. To put that number into perspective, one section is about ten times thinner than the diameter of a single human hair. We can then stain these brain sections using a technique called Nissl staining […].

This means that, when you visualize the sections under a microscope, the structures and layers within the brain become apparent. […]

We are very much looking forward to tomorrow's practical where we will be shown how to visualize specific cells within a population.

Molecular imaging practical: Discussing the results

IN HIS OWN WORDS
TANNY PHILLIPS

»I really liked Yadin's talks. He was one of the best speakers I have seen in a long time.«

Oscillations in the brain: György Buszáki's lecture

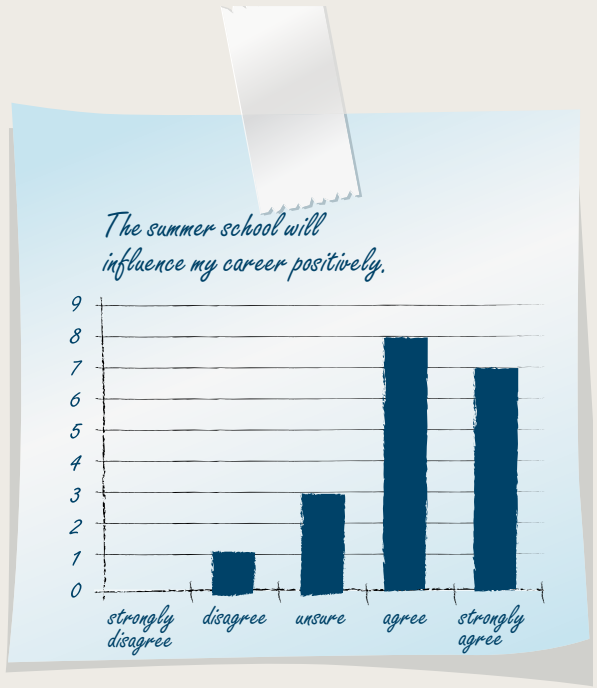
A close look into the cells: Detecting gene products

14. September 2011

During the ECE Neuroscience Summer School, we had the opportunity to travel through the brain from the macroscopic to the microscopic level. […] We wanted to look for specific genes in the cells. […] If you know which genes you are looking for, in-situ hybridization is the method that you need. With in-situ hybridization, we can detect certain fragments of the genetic code (mRNA) in the cells. It is an amazingly sensitive technique! Threshold levels of detection are in the region of 10-20 mRNA molecules per cell. It is a long process involving several steps. You should keep your protocol with you and follow all steps carefully. […]

ASAF GILBOA:
»I only had a brief chance to interact with ECE students and faculty, but was truly impressed by the diversity of the participants and the sense of cohesion that developed over a relatively brief period. I found the intellectual environment to be stimulating, with students taking a very active part, asking questions, contributing from their own research and academic experience and showing true curiosity and scholarship.«

Teaching about sleep and memory: Jan Born



Testing a mouse's memory

16. September 2011

Modern biochemical techniques allow us to investigate molecular correlates of memory in mice. As a prerequisite for this method we need to have control over the mouse's learning performance. How can that be accomplished? In today's practical, we learned how to conduct experiments and analyze recognition memory function with mice. As a first step, the mouse is placed in a box that contains two objects. Due to its natural tendency to explore, the mouse will immediately start to investigate and thereby learn about the objects. […]

The exploration behavior is later quantified by evaluating every single second of a video recording. This is quite a demanding task. […]

Therefore, usually two persons judge a video sequence to account for these difficulties of measurement.

MORNING LECTURES

Howard Eichenbaum, Boston University, U.S.A.
» Towards a neurobiology of recollection
» The hippocampus in space and time

Andrew Mayes, University of Manchester, U.K.
» Medial temporal lobe functional heterogeneity in memory: Recollection, familiarity and kind of information

Magdalena Sauvage, Ruhr University Bochum, Germany
» Memory function: New developments in behavioral, molecular and imaging techniques

Boris Suchan, Ruhr University Bochum, Germany
» fMRT Practical: Data analysis and theoretical input

KEY-NOTE SPEECHES

Oliver Wolf, Ruhr University Bochum, Germany
» How memories are influenced by stress

Alessandro Treves, International School for Advanced Studies, Trieste, Italy
» Self organization of multiple spatial memories in the mammalian hippocampus

György Buzsáki, Rutgers State University, U.S.A.
» Oscillations define neural syntax and cell assemblies

Max Colthart, Macquarie University, Australia
» Understanding delusional belief: A cognitive-neuropsychiatric theory

MAGDALENA SAUVAGE
ORGANIZER OF THE SECOND SUMMER SCHOOL WEEK:

»I think the ECE was intense as well as very rewarding. The students were really motivated and inspired, and we have listened to top-notch speakers. The best for me was the unusual level of interaction during class: students asking questions and brainstorming together with the lecturers. For the students, the best thing seems to have been the combination of theoretical and practical classes and the unique opportunity to talk to the leading experts in the field of memory function – not only during the class, but also at a more private level during lunch or dinner.«

LOOKING FOR STABILITY

SCIENTIFIC INSIGHTS ON HOW TIME IS REPRESENTED IN OUR MIND

How can we understand the world? Every second of our lives is different from the next and still, we are able to make sense of the regularities in our surroundings. For many years, scientists have been puzzled how we can extract and use information from the world. Latest research by Prof. Eichenbaum brings light into this eternal query.

Imagine your first day at the university. You enter your class and have a glimpse on your new fellow students. Scientists have known for many years that the hippocampus, a region located deep in the brain, is responsible for spatial orientation. The first time you enter the room, you create a memory of it, like a virtual room in your own mind that enables you to find your way around it. In the hippocampus, you find neurons that are active when you are in a specific location, e.g., one neuron is active every time you walk past the dustbin. Moreover, the hippocampus enables you to learn the path that had led you to the new class so that you will be able to reach it again. The activity of neurons in the hippocampus codes specific locations of that path. For instance, on your way to the lecture, a neuron fires every time you turn the corner in your street. But, is there any other utility of this hippocampus?

Researchers observed that patients with damage to the hippocampus, caused by epileptic seizures, surgeries or strokes, were unable to create any kind of new memories or even remember old ones. A loss of the hippocampus does not only leave you lost in space, but also implies that from that moment on, you will not be able to remember any event that happened to you nor store new ones. Go to your first lecture and in the time span of 10 to 15 minutes, you will not know how you arrived in that room or even what you are doing in there.

For many years, scientists had struggled to find out how the hippocampus supports memory and spatial navigation. Finally, research by Prof. Eichenbaum and his team led to a new hypothesis. Consider that any event in your life has a timeline: arriving at the room, entering, finding a seat, saying hi to someone, sitting down, being given a candy by your neighbor. After repeating the situation in the course of a few days, you learn that, approximately ten seconds after you had sat down, you received the candy. Scientists discovered that these timelines are represented in the hippocampus once they have been learned. The striking part is that different cells in the hippocampus are active at different points in time, e.g., one cell fires after two seconds, another after five seconds. This temporal representation is similar to the spatial representation in the hippocampus.

Scientists propose that the hippocampus parses the stable characteristics of the environment, whether this characteristic is distance, position or time. This idea implies that, when experiencing new things, it is responsible for learning the stationary characteristics of the world so that we do not need to be aware of all the small details that do not influence us. Hopefully, this new idea will allow us to understand how we learn and remember.

