Donders Institute Newsletter

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The Donders Newsletter is published twice a year by the Donders Institute for Brain, Cognition and Behaviour, which brings together research groups at Radboud University and the Radboudumc as well as the Max Planck Institute for Psycholinguistics. Its purpose is to keep you informed of developments within the Donders Institute and the field of neuroscience.

Radboud University

Making invisible problems visible

Being the best by selecting the best

The top-down control of feature and spatial-based attention

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Donders Institute
for Brain, Cognition and Behaviour

"I see myself more as a problem creator than as a problem solver."

Making invisible problems visible

In order to explain cognition, scientists need to look not only *inside* the brain, but also *outside* the brain. That's the view of computational cognitive scientist Iris van Rooij.

What enables us as to employ our cognitive capacities? This is the fundamental question that cognitive scientist Iris van Rooij – leader of the Computational Cognitive Science group at the Donders Institute – poses. She investigates this question in relation to computational models that can be used to develop artificial intelligence, i.e. smart robots and virtual agents. She believes that humans do not owe their remarkable cognitive capacities to the biological and chemical stuff that their brains are made of. In her view, the same functional properties can – at least in principle – be mimicked by artificial 'agents' as well.

Van Rooij: "I'm particularly interested in cognitive capacities that are extremely hard for machines, such as developing what we call common sense. This is illustrated, for instance, by meanings that cannot be expressed literally or put into words. For example, when we talk with each other, you know that I know certain things and I know that you know

The limits of computation

Thinking naively, you might expect that if you were able to bring enough computer power to bear, you could solve any mathematical problem that has a finite number of solutions. However, this is not the case. Even if you could calculate using all the atoms in the universe, and even if you had done that from the nanosecond when the universe began, it would still be impossible to calculate all solutions to certain types of problems. In mathematics these are called NP-hard, i.e. the hardest problems in the class *nondeterministic polynomial time*. Unfortunately, such problems are very common in everyday life. The best-known NP-problem is the 'travelling salesman' problem. A travelling salesman has to find the shortest route to allow him to visit a given number of cities. The number of possible routes explodes very rapidly as the number of cities increases. For fifty cities there are more than 10^{62} possible routes (that's a 1 followed by 62 zeroes). Even with a trillion super-powerful computers, it would take more than the lifetime of the universe to check out all potential routes. Many computational-level theories of cognition are equivalent to NP-hard problems, including those related to vision, planning, learning a language, decision-making, categorizing and making analogies. For cognitive scientists the 'grand challenge' is to explain how the brain nevertheless manages to solve such problems, even though they seem to be intractable from a computational point of view.

certain things. Each of us uses this knowledge to read things, as we put it, 'between the lines'. This capacity goes way beyond what artificial intelligence systems are currently able to do."

Fundamental problems

Cognitive capacities require an explanation at three levels, she explains, referring to the seminal work by the British neuroscientist and psychologist David Marr. The first explanation is provided at the computational level. That's the 'what' question: what precisely is the problem that the cognitive process attempts to solve? For example, mapping from the sensory input on the retina to a three-dimensional visual representation of the world. The answer to this question can be formulated in the form of a mathematical function that maps an input to an output. Then, there's the explanation at the algorithmic level. That's the 'how' question. Given the function at the computational level, how does this form of mapping work? Which algorithm can be used? The third part of the explanation of cognitive capacity lies at the level of implementation. How is the mapping achieved physically? It can be done in a biological way, but also in a non-biological way, for example in a computer.

"My research, which focuses on the computational level, is largely meta-theoretical," explains Van Rooij. "I explore ways of modelling cognition. So my approach is applicable to all types of cognitive models, no matter whether they are neural networks, Bayesian models, dynamical systems, or whatever else. Too often there are discussions about which of these models is better, whereas I see fundamental problems in all of these models."

Van Rooij applies her thinking to a wide variety of areas: from learning and communication to sense of agency and self-awareness. Many models of these cognitive capacities are computationally intractable. In mathematics such problems are known as NP-hard problems (see boxed text above). Van Rooij: "Scientists have very different explanations for why some problems are so hard computationally. Some claim that optimizing makes problems hard, while others argue that it's the large search space that causes problems to become so intractable. Still others think approximation makes problems easier. However, I argue that none of these classical approaches are useful."

