DONDERS INSTITUTE

Newsletter 31

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DROSOPHILA DRIVES NUMEROUS STUDIES

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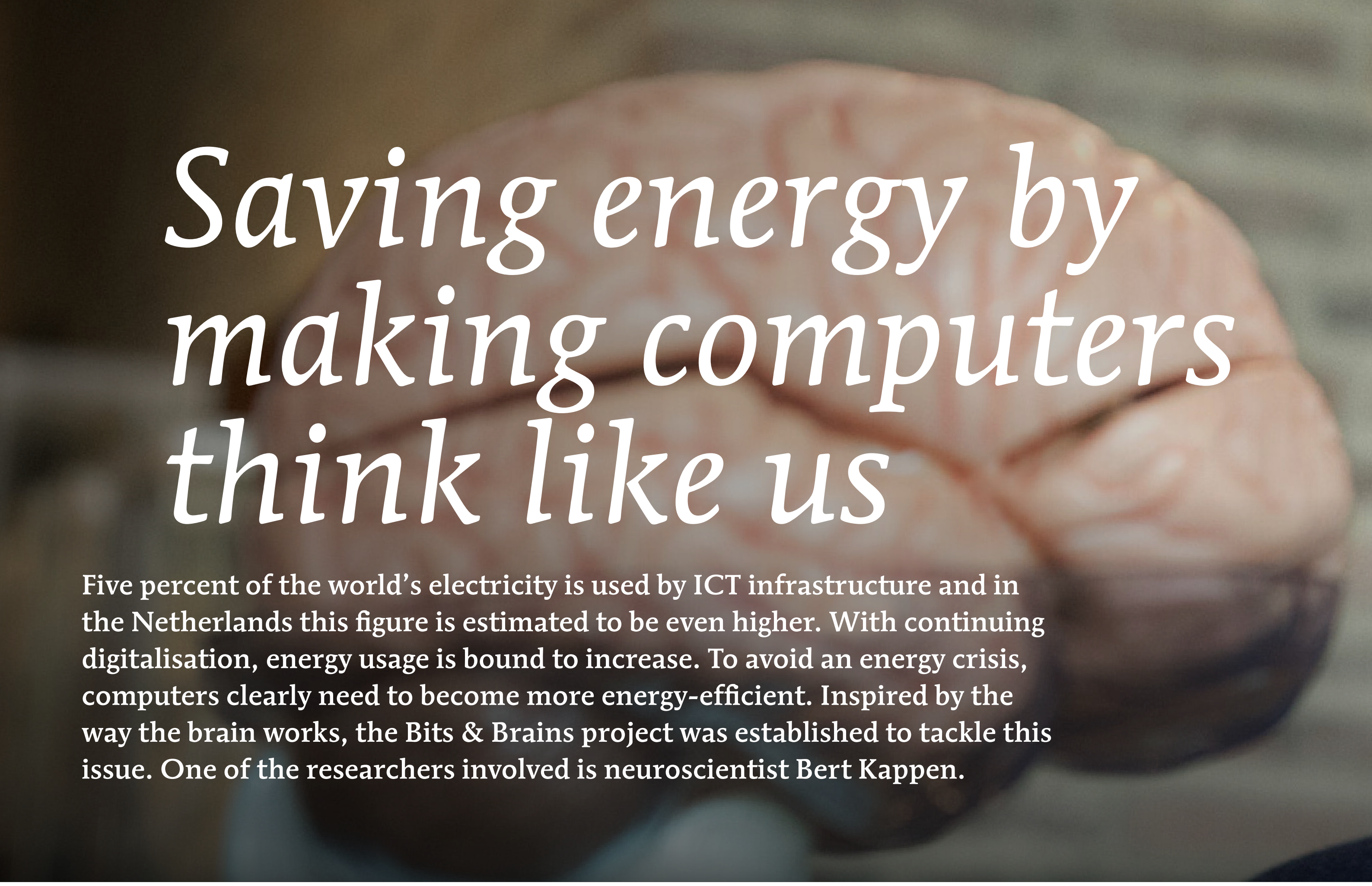


Saving energy by making computers think like us

Five percent of the world's electricity is used by ICT infrastructure and in the Netherlands this figure is estimated to be even higher. With continuing digitalisation, energy usage is bound to increase. To avoid an energy crisis, computers clearly need to become more energy-efficient. Inspired by the way the brain works, the Bits & Brains project was established to tackle this issue. One of the researchers involved is neuroscientist Bert Kappen.

