

Neurobiology Research Unit

Annual Report 2025



Department of Neurology, Neuroscience Centre
Copenhagen University Hospital, Rigshospitalet

www.nru.dk



Contents

Preface 4

Our Mission & Activities 7

Education 8

Facilities 10

Staff in 2025 12

 - PhD Degrees 18

 - Honors and Awards 22

 - Positions of Trust 24

Strategic Collaborations 26

BrainDrugs 30

The NRU Neuroimaging Laboratory 34

Clinical Neuropsychiatry 38

Psychedelics 41

Preclinical Neurobiology 42

Data Analysis 44

OpenNeuroPET 46

Dissemination in 2025 48

Acknowledgements 64

Preface

Once again, I am pleased to share the annual report, which outlines the work and achievements of the Neurobiology Research Unit (NRU) during 2025.

During 2025, we welcomed 55 new members and collaborators, including 3 postdoctoral researchers, 2 research assistants, 6 scholarship students, 24 pre-graduate students, 14 student assistants, and 6 visiting researchers. By December 2025, the NRU community had grown to 160 individuals.

External funding continues to play a crucial role in supporting our mission. Over the course of the year, 35 of our grant applications were successful, securing more than 41 million DKK in external funding. NRU also became a partner in the Nordic Center for Glymphatic Biology, an ambitious five-year initiative funded by the Lundbeck Foundation and led by our close collaborator, professor Maiken Nedergaard from the Center for Translational Neuromedicine (CTN) at the University of Copenhagen.

NRU maintained a strong focus on academic excellence. Four PhD students successfully defended their theses, marking important milestones in their careers. Our researchers presented innovative findings at numerous international congresses, conferences, and meetings, and we achieved a record output of 105 peer-reviewed scientific publications.

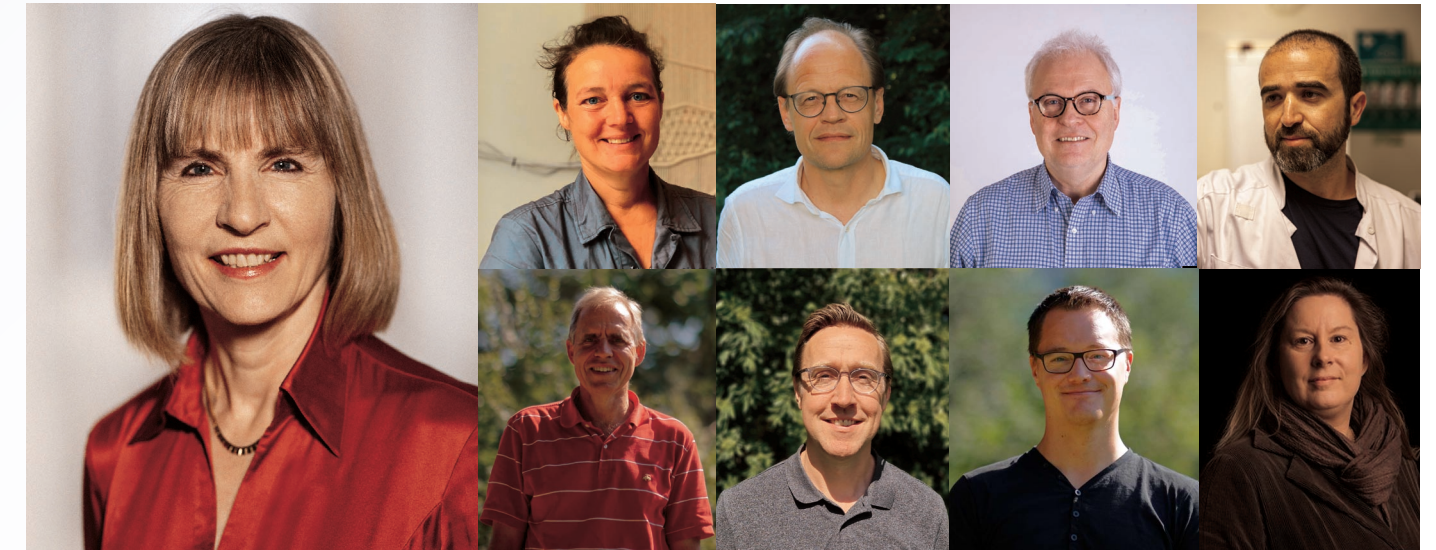
I would like to express my sincere appreciation to all NRU staff for their dedication, as well as to our host institution, Rigshospitalet, and our valued national and international collaborators. Their continued support has been essential to another successful year for NRU.

I encourage you to explore the 2025 annual report and invite interested readers to follow our latest updates via our website, <https://nru.dk>.

On behalf of the NRU management group



Gitte Moos Knudsen
Professor, Head of Department



The NRU management group was in 2025 composed of professor Gitte Moos Knudsen (photo credit to Royal Academy of Sciences and Letters) and (from left to right, top row first) professors Vibe G. Frøkjær, Lars H. Pinborg, and Jens H. Mikkelsen, laboratory manager Arafat Nasser (until Aug 31, 2025), chief engineer Claus Svarer, associate professor Patrick M. Fisher, center manager Peter S. Jensen (from Sep 1, 2025), and associate professor Dea S. Stenbæk (until Apr 30, 2025).

Our Mission & Activities

The Neurobiology Research Unit (NRU) advances translational neuroscience to drive preventive, diagnostic, and therapeutic innovations for brain disorders. Our research integrates neuropsychological and behavioural assessments with state-of-the-art human imaging modalities, including MRI, PET, SPECT, and EEG, to investigate fundamental neurobiological mechanisms and the neuropharmacological effects of interventions. Advanced image processing and statistical modelling are applied to generate high-quality, reproducible insights. Complementing human studies, preclinical work in animal and cell models accelerates translation from laboratory discoveries to early-phase clinical testing.

NRU's activities span **ten key domains**:

- 1) Basic neurobiological and translational neuroscience research
- 2) Development and validation of novel *in vivo* imaging probes
- 3) Neuropharmacological research
- 4) Open science initiatives, AI, and advanced data analysis
- 5) Neuroimaging research
- 6) Diagnostic brain imaging for neurological patients
- 7) Neuropsychology research
- 8) Cohort studies in epilepsy and major depressive disorder
- 9) Education and training
- 10) Dissemination of research findings.

As a core unit within Rigshospitalet and the Capital Region of Denmark, NRU serves a pivotal role in pioneering neuropharmacological research. Our work is closely integrated with hospital clinics, universities, and industry partners, enabling rapid translation of preventive strategies, diagnostics, innovative drugs, and non-pharmacological interventions to patients. NRU maintains robust national and international collaborations, ensuring that our research impacts both local patient care and the global neuroscience community.

Education

NRU is a major training site for pre- and postgraduate students. In 2025, we supervised more than 25 bachelors- and master theses for University of Copenhagen, Technical University of Denmark and University of Southern Denmark. We train national and international research staff at all levels; medical students, graduate students, PhD students and postdocs.

We organize pre- and post-graduate courses with international speakers and well-attended programs, including the Master's program in Neuroscience, and an international PhD course on pharmacokinetics. During the semester, we have a fixed meeting program with at least 5 weekly research presentations and journal clubs, where the pre- and postgraduate students can train their presentation skills.

NRU faculty members and senior researchers are engaged in research-based teaching and education within their fields of expertise, for example medicine, medicine and technology, and human biology. Below are some of the major contributions to teaching programs.

The Master's program in Neuroscience in Copenhagen

Professor Jens H. Mikkelsen from NRU and Institute of Neuroscience, University of Copenhagen, is the study director of a two-year Master of Science program and education in neurosciences which was started in 2020. Courses are offered in cellular neuroscience, neural circuits, higher brain functions, and experimental neuroscience, as well as elective courses in animal models, drug discovery and computer science. Every year the university enroll about 30 bachelor students in the Master's program in Neuroscience. Every year the program experiences a large interest from students from all over the world. Many applicants come from China, North America and throughout Europe, but unfortunately, only a limited number of qualified applicants can be accepted. The NRU faculty provide teaching in neuropharmacology, homeostasis, cognition, drug discovery and imaging in the form of lectures, exercises, and journal clubs, and we have every year Neuroscience students who do their Master's thesis here.

Danish Institute of Study Abroad

Each semester, associate professor Patrick Fisher guest lectures for the following university-level courses at the Danish Institute of Study Abroad: "Neuroplasticity", "Neuroscience of Creativity", "Neuroscience of Fear", and "Neurological Disorders and Disease".

Basic Kinetic Modelling in PET and MR Imaging

In the period Mar 3-7, 2025, we hosted our annual one-week PhD course on pharmacokinetics with participation of 15 national and international researchers. The course organizers are Gitte Moos Knudsen, Henrik Larsson, Claus Svarer and Dorte Givard.

Joint lab meetings with PET-centers at NIHM, Yale, and Karolinska

Since 2023, NRU has held monthly online seminars with colleagues from PET-centers at NIHM (Innis), Yale (Carson), and the Karolinska Institute (Varrone). The laboratories take turns to present their novel data with PET neuroimaging and to enjoy joint discussions.

OpenNeuroPET

Since 2021, the OpenNeuroPET group (page 46) has been involved in teaching activities around PET open science: Brain Imaging Data Structure training and tools developed by the group: *PET2BIDS* and *PET-prep*.

Facilities

The NRU occupies more than 1,400 m² of research facilities distributed across multiple locations at Rigshospitalet (RH), with the core infrastructure concentrated on the fifth and sixth floors of the North Wing (sections 8057 and 8067).

The fifth floor comprises 822 m² and functions as the primary administrative, clinical, and experimental hub. Facilities include 15 offices (62 workstations), conference and meeting rooms, a science lounge, quiet rooms for video conferencing, a human-specimen laboratory, storage and server facilities, soundproof rooms for neuropsychological and neurophysiological testing, a dedicated sleep/intervention room, and a high-density EEG laboratory with adjacent observation room. This floor also houses the full NRU IT infrastructure, including server and printer rooms.

The sixth floor hosts the NRU experimental laboratory (167 m²), supporting advanced in vitro neuroscience research. The area includes four GMO-1 approved laboratories (one also approved as an isotope laboratory with S1 permission), a -80°C freezer room, a dedicated 4°C cold room, storage facilities, and office space. Laboratory infrastructure includes fully equipped bench facilities, gamma and beta counters, cell culture and harvesting facilities, autoradiography, and specialized analytical equipment.

Additional shared facilities include access to a microscopy suite within the Neuromuscular Research Unit (7th floor) and a 62 m² biobank freezer-core facility in the basement, shared with the Danish Dementia Research Centre and the Memory and Neuromuscular Clinics.

NRU also operates two dedicated in vivo laboratories in Building 93 (RH section 9302), supporting small-animal research, behavioural testing, and isotope-based studies. Both laboratories are S1-approved isotope facilities and are supported by shared -80°C freezer storage.

NRU maintains strategic infrastructure partnerships, including close collaboration with the PET and Cyclotron Unit at RH, providing direct access to radiochemistry production and PET and PET-MR imaging platforms. The unit operates the NRU brain research dedicated 3 Tesla Siemens Prisma MR scanner (MR001) in a 120 m² state-of-the-art facility in the North Wing. Clinical scanning occupies 50% of operational time, with the remaining capacity reserved for NRU research. A full-scale Siemens MR mock-up scanner is installed in the basement for training and patient preparation, particularly for pediatric and claustrophobic populations.

The NRU SPECT laboratory, located adjacent to the Department of Radiology, supports both clinical diagnostics and research. The facility includes an office, a type B isotope laboratory, patient waiting areas, and a scanner room equipped with a three-headed dedicated brain SPECT/CT scanner (Mediso AnyScan) with a multi-pinhole collimator. Together with its basement storage facility, the SPECT infrastructure occupies 130 m².

A central strategic asset is the Cimbi database and biobank, representing one of NRU's most valuable long-term research infrastructures. Over two decades, high-resolution multimodal neuroimaging data (PET, MRI, rsMRI, fMRI) have been systematically collected from thousands of well-characterized healthy participants and patients with neuropsychiatric disorders. These datasets are integrated with extensive demographic, neuropsychological, biochemical, and genetic data in a structured and secure research database. The associated Cimbi biobank contains biological specimens including blood, saliva, and selected urine and hair samples, stored in the dedicated freezer-core facility.

Together, the Cimbi database and biobank constitute internationally competitive, quality-controlled resources for hypothesis-driven and hypothesis-generating research. In 2025 alone, 14 new official Cimbi data-access applications were approved, more than 40 active projects are currently ongoing, and multiple peer-reviewed publications were produced. The PET datasets further contribute to the OpenNeuroPET initiative (see page 46), strengthening NRU's international research integration and data-sharing profile.

Staff in 2025

NRU wishes our staff to reflect the diversity of the scientific community, and we actively seek to have a group of staff composed of many different nationalities and spanning a wide variety of educational backgrounds.

We provide a supportive and enriching environment for researchers at all levels, fostering personal professional growth and development. The corporate language at NRU is English.

During 2025, the following 222 people, representing 20 different nationalities, were affiliated to NRU.

NRU management group

Gitte Moos Knudsen, Head of NRU, professor, MD, DMSc

Arafat Nasser, laboratory manager, PhD

Claus Svarer, chief engineer, PhD

Dea S. Stenbæk, associate professor, PhD

Jens H. Mikkelsen, professor, MD, DMSc

Lars H. Pinborg, professor, MD, DMSc

Patrick M. Fisher, associate professor, PhD

Peter S. Jensen, center manager

Vibe G. Frøkjær, professor, MD, PhD

Administration and research

Birgit Tang (HR)

Dorthe Givard (finances)



Senior researchers

Anjali Sankar, PhD

Brice Ozenne, associate professor, PhD

Cyril Pernet, PhD

Gerda Thomsen, medical technologist

Louise M. Jørgensen, associate professor, MD, PhD

Melanie Ganz-Benaminsen, associate professor, PhD

Olaf B. Paulson, professor emeritus, MD, DMSc

Pontus Plavén-Sigray, PhD

Vibeke H. Dam, PhD

Postdocs

Anders S. Olsen, PhD

Annette Johansen, MD, PhD

Burcu Azak Pazarlar, PhD

Cassis Varlow, PhD

Drummond McCulloch, PhD

Helen Coupland, PhD

Llucia Coll Benejam, PhD

Kristian R. Jensen, MD, PhD

Sara Marie U. Larsen, MD, PhD

Silvia E.P. Bruzzone, PhD

Sofi Kann, MD, PhD

Sophia Armand, PhD

Stinne Høgh, PhD

Søren V. Larsen, MD, PhD

Violette Richin, PhD

PhD students

Annika K. Fuglsang-Damgaard, MD

Charlotte H. Hosford, MD

Clara Madsen, molecular biomedicine

Elisabeth Kolesnik, neuroscience

Emma Høgsted, MD

Janika Fortunato, neuroscience

Kristian Larsen, neuroscience

Kristín Magnúsdóttir, biomedical medicine

Kristoffer Brendstrup-Brix, MD

Maja R. Marstrand-Jørgensen, MD

Malthe T. Andersen, MD

Miriam L. Navarro, pharmacy

Qi Wang, MD

Ruben Dörfel, biomedical engineering

Sidsel H. Andersen, psychology

Sif Olsen, psychology

Research assistants

Alice Schiavone, computer science

Camilla Iavazzo, neuroscience

Catharina Messell, music therapy

Martin Prener, MD

Noa Roumimper, neuroscience

Victoria S. Garre, MD

Vincent Ajoubi, computer science

Technical staff

Emilie L. Henriksen, radiographer
Lone I. Freyr, project nurse
Minna H. Litman, project nurse
Robin de Nijs, medical physicist
Svitlana Olsen, medical technologist

Student assistants

Andrea Præstmark, MRI-student assistant
Asger Gadeberg, MRI-student assistant
Asmus T. Dalsgaard, EEG-student assistant
Asta K. Vølund, MRI-student assistant
Astrid S.N. Nielsen, MRI-student assistant
Cecilie R. Hvass, MRI-student assistant
Frederikke A.J. Petersson, MRI-student assistant
Holger F. Lyng, EEG-student assistant
Ida-Sofia B. Wehner, MRI-student assistant
Johanne M. Pedersen, MRI-student assistant
Julius L. Søgaard, EEG-student assistant
Kasper Skjærbæk, HPLC-student assistant
Kristian G. Lambertsen, MRI-student assistant
Lauge A. Rasmussen, IT-support
Laura Riisager, MRI-student assistant
Laura M. Østergaard, MRI-student assistant
Marc Cummings, IT-support
Mille Rasmussen, HPLC-student assistant
Nina Klee, EEG-student assistant
Robert D. Pedersen, EEG-student assistant
Signe H. Ghodt, EEG-student assistant
Simon G. Sabroe, MRI-student assistant
Wilma Eis, EEG-student assistant