Structure in the world

How is it then that the brain is able to rapidly solve cognitive problems that seem to be computationally intractable?

In Van Rooij's opinion, the only possible answer is that the mathematical function used to map an input to an output over-generalizes. "I believe that the brain only computes on a particular subset of the input domain that is relevant to the way we function in the world. Therefore, to explain cognition, cognitive scientists not only need to look inside the brain, but also outside. We need to take the structures in the world into account, and not just the physical structures, but also the social and cultural structures. We need to understand *that* brain in *that* organism in *that* particular world."

"I believe my main contribution is to make invisible problems visible," says Van Rooij. "Not everyone finds this helpful, but luckily some of my colleagues do." Within the Donders Institute she works together with, among others, Ivan Toni on the puzzle of communication. Together they use a digital board game to study human communication. Two players can move figures on a virtual board and they are not allowed to communicate with each other except by moving these figures. Van Rooij: "It turns out that different pairs of players develop different strategies to communicate during the game. I have shown that the communication problem they solve together is computationally even more challenging than an NP-hard problem. This insight helps explain why it's so hard to build a form of artificial intelligence that can play the game." With a big smile she adds: "In science, helping not only means solving problems, it can also be about *identifying* the right problems. In fact, I see myself more as a problem *creator* than as a problem *solver*."

Bennie Mols

Being the best by selecting the best

Alumnus Christian Utzerath

Second-year student Nadine Dijkstra

The Research Master's programme in Cognitive Neuroscience has once again been ranked as the top Master's programme in its field in the Netherlands (see Keuzegids 2015). What is it that makes this programme, which is taught at the Donders Graduate School for Cognitive Neuroscience, so highly valued? And besides all positive aspects, what can be improved so that it remains a leading course internationally?

"Brain-related studies attract students from several fields," says programme coordinator Arno Koning." We receive applications from national and international students with a Bachelor's degree from a wide range of disciplines and faculties we have at Radboud University, such as Psychology and Artificial Intelligence (Social Sciences), Medical & Biomedical Sciences (Radboudumc), Biology and Physics (Science), Linguistics (Arts) – and even Philosophy (Philosophy and Religious Studies). "The brain is clearly a hot topic. Just look at the popularity of Dick Swaab's books or the level of attention that the perceptual illusion of 'dressgate' got."

Alumnus Christian Utzerath – now a PhD candidate at the Donders Centre for Cognitive Neuroimaging – found this mix of students from different academic backgrounds very valuable. "The programme is certainly intensive, but the lecturers are aware that not everyone has the same level of knowledge and they take the time to explain complex issues. This makes the high level attainable. It also offers a fascinating variety of perspectives, as everyone looks at the brain from the point of view of their own discipline."

Christian does not experience the high standards set by the programme as pressure. "These standards may seem overwhelming to students at the start, but it turns out that they are, in fact, very inspiring. Everyone is highly motivated, which encourages you to go that extra mile."

Theory that comes alive

Arno Koning believes that the programme's strength also lies in the close links between research and education. In 2009 the Donders Graduate School was established to teach this Master's programme as well as the corresponding PhD programme. Three prior existing educational specialisations were then reorganised to coincide with the Donders Institute's research themes (see second info box). "These areas symbolise what we in Nijmegen are particularly good

at. There's a clear link for students between what they are taught in class and cutting-edge research in the institute. In other words, theory comes alive for them."

Koning sees the balance of theoretical courses and practical work as another important plus. "Theory is taught throughout the programme, not just in the first semester. We don't want to give a 'quick and dirty' theoretical basis and then drop students off in a lab. Students get plenty of hands-on research experience, but we guarantee they also get a solid theoretical basis, which they will be able to use in their future careers. This mix of theory and practice calls for students who are highly motivated, because it requires something different than a 9-to-5 attitude."

Selecting the best

The programme is highly selective. "One of the reasons why many of our students' Master's theses have been published in prestigious journals is that they are not only taught by some of the best researchers in the field; they are themselves among the best students out there," says Koning.