»SAVE AS« *AND* »SAVE IN«

HOW AND WHERE THE BRAIN STORES DIFFERENT KINDS OF INFORMATION

Everybody has experienced this situation: We see somebody and we are sure that we know this person, but at the same time, we are unable to retrieve any information about him or her, for instance their name or where we have met. Usually, however, we immediately associate a face with the stored concept of a certain person. Scientists differentiate between the mere feeling of familiarity, as in the first situation, and recognition with associated information, called recollection. One striking difference between these two kinds of memory is the place where they are stored and processed in the brain.

Unlike computers, we cannot choose where to store incoming information; the brain does it all itself. However, neuroscience provides us with some tools for exploring the brain's memory mechanisms. Methods that visualize the brain's activity and studies with patients suffering from brain lesions help to elucidate where information is processed.

In his lecture, Andrew Mayes stated that information is stored in the same place where it is processed. Unlike computer information, however, it is not processed and stored in only one corner of the brain but in different places at the same time. Nevertheless, there are certain regions that seem to be responsible for certain functions. Of major importance for the memory system is the medial temporal lobe (MTL), a part of one of the four lobes of the brain. The MTL is made up of several different substructures, amongst others the hippocampus, which is important for long-term memory.

As Andrew Mayes suggested the two different kinds of recognition memory, recollection and familiarity, are processed by different regions of the MTL. In studies with functional magnetic resonance imaging, a method for visualizing brain activity, researchers found different regions being engaged during recollection and familiarity. The notion that different MTL regions are responsible for these two processes is further supported by studies with patients. If patients with a lesion in a certain brain structure have a specific deficit, researchers can conclude that the damaged area is important for processing the impaired function. The studies gave evidence that recollection and familiarity can be affected by brain lesions separately.

According to Mayes, all subregions of the MTL process different inputs in various ways. Thus, once the brain receives incoming information, it assigns it, according to its nature, to the relevant region. There, the information is processed and stored. The hippocampus, for instance, deals with object and context information, like spatial and probably also temporal information, and is thus ideally suited to mediate recollection. Another MTL region, the perirhinal cortex, is mainly concerned with high-level visual object information and is implicated in familiarity processes.

Capacities are limited and we cannot stick another hard disk in the brain to gain more memory space. Therefore, not every piece of information that comes in stays there, because, by doing so, the capacities would be very soon exhausted. The brain needs to decide what to store. In order to do so, the information has to be consolidated, for instance by retrieving it again and thereby reactivating it. So if you want to remember that our brain processes different kinds of information in different regions and that the medial temporal lobe is of major importance for the memory system, you will have to reactivate this memory. You could update your information by reading more about memory, forgetting, and its related brain structures in this publication.

A VERY FAMILIAR FACE, BUT WHO IS THIS GUY?

THERE IS MORE THAN ONE WAY TO REMEMBER THINGS

Sometimes objects or even faces seem quite familiar, even though we are not able to remember the context in which we have seen the person before or any further detail like the name. Imagine a man greets you in the mall and, while chatting with him, you feel guilty because you have no idea where you know him from and what his name is. This indicates that one memory process is working correctly, you recognize his face. But at the same time, the access to context information is not available. Neuroscientists suggest that different autonomous memory processes are involved in recognition.

A certain brain region called the medial temporal lobe (MTL) is of major interest for memory research. The MTL consists of different subregions, among which the hippocampus is well-known for its important role in memory. However, the exact function of every subregion has not been understood to date. In order to fill in this gap, scientists investigate memory processes in humans and in animals.

Brain damage in humans can result in specific deficits in remembering. Some patients suffer from impairment in recollection: their memory lacks detail and is not accompanied by the strong, vivid sensation of a real experience that healthy people report. Nevertheless, some of these patients perform at a fairly good level when compared to healthy people in recognition tasks when they have to decide quickly if they have seen an object before or not. Scientists call this kind of recognition memory "familiarity", which is a fast process characterized by a vague feeling of knowing the object/person. Recollection, on the other hand, is slower and involves remembering information associated with the object/person.

There is an ongoing discussion whether recollection and familiarity are independent processes, not only on the behavioral level, but also on the neuronal level. To answer this question, scientists search for potentially different neural substrates for recollection and familiarity in the MTL. One problem with investigations in humans is that brain damage often does not follow anatomic boundaries. Thus, it is hard to identify the contributions of specific brain areas to certain impairments.

In order to correctly identify the brain areas that support specific memory functions, researchers work with rodents, especially rats. The team of Magdalena Sauvage in collaboration with the laboratory of Howard Eichenbaum trained rats to distinguish between odors they had seen before and new odors. They then measured the recognition performance, i.e., recollection and familiarity, of animals with lesions in different subregions of the MTL: the hippocampus and the entorhinal cortex. Rats with different lesions exhibited deficiencies in different recognition measures. Thus, the results suggest that familiarity and recollection are two distinct and qualitatively different processes. While recollection seems to be dependent on the hippocampus, familiarity does not seem to be governed by this region, but by other MTL areas, probably the perirhinal cortex and lateral entorhinal cortex. However, for now the puzzle remains partly unsolved, because the neuronal pathways in question are highly complex.

INTERVIEW
WITH ÖMER ÖZTÜRK

»EVERYTHING IS REALLY GREAT.«

What did you want to be as a child?

»I wanted to be an academic. I didn't know which subject to study, but when I was 11 or 10 years old and went to primary school, I admired the teachers. And I knew I would go to university and study. First I wanted to be a physicist, but then I became a doctor.«

How did you get in touch with neuroscience?

»I studied medicine and I think it was after the physiology lectures that I decided to study the brain. I now have to complete my General Practitioner service in Turkey, so I am a bit far away from research.«

How do you like the summer school so far?

»It is really, really well organized. I was happy to see that! I have some difficulties with being in research again, since I have been so far away from it due to my General Practitioner service. But everything is really great.«

What was your motivation to come here? Any particular expectations?

»It is actually my first summer school in neuroscience, I learned about it from my professor. I wanted to experience being in a summer school in neuroscience, what neuroscientists are doing and what I will do. To consider my future career.«

