

Online Summer Course

Digital Brain Twins in Clinical Research

Responsible Person: Prof. Dr. Petra Ritter

Email: petra.ritter@charite.de

Affiliation: Charité, BIH

Office: Robert-Koch Platz 4, Charité Campus Mitte

Official website: <https://www.brainsimulation.org/bsw/zwei/events/single/17209-online-summer-school-2026-digital-brain-twins-in-clinical-research->

BCCN website: <https://www.bccn-berlin.de/courses-and-modules.html>

Charité Promotionsumgebung: https://intranet.charite.de/studium_lehre/promotionskurse

Training type: Webinar

Language: English

Location: Online

Costs: Free

Commercial interests: None

Registration: Online form

Credits: 2 ECTS

Learning Outcomes

After completing this module, participants will know the basic concepts and methods for reproducible biology founded personalized brain network modeling and simulation. Students will gain knowledge about how to construct models, process multimodal imaging data for creating individualized models, run simulations and use supporting neuroinformatics tool such as the Charité/BIH Virtual Research Environment, workflows and build interfaces to related tools via APIs. Students will understand how to run brain simulations to address medical problems and have a good understanding of the open-source neuroinformatics platform The Virtual Brain (TVB; thevirtualbrain.org).

Content

This module provides basic knowledge on personalized brain network modeling for state-of-the-art in clinical research. Required interdisciplinary methods will be introduced. A focus will be set on the open-source simulation platform TVB.

Course overview:

- Theoretical background of large-scale brain network modeling
- Personalization pipelines: processing of brain images for individualization of brain network modeling
- Concepts of nonlinear dynamics
- Running workflows on high-performance computers
- Parameter optimization and model inference

- Application of brain network modeling for clinical questions
- Introduction to the medical condition targeted through brain simulation: dementias, psychosis and epilepsy
- Visualizations of multimodal brain dynamics, ontologies, machine learning, graph theory
- Making use of digital Research Infrastructures used for data integration and simulation in compliance with the EU general Data Protection Regulations (GDPR)

Module Components

Course name	Type	Number	Cycle	SWS
Digital Brain Twins in Clinical Research	VL (lecture)	1	WS & SS	1

Workload and Credit Points

Digital Brain Twins in Clinical Research	Multiplier	Units	Total Units
Attendance	12	2.5	30
Lecture rehearsals / individual studies	12	2.5	30
			60

1unit = 45 min

One ECTS/Credit Point equals 30 units

Total: 2 ECTS

Description of Teaching and Learning Methods

The lecture part consists of virtual teaching using an online web platform. In addition to the presentation of theoretical concepts, it comprises several demonstrations of how to operate workflows, simulation engines, high-performance computers and collaborative platforms. Participants are expected to rehearse content after class, using their class notes, digital jupyter notebooks, video tutorials and recommended literature.

Requirements for Participation and Examination

Mandatory requirements:

- Good English language skills
- Basic programming expertise

Successful module completion will require participation in a written exam. Exam tasks will be provided during the last course session and results need to be submitted by until one week after.

Module Completion

Type of exam: written exam

Grading: none

Duration of the Module

This module can be completed in 1 semester.

Maximum Number of Participants

50

Registration Procedure

Registration via online form is required:

<https://us06web.zoom.us/meeting/register/t6VJqHI9TPeVII-Uex0UhQ>

Recommended Reading

- Kashyap, Geenjaar, Bey, Dhindsa, Glomb, Plis, Keilholz, Ritter. (2025) Using an ordinary differential equation model to separate rest and task signals in fMRI [Nature Communications](#)
- Koller D, Schirner M, Ritter P. Human connectome topology directs cortical traveling waves and shapes frequency gradients [Nature Communications](#)
- Schirner, Deco, Ritter (2023) Learning how network structure shapes decision-making for bio-inspired computing. [Nature Communications](#)
- Hofsähs, Pille, Kern, Negi, Meier, Ritter (2026) The Virtual Brain links transcranial magnetic stimulation evoked potentials and inhibitory neurotransmitter changes in major depressive disorder. [Imaging Neuroscience](#)
- Stasinski, Taher, Meier, Schirner, Perdikis, Ritter (2024) Homeodynamic feedback inhibition control in whole-brain simulations. [PLOS Computational Biology](#)
- Stefanovski, Bülau, Martin, Langford, Palmer, Sacks, Deger, Pille, Schirner, Meier, Neudorfer, Horn, Solodkin, Thirion, Hofmann-Apitius, Jaconbs, Tom Kodamullil, the Alzheimer's Disease Neuroimaging Initiative, Ritter (2025) An Interactive Brain Atlas of Knowledge ([biRxiv](#))
- Them, Deger, Taher, Stasinski, Martin, Meier, Stefanovski, Ritter (2026) Brain network modelling with The Virtual Brain derives pharmacodynamics of ketamine ([bioRxiv](#))
- Martin, Bülau, Pille, Schmitt, Hüttl, Meier, Taher, Perdikis, Schirner, Stefanovski, Ritter (2025) The Virtual Brain Ontology: A Digital Knowledge Framework for Reproducible Brain Network Modeling ([BioRxiv](#))
- Schmitt, Bülau, Martin, Huettl, Schirner, Stefanovski, Ritter (2025) Biological Database Mining for LLM-Drive Alzheimer's Disease Drug Repurposing [bioRxiv](#)
- Pille, Martin, Richter, Perdikis, Schirner, Ritter (2025) Fast and Easy Whole-Brain Network Model Parameter Estimation with Automatic Differentiation ([bioRxiv](#))
- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch, Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan, Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter. Brain

Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS (2022) [Neuroimage](#)

- Schirner & Ritter (2024) Virtuelle Forschungsumgebung für Gesundheitsdaten: Virtual Research Environment (VRE) und Health Data Cloud (HDC). [Nomos](#)
- Meier, Perdikis, Blickensdörfer, Stefanovski, Liu, Maith, Dinkelbach, Baladron, Hamker, Ritter (2022) Virtual deep brain stimulation: Multiscale co-simulation of spiking basal ganglia model and whole-brain mean-field model with The Virtual Brain. [Experimental Neurology](#)
- Schirner, Kong, Yeo, Deco, Ritter (2022) Dynamic primitives of brain network interaction. [Neuroimage](#)
- Triebkorn, Stefanovski, Dhindsa, Diaz-Cortes, Bey, Bülau, Pai, Spiegler, Jirsa, McIntosh, Ritter (2022) Alzheimer's Disease Neuroimaging Initiative. Brain Simulation augments machine-learning-based classification of dementia [Alzheimer's and Dementia Translational Research & Clinical Interventions](#)
- Stefanovski, Meier, Pai, Triebkorn, Lett, Martin, Bülau, Hofmann-Apitius, Solodkin, McIntosh, Ritter (2021). Bridging Scales in Alzheimer's disease: Biological framework for brain simulation with The Virtual Brain. [Frontiers in Neuroinformatics](#)
- Stefanovski, Triebkorn, Spiegler, Diaz-Cortes, Solodkin, Jirsa, McIntosh, Ritter; for the Alzheimer's Disease Neuroimaging Initiative (2019). Linking molecular pathways and large-scale computational modeling to assess candidate disease mechanisms and pharmacodynamics in Alzheimer's disease. [Frontiers Computational Neuroscience](#)
- Schirner, McIntosh, Jirsa, Deco, Ritter (2018) Inferring multi-scale neural mechanisms with brain network modelling. [eLife](#)
- Deco, Kringelbach, Jirsa, Ritter (2017) The dynamics of resting fluctuations in the brain: metastability and its dynamical core. [Scientific Reports](#)
- Schirner, M., S. Rothmeier, V. Jirsa, A. R. McIntosh and Ritter, P. (2015). An automated pipeline for constructing personalised virtual brains from multimodal neuroimaging data. [Neuroimage](#)
- Ritter, P., M. Schirner, A. R. McIntosh and V. K. Jirsa (2013). "The virtual brain integrates computational modeling and multimodal neuroimaging." [Brain Connect](#)

Lecture Notes

Lecture presentations will be made available and published here:

YouTube: <https://www.youtube.com/channel/UCZxHt1mmrCafBwS4iPoUSrQ/playlists>

Assigned Degree Programs

Students of other courses can take this module if capacity allows.