After it has been established that a student's prior education is adequate and that their grades are above average, they are invited for an interview. "Besides the standard questions about their strengths, weaknesses and future plans, we ask why they chose us and not another programme or university. Not because we want to hear how good they think we are, but because it gives us a good idea of how thorough they are when selecting a Master's programme and thus how carefully thought-out their choice is."

"I was worried I wouldn't be admitted," admits current second-year student Nadine Dijkstra. "But I think the approach works really well. In the interview my weaknesses were discussed and they advised me as a psychology student to take a basic course in mathematics. A course I couldn't have done without."

The programme also promotes two double-degree programmes that allow students with certain specialisations to get two research qualifications in three years: degrees in Artificial Intelligence and Neuroscience. Arno Koning: "There are only a handful of students who do this, but we offer it, because the collaboration makes the most of the strengths of each programme."

Room for growth and improvement

The programme began in 2003 with a mere nine students, but this past academic year more than fifty students joined. "The aim is to keep growing, but not to become a victim of our own success," says Koning. "You can't be taken seriously as a selective Master's programme if you admit 500 students. Currently, we're striving for about eighty students, which will ensure that the programme's strengths are maintained."

And more plans are being made for the future. "With the exception of 2014, our Master's programme has been ranked the best since 2010. The break in this winning streak presented us with a good incentive to revitalise the programme. We asked students and researchers what was working and what wasn't. That same year, we were also evaluated by the Dutch Flemish Accreditation Organisation (NVAO). Besides referring to our programme in their final report as 'leading internationally', they also suggested some improvements. Based on this input, we're about to make a number of changes, ranging from low-level issues, such as making better thesis evaluation forms to more far-reaching ones. For example, the content of the Language and Communication specialisation will be adapted to make sure it has a stronger neuroscientific grounding."

You can read the full interviews with Nadine Dijkstra and Christian Utzerath on the Master's programme website: www.ru.nl/master/cns.

Vanessa Deij

Programme outline

Students must take the following courses, regardless of specialisation:

- *Trends in cognitive science*
- *Neuroimaging I*
- *Neurophilosophy*
- *Lab rotation*
- *Neuroimaging II: haemodynamic methods*
  OR
  Neuroimaging II: electrophysiological methods

And they may then choose two of the following skills training courses:

- *Neuroanatomy*
- *Basic mathematics*
- *Basic statistics*
- *Advanced mathematics*
- *Practical training in event-related potentials (ERP)*
- *Academic writing*

After five specialisation courses and two elective courses, the programme concludes with a long internship (worth 45 EC) and a thesis.

Master's specialisations and Donders' themes

1. *Language and Communication*
   A study of the acquisition, understanding and production of language.
2. *Perception, Action and Control*
   A study of basic sensorimotor aspects as well as the cognitive, contextual and social components of perception-action coupling.
3. *Plasticity and Memory*
   A study of the mechanistic underpinnings and behavioural consequences of long-term changes in neural structure and function.
4. *Brain Networks & Neuronal Communication*
   A study of the interaction between and within groups of neurons, and with the outside world.

Donders Lecture on 25 June 2015

The top-down control of feature and spatial-based attention

Professor Robert Desimone

McGovern Institute for Brain Research, Massachusetts Institute of Technology

"Robert Desimone was one of the first people to postulate and validate a neurobiological mechanism for a cognitive function. He set himself this ambition very early in his career."

For a long time, scientists saw the brain as an organ, just like the liver or the lungs and, as a result, the cognitive aspect was long ignored. "Desimone has explained how a crucial cognitive function – selective attention – can be accomplished using a neurobiological mechanism." Dr. Eric Maris, who leads the Neurophysiology of Active Perception group at the Donders Institute, also works on the neural mechanisms behind attention. He will host Robert Desimone during his stay in Nijmegen.

Dr. Maris: "Desimone is a very important figure in cognitive neuroscience. At the core of his contribution is the finding that biased competition in neurons of the visual system can explain the behavioural consequences of selective attention. In short: how attention overrules the default specificity of neurons in the visual system." To describe this mechanism he worked together with both biologists and psychologists – an unusual approach in the late 1980s.