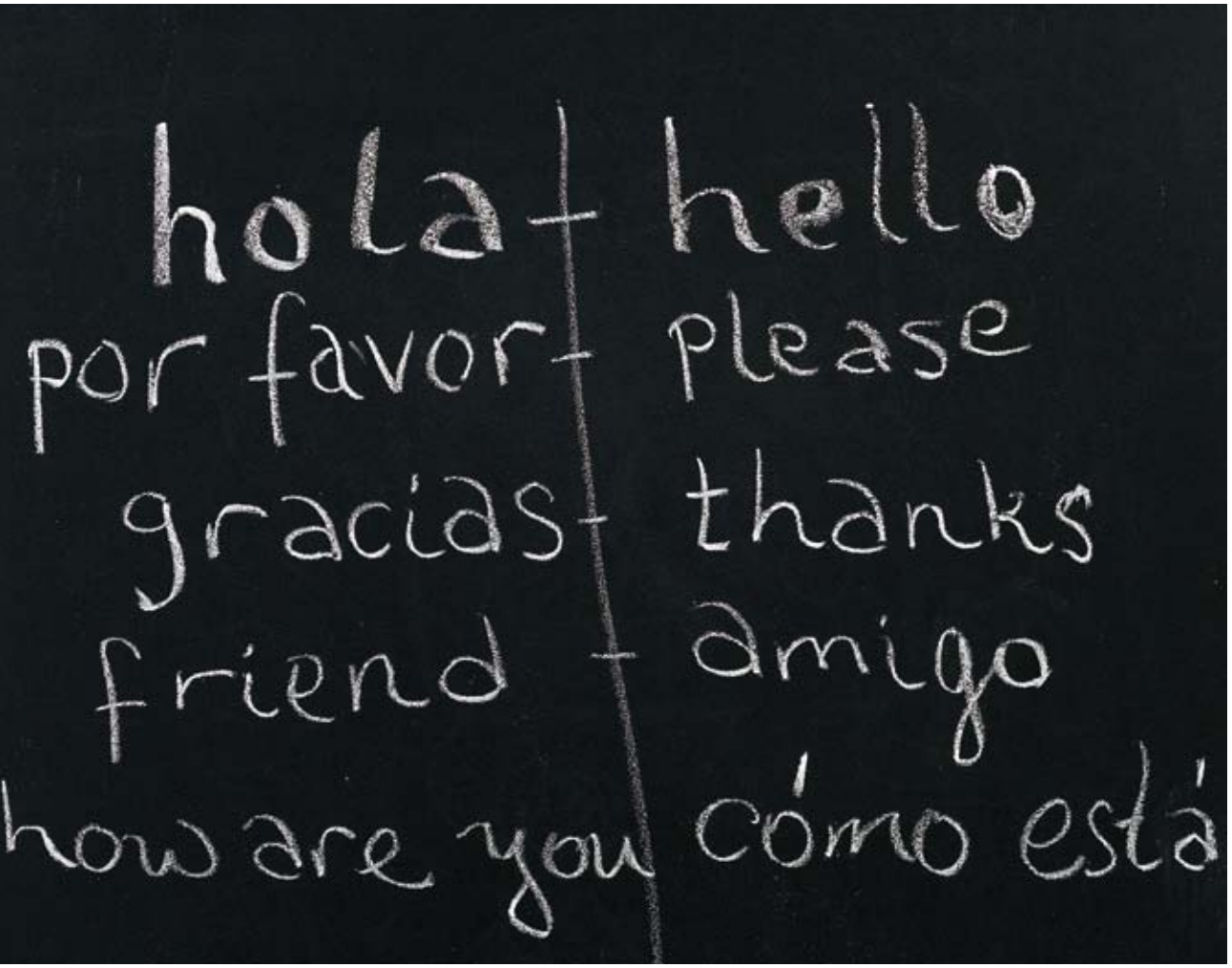
Have your expectations been met?

»Yeah! Sometimes I feel it will be difficult to switch to science, but I think it is just a matter of being untrained right now.«

THE BRAIN´S VOCABULARY

SEARCHING FOR THE MEANING OF OSCILLATIONS

Heartbeat, respiration, sleeping and waking, hormonal secretion, and menstruation are only a few examples for biological cycles. Their repetitive nature merely reflects synchronized biological activity. A similar rhythm is also at work in the neurons of the brain. Researcher György Buzsáki compares these neural oscillations to a foreign language. Experimenters need to understand the brain's vocabulary, its syntax, the hierarchical relationships, algorithms and the tempo of the neurons. This is where oscillations come in.



Neurons can exhibit spontaneous activity that fluctuates rhythmically; it oscillates. But why does the brain need oscillations? And how are the oscillations organized? To answer the first question, Buzsáki gives the example of clapping. Following a concert, the audience first claps randomly, after a while the clapping becomes synchronized. The synchronized clapping creates a louder sound than random clapping. Similarly, when neurons fire simultaneously, they generate a greater output. Therefore, by temporally adjusting their activity, they are able to increase their output, without increasing energy expenditure. Since an adult brain uses 20 % of the whole body's energy reserve, it is reasonable that the neuronal activity is cost-effective.

The answer to the question regarding the organization of the oscillations is not as easy. In 1971, O'Keefe and Dostrovsky recorded neural activity in the rat's brain structure called hippocampus during spatial navigation. They found that some neurons selectively increased the frequency of oscillation, when the animal was in a particular location of the maze. These special neurons are called place cells because of their selectivity to environmental landmarks and directions.

Researchers in Buszáki's lab created an experimental setup to explore the origins of these oscillations. More specifically, they tested whether the neural activity resulted from cues in the environment or from internal generation. The scientists trained rats to alternate running in the left and right arms of a figure eight maze. In between visiting the different arms, the rats had to run in a wheel. While running in the wheel, the rat is still physically moving, but in a stable position. Thus, the landmarks that it perceives do not change. If the activity of the place cells reflects a set of landmarks, the cells should exhibit sustained firing during wheel running, because the landmarks do not change. However, if the activity is generated by internal mechanisms, the firing of the cells could change continually.

The researchers investigated hundreds of neuronal cells in the hippocampus. Neural activity changed continually during both spatial navigation through the maze and wheel running. This suggests that the oscillations are internally generated and operate independently from environmental stimuli. Moreover, some cells were more active before the left or right turns, indicating an involvement in spatial decision making. The research team further found different neural activation when the rat made the correct alternation and when it made errors. Hence, only by looking at the activity, it was possible to predict which direction the rat will choose to go and whether or not it will make an error.

These studies demonstrate that cognitive tasks like spatial navigation and decision making generate oscillations. Further observations indicate that they are also linked to learning and memory performance. Thus, oscillations are not artifacts, but reflect neural activity related to cognitive processing.

THE END *OF THE MEMORY TRACE*

How and why the brain forgets

John P. found himself alone on a beach, not knowing why he was there or where he was exactly. The sun was setting slowly, it was warm, and the salty smell of the ocean was all around him. Everything felt like vacation, but he was scared, for he could not remember a single thing that had happened to him during the last months. Many researchers are concerned with how our brain stores new memories. However, the question of how we forget is equally important and interesting.

Everybody experiences moments of memory failure in his or her life. Suddenly, we do not remember an important piece of information, for instance a certain anatomic label of a brain structure in an exam. However, several hours after the exam, when we are no longer under pressure, the information may suddenly come back to us. Thus, forgetting must not always mean that we deleted a piece of information; it may just be temporally inaccessible.

Severe psychological trauma sometimes leads to a profound memory disturbance, and even milder stress can affect our ability to learn and remember. Alexandra Bieber describes in "Blessing or curse?" how stress influences our memory system in a positive or a negative manner. On the other hand, remembering may also influence our psychological well-being. In "Never forget", Marie-Theres Meemken introduces a theory relating depression to the extinction of previously learned associations.

Many people suffer from memory impairments not because of emotional disturbance, but because of brain damage. In "Why Jon forgot about the snake", Daniela Schwab writes about the impact of early oxygen lack in children on brain anatomy and memory abilities. However, she and Anne Petzold ("Remember the numbat") also give grounds for hope by showing how the different memory systems of the brain can be used to benefit people with such impairments.

While it is clear that several conditions can lead to impaired memory, the question as to what happens in the cells during forgetting has yet to be unraveled. In "Hold that thought", Offir Laufer writes about important steps that have already been taken towards solving this mystery by investigating a special protein that seems to be involved in the maintenance of memories.

