DONDERS INSTITUTE

Newsletter 30

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PLAYFUL CROSS-POLLINATION

Predicting, perceiving and learning spoken words

DONDERS LECTURE

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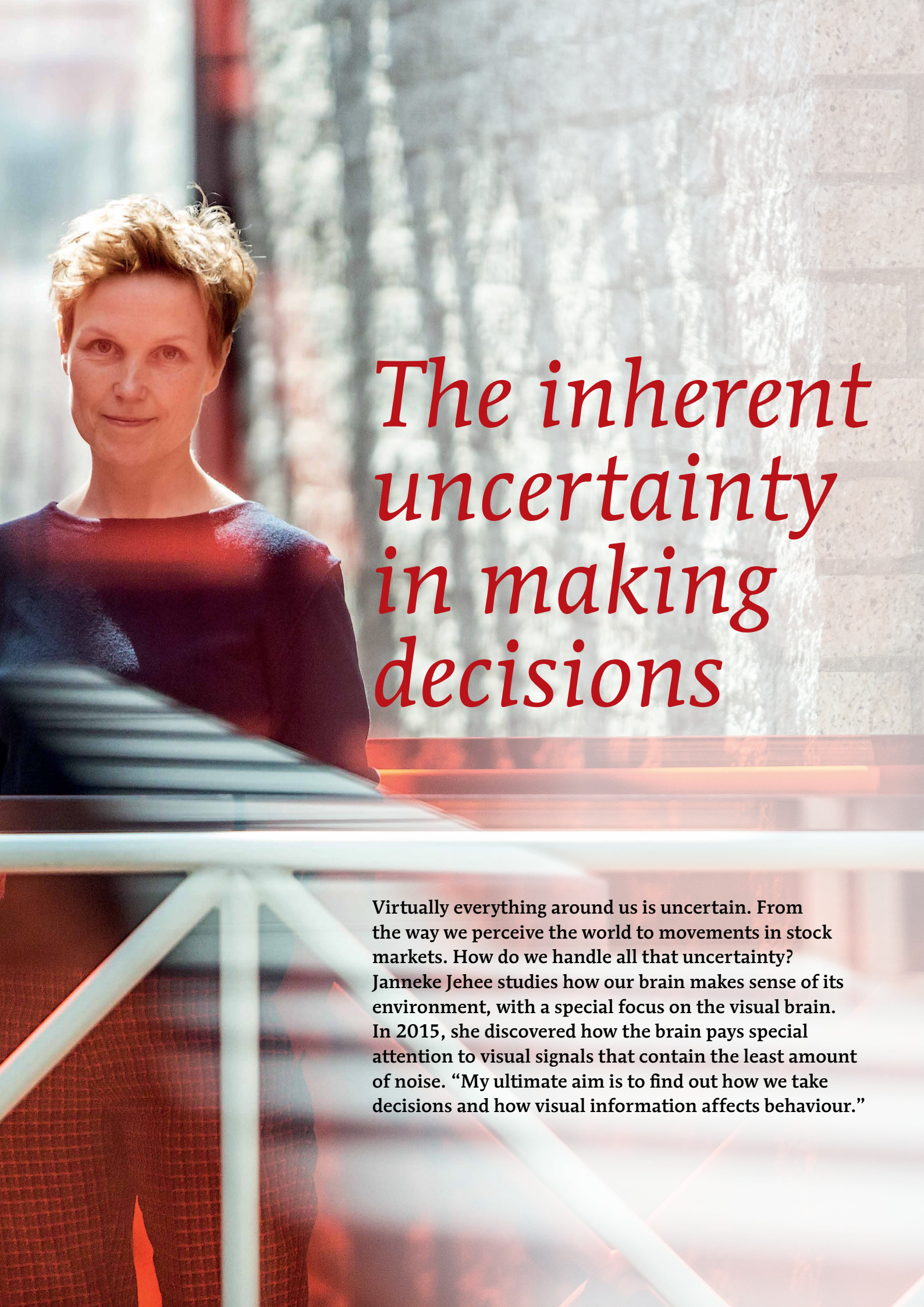
Radboud University Radboudumc



The inherent uncertainty in making decisions

Virtually everything around us is uncertain. From the way we perceive the world to movements in stock markets. How do we handle all that uncertainty? Janneke Jehee studies how our brain makes sense of its environment, with a special focus on the visual brain. In 2015, she discovered how the brain pays special attention to visual signals that contain the least amount of noise. "My ultimate aim is to find out how we take decisions and how visual information affects behaviour."