Student helpers

Asta Aakjær, student helper
Astrid W. Jensen, student helper
Ban Shiwalia, student helper
Delal Yücel, student helper
Emilia A. Steenstrup, student helper
Emma B. Højte, student helper
Frederikke Frost Nielsen, student helper
Freya Kretzschmar, student helper
Ingrid Amundrud, student helper
Isabella Kempff-Andersen, student helper
Karoline Bjerregaard, student helper
Kristina Jacobsen, student helper
Lea Durhuus, student helper
Lea Saarp, student helper
Line Christiansen, student helper
Louise Bom, student helper
Louise Le, student helper
Maria Grzywacz, student helper
Maria Schriver, student helper
Marie B. Gad, student helper
Peter M. Skov-Andersen, student helper
Rose Garly, student helper
Sara V. Rehtmar, student helper
Silas W. Østergaard-Christensen, student helper
Sofie Larsen, student helper
Tami Jacobsson, student helper

Pregraduate students

Aje Al-Awssi, medicine
Alexander T. Ysbæk-Nielsen, psychology
Ali M. Ahmad, medicine
Alma Mouritzen, psychology
Amani Bakrawi, psychology
Anton W. Lauritzen, psychology
Ása Michelsen, medicine
Bóas S. Majurnarson, medicine
Camilla Xu, medicine
Caroline G. Johansen, molecular biology
Despoina Kazani, neuroscience
Dilja Ketilsdottir, medicine
Elisa Nabizada, human biology
Emilie Mauritzon, medicine
Emily Araghipour, psychology
Evi Potsi, bioinformatics
Frederikke Andersen, biology
Frederikke Hassing, medicinal chemistry
Giulia Terrusso, immunology & inflammation
Hannah W. Julsgart, biomedical engineering
Hannah K. Sørensen, pharmaceutical sciences
Helene Kaas, medicine
Helga Appel, medicine
Ida Willumsen, medicine
Ida P. Østergaard, medicine
Jacob S. Lillelund, molecular biomedicine
Janne Bostrup, psychology
Javier B. Arechavaleta, molecular biomedicine
Jonas S. Ingerslev, human physiology
Jonathan Gelvan, psychology

Jonathan G. Ulrich, medicine & technology
Josefine S. Galatius, psychology
Josephine Tyron, medicine
Julie Wedel-Heinen, pharmaceutical sciences
Julius S. Vandel, medicine
Kamilla G. Nielsen, medicine
Konstantinos Vosinas, computer science
Krzysztof Oldakowski, computer science
Laura A. Juul, medicine
Lea Marston, medicine
Lea Saarp, psychology
Line Wiberg, medicine
Lorenz Prösser, medical & pharmaceutical Biotechnology
Louise Jensen, medicine
Lukas Schüler, computer science
Magnus L. Christensen, computer science
Magnus Dickmeiss, psychology
Manuel Wegmann, statistics
Markus Rex, medicine & technology
Martina V. Cobis, psychology
Mathilde E. Brøgger-Jensen, medicine
Matilde Rasmussen, medicine
Matthijs Michielsen, psychology
Migle Barkauskaite, psychology
Mira Baumgartinger, neuroscience
Monica Wiese, psychology
Nanna N.B. Jensen, psychology
Nikita Morel, psychology
Nina Fultz, neuroscience
Oliver Iversen, medicine

Parmida Rezai, medicine
 Paw Randrup, psychology
 Peder Glad-Digernes, psychology
 Randi T. Kjær, medicine
 Rói Hansen, medicine
 Sabrina Galimberti, immunology & inflammation
 Safia Alakhir, medicine
 Sara Hanson, psychology
 Sarah F. Akobe, medicine
 Sofie P. Boesgaard, neuroscience
 Sofie B. Holst, molecular biomedicine
 Sofie Hvitved, medicine
 Sophie Bolwig, medicine
 Souline Ahmand, medicine
 Thereza Rørvik, psychology
 Thomas Westenholz, psychology
 Tobias B.A. Andersen, computer science
 Travis Kovaleinen, medicine
 Vanessa K. Dreijfeldt, medicinal chemistry
 Vibeke Serup, psychology
 Virginia Camporesi, neuroscience
 Zinet Ritschel, psychology

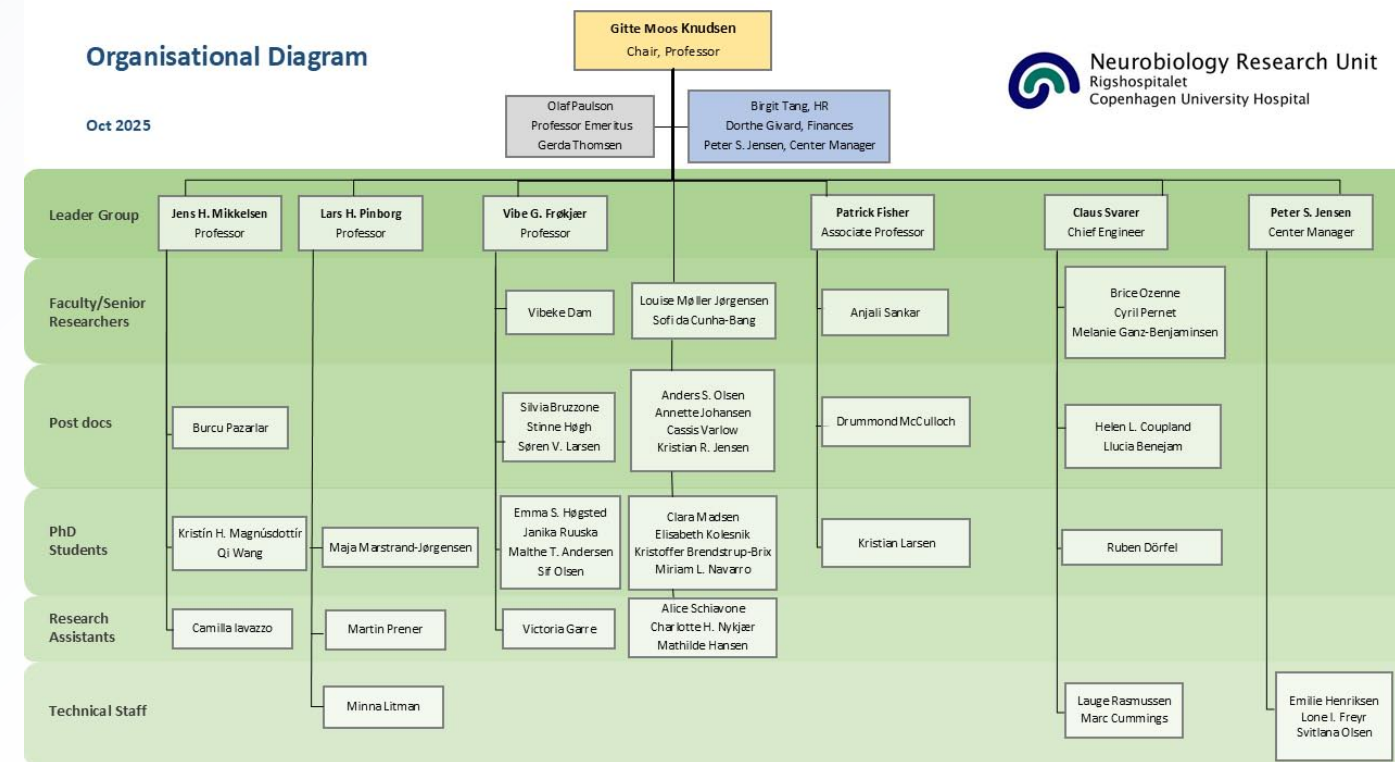
Visiting scientists

Aline Morais de Souza, PhD-stud, Univ. Copenhagen
 Caroline Degel, research assistant, Univ. Copenhagen
 Dan Peters, PhD, DanPET, Sweden
 Darja Beyer, postdoc, Univ. Copenhagen
 Edvin Marklund, MD
 Friederike Holze, PhD, Univ. Basel, Switzerland

Gjertrud Laurell, postdoc, Columbia Univ., USA
 Júlia Díaz I Calvete, research assistant, Univ. Copenhagen
 Kristian Sandberg, associate professor, Univ. Aarhus
 Martin Korsbak Madsen, PhD, MD
 Martin Nørgaard, assistant professor, Univ. Copenhagen
 Mathilde Hansen, research assistant, Univ. Copenhagen
 Mattias Horan, PhD, MD
 Merlin Zabrocki, PhD-stud, Univ. Copenhagen
 Mostafa El Nagggar, pregraduate student, Univ. Copenhagen
 Nadia B. Pedersen, PhD-stud, Univ. Copenhagen
 Nadia Khavary, pregraduate student, Univ. Southern Denmark
 Paolo Tucci, associate professor, Univ. Foggia
 Philippe Ryvlin, professor, Lausanne University Hospital
 Samantha Delaney, postdoc, Univ. Copenhagen
 Sabrina Salim, pharmacy, Univ. Southern Denmark
 Sara Giopato, Univ. Padova
 Sedra Sbih, pregraduate student, Univ. Southern Denmark
 Sophie Stotz, postdoc, Univ. Copenhagen
 Sumit Pandey, PhD-stud, Univ. Copenhagen
 Thorhalla Sigurardottir, Univ. Copenhagen
 Tobias Gustavsson, postdoc, Univ. Copenhagen
 Vincent Beliveau, postdoc, Innsbruck Medical University
 Vladimir Shalgunov, postdoc, Univ. Copenhagen

Organisational Diagram

Oct 2025



The NRU organisational diagram as of October 2025.

PhD Degrees

Drummond E-Wen McCulloch

Pharmacokinetic and pharmacodynamic evaluation of classical psychedelic substances in the human brain

Summary: This PhD thesis examines the neurological underpinnings of the acute and lasting effects of psychedelics using functional magnetic resonance imaging (fMRI) and Positron Emission Tomography (PET), and to evaluate the relation between the acute mystical-type effects and persisting effects in healthy people. In conclusion, the work constitutes a wide knowledge base describing the acute and lasting effects of psychedelics both behaviorally and neurologically. The outcome of the PhD can help design future studies and highlights candidate biomarkers that can be used to develop our understanding of altered states of consciousness. By measuring psychedelic effects and combining with plasma drug levels, behavioural questionnaires, and fMRI and PET imaging our understanding of the psychedelic drug effects on the human brain is a basis for future development of therapeutics.

Main supervisor: Associate professor Patrick M. Fisher, NRU.

Co-supervisor: Professor Gitte Moos Knudsen, NRU and Dept of Clinical Medicine, Univ. Copenhagen.

Funding: An unrestricted grant from Compass Pathways.

Defense: The successful PhD defense took place on Sep 5th, 2025, with professor Anders Fink-Jensen, Psychiatric Center Copenhagen, Copenhagen University Hospital - Mental Health Services CPH, as chair and with professor David Nutt, Imperial College London, United Kingdom, and professor Diego Vidaurre, Aarhus University, Denmark as opponents.



Kristian Høj Reveles Jensen

Neurobiological Substrates of Depression and Treatment Response. From Brain Structure to Sex Hormones

Summary: This thesis investigates neurobiological mechanisms and biomarkers of treatment response in Major Depressive Disorder (MDD) through three studies using data from the NeuroPharm-1 study conducted previously at NRU. These studies highlight how depression and its treatment involve complex and sex-specific mechanisms that cannot be reduced to simple biomarker-outcome relations. The work provides a foundation for a more nuanced approach to precision psychiatry that accounts for sex differences and multiple interacting biological systems. The thesis also presents the status of the ongoing BrainDrugs-Depression (BDD) cohort study which conducts deep phenotyping of first-episode depression patients in a naturalistic clinical setting in the Capital Region of Denmark. On the basis of the BDD cohort, studies of predictors and mechanisms of treatment response will be enabled, to identify and understand *who benefits from what*.

Main supervisor: Professor Martin Balslev Jørgensen, Psychiatric Center Copenhagen, Copenhagen University Hospital - Mental Health Services CPH.

Co-supervisors: Professor Gitte Moos Knudsen, NRU and Dept of Clinical Medicine, Univ. Copenhagen, senior researcher Vibeke Naja Høyrup Dam, NRU, professor Merete Osler, Frederiksberg Hospital Center for Clinical Research and Prevention, and associate professor Anders Jørgensen, Psychiatric Center Copenhagen, Mental Health Services CPH.

Funding: BrainDrugs center grant.

Defense: Dr. Jensen successfully defended his thesis on Mar 7th, 2025, with professor Jessica M.C. Lohmann, Competence Centre for Transcultural Psychiatry, Mental Health Services CPH as chair, and professor Philip Cowen, Dept of Psychiatry, University of Oxford, United Kingdom, and associate professor Daniel Lindqvist, Dept of Clinical Sciences, Faculty of Medicine, Lund University, Sweden, as opponents.



Sara Marie Ulv Larsen

Homeostatic sleep mechanisms and brain-fluid dynamics in humans

Summary: This thesis examines the interplay between homeostatic sleep mechanisms and brain-fluid dynamics in healthy humans. Sara's work presents the first data linking brain fluid dynamics to sleep slow waves, heightened sleep pressure and norepinephrine. It also disentangles the effects of sleep deprivation and autonomic arousal from those of sleep itself and suggests that sleep may not be the sole driver of brain clearance, as cerebrovascular oscillations are regulated by heightened sleep need and norepinephrine levels.

Main supervisor: Professor Gitte Moos Knudsen, NRU and Dept of Clinical Medicine, Univ. Copenhagen.

Co-supervisor: Dr. Sebastian Camillo Holst, NRU and Roche, Switzerland.

Funding: The work was supported by the Danish Research council.

Defense: The successful PhD defense took place on Apr 4th, 2025, with professor Adam Espe Hansen, Dept of Clinical Medicine, Univ. Copenhagen, as chair and with professor Rune Enger, GliaLab and Letten Centre, Division of Anatomy, Dept of Molecular Medicine, Institute of Basic Medical Sciences, University of Oslo, Norway, and associate professor Swati Rane Levendovszky, Dept of Radiology, University of Washington Medical Center, USA, as opponents.



Silvia Elisabetta Portis Bruzzone

Genetic and Epigenetic Determinants of Serotonin Neurotransmission: Mapping Predictive Risk- and Treatment Markers for Depressive Episodes

Summary: This thesis assesses how genetic and epigenetic variation within genes relevant for serotonin function can shape in-vivo serotonergic neurotransmission, both in the healthy and in the depressed state, to gain a better understanding of how DNA methylation of serotonin-related genes can be used as a biomarker in the context of depression and antidepressant treatment.

Main supervisor: Professor Vibe G. Frøkjær, NRU and Dept of Clinical Medicine, Univ. Copenhagen.

Co-supervisors: Associate professor Patrick M. Fisher and professor Gitte Moos Knudsen, NRU, and professor Klaus-Peter Lesch, Division of Molecular Psychiatry, University Hospital Würzburg, Germany.

Funding: The European "Serotonin and Beyond" Innovative Training Network consortium.

Defense: Dr. Bruzzone's successful defense took place on Feb 7th, 2025, with professor Bjørn H. Ebdrup from Centre for Neuropsychiatric Schizophrenia Research, Univ. Copenhagen as chair, and associate professor Charlotte Cecil from Dept of Child and Adolescent Psychiatry/Psychology, Erasmus MC University Medical Center, Rotterdam, The Netherlands, and associate professor Christiane Gasse, Dept of Affective Disorders and Psychosis Research Unit, Aarhus University Hospital Psychiatry, Denmark, as opponents.



Honors and Awards

The achievements of our employees continue to reflect the high level of expertise, dedication, and scientific excellence that define our organization. Throughout 2025, several colleagues received prestigious honors and awards in recognition of their outstanding contributions to research, innovation, and academic leadership.

These distinctions not only celebrate individual accomplishments but also underscore our commitment to advancing scientific discovery and translating research into meaningful benefits for patients and society. We are proud to highlight the recognitions received by our employees during the year and congratulate them on these well-deserved achievements.

Among the notable recognitions in 2025, professor Lars H. Pinborg was awarded the 2025 Niels A. Lassen Prize in recognition of his significant contributions to clinical neuroscience and brain imaging research. Named after one of Denmark's most influential medical researchers and a pioneer in the measurement of cerebral blood flow and brain function, the prize honors researchers who have made outstanding contributions to the field. The award reflects professor Pinborg's longstanding commitment to advancing the understanding of epilepsy and improving patient care through translational and clinically relevant research.

Professor Gitte Moos Knudsen received the University of Copenhagen's Clinical KFJ Prize, awarded by the Kirsten and Freddy Johansen Foundation. The award recognizes her internationally leading contributions to neuroscience and brain imaging research, and in particular her pioneering work in advancing the understanding of brain biology and function through innovative neuroimaging methods. Over several decades, her research has helped establish new approaches for investigating neurological and psychiatric disorders, contributing significantly to the development of more precise diagnostic and therapeutic strategies.



Professors Lars H. Pinborg and Gitte Moos Knudsen.