The Summer School Diary

The last days of exploring the memory trace

Two weeks about learning and remembering had gone by quite fast and the last week of the summer school, dedicated to extinction and forgetting, had arrived. In the third week's blog excerpts, the students Monika Schönauer, Ilona Lipp, Nora Oehler, Tobias Ruff, and Andrea Merseburg report about the last five days in Bochum, which were full of behavioral experiments on stress and extinction. Moreover, they also share their experiences on the food experiments that they conducted during their time in Bochum. Amie Doidge, Tanny Phillips, and Anne Petzold provide some insights into the recipes that the students tested. The full diary and a lot more information about the summer school can be found at:
http://eceneuroscience.blogs.rub.de/

International food evening: The students prepare specialties from their home countries

IN HIS OWN WORDS
OFFIR LAUFER

»Although brain research has produced vast amounts of knowledge about the brain, we still understand very little and I believe that meeting other individuals with shared interests and being exposed to new ideas, views, and experimental methods, are necessary steps toward understanding that which makes us human.«

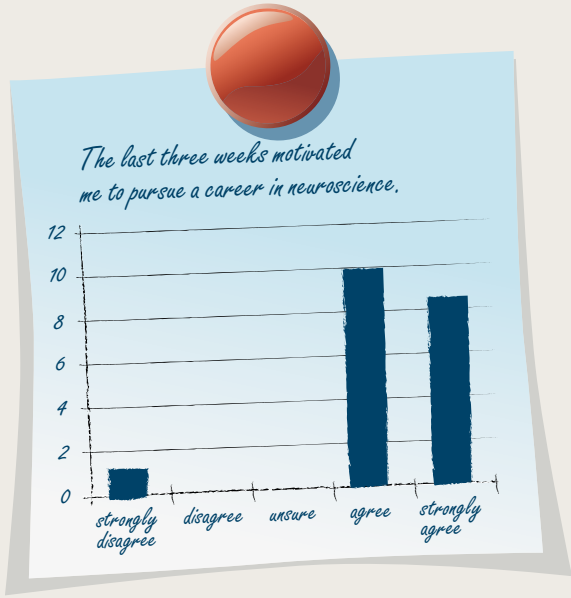
Fascinated by reconsolidation: Karim Nader

JOSEPH HUSTON:
»I thoroughly enjoyed my visit to Bochum. The atmosphere during and after my presentation was very pleasant. I particularly appreciated the intelligent and spirited participation of the students in the discussion of my talk, including suggestions for further experiments to do.«

Students in a maze

20. September 2011

In our practical today, we set out to explore the manifold effects of stressful experiences on memory formation. We split into groups and conducted a number of behavioral experiments with volunteer participants. In one of these experiments, our subjects had to learn a challenging spatial memory task, where they navigated through a virtual maze and had to locate a number of objects that were hidden there. After they had (hopefully) learned how to do this task, we did a stressful intervention with one half of the group. Participants were asked to put their hand and wrist into ice-cold water for an unspecified period of time. […]



This intervention is a standard paradigm in psychological research. It has been shown to induce a reliable increase in stress hormone release, which in turn acts on brain processes. […]

Is it not a question of stress versus distress, but when we experience stress, what decides whether its effects on memory will be for good or for evil? […]

We will find out tomorrow – so keep your fingers crossed that we can shed some light onto the mysterious workings of stress on our behavior.

Where is the falafel gone?

21. September 2011

One major aspect of our stay in Bochum has been food. Great breakfast in the morning, salad buffet in the mensa for lunch, and visits to various restaurants in the evening made up a great part of our social lives here. However, one day we decided it would be time to actually prepare something ourselves, and in order to not lose the social aspect of food, the idea of the "International Food Evening" was born. We all split up into groups and everyone contributed to a huge buffet of amazing dishes (as well as amazing Sangria!), which we enjoyed together in the Euro Eck. Because of its huge success, the International Food Evening underwent its revival only one week later, to which the lecturers were invited and more amazing dishes were introduced. According to unstandardized interviews and behavioral observation, the winner of the unannounced food competition was the homemade falafel that was finished almost before it was even served. Thanks to everyone for the great food! So only one question remains: What are we going to do with 4 kg of onions…?

Crispy Cakes! (not vegan, unfortunately)

Recipe feeds 30! (You may want to consider reducing the amount of ingredients!)

9 bars of chocolate (yes really! German-sized ones though, not the industrial-sized UK ones). Any flavor of your choice! To get the maximum layered effect though we suggest the full range of white, milk and dark (3 of each obviously).

1 bag of cornflakes.

1) Melt chocolate in a glass bowl placed over a saucepan of boiling water. Depending on whether you are going for the layered effect, and how much washing up you want to do, you may want to think carefully about which flavor you melt first!

2) When chocolate is silky smooth, add cornflakes bit by bit until satisfied the cornflakes are sufficiently coated and all chocolate is used.

3) If going for the layered effect, get a large container and spread evenly across the bottom. If making individual portions, fill up the cupcases (as many as required).

4) Place in the fridge to set.

5) Repeat steps 1-4 until all chocolate and cornflakes have been used.

6) Enjoy with friends!!

Delicious: Everyone enjoys the international food evening

Curried Apple Couscous Recipe

4 tablespoons unsalted butter (use soya butter or olive oil to make it vegan!)

1 tablespoon curry powder

1 medium apple, cored and chopped

3 green onions, washed, trimmed, and thinly sliced

1 cup whole-wheat couscous (or regular)

1 3/4 cup water

1 teaspoon sea salt

1/2 cup pine nuts, toasted

Small handful of mint, chopped

In a large saucepan over medium-high heat add 3 tablespoons of the butter, the curry powder, and a couple of generous pinches of salt, and cook for a minute or until the spices are fragrant. Stir in the chopped apples and cook for about 3 minutes, enough time for the apples to soften up a bit and absorb some of the curry. Scoop the apples from the pan and set aside in a separate bowl.

In the same pan, again over medium-high heat, add the remaining tablespoon of butter. Stir in the green onions, let them soften up a bit and then add the water and salt. Bring to a boil, stir in the couscous, cover and remove from heat. Steam for 5 to 10 minutes and then use a fork to fluff up the couscous. Stir in the apples, pine nuts, and chopped mint. Season with more salt and curry powder to taste.

Laurentian Noodle Salad (vegan)

1 kg of pretty noodles (Liche, Farfalle etc.)

200 g cocktail tomatoes

50 g Rucola

50 g Pine nuts

1 glass of dried tomatoes in oil

a lot of garlic

Cook the noodles, add garlic in very small pieces, salt, pepper, and dried tomatoes – leave over night or a while or just go on right away.

Add fresh tomatoes, rucola.

Put pine nuts in pan (no oil, no water) and roast briefly. When nuts show the first tiny patches of black – take off. Put salad on just before serving.

yamyam *)

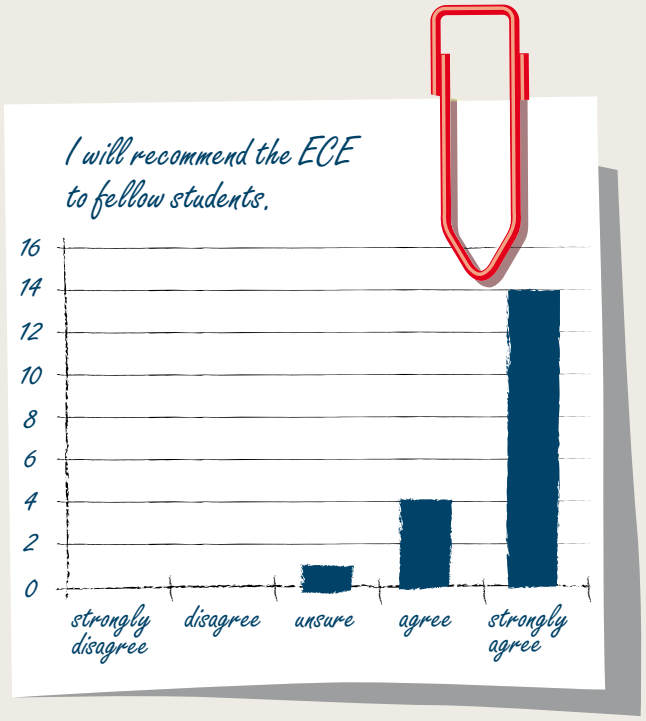
Good-bye gift from the students: Onur Güntürkün proudly presents a knitted nerve cell

On the other side of the lecture hall

22. September 2011

After having collected data in different studies on Tuesday, the topic of our practical on Wednesday was data analysis. Due to the fact that the data collection took place on only one afternoon, the sample sizes were very small – between 8 to 12 participants in each study. Nevertheless, we exceptionally ignored these circumstances and looked at the differences within and between subjects using SPSS, a statistic program. During the last day of our practical, on Thursday, each of the four groups had to present their studies in a mini symposium. […]

The conclusion one can draw based on the results of the studies is that it is indicated to have enough subjects to get a significant effect. But given the temporal limitations, it was interesting running a whole study in just four days. So I want to end by thanking the tutors who were very supporting during the projects.