People tend to forget that decision-making is about more than processing information. It is also about weighing the certainty or uncertainty of that information. Imagine a kind of error bar on all the decisions you make. When you're not completely sure that it's your neighbour on the other side of the street, you will wave more hesitantly than when you *are* sure.

Together with her colleagues in the Donders Institute's Visual Computation & Neuroimaging group, Janneke Jehee studies how the brain 'decides' what we see based on uncertain visual evidence. To do that, she combines computational modelling, psychophysical experimentation and imaging techniques such as fMRI.

"I WANT TO UNDERSTAND EVERYTHING"

"My ambition was to study medicine, starting from the age of twelve. But, when I was eliminated from applying to Medical School by lottery, I started studying psychology instead. To my surprise, that turned out to be a very good choice. I found out that I don't just want to identify and solve problems, but rather to *understand* these problems at a deeper level. That's what really drives me: I want to understand everything. Not only how the brain works, but also how to investigate brain mechanisms in the best possible way by optimising study designs and developing novel statistical analyses."

JANNEKE JEHEE

Janneke Jehee received her PhD in Psychology from the University of Amsterdam. After post-doctoral work at the University of Rochester (NY, USA) and Vanderbilt University (TN, USA), she joined the Donders Institute in 2010, where she is the Principal Investigator of the Visual Computation & Neuroimaging group. She received an ERC Starting Grant worth €1.5 million in 2016 and, in April this year, the Vision Sciences Society awarded her their Young Investigator Award. She will receive this prestigious award during the Vision Science Society's Awards Session on May 22 in Florida.

"Every day, I can choose new skills to learn. And that's what I love most about my job," she says with an almost apologetic grin, "discovering new ways of tackling computer programming problems, and learning about new imaging techniques and mathematical tools."

In late 2015, she published an article in *Nature Neuroscience* showing how the visual brain has found a way to pay special attention to signals that contain the least amount of noise. It estimates the reliability of sensory information and integrates that in the neural decision-making process. In this way, we are able to make decisions that are just a bit more precise. "We were the first to demonstrate the neural mechanisms of sensory uncertainty in the visual cortex and the paper in *Nature Neuroscience* was the very first publication by my group. Looking back, it's one of the things I'm most proud of, although I feel a certain reluctance to talk about my own achievements."