In Nijmegen, researchers from different fields are combining efforts in the hope of saving energy when computing: for example, linking experimental and material physics with neuroscience. Imagine a computer that could process information as energy efficiently as our brain. To achieve this, we would need to know what makes the brain such an energy-efficient information processing machine. And then we need to find out how we can build a computer to work in a similar way.

THE POWER OF A MEDIOCRE LIGHT BULB

Bert Kappen, who works at the Donders Institute, conducts theoretical research at the intersection between machine learning, computational biology and artificial intelligence. "We've all experienced a laptop heating up on our lap. We can literally feel the energy computers use," Kappen explains. "Even though the brain uses one fifth of the body's total energy, it's still incredibly energy-efficient. Our brains can process huge amounts of data using no more than 20 to 25 watts, the same power as a mediocre light bulb. Performing 30 Google searches consumes about as much energy as heating a litre of water." He continues: "The brain has of course some disadvantages. When it comes to certain computations, such as number crunching, computers outperform human brains. But, in many other areas, our brains win hands down. Think of pattern recognition, game playing, learning, or to put it more concisely: intelligence. That's why we're using the brain as a source of inspiration."

BOTTLENECK

"What are the main differences between the brain and computers? Most modern computers have a von-Neumann-based architecture, which means that memory is used to handle both data and program instructions. For this to work, there is continuous interaction between the central processing unit (CPU) and the memory unit. This constant back and forth between processes and memory not only takes time, but also consumes a great deal of energy. The brain, like a computer, is swarming with electrical signals – but, unlike in a computer, information processing and storage are combined, thus saving energy."

ADVANCES

"A lot of progress is already being made towards building self-learning computers. Just recently, Google published an exciting paper on deep learning. And there's a computer that can learn to play the game Go from scratch without the need to input any human expert knowledge. It's simply given the rules and then learns by practising the game. This learning computer can already outplay a programmed computer 100 to 0.

"Right here in Nijmegen we're making advances using neural accelerators. This is specialised hardware that is designed to function like a neuroprocessor for deep learning. But, with Bits & Brains research, we intend to go further. All the recent spectacular developments in AI and machine learning still involves the use of a conventional von-Neumann computer, which processes

one instruction at a time. In some cases, the learning is done off-chip and then transferred to the neuron board. So the execution is done on the neuron board, but not the learning. That means there is no energy saving. Developing hardware that supports self-learning is our goal."

UNRELIABILITY: A STRENGTH?

"I enjoy the theoretical challenge that this presents. Can we use the quantum properties of matter for computing? And what do we do with the unreliable aspects of the way our brain functions? Some people believe that the brain's unreliability is in fact its main strength, because making mistakes is how it learns to make new connections. But how can we get a computer to use unreliability?

"What's great about the Bits & Brains project is the team that's been assembled: experts from many different fields are working together to develop neuromorphic computing. The project is the brainchild of experimental physicist Theo Rasing. He works at the Institute for Molecules and Materials in the University and specialises in the properties and structure of nano-materials and laser physics. His expertise can help us construct the devices we need.

"Also on board are theoretical physicists working on condensed matter such as Mikhail Katsnelson and Johan Mentink. Alex Khajetoorians, who specialises in scanning probe microscopy, is also part of this team. Outside of Radboud University the consortium includes materials scientists from Groningen and Twente and theorists from Utrecht and Amsterdam."

THE NEED TO ATTRACT FINANCE

"Right now finance is an issue. We attempted to get NWO Zwaartekracht funding worth around €20-25 million, but just didn't make it, coming in eighth (six projects were offered funding). We did get money from the Nationale Wetenschapsagenda Green ICT programme, which funds computing research designed to make a significant contribution to a more sustainable society. And we've now submitted another proposal for European funding, expanding the consortium to include other European scientists and companies. One of the strengths of the consortium is the strong representation of neuroscientists."

LONG WAY TO GO

"But we have to be realistic. Finding adaptive, learning materials that mimic the clever design of the brain is ambitious and many difficult issues need to be tackled. It will take time. I'm not talking about a few years, probably closer to ten. Hopefully, ICT energy consumption won't have got out of control before we succeed. But, in the meantime, this research is great fun. And the possibility of discovering something that can make a real difference to society is very rewarding."

Vanessa Deij

Gelderland: the Netherland's healthiest province?

Could what we eat help prevent age-related diseases, such as dementia? How can veggie snacks be made more appealing? To tackle these and many more research questions, Radboud University, Radboud university medical center and Wageningen UR are joining forces. Together they are trying to make Gelderland the healthiest province in the country. Donders cognitive neuro-scientist Esther Aarts explains how.