In addition to these senior recognitions, several early-career researchers received awards for excellence in scientific communication and presentation of their research. PhD student Sif Olsen was awarded first prize for Best Poster at the Annual Psychiatric Research Day at Rigshospitalet for her presentation of research on emotion processing bias and cerebral serotonin 1B receptor binding in violent offenders with psychopathic traits. PhD student Clara Madsen received the award for the second-best poster at the NeuroGrad Winter School for her work on cerebral serotonin 2A receptor occupancy and the behavioural effects of classic serotonergic psychedelic drugs. Furthermore, postdoc Søren Vinther Larsen was awarded the Danish Society for Affective Disorders' dissemination prize "Affekten" for his contribution to research on the association between intrauterine system hormone dosage and depression risk.

Together, these awards highlight the high quality of research conducted by our early-career scientists and their ability to effectively communicate complex scientific findings to both specialist and broader audiences.



PhD students Sif Olsen and Clara Madsen and postdoc Søren Vinther Larsen.

Positions of Trust

Professor Gitte Moos Knudsen

Past-president of European College of Neuropsychopharmacology (ECNP), chair of the ECNP Psychedelics Network, board member of the Neuroscience Academy Denmark, the Bridge Program, and the Elsass Foundation and the Warawara Larsen Foundation, and member of Scientia Fellows program assessment committee at the University of Oslo, Norway. Representing Professor for Neurology at Univ. Copenhagen. Scientific advisor for the Savværksejer Jeppe og hustru Ovita Juhls mindelegat. Adjunct professor at University of Vienna, Austria. In 2025, PhD-examiner of Dr Saeka Shimochi, University of Turku, Finland, and Dr Laust Vind Knudsen, University of Southern Denmark, and reviewer for several journals, including Nature Neuroscience, Nature, and Molecular Psychiatry.

Professor Emeritus Olaf B. Paulson

Member of the Research Ethical Committee for Science and Health at Univ. Copenhagen and of the Research Ethical Committee of the Capital Region of Denmark. Member of the International Advisory Board for the NeurInsight LLC project, a program led by Prof. Stefan Posse, Albuquerque, USA and supported by the NIH. Auditor for Danish Society for Neuroscience.

Professor Jens D. Mikkelsen

Deputy Chairman for external evaluations of medical educations in Denmark (Censorformandskabet for Lægeuddannelsen i Danmark). Reviewer for several journals including PNAS and Translational Psychiatry.

Professor Vibe G. Frøkjær

Appointed Danish representative in the management committee for the EU-based Riseup-Post Partum Depression (PPD) COST Action, and member of the Neuroimaging Network, the Psychedelics Thematic Working Group and the Meta network on depression of ECNP. Board member of Danish Society for Affective Disorders. Research advisory board member for “Sygeforsikring Danmark” donations and Independent Research Council Norway. PhD-assessor at Karolinska University, Sweden, Tübingen University, Germany, and Univ. Copenhagen, Denmark, and reviewer for several scientific journals including Nature Mental Health and Molecular Psychiatry.

Professor Lars Pinborg

Member of the board of the Danish Epilepsy Society, and chair of the Danish Epilepsy Surgery Programme.

Associate professor Patrick M. Fisher

Core member of the ECNP Psychedelics Network. Working Group Leader for PSY-NET, an EU COST Action network around advancing psychedelic research. Auditor for the Danish Society for Neuroscience. Editorial Board member of the Psychedelic Medicine peer-review journal publication. Reviewer for several scientific journals.

Associate professor Melanie Ganz

Member of the Cross-Academy Collaboration sub-committee under the Danish Data Science Academy, of the ELIAS node Copenhagen, and of the Pioneer Center for AI. Secretary of the ISMRM Motion Detection & Correction study group. Reviewer for several journals, including Lancet Digital Health and Magnetic Resonance in Medicine.

Associate professor Louise Møller Jørgensen

Committee member of The National Medical Ethical Committee (National Ethic Center). Chairman of the committee for spine surgery (DNKS). Member of ‘Innovation Working Group’ (SUND, Univ. Copenhagen), ‘Strategic Partnerships’ (DTU and Rigshospitalet) and ‘New National Research Network for Spine Surgery’ (DRKS). Course co-leader of “Innovation” (SUND, Univ. Copenhagen). Reviewer for scientific journals (Acta Neurochirurgica, Brain Sciences).

Senior Research Software Developer Cyril Pernet

Past-chair of the Organization for Human Brain Mapping (OHBM) Best Practice Committee. Permanent guest of the Ethic and Society committee for EBRAINS, the EU neuroscience infrastructure. Editorial board member for Scientific Report. Reviewer for several scientific journals.

Strategic Collaborations

Strong collaborations are fundamental for excellent brain research to happen. We have for many years worked closely together with many different researchers, both within Denmark and internationally. Listed below are some of our major strategic collaborations outside the Dept of Neurology.

PET and Cyclotron Unit, Rigshospitalet

We highly appreciate our long-lasting and outstanding collaboration with all the dedicated staff at the PET and Cyclotron Unit at Dept of Clinical Physiology, Nuclear Medicine & PET. The collaboration covers research and developmental activities and provides NRU with excellent expertise and infrastructure for radiochemistry (Jacob Madsen, Nic Gillings and Vladimir Shalgunov), and PET-, and MR-PET scanner facilities. We highly appreciate this crucial collaboration and look forward to continuing the joint research activities.

Dept of Radiology, Rigshospitalet

Over the last decade, we have had a well-established collaboration with the Dept of Radiology. In 2025, we worked closely together with Dr. Vibeke Andrée Larsen, professor Adam Espe Hansen, chief radiographer Susanne Stampe and radiographers Kevin Robert Brow and Rasmus Nagstrup Jensen.

Dept of Obstetrics and Gynaecology, Rigshospitalet, Herlev, Hvidovre and Hillerød

NRU collaborate in translational clinical trials with senior consultants Kristina Renault, Eleonora Cvetanovska, Ellen Løkkegaard and Anette Kjærbye-Thygesen at Obstetrics Depts in the Capital Region of Denmark in projects aiming at evaluating preventive strategies for perinatal depression in high-risk groups. Our collaboration with professor Øjvind Lidegaard in epidemiological studies on the brain and mental health consequences of oral contraceptive use continues.

Dept of Growth and Reproduction, Rigshospitalet

We collaborate with professor Anders Juul at Dept of Growth and Reproduction on determination of sex steroids in large clinical populations related to brain signatures of hormonal rhythms.

University of Copenhagen

For two decades, we have had a close collaboration on PET radioligand development with Dept of Drug Design and Pharmacology (professors Herth, Kristensen and Jensen). The collaboration was launched through our previous Cimbi project, and today, it includes various joint projects focusing on preclinical evaluation of novel radiopharmaceuticals. The Cimbi group meet regularly, and in September 2025 an annual symposium was held.

Likewise, we have had a long-standing collaboration on biostatistics with Section of Biostatistics, Faculty of Public Health, with whom we share a biostatistical associate professor (Dr. Ozenne) through the *BrainDrugs* project. Also, we appreciate our important collaboration with The Center for Translational Neuromedicine (professor Nedergaard), not the least through the newly established Nordic Center for Glymphatics, and with the Dept of Psychology with associate professor (Dr. Stenbæk). Finally, we also highly appreciate our strategic collaboration with Dept of Computer Science, facilitated by a joint associate professor (Dr. Ganz) as well as cooperation in the *BrainDrugs* project. Professor Jens H. Mikkelsen heads the Master's program in Neuroscience.

Mental Health Services in the Capital Region of Denmark

NRU has close collaborations with Mental Health Services in the Capital Region of Denmark, including with professors Martin Balslev Jørgensen and Lars Vedel Kessing who are both directly involved in *BrainDrugs*, with professor Kamilla Miskowiak and her Neurocognition and Emotion in Affective Disorders (NEAD) group through, e.g., *BrainDrugs*, as well as with professor Anders Fink Jensen.

For our *BrainDrugs* project, we benefit greatly from our close collaboration with Eva Hundrup from CVD ('Center for Visitation og Diagnostik'), a unique central referral site for 'treatment packages', e.g., for patients with depression or obsessive-compulsive disorder who can be treated in outpatient settings.

University of Cambridge, UK

We are collaborating with professor Trevor Robbins from University of Cambridge on a joint research project funded by the Lundbeck Foundation. The collaboration has included bilateral secondments. Data acquisition was completed in 2024, and data are currently being analysed.

Stanford University, National Institutes of Health, and Martinos Center, US

The OpenNeuroPET project, funded through the BRAIN initiative and the Novo Nordisk foundation has been going on since 2019. You can read more about the project on page 46. The collaboration with Stanford was further strengthened in 2024 by the international KFJ Award being given to professor Russ Poldrack.

Martinos Center, Massachusetts General Hospital, US

We have for more than 15 years had a fruitful collaboration with the Athinoula A. Martinos Center for Biomedical Imaging in Boston, US. The collaboration has included retreat meetings, the successful achievement of a joint 2-year NIH grant, the NRU-anchored *NeuroPharm* Center grant (2015-22) from the Innovation Fund Denmark, and funding from Lundbeck Foundation for instructor at Harvard University, Dr. Hansen, as well as bilateral exchange of scientists. Joint research areas include PET-MR of animals, PET data modelling, motion correction, and the OpenNeuroPET initiative, funded by the US Brain Initiative and the Novo Nordisk Foundation. The collaboration has so far resulted in more than 27 joint publications.

The Serotonin and Beyond European Innovative Training Network (ITN)

We have been partners in the consortium *Serotonin and Beyond* (www.serotonin-and-beyond-project.eu/) since its establishment in 2021. The consortium aims to establish fundamental insights in how early life changes in serotonin caused by genetic or environmental factors alter brain development and thereby contribute to brain health.

GoodVibes (Neurodegenerative Disease Research, JPND)

In this project funded jointly by EU and the Innovation Fund Denmark, we collaborate with University of Copenhagen, University of Oulu, Semmelweis University, University Hospital of Porto, and Radboud University to establish neuroimaging methods to assess the brain fluid fluxes during sleep and other interventions.

EBRAINS

EBRAINS (www.ebrains.eu) is an EU-funded project (38 million Euro) that provides a digital research infrastructure to accelerate collaborative brain research between leading organizations and researchers across the fields of neuroscience, brain health, and brain-related technologies. We are collaborating with sites in Padova, Munich and Vienna to acquire state-of-the art simultaneous FDG-PET, MRI, and EEG data from a total of 206 healthy individuals. NRU contributes with data acquisitions in 60 of these, and by the end of 2025, 25 studies had been completed.



*For the science and treatment
of disorders of the brain*

The European College of Neuropsychopharmacology (ECNP) is an independent scientific association dedicated to the science and treatment of disorders of the brain. It is the largest non-institutional supporter of applied and translational neuroscience research and education in Europe.

Every year, NRU receives interns through the ECNP visiting scientists' program. Also, NRU is involved in several of the ECNP Networks and in October 2025, several NRU scientists were represented with orals or posters at the 38th annual ECNP Congress in Amsterdam, The Netherlands.

As president of ECNP from 2019-22, professor Gitte Moos Knudsen was in 2025 board member as ECNP past-president, from 2022-25. She is also chair of the ECNP Network on Psychedelics, a European network on translational research in classic psychedelics. Professor Vibe G. Frøkjær was in 2025 elected as a new ECNP board member.



NRU participants at the ECNP Congress 2025 in Amsterdam.

BrainDrugs

The strategic research alliance *BrainDrugs* (2019-26) is our large-scale precision medicine project in epilepsy and major depressive disorder (MDD) (<https://braindrugs.nru.dk>) founded based on a generous grant worth 40 mio DKK from the Lundbeck Foundation. The research programme in the alliance is composed of five work packages which together aim to establish key features predictive of drug response in patients with epilepsy or MDD by uniquely combining register data, advanced neuroimaging, and translational cohorts.

In 2025 we have seen the completion of some of the work packages, while the remaining ones have been fully engaged in data collection and analysis. We have devoted significant effort to disseminating our exciting findings. In total, we have published nearly 20 new papers, bringing our all-time *BrainDrugs* publication count to 56. In October 2025 we hosted for the sixth time a productive *BrainDrugs* annual meeting with more than 35 participants (see photo below). On the following pages you will find a short update from each of the work packages.

Center director
Gitte Moos Knudsen



Participants at the BrainDrugs 2025 Annual Meeting.

WP1: National registries

All the planned activities in this WP have been completed. We have focused on epilepsy/MDD patients' drug intake to identify comorbidity, potential side effects, and drug response. Also, we have used Danish population-based registries to validate the outcome of various pharmacological interventions. The outcome of the research in WP1 has helped shape the work in the other work packages.

In summary, since 2019 we have had two successful PhDs (Eva Bølling-Ladegaard in Aarhus and Simon Ziersen in Copenhagen) and have published in total 13 peer-reviewed papers.



WP1-leader: Professor
Lars V. Kessing

WP2: Electronic patient data: Text mining and machine learning

Last year, we finally received the new Electronic Patient Records from Filadelfia, this time including biochemical data, and we now use the clinical notes from Filadelfia to identify subgroups of focal and generalised epilepsy using our text mining algorithm published in 2023.

Furthermore, we include the biochemical values from Filadelfia to expand our analysis of potential adverse drug events related to anti-epileptic medications by identifying initial exposure to anti-epileptic drugs and detect first-time occurrences of abnormal laboratory test results. For this, we developed a Cox multistate model that computes hazard ratios for changes in laboratory test results before and after exposure to anti-epileptic medications. We have identified several potential adverse drug events following specific anti-epileptics. However, as majority of these patients will receive more than one drug at a time, we will adjust for polypharmacy. One challenge with polypharmacy is that specific combinations is often only given to one patient, hence we will investigate drug combinations within several patients.



WP2-leaders: Professor Søren Brunak &
associate professor Desmond Elliott

WP3. Deep phenotyping data from established research cohorts

We have completed processing of second wave of our deep phenotyping data from the Cimbi and NEAD databases, including functional and structural imaging outcomes, available at our data platform at Denmark Statistics in combination with relevant outcomes from the National Health Register and the drug prescription register.

In 2025 we presented WP3 findings at international conferences, including the Society for Biological Psychiatry in Toronto, CINP in Melbourne, and the ECNP in Amsterdam, and published eight papers [10, 19, 21, 41, 72, 75, 77, 90].

WP4. Deep phenotyping data from new research cohorts

In WP4, we have continued data collection in the two growing cohorts of patients with MDD and epilepsy, most of them with a first-time diagnosis. Patients are deep phenotyped and followed longitudinally. With the experience gained from the other work packages, we use these cohorts to address new research questions and if relevant, to replicate previous findings.

In collaboration with Mental Health Services in the Capital Region, MDD patients are recruited to the BrainDrugs-Depression (BDD) study via the central visitation and all clinics. By end of 2025, a total of 473 patients had been included so far across three cohorts. Cohort 1 includes basic data, cohorts 2-3 expanded clinical, cognitive, psychometric and biological data; cohort 2 also includes MRI and EEG, while cohort 3 adds PET imaging ([11C]-UCB-J) in medication-naïve patients. Early analyses show similar severity across cohorts, suggesting limited selection bias.

In 2025, six BDD-related papers [4, 42, 43, 44, 51, 98] were published, and Kristian R Jensen defended his thesis and received his PhD degree. He is continuing as a postdoc in BDD as well as in a new project that continues to build on the BDD framework - this is funded by the Independent Research Council aiming to advance our understanding and treatment of depression by leveraging the wealth of BDD data collected so far. In combination with existing BrainDrugs funding, the new project enabled in Aug 2025 the employment of Malthe T. Andersen as a new 3-year PhD student for BDD.

Over the past year, the BrainDrugs-Epilepsy (BDE) cohort has expanded steadily and now includes 275 patients. This reflects strong collaboration between the



WP3-leaders: Professors Vibe Frøkjær & Kamilla Miskowiak



WP4-leaders: Professors Lars Pinborg & Martin B. Jørgensen

NRU team, who oversees testing and coordination, and the multidisciplinary teams from hospitals in the Capital Region. We expect to reach 340-350 patients by the end of 2026.

Early analyses from MSc and student projects have informed clinical practice and are now incorporated as quality indicators in the national epilepsy database launched in 2025 by 'Sundhedsvæsenets Kvalitetsinstitut' and the Danish Epilepsy Society, co-chaired by Professors Lars Pinborg (WP4) and Jakob Christensen (WP1).