GOING BEYOND THE VISUAL BRAIN

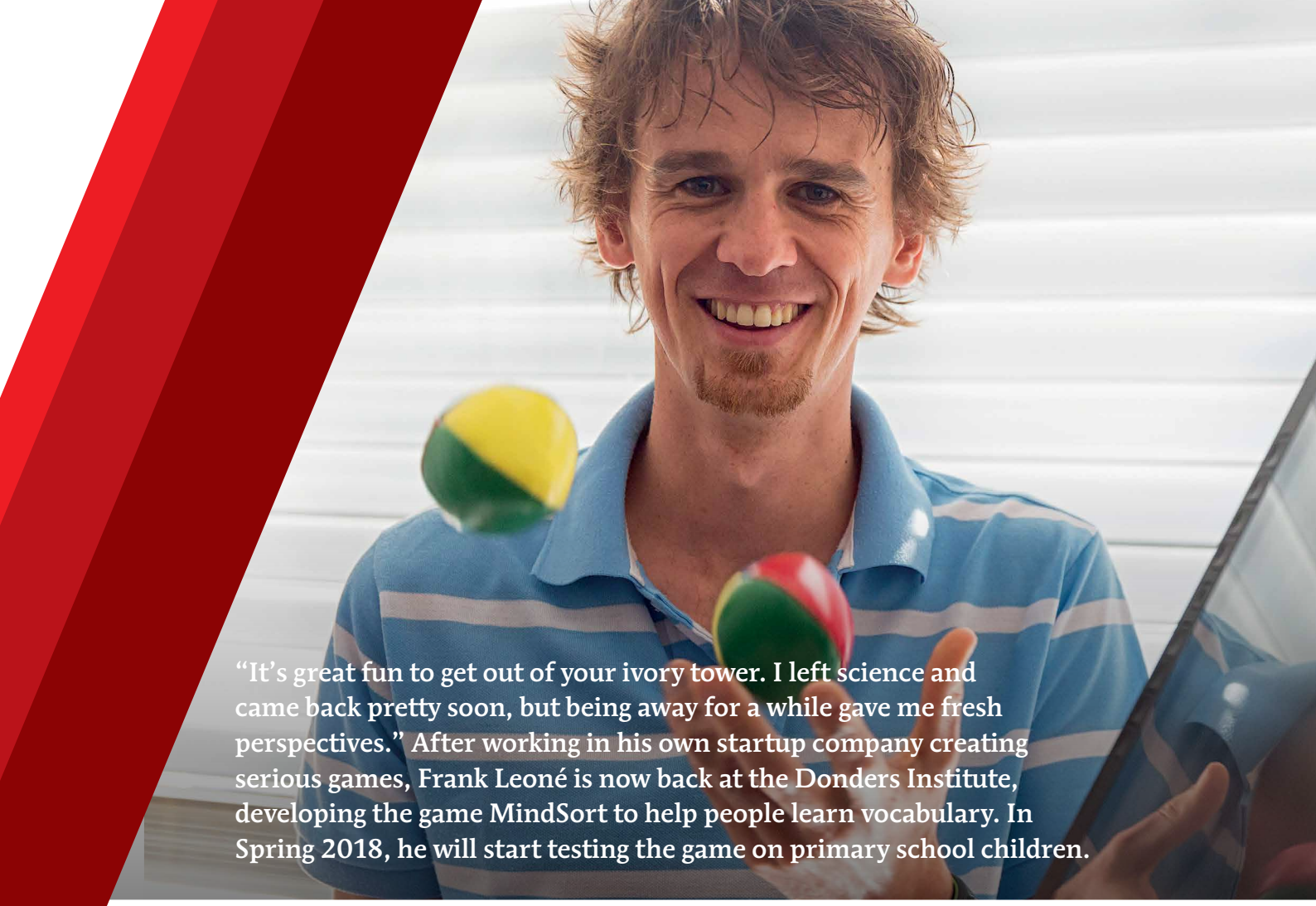
Eventually, Janneke Jehee and her colleagues aim to express the brain's decision-making processes in computational models. In optimal models, more weight will be given to information that is more certain. Just like in the visual brain. The group aims to determine whether this principle can be generalised to areas beyond the visual cortex. There are some challenges ahead though: neuroscientists know quite a lot about some areas in the visual system, but the areas beyond them are mostly unexplored terrain. Furthermore, these areas beyond the visual cortex represent visual input quite differently, as they focus more strongly on aspects that are important to the brain's output – our behaviour – rather than sensory input.

"Unfortunately for us, it's very hard to capture those aspects linked to behaviour in the mathematics that is required for our computational models," she explains. "So we will start by investigating these processes in the visual brain, and hopefully in the future extend our models to include other domains as well. We are, comparatively, a rather technical group, with a relatively strong basis in computer science and mathematics. We develop computational theories in order to make better predictions, and test those predictions in experiments. But in the end, models are just models. I believe you must always be able to explain your models in words. Otherwise, you simply don't understand your models well enough." With twinkling eyes, she adds: "I love to explain what we study, and why that's fascinating and important."

One of her favourite examples when explaining her research is to imagine driving on a motorway. You are constantly estimating distances between vehicles and maybe reducing your speed in reaction to that. Think about how you do that during the day compared to your behaviour at night time. We just know that we need to be a bit more careful in the dark. But *how* do we know that?

"Without realising it, you're constantly combining information from various sources, while at the same time estimating the reliability of these sources and integrating that uncertainty into your final decision. But the big question remains: how does our brain do that? Such questions are very important, because they underpin all the other questions about uncertain information as well. That's why they're so fundamental to many of our decision-making processes."

Iris Kruijen



"It's great fun to get out of your ivory tower. I left science and came back pretty soon, but being away for a while gave me fresh perspectives." After working in his own startup company creating serious games, Frank Leoné is now back at the Donders Institute, developing the game MindSort to help people learn vocabulary. In Spring 2018, he will start testing the game on primary school children.

Brain-tailored learning

"Doing pure, fundamental work wouldn't have kept me in science," Frank Leoné says. "What I hope to do with my research is to bridge the gap with practice and see how it might be possible to apply neuroscience principles in education." To study the effectiveness of the ideas underlying MindSort, he recently received €600,000 from the Dutch 'Nationaal Regieorgaan Onderwijsonderzoek'.