Bad eating habits are risk factors for major chronic diseases such as cancer, diabetes and cardiovascular conditions. Moreover, healthy development in early life could provide a sound basis for vitality throughout life. The interaction between food, brain and cognition is reciprocal: our brain determines what we eat and what we eat influences our brain. But the mechanisms of this interaction are still largely unknown.

Researchers in Nijmegen and Wageningen have been doing collaborative research in the field of food and cognition for many years. Esther Aarts and her colleagues believe it's time to strengthen these ties. Esther is a senior researcher at the Donders Institute and coordinator of the Food & Cognition collaboration.

"In May 2016, some 15 principle investigators working at the two universities sat together to explore how our research could be optimised. It seemed a perfect fit. Researchers in Wageningen have extensive knowledge of food manipulation, dietary parameters, consumer behaviour and nutritional interventions. At Radboud University we specialise in brain imaging and behavioural science and at the Radboud university medical center we have access to patient populations."

THE BIGGER PICTURE

Through sharing knowledge a clearer picture can emerge. “Think of trying to change people’s eating behaviour so that they don’t eat beyond satiety,” Aarts explains. “In Wageningen they’re looking at how to manipulate food so that people chew it better. The idea is to get people to eat more slowly, which helps quell hunger, making them eat less. In Nijmegen we look at what happens in the brain when you consume certain foods in more or less distracting situations (distraction makes you eat more). By combining this work, we can discover the food-related and cognitive processes that underlie feelings of satiation.”

GETTING EVERYONE INVOLVED

“Besides neuroscientists at the Donders Institute, colleagues from other institutes and faculties on the Radboud campus are also involved, including the Behavioural Science Institute and the Marketing department.”

Esther Aarts’ own main interests lie in controlling food intake, and how intestinal microbiota can influence our brain and behaviour. Fellow researchers at Wageningen help her find the answers she’s looking for. “I’m a biologist. I analyse brain images and cognitive measures. What I need is more food knowledge: how nutrients are absorbed, which satiety hormones are involved, and so on. These are areas where I can cooperate with researchers in Wageningen.”

SECURING FUNDING

The ultimate aim is to set up a long-term rolling agenda and research programme. “Instead of writing individual project proposals and then seeking collaborators and funding for each project, we want to build a community of stakeholders who commit to the entire programme. On the basis of this shared agenda, the community of stakeholders will allocate financial contributions to research projects that fit their priorities.

“We are right in the middle of the process of negotiating this plan with target companies that are interested in this field of research. Think of food and tech companies, but also public bodies such as the Province of Gelderland. We’re hoping they will make a long-term commitment to the agenda and research programme. Then we can guarantee that future research will be in line with their priorities, and they will no longer need to evaluate every proposal separately. The exact set-up will be determined with these financial backers: it will be a joint effort.”

THEMES

Together Food & Cognition researchers have grouped their collective research within two main themes: eating behaviour and personalised nutrition. Eating behaviour is studied across the life span: from food science to sensory and gut-brain homeostatic aspects, as well as individual differences in reward motivation, emotion, impulsivity and self-regulation. The consumer’s environment is also investigated.

In personalised nutrition topics from food to nutrients and from nutrients to brain and cognition are studied, with a major role for the gut microbiome and immunology. The effect of dietary patterns, nutrients and food supplements is studied during healthy development, adulthood and ageing, but also when there are neurodevelopmental, degenerative, mood and metabolic disorders.

SMART DEVICES

The Food & Cognition programme also focuses on the influence of technology. “Errors can occur when you ask people to write down what they eat; they forget or don’t want to admit eating another cookie,” Aarts gives as an example. “Is there perhaps a way to digitally keep track of a person’s food intake?”

“Apart from helping with assessments, we also want to find out whether technology can be used as part of an intervention. For example, colleagues at Radboud University’s Behavioural Science Institute investigate whether they can train someone to spontaneously choose healthy food. In future research with Wageningen UR, we intend to study the effects of such training on the brain and, eventually, on the choices made in supermarkets.”

THE IMPORTANCE OF FOOD

Esther Aarts says she believes that a healthy brain depends on a healthy body. “Besides exercise and stress reduction, food is important. With obesity now being such a major health problem, food should play a much bigger role in healthcare. It could contribute to a shift from treatment to prevention and from hospitalisation to self-care. Preventing obesity is so much more (cost) effective than treating it. Food could even play a role in treatment. For example, we now begin to better understand how diet plays a role in children with ADHD, and how it affects older adults with Parkinson’s disease. With a stable research programme in place, we hope to be able to motivate future scientists so that food and cognition research really flourishes.”