BDE PhD-student Maja Marstrand-Jørgensen is currently on leave but two manuscripts are planned on SV2A in epilepsy surgery and new-onset epilepsy, including rsfMRI/connectome work. During her secondment at King's College London, Maja explored AI-based tools for detecting epilepsy-related MRI abnormalities in the BDE cohort. Maja will hand in her PhD thesis in late 2026. Helene Kaas also completed a stay at King's College in 2025 and she was enrolled as a new PhD-student in BDE in Dec 2025. Martin Prener has covered BDE clinics and leads a WP4-WP5 project building a dataset of 1,000 newly diagnosed epilepsy patients from electronic health records in the Capital Region and Region Zealand. This dataset will train large language models to extract structured data from tens of thousands of patient records in Eastern Denmark, enabling a retrospective cohort to complement the WP4 database. Martin's project focuses on psychiatric/cognitive dysfunction and polypharmacy patterns in epilepsy. He is expected to enroll as a PhD-student at NRU in early 2026.

WP5. Mining neuroimaging data

WP5 focuses on establishing models to identify structural abnormalities relevant to epilepsy in structural MR images in order to establish criteria to assist clinicians in their future diagnostic work. To train these models, we leverage existing MR data available from the PACS medical imaging archival system of the Capital Region of Denmark. We aim to create language models able to process the associated radiology reports and provide corresponding labels characterizing the pathologies described.

We have completed our evaluation of deep learning models for detection of focal cortical dysplasia, and this will be published early 2026. Image data preparation and BIDS conversion also progressed, with our new WP5 postdoc Lluçia C. Benejam collecting a large dataset of epilepsy patients with polymicrogyria and controls. She is preparing a data descriptor article and testing algorithms for automatic polymicrogyria detection. Collaboration with WP2 (Desmond Elliot) has expanded with research assistant Alice Schiavone, leading to development of new advanced multilingual models for radiological report classification.



WP5-leaders: Associate professor Melanie Ganz-Benjamin & professor Gitte Moos Knudsen

The NRU Neuroimaging Laboratory

3T MRI scanner

Magnetic resonance imaging (MRI) is central to many of our research projects. We also facilitate collaborative, high-quality clinical brain imaging research studies at Rigshospitalet. We acquire MRI data primarily at MR001, NRU's own Siemens 3T Prisma scanner in the North Wing building. We have trained MR-assistants that help with research studies during working hours as well as evenings and weekends.

We continue to enjoy a great collaboration with Siemens which facilitates the implementation of new plans to be established at the scanner.

Below is a brief overview of MRI-based studies that were on-going in 2025:

- The ALTIBRAIN, CAVIR, TRANSCIN, EPIC, PREDICT-10 and BACE studies rooted in the NEAD group led by professor Kamilla Miskowiak from Psychiatric Center Copenhagen acquires structural and functional MRI (fMRI) to evaluate brain imaging markers associated with mood disorders, associated treatments, alterations in cognition, and neuroplasticity.
- The BrainDrugs initiative collects MRI data in cohorts with depression and epilepsy.
- Projects using ultra-fast and non-invasive MRI tool for measuring brain pulsations in collaboration with profs. Rigmor Jensen and Steen G Hasselbalch to aid diagnosing patients with increased intracranial pressure and idiopathic normal pressure hydrocephalus, respectively.
- The MAMA project with professor Vibe Frøkjær examines the effect of breast-feeding and oxytocin on brain structure and function.
- The Stroke Project led by professor Gitte Moos Knudsen from NRU applies MRI to evaluate structural, neuroplastic and functional brain changes following stroke.
- The ADHD project led by Sofi da Cunha at NRU uses fMRI and spectroscopy to evaluate brain activation during reward, response inhibition, and working memory in individuals with ADHD.
- The NP2-P2c project led by Patrick Fischer uses structural and functional MRI scans to investigate whether a single dose of psilocybin induces lasting changes in brain activity and how music influences the experience and effects.



Emilie Henriksen
Radiographer

- The COG-iEEG project with Drs. Pascal Stevens and Ron Kupers aims to compare responses to sensory, cognitive, social, and affective stimuli measured with sEEG with functional MRI responses to the same type of stimuli in epilepsy patients.
- The QUANTUM Trip Trial with professor Anders Fink Jensen from Psychiatric Center of Copenhagen is a randomized trial that aims to compare placebo vs. psilocybin treatment in alcohol abuse disorder.
- The SEMALCO study with professor Anders Fink Jensen investigates GLP-1 receptor agonist treatment for reducing alcohol intake in patients with alcohol use disorder and comorbid obesity, it applies fMRI and MRS Spectroscopy (MRS) to evaluate brain effects.
- The SEPTUM study with professor Anders Fink Jensen investigates differences in fMRI signal during alcohol related images between patients with alcohol abuse disorder and healthy controls
- The DUAL-Psych study with professor Anders Fink Jensen uses fMRI during alcohol cue paradigm to investigate changes in reactivity after 24 weeks of treatment with GIP/GLP-1 medicine in patients with alcohol abuse disorder and schizophrenia.
- The RESETTLE project led by professor Signe Sørensen Torekov acquires structural and functional MRI data to characterize brain effects of lifestyle-intervention treatment of obesity in young adults.
- The BHB project led by professor Nadia Micali from Center for Eating and feeding Disorders research applies fMRI and MRS to evaluate tolerance of a ketone-based nutritional supplement in refeeding in patients with anorexia nervosa.
- The MECT study with associated professor Anders Jørgensen from Psychiatric Center Copenhagen aims to examine brain morphology and focus on cognition and brain age in relation to ECT treatment.
- In the randomized controlled trial FLEET with associated professor Anders Jørgensen, structural and functional MRI assess how flumazenil-mediated benzodiazepine reversal versus standard benzodiazepine holding before ECT alters brain structure and function and relates to cognitive outcomes after ECT.
- The ASCEND study aims to investigate central nervous system alterations associated with diabetic peripheral neuropathy (DPN) in individuals with type 2 diabetes (T2D) using structural and functional MRI. We will compare brain structure and functional activity between individuals with T2D and DPN, T2D without DPN, and healthy controls.
- The cross sectional and longitudinal DISCOVER project with professor Messoud Ashina aims to investigate exhibitory and inhibitory pain modulators in headache, pain disorders and across migraine phases using structural MRI, fMRI and MRI spectroscopy.

SPECT-CT system

Our 3rd generation high-resolution AnyScan SPECT-CT Mediso scanner provides high-resolution images, and we continue to develop new methodologies in collaboration with Mediso.

Ongoing research projects

DAT-neuromelanin

We have enrolled and scanned patients referred for diagnostic molecular neuroimaging to conduct a 'head-to-head' comparison of the [¹²³I] FP-CIT SPECT-CT and [¹⁸F] FE-PE2I PET-CT modalities as well as an evaluation of the usefulness of adding MR-based neuromelanin measurements. The data analysis has been completed and the article is submitted.

CENTCIST

We are collaborating with Professor Marianne Juhler and Dr. Casper Schwartz Riedel from Dept. Neurology on a study investigating whether central radionuclide cisternography with SPECT can predict the need for permanent cerebrospinal fluid (CSF) diversion in patients with subarachnoid hemorrhage (SAH) treated with external ventricular drains (EVD). By injecting a radiotracer directly into the brain's ventricles, the study aims to better assess CSF circulation and absorption compared to conventional methods. The primary outcome is tracer clearance and its association with later ventriculoperitoneal (VP) shunt requirement.

ADHD

In a study evaluating the dopamine transporter in ADHD patients, NRU postdoc and psychiatrist Sofi Kann finalized data acquisitions from 60 patients. Data analysis is currently ongoing.

Glymphatics

In a series of pig experiments in the GoodVibes project (page 26) we are employing cisterna magna injections of Tc99m-DTPA and following the tracer distribution in the brain by kinetic analysis.

Translocator protein (TSPO)

The SPECT-laboratory also contribute to understanding neuroimmune dynamics in cerebrovascular disease. Using [¹²³I]-CLINDE SPECT imaging, we characterize post-stroke translocator protein (TSPO) expression dynamics and demonstrate correlations between inflammatory responses and chronic infarction burden [48], providing insight into temporal neuroinflammatory processes after ischemic injury and supporting TSPO imaging as a biomarker in stroke recovery research.



Svitlana Olsen
Medical technologist

Clinical work

Patients with neurological disorders are referred to the NRU SPECT-laboratory for diagnostic SPECT investigations from Dept of Neurology, Rigshospitalet and other hospitals in Denmark. The diagnostic investigations include:

Regional cerebral blood flow (CBF) with the SPECT ligand [^{99m}Tc] HMPAO

This examination is mostly used for localizing the epileptic focus in patients with drug-resistant epilepsy that are candidates for epilepsy surgery. We are the only laboratory in Denmark to conduct ictal-interictal SPECT imaging with co-registration to MRI (SISCOM) This requires personnel specifically trained to inject as soon as the epileptic activity commences.

Striatal dopamine transporter (DAT) imaging with the SPECT ligand [¹²³I] FP-CIT

This is a robust technique for early detection of dopaminergic deficits and is used diagnostically in patients with movements disorder and/or dementias of uncertain origin. All hospitals can refer patients suspected for dopaminergic deficits for a diagnostic scan. The diagnostic report comes with a reference to healthy age-matched individuals and is evaluated by a neurologist specialized in reading DAT-SPECT scan data.

Clinical Neuropsychiatry

Apart from BrainDrugs, we also identify brain-based mechanisms underlying neurological and psychiatric disorders and translate these insights into improved strategies for prevention, diagnosis, and treatment. This work combines molecular imaging, multimodal MRI, PET, EEG, neuropsychology, and large-scale epidemiological and computational approaches to uncover clinically relevant biomarkers and mechanistic pathways across disease domains.



Professors Gitte Moos Knudsen, Lars Pinborg, and Vibe G. Frøkjær
(from left to right)

In epilepsy research, our 2025 findings span molecular pathology, reproductive health, and advanced computational diagnostics. In patients with mesial temporal lobe epilepsy, we demonstrated a positive correlation between cortical inflammatory markers and cognitive performance [1], challenging the conventional assumption that neuroinflammation is solely detrimental and suggesting a more nuanced role of inflammatory signaling in disease adaptation or compensation. In women of reproductive age with epilepsy, we identified alterations in ovarian reserve markers [16], highlighting important interactions between epilepsy, antiepileptic treatment, and reproductive endocrine health. At the methodological frontier, NRU contributed to the international MELD consortium study demonstrating that graph neural networks can detect epileptogenic focal cortical dysplasia from MRI data with high sensitivity across multicenter datasets [85]. Published in *JAMA Neurology*, this work represents a major advance in AI-assisted diagnosis and surgical planning for pharmacoresistant epilepsy.

In major depressive disorder (MDD), several studies converged on a mechanistic and biologically stratified understanding of treatment response. We showed that DNA methylation patterns in serotonin-related genes predict antidepressant treatment response [10], supporting epigenetic stratification of patients prior to treatment. Using PET imaging, we demonstrated that antidepressant treatment alters cerebral serotonin 4 (5-HT₄) receptor binding and that these changes are associated with both clinical improvement and verbal memory performance [19], strengthening the rationale for serotonergic receptor-based

interventions. Complementing this, we showed that changes in hippocampal volume, 5-HT₄ receptor binding, and verbal memory co-evolve during treatment [42], linking molecular and structural plasticity to cognitive outcomes. At the systems neuroscience level, whole-brain turbulent dynamics were shown to predict pharmacological treatment responsiveness [30], identifying a novel network-based biomarker of treatment sensitivity. Finally, we demonstrated that whole blood BDNF levels are reduced in patients with depression but remain unchanged following escitalopram treatment [77], suggesting that peripheral BDNF may represent a trait marker rather than a treatment-responsive state marker.

A major area of impact in 2025 has been hormonal transitions and psychiatric vulnerability. In a nationwide longitudinal study published in *JAMA Network Open*, we showed that postpartum initiation of hormonal contraceptives is associated with an increased risk of depression [63], identifying the postpartum period as a particularly vulnerable hormonal transition window. We further contributed methodological analyses highlighting key obstacles in establishing causal links between hormonal contraception and depression in observational studies [65], strengthening the interpretation of epidemiological findings in the field. Extending this line of research to prognostic biomarkers, we demonstrated that amygdala reactivity to threat and negative facial perception predict future psychiatric hospitalizations in patients with major depressive and bipolar disorders [75], linking emotional brain circuitry to long-term clinical outcomes.

In a comprehensive study of brain oscillations after prolonged sleep deprivation, we provide mechanistic evidence that 33 hours of wakefulness exert distinct effects on low frequency brain oscillations. In support of these representing cerebral vasomotion, we find that the vasodilator carvedilol reduces the power of the oscillations. Moreover, sleep deprivation increases vasomotion more than nonrapid eye movement (NREM) sleep does and during sleep, vasomotion correlates with cognitive measures of sleep pressure [99], see **Figure 1**. These findings support the emerging hypothesis that sleep plays a central role in regulating cerebrovascular dynamics and brain clearance mechanisms, with implications for cognition, neurodegeneration, and brain homeostasis.

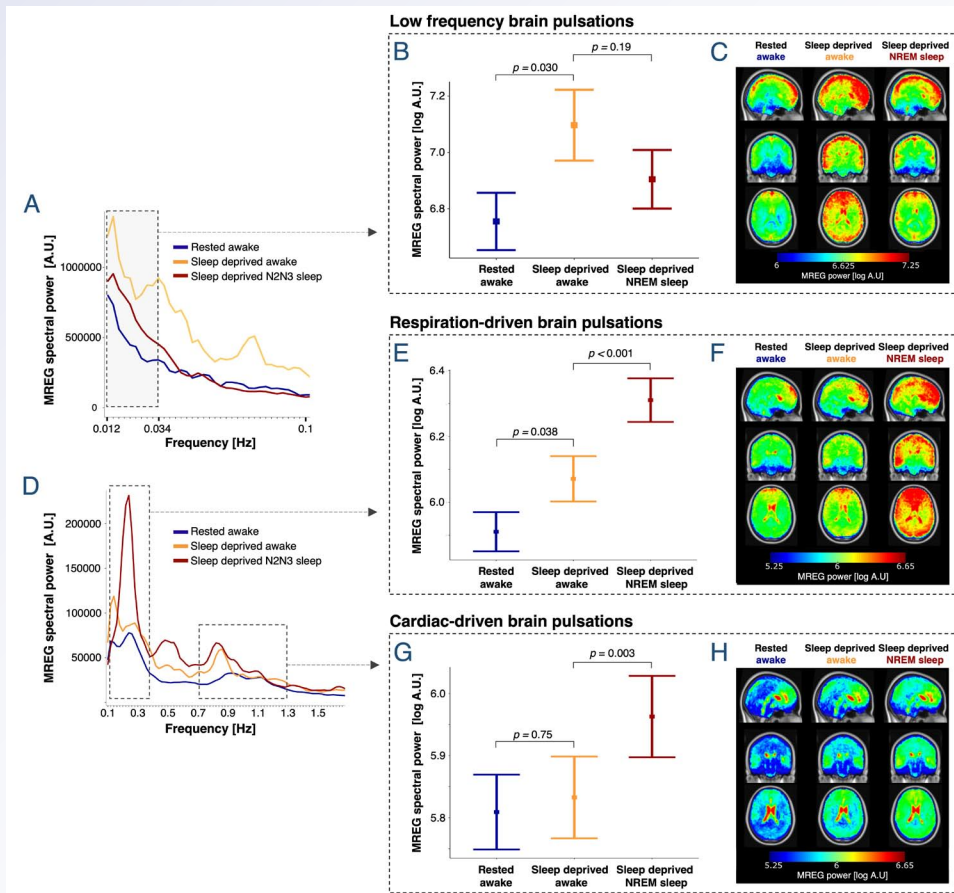
Taken together, these findings illustrate NRU's strength in integrating molecular, structural, functional, computational, and population-based neuroscience approaches to generate mechanistic insights with direct translational relevance. Across epilepsy, depression, hormonal psychiatry, and sleep physiology, our 2025 research has identified biomarkers, mechanisms, and predictive models that support the development of precision medicine in neurology and psychiatry.

Figure 1: Sleep deprivation increases low-frequency brain pulsations (LFP) strength, while NREM sleep is the primary enhancer of respiration- and cardiac-driven brain pulsations.

(A, D) Mean whole-brain MREG spectra across participants. Dashed boxes denote frequency ranges for low-frequency brain pulsations, LFPs, (0.012-0.034 Hz) and for respiration- and cardiac-driven brain pulsations.

(B, E, G) Estimated means±SEM and p-values are from linear mixed models evaluating effects of sleep deprivation and NREM sleep on log spectral power.

(C, F, H) Whole-brain maps illustrate the regional spectral power [log A.U.] in the LFP, respiration, and cardiac frequency bands across all 5-min scans (LFP) or 30-s epochs (respiration and cardiac), averaged across first epochs/scans, then participants (warped into MNI space). N included in analyses=20. From [99], Copyright © 2025, The Authors.



Psychedelics

Psychedelic drugs alter perception and have gained increasing attention due to emerging evidence for their therapeutic potential in hard-to-treat brain disorders. The psychedelic research programme at NRU spans receptor pharmacology, systems neuroscience, subjective effects, and clinical translation, with a focus on establishing mechanistic understanding and informative biomarkers.