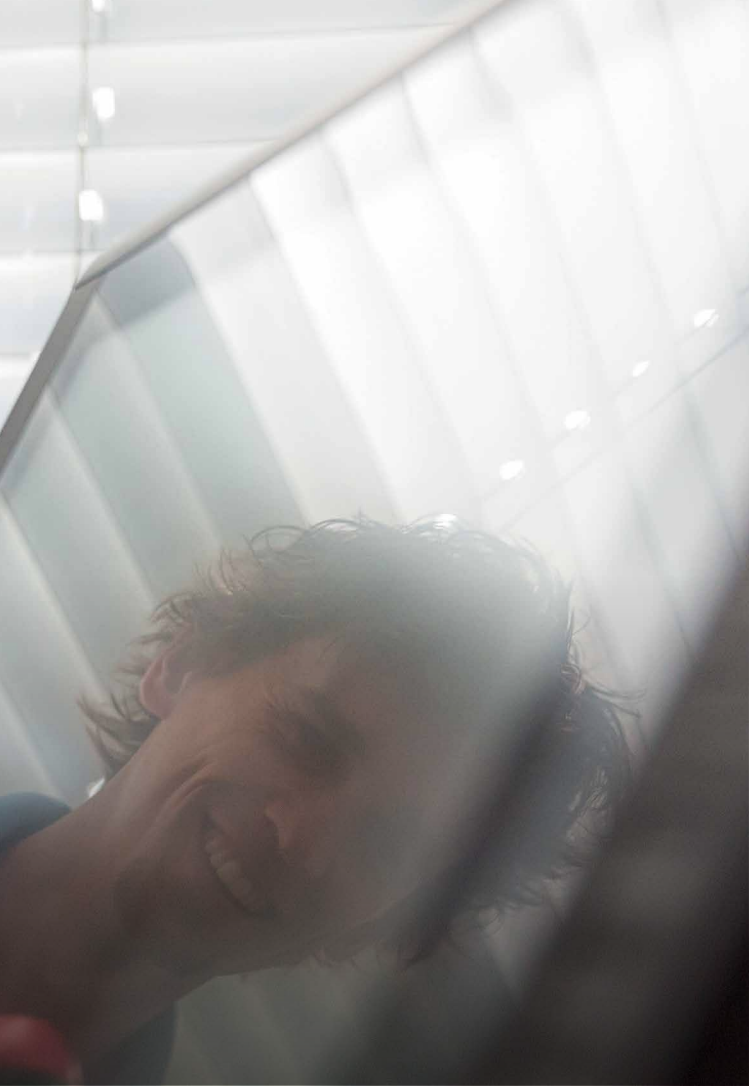
MindSort is a card game based on Memory that helps people to learn new words and build vocabulary in their native language as well as in new languages. Players have to find two matching cards by combining their meaning and spelling, so for example combining an image of a lion with the word 'lion'. The cards are sorted into two sets based on similarity in meaning and in pronounciation: for example, the lion image is next to the tiger image, whereas the word 'tiger' is next to the Dutch word 'steiger'. Leoné: "Unlike in Memory, you can actually learn something here, as the position of words is informative and the game gives you feedback on how close you are to the right answer."

GAMES, NO BORING LISTS

The design of MindSort is based on several principles inspired by neuroscientific research, such as a theory that words that are similar in spelling and pronounciation are stored in similar locations in the brain or handled in a similar fashion. "In conceptual areas of the brain, the images of 'lion' and 'tiger' are close together, while 'beer' and 'bear' are close in the word area," Leoné explains.

Another neuroscientific principle on which MindSort is based, is that learning in the brain seems to be at least partially spatial in nature. The hippocampus, which is the brain area involved in learning and memory, also plays a role in representing spatial maps in the brain. Leoné: "Because you see the cards and learn their physical and relative locations on the board, the card locations are connected to the meanings in your memory."

"Currently, school children mostly learn words from boring lists. But, if these scientific principles are true, there



might be a more effective way to acquire new vocabulary. Shouldn't we present new information in a way that is similar to how it is stored in our brains? Ideally, even tailored to how it is stored in *individual* brains?" That's what he hopes to find out with his research. "It should be clear that we are testing an hypothesis, so the game might not work as well as we hope. But, even if it doesn't work, interesting things are bound to come out. We willl learn from it, I'm sure."