Miscellaneous

Open-source software The Virtual Brain (thevirtualbrain.org) can be installed on own notebook/computer (runs on MacOS, Linux, Windows) or used via the research infrastructure EBRAINS (requires free registration at <https://ebrains.eu/register/>).

Course Structure

The courses take place in the summer and winter semester and consist of the following parts:
Lectures and self-study: 2 ECTS

Dates SS 2026:

June 15, 2026 – June 30, 2026

1. Jun 15	16:30-18:30 = 2.5 units á 45 min (Ritter)
2. Jun 16	16:30-18:30 = 2.5 units á 45 min (Martin)
3. Jun 17	16:30-18:30 = 2.5 units á 45 min (Schirner& Sacks)
4. Jun 18	16:30-18:30 = 2.5 units á 45 min (Schirner & Brandt)
5. Jun 19	17:00-19:00 = 2.5 units á 45 min (Stefanovski)
6. Jun 22	16:30-18:30 = 2.5 units á 45 min (da Costa Zemsch & Daubner)
7. Jun 23	16:30-18:30 = 2.5 units á 45 min (Pille & Perdikis)
8. Jun 24	16:30-18:30 = 2.5 units á 45 min (Lagunas & An)
9. Jun 25	16:30-18:30 = 2.5 units á 45 min (Meier & Felicetti)
10. Jun 26	16:30-18:30 = 2.5 units á 45 min (Liu & Deger & Bragin)
11. Jun 29	16:30-18:30 = 2.5 units á 45 min (Bülau & Hüttl)
12. Jun 30	16:30-18:30 = 2.5 units á 45 min (Taher & Them & Schmitt)

Total: 30 units á 45 min

Each session has a short bio break of 7 minutes.

Target Group

Master and PhD students with interest in the topic of computational neuroscience and its applications in clinical research.

Course Certificate

Students have to pass a written exam that can be completed at home. The exam tasks are given in the last session of the course and must be solved until one week later. Students who successfully pass the written exam are awarded 2 ECTS.

Program

The order of lectures may change.

Session 1 “The Virtual Brain - Overview” Prof. Dr. Petra Ritter

Recommendation for self-study:

- Schirner, Deco, Ritter (2023) Learning how network structure shapes decision-making for bio-inspired computing. [Nature Communications](#)
- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch, Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan,

Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter. Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS (2022) [Neuroimage](#)

Session 2 “Introduction to TVB modeling framework and The Virtual Brain Ontology for reproducible and comparable computational modeling” Leon Martin, MSc.

Recommendation for self-study:

- Martin, Bülau, Pille, Schmitt, Hüttl, Meier, Taher, Perdikis, Schirner, Stefanovski, Ritter (2025) The Virtual Brain Ontology: A Digital Knowledge Framework for Reproducible Brain Network Modeling ([BioRxiv](#))
- Sanz-Leon, P., Knock, S. A., Spiegler, A., & Jirsa, V. K. (2015). Mathematical framework for large-scale brain network modeling in The Virtual Brain. *Neuroimage*, 111, 385-430. doi: [10.1016/j.neuroimage.2015.01.002](https://doi.org/10.1016/j.neuroimage.2015.01.002)
- Ritter, P., M. Schirner, A. R. McIntosh and V. K. Jirsa (2013). "The virtual brain integrates computational modeling and multimodal neuroimaging." [Brain Connect](#)

Session 3 “Digital Brain Twins on GDPR compliant platforms: Virtual Research Environment and Health Data Cloud” Dr. Michael Schirner & Marc Sacks, MSc.