Using simultaneous PET-MRI, we characterized the neurochemical profile of serotonin 2A (5-HT_{2A}) receptor partial agonists [7], demonstrating substantial receptor occupancy alongside downstream hemodynamic responses in vivo. This work provides a framework for linking receptor pharmacology to systems-level brain effects.

We showed in healthy humans that psilocybin acutely increases cerebral blood flow and induces arterial constriction, whereas the 5-HT_{2A} receptor antagonist ketanserin had little effect [62], providing evidence for 5-HT_{2A}-mediated modulation of cerebral perfusion and brain physiology.

In collaboration with professor Anders Fink-Jensen from Psychiatric Center Copenhagen, we conducted an open-label single-dose psilocybin therapy study for alcohol use disorder. The study demonstrated feasibility, acceptable safety, and promising efficacy signals [46], while characterizing pharmacokinetic properties relevant for dose optimization and future randomized trials. This work expands the therapeutic potential of psychedelic interventions beyond mood disorders.

We also validated the Danish translation of the Revised Mystical Experience Questionnaire (MEQ30) [38], showing that setting, dose, and participant intention significantly influence the intensity and character of psychedelic experiences, providing an important psychometric tool for Danish clinical and experimental studies.

NRU researchers contributed to several international collaborations. We reviewed two decades of psilocybin trial materials [105], highlighting methodological heterogeneity and opportunities to harmonize protocols and outcome measures. We also addressed the debate on psychotherapy versus minimal psychological support in psychedelic-assisted treatment [58], contributed to a scoping review of antidepressant use with classical psychedelics [97], identifying key knowledge gaps in safety, efficacy, and pharmacodynamic interactions, and participated in validation studies of psychometric and cognitive tools for altered states, including subjective cannabis effects [86] and the Multifaceted Empathy Test in the context of cannabis use and social cognition [87]. Together, these studies strengthen the methodological framework for altered states and socio-emotional research.



Patrick Fisher
Senior researcher

Preclinical Neurobiology

The Experimental Laboratory at NRU conducts translational preclinical research aimed at identifying molecular and cellular mechanisms underlying neurological and psychiatric disorders and at developing neuroimaging radioligands and therapeutic targets. The techniques covered include autoradiography, radioligand validation, molecular neurobiology, biochemical assays, in vivo imaging, and animal behavioral studies; these are used to characterize disease-relevant molecular processes in human tissue and experimental models.

A major research line in 2025 focused on synaptic pathology and neuroinflammation in epilepsy and neurodegeneration. In patients with mesial temporal lobe epilepsy, we demonstrate a positive correlation between cortical inflammatory markers and cognitive performance [1], suggesting that inflammatory processes may reflect compensatory or adaptive mechanisms rather than solely pathological burden. Complementing this, we showed that binding of the monoacylglycerol lipase (MAGL) radioligand [³H]T-401 is altered in both human temporal lobe epilepsy tissue and experimental mouse models [3], supporting MAGL as a translational biomarker of neuroinflammation and a potential therapeutic target. This work, conducted in collaboration with Lundbeck A/S, strengthens the role of the endocannabinoid system in epilepsy-related pathology.

Synaptic imaging and synaptic biology remain a central focus area. We demonstrate that SV2A binding is increased in ApoE ε4 allele carriers with Alzheimer's disease (AD) [71], whereas previous work showed reductions in non-carriers, indicating a genotype-dependent modulation of synaptic markers in AD. These findings challenge the interpretation of SV2A solely as a static marker of synaptic density and support the hypothesis that SV2A may also reflect dynamic presynaptic or physiological adaptations. Extending this concept beyond neurodegeneration, we find increased SV2A expression in the brains of chronic diabetic rats [82], suggesting that synaptic vesicle biology is also altered in metabolic disease states.

Another important focus in 2025 was the development and therapeutic evaluation of molecular imaging targets. Two papers summarize recent advances in PET imaging of the α7 nicotinic acetylcholine receptor and its translational CNS applications [68], as well as the therapeutic challenges and prospects of targeting α7-nAChR for cognitive improvement in AD and schizophrenia [69]. These works consolidate current knowledge on receptor imaging, target engagement, and drug development strategies for cognitive enhancement.



Jens H. Mikkelsen
Professor

In psychoplastogen and neuroplasticity research, NRU contributed to a study published in *Nature Neuroscience* demonstrating that tabernanthalog induces structural and functional neuroplasticity without proximate activation of immediate early genes [5]. These findings challenge prevailing assumptions regarding the necessity of acute transcriptional activation for psychoplastogenic effects and may inform the development of next-generation non-hallucinogenic therapeutics.

The laboratory also completed work from a previous collaboration with the company Arla. We show that in aged animal models, dietary supplementation with a milk sphingolipid-rich MFGM/EV concentrate ameliorated age-related metabolic dysfunction [91]. However, complementary analyses showed that aging itself predominates over supplementation in shaping the brain lipidome and cognitive decline [92], highlighting the complexity of nutritional interventions in brain aging.

These papers demonstrate the breadth of the Experimental Laboratory's translational research program, spanning synaptic biology, neuroinflammation, molecular imaging, neuroplasticity, and metabolic neuroscience. By combining human brain tissue studies, animal models, and radioligand development, the laboratory contributes mechanistic insights and translational tools for precision diagnostics and therapeutic development in CNS disorders.

Data Analysis

The NRU Data Analysis Group develops advanced computational, statistical, and methodological tools for analyzing complex biomedical data across neuroimaging, neurophysiology, and clinical neuroscience. A central goal is to improve robustness, interpretability, and reproducibility in studies characterized by limited sample sizes, multimodal data, and substantial biological and technical noise. In 2025, the group made important contributions to three key methodological challenges in translational neuroscience: brain-age prediction, interpretation of brain imaging correlations, and robustness of analytical pipelines.

A major contribution concerns the development and evaluation of biomarkers for brain aging. In a large comparative study using structural MRI data, we systematically assessed the clinical utility of publicly available brain-age prediction software packages [26]. As illustrated in **Figure 2**, the study demonstrated substantial variability in prediction accuracy and bias across tools, highlighting that software choice can markedly influence estimated brain age and downstream clinical interpretation. These findings provide critical guidance for the selection and standardization of brain-age models in both research and clinical settings and emphasize the need for benchmarking and harmonization before implementation in precision medicine.

Another study addressed a fundamental issue in the interpretation of neuroimaging data. In [32], we demonstrated that spatial correlations within brain maps and population-level correlations across individuals can diverge substantially and may even point in opposite directions. This finding challenges a common implicit assumption in molecular and functional brain imaging research; that spatial associations between modalities or markers necessarily reflect inter-individual biological relationships. By formally distinguishing these two levels of inference, the study provides an important conceptual framework for interpreting multimodal brain imaging data and for avoiding ecological fallacies in neuroscience analyses.

The group also made significant advances in improving analytical robustness and reproducibility in neuroimaging. In [81], we performed a systematic sensitivity analysis of preprocessing pipelines and demonstrated how analytical choices can substantially influence final imaging results. The study proposes a practical framework for “multiverse analyses,” allowing researchers to



Claus Svarer
Chief engineer

quantify the robustness of findings across multiple reasonable preprocessing strategies. This work addresses a major challenge in imaging neuroscience by improving transparency, reproducibility, and confidence in reported findings.

Together, these contributions position the NRU Data Analysis Group at the forefront of methodological neuroscience. By addressing key challenges in biomarker development, statistical inference, and reproducibility, the group provides essential infrastructure for high-quality translational neuroscience and precision medicine research.

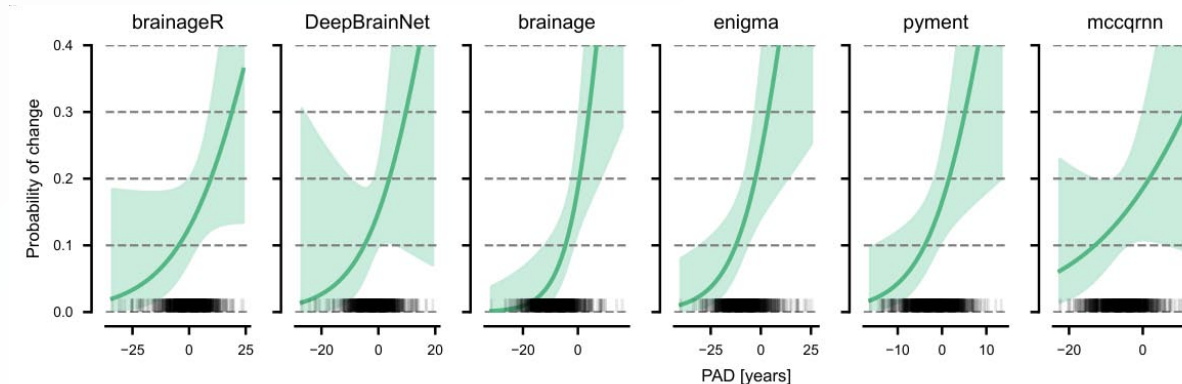


Figure 2: Longitudinal analysis of predicted age deviation (PAD), i.e., the deviation of the predicted brain age from the individual's actual chronological age, for six publicly available brain-age prediction software packages and using data from the Alzheimer's Disease Neuroimaging Initiative (ADNI). A PAD close to zero suggests that the brain appears typical for its age. Each subplot shows the probability of conversion from cognitively normal to mild cognitive impairment or Alzheimer's disease plotted against baseline PAD values for each package. The black rug plot at the base of each subplot shows individual PAD values from the dataset. The shaded areas represent the 95% confidence intervals. Modified from [32], Copyright © 2025, The Authors.

OpenNeuroPET

The NovoNordisk Foundation funded [OpenNeuroPET](#) initiative is done in collaboration with NIH, the Martinos Center, and Stanford University and the Karolinska Institute. It aims at enabling reproducible PET data analysis through data sharing and open analytical tools.

We have previously extended the Brain Imaging Data Structure (BIDS) to cover PET data and published the companion software PET2BIDS (<https://github.com/openneuropet/PET2BIDS>) to convert raw PET data and blood recordings to BIDS. Following BIDS conversion, automated data processing can now be done using *PETPrep* (<https://github.com/nipreps/petprep>) and modelling using *PETfit* (<https://github.com/mathesong/petfit>).

Atlasing activities with *PETprep* and *PETfit* are ongoing, demonstrating the success of OpenNeuroPET at delivering fully reproducible PET analyses. We have also worked on a new multivariate atlas for beta-amyloid from ADNI data [29], see **Figure 3**, and are developing the workflow to generate future templates.

The platform for data sharing, *publicneuro.eu*, is running and hosting multiple datasets. Together, our OpenNeuroPET efforts enable expensive PET neuroimaging data to be shared in a FAIR (Findable, Accessible, Interoperable, and Reusable) manner.



Cyril Pernet
Senior researcher

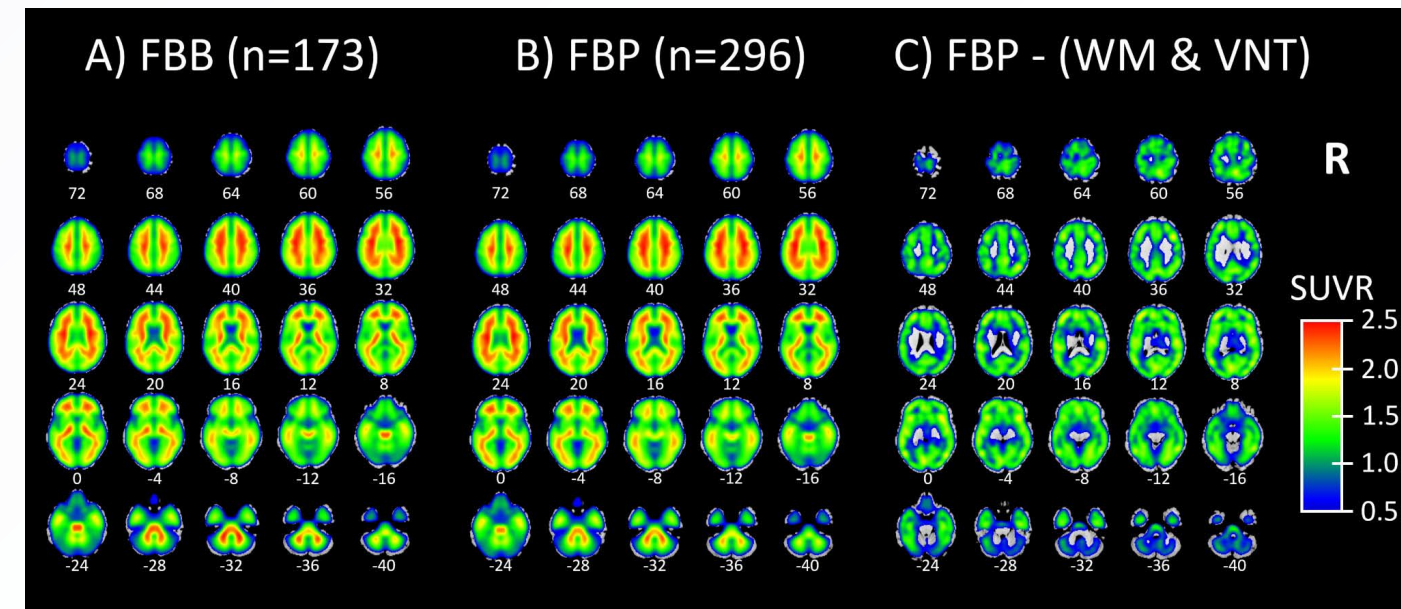


Figure 3: A) Molecular Image Brain Atlas (MIBA) average from 173 florbetaben participants. B) MIBA average of 296 florbetapir participants. C) Florbetapir MIBA average subtracted by white matter (WM) and ventricular (VN) related independent components. In (C) it is seen that the subtraction of WM and ventricles leaves the SUVR signal in gray matter. From [29], Copyright © 2025, The Authors.

Dissemination in 2025

Since the beginning of 2025, NRU has published a total of 4 PhD dissertations, 28 Master's or Bachelor theses and reports, 5 book chapters, and 105 scientific peer-reviewed papers. The list below encompasses all papers that have either been printed or were online ahead of print during 2025.

PhD dissertations

- Silvia Elisabetta Portis Bruzzone. Genetic and Epigenetic Determinants of Serotonin Neurotransmission: Mapping Predictive Risk- and Treatment Markers for Depressive Episodes. University of Copenhagen, Faculty of Health and Medical Sciences. Defended Feb 07, 2025
- Kristian Høj Reveles Jensen. Neurobiological Substrates of Depression and Treatment Response. From Brain Structure to Sex Hormones. University of Copenhagen, Faculty of Health and Medical Sciences. Defended Mar 07, 2025
- Sara Marie Ulv Larsen. Homeostatic sleep mechanisms and brain-fluid dynamics in humans. University of Copenhagen, Faculty of Health and Medical Sciences. Defended Apr 04, 2025
- Drummond McCulloch. Pharmacokinetic and pharmacodynamic evaluation of classical psychedelic substances in the human brain. University of Copenhagen, Faculty of Health and Medical Sciences. Defended Sep 05, 2025

Master's and Bachelor theses and reports

The following list of NRU-affiliated students have successfully defended their theses or research year reports during 2025:

- Alexander Tobias Ysbæk-Nielsen - *Same-same or different? Brain network characteristics during rest and tasks in major depressive disorder - An fMRI-based independent component analysis*. Master's thesis in psychology, University of Copenhagen. Primary supervisor: Signe Allerup Vangkilde
- Ali Ahmad - *Dynamic Changes in Altered States of Consciousness and Subjective Drug Intensity Following Repeated Psilocybin Administration*. Bachelor's thesis in medicine, University of Copenhagen. Primary supervisor: Gitte Moos Knudsen, co-supervisor Martin Korsbak Madsen
- Anne Damgaard Tophøj - *Betydningen af rutine-EEG, optaget 24-måneder post epilepsi-kirurgi, for forudsigelsen af anfaldsfrihed og brugen af antiepileptika (ASM)*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Lars H. Pinborg