CROSS-POLLINATION

Besides working on MindSort, Leoné also organizes other activities that cross-pollinate neuroscientific knowlegde and education. He is expecting to organize a second Donders Hackathon. In such an event, scientists, software developers and teachers are challenged to jointly develop innovative brain-inspired apps and games for education in just 24 hours. Another future plan is the setup of an Innovation Hub for education at Radboud University together with Professor Harold Bekkering. "Improving education is my personal passion. It's what I've have done throughout my career. I live and breathe education."

Harriëtte Koop

DONDERS INNOVATION PROGRAMMES

Bart van de Warrenburg wears two hats at the Donders Institute. As Principal Investigator and Associate Professor in Neurology, he studies rare genetic movement disorders. But, since May 2016, he has also been a Societal Impact Officer. His task in this position is to strategically build a stimulating environment that will generate more societal impact from the neuroscience done at the Institute.

Bart van de Warrenburg has defined five Donders Innovation Programmes, which capture the current and future potential of Donders research in terms of influencing societal issues and benefiting societal needs. These programmes are Health & Healthcare, Food & Cognition, Learning & Education, Neurotechnology & Big data and Public & Policy.

With these programmes, he hopes to inspire Donders researchers to think about societal relevance and to interact with societal partners early in their research. "The advantage of also being a neuroscientist is that I speak their language; I am a brother in arms. I have a realistic view of what you can and cannot expect from scientists." Van de Warrenburg believes that scientists should be able to continue doing fundamental science and not be asked to cover all the steps from concept to concrete solution or product. "That's something for entrepreneurial scientists, who are rare, and that's fine." "I'm trying to connect scientists to the right people to make sure that good ideas end up solving real societal issues, recognising that this could take a long time."

In addition to Frank Leoné's MindSort game in the Learning & Education programme, there is also, for example, much more to be expected in the near future from the Food & Cognition programme. By tackling clear societal issues, including preventing diseases such as obesity and promoting a healthy lifestyle, this campus-wide theme has great potential to be a sustainable programme in terms of structure and funds. The research is done in collaboration with Wageningen University Research as well as several public and private partners.

Also see www.ru.nl/donders/societal-impact

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

Meanwhile at www.ru.nl/donders

SOME RECENT HEADLINES

- **Vici grant for Anneke den Hollander**
  Anneke den Hollander has been awarded a €1.5 million Vici grant, which she will use to develop an 'eye chip' for patients that will mimic the structure and functions of the eye.
- **Two Marie Curie ITN grants**
  Sabine Hunnius and Francesco Battaglia will both lead new European training networks. The aim of the first is to study children in natural interactions with their environment, while that of the second is to investigate the brain mechanisms of memory.
- **Ammodo KNAW Award for Roshan Cools**
  Professor Roshan Cools received an Ammodo Award from the Royal Netherlands Academy of Arts and Sciences (KNAW) to explore new avenues in her fundamental research.
- **Serious games for police officers**
  Supported by an NWO grant worth over €750,000, Donders researchers Karin Roelofs, Isabela Granic and Floris Klumpers will develop a game to train police officers to respond optimally when under stress.
- **Barbara Franke elected as a member of KNAW**
  Professor Barbara Franke has been elected to join the KNAW as well as the Netherlands' oldest society of scholars: the Royal Holland Society of Sciences and Humanities.

SOME RECENT HIGH-IMPACT PUBLICATIONS

- **Super-sized memory is trainable and long lasting**
  Researchers at the Donders Institute and Radboudumc have discovered that feats of memory, such as remembering lists of several dozen words, can be learned. *(Neuron)*
- **Handedness arises from genes in the spinal cord of embryos**
  An international team led by scientists at MPI and Donders Institute have shown that the left side of the spinal cord matures slightly faster than the right. This is the earliest left-right difference that has been discovered in the development of the human nervous system. *(Biological Psychiatry)*
- **Extra fibres in the diet reduce forgetfulness in mice**
  Ilse Arnoldussen and Amanda Kiliaan showed that by adding butyrate to the diet of obese mice they can recover from the memory impairment that is caused by fatty diets. *(International Journal of Obesity)*
- **Addicted individuals less responsive to reward anticipation**
  Arnt Schellekens and colleagues found that addicted individuals have difficulty learning when they can expect a reward, which could explain why they are more prone to addiction. *(JAMA Psychiatry)*

