MAX PLANCK INSTITUTE
FOR PSYCHOLINGUISTICS

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RESEARCH REPORT 2017 | 2018

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MAX PLANCK

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The current board of directors (left to right):
Caroline Rowland (Managing Director), Peter Hagoort, Laura Manko (COO), Antje Meyer, Simon Fisher.

PREFACE

Language plays too central a role in human affairs to be the prerogative of any single discipline. Since its creation in 1980, the Max Planck Institute has been at the forefront of interdisciplinary research into the foundations of language and communication. The research conducted here combines perspectives from disciplines as diverse as linguistics, psychology, neuroscience, genetics, anthropology, informatics, medicine and acoustics. We investigate how children and adults acquire their language(s), how speaking and listening happen in real time, how the brain processes language, how the human genome contributes to building a language-ready brain, and how language is related to cognition and culture, and shaped by evolution. Our approach to the science of language and communication is unique because we address these fundamental issues at multiple levels, from molecules and cells, to circuits and brains, all the way through to the behaviour of individuals and populations.

This report demonstrates the value of such an integrated strategy, providing some highlights of our work in 2017 and 2018. For interested readers who want to learn more about the research, details can be found in the news archives, on the departmental pages and blogs of our website (www.mpi.nl), as well as in the many primary publications, review articles, chapters, books and PhD dissertations that we have produced during this time.

The years 2017-2018 have witnessed major changes at the Institute. December 2017 saw the retirement of Stephen Levinson, who had headed up the Language and Cognition Department since 1991. The work of Levinson and his department over the last 30 years has had a critical effect on the way we understand language, linguistic diversity, and the effect of language on human cognition. His ground-breaking research on language and space, much of it conducted with his colleagues Penny Brown and the sadly missed Melissa Bowerman, transformed our understanding of the effect of language on thought, by showing that the spatial system of a person's language affected how they conceptualised space in the world. Levinson's department has also played a pioneering role in language documentation, providing important records of many of the world's most endangered languages. In recent years, Levinson and his colleagues worked on the cultural diversity of conceptual structure and the study of universals and cultural specialisations in verbal interaction. We are pleased to include here the final report of the Language and Cognition department.

There have been other, happier, changes too. The Language Development department, which opened in September 2016, now houses nearly 40 research and research support staff, students, student assistants and trainees, and a brand-new child language lab including a state-of the art observation suite, and static and mobile eyetracking equipment. A new EEG suite and an experiment van will arrive in 2019. At the same time we were pleased to welcome Laura Manko as our Chief Operating Officer (COO). Laura has quickly become an invaluable member of our Institute management team.

The Institute's relationship with the non-academic world has also experienced a significant change. Modern society hinges on the ability to communicate using language, yet society faces many communication challenges, from questions about how to integrate the children of immigrants into Dutch society, to questions about how best to help people recover after stroke. In recognition of the fact that our work on language has important implications for society, the Institute held the inaugural meeting of our Kuratorium (Board of Trustees) in 2016. The establishment of the Kuratorium is an important new initiative, designed to be a bridge between the scientists at the Institute and the wider society, promoting interactions with the public, acting as ambassadors for our research and advising us on issues of social concern. Our Kuratorium has already provided important insight and advice, and we are excited to be working closely with them, and with our new Senior Communications Advisor, Marjolein Scherphuis, over the next few years.

And finally, in 2017 the Institute received an important addition to its library collection – the Bruner Library. Jerome Bruner, who sadly died in 2016 at the age of 100, was an American psychologist who made a profound contribution to cognitive, developmental and educational psychology, as well as being a valuable friend to the Institute. His library contains some 3500 books; a fascinatingly rich collection of cognitive psychology, linguistics, psycholinguistics, developmental and educational psychology, anthropology, and philosophy, reflecting Bruner's own great intellectual breadth. We are very pleased to have been given the opportunity to preserve the Jerome Bruner collection in its entirety, and make it accessible to the scientific world. The collection will open in late 2019.

This is an exciting time for the language sciences. Substantive changes in technology have opened up new areas of research that were not even on the horizon 20 years ago, techniques that allow us to detect how a newborn baby interprets the speech she hears, that allow us to investigate how humans communicate in virtual reality environments, and that enable us to grow networks of neurons in the lab to investigate the effect of different genes on brain development. We hope that the pages that follow will give you an impression of what we have achieved in 2017 and 2018.

Caroline Rowland
Managing Director

OPENING **COMMON GROUND**

In June 2017 we opened our new meeting space, the Common Ground, a place for MPI students and staff to meet, discuss, and debate, or just read or think quietly by themselves. The name is purposefully chosen; in linguistics, common ground refers to the pragmatic language skill in which speakers expertly modify the contents of their speech based on their listeners' perceived understanding; adjusting their language, moment by moment, to reflect the background knowledge they share with their listener.

RETIREMENT **STEPHEN LEVINSON**

December 2017 saw the retirement of Stephen Levinson, who had headed up the Language and Cognition Department since 1991. The event was celebrated with current and former students and staff, who gave talks highlighting Levinson's substantial contribution to linguistics, and the unexpected appearance of a crocodile, to symbolise Levinson's adventurous life around the globe.

OPENING **LADD LABS**

The Language Development department celebrated the official opening of its new labs in March 2018. The labs, based at the MPI, form part of the Baby and Child Research Centre, a public-facing collaboration between MPI and Radboud University, and augment the equipment already available at Radboud University, and the Donders Centre for Cognitive Neuroimaging. They house a state-of the art observation suite, and static and mobile eyetracking equipment, with a new EEG suite and an experiment van arriving in late 2019.

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2017 | 2018

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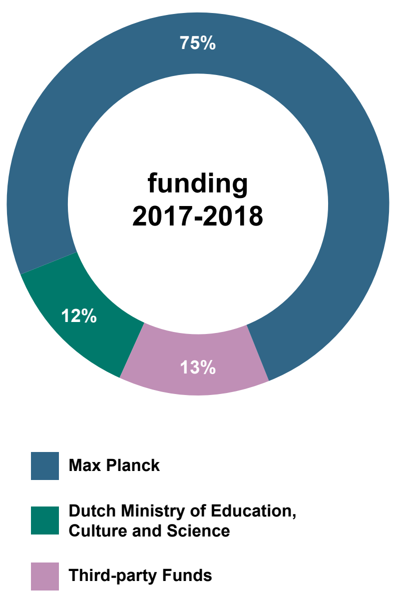
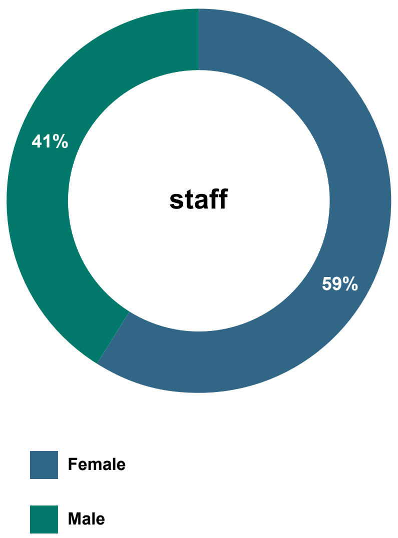
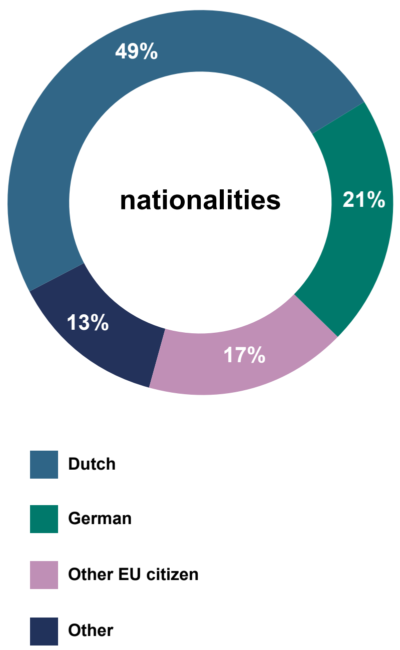






Board of Trustees
The Board of Trustees plays a valuable role at the interface between science and society, promoting interactions with the public, acting as ambassadors for our research and advising us on issues of social concern.

HONOURS AND AWARDS

2017
Linda Drijvers received a Christine Mohrmann Stipend from Radboud University. This stipend is awarded to promising female PhD candidates to pursue a career in academia after completing their PhD theses.

Judith Holler received a Consolidator Grant from the European Research Council (ERC) to investigate how bodily signals are used in conversation and influence how we understand language.

Stephen Levinson was elected an Honorary Member for life of the Linguistic Society of America.

David Peeters received a VENI award from the Netherlands Organisation for Scientific Research (NWO) for his project 'What are you talking about? Understanding reference in speech and gesture'.

2018
Mark Dingemanse received a VIDI award from the Netherlands Organisation for Scientific Research (NWO) for his project 'Elementary particles of conversation'.

Jolien Francken (MPI/DCCN) was awarded the Otto Hahn Medal from the Max Planck Society.

Peter Hagoort was elected as foreign associate of the US National Academy of Sciences (NAS) and as Fellow of the Cognitive Science Society.

Andrea Martin received a VIDI award from the Netherlands Organisation for Scientific Research (NWO) for her project 'Combining words during speaking and listening'.

Antje Meyer was elected as member of the Royal Netherlands Academy of Arts & Sciences (KNAW) and of Leopoldina, the German National Academy of Sciences.

Sebastian Sauppe was awarded the Otto Hahn Medal from the Max Planck Society.

Beate St Pourcain was awarded a grant from The Simons Foundation Autism Research Initiative (SFARI) to fund her project entitled: 'Disentangling autism heterogeneity through multivariate genetic analyses'.

Simon E. Fisher received an Enabling Technologies Hotel grant from ZonMw to fund a project investigating the neural basis of social vocalizations, together with Bernhard Englitz (U. Radboud), and a grant from the SETBP1 Society to investigate a neurodevelopmental syndrome involving expressive speech impairment and developmental delay, together with Bregje van Bon (Raboud UMC).

Simon E. Fisher was selected by the International Dyslexia Association to deliver the Norman Geschwind Memorial Lecture.

PHD COMPLETIONS

2017
Tulio Guadalupe The biology of variation in anatomical brain asymmetries

Richard Kunert Music and language comprehension in the brain

Nietzsche Lam Comprehending comprehension: Insights from neuronal oscillations on the neuronal basis of language

Lotte Schoot Language processing in a conversation context

Will Schuerman Sensorimotor experience in speech perception

Elizabeth Manrique Achieving mutual understanding in Argentine Sign Language (LSA)

Gwilywm Lockwood Talking sense: The behavioural and neural correlates of sound symbolism

Franziska Hartung Getting under your skin: The role of perspective and simulation of experience in narrative comprehension

Ashley Lewis Explorations of beta-band neural oscillations during language comprehension: Sentence processing and beyond

Evelien Heyselaar Influences on the magnitude of syntactic priming

Elliott Hoey Lapse organization in interaction

Cornelia Moers The neighbors will tell you what to expect: Effects of aging and predictability on language processing

Sebastian Sauppe The role of voice and word order in incremental sentence processing: Studies on sentence production and comprehension in Tagalog and German

2018
Vishnupriya Kolipakam A holistic approach to understanding pre-history

Sara Busquets Estruch Characterization of transcription factors in monogenic disorders of speech and language

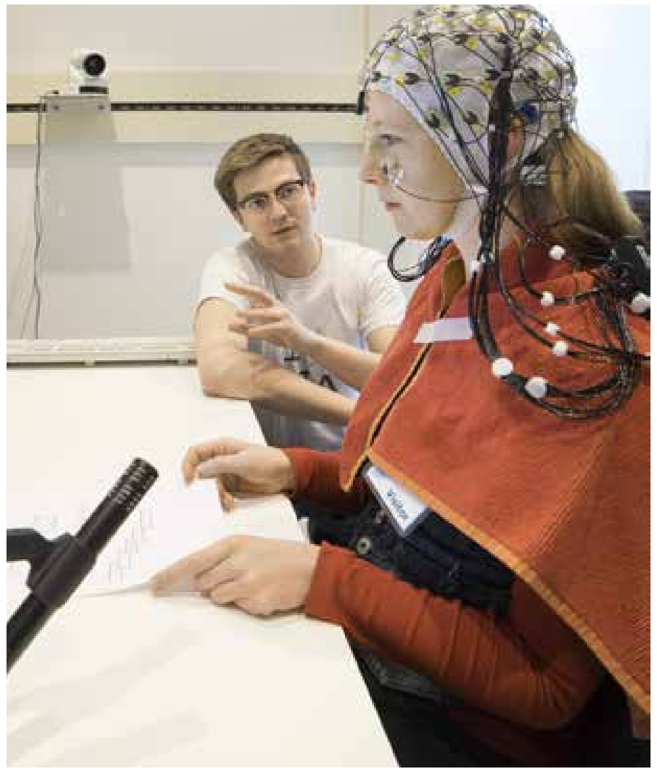
Johanne Tromp Indirect request comprehension in different contexts

Markus Ostarek Envisioning language: An exploration of perceptual processes in language comprehension

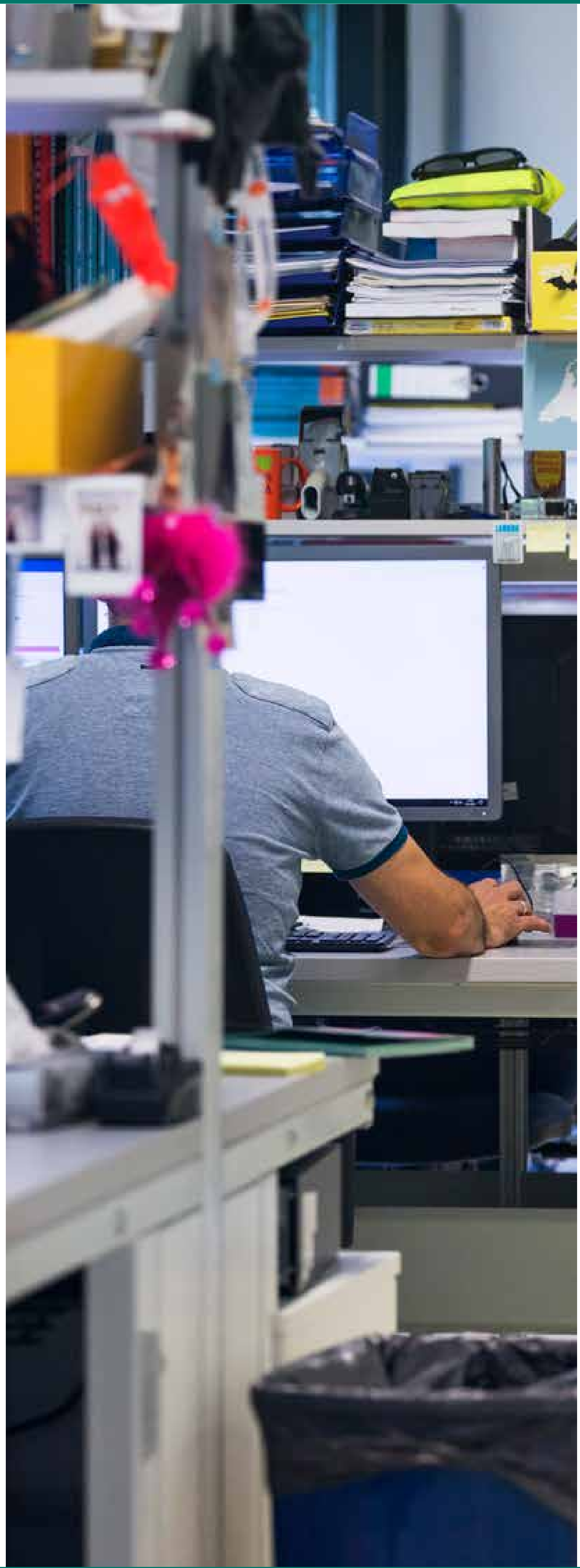
Rick Janssen Let the agents do the talking: On the influence of vocal tract anatomy on speech during ontogeny

Claire Hill Person reference and interaction in Umpila/Kuuku Ya'u narrative

Nina Mainz Vocabulary knowledge and learning: Individual differences in adult native speakers



Gwilywm Lockwood working with an EEG participant.



ACRONYMS

BOLD	blood oxygen level dependent
DOBES	dokumentation bedroter sprachen
EEG	electroencephalography
EPI	echo-planar imaging
ERP	event-related potential
fMRI	functional magnetic resonance imaging
fROI	functional region of interest
GWDG	gesellschaft für wissenschaftliche datenverarbeitung
HMD	head-mounted display
HPC	high performance computing/cluster
MEG	magnetoencephalography
TMS	transcranial magnetic stimulation
VR	virtual reality

DEPARTMENT
LANGUAGE AND COGNITION

Director Stephen C. Levinson
Department members Julija Baranova, Sara Bögels, Marisa Casillas, Ludy Cilissen, Mark Dingemanse, Elma Hilbrink, Paul Hoemke, Judith Holler, Kobin Kendrick, Tayo Neumann, Sean Roberts, Sebastian Sauppe, Gunter Senft, Sylvia Tufvesson, Emma Valtersson, Connie de Vos

This is the final report from the Department, as the head Stephen Levinson retired at the end of 2017. The department had a number of missions, but in recent years concentrated on two main topics – the cultural diversity of conceptual structure and the study of universals and cultural specialisations in verbal interaction. Here we report on two recent studies that reflect these research priorities.