- Asmus Tang Dalsgaard - *The acute effect of intravenous administration of levetiracetam on brain functional networks in patients with epilepsy and healthy controls*. Bachelor's thesis in medicine, University of Copenhagen. Primary supervisor: Lars H. Pinborg
- Astrid Skytte Nordentoft Nielsen - *B-waves in healthy people - and how to measure it*. Bachelor's thesis in Medicine, University of Copenhagen. Primary supervisor: Gitte Moos Knudsen
- Ása Michelsen - *Association between trait neuroticism and emotion processing biases in the healthy and depressed state*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Martin Balslev Jørgensen
- Caroline Emilie Ramm & Rosalina Bergenfelt Dioneli - *Investigating Psilocybins Effects on Structural and Functional Plasticity with Focus on 5-HT2A Receptor Involvement*. Bachelor's thesis in Medicine, University of Copenhagen. Primary supervisor: Gitte Moos Knudsen
- Despoina Kazani - *Acute Effects of Psychedelic and Non-Psychedelic 5HT2A Receptor Agonists on Pig's Social Behavior*. Master's thesis in Neuroscience, University of Copenhagen. Primary supervisor: Gitte Moos Knudsen
- Frederikke Jia Ying Bonvig Hassing - *Investigating Psychedelic-Induced Neuroplasticity and Synaptic Density in the Pig Brain: An in vitro Analysis of SV2A, BDNF and PSD-95*. Master's thesis in Medicinal Chemistry, University of Copenhagen. Primary supervisor: Gitte Moos Knudsen
- Ida Vigdis Willumsen - *Forekomst af kognitiv og psykiatrisk dysfunktion hos patienter med første epileptiske anfald, nydiagnosticeret epilepsi og raske kontroller*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Lars H. Pinborg
- Jonas Schultz Ingerslev - *Serotonin 4-receptor-agonists effekt på kognition og depression: Et scoping review*. Master's thesis in human physiology, University of Copenhagen. Primary supervisors: Anke Ninija Karabanov & Vibeke Høyrup Dam
- Julie Frederikke Melander Wedel-Heinen - *Pharmacological characterization of psychedelic and non-psychedelic 5-HT2A receptor agonists towards serotonergic receptors in the pig brain*. Master's thesis in Pharmacy, University of Copenhagen. Primary supervisor: Gitte Moos Knudsen
- Kamilla Gulbæk Nielsen - *Brain 5-HT4 receptor levels, gastrointestinal symptoms and SSRI-related nausea in depression*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Martin Balslev Jørgensen
- Konstantinos Vosinas - *Acute psilocybin effects on mode decomposition-based brain functional connectivity*. Master's thesis in computer science, University of Copenhagen. Primary supervisor: Melanie Ganz-Benjaminen
- Line Wiberg - *Persistent psilocybin-induced changes in personality and association with brain serotonin 2A receptor levels*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Patrick M. Fisher

- Louise Jensine Jensen - *Internationale standarder for postoperative undersøgelser og kliniske kontroller efter epilepsikirurgi*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Lars H. Pinborg
- Magnus Lindberg Christensen - *FmapSynth: Deep Learning-Based Fieldmap Synthesis for BOLD fMRI Distortion Correction*. Master's thesis in computer science, University of Copenhagen. Primary supervisor: Melanie Ganz-Benaminsen
- Manuel Wegmann - *Machine Learning for Longitudinal Brain-Age Prediction*. Master's thesis in computer science, University of Copenhagen. Primary supervisor: Melanie Ganz-Benaminsen
- Maria Philippa Skaadstrup Boesdal - *Præmenstruel forværring af ADHD Forekomst, komorbiditet med PMDD og behandlingsmuligheder*. Bachelor's thesis in medicine, University of Copenhagen. Primary supervisor: Kristian Høj Reveles Jensen
- Markus Rex & Jonathan Ulrich - *Effect of segmentation technique on the quantification of serotonin binding potential using PET and MRI data*. Bachelor's thesis in biomedical engineering, Technical University of Denmark and University of Copenhagen. Primary supervisor: Patrick M. Fisher
- Noa Lorette Roumimper - *Maternal Brain reORganisation (MOR): Intracortical myelin Signatures of Peripartum Structural Remodelling*. Master's thesis in neuroscience, University of Copenhagen. Primary supervisor: Vibe G. Frøkjær
- Randi Thorbøll Kjær - *Parental Bonding Quality and Familial risk for depression: A Neuroimaging Study of Neostriatal 5-HT₄ Receptors*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Martin Balslev Jørgensen
- Rikke Brandt Bangsgaard - *Sleep quality in late pregnancy is associated with maternal mental health in the early postpartum period*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Vibe G. Frøkjær
- Siri Vulpus - *Text mining of electronic health records can validate a register-based diagnosis of epilepsy and subgroup into focal and generalized epilepsy*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Lars H. Pinborg
- Sofie Vinther Skriver - *The acute effects of DMT or ayahuasca on EEG spectral power in humans*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Patrick Fisher
- Sophie Christine Bolwig - *Pineal Gland Volume, Sleep Quality, and Psychiatric Disorders: A Systematic Review and Meta-Analysis*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Kristian Høj Reveles Jensen
- Souline Ahmad - *Longitudinal Assessment of Choroid Plexus Dynamics in Natural and Contraceptive Cycles*. Master's thesis in medicine, University of Copenhagen. Primary supervisor: Kristian Høj Reveles Jensen
- Victor Kaplan Kjellerup - *Predicting the psychedelic experience from brain imaging data*. Bachelor's thesis in biotechnology, University of Copenhagen. Primary supervisor: Patrick M. Fisher

Books and book chapters

- B1. Deltuvaite-Thomas V, Ozenne B, Péron J, de Backer M. Right-censored data. In: Buyse M, Verbeeck J, Saad ED, De Backer M, Deltuvaite-Thomas V, Molenberghs G. (eds) Handbook of Generalized Pairwise Comparisons: Methods for Patient-Centric Analysis. CRC Press. 2025. s. 98-109 doi: <https://doi.org/10.1201/9781003390855-4>
- B2. Feragen A, Petersen E, Ganz-Benaminsen M. The cause and effect of an MR image: Robustness and generalizability. In: Kuestner T. (eds) Machine Learning in MRI - From Methods to Clinical Translation. Advances in Magnetic Resonance Technology and Applications, 2025, Volume 13, 2025, Pages 465-485. Academic Press. <https://doi.org/10.1016/B978-0-443-14109-6.00016-X>
- B3. Ozenne B, Verbeeck J. Inference. In: Buyse M, Verbeeck J, Saad ED, De Backer M, Deltuvaite-Thomas V, Molenberghs G. (eds) Handbook of Generalized Pairwise Comparisons: Methods for Patient-Centric Analysis. CRC Press. 2025. s. 98-109 doi: <https://doi.org/10.1201/9781003390855-4>
- B4. Ozenne B, De Backer M. An R software package for GPC. In: Buyse M, Verbeeck J, Saad ED, De Backer M, Deltuvaite-Thomas V, Molenberghs G. (eds) Handbook of Generalized Pairwise Comparisons: Methods for Patient-Centric Analysis. CRC Press. 2025. s. 316-350 doi: <https://doi.org/10.1201/9781003390855-4>
- B5. Pernet CR, Fisher PM. Functional MRI: Applications in Cognitive Neuroscience. In: Filippi M. (eds) fMRI Techniques and Protocols. Neuromethods, 2025, vol 220. Humana, New York, NY. <https://doi.org/10.6084/m9.figshare.30499532>

Papers in peer-reviewed journals

1. Al-Awssi A, Pazarlar BA, Pinborg LH, Mikkelsen JD. Positive correlation between cognition and inflammation in the cerebral cortex of patients with mesial temporal lobe epilepsy. *Epilepsy Behav.* 2025 Dec;173:110752
2. Andreu H, Miskowiak KW, Macoveanu J, Kessing LV, Vieta E, Knudsen GM, Frøkjær VG, Sankar A. Reduced ventromedial prefrontal cortex volume and impaired attention associated with past suicide attempts in patients with mood disorders. *J Psychiatr Res.* 2025 Nov;191:501-506
3. Aripaka SS, Pazarlar BA, Pinborg LH, Larsen KB, Gastambide F, Bang-Andersen B, Bastlund JF, Mikkelsen JD. [3H]T-401 binding to monoacylglycerol lipase (MAGL) in the brains of patients and mice with temporal lobe epilepsy. *Neuroscience.* 2025 Oct 1;584:240-249
4. Aarestrup MR, Reveles Jensen KH, Larsen SV, Ozenne B, Köhler-Forsberg K, Knudsen GM, Jørgensen MB, Frøkjær VG. Sex hormones and serotonin 4 receptor brain binding in men with and without major depressive disorder. *Neurosci Appl.* 2025 Feb 28;4:105517

5. Aarrestad IK, Cameron LP, Fenton EM, Casey AB, Rijsketic DR, Patel SD, Sambyal R, Johnson SB, Ly C, Viswanathan J, Barragan EV, Lozano SA, Seban N, Hu H, Powell NA, Chytil M, Meyer R, Rose D, Hempel C, Olson E, Hansen HD, Madsen CA, Knudsen GM, Redd C, Wheeler DG, Guanzon N, Muir J, Hennessey JJ, Quon G, McCorvy JD, Gandhi SP, Rasmussen K, Liston C, Gray JA, Heifets BD, Nord AS, Kim CK, Olson DE. The psychoplastogen tabernanthalog induces neuroplasticity without proximate immediate early gene activation. *Nat Neurosci*. 2025 Sep;28(9):1919-1931
6. Baayen C, Blanche P, Jennison C, Ozenne B. Design and Analysis of Group Sequential Trials for Repeated Measurements When Pipeline Data Occurs: A Tutorial. *Stat Med*. 2025 Jun;44(13-14):e70130
7. Bagdasarian FA*, Larsen K*, Deng HP, Fisher PM, Mandeville JB, Sander CY, Wey HY, Hansen HD. Neurochemical characterization of 5-HT2AR partial agonists with simultaneous PET-MRI. *J Cereb Blood Flow Metab*. 2025 May;45(5):908-919 *Shared first-authors
8. Bangsgaard RB, Høgh S, Borgsted C, Cvetanovska E, Pinborg A, Hegaard H, Høgsted ES, Frokjaer VG. Sleep quality in late pregnancy is associated with maternal mental health in the early postpartum period. *Eur J Obstet Gynecol Reprod Biol*. 2025 Jul;311:113980
9. Bjertrup AJ, Andreu H, Macoveanu J, Sankar A, Moszkowicz M, Nielsen RE, Pagsberg AK, Vieta E, Kessing LV, Miskowiak KW. Reduced prefrontal response to fearful faces in recent mothers with bipolar disorder and its association with mother-infant interaction and infant development. *Psychiatry Res*. 2025 Sep;351:116610
10. Bruzzzone SEP, Ozenne B, Fisher PM, Ortega G, Jørgensen MB, Knudsen GM, Lesch KP, Frokjaer VG. DNA methylation of serotonin genes as predictive biomarkers of antidepressant treatment response. *Prog Neuropsychopharmacol Biol Psychiatry*. 2025 Jan 10;136:111160
11. Bruzzzone SEP, Garre VFS, Høgh S, Frokjaer VG, O'Donnell KJ, Eid RS. A scoping review of functional genomics in perinatal depression. *Front Neuroendocrinol*. 2025 Jul;78:101202
12. Carlomagno F, Bruzzzone SEP, Bonetti L, Brattico E. How To Keep a Brain Plastic with Music: A Mini-Review of Neurophysiological Findings on Music and Ageing. *Ageing Int*. 2025 Oct;50, 51
13. Carney BN, Illiano P, Pohl TM, Desu HL, Mini A, Mudalegundi S, Asencor AI, Jwala S, Ascona MC, Singh PK, Titus DJ, Pazarlar BA, Wang L, Bianchi L, Mikkelsen JD, Atkins CM, Lambertsen KL, Brambilla R. Astroglial TNFR2 signaling regulates hippocampal synaptic function and plasticity in a sex dependent manner. *Brain Behav Immun*. 2025 Oct;129:757-777
14. Christiansen CH, Christensen KB, Høgh S, Renault KM, Emborg MS, Frokjaer VG, Hegaard H. Measuring psychological well-being in a danish pregnancy cohort using the self-reported WHO-5 index. *BMC Psychol*. 2025 Jan 15;13(1):41

15. Colic L, Sankar A, Goldman DA, Kim JA, Blumberg HP. Towards a neurodevelopmental model of bipolar disorder: a critical review of trait- and state-related functional neuroimaging in adolescents and young adults. *Mol Psychiatry*. 2025 Mar;30(3):1089-1101
16. Colombo C, Bentzen JG, Oettinger M, Ewers H, Pinborg LH, Pinborg A, Sabers A. Ovarian reserve markers in women of reproductive ages with epilepsy. *Epilepsy Behav*. 2025 Nov;172:110661
17. Coray RC, Beliveau V, Zimmermann J, Preller KH, Wunderli M, Baumgartner MR, Seifritz E, Stock AK, Beste C, Cole DM, Quednow BB. Memory deficits of MDMA users are linked to cortical thinning related to 5-HT receptor densities. *Brain*. 2025 Oct 22:awaf391. doi: <https://doi.org/10.1093/brain/awaf391>. *Epub ahead of print*
18. Cumming P, Egger K, Knudsen GM. Molecular brain imaging of psychedelic action. *Int Rev Neurobiol*. 2025;181:203-230
19. Dam VH*, Köhler-Forsberg K*, Ozenne B, Larsen SV, Ip CT, Jørgensen A, Stenbæk DS, Madsen J, Svarer C, Jørgensen MB, Knudsen GM*, Frokjaer VG*. Effect of Antidepressant Treatment on 5-HT4 Receptor Binding and Associations With Clinical Outcomes and Verbal Memory in Major Depressive Disorder. *Biol Psychiatry*. 2025 Feb 1;97(3):261-268
20. Damgaard V, Fortea L, Schandorff JM, Macoveanu J, Little B, Gallagher P, Knudsen GM, Kessing LV, Miskowiak KW. Multivariate patterns among multimodal neuroimaging and clinical, cognitive, and daily functioning characteristics in bipolar disorder. *Neuropsychopharmacology*. 2025 May;50(6):976-982
21. Damgaard V, Schandorff JM, Macoveanu J, Sankar A, Zarp J, Fisher PM, Jørgensen MB, Kessing LV, Knudsen GM, Frokjaer VG, Miskowiak KW. Network-wide aberrancies in neuronal activity during working memory in a large cohort of patients with mood disorders: associations with cognitive impairment and functional disability. *Mol Psychiatry*. 2025 Oct;30(10):4836-4844
22. Deininger-Czermak E, Spencer L, Zoelch N, Sankar A, Gascho D, Guggenberger R, Mathieu S, Thali MJ, Blumberg HP. Magnetic resonance imaging of regional gray matter volume in persons who died by suicide. *Mol Psychiatry*. 2025 Mar;30(3):1029-1033
23. Dhanda DS, Olsson TK, Pinborg LH, Jensen P. Flaming heart syndrome: kollektive falske minder i en dansk populærkulturel kontekst [Christmas article: Flaming heart syndrome: Shared false memories in Danish popular culture]. *Ugeskr Laeger*. 2025 Dec 8;187(50):V202513
24. Dichman C, Christensen AV, Berg SK, Stenbæk DS, Winkel BG, Borregaard B, Kjaergaard J, Wagner MK. Early cognitive and psychological symptoms in cardiac arrest survivors and mental health outcomes among relatives: findings from the REVIVAL cohort. *Resusc Plus*. 2025 May 21;24:100975
25. Donath VM, Ries ES, Mariegaard L, Kristensen TD, Ebdrup BH, Strauss GP, Fisher PM, Rostrup E, Nordentoft M, Hilker R, Melau M, Bockting CL, Albert N, van Bennekom MJ, Ambrosen KS, Glenthøj LB. Alleviating negative symptoms in schizophrenia using

- a virtual reality-based therapy targeting social reward learning (ENGAGE): Protocol for a randomised, controlled, assessor-blind pilot study. *PLoS One*. 2025 Oct 8;20(10):e0331632
26. Dörfel RP, Ozenne B, Ganz M, Svensson JE, Plavén-Sigray P; Alzheimer's Disease Neuroimaging Initiative (ADNI). Prediction of brain age using structural magnetic resonance imaging: a comparison of clinical utility of publicly available software packages. *EBioMedicine*. 2026 Jan 2;123:106094. doi: <https://doi.org/10.1016/j.ebiom.2025.106094>. *Epub ahead of print*
 27. Ebrahimifard A, Rajabi H, Geramifar P, Luster M, Yousefi BH, de Nijs R. The impact of the xSPECT reconstruction algorithms on the recovery coefficients value for small tumors: a phantom study with 177Lu. *Nuklearmedizin*. 2025 Apr;64(2):132-140
 28. Egebjerg C, Kolmos MG, Ojeda AV, Breum AW, Frokjaer V, Kornum BR. Disturbing sleep in female adolescent mice does not increase vulnerability to depression triggers later in life. *Brain Behav Immun*. 2025 Mar;125:9-20
 29. Eierud C, Norgaard M, Bilgel M, Petropoulos H, Fu Z, Iraj A, Matheson GJ, Ganz M, Pernet C, Calhoun VD. Building multivariate molecular imaging brain atlases using the NeuroMark PET independent component analysis framework. *Aperture Neuro*. 2025;5. doi: <https://doi.org/10.52294/001c.142578>
 30. Escrichs A, Sanz Perl Y, Fisher PM, Martínez-Molina N, G-Guzman E, Frokjaer VG, Kringelbach ML, Knudsen GM, Deco G. Whole-brain turbulent dynamics predict responsiveness to pharmacological treatment in major depressive disorder. *Mol Psychiatry*. 2025 Mar;30(3):1069-1079
 31. Faulkner P, Knudsen GM, Frokjaer VG, Erritzoe D. Cigarette smoking is associated with levels of the serotonin transporter in the brain: a [11C]DASB PET Study. *Int J Neuropsychopharmacol*. 2025 May 9;28(5):pyaf026
 32. Fisher PM, Larsen K, Plavén-Sigray P, Knudsen GM, Ozenne B. Discordance Between Spatial and Population Correlations From Human Brain Imaging Data. *Hum Brain Mapp*. 2025 Dec 1;46(17):e70421
 33. Fortea L, Ysbæk-Nielsen AT, Zarp J, Fisher PM, Kessing L, Jørgensen MB, Knudsen GM, Radua J, Vieta E, Macoveanu J, Miskowiak KW. Functional connectivity differences in patients with mood disorders: an exploratory fMRI study comparing electroconvulsive therapy with pharmacological treatment. *Neurosci Appl*. 2025 Jun 11;4:105522
 34. Gollion C, Christensen RH, Ashina H, Al-Khazali HM, Fisher PM, Amin FM, Lauritzen M, Ashina M. Somatosensory migraine auras evoked by bihemispheric cortical spreading depression events in human parietal cortex. *J Cereb Blood Flow Metab*. 2025 Mar;45(3):558-567
 35. Gustavsson T, Kustermann T, Hvass L, Wuensche TE, Clausen AS, Stotz S, Shalgunov V, Lopes van den Broek S, Knudsen GM, Aldana B, Ferri E, Cannazza G, Niewoehner J, Gobbi L, Honer M, Battisti UM, Kjaer A, Herth MM. Pretargeted Immuno-PET Enables Monoclonal Antibody Imaging Beyond the Blood-Brain Barrier. *Mol Pharm*. 2025 Dec 1;22(12):7600-7610