PhD defences

- 13 January 2017, DS. 252. **Wagner, I.**, On *memory organization: Imaging memory representations during encoding, consolidation and retrieval.*
- 24 January 2017, DS 259. **Schaapsmeerders, P.**, *Long-term cognitive impairment after first-ever ischemic stroke in young adults.*
- 7 February 2017, DS 264. **Miceli, S.**, *Modulation of barrel cortex microcircuitry by serotonin.*
- 10 February 2017, DS 253. **Emmanouel, A.**, *Look at the frontal side of life. Anterior brain pathology and everyday executive function.*
- 10 February 2017, DS 254. **Endedijk, H.**, *Peer interaction under construction.*
- 14 February 2017, DS 257. **Van Uden, I.**, *The behavorial consequences of cerebral small vessel disease. An MRI approach.*
- 16 February 2017, DS 258. **Arntz, R.**, *The long-term risk of vascular disease and epilepsy after stroke in young adults.*
- 3 March 2017, DS 261. **Van Dijk, F.**, *Symptomatic overlap between ADHD and Borderline Personality Disorder: The role of temperament, personality and cognition.*
- 16 March 2017, DS 268. **Wiesmann, M.**, *Vascular risk factors and Alzheimer's disease. Therapeutic approaches in mouse models.*
- 20 March 2017, DS 277. **Ba, W.**, *Mind the GAPs (and GEFs)! Rho GTPase signalling in excitatory synapse development and intellectual disability.*
- 22 March 2017, DS 250. **Albers, A.**, *On mental images in the early visual cortex.*
- 29 March 2017, DS 269. **Vanlangendonck, F.**, *Finding common ground: On the neural mechanisms of communicative language production.*
- 5 April 2017, DS 266. **Van der Holst, E.**, *Mind the step in cerebral small vessel disease. Brain changes in motor performance.*
- 10 April 2017, DS 272. **Gong, X.**, *Cognition and emotions in social interactions.*
- 18 April 2017, DS 278. **Rijpma, A.**, *Multi-nutrient interventions and brain metabolism in Alzheimer's disease: A spectrum of effects.*
- 4 May 2017, DS 275. **Geurts, D.**, *Translational Psychiatry: When affect motivates effect.*
- 8 May 2017, DS 265. **Bloemendaal, M.**, *Neural mechanisms of cognitive control: modulation by age and dopamine.*
- 11 May 2017, DS 283. **De Voogd, L.**, *Do you remember what you did last summer? On the formation and alteration of memories for stressful experiences.*
- 12 May 2017, DS 263. **Van Aken, L.**, *The relationship between intelligence and executive function: Understanding theory in clinical practice.*
- 15 May 2017, DS 267. **Smeets, K.**, *Subtyping aggression and predicting cognitive behavioral treatment response in adolescents. What works for whom?*
- 22 May 2017, DS 270. **Janssen, M.**, *Cognitive assessment, wellbeing and brain correlates in HIV-infected patients on cART.*
- 23 May 2017, DS 280. **Benevento, M.**, *The epigenetic role of the Kleefstra syndrome protein EHMT1 in synaptic scaling and in cognition.*
- 1 June 2017, DS 276. **De Werd, M.**, *Errorless learning in dementia.*
- 2 June 2017, DS 273. **De Boer, M.**, *Between the lines: A study into the cognitive, neural and endocrine underpinnings of generating communicative behaviours.*
- 8 June 2017, DS 262. **Janssen, L.**, *Breaking bad habits – A meditation on the neurocognitive mechanisms of* compulsive behaviour.
- 19 June 2017, DS 271. **Smeijers, D.**, *Severe aggressive behaviour: Towards understanding some of the underlying characteristics and treatment responsivity.*

DONDERS LECTURE 28 SEPTEMBER 2017

Predicting, perceiving and learning spoken words

What is going on in your brain right now, while you are understanding language? That is what language researcher Matt Davis from the MRC Cognition and Brain Sciences Unit (MRC-CBU) aims to understand. He heads the Hearing and Language Group at the MRC-CBU in Cambridge, England, and will give the Donders Lecture in September 2017. James McQueen, Professor of Speech and Learning at Radboud University, will be hosting Davis during his stay in Nijmegen. Both are interested in questions such as what changes in your brain when you learn new words and their meanings.