Recommendation for self-study:

- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch, Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan, Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter. Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS (2022) [Neuroimage](#)
- Schirner & Ritter (2024) Virtuelle Forschungsumgebung für Gesundheitsdaten: Virtual Research Environment (VRE) und Health Data Cloud (HDC). [Nomos](#)

Session 4 “Digital Twins, Intelligence & Plasticity” Dr. Michael Schirner & Luca Brandt, MSc.

Recommendation for self-study:

- Schirner, Deco, Ritter (2023) Learning how network structure shapes decision-making for bio-inspired computing. [Nature Communications](#)
- Schirner, Kong, Yeo, Deco, Ritter (2022) Dynamic primitives of brain network interaction. [Neuroimage](#)
- Schirner, McIntosh, Jirsa, Deco, Ritter (2018) Inferring multi-scale neural mechanisms with brain network modelling. [eLife](#)

Session 5 “Integrating biological knowledge in brain network models & modeling neurodegeneration” Dr. Leon Stefanovski

Recommendation for self-study:

- Stefanovski, Bülau, Martin, Langford, Palmer, Sacks, Deger, Pille, Schirner, Meier, Neudorfer, Horn, Solodkin, Thirion, Hofmann-Apitius, Jaconbs, Tom Kodamullil, the Alzheimer’s Disease Neuroimaging Initiative, Ritter (2025) An Interactive Brain Atlas of Knowledge ([biRxiv](#))
- <https://www.youtube.com/watch?v=QzEyD-9H0w8&t=5s>
- <https://www.youtube.com/watch?v=UyS7Tt3oVuE>
- Stefanovski, Triebkorn, Spiegler, Diaz-Cortes, Solodkin, Jirsa, McIntosh, Ritter; for the Alzheimer’s Disease Neuroimaging Initiative (2019). Linking molecular pathways and large-scale computational modeling to assess candidate disease mechanisms and pharmacodynamics in Alzheimer’s disease. [Frontiers Computational Neuroscience](#)
- Triebkorn, Stefanovski, Dhindsa, Diaz-Cortes, Bey, Bülau, Pai, Spiegler, Jirsa, McIntosh, Ritter (2022) Alzheimer’s Disease Neuroimaging Initiative. Brain Simulation augments machine-learning-based classification of dementia [Alzheimer’s and Dementia Translational Research & Clinical Interventions](#)

Session 6 “Generating virtual brains using tailored brain image processing workflows” Luise da Costa Zemsch, MSc. & Davi Daubner, BSc.

Recommendation for self-study:

- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch, Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan, Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter. Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS (2022) [Neuroimage](#)
- Schirner, M., S. Rothmeier, V. Jirsa, A. R. McIntosh and Ritter, P. (2015). An automated pipeline for constructing personalised virtual brains from multimodal neuroimaging data. [Neuroimage](#)
- <https://www.youtube.com/watch?v=vFsi7L9zPdk&t=8s>

Session 7 “Brain network model optimization and multiscale co-simulation” Marius Pille, MSc. & Dr. Dionysios Perdikis

Recommendation for self-study:

- Pille, Martin, Richter, Perdikis, Schirner, Ritter (2025) Fast and Easy Whole-Brain Network Model Parameter Estimation with Automatic Differentiation ([bioRxiv](#))
- TVB advanced tutorials <https://training.incf.org/course/virtual-brain-node-6-workshop>
- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch, Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan, Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter. Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS (2022) [Neuroimage](#)
- Stefanovski, Meier, Pai, Triebkorn, Lett, Martin, Bülau, Hofmann-Apitius, Solodkin, McIntosh, Ritter (2021). Bridging Scales in Alzheimer's disease: Biological framework for brain simulation with The Virtual Brain. [Frontiers in Neuroinformatics](#)
- Schirner, McIntosh, Jirsa, Deco, Ritter (2018) Inferring multi-scale neural mechanisms with brain network modelling. [eLife](#)