Language and perception: Culture shapes how we talk about the senses

Ever since Aristotle, it has been assumed that the senses can be ordered hierarchically from higher senses more accessible to language (sight, hearing) to lower ones that are more ineffable (touch, taste, and smell). The expectation has thus been that communicating about colours and shapes would be easier than about tastes and textures, but our recent study (Majid et al. 2018) has now shown that this depends on the surrounding culture. A team of 26 scientists carried out fieldwork in 20 places across the globe, as shown in Figure 1, where they investigated 17 spoken languages and 3 signed languages. Every researcher used the same set of stimuli for colours, shapes, textures, sounds, smells and tastes. Prior research has shown that English speakers find it easy to talk about the things that they can see, such as colours and shapes, but struggle to name the things that they smell. If this commonly accepted hierarchy of accessibility to language is universally true, participants from all cultures should have been able to communicate about vision most easily, followed by sounds, such as loud and quiet; textures, such as smooth and rough; taste, such as sweet and sour; and smell, such as chocolate and coffee. That turned out not to be the case. For instance, speakers of Farsi and Lao could easily communicate about basic tastes, which turned out to be much harder for English speakers. Conversely, speakers of Kilivila and Yélî Dnye found it hard to communicate about colours, which are highly codable in English and Malay (see Figure 2 for a summary of the findings). The study suggests that the accessibility to language of distinct perceptual domains is dependent on culture and language history.

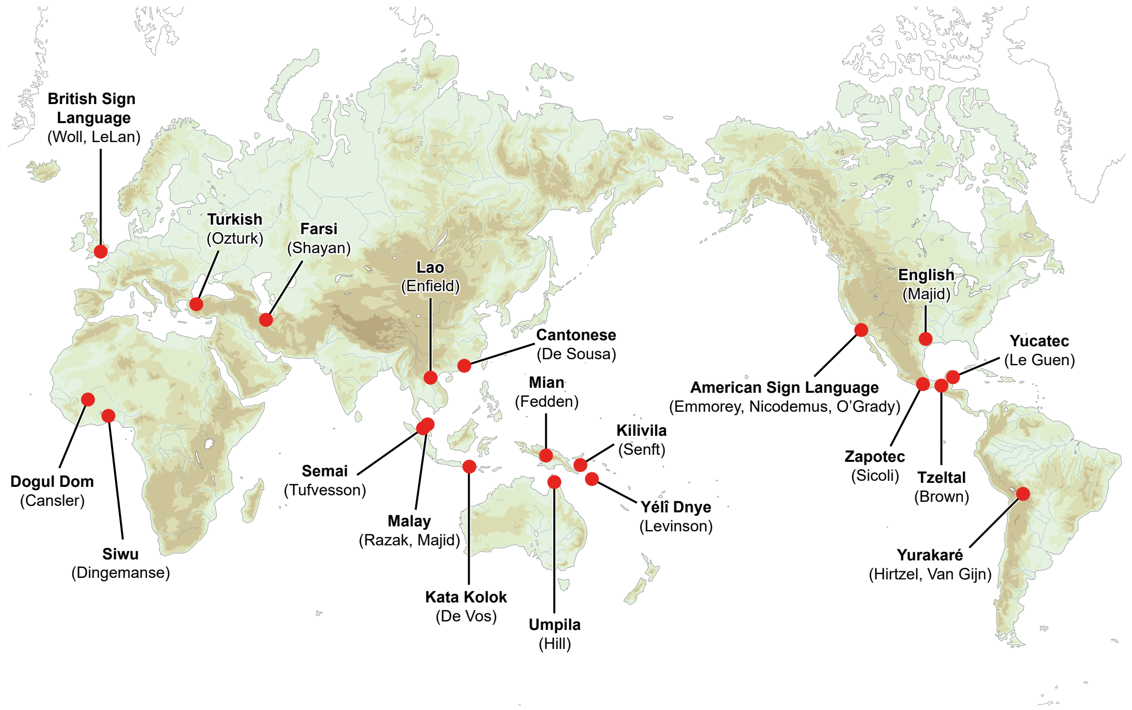


Figure 1. Languages and cultures investigated in the language and perception study.

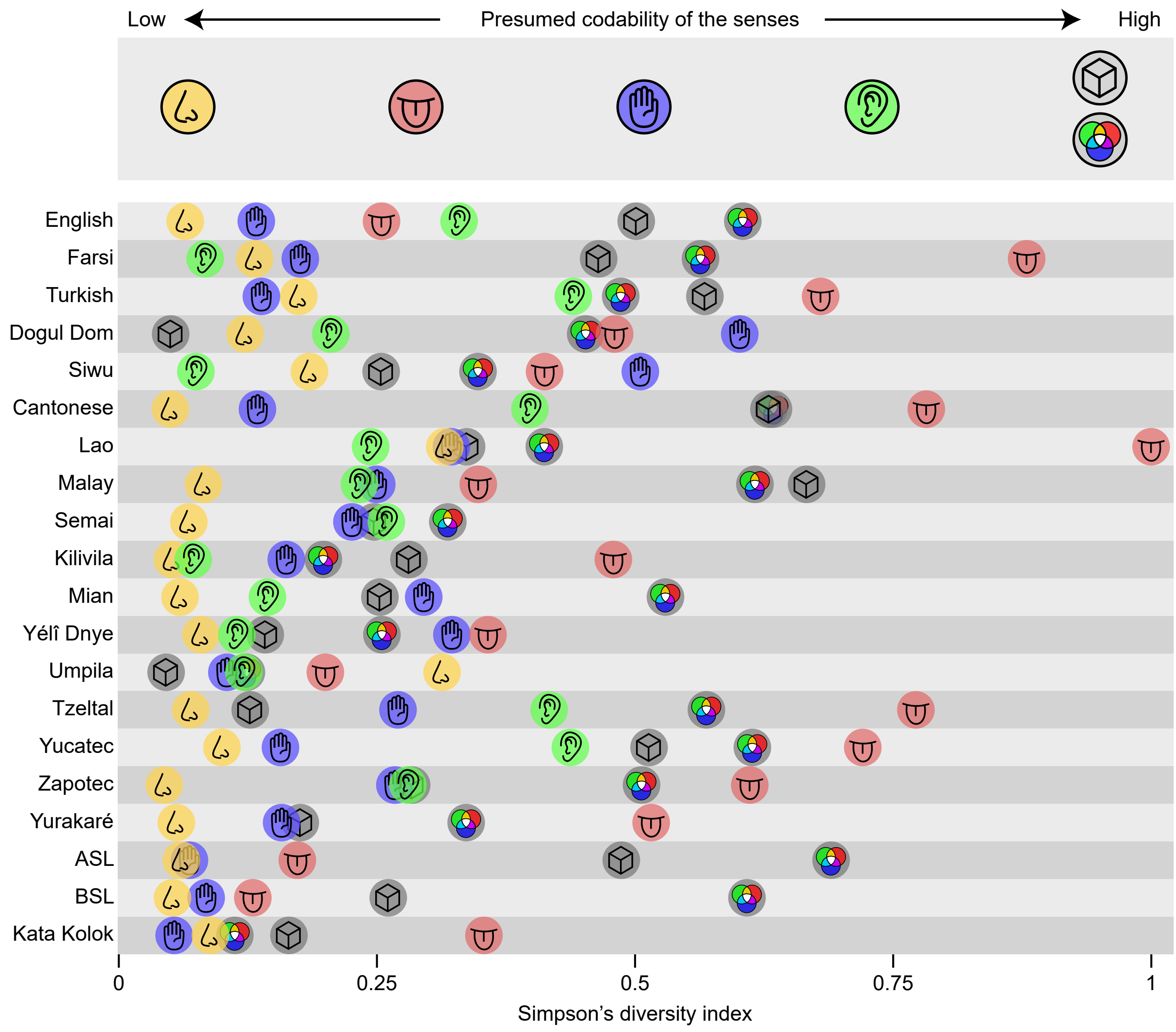


Figure 2. The hierarchy of the senses in a cross-cultural perspective.
The Aristotelian hierarchy is given at the top, while the divergence of different languages is clearly visible (Simpson's diversity index is used as a measure of coding agreement within each language community).

DEPARTMENT
LANGUAGE AND COGNITION

Language and social interaction: Gratitude goes without saying
Doing things for and with others is one of the foundations of human social life. Language plays a crucial role in this by helping us to organise assistance and collaboration. New research in eight societies around the world found two key things: (i) requests are usually complied with; (ii) counterintuitively, people hardly ever say thanks as a result (Figure 3). Rather than implying that people are universally rude, the discovery reveals a cooperative stance in human affairs: social life thrives because it is in our nature to ask for help and to pay back in kind, rather than just in words.

The researchers studied everyday social interaction in eight languages around the globe, collecting over a thousand instances of simple requests and tracking their fulfilment and aftermath. They found that everywhere, people were much more likely to comply than decline (at a rate of seven to one), but that overall, thanks were given only one out of fifty times. Even in societies where children are aggressively taught to say 'thank you' (e.g., English or Italian children) the rate of 'thank you's was very low in informal interaction (only one out of seven times). This shows that in human interaction around the world, there is literally an unspoken agreement that people will cooperate.

The research has also shown that several languages in the sample did not have a word for 'thank you', and more generally reserved expressions of gratitude only for very special situations when people go beyond the normal call of duty. Many of the world's languages are spoken in close-knit communities that allow people to cooperate and reciprocate without ever needing to say thanks. So the universal tendency for social reciprocity should not be equated with more culturally variable practices of expressing gratitude: actions speak louder than words.

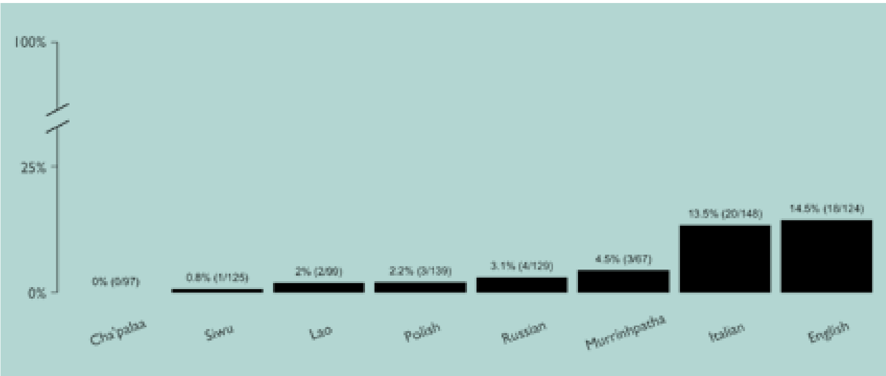


Figure 3. Rates of verbal acknowledgements like 'thank you' across cultures.

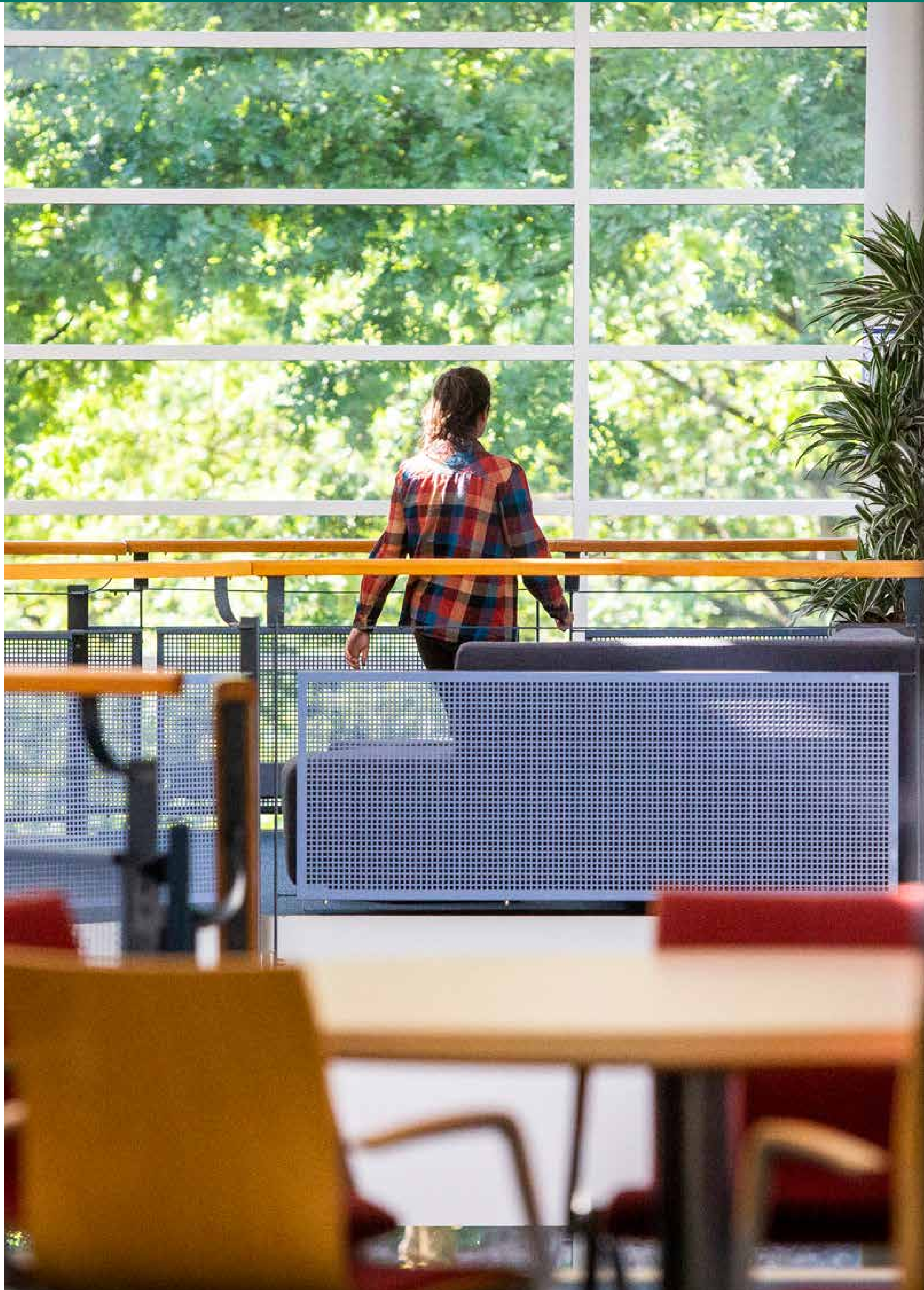
Selected publications

Floyd, S., Rossi, G., Baranova, J., Blythe, J., Dingemanse, M., Kendrick, K. H., Zinken, J., & Enfield, N. J. (2018). Universals and cultural diversity in the expression of gratitude. *Royal Society Open Science*, 5, 180391. doi:10.1098/rsos.180391.

Levinson, S. C., Cutfield, S., Dunn, M., Enfield, N. J., & Meira, S. (Eds.). (2018). *Demonstratives in cross-linguistic perspective.* Cambridge: Cambridge University Press.

Majid, A., Roberts, S. G., Cilissen, L., Emmorey, K., Nicodemus, B., O'Grady, L., Woll, B., LeLan, B., De Sousa, H., Cansler, B. L., Shayan, S., De Vos, C., Senft, G., Enfield, N. J., Razak, R. A., Fedden, S., Tufvesson, S., Dingemanse, M., Ozturk, O., Brown, P., Hill, C., Le Guen, O., Hirtzel, V., Van Gijn, R., Sicoli, M. A., & Levinson, S.C. (2018). Differential coding of perception in the world's languages. *Proceedings of the National Academy of Sciences of the United States of America*, 115(45), 11369-11376. doi:10.1073/pnas.1720419115.

Sauppe, S. (2017). Symmetrical and asymmetrical voice systems and processing load: Pupillometric evidence from sentence production in Tagalog and German. *Language*, 93(2), 288-313. doi:10.1353/lan.2017.0015.



DEPARTMENT **LANGUAGE AND GENETICS**

Director Simon E. Fisher
Department members Jasper Bok, Jelle de Boer, Amaia Carrión Castillo, Lara Clauss, Dan Dediu, Pelagia Deriziotis, Karthikeyan Devaraju, Else Eising, Clyde Francks, Margot Gerritse, Tulio Guadalupe, Jurgen Heijsen, Fabian Heim, Joery den Hoed, Rick Janssen, Tulya Kavaklioglu, Xiangzhen Kong, Carolien de Kovel, Grazia di Pisa, Merel Postema, Pauline Roost, Beate St Pourcain, Fenja Schlag, Ulrike Schnell, Janna Schulze, Chin Yang Shapland, Cleo Smeets, Lot Snijders Blok, Elliot Sollis, Amanda Tilot, Ellen Verhoef, Arianna Vino, Maggie Wong

Goals of the Department
Human children have an unparalleled capacity to acquire sophisticated speech and language skills. Despite the huge complexity of this task, most children learn their native languages almost effortlessly and do not need formal teaching to achieve a rich linguistic repertoire. The Language and Genetics Department was established in 2010 with the goal of shedding new light on this enigma. We adopt the latest innovations in molecular methods to discover how your genome helps you speak. Our work identifies genes that are important for the development of speech, language, reading and social communication, and uses those genes as windows into the key neural pathways. Success depends on interdisciplinary research at multiple levels, from determining molecular interactions and functional roles in neural cell-biology to effects on brain structure and activity. We go further to ask how genes may help to explain both the evolution and variability of human language.