36. Hansen N, von Tangen Gehrt Sivertsen C, Stenbæk DS, Blakoe M, Dichman C, Winkel BG, Wieghorst A, Borregaard B, Wagner MK. Assessing adult attachment after out-of-hospital cardiac arrest: an exploratory analysis and construct validation of the ECR-RS. *Resusc Plus*. 2025 Dec 24;27:101209. doi: 10.1016/j.resplu.2025.101209. PMID: 41552630; PMCID: PMC12811464.
37. Hochheim MC, Frokjaer VG, Larsen SV, Dam VH. Effect of combined oral contraceptive use on verbal memory function in healthy women. *Arch Womens Ment Health*. 2025 Oct;28(5):1211-1219
38. Hovmand OR, Ebbesen Jensen M, Søgaard Juul T, Korsbak Madsen M, MacDonald Fisher P, Siggaard Stenbæk D. Validation of the Danish Translation of the Revised Mystical Experience Questionnaire (MEQ30) and Possible Impact of Setting, Dose and Intention. *J Psychoactive Drugs*. 2025 Jan-Mar;57(1):37-46
39. Høgh S, Borgsted C, Hegaard HK, Renault KM, Ekelund K, Bruzzone SE, Clemmensen C, Klein AB, Frokjaer VG. Growth Differentiation Factor 15 during pregnancy and postpartum as captured in blood, cerebrospinal fluid and placenta: A cohort study on associations with maternal mental health. *Psychoneuroendocrinology*. 2025 Jan;171:107212
40. Høgh S, Hegaard HK, Renault KM, Svendsen MN, Navne LE, Frokjaer VG. Women's perceptions of biological causes and potentials of genomic risk markers in postpartum depression: A qualitative study. *Sex Reprod Healthc*. 2025 Mar;43:101057
41. Høgsted ES, Beliveau V, Ozenne B, Madsen MK, Svarer C, Dam VH, Johansen A, Fisher P, Knudsen GM, Frokjaer VG, Sankar A. Consistent evidence that brain serotonin 2A receptor binding is positively associated with personality-based risk markers of depression. *Br J Psychiatry*. 2025 Mar;226(3):137-143
42. Jensen KHR, Dam VH, Köhler-Forsberg K, Ozenne B, Stenbæk DS, Ganz M, Fisher PM, Frokjaer VG, Knudsen GM, Jørgensen MB. Changes in hippocampal volume, 5-HT4 receptor binding, and verbal memory over the course of antidepressant treatment in major depressive disorder. *J Psychiatr Res*. 2025 Jan;181:197-205
43. Jensen KHR. Gender-stratified national mental health norms of BSI-53, BSI-18, SCL-10, ADHD-9, and ADHD-6 for Denmark. *Nord J Psychiatry*. 2025 Jan;79(1):96-102
44. Jensen KHR, Sørensen M, Spanggård A, Juvik AK, Olsen S, Dam VH, Jørgensen MB. Treatment preferences and self-stigma in depression: Development and validation of the brief ATDT-SF. *J Affect Disord*. 2026 Jan 1;392:120233
45. Jensen KHR. Letter to the editor: Needling critical details in acupuncture for delirium. *J Psychiatr Res*. 2026 Jan;192:458-459
46. Jensen ME, Stenbæk DS, Messell CD, Poulsen ED, Varga TV, Fisher PM, Nielsen MKK, Johansen SS, Volkow ND, Knudsen GM, Fink-Jensen A. Single-dose psilocybin therapy for alcohol use disorder: Pharmacokinetics, feasibility, safety and efficacy in an open-label study. *J Psychopharmacol*. 2025 May;39(5):463-473

47. Jensen ME, Klausen MK, Bergmann ML, Knudsen GM, Vilsbøll T, Stove C, Fink-Jensen A. Blood phosphatidylethanol measurements indicate GLP-1 receptor stimulation causes delayed decreases in alcohol consumption. *Alcohol Clin Exp Res* (Hoboken). 2025 May;49(5):1161-1165
48. Jensen P, Ozenne B, Meden P, Feng L, Thomsen G, Knudsen L, Steglich-Arnholm H, Møller K, Thomsen C, Svarer C, Beliveau V, Mikkelsen J, Knudsen G, H Pinborg L. Poststroke Translocator Protein Expression Dynamics and Correlations to Chronic Infarction: A [123I]-CLINDE-SPECT Study. *J Neuroimaging*. 2025 Jan-Feb;35(1):e70002
49. Joshi VL, de la Cour FD, Stenbæk DS, Borregaard B, Hassager C, Wagner MK. The role of in-hospital traumatic distress after out-of-hospital cardiac arrest in later fatigue, sleep quality, and health-related quality of life. *Int J Cardiol*. 2026 Feb 15;445:134043
50. Kas MJH, Penninx BWJH, Knudsen GM, Cuthbert B, Falkai P, Sachs GS, Ressler KJ, Bałkowiec-Iskra E, Butlen-Ducuing F, Leboyer M, Marston H, Luthman J, Mantua V. Precision psychiatry roadmap: towards a biology-informed framework for mental disorders. *Mol Psychiatry*. 2025 Aug;30(8):3846-3855
51. Ketildottir GD, Ip CT, Frokjaer VG, Giraldi A, Jørgensen MB, Reveles Jensen KH. Serotonergic activity estimated by EEG loudness-dependent auditory evoked potentials as a predictor of sexual SSRI side effects. *J Psychiatr Res*. 2025 Nov 5;192:409-416
52. Kim JA, Sankar A, Marks R, Carrubba E, Lecza B, Quatrano S, Spencer L, Constable RT, Pittman B, Lebowitz ER, Silverman WK, Swartz HA, Blumberg HP. Chronotherapeutic intervention targeting emotion regulation brain circuitry, symptoms, and suicide risk in adolescents and young adults with bipolar disorder: a pilot randomised trial. *BMJ Ment Health*. 2025 Feb 19;28(1):e301338
53. Kjeldsen MZ, Liu X, Madsen KB, Elliott AF, Kjeldsen SZ, Mægbæk ML, Bergink V, Frokjaer VG, Munk-Olsen T. Partner status and partner mental health and the risk of postpartum depression. *Nat. Mental Health*. 2025; 3, 814-820
54. Kjærstad HL, Jespersen AE, Bech JL, Weidemann S, Bjertrup AJ, Jacobsen EH, Simonsen S, Glenthøj LB, Nordentoft M, Reveles K, Wøbbe T, Lopes M, Lyngholm D, Miskowiak KW. Optimizing differential diagnostics and identifying transdiagnostic treatment targets using virtual reality. *Eur Neuropsychopharmacol*. 2025 Mar;92:1-9
55. Kjærstad HL, Macoveanu J, Ysbæk-Nielsen AT, Damgaard V, Frangou S, Knudsen GM, Coello K, Stanislaus S, Faurholt-Jepsen M, Vinberg M, Kessing LV, Miskowiak KW. Longitudinal Trajectory of Cognition, Brain Morphometry, and Brain Predicted Age in Unaffected First-Degree Relatives of Patients With Bipolar Disorder. *Bipolar Disord*. 2025 Sep;27(6):424-434
56. Klausen MK, Kuzey T, Pedersen JN, Justesen SK, Rasmussen L, Knorr UB, Mason G, Ekstrøm CT, Holst JJ, Koob G, Benveniste H, Volkow ND, Knudsen GM, Vilsbøll T, Fink-Jensen A. Does semaglutide reduce alcohol intake in Danish patients with alcohol

use disorder and comorbid obesity? Trial protocol of a randomised, double-blinded, placebo-controlled clinical trial (the SEMALCO trial). *BMJ Open*. 2025 Jan 8;15(1):e086454

57. Klausen MK, Knudsen GM, Vilsbøll T, Fink-Jensen A. Effects of GLP-1 Receptor Agonists in Alcohol Use Disorder. *Basic Clin Pharmacol Toxicol*. 2025 Mar;136(3):e70004
58. Knudsen GM. Classical psychedelics in therapy: Essential psychotherapy or minimal support? *Eur Neuropsychopharmacol*. 2025 Apr;93:27-28
59. Koc D, Nørgaard M, Ganz M, Muetzel RL, El Marroun H, Tiemeier H, Frokjaer VG. Associations of serotonin-related brain morphology in early adolescence with behavioral and emotional problems. *Neuroimage Clin*. 2025;48:103851
60. Kvamme TL, Lumaca M, Bajada CJ, Gregersen SD, Hobot J, Paunovic D, Wierzbach M, Zana B, Silvanto J, Sandberg K. Neural network topologies supporting individual variations in vividness of visual imagery. *Neuroimage*. 2025 Nov 1;321:121520
61. Langley C, Murray GK, Armand S, Knolle F, Cardinal RN, Johansen A, Jensen PS, Feng J, Stenbæk DS, Knudsen GM, Fisher PM, Sahakian BJ. Computational modelling and neural correlates of reinforcement learning following three-week escitalopram: a double-blind, placebo-controlled semi-randomised study. *Transl Psychiatry*. 2025 May 21;15(1):175
62. Larsen K, Lindberg U, Ozenne B, McCulloch DE, Armand S, Madsen MK, Johansen A, Stenbæk DS, Knudsen GM, Fisher PM. Acute psilocybin and ketanserin effects on cerebral blood flow: 5-HT_{2A}R neuromodulation in healthy humans. *J Cereb Blood Flow Metab*. 2025 Jul;45(7):1385-1401
63. Larsen SV, Ozenne B, Mikkelsen AP, Liu X, Bang Madsen K, Munk-Olsen T, Lidegaard Ø, Frokjaer VG. Postpartum Hormonal Contraceptive Use and Risk of Depression. *JAMA Netw Open*. 2025 Mar 3;8(3):e252474
64. Larsen SV, Mikkelsen AP, Madsen KB, Liu X, Munk-Olsen T, Frokjaer VG, Lidegaard Ø. Postpartum hormonal contraceptive use in Denmark during 1997-2021. *Sex Reprod Healthc*. 2025 Mar;43:101075
65. Larsen SV, Frokjaer VG, Ozenne B. Methodological obstacles in studies linking hormonal contraception and depression. *Br J Psychiatry*. 2025 Jun;226(6):334-336
66. Macoveanu J, Zarp J, Vinberg M, Brendstrup-Brix K, Kessing LV, Jørgensen MB, Miskowiak KW. Exploring the effects of erythropoietin treatment on cortical thickness and hippocampal volume in patients with mood disorders undergoing electroconvulsive therapy: A randomized, placebo-controlled trial. *J Psychopharmacol*. 2025 Feb;39(2):164-170
67. Madsen MK. Comment on 'Dopamine D₂/3R availability after discontinuation of antipsychotic treatment: a [11C]raclopride PET study in remitted first-episode psychosis patients' by de Beer et al. 2025. *Psychol Med*. 2025 Nov 19;55:e348
68. Magnussen JH. Advances in PET Imaging of α₇ Nicotinic Receptors: From Radioligand Development to CNS Applications. *Basic Clin Pharmacol Toxicol*. 2025 Apr;136(4):e70025

69. Magnussen JH. Therapeutic Targeting of the $\alpha 7$ Nicotinic Receptor: Challenges and Prospects for Cognitive Improvement in Alzheimer's and Schizophrenia. *Basic Clin Pharmacol Toxicol*. 2025 Jul;137(1):e70061
70. Marchetto E, Eichhorn H, Gallichan D, Schnabel JA, Ganz M. Agreement of image quality metrics with radiological evaluation in the presence of motion artifacts. *MAGMA*. 2025 Dec;38(6):991-1002
71. Mikkelsen JD, Linde-Atkins P, Pazarlar BA. Higher level of [3H]UCB-J binding in ApoE $\epsilon 4$ allele carriers with Alzheimer disease. *Neurosci Lett*. 2025 Feb 16;849:138135
72. Miskowiak KW, Macoveanu J, Ozenne B, Beaman EE, Dam VH, Fisher PM, Knudsen GM, Kessing LV, Jørgensen MB, Frokjaer VG, Sankar A. Relation Between Brain Morphological Features and Psychiatric Hospitalization Risk in Major Depressive and Bipolar Disorders. *Acta Psychiatr Scand*. 2025 Jun;151(6):689-697
73. Miskowiak KW, Bjerregaard SM, Fink-Jensen A, Kessing LV, Damgaard V, Schandorff JM, Kjærstad HL, Macoveanu J, Frokjaer VG, Knudsen GM, Sankar A. Brain structural correlates of prior alcohol use disorder and their relation to cognitive impairment in individuals with mood disorders. *J Affect Disord*. 2025 Dec 1;390:119841
74. Miskowiak K, Kjærstad HL, Lystlund S, Sankar A, Kessing L, Vinberg M. Associations Between Cognitive Functions and Subsequent Mood Disorder Prognosis in Low-Risk, High-Risk and Affected Monozygotic Twins: A Seven-Year Follow-Up Study. *Acta Psychiatr Scand*. 2025 Aug 20. doi: <https://doi.org/10.1111/acps.70025>. *Epub ahead of print*
75. Miskowiak KW, Ozenne B, Kjærstad HL, Fisher PM, Beaman EE, Dam VH, Ysbæk-Nielsen AT, Knudsen GM, Kessing LV, Macoveanu J, Frøkjær VG, Sankar A. Amygdala reactivity to threat, negative facial perception, and risk of future psychiatric hospitalizations: a longitudinal study in major depressive and bipolar disorders. *Neuropsychopharmacology*. 2025 Dec 15. doi: <https://doi.org/10.1038/s41386-025-02291-0>. *Epub ahead of print*
76. Morssinkhof MWL, Larsen SV, Ozenne B, Nasser A, Hvitved S, van der Werf YD, Penninx BWJH, Broekman BFP, Frokjaer VG. Cortisol dynamics and sleep quality: The role of sex and oral contraceptive use. *Psychoneuroendocrinology*. 2025 Aug;178:107497
77. Navarro ML, Breum AW, Ozenne B, Nasser A, Aripaka SS, Armand S, Jorgensen MB, Frokjaer VG, Knudsen GM. Whole blood BDNF is lower in patients with depression and unchanged by escitalopram in patients and healthy controls. *Prog Neuropsychopharmacol Biol Psychiatry*. 2025 Aug 30;141:111470
78. Nielsen KG, Köhler-Forsberg K, Jørgensen MB, Froekjaer VG, Jensen KHR. Brain 5-HT₄ receptor, gastrointestinal symptoms, and SSRI-related nausea in depression. *Eur Neuropsychopharmacol*. 2025 Dec 27;104:112744. doi: <https://doi.org/10.1016/j.euroneuro.2025.112744>. *Epub ahead of print*