He has since proved to be a man of many talents. According to Dr. Maris, "A few years ago, he made a big step extending his intracranial studies with non-invasive magnetoencephalography (MEG). And, in 2014, this resulted in one of the most beautiful MEG studies ever published in *Science*, revealing the neural mechanisms of object-based attention. This shows an extremely high level of skill as well as considerable thoroughness. He is clearly able to excel, working with a wide variety of tools and techniques."

"There are still many cognitive functions for which we don't have a convincing neurobiological mechanism, such as short-term memory and the retrieval of semantic memories. So I hope – and trust – that he will be an example and inspiration for all who come to the lecture."

The Donders Lecture will take place on the University campus at the Linnaeus Building, Heyendaalseweg 137, Nijmegen, starting at 4.00 pm.

For more information about the 2015 lecture series, go to www.ru.nl/donders.

Iris Kruijen

Meanwhile at www.ru.nl/donders

Donders researchers on Dutch TV
The group led by Jeffrey Glennon presented some of their aggression research in the March 2 episode of the popular Dutch science TV show Proefkonijnen ('Guinea pigs') on Dutch TV channel NPO3.

Dutch actress, singer and television personality Katja Schuurman visited the Donders Institute twice for episodes of 'Katja's Bodyscan' on TV channel NPO 1. On February 26, she investigated her stress system together with Karin Roelofs, Hannah Niermann and other researchers at the Experimental Psychopathology and Affective Neuroscience lab. In the March 4 episode, she investigated her memory system with Christian Doeller, Sander Bosch and Silvy Collin from the Memory and Space research group.

Marloes Henckens to meet Nobel laureates
Marloes Henckens has been selected to attend the 65th edition of the Lindau Foundation's Nobel Laureate Meetings. These meetings, which are scheduled from 28 June to 3 July in Lindau (Germany), are intended to help scientists excel and build international networks.

Hermesdorf International Prize for Marijn Kroes
Marijn Kroes was awarded the Hermesdorf International Prize during the New Year's speech in the University's Aula as a result of his article in *Nature Neuroscience* on the use of electro-convulsive therapy to erase the memories of patients with

Donders Sessions

The monthly 'Dondersdag' will be revitalized as of September 2015 and has been renamed 'Donders Sessions'. The event will be coordinated by the Donders Sessions Council, which includes young researchers and the speakers of the research themes. At the same time two speakers, Barbara Franke and Ole Jensen, will step aside. The entire Donders community is extremely grateful for their relentless efforts and inspiration as theme speakers. This allows two enthusiastic PIs to become the new speakers of theme 3 and 4: Indira Tendolkar and Tansu Celikel. We wish the two new speakers good luck and the support from the entire Donders community for their new and crucial task.

Indira Tendolkar – *Plasticity and Memory*
Indira Tendolkar chairs the PI group "Cognitive Psychiatry". Being a neurologist and psychiatrist by training, she tries to bridge the gap between clinical psychiatry and cognitive neuroscience. Her research is related to the declarative memory system and its related brain systems.

Tansu Celikel – *Brain Networks and Neuronal Communication*
Tansu Celikel chairs the PI group "Neurophysiology". His work involves system level descriptions of the neural circuits that process sensory information, in order to determine how adaptive changes in neural representations are translated into cognition and action.