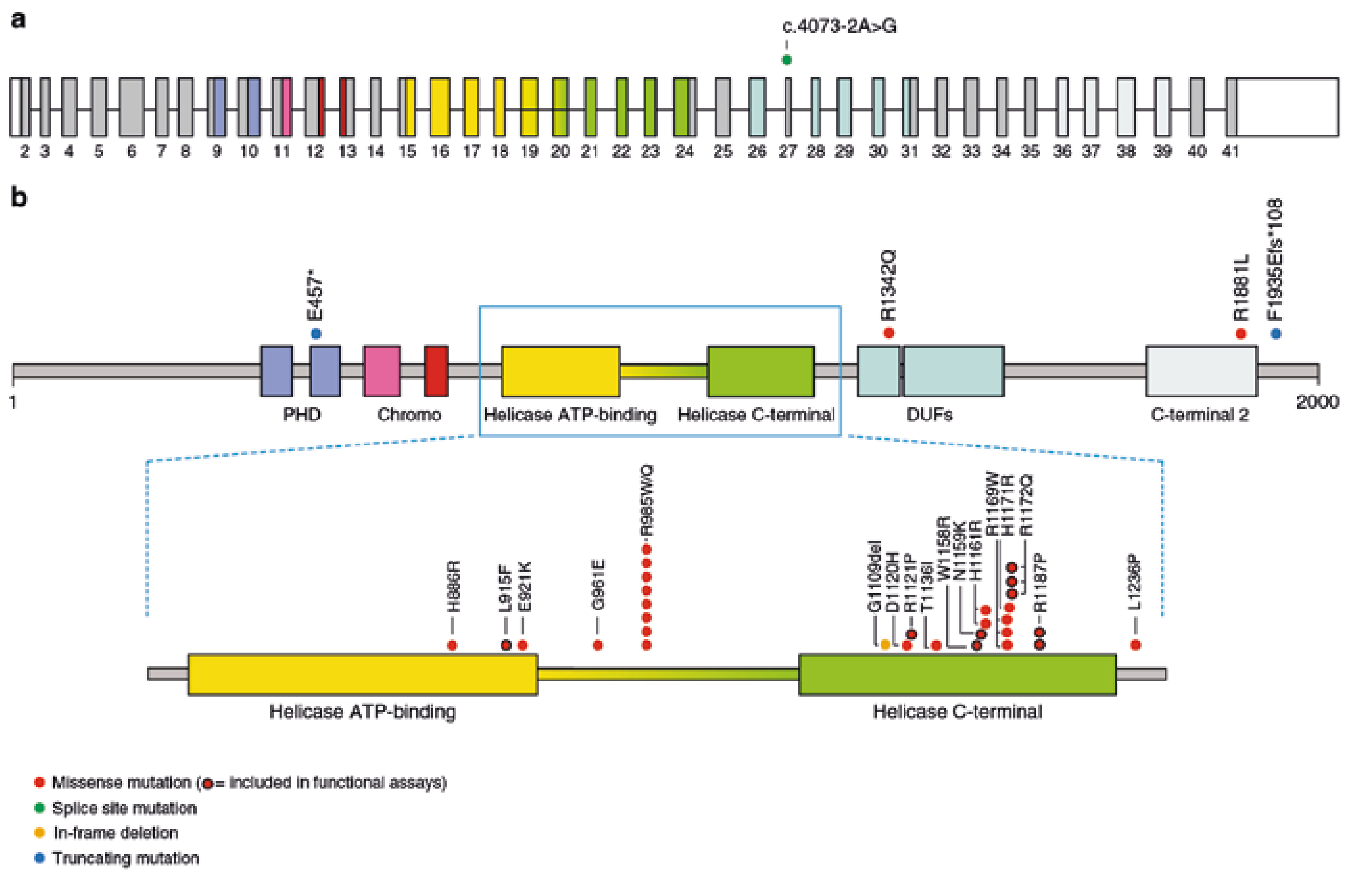


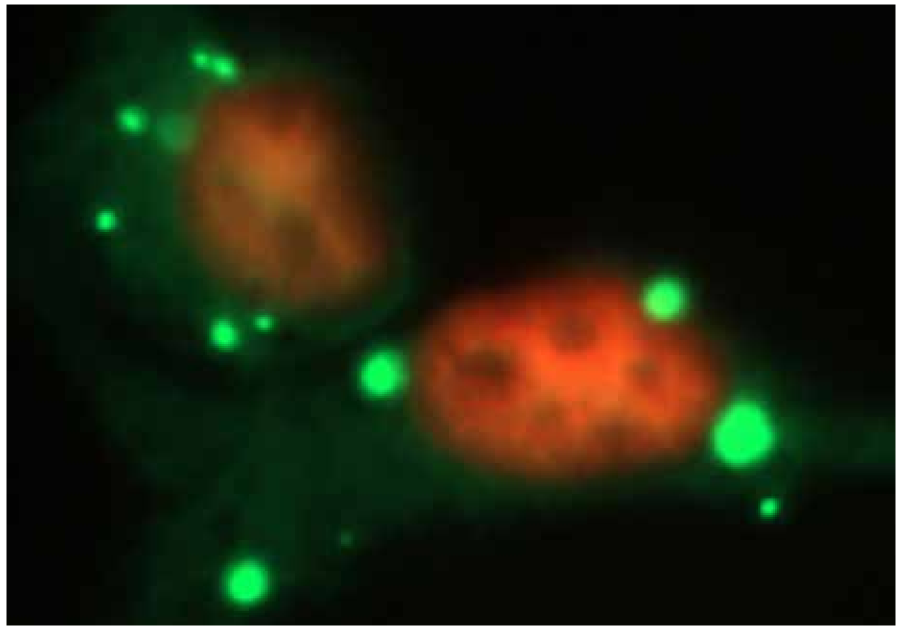
Figure 1. Schematic view of CHD3 transcript and protein indicating de novo mutations found in 35 cases of disorder. Five different types of domains are specified: plant homeodomains (PHD), chromodomains (Chromo), a Helicase domain consisting of two parts (Helicase ATP-binding and Helicase C-terminal), domains of unknown function (DUF), and a C-terminal 2 domain. (A) CHD3 exons with location of a splice site mutation indicated. (B) Linearised CHD3 protein with all other mutations indicated. Almost all missense mutations cluster in or around the Helicase domain of the protein.

Mutations of regulatory genes disrupt speech development
It is more than 15 years since rare mutations in the *FOXP2* gene were first implicated in childhood apraxia of speech, a developmental disorder characterised by difficulties with automatically and accurately sequencing speech sounds into syllables, syllables into words, and words into sentences with correct prosody. Investigations of *FOXP2* function have opened up novel avenues for understanding the neurobiological underpinnings of human speech. Nonetheless, disruptions of this gene account for only a small proportion of cases of disorder. Together with expert speech pathologists from the USA and Australia, Eising and colleagues performed whole genome sequencing in 19 unrelated children with severe speech apraxia. In almost half of the children, they identified distinct disruptive mutations of potentially large effect, affecting genes such as *CHD3, SETD1A, WDR5, KAT6A, SETBP1, ZFHX4, TNRC6B* and *MKL2*. The researchers went on to show that the genes belonged to a shared molecular network, active in the human brain during embryogenesis.

The value of these genome sequencing studies is illustrated by follow-up work on *CHD3* mutations, led by Snijders Blok in collaboration with the Radboud University Medical Centre (Radboudumc) in Nijmegen and researchers in Canada and the USA. Through international networks of clinical geneticists, the team identified 35 unrelated individuals carrying mutations that disrupted *CHD3* (Figure 1). Each mutation was 'de novo', a newly arising gene variant present in the affected person but not found in her/his parents. All cases had developmental delays and/or intellectual disability, although there was a high degree of variability in severity. Many had unusually large heads, along with characteristic facial features. A prior study identified interactions between the proteins encoded by *CHD3* and *FOXP2*. Speech capacities of individuals with de novo *CHD3* mutations were more affected than expected based on general cognitive performance. The protein encoded by *CHD3* regulates activities of other genes in the developing nervous system. Laboratory experiments were performed to test the impact of a selection of the mutations on the way the protein works. Most mutations clearly affected its capacity to modulate gene expression. Researchers in the department are currently using human neuronal cell models and brain organoids to discover more about the functional effects of mutations disrupting *CHD3*, *FOXP2* and other genes of interest.

Understanding developmental changes in genetic architecture
Beyond the impact of rare mutations on severe disorders, the department investigates genetic contributions to a range of skills related to language and communication in large epidemiological samples from the general population, comprising thousands of unrelated participants. As well as being assessed on behavioural and cognitive measures, the participants are characterised using DNA chips that assess hundreds of thousands of variable genetic markers across the genome. With such cohorts it is possible to ask sophisticated questions about the genetic architecture underlying different traits, or similar traits measured at different ages. For example, St Pourcain and colleagues investigated quantitatively assessed social communication problems in approximately 5,500 individuals from a UK birth cohort (ALSPAC: Avon Longitudinal Study of Parents and Children), studying longitudinal data from children aged 8 to 17 years of age. They adapted structural-equation modelling methods that are normally used to study twin samples, instead incorporating the genetic information available from the genome-wide DNA chips. The findings indicate that social communication behaviour is not genetically homogeneous through development, but rather that there are multiple genetic influences with differential effects at distinct stages of life. The St Pourcain group is applying these novel approaches to a range of social, reading and language traits.

A definitive map of asymmetry in the human brain
Left-right asymmetry is a fundamental property of the human brain, yet one that is poorly understood. Many cognitive processes are lateralised towards one side or the other. For example, in about 90% of people, the left hemisphere is dominant for language processing and



DEPARTMENT
LANGUAGE AND GENETICS

controlling hand movements. In healthy people, differences in brain structure for corresponding regions of the two hemispheres are detectable in post-mortem tissue or through magnetic resonance imaging (MRI), but these differences are subtle and difficult to study. Disturbed brain asymmetries have been reported in neurodevelopmental and psychiatric disorders, including dyslexia, language impairments, autism and schizophrenia, although such findings are typically based on small samples and independent replications are scarce.

Kong and Francks sought to develop a definitive atlas of structural asymmetries in the healthy human brain. Leading an international team of more than 270 scientists from 99 research groups, they analysed MRI scans of 17,141 participants across the lifespan (3-to-90 years), from diverse ethnic backgrounds. This work, carried out in the context of the ENIGMA (Enhancing Neuro Imaging Genetics through Meta-Analyses) consortium, represented the largest ever anatomical study of the cerebral cortex and its various subregions. The team found that brains of people from around the world, male or female, young and old, are asymmetrical on average. Compared to the right cortex, the left is relatively thicker at the front and thinner towards the back. On examining different regions, the researchers identified asymmetries of cortical thickness or surface area in the inferior frontal gyrus, transverse temporal gyrus, parahippocampal gyrus, and entorhinal cortex. Intriguingly, these regions have been linked to lateralised functions, including language processing and the perception and memory of spatial relationships.

While interindividual variability in brain asymmetries was subtly related to sex and age, there was no significant connection to handedness. The researchers found that variation between people is partly explained by genetic factors, opening up the possibility of future studies defining the molecular networks involved.
The results provide the field with an invaluable resource for investigating human brain anatomy in health and disease. Francks and his team are now working with ENIGMA on several large-scale studies to robustly establish whether altered asymmetries contribute to major brain-related disorders.

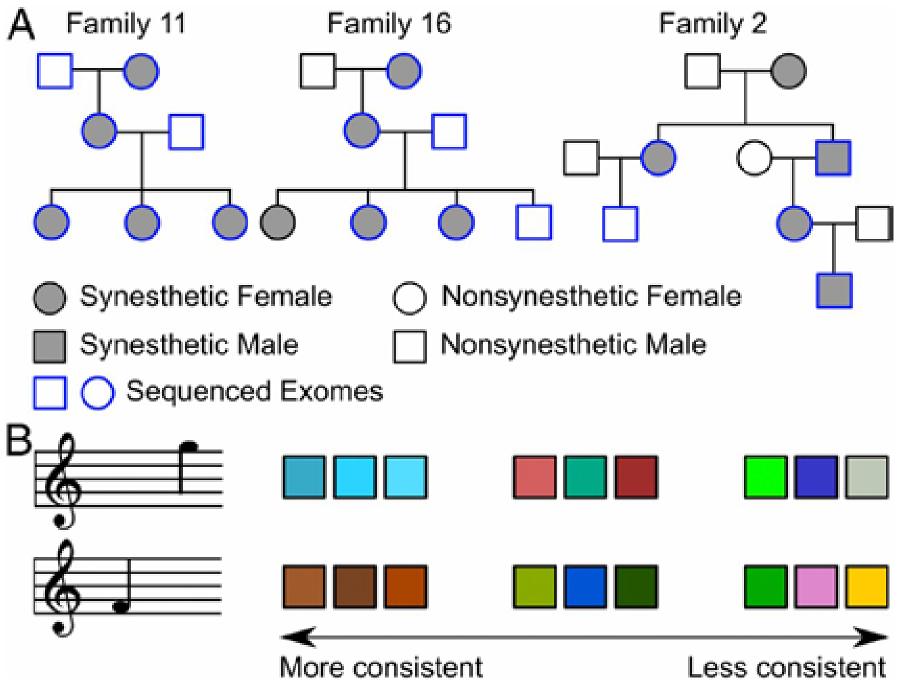


Figure 2. Sound-colour synaesthesia in three families. (A) Pedigrees of the families. Circles indicate females, squares refer to males, and gray shading indicates synaesthesia. Blue outlines show which members underwent next-generation DNA sequencing. (B) An illustration of sound-colour matching over three trials (coloured boxes) for three hypothetical individuals presented with two auditory stimuli. A synaesthete (boxes on the left) would show high consistency across trials, while a nonsynaesthete (boxes on the right) would be inconsistent in their colour choices.

Artwork by Alexandra Dima

Seeing sounds: uncovering molecular clues for synaesthesia
As many as 1 in 25 people have synaesthesia, a condition in which an experience with one sense automatically leads to perception in another. This kind of sensory cross-talk develops during early childhood and takes diverse forms: some people with synaesthesia see colours when listening to music, others experience taste sensations when reading particular words, and so on. Neuroimaging studies have compared synaesthetic adults to people who don't make these extra sensory associations, revealing slight differences in brain wiring. It has been known for well over a century that synaesthesia runs in families, suggesting a role for inherited factors. Still, the biology underlying this intriguing trait remains largely mysterious.

Tilot and colleagues applied the latest genomic methods to search for molecular genetic clues. Together with collaborators at Cambridge University, UK, they investigated three extended families in which multiple relatives, across several successive generations, experience colour when listening to sounds (Figure 2). Using next-generation sequencing, the researchers systematically identified and catalogued DNA variants in the family members, tracking how they were passed on from one generation to the next. In particular, they zeroed in on rare DNA changes that alter the way genes code for proteins, and that perfectly matched the inheritance of synaesthesia in each family.

Prior research had suggested that no single gene can by itself account for the condition, and that even families who experience the same type of synaesthesia are likely to differ in terms of specific genetic explanations. Against this background of genetic heterogeneity, the team aimed to identify shared molecular mechanisms that could give insights into relevant biological pathways. Indeed, while the highlighted DNA variants differed between the families, a common theme emerged to connect them: an enrichment for genes (including *ROBO3* and *SLIT2*) involved in axonogenesis and cell migration. Axonogenesis is a key process enabling brain cells to wire up to their correct partners. The results are consistent with a prominent account of synaesthesia neurobiology that hypothesizes a role for increased neural connectivity in the condition.

Selected publications

Eising, E., Carrion Castillo, A., Vino, A., Strand, E. A., Jakielski, K. J., Scerri, T. S., Hildebrand, M. S., Webster, R., Ma, A., Mazoyer, B., Francks, C., Bahlo, M., Scheffer, I. E., Morgan, A. T., Shriberg, L. D., & Fisher, S. E. (2018). A set of regulatory genes co-expressed in embryonic human brain is implicated in disrupted speech development. *Molecular Psychiatry*, Advance online publication. doi:10.1038/s41380-018-0020-x.

Kong, X., Mathias, S. R., Guadalupe, T., ENIGMA Laterality Working Group, Glahn, D. C., Franke, B., Crivello, F., Tzourio-Mazoyer, N., Fisher, S. E., Thompson, P. M., & Francks, C. (2018). Mapping cortical brain asymmetry in 17,141 healthy individuals worldwide via the ENIGMA consortium. *Proceedings of the National Academy of Sciences of the United States of America*, 115, E5154-E5163. doi:10.1073/pnas.1718418115.

Snijders Blok, L., Rousseau, J., Twist, J., Ehresmann, S., Takaku, M., Venselaar, H., Rodan, L. H., Nowak, C. B., Douglas, J., Swoboda, K. J., Steeves, M. A., Sahai, I., Stumpel, C. T. R. M., Stegmann, A. P. A., Wheeler, P., Willing, M., Fiala, E., Kochhar, A., Gibson, W. T., Cohen, A. S. A., Agbahovbe, R., Innes, A. M., Au, P. Y. B., Rankin, J., Anderson, I. J., Skinner, S. A., Louie, R. J., Warren, H. E., Afenjar, A., Keren, B., Nava, C., Buratti, J., Isapof, A., Rodriguez, D., Lewandowski, R., Propst, J., Van Essen, T., Choi, M., Lee, S., Chae, J. H., Price, S., Schnur, R. E., Douglas, G., Wentzensen, I. M., Zweier, C., Reis, A., Bialer, M. G., Moore, C., Koopmans, M., Brilstra, E. H., Monroe, G. R., Van Gassen, K. L. I., Van Binsbergen, E., Newbury-Ecob, R., Bownass, L., Bader, I., Mayr, J. A., Wortmann, S. B., Jakielski, K. J., Strand, E. A., Kloth, K., Bierhals, T., The DDD study, Roberts, J. D., Petrovich, R. M., Machida, S., Kurumizaka, H., Lelieveld, S., Pfundt, R., Jansen, S., Deriziotis, P., Faivre, L., Thevenon, J., Assoum, M., Shriberg, L., Kleefstra, T., Brunner, H. G., Wade, P. A., Fisher, S. E., & Campeau, P. M. (2018). CHD3 helicase domain mutations cause a neurodevelopmental syndrome with macrocephaly and impaired speech and language. *Nature Communications*, 9, 4619. doi:10.1038/s41467-018-06014-6.

St Pourcain, B., Eaves, L. J., Ring, S. M., Fisher, S. E., Medland, S., Evans, D. M., & Smith, G. D. (2018). Developmental changes within the genetic architecture of social communication behaviour: A multivariate study of genetic variance in unrelated individuals. *Biological Psychiatry*, 83, 598-606. doi:10.1016/j.biopsych.2017.09.020.

