

## **Digital & Computational Platform**

Charité Mental Health  
Infrastructure Platform

### **Platform Leadership:**

Malek Bajbouj<sup>2</sup>, Raymond J. Dolan<sup>1</sup>, Roland Eils<sup>2,3</sup>, Soyoung Q. Park<sup>2,6</sup>, Philipp Sterzer<sup>4,5</sup>

### **Members:**

Thore Buerge<sup>2,3</sup>, Christian Conrad<sup>2,3</sup>, Juergen Eils<sup>2,3</sup>, Andreas Heinz<sup>4,5</sup>, Naveed Ishaque<sup>2,3</sup>, Irina Lehmann<sup>2,3</sup>, Kerstin Ritter<sup>4,5</sup>, Florian Schlagenhaut<sup>4</sup>, Surjo Soekadar<sup>4</sup>, Henrik Walter<sup>4</sup>

### **Participating Institutions:**

- 1) *Max Planck UCL Centre for Computational Psychiatry and Ageing Research, and Humboldt University Berlin.*
- 2) *Charité - Universitätsmedizin Berlin*
- 3) *Berlin Institute of Health (BIH), Center for Digital Health, Berlin, Germany*
- 4) *Department of Psychiatry and Psychotherapy, Campus Charité Mitte, Charité - Universitätsmedizin Berlin*
- 5) *Bernstein Center for Computational Neuroscience Berlin*
- 6) *Department of Decision Neuroscience / Nutrition, German Institute of Human Nutrition (DfE)*

### **Digital & Computational platform**

A platform facilitating data management, big data analytics /machine learning, computational modeling, and digital mental health solutions.

### **Aims**

For new health solutions in psychotherapy and prevention of mental illness/ psychiatric disorders, the Digital and Computational Health platform will use big data analytics, including machine learning approaches, and computational modeling to link and analyze data sets from (epi)genomics, transcriptomics, metabolomics, pharmaco-omics, therapeutic interventions, neuromodulation and neuroimaging with clinical data. On the same methodological foundation, the platform serves as an interface between big data analytics and clinical applications by promoting tailored digital interventions and by providing (hierarchical) models translating sensor and linguistic data into digital phenotypes reflecting behaviors and states related to mental health. The overall goal is to advance the development of personalized medicine in this field.

### **Expertise:**

The Digital and Computational Health platform brings together complementary expertise in computational modeling of neural processes and brain-behavior relationships as well as data management, data science and artificial intelligence /machine learning and digital mental health. Prof. Dolan is a pioneer and leading researcher in the field of computational psychiatry. The work of his group focuses on the neurocomputational mechanisms underlying behavioral control and its breakdown in psychopathology. The group avail of a range of data derived from behavioral analysis, computational modeling, psychopharmacological manipulations as well as brain imaging (fMRI and MEG). The work of Prof. Sterzer is dedicated to the investigation of the neural underpinnings of psychiatric disorders such as schizophrenia, depression, and addiction. His group approaches these issues using a unique combination of state-of-the-art methods, including brain imaging, psychophysics, computational modeling and machine learning. The interdisciplinary Bajbouj group has a strong focus on stress relat-

ed disorders and global mental health and has a track record in the development of personalized digital mental health care solutions (e.g. within the German Network University Medicine), tailored mobile health applications, dynamic digital stepped care models, digital phenotype approaches as well as machine learning approaches in neuromodulation. The multidisciplinary Park group investigates how metabolism, lifestyle and social environment interact with brain function, well-being and mental health. The research aims to develop individualized treatment strategies by combining fine-grained metabolic profiling (metabolic core unit at DIfE) with the state-of-the-art neuroimaging and behavioral modeling. The Park group has developed tailored mobile health applications that track daily changes of mental health and nutritional dynamics. The Eils group has extensive experience in linking multi-modal data such as omics and imaging data with clinical phenotypes by machine learning based methods. Besides his major contributions in cancer and infectious diseases he recently engaged in linking molecular profiles with comorbidities of psychosis within the field of mental health. In collaboration with Prof. Lehmann (BIH Molecular Epidemiology Unit) epigenetics and environmental triggered responses in different aspects of diseases are addressed. The multidisciplinary team of experts from the Center of Digital Health headed by Roland Eils brings together specialists in epidemiology, molecular biology and epigenetics with computer scientists and bioinformaticians.