Go to our website to check out the latest news and events

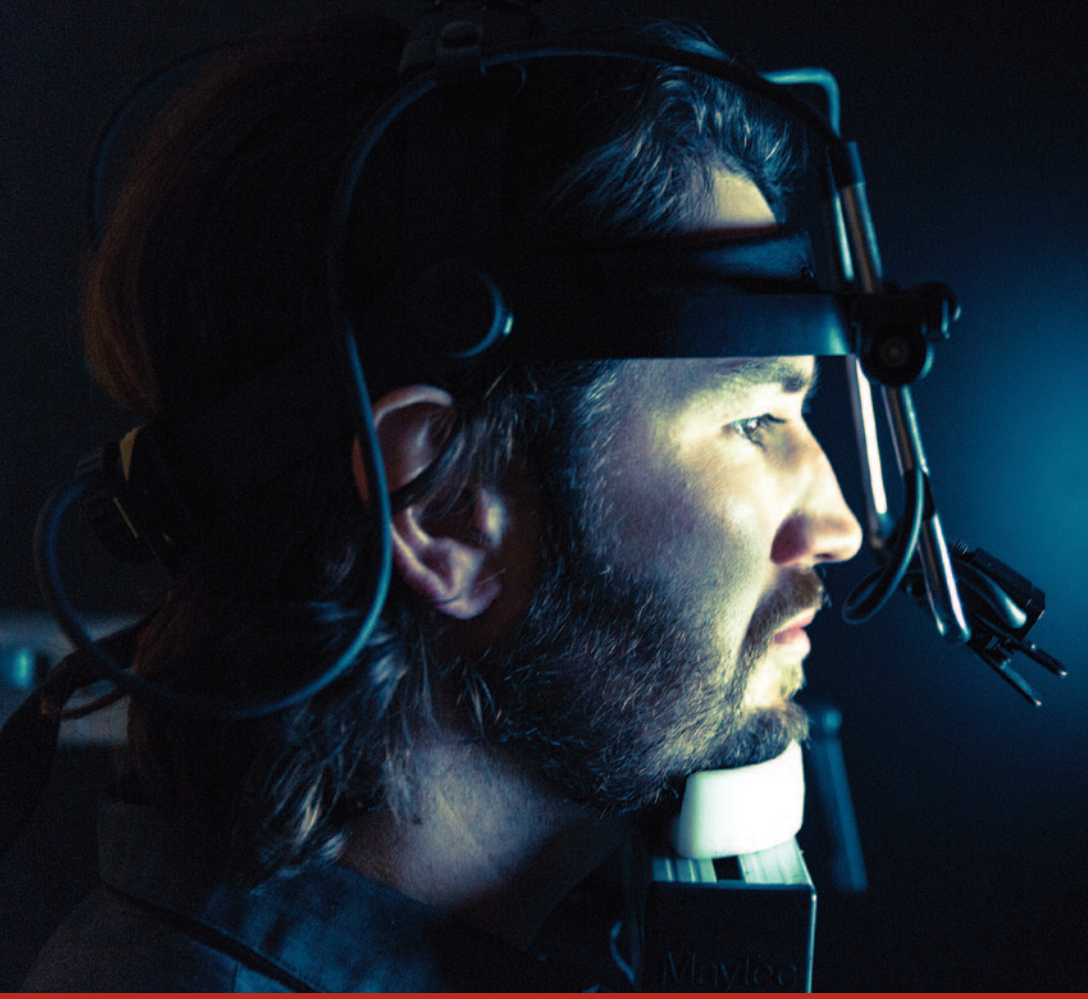
post-traumatic stress disorder (PTSD). His research, which touches on a problem affecting many people with traumatic experiences, could lead to new treatments.

Four VIDI grants for Donders researchers
Floris de Lange, Marcel van Gerven, Jan-Mathijs Schoffelen, and Roel Willems have each obtained a Vidi grant from the Netherlands Organisation for Scientific Research (NWO) to study the influence of expectations on perception, methods to read brain representations, the orchestration of brain activity, and what makes us like a story.

Three Vici grants for Donders researchers
Roshan Cools, Asli Özyürek and Joris Veltman have each obtained a Vici grant from the Netherlands Organisation for Scientific Research (NWO) to study the effects of neuro-enhancers, the impact of sign language on spatial cognition, and the consequences of genetic mutations. Vici grants – the highest level of NWO awards – are extremely competitive.

Nijmegen researchers identify new genes for brain structure
An international study, which included nineteen researchers from the Donders Institute and the Max Planck Institute for Psycholinguistics, has identified several new genes that influence the size of our brains and specific brain structures. Alejandro Arias Vasquez was one of the first authors and Barbara Franke one of the senior authors of the paper, which was published in *Nature*.

New colloquium room
In January 2015, the Donders Institute's Centre for Cognitive Neuroimaging (DCCN) proudly unveiled its new, bright red colloquium room, which has been nicknamed 'the red room'. This is part of ongoing major renovations so that the DCCN can accommodate the many researchers and support staff who have joined the Donders Institute in recent years.



The machine

The *Eyelink II* eye tracker consists of three miniature cameras mounted on a headband: two eye cameras and one integrated head-tracking camera. Thanks to its very fast data rate and high resolution, this eye tracker is ideal for saccade analysis and smooth pursuit studies.