Tilot, A. K., Kucera, K. S., Vino, A., Asher, J. E., Baron-Cohen, S., & Fisher, S. E. (2018). Rare variants in axonogenesis genes connect three families with sound-color synesthesia. *Proceedings of the National Academy of Sciences of the United States of America*, 115, 3168-3173. doi:10.1073/pnas.1715492115.

DEPARTMENT
LANGUAGE DEVELOPMENT

Director Caroline Rowland
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Goals of the Department
Language is the most complex communication system in the known universe, yet children master it before they learn to tie their shoelaces. They learn to mimic the sounds of their language, to associate thousands of words with their meanings, to combine these words into long, grammatical sentences, and to use these sentences to convey complex messages about their world, their thoughts, their feelings and beliefs. The research of the Language Development Department (LaDD) is designed to discover how they achieve this. We build and test models of language acquisition that address the central question: How do the learning mechanisms in children's brains use information in their environment to build mature linguistic knowledge?

What predicts how quickly children learn words?
Children differ considerably in how, and how quickly, they learn language. However, this fact has traditionally been downplayed in research, so we know very little about why this is, or how early in life these differences emerge. In collaboration with the ARC CoEDL Centre in Australia, we are charting individual differences in children's language processing, acquisition, and input across the first years of life.

For example, an important skill in language acquisition is the ability to segment the speech stream into individual words. Infants are remarkably good at this, and can segment words out of continuous speech after only a few minutes of exposure, but some are better at it than others. Kidd and colleagues have recently reported that nine-month-old infants differ substantially in how their brains respond to the segmentation task, differences that predict later vocabulary size. They used an EEG machine to record the brain responses (ERPs) of 113 infants who were listening first to sentences containing target words (e.g. *he saw a wild eagle up there*), and then to either the same word (*eagle*) or a control word (*coral*) in isolation. Infants who later developed bigger vocabularies showed a more mature brain response to the target words (a relative negativity in left frontal quadrant of the brain), than those with smaller vocabularies (who showed an immature relative positivity). In addition, the size of the difference in ERP response to target and control words was associated with the child's vocabulary size three and six months later. In other words, some children start out with an advantage. As early as nine months of age, their brains are responding in a more mature way to the task of segmenting the input. In follow up work, the team is now investigating other precursor abilities to language development, including the speed with which children process speech.

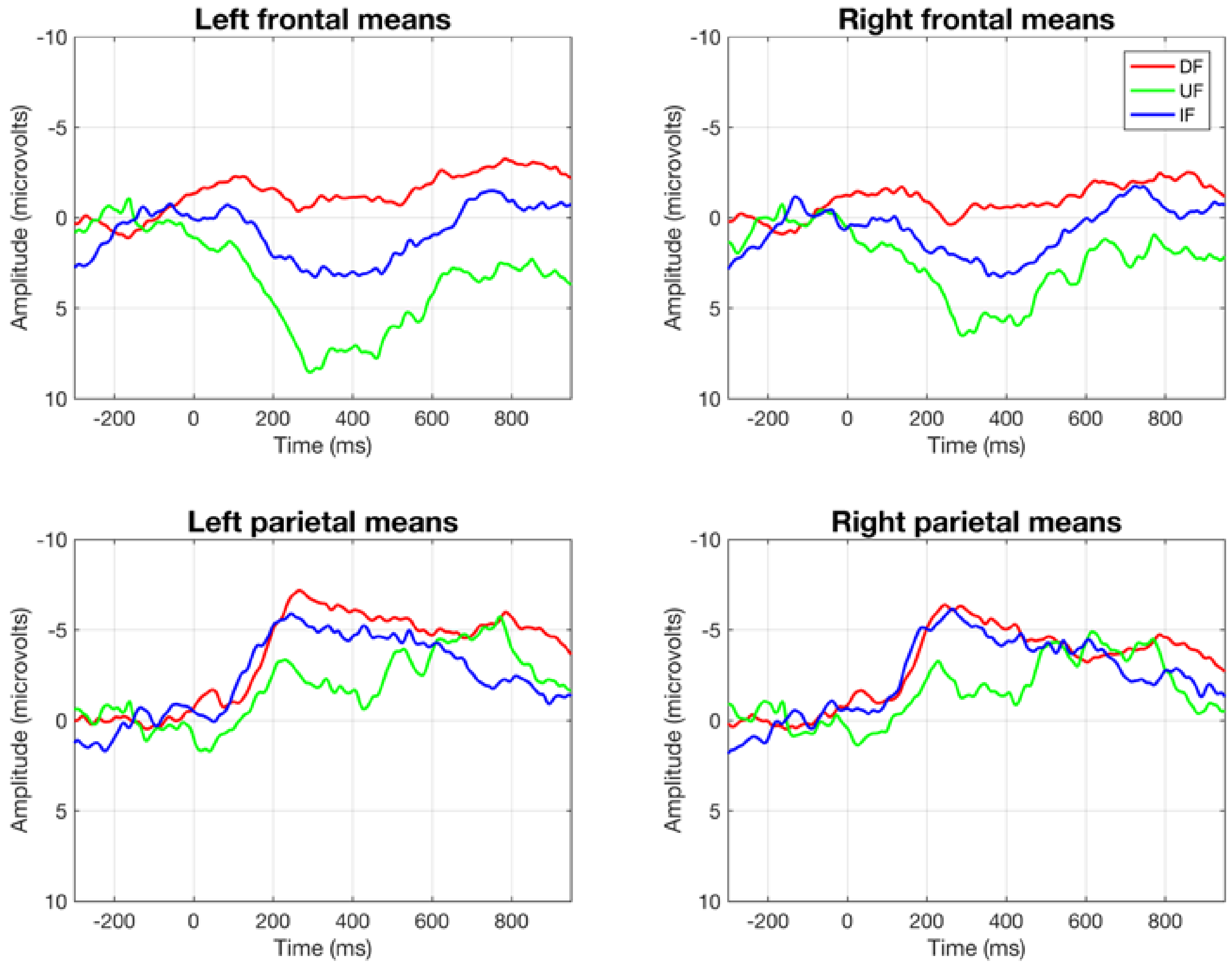

Figure 1. An ERP graph of the left frontal quadrant of the brain showing that infants can distinguish between words they have just heard (DF), words they heard about a minute ago (IF) and words they have never heard (UF). Reprinted from Kidd et al. (2018) with permission from the publishers, license number 4474200025117.

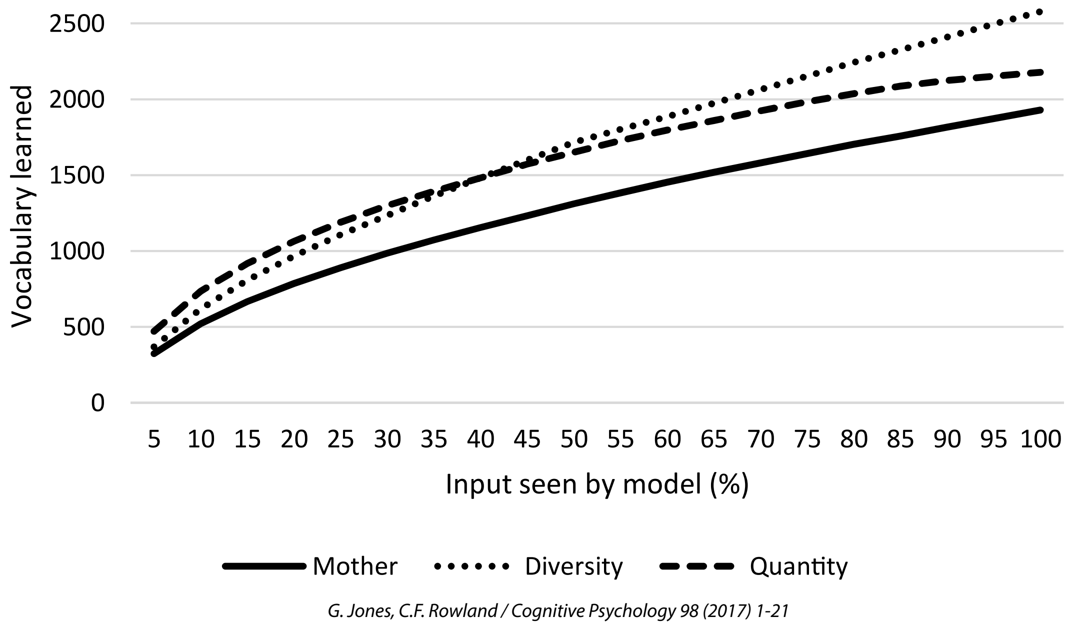

Figure 2. Number of vocabulary items learned by a computational model exposed to real mothers' input, to an input sample manipulated to increase the number of different words (word types) while keeping the number of work tokens constant (Diversity sample) and an input sample manipulated to increase the number of word tokens while keeping word types constant (Quantity sample). The model exposed to the Diversity input ultimately outperforms both the other samples.

How do children learn language from statistics?
In order to learn words, infants must not only work out how to spot words in the speech stream, but also figure out how these words are combined according to the language's grammar. These tasks are highly complex, not least because speech is fast and continuous, and because the creative power of language means that individual words can be combined in an infinite number of ways. Yet, infants succeed at these tasks with remarkable ease, thanks in part to their expert ability to spot statistical patterns in the speech stream. Even without trying to, infants can compute information about the way items in speech co-occur (be that syllables in words, or words in grammatical structure), helping them to identify the boundaries of words, and the constraints that govern the way those words are used. This computation of co-occurrences is called statistical learning.

We have been studying the way infants draw on the regularities in speech to shape their understanding of words and grammar. This research combines the analysis of spontaneous speech with experimental studies to a) examine infants' capacity for language learning from statistical patterns in speech, and b) document the way that sensitivity to these patterns emerges over development. For example, Frost and colleagues recently trained 16-month-old infants on an artificial language containing novel trisyllabic words (bamuso, bagaso, ligafe, limufe) which all adhered to the same structure (first and last syllables always appeared together, while the medial syllable could vary). Not only could infants draw on the co-occurrence statistics to segment the words from speech, but their ability to do this was significantly related to their vocabulary size both concurrently and over time (between 16 and 30 months of age). In addition, infants developed sensitivity to the within-word structure, indicating that similar statistical learning mechanisms may contribute to discovery of words and structure in speech. In this way, we shed critical light on the way that infants draw on statistical information when learning to identify words and structure from speech.

How do children learn language in traditional societies?
Across the world's cultures, caregivers have very different ideas about how to talk to children. These cultural differences are bound to impact on how children learn language, but we still know very little about language development in different cultures. In one project, partly funded by a Netherlands Organisation for Scientific Research (NWO) award to Casillas, we focus on language development in two non-Western traditional societies, one Mayan and one Papua New Guinean. Although these two communities are similar in many ways, their ideas about talking to young children are radically different: the Papuan caregivers frequently engage in face-to-face talk with their infants, while the Mayan caregivers emphasize a calm infancy, so tend to talk to their infants less frequently. Our project leverages this difference to ask how infants' experience with language influences the way they attend to, process, and use linguistic information. We integrate anthropological methods and psycholinguistic measures of language development in both communities, focusing on children's babbling, word learning, phonological development, conversational turn-taking skills, and the kind and quantity of speech they hear around them. For example, we used at-home audio recordings of 10 Mayan children's waking days (08:00 - 18:00) to find out when they were spoken to, who was speaking to them, and for how long. These children were directly spoken to for an average of 3.6 minutes per hour (vs. >10 minutes per hour for North American children), with an estimated 100 minutes of high-intensity interaction during a 12-hour waking day. Despite this relatively small amount of child-directed speech, the Mayan children's use of babbles, first words, and first word combinations was on track with expectations based on Western children. These intriguing results intensify the puzzle of how Mayan children learn language efficiently - a topic of active research in our group.

How do children learn language from their input?
Children's language learning is influenced by what adults say to them. However, adult speech to children is also influenced by what children say. This means that the language adults use with children changes as those children develop and become more sophisticated language users. In one project, Rowland and her collaborator Jones used computational modelling to model the effect of this changing input on vocabulary learning over time. They showed that while input quantity (the amount of speech children hear) may be important early in learning, the models exposed to a more lexically diverse input (with a greater range of different words), ultimately learned more words, a prediction confirmed against children's data. The models trained on a more diverse input also performed better on other language tasks - such as non-word repetition and sentence recall tests - and were quicker to learn new words over time. The results suggest that, in the early stages of language development it is important that children hear a few words repeated often, to get a toehold into language. However, as they develop a bigger vocabulary, they start to use previously stored linguistic knowledge to learn from incoming speech more quickly. This provides a possible explanation of why the vocabulary gap across children gets bigger as children age: children who learn more words early in life not only start out with an advantage, but may subsequently learn new language at a faster rate over the preschool years.

Selected publications

Bergmann, C., & Cristia, A. (2018). Environmental influences on infants' native vowel discrimination: The case of talker number in daily life. *Infancy*, 23(4), 484-501. doi:10.1111/infa.12232.

Bergelson, E., Casillas, M., Soderstrom, M., Seidl, A., Warlaumont, A.S., & Amatuni, A. (2019). What do North American babies hear? A large-scale cross-corpus analysis. *Developmental Science*, 22(1): e12724. doi:10.1111/desc.12724.

Frost, R. L.A., Monaghan, P., & Christiansen, M.H. (2019). Mark my words: High frequency marker words impact early stages of language learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition.* doi:10.1037/xlm0000683.

Jones, G., & Rowland, C.F. (2017). Diversity not quantity in caregiver speech: Using computational modeling to isolate the effects of the quantity and the diversity of the input on vocabulary growth. *Cognitive Psychology*, 98, 1-21. doi:10.1016/j.cogpsych.2017.07.002.

Kidd, E., Junge, C., Spokes, T., Morrison, L., & Cutler, A. (2018). Individual differences in infant speech segmentation: Achieving the lexical shift. *Infancy*, 23(6), 770-794. doi:10.1111/infa.12256.

DEPARTMENT
NEUROBIOLOGY OF LANGUAGE

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Goals of the Department

The focus of the Neurobiology of Language Department is the study of language production, language comprehension, and language acquisition from a cognitive neuroscience perspective. This includes using neuroimaging, behavioural and Virtual Reality techniques to investigate the language system and its neural underpinnings. Research facilities at the MPI include a high-density EEG lab, a Virtual Reality lab, and several behavioural labs. With part of the department stationed at the Donders Institute for Brain, Cognition and Behaviour Centre for Cognitive Neuroimaging, we also have access to a whole-head 275 channel MEG system, MRI-scanners at 1.5, 3 and 7 Tesla, a TMS-lab, and several EEG labs. Most of the research in the department focuses on foundational aspects of language processing beyond the single word level.

Neuropharmacolinguistics

In earlier work we have shown the influence of the hormone oxytocin on the N400, an ERP component sensitive to semantic information. In a follow-up experiment we investigated the influence of catecholamine function on language processing. Catecholamines belong to a family of neurotransmitters that includes adrenaline, noradrenaline and dopamine. We examined the effects of a catecholamine agonist (i.e., methylphenidate) on the N400. Participants were instructed to read semantically congruent and incongruent sentences (e.g. 'Dutch trains are yellow and blue' vs. 'Dutch trains are sour and blue') after receiving a capsule of methylphenidate or placebo. In one condition, participants were asked to judge whether or not the test sentences were semantically acceptable. In another condition, subjects were asked whether a word was printed in the same font size as the test sentences, for which no semantic processing is necessary. Results showed a task-dependent effect of methylphenidate on semantic processing. When semantic processing was task-irrelevant (i.e. when subjects only paid attention to perceptual information), methylphenidate enhanced the detection of semantic incongruence, resulting in a larger N400 effect. When semantic processing was task-relevant (i.e. when subjects judged the meaning of the sentences), methylphenidate enhanced the processing of semantically congruent sentences. These results suggest that catecholamine-related neurotransmitters, such as dopamine, may play a role in sentence processing by signaling salience. The projections between striatal and prefrontal cortex, which contain a large number of catecholamine receptors, might mediate the language processing effects of these neuropharmacological agents. This research attempts to establish the modulatory role of neuro-pharmacological agents in the brain on linguistic processing.

Laminar fMRI

The six layers of neocortex have different roles in accommodating lower level sensory (bottom-up) information and higher level cognitive (top-down) information. Laminar functional magnetic resonance imaging (lfMRI) is a noninvasive technique with the potential to distinguish top-down and bottom-up signals that are specific to the separate cortical layers and specific for the interaction with other brain areas. Hitherto, lfMRI could not be demonstrated for either whole-brain distributed networks or for complex cognitive tasks. We are the first to show that lfMRI at a high field strength (7 Tesla) can reveal whole-brain directed networks during word reading. In a first study we extracted depth-dependent time-courses from submillimeter BOLD measurements. From these, we identified distinct distributed networks corresponding to top-down and bottom-up signal pathways which targeted the left occipito-temporal sulcus (lOTS; also known as the Visual Word Form area, see Figure 1.) during word reading. We showed that reading words compared to pseudo-words increased the top-down BOLD signal observed in the deep layers of the lOTS. The depth-dependent signals demonstrated unique connectivity patterns with other regions, thereby establishing directionality of interaction within the reading network. This also gives the first direct evidence that a top-down signal from middle temporal gyrus areas to the lOTS is involved in reading. Signals observed at specific depths contained information that was not visible at non-laminar resolutions, indicating that different cognitive processes occur at distinct layers of neocortex. The ability to observe this level of organisational detail in functional circuits will in turn allow us to greatly improve the understanding of the neurobiological organisation for language. We expect to use laminar imaging in the immediate future to expand our understanding of the processes and neurobiological components underlying the memory and unification aspects of language processing.