Vanessa Deij

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

Meanwhile at www.ru.nl/donders

SOME RECENT HEADLINES

- **Veni grants for Vitória Piai and David Peeters**
  A €250,000 Veni grant has been awarded to Vitória Piai, which she will use to investigate how the right-hemisphere language system works. David Peeters will use his Veni grant to develop a neurocognitive model that explains how our brain understands references in speech and gestures.
- **Over €2.5 million for dementia research**
  The Dutch national funding programme Memorabel II (ZonMw) has granted €2.5 million to six research projects and three partner projects. This funding gives an extra impulse to the dementia research at the Donders Institute and Radboudumc.
- **New research group that specialises in understanding visual information in the brain**
  Neuroscientist Marius Peelen has joined the Donders Institute to head up the new Visual Cognitive Neuroscience research group. He has received a Consolidator Grant worth €2 million for this research.
- **Peter Desain's research referred to in The Guardian**
  The NoiseTag method, a non-surgical brain computer interface developed by Peter Desain was referred to in an article about breakthroughs in communication technology.

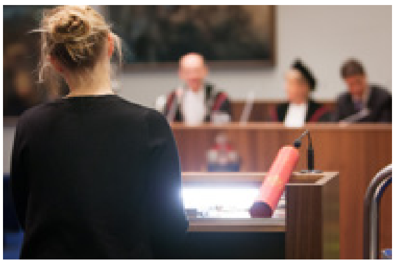
SOME RECENT HIGH-IMPACT PUBLICATIONS

- **Storage of emotional memories follows a special neurological trajectory**
  Benno Roozendaal's group discovered that storage and retrieval of emotional memories remains dependent of the hippocampus, while other memories are transported from the hippocampus to the cortex. This difference explains why emotional memories are so detailed. (PNAS)
- **Mutations altering gene function important cause of intellectual disabilities**
  A research team led by Christian Gilissen developed a method that is able to detect mutations that do not eliminate genes but rather affect them in another way. This mechanism, which has not been studied before, is expected to play a prominent role in understanding intellectual disabilities. (American Journal of Human Genetics)
- **Expectations enhance perception by early activation of the brain**
  Floris de Lange and colleagues have shown that predictions about a stimulus forestall expected sensory input and thus enhance perception. (PNAS)
- **Oxytocin influences how we share knowledge by promoting cognitive exploration**
  Ivan Toni's group discovered that when someone receives a dose of oxytocin, they will more rapidly adjust their communication to what their audience understands. (Psychoneuroendocrinology)

PhD defences

**Donders series number*

- 4 July 2017, DS. 286*. **Visser, J.**, *Autism spectrum disorder in early childhood. Presentation, risk factors and trajectories.*
- 7 July 2017, DS. 281. **Van Schaik, J.**, *Little Chameleons: An Investigation into the Development and Mechanisms of Behavioral Mimicry.*
- 30 Augustus 2017, DS. 293. **Pruim, R.**, *Disentangling the functional architecture of the brain in psychiatric disorders.*
- 7 September 2017, DS. 284. **Barendse, E.**, *Autism spectrum disorders in high functioning adolescents; Diagnostic considerations (AHA).*
- 8 September 2017, DS. 294. **Van Bergen, R.**, *Sensory uncertainty and response variability in the human visual cortex.*
- 14 September 2017, DS. 279. **Naaijen, J.**, *Compulsivity and glutamate in neurodevelopment.*
- 22 September 2017, DS. 295. **Backus, A.**, *Connecting the dots: the mechanism of associative memory in the hippocampus and neocortex.*
- 22 September 2017, DS. 289. **Gips, B.**, *Mechanisms and functional interpretations of oscillatory neuronal activity.*
- 4 October 2017, DS. 292. **Van de Bovenkamp-de Kam, D.**, *Postural instability in people with chronic stroke and Parkinson's disease: dynamic perspectives.*
- 12 October 2017, DS. 291. **Schulz, J.**, *Simultaneous multi-slice imaging techniques for MRI acquisitions.*
- 20 October 2017, DS. 297. **Schipper, P.**, *Smart coping: serotonin transporter gene variation and environmental interact in determining the behavioural adaptation to stress.*
- 27 October 2017, DS. 288. **Nieuwhof, F.**, *The complexity of walking. Cognitive control of gait in aging and Parkinson's disease.*
- 31 October 2017, DS. 298. **Monroy, C.**, *Neurocognitive mechanisms of action sequence processing.*