Session 8 “Understanding principles of brain function in the mouse model” Simon Adriano Munoz Lagunas, MSc & Jeehye An, MSc

Recommendation for self-study:

- Munoz Lagunas, An, Stefanovski, Ritter (2025) From Ions to Chaos: exploring a whole-brain modelling framework in the mouse ([bioRxiv](#))

Session 9 “In silico optimization of brain stimulation” Dr. Jil Meier & Tiago Felicetti

Recommendation for self-study:

- Hofsähs, Pille, Kern, Negi, Meier, Ritter (2026) The Virtual Brain links transcranial magnetic stimulation evoked potentials and inhibitory neurotransmitter changes in major depressive disorder. [Imaging Neuroscience](#)
- Meier, Perdikis, Blickensdörfer, Stefanovski, Liu, Maith, Dinkelbach, Baladron, Hamker, Ritter (2022) Virtual deep brain stimulation: Multiscale co-simulation of spiking basal ganglia model and whole-brain mean-field model with The Virtual Brain. [Experimental Neurology](#)

Session 10 “Modeling mechanisms of consciousness” Dr. Qin Liu & Lion Deger, MSc. & Valery Bragin, MSc.

Recommendation for self-study:

- Lee, Liu, Dadgar-Kiani (2022) Solving brain circuit function and dysfunction with computational modeling and optogenetic fMRI. [Science](#)
- Liu, Ulloa, Horwitz (2022) The spatiotemporal neural dynamics of entorsensory attention capture salient stimuli: a large-scale auditory-visual modeling study. [Frontiers Comp Neurosci](#)
- Liu, Ulloa, Horwitz (2017) Using a Large-scale Neural Model of Cortical Object Processing to investigate the Neural Substrate for Managing Multiple Items in Short-term Memory. [J Cogn Neurosci](#)

Session 11 “Modeling mechanisms of psychosis” Dr. Konstantin Bülau & Christoph Hüttl

Recommendation for self-study:

- Costa Klein, Ettinger, Schirner, Ritter, Rujescu, Falkai, Koutsouleris, Kambeitz-Illankovic, Kambeitz. (2020) Brain Network Simulations Indicate Effects of Neuregulin-1 Genotype on Excitation-Inhibition Balance in Cortical Dynamics. [Cerebral Cortex](#).
- Domingo-Fernández, D., Kodamullil, A. T., Iyappan, A., Naz, M., Emon, M. A., Raschka, T., . . . Hofmann-Apitius, M. (2017). Multimodal mechanistic signatures for neurodegenerative diseases (NeuroMMSig): a web server for mechanism enrichment. *Bioinformatics*, 33(22), 3679-3681. doi: [10.1093/bioinformatics/btx399](https://doi.org/10.1093/bioinformatics/btx399)

Session 12 “TVB-Positron Emission Tomography & In silico drug discovery and testing” Dr. Halgurd Taher & Jennifer Them, MSc. & Rico Schmitt

Recommendation for self-study:

- Stasinski, Taher, Meier, Schirner, Perdakis, Ritter (2024) Homeodynamic feedback inhibition control in whole-brain simulations. [PLOS Computational Biology](#)
- Them, Deger, Taher, Stasinski, Martin, Meier, Stefanovski, Ritter (2026) Brain network modelling with The Virtual Brain derives pharmacodynamics of ketamine ([bioRxiv](#))
- Schmitt, Bülau, Martin, Huettl, Schirner, Stefanovski, Ritter (2025) Biological Database Mining for LLM-Drive Alzheimer’s Disease Drug Repurposing [bioRxiv](#)
- Stefanovski, Triebkorn, Spiegler, Diaz-Cortes, Solodkin, Jirsa, McIntosh, Ritter; for the Alzheimer’s Disease Neuroimaging Initiative (2019). Linking molecular pathways and large-scale computational modeling to assess candidate disease mechanisms and pharmacodynamics in Alzheimer’s disease. [Frontiers Computational Neuroscience](#)