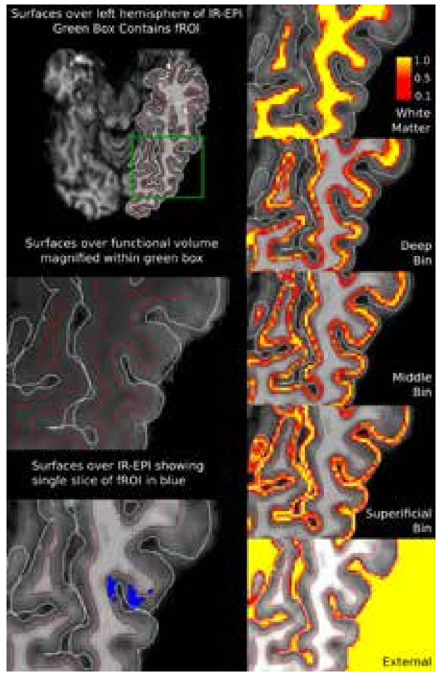

Figure 1. Surfaces and volumetric layering in one subject. Left column: White matter (shown in red) and pial (shown in white) surfaces are shown overlaid on anatomical and T2 - weighted images. A slice through left OTS (our fROI) is shown in blue. The Inversion recovery EPI (IR-EPI) is a T1-weighted EPI acquisition used to facilitate co-registration. Magnification within the green box highlights fROI location. Right column: Equivolume depth laminae shown in volume space. A value of 1 (yellow) indicates that the voxel is fully contained at a given depth, 0 (black) indicates that it is not within the given depth. Intermediate values indicate the fractional volume within a given laminar level.*

The neural basis of shared meaning between speakers and listeners of discourse

Telling a story and listening to it are highly complex neurocognitive activities. In an fMRI study, we attempted to shed light on the brain activity of speakers and listeners who share the meaning of a story, i.e. who engage in a discourse-level conceptual pact, which is one of the major groundings of successful communication. The conceptual pact was manipulated by adding a highly informative title (HT), a title that was somewhat informative (IT), or no title (NT) to an otherwise ambiguous story. Critically, we assessed the relationship between speakers' and listeners' neural activation time courses when processing discourse.
The comprehension of coherent discourse meaning was found to involve (shared) activation in bilateral inferior parietal (see Figure 2) and in left medial frontal regions. These regions seem to play a crucial role in integrating and representing information over extended periods, and in constituting large-scale conceptual representations

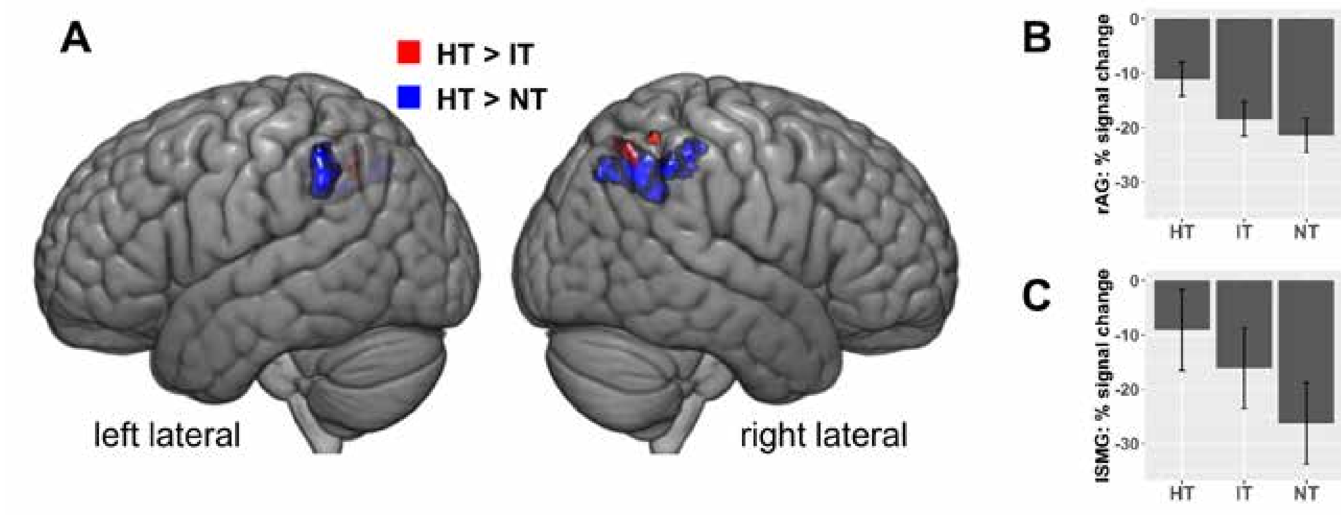

Figure 2. BOLD contrasts HT > IT (warm colours) and HT > NT (cool colours) in listeners. Clusters with a significant BOLD effect in the contrasts HT > IT and HT > NT are displayed. B: Percent signal change is indicated for the peak voxel with maximal differential effect size in the right Angular Gyrus; rAG). C: Percent signal change is indicated for the peak voxel with maximal differential effect size in the left supramarginal gyrus; lSMG). HT, Highly informative title before ambiguous story; IT, Intermediately informative title; NT, No title.

of naturalistic discourse. Importantly, discourse-level conceptual pacts seem to draw on regions that overlap with parts of the default-mode network and also play an important role in recollecting the past and simulating the future.

The cost of prediction

Expectations might support rapid language processing. For example, when we hear a sentence such as "he ate the ..." we predict a certain type of word to occur next (e.g. "cake"). However, what happens when the expectation is disconfirmed (e.g. we hear "boat")? Is the expectation appropriately suppressed, or does it linger? In an ERP study, we manipulated whether words were actually seen or were only expected (e.g., "Be careful, because the top of the stove is very dirty", where "hot" would be expected), and then probed their fate in memory by presenting the words (again) a few sentences later. If disconfirmed expectations linger, subsequent presentation of the previously expected but not presented word should yield a similar effect to actual word repetition. Actual repetition resulted in a strong attenuation of the N400, an electrophysiological marker of reduced semantic processing effort. Critically, like repeated words, previously expected but not presented words also attenuated the N400. This 'pseudo-repetition effect' suggests that the brain does not completely or consistently suppress expectations when they are disconfirmed, revealing a possible cost of prediction in language processing.

Selected publications

Dai, B., Chen, C., Long, Y., Zheng, L., Zhao, H., Bai, X., Liu, W., Zhang, Y., Liu, L., Guo, T., Ding, G., & Lu, C. (2018). Neural mechanisms for selectively tuning into the target speaker in a naturalistic noisy situation. *Nature Communications,* 9, 2405. doi:10.1038/s41467-018-04819-z.

Kösem, A., Bosker, H.R., Takashima, A., Meyer, A.S., Jensen, O., & Hagoort, P. (2018). Neural entrainment determines the words we hear. *Current Biology,* 28, 2867-2875. doi:10.1016/j.cub.2018.07.023.

Nieuwland, M.S., Politzer-Ahles, S., Heyselaar, E., Segaert, K., Darley, E., Kazanina, N., Von Grebmer Zu Wolfsthurn, S., Bartolozzi, F., Kogan, V., Ito, A., Mézière, D., Barr, D.J., Rousselet, G., Ferguson, H.J., Busch-Moreno, S., Fu, X., Tuomainen, J., Kulakova, E., Husband, E.M., Donaldson, D.I., Kohút, Z., Rueschemeyer, S.-A., & Huettig, F. (2018). Large-scale replication study reveals a limit on probabilistic prediction in language comprehension. *eLife,* 7, e33468. doi:10.7554/eLife.33468.

Hagoort, P. (2017). The core and beyond in the language-ready brain. *Neuroscience & Biobehavioral Reviews,* 81, 194-204. doi:10.1016/j.neubiorev.2017.01.048.

Schoffelen, J.-M., Hulten, A., Lam, N.H.L., Marquand, A.F., Udden, J., & Hagoort, P. (2017). Frequency-specific directed interactions in the human brain network for language. *Proceedings of the National Academy of Sciences of the United States of America,* 114(30), 8083-8088. doi:10.1073/pnas.1703155114.

DEPARTMENT **PSYCHOLOGY OF LANGUAGE**

Director Antje S. Meyer
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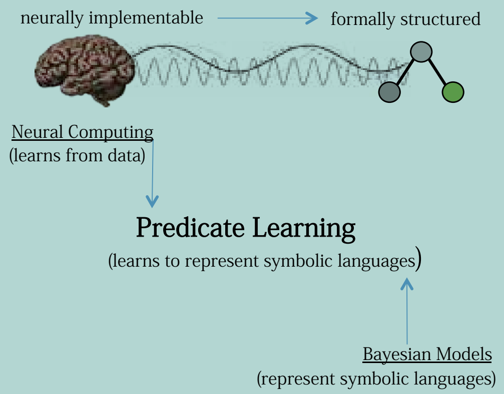
Goal of the Department
The goal of the department is to generate parsimonious, yet sufficiently detailed and comprehensive models of all the different ways we use language in everyday contexts. A guiding theoretical principle is that there is a small set of basic cognitive components, or tools, that people use in different configurations to accomplish tasks involving language. The department aims to identify these basic tools, to describe the blueprints for their combinations in different tasks such as listening, reading, or speaking, and to explain how different skill sets and processing strategies lead to individual differences in language proficiency. To address these questions we use a broad range of methods including analyses of corpora of spoken language, computer simulations, classic behavioural experiments, individual differences studies, and neurobiological methods. The work in the department is organised into clusters introduced below.

The Cultural Brain Cluster ***(Falk Huettig)***
Human cognition is a product of both the cultural environment in which we are immersed and our genetic makeup. The Cultural Brain cluster explores how cultural inventions such as written words, numbers, music, and belief systems shape the mind and brain. In essence, the Cultural Brain cluster asks to what extent culture determines what it means to think as a human.

Research in one of the sub-clusters, the Literate Brain, has shown that the impairments observed in individuals with dyslexia are, to a striking degree, also shown by illiterate individuals who have received no or only little reading instruction. Huettig and colleagues propose that this is no coincidence: The performance differences of both illiterates and individuals with dyslexia compared to literate controls are, to a substantial extent, secondary consequences of reduced or suboptimal reading experience. The search for the primary causes of reading impairments in persons with dyslexia will make progress if the consequences of quantitative and qualitative differences in reading experience are taken into account and not mistaken for the causes of reading disorders.

The Representation and Computation of Structure (RepCom) Cluster ***(Andrea Martin)***
Few contemporary models of language processing explain phenomena in both speech production and comprehension, and even fewer focus on mechanistic models that have neurophysiological plausibility. The RepCom cluster attempts to reconcile the core properties of linguistic structure with principles from cognitive psychology, network computation, and neurophysiology, in order to develop a theory of how linguistic structure and meaning arise in the mind and brain and underlie both speaking and listening. Martin is developing a theory of how the brain converts the sensory correlates of speech and language into hierarchical linguistic structures, based on the idea that the way we understand language may be partly based on common mechanisms of perception. For instance, when we perceive objects we combine multiple cues, such as the shape, sound, smell or function of an object. We may also infer that a knock at the door comes from someone hitting it. Similarly, for language comprehension, our brain uses multiple cues to infer more complex linguistic representations based on 'smaller' or 'simpler' ones. A key aspect is the use of information across multiple timescales to represent incremental (de)compositional meaning. The model's architecture is based on a multidimensional coordinate system resembling neurophysiological models of sensory processing. The model contains a dynamically weighted state space where sensory, motor, and abstract linguistic information are processed in the brain in accordance with behaviour. Language can be produced and comprehended via a shared mechanism that composes and sequences input and output representations from a hierarchy across multiple timescales, yielding predictive information about upcoming sensory input without a separate operation (see Figure 1).

The Double-Act: Speaking and Listening Cluster ***(Suzanne Jongman)***
The Double-Act research cluster is concerned with the coordination of language production and comprehension. Engaging in fluent conversation requires speakers to switch quickly and smoothly between listening and speaking. Such coordination goes unnoticed in normal language use, but when speakers perform more demanding linguistic tasks, coordinating speech comprehension and production becomes difficult. This difficulty can provide valuable insights into the underlying cognitive processes.



The core claims of predicate learning

- learning structured representations that support **extrapolatory generalization** and **compositionality** in neural systems are crucial for human behaviour
- functionally symbolic structures can be learned from unstructured data using **sensitivity to time** as an informational degree of freedom
- predicate learning can be implemented via **desynchronization** of neuronal assemblies

predicate learning: a series of algorithms that perform intersective comparison and use rhythmic computation to discover latent structures

rhythmic computation: the exploitation of endogenous neural oscillations, such as (de)synchronization of aggregate unit firing over time, to compute separable information types over multiple timescales.

Figure 1. Predicate learning through intersection discovery. By comparing neural patterns and keeping track of what is the same about them (their intersection), neural systems (e.g. cortical cell assemblies and artificial neural networks) can generate abstractions over sensory input. By firing the patterns with slight asynchronies across layers of the network, the representations that went into the intersection and the intersection itself can be represented in the system independently while also being dynamically bound together.

One such demanding linguistic task is simultaneous interpreting, the act of instantaneously translating spoken input into spoken output in another language. Van Paridon compared interpreting to shadowing, a same-language control task. The key difference between these tasks is that unlike shadowing, interpreting requires conceptual mediation between lexical items in both languages: Rather than directly pairing words to their translational equivalents (e.g. English CAT and Dutch KAT), proficient speakers use shared representations for concepts in both languages. Interpreting accuracy was only slightly lower than shadowing performance at low speech rates, but suffered more under increasing speech rate. A computational model derived from prior psycholinguistic processing models was used to simulate the accuracy patterns. The obtained model fit suggests that a lexical selection bottleneck is sufficient to explain the difference in accuracy between interpreting and shadowing over a range of speech rates.

The TEMPoral Organization of Speech (TEMPOS) Cluster ***(Hans Rutger Bosker)***
The TEMPOS cluster investigates how speakers control the temporal encoding of spoken utterances and how listeners decode the transitory speech signal. For instance, a reduced pronunciation of the German word *Bahnen* /ba:nən/ 'tracks' (with long /a:/) can be acoustically identical to the word bannen /banən/ 'to banish' (with short /a/). How do listeners identify the intended words when duration cues are so variable?

Part of the solution to this puzzle comes from MEG evidence, indicating that listeners normalise speech sounds for the surrounding speech rate by 'aligning' their brainwaves (neural oscillations) to the syllable rhythm of the speech. Through a process known as 'entrainment', the brain actively synchronises its brainwave frequency to sensory stimuli, such as the syllabic rate of speech. This process

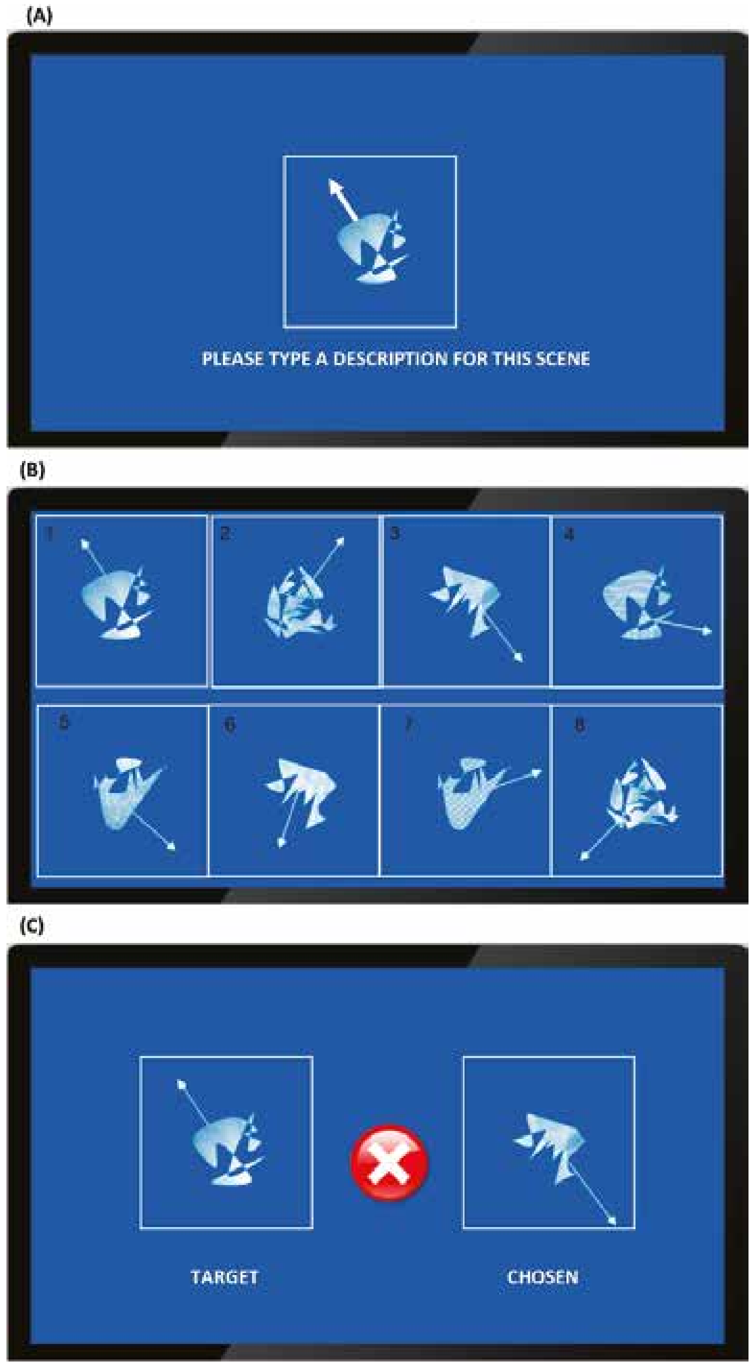


Figure 2. Example screen shots (producer (a), guesser (b), feedback (c)) of the communication game. Arrows illustrate direction of movement.

is endogenous, i.e. the synchronisation of brain activity to external stimuli is initiated by the brain and not merely an evoked response. In a study by Kösem and colleagues, a collaboration with the Neurobiology of Language department, brain activity was recorded while participants were listening to fast (5.5 Hz syllable rate) and slow (3 Hz) carrier sentences followed by ambiguous /a-a:/ target words, which they then had to categorise as containing /a/ or /a:/. We observed neural entrainment to speech rhythms: neural oscillatory responses peaked at 5.5 Hz in fast and at 3 Hz in slow carrier sentences. This entrainment persisted for several cycles after the offset of the carrier sentence. Moreover, this sustained entrainment correlated with changes in the perception of the target's vowel: When the brain was entrained at a higher frequency, participants gave more long /a:/ responses; when entrained at a lower frequency, they gave more short /a/ responses. These findings support oscillatory models of speech processing, suggesting that neural oscillations shape speech perception.