McQueen: "Our research overlaps quite a bit, but Matt does more neuroscience than I do, to put it bluntly. A lot of his work involves fMRI and other types of imaging, while I focus more on the behavioral aspects of language processing."

Davis publishes on a variety of topics, from speech perception by humans and machines to phonological processing and short-term memory. In a recent *PNAS* article on the processing of acoustically degraded speech, he explains how a commonly used training method – using written subtitles – helps people with cochlear implants to understand speech.

"Matt started working on prediction in speech processing relatively recently. I hope he will talk about prediction during his lecture," says McQueen. "His work is very interesting, also for researchers who do not work on language, because it shows how adaptive we humans are to our environment. It should be valuable for everyone, because he uses advanced cognitive neuroscience to ask key questions about the nature of perception and cognition."

This Donders Lecture takes place at the Linnaeus building (lecture hall LIN3) on the Radboud University campus, Heyendaalseweg 137, Nijmegen, at 4.00 p.m. The last speaker of the 2017 series will be Thomas Inseln from Verily Life Sciences on November 2, who is collaborating with the Donders Institute and ParkinsonNet on the new Personalized Parkinson Project.

Iris Kruijen

RADBOUD SCIENTISTS RECEIVE 'MEMPRIZE'

Nijmegen researchers, including five (former) scientists at the Donders Institute, were declared the winners of the first international Memrise prize in March 2017. Memrise is a language learning platform aiming to make language learning recreational. The competition, which was established to find the world's most effective vocabulary learning technique, included teams from MIT (US) and the University of Oxford (UK). The winning method was based on a clever combination of techniques derived from research on memory and learning that were contributed by the various experts in the team. The Nijmegen researchers won the prize after more than a year of in-depth real-life empirical experiments carried out by Memrise and involving more than 10,000 participants. The participants found the winning method both the most effective and the most enjoyable of all the submissions.

Many interviews followed, including with The Guardian, Volkskrant, NRC Handelsblad, and on Dutch television. Besides media attention, the team regularly receives requests for help or collaboration from high schools and education professionals. Overall, this was an innovative collaborative effort between scientists contributing a range of expertise that has the potential to lead to both new scientific insights *and* valorisation. Congratulations to the whole team!

The winning team (from left to right): Paul Konstantin Gerke, Nils Müller, Anke Marit Albers, Boris Konrad, Gesa van den Broek, Ruud Berkers, and Marlieke van Kesteren. Paul works at Radboudumc and Gesa at the Behavioural Science Institute. All others are (former) Donders researchers.

THE MACHINE

Meet Pepper, the Donders Institute's new humanoid robot

Donders welcomed a new recruit last December: the humanoid robot Pepper. Weighing in at 28 kilograms and 120 centimetres long, it has the ability to move around at a maximum speed of three kilometres per hour. Pepper can both recognise and express emotions such as happiness and sadness, and it can recognise and react to speech. It also has tactile sensors in its head, enabling it to react to touch.

Beata Grzyb, a researcher in cognitive robotics explains: "Pepper is being prepared to work as a sign language tutor. We've already implemented a small subset of signs into the robot, all related to time like the signs for evening, weekend, Christmas, and months of the year. Does Pepper have advantages as a tutor, compared to other sign language learning techniques? Experiments started in May 2017.

Another project that started involves trials on trust. Presumably, people feel more comfortable around smaller robots as they are less intimidating than Pepper. On the other hand, Pepper might be easier to interact with because it is bigger. Beata Grzyb and her colleagues will be comparing the interactions with Pepper with the way test subjects respond to the much smaller NAO robots, to see if they can detect differences. "Since we're really not sure what to expect, I'm looking forward to the first results."

Later this year, two new PhD projects using Pepper will commence. One will be investigating the predictive processing of new skills in babies and robots, in collaboration with Sabine Hunnius (Baby Research Centre) and Johan van Kwisthout (Computational Cognitive Science). The other project, in collaboration with Donders researchers Pim Haselager and Marcel van Gerven, focuses on deep learning networks. Could these networks be expanded to process affective information about emotions and personality traits, for example? Affective computation is an essential ingredient for meaningful human-robot interaction and therefore an important goal in research in artificial intelligence.

Pepper is also being used for various outreach projects, like lab tours for primary school children. "People love interacting with Pepper," Beata concludes, foreseeing a lively future for the robot within the Institute.

Iris Kruijen

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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