79. Olson HA, Camacho MC, Abdurokhmonova G, Ahmad S, Chen EM, Chung H, Lorenzo RD, Dineen ÁT, Ganz M, Licandro R, Magnain C, Marrus N, McCormick SA, Rutter TM, Wagner L, Woodruff Carr K, Zöllei L, Vaughn KA, Madsen KS. Measuring and interpreting individual differences in fetal, infant, and toddler neurodevelopment. *Dev Cogn Neurosci*. 2025 Jun;73:101539
80. Overgaard M, Fazekas P, Kirkeby-Hinrup A, Sandberg K, Wiese W. There can be more to consciousness research than theory testing. *Commun Psychol*. 2025 Nov 26;3(1):172
81. Ozenne B, Nørgaard M, Pernet C, Ganz M. A sensitivity analysis of preprocessing pipelines: Toward a solution for multiverse analyses. *Imaging Neurosci (Camb)*. 2025 Apr 28;3:imag_a_00523
82. Pazarlar BA, Egilmez CB, Oyar EÖ, Mikkelsen JD. Increased Expression of Synaptic Vesicle Glycoprotein 2A (SV2A) in the Brain of Chronic Diabetic Rats. *Synapse*. 2025 May;79(3):e70018
83. Raffaele S, Mannella FC, Thougaard E, Nielsen PV, Blickfeldt-Eckhardt M, Tolosa E, Münsterberg J, Magnus T, Mikkelsen JD, Gelderblom M, Nielsen HH, Clausen BH, Brambilla R, Fumagalli M, Lambertsen KL. TNFR2 signaling shapes the sex-specific remyelinating properties of microglia after experimental stroke. *Neurotherapeutics*. 2025 Oct;22(6):e00745
84. Reed MB, Cocchi L, Sander CY, Chen J, Matheson GJ, Fisher P, Volpi T, Khattar N, DeLorenzo C, Gryglewski G, Silberbauer LR, Murgaš M, Godbersen GM, Nics L, Walter M, Hacker M, Bertoldo A, Lubberink M, Silfstein M, Ogden RT, Mann JJ, Suhara T, Varrone A, Boellaard R, Gunn RN, Hammers A, Biswal B, Rosen B, Knudsen GM, Carson R, Price J, Lanzenberger R, Hahn A. Connecting the dots: approaching a standardized nomenclature for molecular connectivity in positron emission tomography. *Eur J Nucl Med Mol Imaging*. 2025 Dec;53(1):48-58
85. Ripart M, Spitzer H, Williams LZJ, Walger L, Chen A, Napolitano A, Rossi-Espagnet C, Foldes ST, Hu W, Mo J, Likeman M, Rüber T, Caligiuri ME, Gambardella A, Guttler C, Tietze A, Lenge M, Guerrini R, Cohen NT, Wang I, Kloster A, Pinborg LH, Hamandi K, Jackson G, Tortora D, Tisdall M, Conde-Blanco E, Pariente JC, Perez-Enriquez C, Gonzalez-Ortiz S, Mullatti N, Vecchiato K, Liu Y, Kalviainen R, Sokol D, Shetty J, Sinclair B, Vivash L, Willard A, Winston GP, Yasuda C, Cendes F, Shinohara RT, Duncan JS, Cross JH, Baldeweg T, Robinson EC, Iglesias JE, Adler S, Wagstyl K; MELD FCD writing group; Fawaz A, De Benedictis A, De Palma L, Zhang K, Labate A, Barba C, You X, Gaillard WD, Tang Y, Wang S, Davies S, Semmelroch M, Severino M, Striano P, Chari A, D'Arco F, Mankad K, Bargallo N, Pascual-Diaz S, Delgado-Martinez I, O'Muircheartaigh J, Abela E, Kandasamy J, McLellan A, Desmond P, Lui E, O'Brien TJ, Whitaker K. Detection of Epileptogenic Focal Cortical Dysplasia Using Graph Neural Networks: A MELD Study. *JAMA Neurol*. 2025;82(4):397-406
86. Sainz-Cort A, Martín-Islas M, Oña G, Jimenez-Garrido D, López-Navarro M, Muñoz-Marron E, Viejo-Sobera R, Bouso JC. Spanish versions and validation of a series of rating scales and visual analogue scales to assess the subjective effects of cannabis. *Int Clin Psychopharmacol*. 2025 Mar 1;40(2):91-99

87. Sainz-Cort A, Martín-Islas M, Jimenez-Garrido D, López-Navarro M, Oña G, Muñoz-Marron E, Heredia L, Gil-Pérez M, Torrente M, Vicens P, Bouso JC. Validation of the Spanish version of the multifaceted empathy test: comparison between cannabis use effects and controls in social cognition. *Int Clin Psychopharmacol*. 2025 Mar 1;40(2):100-109
88. Sandberg K, Overgaard M. Comment on ‚Criterion placement threatens the construct validity of neural measures of consciousness‘. *Elife*. 2025 Aug 21;14:e106963
89. Sankar A, Colic L, Marks RB, Rajashekar N, Pittman B, Constable RT, Sajatovic M, Eyler LT, Blumberg HP. Brain White Matter Microstructure in Middle and Older Aged Adults With Bipolar Disorder: A 2-Site Study. *Am J Geriatr Psychiatry*. 2025 Sep 19: S1064-7481(25)00482-8. doi: <https://doi.org/10.1016/j.jagp.2025.09.013>. *Epub ahead of print*
90. Schandorff JM, Madsen ABF, Damgaard V, Little B, Sankar A, Macoveanu J, Frokjaer VG, Kessing LV, Jørgensen MB, Knudsen GM, Gallagher P, Miskowiak KW. Multivariate associations between structural brain changes and cognitive impairment in partially or fully remitted persons with bipolar disorder. *Prog Neuropsychopharmacol Biol Psychiatry*. 2025 Jul 13;140:111425
91. Sprenger RR, Kiilerich KF, Palner M, Oliveira AR, Croyal M, Ostenfeld MS, Bjørnshave A, Knudsen GM, Ejning CS. Dietary Intake of a Milk Sphingolipid-Rich MFGM/EV Concentrate Ameliorates Age-Related Metabolic Dysfunction. *Nutrients*. 2025 Jul 31;17(15):2529
92. Sprenger RR, Kiilerich KF, Palner M, Ostenfeld MS, Bjørnshave A, Knudsen GM, Ejning C. Aging predominates over an MFGM/EV-rich supplement in modulating the brain lipidome and cognitive decline of aged rats. *Food Bioscience*. 2025; 68. 106689
93. Stockart F, Schreiber M, Amerio P, Carmel D, Cleeremans A, Deouell LY, Dienes Z, Elozegi P, Gayet S, Goldstein A, Halchin AM, Hesselmann G, Kimchi R, Lamy D, Loued-Khenissi L, Meyen S, Micher N, Pitts M, Salomon R, Sandberg K, Schnepf IA, Schurger A, Shanks DR, Soto D, Tal A, Trübtschek D, Vadillo MA, van Gaal S, Yaron I, Zheng Z, Faivre N, Mudrik L. Studying unconscious processing: Contention and consensus. *Behav Brain Sci*. 2025 Jul 22:1-77. doi: <https://doi.org/10.1017/S0140525X25101489>. *Epub ahead of print*
94. Strzelec M, Detka J, Kot M, Wang Q, Sobocińska MK, Mikkelsen JD, Majka M. Cytoprotective and Immunomodulatory Properties of Mesenchymal Stem Cell Secretome and Its Effect on Organotypic Hippocampal Cultures in Mouse Model of Temporal Lobe Epilepsy. *Int J Mol Sci*. 2025 Dec 26;27(1):265
95. Sturchio A, Svensson JE, Tiger M, Morén AF, Varrone A, Svenningsson P, Okubo Y, Tateno A. [18F]FE-PE2I PET is a diagnostic tool in dementia with Lewy bodies. *PCN Rep*. 2025 Jun 2;4(2):e70123
96. Svensson JE, Schain M, Plavén-Sigray P. In vivo medical imaging for assessing geroprotective interventions in humans. *Geroscience*. 2025 Jun;47(3):2721-2737
97. Tap SC, Thomas K, Páleníček T, Stenbæk DS, Oliveira-Maia AJ, van Dalen J, Schoevers R. Concomitant use of antidepressants

and classic psychedelics: A scoping review. *J Psychopharmacol*. 2025 Oct;39(10):1072-1088

98. Tyron JM, Ip CT, Jørgensen MB, Jensen KHR. Loudness dependent auditory evoked potentials and suicidality in depression - A meta-analysis with replication in unmedicated patients. *J Affect Disord*. 2025 Mar 1;372:18-26
99. Ulv Larsen SM, Holst SC, Olsen AS, Ozenne B, Zilstorff DB, Brendstrup-Brix K, Weikop P, Pleinert S, Kiviniemi V, Jennum PJ, Nedergaard M, Knudsen GM. Sleep deprivation and sleep intensity exert distinct effects on cerebral vasomotion and brain pulsations driven by the respiratory and cardiac cycles. *PLoS Biol*. 2025 Nov 20;23(11):e3003500
100. Voets NL, Price CJ, Glasser MF, Benjamin C, Rutten GM, Plaha P, Benzinger T, Mian A, Gawryluk J, Pernet C, Parker Jones O, Haller S, Sierpowska J, Talib G, Binder J, Williams L, Jovicich J, Zeineh M, Ashtari M, Shimony J, Polczyńska-Bletsos M, Bizzi A, Chang EF, Scheel M, Bjornson B, Nichols TE, Beckmann CF, Geletneky K, Bookheimer S, Bartsch AJ. Challenges and opportunities for advancing functional MRI in clinical practice. *Brain*. 2025 Jul 7;148(7):2242-2246
101. Wagner MK, Hirsch LF, Berg SK, Hassager C, Borregaard B, Rasmussen TB, Ekholm O, Stenbæk DS. Clinical utility of the ‚Impact of Event Scale-Revised‘ for identifying Acute Stress Disorder in survivors of sudden out-of-hospital cardiac arrest: Results from the multicenter REVIVAL cohort. *Resuscitation*. 2025 Apr;209:110558
102. Wagner MK, Berg SK, Hassager C, Borregaard B, Petrova D, Agarwal S, Stenbæk DS, Blakoe M. Posttraumatic growth in out-of-hospital cardiac arrest survivors: prevalence and associated factors. *Resusc Plus*. 2025 May 8;24:100980
103. Wallgren HA, Kivipelto M, Plavén-Sigray P, Svensson JE. Pharmacokinetic analysis of intermittent rapamycin administration in early-stage Alzheimer’s Disease. *Geroscience*. 2025 Oct 5. doi: <https://doi.org/10.1007/s11357-025-01911-3>. *Epub ahead of print*
104. Xiao W, Woodham RD, Cui Y, Wen J, Antoniadis M, Srinivasan D, Fan Y, Erus G, Garcia JA, Arnott SR, Chen T, Choi KS, Chin Fatt C, Frey BN, Frokjaer VG, Ganz M, Godlewska BR, Hassel S, Ho K, McIntosh AM, Qin K, Rotzinger S, Sacchet MD, Savitz J, Shou H, Singh A, Stolicyn A, Strigo I, Strother SC, Tosun D, Wei D, Anderson IM, Craighead WE, Deakin JFW, Dunlop BW, Elliott R, Gong Q, Gotlib IH, Harmer CJ, Kennedy SH, Knudsen GM, Mayberg HS, Paulus MP, Qiu J, Trivedi MH, Whalley HC, Yan CG, Young AH, Davatzikos C, Fu CHY. Neuroanatomical dimensions in major depression linked to cognition, adverse life events, self-harm, metabolomics and genetics. *Commun Med (Lond)*. 2025 Nov 15;5(1):502
105. Yaden DB, Graziosi M, Owen AM, Agin-Liebes G, Aaronson ST, Allen KE, Barrett FS, Bogenschutz MP, Carhart-Harris R, Ching THW, Cosimano MP, Danforth A, Davis AK, Garcia-Romeu A, Griffiths R, Grob CS, Gründer G, Gukasyan N, Heinzerling KG, Hendricks PS, Holze F, Horton DM, Johnson MW, Kelmendi B, Knatz Peck S, Koslowski M, Liechti ME, Mertens LJ, Moreno FA, Nayak SM, Nicholas CR, Preller KH, Rieser NM, Ross S, Sergi K, Sloshower J, Smigielski L, Stenbæk DS, Vollenweider FX, Weiss B, Wolff M, Yaden ME. A Field-Wide Review and Analysis of Study Materials Used in Psilocybin Trials: Assessment of Two Decades of Research. *Psychedelic Med (New Rochelle)*. 2025 Feb 27;3(1):1-18

Media attention and public dissemination

Mar 10: Postdoc Kristian R. Jensen in the KU-Uniavisen article “<https://uniavisen.dk/hormonpraevention-har-faaet-kritik-men-for-nogle-kvinder-kan-det-stabilisere-psyken/>”.

Mar 10: Postdoc Kristian R. Jensen in the article “[Når Lise-Lotte havde ægløsning blev hun depressiv og fik tanker om at tage livet af sig selv: “Det var en øjenåbner at fortælle, hvordan jeg havde det”](#) on Livslinien.dk.

Apr 22: Professor Gitte Moos Knudsen gave a public lecture entitled “Er magiske svampe syretrip eller lægemiddel?” in the Royal Danish Academy of Sciences and Letters during Forskningsens Døgn 2025, <https://royalacademy.dk/event/forskningens-doen-2025/>.

Sep 20: Professor Gitte Moos Knudsen “Det røde felt - kan vi styre vreden?” Heart and Mind festival, Doc1, Aarhus.

Oct 9: Professor Vibe G. Frøkjær gave a lecture about depression on “Sindets dag”.

Oct 10: Professor Vibe G. Frøkjær gave a lecture about hormones and the brain on “Hjernedag” arranged by Dansk Medicinsk Selskab.

Oct 10: Professor Vibe G. Frøkjær gave a Kulturnat lecture at UCPH entitled ‘Hormoner og kvinders sind’.

Oct 13: Postdoc Kristian R. Jensen in the CNN Health article “[A brain test may predict antidepressant-related sexual problems, early research suggests](#)”.

Oct 15: Postdoc Kristian R. Jensen in the online article “[Can a Test Predict SSRI-Related Sexual Dysfunction?](#)”.

Oct 28: Professor Gitte Moos Knudsen in the online interview on Spiriterritory.com entitled “[The Science of Serotonin: Psychedelics and Brain Plasticity](#)”.

Nov 6: Professor Gitte Moos Knudsen. Den psykedeliske renæssance - og videnskaben bag den. Ungdommens Naturvidenskabelige Forening. HCØ, København.

Nov 25: Senior researcher Patrick Fisher in the Politiken article “[Et sted uden for byen løsner han den fra jorden: »Du kommer ikke til at kunne mærke noget«](#)”.

Acknowledgements

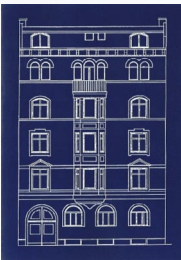
NRU research is primarily funded from external sources and we are extremely grateful to all the public and private foundations, organizations and companies that have generously provided support for our research activities.

NRU has received larger grants from:

- Lundbeckfonden for BrainDrugs and many other projects.
- Kirsten og Freddy Johansens Fond for our brain-dedicated 3 Tesla research MRI-scanner.
- Novo Nordisk Fonden for OpenNeuroPET and two Tandem initiatives.



novo nordisk **fonden**



NRU thanks our industrial collaborators:

- AbbVie Inc.
- Advanced Brain Monitoring, Inc
- COMPASS Pathways Limited
- Delix Therapeutics, Inc
- GLX Analytix ApS
- H. Lundbeck A/S
- Mediso Medical Imaging Systems
- Siemens Healthineers
- TracInnovations ApS

NRU would like to thank the following list of funders for generous support during 2025:

Aage og Ulla Filtenborgs Fond af 8. nov.
American Society for Suicide Prevention
Beta.Health
Capital Region of Denmark's Research Fund for Health
Danish Neurological Society
Danish Psychiatric Society
Desiree og Niels Ydes Fond
Direktør Ib Henriksens Fond
Elsass Foundation
EU H2020 and Horizon programmes
Ferd og Ellen Hindsgauls Almennyttige Fond
Fonden for Neurologisk Forskning
Grosserer L.F. Foghts Fond
Incentive Fonden
Independent Research Fund Denmark | Medical Sciences
Innovation Fund Denmark
Ivan Nielsens Fond for personer med specielle sindslidelser
Longevity Impetus Grants
Læge Sofus Carl Emil Friis og Hustru Olga Doris Friis' legat
Mental Health Services, Capital Region of Denmark
Neuroscience Academy Denmark
Research Council of Rigshospitalet and Rigshospitalets Jubilæumsfond
Savværksejer Jeppe Juhl og hustru Ovita Juhls Mindelegat
The A.P. Moller Foundation
The Toyota Foundation



Nordic Swan Ecolabel
5041 0826

This report is published by

Neurobiology Research Unit
Copenhagen University Hospital Rigshospitalet
Section 8057
Blegdamsvej 9
2100 Copenhagen Ø
Denmark

mail: info@nru.dk
tel: (+45) 3545 6711
web: www.nru.dk

Editing
Gitte Moos Knudsen
Peter Steen Jensen

Layout
Peter Steen Jensen

Annual Report 2025
© Copyright 2025-26 NRU