Learning, Memory and Adaptation
(Alastair Smith & Laurel Brehm)
As language users we must learn, store and retrieve words and the concepts they represent. We assume that the core mechanisms that support these language processes are largely the same for all language users. However, differences in when or how we use and experience language lead to differences in learning, and storage of linguistic knowledge. We aim to understand the relationship between language experience and variation in language structure and language abilities.

Structure exists in language at many levels of representation, for example at the level of words (morphology) or sentences (syntax). How does such structure evolve? It has been argued

that compositional languages can emerge only when a language is transmitted across multiple generations. A recent experiment conducted by Raviv, Meyer and Lev-Ari challenges this view. In this experiment, groups of four participants interacted in alternating pairs. They had to communicate about moving novel objects that appeared on their computer screens (see Figure 2). They could only do so using an artificial language which they created during their interactions. Over time, the languages they created became more structured, with participants converging on shared and stable compositional vocabularies. These results demonstrate that linguistic structure can develop during communication within a single generation, in the absence of new learners entering a community.

Individual Differences in Language Skills *(Florian Hintz, NWO Language in Interaction)*
Though native speakers clearly differ in language skills, clear descriptions and comprehensive theories of the causes of such differences are currently missing. In fact, we even lack suitable instruments to systematically assess differences in language skills in healthy adults. The largely NWO-funded cluster Individual Differences in Language Skills develops a comprehensive battery of language tests for young adults. For further information see *www.languageininteraction.nl/BigQuestion4.html*

Selected publications

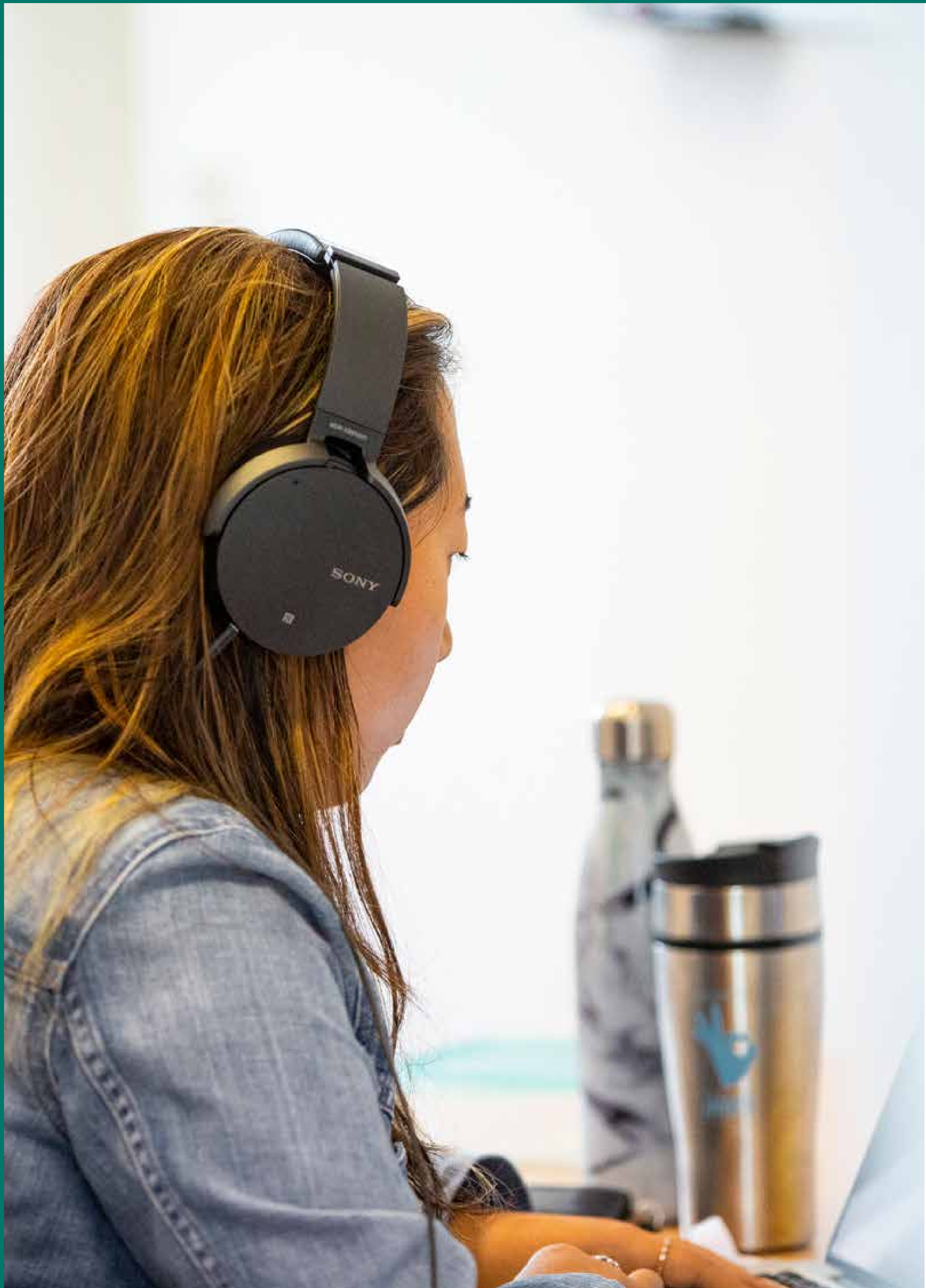
Huettig, F., Lachmann, T., Reis, A., & Petersson, K.M. (2018). Distinguishing cause from effect - many deficits associated with developmental dyslexia may be a consequence of reduced and suboptimal reading experience. *Language, Cognition and Neuroscience*, 33(3), 333-350.

Kösem, A., Bosker, H.R., Takashima, A., Meyer, A.S., Jensen, O., & Hagoort, P. (2018). Neural entrainment determines the words we hear. *Current Biology*, 28, 2867-2875. doi:10.1016/j.cub.2018.07.023.

Doumas, L.A.A., & Martin, A.E. (2018). Learning structured representations from experience. *Psychology of Learning and Motivation*, 69, 165-203.

Van Paridon, J., Roelofs, A., & Meyer, A.S. (2019). A lexical bottleneck in shadowing and translating of narratives. *Language, Cognition and Neuroscience*. Advance online publication. doi:10.1080/23273798.2019.1591470.

Raviv, L., Meyer, A., & Lev-Ari, S. (2019). Compositional structure can emerge without generational transmission. *Cognition*, 182, 151-164.



MAX PLANCK RESEARCH GROUP **NEUROGENETICS OF VOCAL COMMUNICATION**

Group Head Sonja Vernes
Group members
Ine Alvarez van Tussenbroek, Midas Anijs, Laura Baas, Paolo Devanna, Katharina Foreman, Janine Mengede, Ella Lattenkamp, Ksenia Lavrichenko, Jon-Ruben van Rhijn, Kai Wanke

Goals of the Group
The Neurogenetics of Vocal Communication Group studies human speech and language via a range of complementary approaches, from genetics to neuroscience and behaviour, to understand how these abilities are biologically encoded. The overarching goal is to understand how an organism capable of speech and language is built at a biological level. We address this by studying speech and language-relevant traits in animal models - in particular, in bat species. We aim to understand the neurogenetic mechanisms underlying these behaviours including their neural circuitry, molecular pathways, and genomic underpinnings. We also investigate the causes of language disorders in clinical populations to gain insight into these disorders, and to understand the genetic factors underlying normal language development. Candidate genes identified in clinical populations are explored in animal models to understand what role they play and why their disruption leads to language-related disorders.

What vocal learning bats can tell us about human speech and language
Although language is unique to humans, there are language-relevant traits found in animals that can help us to understand how language might have evolved and how it is biologically encoded. Vocal learning is the ability to learn new vocalisations and is crucial to human spoken language, as it gives us the ability to produce the vast range of meaningful sounds that we use to communicate via speech. Many species of mammal, including our primate cousins, have limited vocal repertoires. But a few mammals such as bats, whales and elephants use complex and varied vocalisations that share some characteristics with human speech, such as the ability to learn vocalisations from other members of their social group.

For us, bats represent an ideal model to explore the biological underpinnings and evolution of vocal learning. Bats famously use vocalisations to navigate their environment via echolocation. Perhaps less well known - but just as fascinating - is their use of vocalisations to facilitate complex social interactions. In some bat species, these social interactions rely on learning new calls, which can be thought of as comparable to how humans learn new vocalisations to communicate via speech.

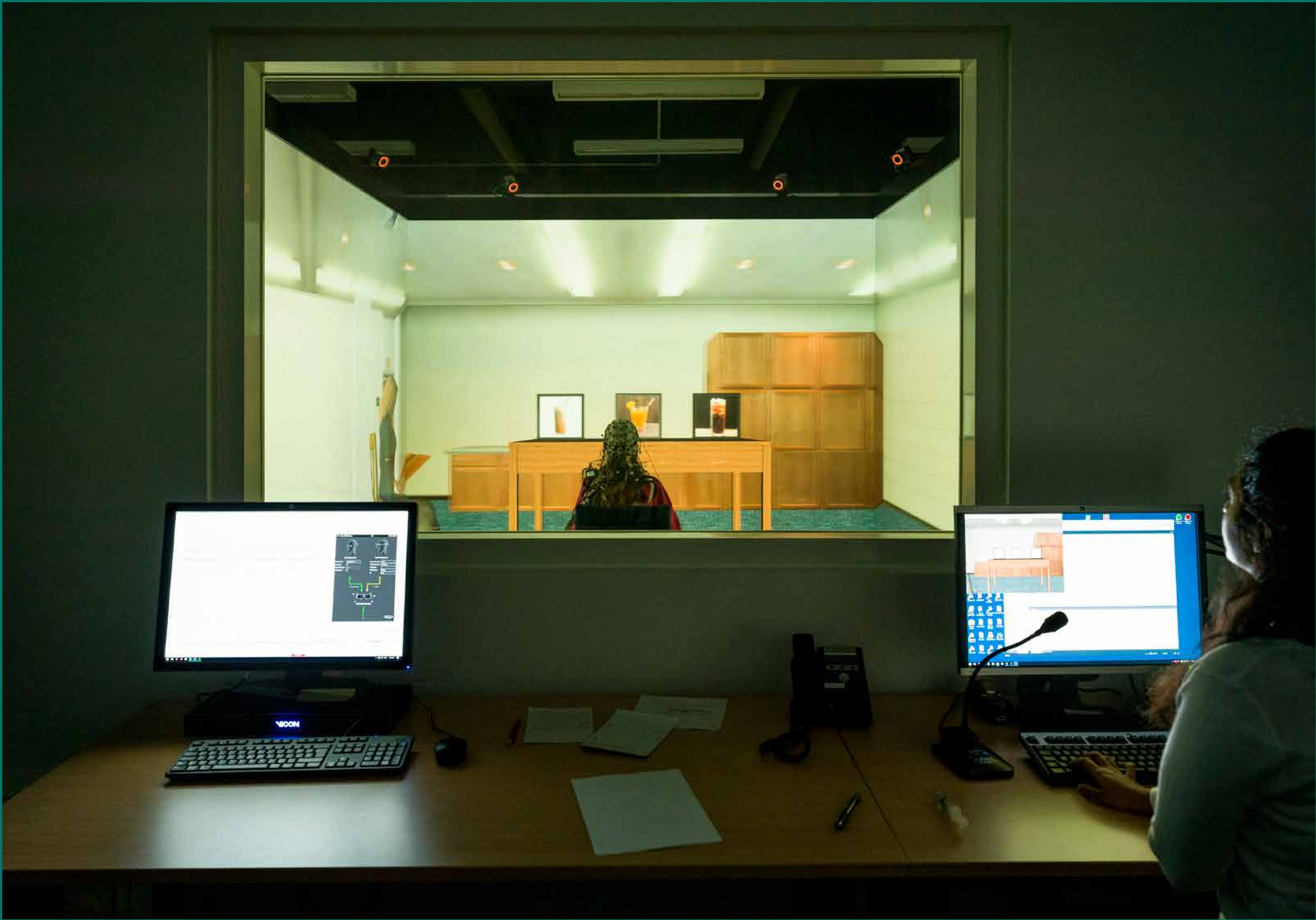
A major goal of the group is to use a comparative approach to study this trait in bats and understand how it is biologically encoded. To make this possible, the group has established two vocal learning species of bats as model systems; the pale spear nose bat *(Phyllostomus discolor)* and the Egyptian fruit bat *(Rousettus aegyptiacus)*. We use these bat models to study vocal learning and vocal communication via comprehensive investigations of the behavioural, neurological, and molecular mechanisms underlying these abilities. These studies may provide clues about the origins of mammalian vocal communication and may ultimately give insight into how human spoken language evolved, and how language abilities are encoded in the human genome.

Selected publications

Rodenas-Cuadrado, P., Mengede, J., Baas, L., Devanna, P., Schmid, T.A., Yartsev, M., Firzlaff, U., & Vernes, S.C. (2018). Mapping the distribution of language related genes FoxP1, FoxP2 and CntnaP2 in the brains of vocal learning bat species. *Journal of Comparative Neurology*, 526(8), 1235-1266. doi:10.1002/cne.24385.

Pika, S., Wilkinson, R., Kendrick, K.H., & Vernes, S.C. (2018). Taking turns: Bridging the gap between human and animal communication. *Proceedings of the Royal Society B: Biological Sciences*, 285(1880): 20180598. doi:10.1098/rspb.2018.0598.

Lattenkamp, E.Z., Vernes, S.C., & Wiegrebe, L. (2018). Volitional control of social vocalisations and vocal usage learning in bats. *Journal of Experimental Biology*, 221(14). doi:10.1242/jeb.180729.


VICON

EXTERNAL GROUP
MULTIMODAL LANGUAGE AND COGNITION

Goals of the Group
The human capacity for language can be instantiated in vocal and/or visual modalities. This group studies language in its multimodal context, to understand which aspects of our language capacity are dependent on the modalities it is conveyed/perceived through and which aspects are modality independent. Our focus is on the way visible communicative behaviors are used both by hearing (e.g., gestures, eye gaze) and deaf people (e.g., in sign languages, and by deaf children with no or delayed language input). The group investigates the role that multimodality plays in three domains of language; a) language use in context such as discourse and dialogue, b) cognitive and neural processing of language, and c) language acquisition and learning. We study cross-linguistic comparisons, (bimodal) bilinguals, and special populations (blind people and adults with autism), with multiple methodologies (such as experimental neuroimaging) to understand how humans use multiple modalities for communication, thinking and interacting. Finally, our group develops new techniques (e.g. Kinect and artificial intelligence) to analyse visual communicative behauviors automatically.

Group Head Asli Özyürek
Group members Zeynep Azar, Mark Dingemanse, Linda Drijvers, Dilay Karadöller, Ezgi Mamus, Francie Manhardt, Kimberley Mulder, Gerardo Ortega, Marlou Rasenberg, Lilia Rissman, Louise Schubotz, Kazuki Sekine, Beyza Sümer, Hükümran Sümer, James Trujillo, Tom Uittenbogert

Children process semantic information from speech and gesture like adults in clear, but not in noisy, listening conditions
Adults integrate semantic information from both speech and gesture. Yet we know almost nothing about how children process multimodal utterances, even though most of their input is multimodal. As part of a Marie-Curie funded postdoctoral project, Sekine investigated how 6-to-7 year old Dutch speaking children integrate iconic gestures with spoken words. Children were presented with clear individual actions words (e.g. writing) and with simultaneously presented matching (writing) and mismatching (typing) iconic gestures while EEGs were recorded. An N400 effect was found in mismatching conditions compared to matching conditions, as was previously found for adults, showing that children integrate multimodal semantic information at the neural level.

In a follow-up experiment, the researchers asked if and how children benefit from iconic gestures when disambiguating noisy speech, compared to adults. Participants were presented with action words in different noise levels (two levels of degraded speech and clear speech) in three conditions: 1) speech only, 2) speech and gesture, and 3) gesture only, and were asked to say what they heard. Children were less accurate than adults in the speech only (degraded conditions) and the gesture only conditions. However, in the speech and gesture condition they reached adult levels of degraded-speech comprehension. Thus in adverse listening children need multimodal input to reach adult levels of unimodal speech comprehension. Furthermore, both adults and children were faster in uttering responses in multimodal conditions than unimodal conditions, suggesting that gestures might provide a link between comprehension and production systems.

"Visible" intent: Communicative context modulates space and time kinematics of both gestures and actions
In his PhD project, Trujillo investigated how people move their hands when they perform actions with objects (e.g., opening a jar) and when they gesture without the object (e.g., hands move as if opening a jar). Specifically, Trujillo was interested whether there are changes in movements (kinematic modulations) when such actions or gestures are used with communicative intent. Two groups of participants were asked to perform actions or gestures (e.g., how to cut paper), imagining they were producing them either for themselves (without communicative intent) or for someone who is supposed to learn from them (with communicative intent). When people acted with communicative intent, they adapted the space-time dimensions of their hand movements. For instance, their hands showed a wider range of motion and faster movements. The communicative context also elicited an increase in addressee-directed eye-gaze. Naïve participants detected the communicative intent from kinematic information only when eye-gaze was unavailable. The communicative intent modulation also enhanced the comprehension of the semantic content of the gestures. Kinematic modulations of communicative intent are generalisable across gesture and actions, which then enhance their semantic processing and "intent reading" by the addressees.