IN HER OWN WORDS
MONIKA SCHÖNAUER

»The summer school was amazing. I could not think of a better opportunity to get to know the people in the field of memory research and learn about their take on recent theories.«

Influencing existing memories

22. September 2011

In 2001, Karim Nader – one of the lecturers in the third week of the ECE Summer School, performed a very interesting experiment: He reactivated a distinct, one-day-old memory in rats and subsequently blocked the protein synthesis in a certain brain region. Existing memory theories of that time suggested that this would not influence this memory which was presumed to be stable. But by doing so, he was able to alter the memory […].

Alessandro Treves: New insights about the self organization of spatial memories

Time for fun and more "neuro discussions": Mina Shahi and Charlotte Falkenberg

Since then, huge efforts have been made to transfer this knowledge to humans, where it might be of benefit in treating addiction or post-traumatic stress disorders. In a practical in the third week, we therefore examined the potential of a related approach in human subjects. After having seen 30 neutral photos, some of the participants were instructed to describe the photos they remembered (in order to induce memory reactivation). Several members of each of these two respective groups were then again shown a sample of 30 new photos. In the final evaluation, these participants remembered fewer pictures of the first set than the people who had not seen the second group of photographs. This indicated that the effect and its underlying mechanisms observed by Karim Nader in mice also exist in humans: Memories do not seem to be stable, but can be altered in hindsight opening up the way for new therapies.

Is it all fading away from now on?

23. September 2011

The very last day of the Summer School arrived, leaving behind three weeks of comprehensive lectures, practicals, and intense social – in fact, almost always eating – events. And of course, after having spent a lot of time in the "Ruhrpott", one cannot think of a better location than "Zeche Zollern" in Dortmund to say goodbye in the proper ambience the area is most famous for. During a really great dinner at the restaurant "Pferdestall", Prof. Onur Güntürkün ceremonially handed out the certificates to each of us individually, and we used the occasion to thank everyone for this unique event.

The summer school slowly comes to an end…

Amie Doidge studies radiographs

A close look at the exhibits: Anne Petzold at Zeche Zollern museum

… Guided tour through Zeche Zollern

A huge screen in the background showed photos of us during the numerous activities of the last weeks: go reactivation! Although at some point every one of us may have asked him- or herself: "will this ever come to an end?", we were also kind of sad to say goodbye to many great people, organizers as well as fellow participants. […]

Zollern: Impressive sights on the last night of the summer school

Saying thank you to the lecturers and organizers: Anne Petzold presents Daniela Schiller with flowers

ECE FACULTY
WEEK 3

MORNING LECTURES

Karim Nader, McGill University, Montreal, Canada
» The cognitive nature of memory
» Memory consolidation
» The history of reconsolidation
» The state of reconsolidation

Daniela Schiller, New York University, U.S.A.
» From animals to humans
» The human amygdala
» Amygdala-prefrontal interactions in human extinction studies
» Does reconsolidation occur in humans?

KEY-NOTE SPEECHES

Joseph Huston, Heinrich-Heine University of Dusseldorf, Germany
» Extinction of positively and negatively reinforced behavior as a source of depression

Faraneh Khadem, University College London, U.K.
» Memory impairment due to hippocampal injury after neonatal hypoxia-ischemia

Asaf Gilboa, University of Toronto, Canada
» Neocortical plasticity in the adult human brain

OLIVER WOLF
ORGANIZER OF THE THIRD SUMMER SCHOOL WEEK:

»Those three weeks were really stimulating and motivating for me. I was very impressed by the students. They were very motivated, determined, and critical independent thinkers. It was, of course, also a real treat to listen to the lectures and key-note speeches of some of the most important figures in memory research and to be able to discuss current hot topics with them.«

REMEMBER THE NUMBAT

WHY BRAIN LOSS IS JUST A MATTER OF PERSPECTIVE

Little Emily is sitting in her playpen, while Mommy is tidying up, chatting. "Dummy" ends up in the dust bin, "teddy" enters the pen, before "Mommy" is piling "jammies" and "didees". By the age of 12 months, little Emily follows the verbalization of the tidying process intently. Only a few months later, she will be the most apt labeler in the nursery herself.

The astonishing ability of children to rapidly match an abundance of labels to their respective objects implicitly, simply by way of natural conversation, is termed "fast mapping". But do we retain this ability throughout life?

Emily's granny is sitting in her wheelchair, while Emily's mother proudly presents the new baby pictures, chatting. Granny, however, fails to hold the conversation as she cannot remember even its preliminaries: Who is "Emily"? Who is the cute baby on the picture? It is not dementia erasing any new information in her mind, though. She underwent cancer-related brain surgery in the medial temporal lobe – a structure long known to play a key role in explicit memory formation.

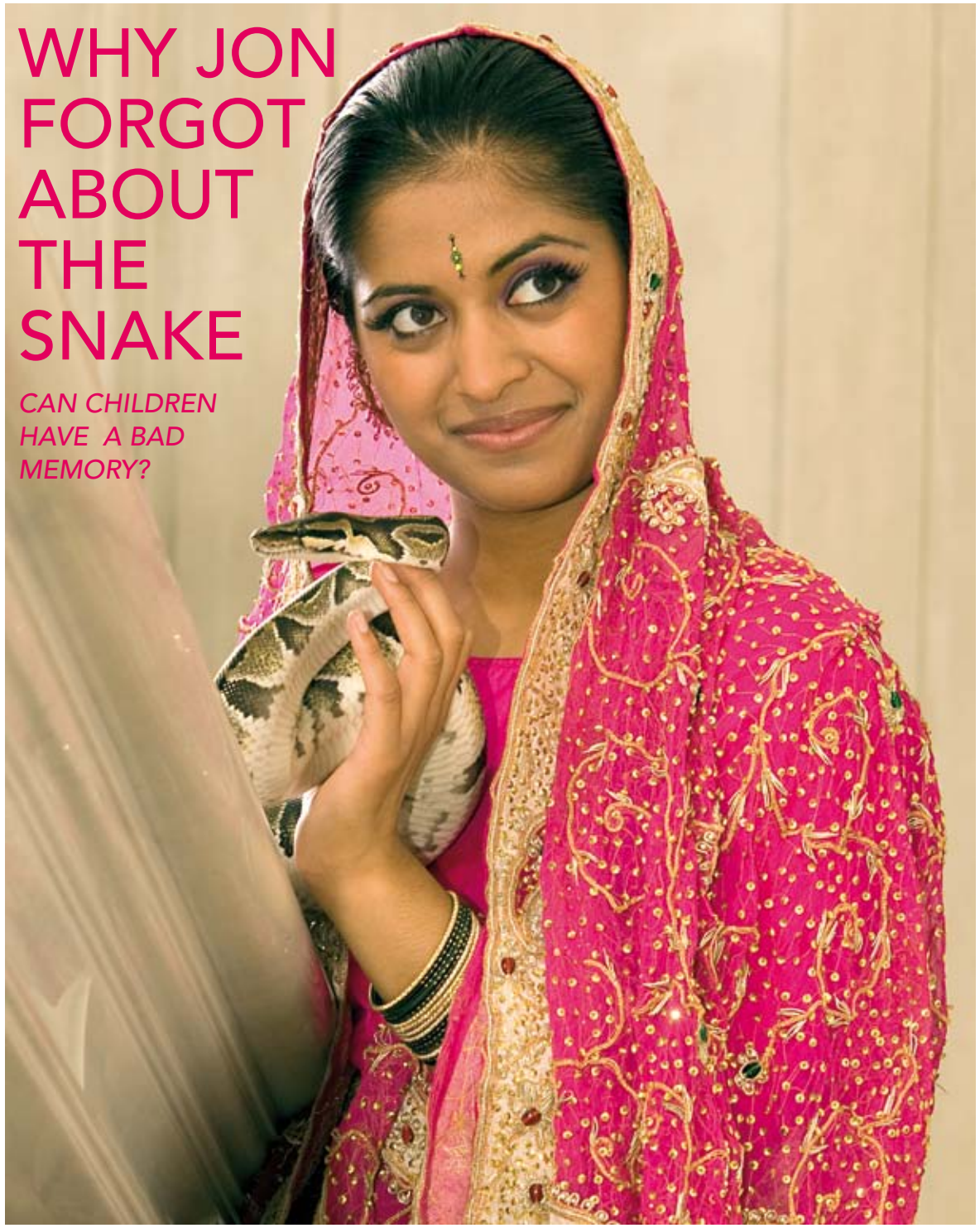
Loss of brain tissue in the medial temporal lobe leaves a person unable to learn new contents explicitly. Telling the grandmother over and over again that her new grandchild is called "Emily" will be of no help to her. She would fail classical memory tasks: If a list of items and associated objects were presented to her for study, she would not be able to confidently remember a single one of them.