Tjerk Gutteling, postdoctoral researcher in the Sensorimotor Lab, uses the eye tracker in combination with EEG during passive translation on a vestibular sled in order to study sensorimotor integration during passive self-motion.

Diary

10 June 2015, **A Celebration of Language with a keynote lecture by Prof. Evan Eichler** about '*What makes us human: insights from a dynamic genome*' and several artistic performances. Grotius building, 14:00–17:00

22 June 2015, **Valkhof symposium and lecture by Prof. Carmen Sandi**, director of the Brain Mind Institute, Ecole Polytechnique Federale de Lausanne, about '*The stressed social brain: from rodents to humans*'. Radboudumc Auditorium, 12:00-16:00

25 June 2015, **Donders Lecture by Prof. Robert Desimone**, Massachusetts Institute of Technology, about '*The top-down control of feature and spatial based attention*'. Linnaeus Building, 16:00-17:15

3 July 2015, **Inaugural lecture by Alan Sanfey**: '*Psychological and neural bases of decision-making*'. Aula Radboud University, 15:45

20-23 April 2015, **four-day toolkit course** '*Advanced analysis and source modeling of EEG and MEG data*'. For more information, send an e-mail to tildie.stijns@donders.ru.nl

18-20 May 2015, **three-day toolkit course** '*Computational approaches to neuroimaging*'. For more information, send an e-mail to tildie.stijns@donders.ru.nl

30 June - 2 July 2015, **three-day toolkit course** '*Advanced topics in MR imaging of the brain*'. For more information, send an e-mail to tildie.stijns@donders.ru.nl

13-17 July 2015, **intensive five-day toolkit course** '*Essentials of major neuroimaging techniques (EEG, MEG, fMRI, PET, TMS)*'. For more information, send an e-mail to tildie.stijns@donders.ru.nl

August 2015, **Brain & Behaviour courses in the Radboud summer school**:
- 3-7 August, *Language Science: Current Methods and Interdisciplinary Perspectives*
- 10-14 August, *Introduction to Cognitive Neuroscience: From Molecule to Behaviour*
- 10-14 August, *Brain Computer Interfaces: How They Work and How to Build One*
- 10-14 August, *Neural Metrics 2.0: Quantitative Methods in Neuroscience*
- 10-14 august, *Neurocomputational Approaches to Decision Making: From Perception to Social Cognition*

See www.ru.nl/radboudsummerschool/ for more information

22-25 September 2015, **four-day toolkit course** '*Transcranial Brain Stimulation*'. For more information, send an e-mail to tildie.stijns@donders.ru.nl

1 October 2015, **Donders Lecture by Prof. Dorothy Bishop**, University of Oxford, about '*The enigma of cerebral lateralization*'. Linnaeus Building, 16:00-17:15

29 October 2015, **Donders Lecture by Prof. Stephen Faraone**, SUNY Upstate Medical University, about '*Advances in the genetics and neurobiological mechanisms underlying neuropsychiatric disorders – the example of ADHD*'. Linnaeus Building, 16:00-17:15

3 December 2015, **Donders Lecture by Prof. Erich Jarvis**, Duke University Medical Center, about '*Learned birdsong and the neurobiology of human language*'. Linnaeus Building, 16:00-17:15

PhD defences

6 May 2015 - **Van der Doelen, R.** *Translational psychiatry; the twists and turns of early life stress and serotonin transporter gene variation* (Donders Series 178)

2 June 2015 - **Van der Meij, R.** *On the identification, characterization and investigation of phase dependent coupling in neuronal networks* (Donders Series 183)

8 June 2015 - **Horschig, J.** *Flexible control and training of posterior alpha-band oscillations* (Donders Series 185)

12 June 2015 - **Maaijwee, N.** *Long-term neuropsychological and social consequences after stroke in young adults* (Donders Series 181)

23 June 2015 - **Meijer, F.** *Clinical application of brain MRI in Parkinsonism: from basic to advanced imaging* (Donders Series 182)

9 July 2015 - **Spaak, E.** *On the role of alpha oscillations in structuring neural information processing* (Donders Series 177)

Donders Institute Newsletter

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