Selected publications

Trujillo, J.P., Simanova, I., Bekkering, H., & Özyürek, A. (2018). Communicative intent modulates production and perception of actions and gestures: A Kinect study. *Cognition*, 180, 38-51. doi:10.1016/j.cognition.2018.04.003.

Azar, Z., Backus, A., & Özyürek, A. (2018). General and language specific factors influence reference tracking in speech and gesture in discourse. *Discourse Processes*. Advance online publication. doi:10.1080/0163853X.2018.1519368.

Drijvers, L., Özyürek, A., & Jensen, O. (2018). Hearing and seeing meaning in noise: Alpha, beta and gamma oscillations predict gestural enhancement of degraded speech comprehension. *Human Brain Mapping*, 39(5), 2075-2087. doi:10.1002/hbm.23987.

INFRASTRUCTURE
TECHNICAL GROUP

Goals of the Group
The Technical Group (TG) has two major goals: (1) to provide the IT infrastructure of workplace, labs, servers, and field equipment for the day-to-day running of the institute, and (2) to devise experiment systems and software that enable new scientific developments within the institute. The members of the group have very different skills, such as: HPC and storage technology skills, knowledge and experience in hardware development (Arduino, Raspberry and other microprocessor-driven systems), as well as extensive knowledge in software development (Java, Python, PHP, JavaScript, PostgreSQL- and Oracle Databases). Furthermore, the TG has extensive knowledge and experience in the field of managing and archiving scientific data.

Head of Technical Group Reiner Dirksmeyer
Group members Herbert Baumann, Dik van den Born, Jeroen Derks, Alex Dukers, Ronald Fischer, Peter Nijland, Albert Russel, Tobias van Valkenhoef, Kees van der Veer, Ad Verbunt, Rick van Viersen, Johan Weustink, Peter Withers, Gert-Jan de Bresser, Ibrahim Abdullah, Pavithra Srinivasa

Computer systems
In 2018 the HPC cluster was extended by 32 nodes. The cluster now consists of 1,104 cores with a total of 15 TB of RAM. One 4-CPU cluster node is equipped with 4 TB of RAM. A parallel file system (BeeGFS) was installed for the HPC cluster to provide a high-performance local file system. Most of the general-purpose servers are virtualized in a VMware cluster system.

Our Hierarchical Storage Management system (HSM, brand: Versity) is now configured to store another copy of important data to an S3 storage area of the GWDG's computer centre.

Experimental labs
The Institute has built and maintains eight reaction time labs, six eye movement labs, various portable eye-tracker setups (glasses and remote eye-tracker), one HMD based Virtual-Reality lab, two EEG labs (Faraday-caged), one gesture lab, one baby lab and two interaction labs. In the period 2017-2018, the Technical Group successfully set up two new child observation labs, developed a new web and app experiment system (Frinex, currently in production), and re-developed and released the MPI Archive system that still contains all speech corpora data and all DOBES collections.

The main neuroimaging facility is housed in the Donders Centre for Cognitive Neuroimaging, where 1.5, 3 and 7 Tesla fMRI, MEG and EEG labs are maintained by a dedicated Technical Group.

Molecular Biology labs
Since January 2015, the Institute has had its own state-of-the-art wet-lab facilities for molecular biology, housed in the new wing. The laboratory area consists of 250 square metres of space, with dedicated rooms for general molecular biology (DNA extraction, processing and analysis), RNA work, histology, microscopy, and tissue culture, used for growing human neurons and brain organoids. The laboratories have extensive equipment to support this work, for example Tecan microplate readers that are able to measure fluorescence and luminescence in living cells and a Zeiss confocal microscope used to image macromolecules and neural networks and their activity.

The wet-lab facilities for molecular biology housed in the new wing of the MPI in Nijmegen

THE LANGUAGE ARCHIVE

Gunter Senft with speakers of the Kilivila language during fieldwork on the Trobriand Islands, 1992

Goals of the Language Archive
The Language Archive (TLA) maintains one of the largest collections of spoken and signed language data, currently covering more than 200 different languages spoken around the world. Its goal is to preserve these materials for the long term and to provide access to them now and in the future. The collections stored in the archive include endangered languages data from the DOBES (Documentation of Endangered Languages) programme of the Volkswagen Foundation, first and second language acquisition corpora, and sign language corpora, as well as studies of gesture and multilingualism. TLA is also developing software for improved archiving of research data, as well as linguistic tools such as ELAN, a leading tool for the scientific annotation of multimedia recordings. The archive's infrastructure meets the highest archiving requirements (it is CoreTrustSeal certified) and serves as a model and reference for similar initiatives.

Scientific Director Caroline Rowland
Head of TLA Paul Trilsbeek
Group members Ibrahim Abdullah, Ludy Cilissen, Jeroen Geerts, André Moreira, Daniel von Rhein, Han Sloetjes, Pavithra Srinivasa, Paul Trilsbeek, Nick Wood †

After several years of development, the archive was migrated to a new technical infrastructure in February 2018. This new infrastructure is based on existing open source software (Fedora Commons/ Islandora) and is developed in collaboration with the Meertens Institute. The goal of this new infrastructure was on the one hand to create a more user friendly and up-to-date front-end for the archive, and on the other hand to have a system that is easier and less costly to maintain. A first version of a new deposit tool that forms an integral part of the new system was released in the spring of 2018 and was made available more widely in October 2018.

In December 2016, TLA was added to the "National Roadmap Large-Scale Scientific Infrastructure" of Dutch research funding organisation NWO, as part of the CLARIAH-PLUS consortium. Infrastructures on this roadmap are entitled to request funding for the construction or further development of the infrastructure. The CLARIAH-PLUS consortium submitted a grant proposal, which was awarded 13.8 million Euro in April 2018 for a period of 5 years (2019-2023). TLA will be working on improvements for the archive as well as the modularisation and enhancement of the ELAN multimedia annotation tool.

Selected publications

Klamer, M., Trilsbeek, P., Hoogervorst, T. & Haskett, C. (2017). Creating a language archive of insular South East Asia and West New Guinea. In: Odijk J. & van Hessen A, *CLARIN in the Low Countries*. London: Ubiquity Press.
doi:10.5334/bbi.10

Casillas, M., Bergelson, E., Warlaumont, A. S., Cristia,A., Soderstrom, M., VanDam, M., & Sloetjes, H. (2017). A new workflow for semi-automatized annotations: tests with long-form naturalistic recordings of childrens language environments. In *Proceedings of Interspeech 2017* (pp. 2098-2102).
doi:10.21437/Interspeech. 2017-1418.

LIBRARY

Head of Library Karin Kastens
Members Meggie Uijen, Rob Matser

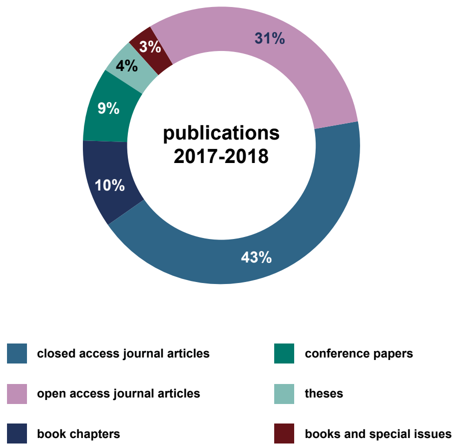
Goals of the Group
The Library Group supports our researchers in all their information needs, whether in printed or electronic content. The group supports the publication management and display of the Institute's publications and assists in compiling bibliometric impact measures of publications.

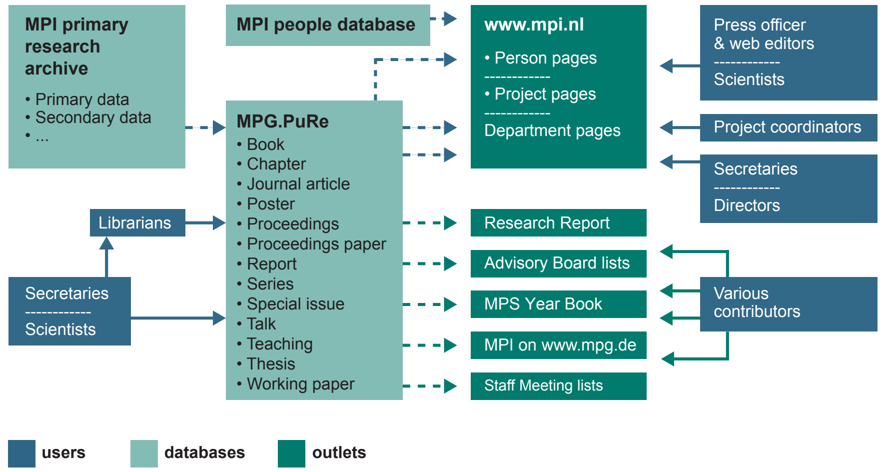
Hybrid library
The library's collection closely follows the research focus of the Institute. Max Planck-wide licenses, together with dozens of locally licensed e-journal subscriptions specifically aimed at our research fields, provide access to more than 80,000 academic e-journals. Next to our print book collection, e-books have also become a valuable resource. Fast interlibrary loan support complements the provided service.

Jerome Bruner Library
Jerome Bruner played an important role in the establishment of the Institute. After his death in 2016, the Bruner family donated his scientific library of 3500 books to our Institute. Cataloging of the books started in 2017, with special attention to dedications from the authors and notes by Jerome Bruner. Once processed, the books will be on display in specially designed shelves within the Institute.

Publication support
The librarians archive the complete publication output of MPI researchers in the institutional publication repository MPG.PuRe (http://pure.mpg.de). The publication and presentation data are uploaded onto the Institute's website with links to full texts and supplementary material. The librarians inform MPI researchers of newly added or updated publications on their homepages and work closely together with the Press officer to enhance the visibility of publications.

Open Access
Information about Open Access is provided by the Library as well, especially about Max Planck-wide agreements regarding Article Processing Charges. In 2017-2018 thirty-one percent of our Institute's publications were Open Access journal articles.





INTERNATIONAL MAX PLANCK RESEARCH SCHOOL (IMPRS) FOR LANGUAGE SCIENCES

Spokesperson Peter Hagoort *(director)*
Coordinator Kevin Lam

Goals of the IMPRS
The International Max Planck Research School (IMPRS) for Language Sciences is a joint initiative between the Max Planck Institute for Psycholinguistics and two partner institutes based at Radboud University – the Donders Institute for Brain, Cognition and Behaviour & the Centre for Language Studies. Founded in 2009, the IMPRS continues its tradition of training future language scientists in an interdisciplinary approach, and promoting all aspects of rigorous scientific practice. Its future-oriented curriculum prepares doctoral students for promising and fulfilling careers in academia and beyond. As the IMPRS approaches its 10th anniversary, we are proud to celebrate the many accomplishments of its international student body.

Coordination
As of January 2017, IMPRS alumnus and assistant coordinator Kevin Lam took on the role as Coordinator. Drawing from first-hand experience with the curriculum, he is imparting his vision of graduate training while also carrying on the work set out by former Coordinator Els den Os who, together with Stephen Levinson, established the School in 2009 with support from the Max Planck Society (MPS) for the Advancement of Science.

Student body composition
As of December 2018, there were 69 active members, forming Cohorts 2015 through 2018, with women making up 70% of the student body. The student body is highly international. Fewer than half our students come from the Netherlands and from Germany. There is roughly equal distribution between projects funded by the MPI (55%) and its partner institutes (45%) at Radboud University.

Student body achievements
By the end of 2018, 72 IMPRS members had successfully defended their dissertations. Notable mentions include an Otto Hahn Medal from the Max Planck Society to Sebastian Sauppe for his outstanding dissertation on the Tagalog language of the Philippines; an NWO Rubicon grant each to Elliott Hoey (University of Basel) and Elizabeth Manrique (University College London); and an NWO Veni grant each to Vitória Piai (Radboud University) and David Peeters (Tilburg University). Current member Linda Drijvers won a Christine Mohrmann Stipend from Radboud University, which will support her in pursuing a scientific career after completion of her doctoral dissertation.

Training programme highlights
The largest yet student-organised event took place successfully in June 2018 in the form of an IMPRS conference. Over 100 participants attended the 3-day event led by 7 keynote speakers. In 2017, the first IMPRS Alumni & Career Event was held and received much praise. Preparation is underway to organise the next instalment scheduled for 2019.

Our curriculum will continue to train students to develop a strong foundation in technical skills such as neuroimaging methods, to acquire clear written and spoken communication skills for different audiences, and to develop critical soft-skills for their future careers.

Selection of research projects
- Jinbiao Yang (CLS) *The mechanism of language chunking*
- Merel Wolf (MPI) *Vocabulary acquisition across modalities and development*
- Joery den Hoed (MPI) *Investigating language-related genes using a model of human brain development*
- Theresa Redl (CLS) *To each his own pronoun: Does Dutch masculine generic pronoun zijn ('his') lead to a male bias?*
- Anne Mickan (Donders) *"What was that Spanish word again?": The role of between-language competition in foreign language attrition*

PUBLIC OUTREACH

Senior communications advisor / Press officer Marjolein Scherphuis

Goals for public outreach
The Max Planck Institute in Nijmegen occupies a prominent position in the world of science. To forge deeper connections between science and society, it is important that we as an Institute reach and maintain this leading position in the Dutch, German, European and international press. To this end, the excellent results of in-depth research conducted at the MPI, are communicated in a clear and comprehensible way through various channels. The efforts of the Kuratorium (Board of Trustees) intensify the effects of the above-mentioned communicative processes.

New corporate identity
An organisation sets itself apart from the rest through the image that it presents to the world, and through the resources and materials it uses. It is a physical expression of the organisation's soul, an extension of the culture that is already expressed through its communication style and actions.

MAX PLANCK INSTITUTE FOR PSYCHOLINGUISTICS

The image that the Institute will be presenting to the world is the result of the Institute's communication strategy: a broad view of the world, open to influences and reactions from that very same world.

The specifics of our new logo: the orange L that stands out amidst the green letters - which together form Max Planck - stands for Language. The green is the main colour of the Max Planck Society, of which the MPI in Nijmegen is part. The orange reflects the Dutch national colour, to signify our unique position as the only Max Planck Institute in the Netherlands. It also represents action and innovation; the MPI is a free organisation in motion, rooted in the foundations of the Max Planck Society (MPS).

New website
In addition to the new logo, we have also been working hard on the new website, which will go live in 2019 (www.mpi.nl). The new website is responsive and therefore usable on mobile devices. It communicates the vibrance and the professionalism of the Institute.

Senior communications advisor and Press officer
In 2018 a new Senior Communications Advisor and Press Officer joined the Institute. She advises the directors and the COO on the basis of the organisational strategy and acts as media contact and media coach for the employees.

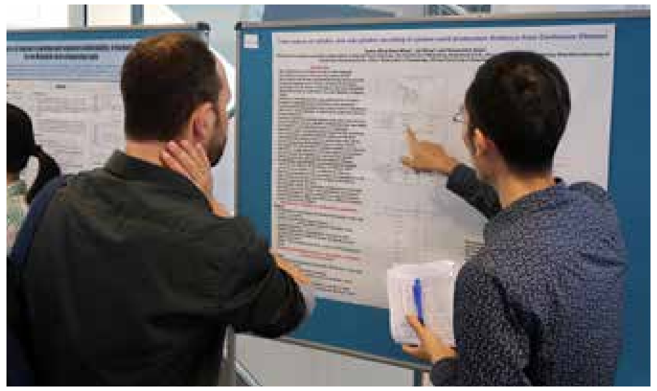
Besides monitoring the excellent reputation of the Institute, building a solid media network and maintaining relevant contacts with the MPS and surrounding stakeholders - such as Radboud University and the Donders Institute - are high on the agenda. In terms of the overall strategy, major results stemming from research conducted at the MPI always take priority.

News and events
In addition to organising and participating in events such as The Nijmegen Lectures, Radboud Reflects and the Kletskoppen Festival, scientists from the MPI also attended the Lowlands Festival in 2018 to research, together with festival goers, communication between people when surrounded by a lot of ambient noise.

In 2017/2018 the research of the Max Planck Institute for Psycholinguistics was featured in The New York Times, BBC News, Fox News, Nature, The Economist, The Guardian, The Scientist, The Telegraph, New Scientist, Time, Washington Post, NewsWeek, The Times, Science Now, Focus, Der Spiegel, Bild der Wissenschaft, Die Welt, NRZ, De Volkskrant, Trouw, NRC and De Taalstaat.

Items and publications as well as contributions to topics were shared through the Institute's Twitter account @MPI_NL, which now has more than 5000 followers.