Researchers from Haifa University have found a different way to relieve patients suffering from brain loss in the medial temporal lobe: Instead of solving classical explicit tasks, patients implicitly learned novel labels for previously unknown objects (i.e., a numbat) in a relaxed situation akin to conversation. Implicit learning was tackled by presenting a group of items containing an unfamiliar one (i.e., a zebra, a giraffe, and a numbat). Together with these items, researchers asked associated questions ("Does the numbat's tail point upwards?") that allowed the patient to narrow down the appropriate label for the novel item by him- or herself. During explicit learning tasks, patients saw single items clearly labeled and were asked to remember the combination of both ("Remember the numbat!"). Patients were perfectly capable of remembering implicitly learned items that they actively "mapped", whereas they never learned those explicitly presented.

Thus, by shifting the task demand, researchers succeeded in mobilizing resources from intact brain structures circumventing the harmed medial temporal lobe. A similar shift in granny's mental training may also allow her to finally catch her granddaughter's name. Thus, for patients suffering from severe brain loss, there might be an alternative to eternal forgetfulness: There is no alternative to learning by doing from 0 to 99+ years of age.

WHY JON FORGOT ABOUT THE SNAKE

CAN CHILDREN HAVE A BAD MEMORY?



When Jon was nine years old, he went to a shopping center with his mother, where he saw a lady in a beautifully colored sari with a snake. Jon was very impressed, because he has never seen a snake before. On their way home, his mother encouraged him to tell his father what he had seen in the shopping center. Surprisingly, Jon did not even know what his mother was talking about. After that incident, his mother realized that something was wrong with Jon. Why was he not able to remember an event that had affected him so much?

Jon is one of a number of children whose memory is impaired, because they did not get enough oxygen at one point in their early life. Brain regions that are not sufficiently provided with oxygen-rich blood get irreversibly damaged. The main reasons for this so called hypoxia-ischemia are heart diseases, heart failures in early life or premature birth. Scientist Faraneh Vargha-Khadem has been doing research on this topic for more than 15 years. She and her colleagues investigate the causes and consequences of children's memory impairments, which are termed developmental amnesia. Additionally, they use methods like magnetic resonance imaging that allow visualizing the structures of the brain.

On the behavioral level, mainly the episodic memory is impaired, i.e., a child with developmental amnesia is not good at memorizing and recalling events that had happened in his or her life. On the structural level, research shows that the hippocampus, a brain area important for memory processes, is particularly prone to damage. More precisely, the volume of the hippocampus is reduced in both hemispheres. This is also what caused Jon's memory impairments. Although he was really excited when he saw the lady with the snake, he had already forgotten his experience in the shopping center some moments later.

Other memory systems, such as the memory for learned facts (called semantic memory), are not affected in developmental amnesia. Children like Jon are able to recognize friends and they can tell when something looks familiar to them. Apart from their memory impairment, they have normal cognitive abilities, for instance normal intelligence.

One of the most interesting questions is whether every infant or child that experiences hypoxia-ischemia suffers from developmental amnesia afterwards. Although a high percentage of the affected children exhibit memory impairments, more than half of them do not suffer from any adverse effects at all, even if they lacked as much oxygen as the impaired children.

A memory impairment is normally diagnosed at the time when children develop autonomy. It is then that the parents realize that their child is not able to care for him- or herself as would be expected from a child of the same age. But a memory impairment does not mean that these children are not able to learn at all, they just need more time and more rehearsal. Nevertheless, they can never recollect the event of learning something or the thoughts they had while they experienced something.

Even though affected children and adolescents are not capable of handling their everyday life independently, they have an easy-going life. In general, the social environment compensates for the memory impairment of the affected person, although not systematically. Parents of children with developmental amnesia describe their children as not demanding. They do not think too much about what happened in the past and do not have concerns about the future. They focus on the present. To give an example, a woman with developmental amnesia knew about her condition, but she was convinced: "In case I get lost, someone will find me."

NEVER FORGET

HOW REMEMBERING CAN IMPROVE THE QUALITY OF LIFE

The concept of operant conditioning entails that a certain behavior will be learnt and favored when it is rewarded by either a positive reinforcement or by the escape from an unpleasant event. A repetition of successful actions can be observed in humans and animals alike. People will for instance continue working, because they receive money or appreciation as a reward. We feel safe when we are able to predict the consequences of our behavior. Knowing our own effectiveness, we can alter the environment to our advantage. But what happens, when this security is taken away from us? And are there ways to explore this topic in an animal model?

If people lose their job, they may initially try to regain their former position or, alternatively, search for a new job. In case this is not successful, they have to accept the fact that chances of finding a new job may be slim. This is a simple example of dealing with situations in which conditioned reward, e.g. money, is taken away. The two options that people consider most often in situations like these are searching for other ways of earning the reward (e.g., retry getting the old job back) or, if this fails, trying to find a new source of reinforcement (e.g., search for new employment).

In animal experiments, this can be tested with the Morris water maze. A rat is put into a swimming pool with a hidden platform just beneath the surface of the water. In order to find that platform and rest on it, the rat has to explore the pool. After several trials, it learns the position of the platform by heart and the time between being put into the pool and finding the platform gets shorter. If the researchers remove the platform, though, the rat will start searching the pool for a new place to rest after having explored the area around the old position thoroughly. Thus, the rat has to learn a new kind of behavior.

If no new source of reinforcement (e.g., job or platform) can be found, two kinds of reactions can be discovered in man and animal: First, the frequency of the previously rewarded behavior decreases, for example, the rat stops searching. Secondly, an increase of alternative actions can be observed. In animals, these include aggression, vocalizations, agitation and escape. Scientist Joseph Huston calls this change in behavior despair. The question is: Is despair in animals an adequate model for depression in people? Can it be used, for example, to test the efficiency of new drugs?