- 1 November 2017, DS. 287. **Veugen, L.**, *From bimodal stimulation toward binaural integration.*
- 2 November 2017, DS. 299. **Janssen, M.**, *Upper extremity function in Duchenne Muscular Dystrophy.*
- 3 November 2017, DS. 285. **Klemann, K.**, *A molecular window into Parkinson's disease.*
- 4 December 2017, DS. 301. **Evereard, D.**, *A load on the Mind. Neural mechanisms of stress sensitivity.*
- 6 December 2017, DS. 300. **Kole, K.**, *Molecules of somatosensory map plasticity.*
- 8 December 2017, DS. 296. **Herring, J.**, *Driving visual cortex to study neuronal oscillations.*

Donders Lectures in 2018

Five times a year, outstanding international researchers in the field of brain and cognition come to the Donders Institute to present their work and ideas. The Donders Lecture series is designed to appeal to a broad scientific audience with a range of backgrounds: from neuroscience to psychology and linguistics. Everyone who is interested is welcome to attend these lectures.

We are proud to announce the Donders Lectures programme for 2018:

- March 8th, Francesca Happé, King's College London
  Theory of Mind and Autism: 30 years on
- June 28th, Zoe Kourtzi, University of Cambridge
  Strategic routes for learning in the human brain
- September 13th, Miguel Nicolelis, Duke University School of Medicine
  Linking Brains to Machines: From Basic Science to Neurological Neurorehabilitation
- October 25th, Jacqueline Gottlieb, Columbia University
  Understanding motivated cognition: challenges and opportunities
- November 22nd, Christian Büchel, University of Hamburg
  How expectations can shape pain

The Donders Lectures take place at the Linnaeus building (lecture hall LIN3) on the Radboud University campus, Heyendaalseweg 137, Nijmegen, at 4.00 p.m. For information about this year's lectures, please go to: www.ru.nl/donders/lectures

Donders celebrates 200 years of brain science

In 2018, the Donders Institute celebrates the 200th anniversary of the birth of the leading scientist Franciscus Cornelis Donders. He was a respected ophthalmologist and also a pioneering researcher in physiology, evolution and mental processes. Among other innovations, FC Donders developed a 'subtraction technique', which could be used to time the different mental processes that the brain goes through when engaged in various tasks. This nineteenth-century concept still forms the basis of much functional brain imaging work today.

In honour of FC Donders, the institute will organise a variety of scientific and public events in 2018, including public lectures, a symposium and several activities for primary and secondary school pupils.

For more information and programme updates, go to: www.ru.nl/donders/200

DONDERS
200 YEARS

THE MACHINE

The fruits of fly research

It may be small in size, but its contribution to science is impressive. The fruit fly, *Drosophila melanogaster*, has been used in biomedical research for many decades. At first, only a few people believed that fruit flies could be relevant to understanding human diseases. However, as three quarters of all human disease genes have a direct counterpart in fruit flies, they are not that different from us. Over the years, these 3 mm-long creatures have given us a lot of insight into numerous fields of research. The fruit fly study of Jeffrey Hall, Michael Rosbash en Micheal Young even received this year's Nobel Prize in Physiology or Medicine. Annette Schenck and Erik Storkebaum, two researchers at the Donders Institute, are no strangers to fruit fly research. Their two labs combined now house close to 100,000 of these insects.

Erik Storkebaum has no doubt that the fruit fly is the way to go in genetics research: "You get the best of both worlds: these are living organisms that in many respects behave much like mammals, and yet they are small, easy to genetically manipulate, and have a short lifecycle. They thus provide an excellent balance between using a model that's relevant for biomedical research and being able to conduct your research fast."

Schenck focuses on improving our understanding of geneticforms of intellectual disability and neuropsychiatric disorders, such as autism and ADHD, while Storkebaum tries to unravel the molecular mechanisms underlying motor neurodegenerative diseases, for example ALS. Both agree that the future lies in finding genetic and chemical modifiers for disease genes and translating this knowledge to humans in order to develop more effective therapies.

As the nervous system of the fruit fly is conceptually similar to ours, these animals are particularly useful in neuroscience. However, they can also be used in other areas. Annette Schenck: "Many more disorders can be modelled in *Drosophila*: from blindness and heart disease to developmental and immune disorders. But you need a specialist with knowledge of the specific disease to know how best to model it in *Drosophila*. All drosophilists benefit from the enhanced toolboxes and techniques, which – together with the efficiency of our model – makes *Drosophila* research an expanding universe of opportunities."

Wieneke van Oorschot

DONDERS INSTITUTE Newsletter

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.

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