EVENTS AND ACTIVITIES



2017

Workshop
Virtual reality as a tool for cognitive science
Organised by David Peeters and Peter Hagoort.
Participants: Manuela Macedonia (Johannes Kepler U. Linz), Max M. Louwerse (Tilburg U.), Antonia Hamilton (U. College London), Ineke J. M. van der Ham (Leiden U.), Albert Rizzo (USC Davis). *January 13.*

Symposium
Advancing behavioural and cognitive understanding of speech (ABACUS)
Organised by Bart de Boer (Vrije U. Brussel), Sabine van der Ham (Vrije U. Brussel) and Hannah Little.
Speakers: Dan Dediu, Marco Gamba (U. Turin), Odette Scharenborg (Radboud U.), Marieke Schouwstra (U. Edinburgh), Tessa Verhoef (UC San Diego), Karin Wanrooij (U. Amsterdam), Anne Warlaumont (UC Merced), Andy Wedel (U. Arizona). *January 14.*

Workshop
Neurobiology of prediction in language processing
Organised by Kirsten Weber and Peter Hagoort.
Participants: Trevor Brothers (US Davis), Sasha Ondobaka (UCL London), Joost Rommers, Mante Nieuwland, Kirsten Weber, Irina Simonava (Radboud U.), Falk Huettig, Floris de Lange (Radboud U.). *January 20.*

Symposium
Linguistics Quo Vadis I
Organised by Peter Hagoort.
Speakers: Artemis Alexiadou (Humboldt-U. Berlin), Adele Goldberg (Princeton U.), Roger Levy (MIT), Antal van den Bosch (Radboud U. & Meertens Institute), Judith Tonhauser (Ohio State U.), Michael Cysouw (Forschungszentrum Deutscher Sprachatlas, Marburg), Theresa Biberauer (U. Cambridge), Balthasar Bickel (U. Zürich). *May 30-31.*

Workshop
Testing individual differences in language and other cognitive abilities [TIDLCab]
Organised by Florian Hintz, Suzanne Jongman, James McQueen and Antje Meyer.
Speakers: Fernanda Ferreira (US Davis, USA), Alexis Hervais-Adelman (U. Zurich), Esther Janse (Radboud U.), Lars Meyer (MPI for Human Cognitive and Brain Sciences), Ardi Roelofs (Radboud U.), Sacha Schroeder (Georg-August-U. Göttingen), Frederick Verbruggen (Ghent U.), Roel Willems (Radboud U.). *June 6-7.*

Workshop
Key questions and new methods in the language sciences
Organised by Mark Dingemanse and Stephen C. Levinson.
Speakers: Séan Roberts (U. Bristol), Katja Liebal (U. Leipzig), Balthasar Bickel (U. Zürich), Susan Goldin-Meadow (U. Chicago), Morten Christiansen (Cornell U.), Julia Uddén (Stockholm U.), David Peeters, Sabine Stoll (U. Zürich), Marisa Casillas, Charles Yang (U. Philadelphia), Alex Cristia (CNRS, Paris), Mairead MacSweeney (U. College London), Andrea Martin, Asifa Majid (Radboud U.), Bodo Winter (U. Birmingham), Sonja Vernes, Cedric Boeckx (U. Barcelona), Clair Bowern (U. Yale), Simon Greenhill (ANU, Canberra), Jeremy Skipper (U. College London), Stephen C. Levinson.
Location: Berg en Dal (Holthurnsche Hof). *June 14-18.*

Conference
DETEC 2017
Organised by Geertje van Bergen & Jennifer Spenader (Institute for Artificial Intelligence, U. Groningen)
Invited Speakers: Torgrim Solstad (Leibniz-Institut Allgemeine Sprachwissenschaft (ZAS), Berlin), Joshua Hartshorne (Boston College). *June 26-27.*

Workshop
Types of iconicity in language use, development, and processing
[CLS-MPI Iconicity Focus Group Workshop]
Organised by Gerardo Ortega, Mark Dingemanse and Asli Özyürek.
Speakers: Kimi Akita (Nagoya U.), Linda Drijvers (Radboud U.), Karen Emmorey (San Diego State U.), Mutsumi Imai (Keio U.), Spencer Kelly (Colgate U.), Marcus Perlman, Hannah Little, Robin L. Thompson (U. Birmingham), Pamela Perniss (Brighton U.), David M. Sidhu & Penny M. Pexman (U. Calgary), Tessa Verhoef, Gabriella Vigliocco (U. College London). *July 6-7.*

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EVENTS AND ACTIVITIES

Kletskoppen Kindertaal Festival / 'Chatterboxes' Child Language Festival. Photo: Duncan de Fey

Conference
Neurogenomics: The road ahead. Cognomics Conference
Organised by Elena Shumskaya, Barbara Franke and Simon E. Fisher.
Keynote lecture: Paul Thompson (USC Los Angeles)
Speakers: Ole Andreassen (U. Oslo), Beate St Pourcain, Leonardo Fazio (U. Bari Aldo Moro), Thomas W. Mühleisen (Research Centre Jülich), Sonja de Zwarte (Utrecht UMC), Henning Tiemeier (Erasmus UMC), Alex Fornito (Monash U. Melbourne), Christian Beckmann (Radboud U.), Ellen Verhoef, Marco Papalino (U. Bari Aldo Moro), Philipp Gunz (MPI Evolutionary Anthropology), Amanda Tilot, Daan van Rooij (Radboud U.), Marieke Klein (Radboud UMC), Hieab Adams (Erasmus UMC), Andries Marees (Amsterdam UMC), Roberta Passiatore (U. Bari Aldo Moro), Dennis van der Meer (U. Oslo). *September 7-8.*

Workshop
Minds, mechanisms and interaction in the evolution of language
Organised by Ashley Micklos, Hannah Little, Yasamin Motamedi, Alan Nielsen, Justin Sulik, and Marcus Perlman.
Speakers: David Leavens (U. Sussex), Monica Tamariz (Heriot Watt U.), Jennie Pyers, (Wellesley College). *September 21-22.*

Symposium
Linguistics Quo Vadis II
Organised by Peter Hagoort.
Speakers: Mark Dingemanse, Birgit Hellwig (U. Cologne), Theresa Biberauer (U. Cambridge), Gerhard Jäger (U. Tübingen). *October 2.*

Workshop
Many paths to language (MPaL)
Organised by Marisa Casillas, Alex Cristia and Caroline Rowland.
Invited speakers: Damián Blasi (U. Zurich), Erika Hoff (Florida Atlantic U.), Elena Lieven (U. Manchester). *October 6-8.*

Workshop
Event representation in brain, language and development
Organised by Monique Flecken, Ercenur Unal and Asli Özyürek.
Hosted by MPI for Psycholinguistics and CLS.
Invited speakers: Gerry Altmann (U. Connecticut), Silvia Gennari (U. York), Sarah Gerson (Cardiff U.), Peter Hagoort, Angeliek van Hout (U. Groningen), Yuki Kamide (U. Dundee), Branka Milivojevic (Radboud U.), Anna Papafragou (U. Delaware), Brent Strickland (ENS & Institut Jean Nicod, Paris), Christiane von Stutterheim (Heidelberg U.), Jeffrey Zacks (Washington U. St. Louis). *October 27-28.*

Kletskoppen Kindertaal Festival ('chatterboxes' Child Language Festival)
Organised by Sharon Unsworth and Caroline Rowland.
Location: Central Library (Mariënburg) and Arthouse LUX, Nijmegen. *October 28.*

Interview
'Taal in het Paradijs: Over sprekende auto's, communicerende marsmannetjes en breintaal'. Jolien Francken interviewed Peter Hagoort in the format of 'Zomergasten' on December 17, 2017 in Paradiso, Amsterdam.

EVENTS AND ACTIVITIES

2018

Workshop

Imaging genetics of human brain laterality

Organised by Clyde Francks and Amaia Carrión Castillo.
Participants: Dorothy Bishop (Oxford U.), Marc Brysbaert (Ghent U.), Nathalie Tzourio-Mazoyer (Bordeaux U.), Manuel Carreiras (San Sebastian U.), Myriam Roussigné (Toulouse U.), Guy Vingerhoets (Ghent U.), Sebastian Ocklenburg (Bochum U.), Bernard Mazoyer (Bordeaux U.), Metten Somers (Utrecht U.), Fabrice Crivello (Bordeaux U.), Marc Joliot (Bordeaux U.), Simon E. Fisher, Peter Hagoort, Clyde Francks, Amaia Carrión Castillo, Xiangzhen Kong, Carolien de Kovel, Merel Postema. *January 30.*

Conference

Interdisciplinary approaches in the language sciences 2018

Organised by Kevin Lam, Linda Drijvers, Anne Mickan, Merel Postema, Jeroen van Paridon, Luis Miguel Berscia, Sara Iacozza, Ellen Verhoef (IMPRS).
Speakers: Chiara Barbieri (MPI Jena), Andrea Ravignani (VU Brussels & Sealcentre Pieterburen), Enoch Aboh (U. Amsterdam), Melissa Duff (Vanderbilt U.), Sophie Scott (U. College London), Jeffrey Binder (Medical College of Wisconsin), Jean-Remi King (New York U.). *June 5-7.*

Conference

International workshop on language production (IWLP 2018)

Organised by Antje Meyer, Ardi Roelofs and Laurel Brehm.
Hosted by MPI for Psycholinguistics and Radboud University.
Keynote speakers: Gary Dell (U. Illinois at Urbana-Champaign), Herbert H. Clark (Stanford U.), Stefanie Shattuck-Hufnagel (MIT), Jennifer Arnold (U. North Carolina), Anna Papafragou (U. Delaware), Sarah Bernolet (U. Antwerp), Fernanda Ferreira (US Davis), David Kemmerer (Purdue U.), Rasha Abdel Rahman (Humboldt U. Berlin), Niels Schiller (Leiden U.), Marina Laganaro (U. Geneva), Frank Guenther (Boston U.), N. Bonnie Nozari (Johns Hopkins U.). *July 2-4.*

Course

Genetics & neurobiology of language

Cold Spring Harbor Laboratory
Organised by Simon E. Fisher, David Poeppel (MPI for Empirical Aesthetics & New York University), Kate Watkins (U. Oxford).
Speakers: Anne Christophe (Ecole Normale Supérieure, Paris), Ruth De Diego-Balaguer (U. Barcelona), Karen Emmorey (San Diego State U.), Evelina Fedorenko (MIT), Tecumseh Fitch (U. Vienna), Reyna Gordon (Vanderbilt UMC), Erich Jarvis (Rockefeller U.), Ellen Lau (U. Maryland), Mairead MacSweeney (UCL London), Brad Mahon (U. Rochester), Angela Morgan (Murdoch Children's Research Institute, Melbourne), Dianne Newbury (Oxford Brookes U.), Jonathan Peelle (Washington U. Saint Louis), Constance Scharff (FU Berlin), Sonja Vernes. Location: Long Island, New York. *July 30-August 5.*

Course

Brain imaging genetics: Genetics for imagers

Radboud University Summer School
Organised by Barbara Franke (Radboud UMC) and Simon E. Fisher.
Speakers: Barbara Franke (Radboud UMC), Alejandro Arias Vasquez (Radboud UMC), Yi Lu (Karolinska Institute, and QIMR Berghofer Medical Research Institute), Marieke Klein (Radboud UMC), Emanuel Schwarz (Central Institute of Mental Health, Mannheim), Beate St. Pourcain, Alberto Llera Arenas (Radboud U.), Thomas Wolfers (Radboud U.), Hieab Adams (Erasmus UMC). *August 13-17.*

Symposium

Bridging senses: New developments in synaesthesia

The Royal Society, London
Organised by Simon E. Fisher and Amanda Tilot.
Speakers: Simon E. Fisher, Julia Simner (U. Sussex), Michiko Asano (Rikkyo U. Japan), Jennifer Mankin (U. Sussex), Jamie Ward (U. Sussex), Tessa van Leeuwen (Radboud U.), Mary Jane Spiller (East London U.), Edward Hubbard (U. Wisconsin-Madison), Amanda Tilot, Kevin Mitchell (Trinity College Dublin), Romke Rouw (U. Amsterdam), Fiona Newell (Trinity College Dublin), David Brang (U. Michigan), Michael Banissy, Anil Seth (U. Sussex). *October 22-23.*

Workshop

Current issues in predictive language processing

Organised by Joost Rommers, Ruth de Diego Balaguer (Barcelona U.), Peter Hagoort
Participants: Peter Hagoort, Stefan Frank (Radboud U.), Roel Willems (Radboud U.), Kirsten Weber, Ashley Lewis, Mante Nieuwland. *December 13.*

LECTURES AND COLLOQUIA

On October 15 and 16 of 2018 world-renowned philosopher professor Daniel C. Dennett delivered the Nijmegen Lectures - the following day he received an Honorary Doctorate from Radboud University

Nijmegen Lectures

2017
January 23 - 25 | Gary S. Dell
Department of Psychology, the University of Illinois at Urbana-Champaign.
Lessons from Freud, rats, and connectionism
The series included three lectures: 'What Freud got right about speech errors', 'Implicit learning, phonotactics, and . . . rats', and 'Psycholinguistics, sentence production, and the P-Chain'. Discussants in the seminars were: Eva Belke (Ruhr U. Bochum), Ardi Roelofs (Radboud U.), Padraic Monaghan (Lancaster U.), Caroline Rowland, Julia Uddén, Holly Branigan (U. Edinburgh) and Falk Huettig. The lectures were organised in collaboration with Radboud U. by Antje Meyer, Ardi Roelofs, Kirsten Weber and Stefan Frank.

2018
February 26 – 28 | Elena Lieven
University of Manchester and ESRC LuCiD Centre
Understanding how children learn language: What progress has been made since 1965?
The series included three lectures: 'Language development and Nativism: A historical perspective on whether we have been going round in circles', 'Usage-based approaches: How far have they got us?' and 'Comparative research on language development: How to find universals and particulars?'. Discussants in the seminars were: James McQueen (Radboud U.), Peter Hagoort, Simon E. Fisher, Petra Hendriks (U. Groningen), Anna Theakston (U. Manchester), Bencie Woll (U. College London), Ludovica Serratrice (U. Reading), Stephen Levinson. The lectures were organised in collaboration with Radboud U. by Christina Bergmann, Susanne Brouwer, Saoradh Favier, Caroline Rowland, Tineke Snijders and Connie de Vos.

October 15-16 | Daniel Dennett
School of Arts and Sciences, Tufts University
Autonomy, Language, and Consciousness
The series included two lectures: 'Autonomy and consciousness' and 'The role of language in human consciousness'. Discussants in the seminars were: Julian Kiverstein (U. Amsterdam), Marc Slors (Radboud U.), Caroline Rowland, Sebo Uithol (Radboud U.). The lectures were organised in collaboration with Radboud U. by Peter Hagoort, Marc Slors and Ceci Verbaarschot.

Donders Lectures

2017
February 2 | Heidi Johansen-Berg, U. Oxford
Imaging and stimulating adaptive brain plasticity
March 9 | Ken Harris, UCL London
The large-scale organization of neural activity
June 22 | Alcino Silva, UCLA
Strategies and principles underlying the integration and planning of experiments in neuroscience in an age of information overload
September 28 | Matt Davis, MRC Cognition and Brain Sciences Unit, U. Cambridge
Predicting, perceiving and learning spoken words

2018
March 8 | Francesca Happé, King's College London
Theory of Mind and autism: 30 years on
28 June 28 | Zoe Kourtzi, U. Cambridge
Strategic routes for learning in the human brain
September 13 | Miguel Nicolelis, Duke U. School of Medicine
Linking brains to machines: From basic science to neurological neurorehabilitation
October 25 | Jacqueline Gottlieb, Columbia U.
Understanding motivated cognition: challenges and opportunities
November 22 | Christian Büchel, U. Hamburg
How expectations can shape pain

Joint Radboud Reflects – MPI Lectures

2018
October 29 | Susan Blackmore, U. Plymouth
Genes, memes and tremes. The future of artificial intelligence

LECTURES AND COLLOQUIA

MPI Colloquium Series

2017
February 21 | Christine M. Freitag, Goethe U. Frankfurt
Autism Spectrum Disorders: Complex disorders with a complex genetic architecture
March 21 | Regine Kolinsky, FU. Brussels
The impact of literacy on memory and knowledge
April 18 | Nathalie Tzourio-Mazoyer, U. Bordeaux
Neuroimaging hemispheric specialization
May 16 | Jennifer Rodd, UCL London
How do we understand what words mean?
June 20 | Jonathan Grainger, U. de Provence Aix-Marseille
Orthographic processing and reading
September 5 | Emmanuel Dupoux, Lab for Cognitive Sciences & Psycholinguistics, CNRS Paris
Reverse engineering infant language acquisition using machine learning
December 5 | Matthew Hurles, Wellcome Trust Sanger Institute
Causes and consequences of new mutations: relevance for neurodevelopmental disorders

2018
April 10 | Kim Plunkett, U. Oxford
The Whorfian Infant
September 25 | Ruth de Diego Balaguer, U. Barcelona
Attention through prediction: a two-stage language learning mechanism
October 23 | Reinhold Kliegl, U. Potsdam
Dynamic modulation of the perceptual span in reading
November 13 | Tecumseh Fitch, Vienna U.
Human language: Unique and shared features
December 11 | Caroline Floccia, U. Plymouth
Language distance and the early bilingual lexicon

Nijmegen Gesture Centre Lecture Series

2017
January 19 | Kazuki Sekine, Radboud U.
Integration of speech and cohesive use of space in gesture
February 9 | Emmanuel Biau, Maastricht U.
Spontaneous beat gestures in audiovisual speech: Prosody may extend to the speaker's hands
February 21 | Alexandra Carstensen, Radboud U.
Gestured word order is not always 'natural': Insights from efficient communication
March 23 | Marieke Hoetjes, Radboud U.
Gesture production in repeated references
May 4 | Laura Raveling, FU Berlin
Methods of annotating co-speech gestures
September 19 | David Leavens, U. Sussex
Intentional communication by great apes
November 7 | Basil Preisig, Radboud U.
Aphasia and gesture
December 7 | Irene Mittelberg, RWTH Aachen U.
Contiguity, reduced actions, and schematic iconicity: How metonymy motivates form and function in gesture

2018
March 28 | Alan Cienki, FU Amsterdam & Moscow State Linguistic U.
Grammar and gesture: Insights on transitivity, argument structure, and aspect
May 7 | Diane Lillo-Martin, U. Connecticut
Asymmetries in pointing: Who, when, where and why
September 4 | Anne Theresa Federikson, UC San Diego
Production and comprehension of American Sign Language referring expressions: Modality-general and modality-specific influences
October 30 | Yagmur Gucluturk, Radboud U.
Deep learning for behaviour analysis
November 6 | Geert Brône and Bert Oben, Leuven U.
A multimodal and temporal account of lexical and gestural alignment
December 6 | Beyza Sumer, Radboud U. and U. Amsterdam
Different effects of iconicity in sign language acquisition

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