There are certain measures that might shed light onto this discussion. One of them is the time after which the rat gives up its search for a platform, which is an indicator of hopelessness. Over time, the rat forgets the conditioned association between searching for a platform and being able to rest on it as a reward. Researchers call this process of erasing conditioned responses “extinction”. The longer the rat searches at the previous platform location, the more resistant is this specific behavior to extinction. Joseph Huston’s team thinks that this behavior may reflect hopefulness, a protective factor against depression. Anxiety, on the other hand, is considered to be one of the main symptoms of depression. It can be observed in people and animals alike. In fact, the researchers showed a relationship between despair and anxiety-like behaviors in aged rats, meaning that this could be a model for depression due to extinction of previously learned reinforcement. People are bound to experience loss and be faced with problematic situations, especially in old age. We should try to concentrate on our alternatives and never forget to keep up a fight.

INTERVIEW
WITH CHRISTIAN PARET

»I LIKED MANY OF THE TALKS.«

How did you become interested in neuroscience?

»In the beginning, I was more interested in clinical psychology. I took up psychology studies with the idea to become a psychotherapist. When I had a class in basic studies, the teacher brought up the ideas of Damasio. He referred to his theory of consciousness – and this was the point when I got interested in emotional psychology and neuroscience.«

What was your motivation for joining the summer school?

»I saw the poster and I thought it would be very interesting to see the speakers and to get a deeper insight in the topic. Psychology in Hamburg does not really include a major in neuroscience. That was a chance for me.«

How do you like it so far?

»I like it very much. It’s very intensive, it’s challenging. But I think it meets the level of my previous knowledge and I can benefit from it.«

Anything you like especially?

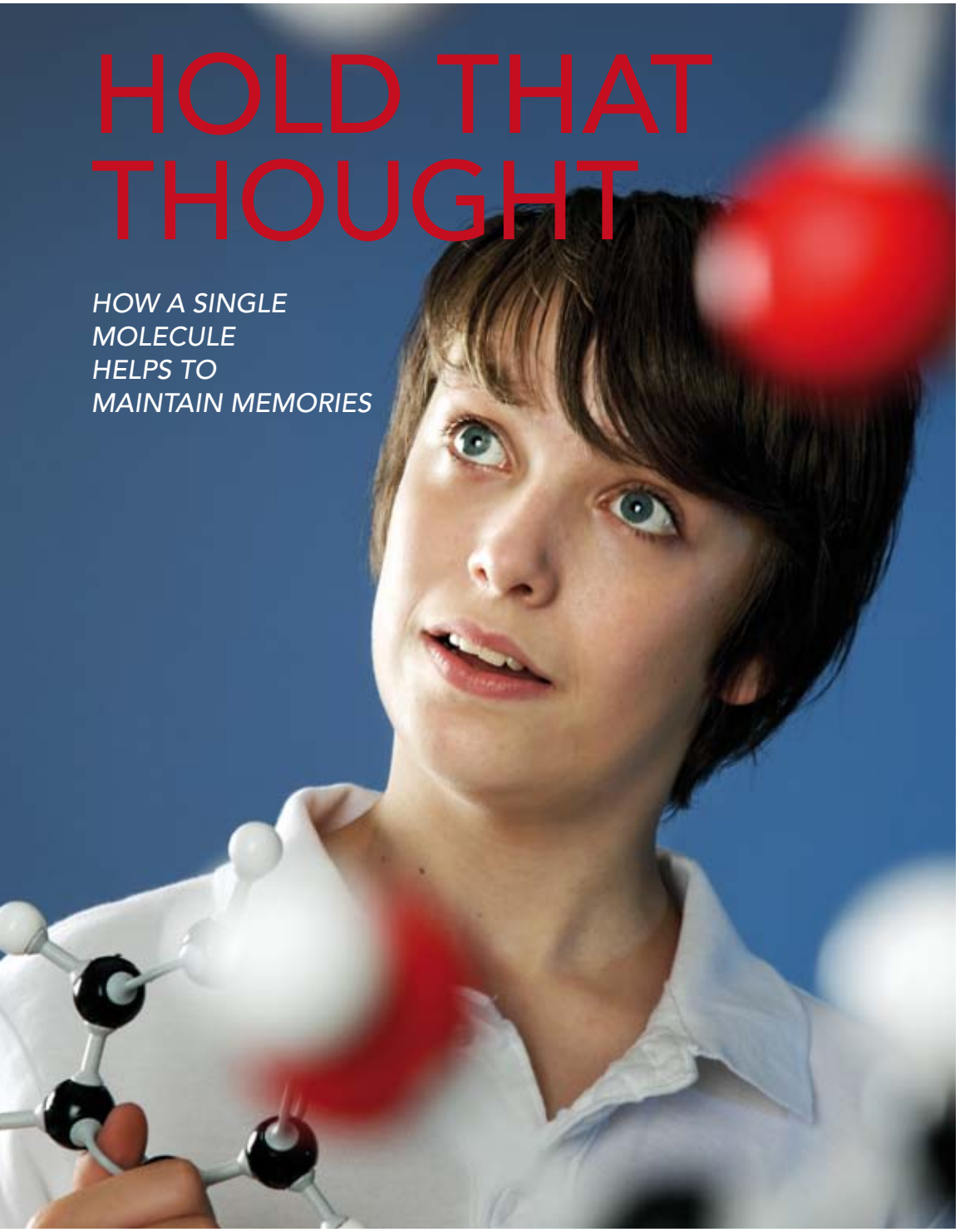
»That’s difficult. I was really looking forward to the third week, because extinction is one of my favorite topics. But I liked many of the talks. Dudai’s lecture was very good, I also liked his manner of speaking. And Eichenbaum too. And I very much liked going to Zeche Zollverein.«

What do you think of Bochum?

»I would not mind moving here for my PhD, for example. I think the city has character. Many people will say that it is not very nice looking here and all that, but that would not be the most important thing for me.«

HOLD THAT THOUGHT

HOW A SINGLE MOLECULE HELPS TO MAINTAIN MEMORIES



One of the most important and intriguing questions in the neuroscience of memory pertains to how memory is represented and maintained over time. Such understanding could lead to interventions that help patients with traumatic memories or even to improvement of memory capabilities in regular individuals.

A promising avenue of research in this regard is the work done on a single protein called PKMzeta which is, to date, the only cellular mechanism found to be involved in active memory maintenance. PKMzeta is an enzyme, a protein that can cause structural and functional changes in other proteins, and is located in the synapses, the contact points between the nerve cells. At the synapse, nerve cells are not directly connected to each other, but each cell is separated from the others by a small cleft. To transfer information from cell to cell, transmitter molecules are used to bridge the gap. The first cell releases the transmitters into the cleft, they diffuse to the other side and contact receptors on the surface of the second cell.

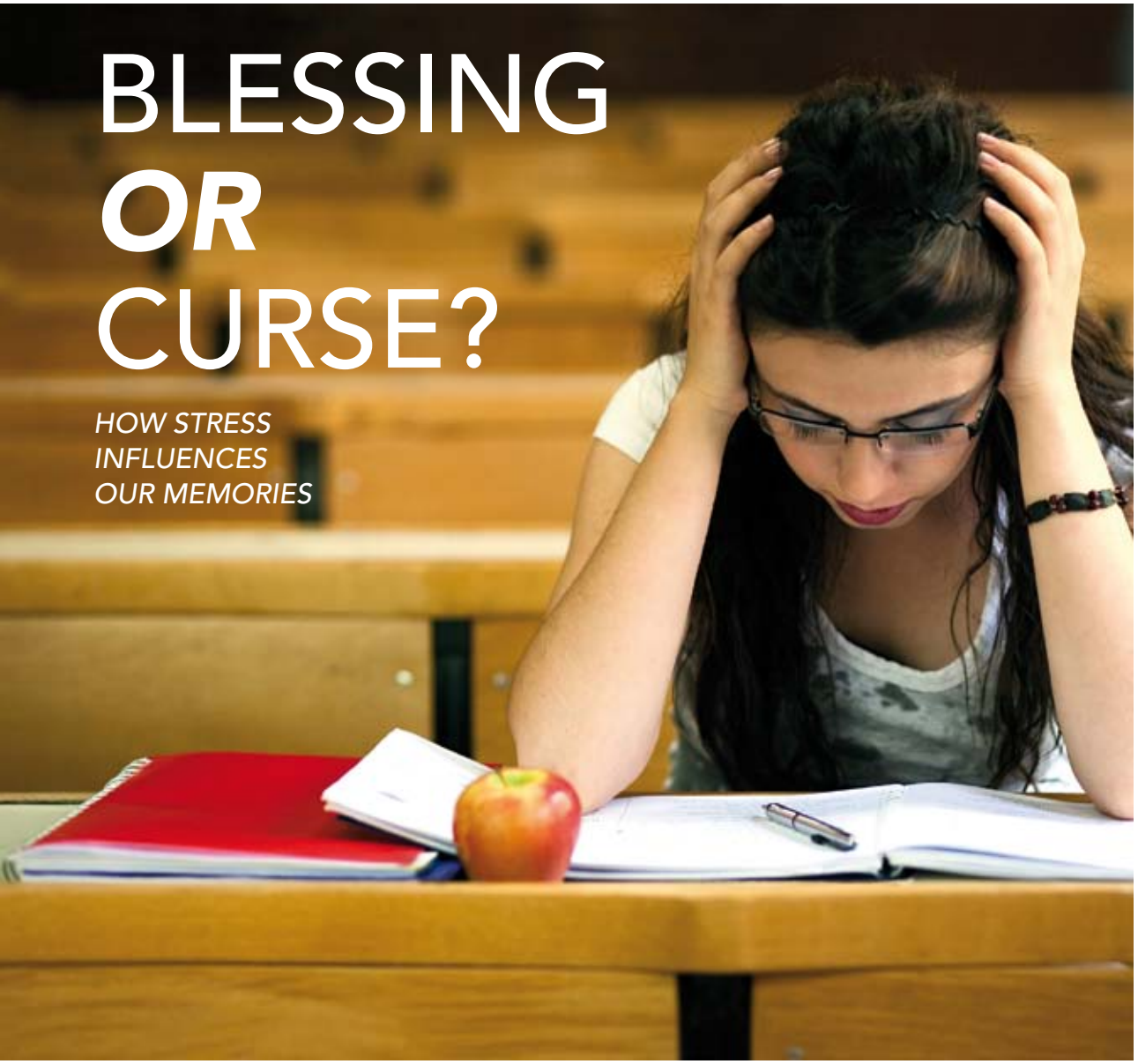
As a result of learning, PKMzeta changes some facets of the structure of the synaptic contacts. It increases, for instance, the amount of receptors, thus strengthening the connection between the cells. However, it must be persistently active to maintain this change. Researchers showed that PKMzeta is involved in long-term memory maintenance in various behavioral tasks and brain regions, including spatial memory in the hippocampus, conditioned taste aversion in the insular cortex, and auditory fear conditioning in the amygdala. Unfortunately, the exact way this enzyme works remained a mystery.

To unravel PKMzeta's mechanism of action, researcher Prof. Karim Nader conducted a variety of experiments. In one study, he used a substance called ZIP that renders PKMzeta inactive. Nader's team administered ZIP to a certain brain region, the amygdala, playing an important role in fear learning. Rats who were under the influence of ZIP exhibited an impairment in fear memory suggesting that a correctly functioning PKMzeta is necessary for remembering.

The researchers revealed that PKMzeta works by preventing the removal of a specific class of synaptic receptors, called AMPA receptors, which play a key role in learning. Inactivating PKMzeta led to a decrease in the number of AMPA receptors which correlated with the impairments in the rats' fear memory. Similar results were also obtained in another brain region, the hippocampus, suggesting that this mechanism by which PKMzeta maintains long-term memory may be a general principle in the brain. This research opens a possibility for developing new pharmacological interventions.

BLESSING *OR* CURSE?

HOW STRESS INFLUENCES OUR MEMORIES



There is that one moment everybody is afraid of: standing in front of the teacher, the professor, the boss or the colleagues and not being able to remember the important information. They stare at you and expect the right answer to their question. You start sweating and your face turns red. You are sure that you know the answer, but there is no chance you will remember it. Afterwards, on the other hand, you are able to remember many details from that embarrassing situation, for instance what the other people and the surrounding looked like. Stress has a huge influence on our memory. It can impair our ability to remember, but it can also enhance our ability to memorize.

We all know what stress is and what it feels like to be in a stressful situation. Acute stress occurs as a response to a perceived threat. This threat can be imagined or real, it can be physical, psychological or even emotional. The way we perceive and interpret the threat is an important factor. In our daily life, stress is mostly caused by uncertainty, novelty, unpredictability and social evaluation. No one likes to be in the focus of attention, being evaluated and at the same time not being able to respond in the right way. In such a situation, our body reacts in a very specific way. Cortisol, the hormone of the stress response, is produced in the adrenal gland and released into our blood stream. Years ago, scientists showed that there is a correlation between induced stress and Cortisol levels. Just before and after a stressful situation, like an oral exam, the Cortisol level increases.

Nowadays, many scientists are interested in the nature of the influence that stress has on our ability to remember. In the laboratory, stress can be induced by using the so-called social stress test. Participants are asked to give a free speech and take a calculation test, each five minutes in duration and in front of an audience. This situation leads to an increase in Cortisol levels, meaning that stress is successfully induced. At the beginning of the study, participants memorize certain items, e.g., pictures or a list of words. After a delay of one day, one group of participants performs the stress test, a second group does not. People in the stress group commonly remember fewer items than people in the group that was not stressed.

Further studies investigated memory performance after participants had been given the stress hormone Cortisol or a placebo, i.e., a control substance without any effect. Cortisol, but not the placebo, impaired the memory ability. Thus, stress has a negative influence on our ability to remember, when it occurs shortly before learning new information. However, it can also improve memory. If participants experience stress while learning new information, their ability to memorize this information is enhanced. Therefore, stress seems to be a blessing and a curse at the same time. Whether it is beneficial or detrimental just depends on when it occurs.

INTERVIEW
WITH KARIM NADER

»ABOVE AVERAGE«

What is your impression of the summer school so far?

»The students all seem to be very keen and fun young people.«

Are the students different from those you interacted with before?

»They certainly seem to be above the average. It's fun! When they're this motivated, it's good! In classes we often get people who are a lot more passive. These students seem a lot more engaged in the topic.«

What advice do you have for the students?

»Don't hold back, I think. Just go for the biggest investigations.«

What to you is the most fascinating aspect of neuroscience?

»There are many things. What we are studying is obviously the most interesting. The answer for me is reconsolidation. Here is a single concept that was brought back from essentially ten years. And now we are trying to improve the quality of life for people with addictions and people suffering from post traumatic stress disorder. The other thing is something called PKM zeta, which is a molecule that people think has to do with maintaining memories over a long period of time.«

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Magdalena Sauvage, Sen Cheng, Oliver Wolf, Emily Andres and Onur Güntürkün

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