This platform will offer service analyses and advice to other researchers on projects within the Charité Mental Health network.

### Research Infrastructure

For the analysis of big data in Life and Health Sciences, extensive computing power, computer hardware and data throughput are required. The Center for Digital Health at the Berlin Institute of Health provides, e.g. 2 Petabyte (PB) of high throughput hierarchical storage (Isilon), more than 3000 Intel CPU cores and several NVIDIA DGX hosts for Medical Imaging and Deep Learning applications. In addition, the Digital Health Center operates the One Touch Pipeline, OTP, (PMID: 28803971), an automated NGS data managing and processing system, which is also the central data management platform for large scale genomics. Further developments will also include the Health Data Platform including interoperability tasks complying with the FAIR data principles, to make data *Findable, Accessible, Interoperable and Reusable*.

### Link Professorships

Prof. Dr. Malek Bajbouj	<a href="https://psychiatrie.charite.de/metasperson/person/address_detail/bajbouj-1/">https://psychiatrie.charite.de/metasperson/person/address_detail/bajbouj-1/</a>
Prof. Dr. Raymond Dolan	<a href="https://www.mps-ucl-centre.mpg.de/11822/dolan-ray.html">https://www.mps-ucl-centre.mpg.de/11822/dolan-ray.html</a> , <a href="https://www.ucl.ac.uk/mental-health/people/professor-ray-dolan">https://www.ucl.ac.uk/mental-health/people/professor-ray-dolan</a>
Prof. Dr. Roland Eils	<a href="https://www.bihealth.org/de/forschung/arbeitsgruppen/roland-eils">https://www.bihealth.org/de/forschung/arbeitsgruppen/roland-eils</a> , <a href="https://www.hidih.org/">https://www.hidih.org/</a>
Prof. Dr. Soyoung Q. Park	<a href="https://www.dife.de/en/person/soyoung-q-park/">https://www.dife.de/en/person/soyoung-q-park/</a>
Prof. Dr. Philipp Sterzer	<a href="https://psychiatrie-psychotherapie.charite.de/en/metasperson_detail/person/address_detail/sterzer/">https://psychiatrie-psychotherapie.charite.de/en/metasperson_detail/person/address_detail/sterzer/</a>

### Key Publications

- Bauer, T., Trump, S., Ishaque, N., Thürmann, L., Gu, L., Bauer, M., Bieg, M., Gu, Z., Weichenhan, D., Mallm, J.-P., Röder, S., Herberth, G., Takada, E., Mücke, O., Winter, M., Junge, K. M., Grützmann, K., Rolle-Kampczyk, U., Wang, Q., ... Lehmann, I. (2016). Environment-Induced Epigenetic Reprogramming in Genomic Regulatory Elements in Smoking Mothers and Their Children. *Molecular Systems Biology*, *12*(3), 861.
- Bellucci, G., Molter, F., & Park, S. Q. (2019). Neural Representations of Honesty Predict Future Trust Behavior. *Nature Communications*, *10*(1), 5184.
- Böge, K., Karnouk, C., Hahn, E., Schneider, F., Habel, U., Banaschewski, T., Meyer-Lindenberg, A., Salize, H. J., Kamp-Becker, I., Padberg, F., Hasan, A., Falkai, P., Rapp, M. A., Plener, P. L., Stamm, T., Elnahrawy, N., Lieb, K., Heinz, A., & Bajbouj, M. (2020). Mental Health in Refugees and Asylum Seekers (mehira): Study Design and Methodology of a Prospective Multicentre Randomized Controlled Trial Investigating the Effects of a Stepped and Collaborative Care Model. *European Archives of Psychiatry and Clinical Neuroscience*, *270*(1), 95–106.
- Borchardt, V., Fan, Y., Dietz, M., Melendez, A. L. H., Bajbouj, M., Gärtner, M., Li, M., Walter, M., & Grimm, S. (2018). Echoes of Affective Stimulation in Brain Connectivity Networks. *Cerebral Cortex*, *28*(12), 4365–4378.
- Brown, E. C., & Park, S. Q. (2020). Obesity and Addiction. *Nature Human Behaviour*, *4*(1), 10–11.
- Chua, R. L., Lukassen, S., Trump, S., Hennig, B. P., Wendisch, D., Pott, F., Debnath, O., Thürmann, L., Kurth, F., Völker, M. T., Kazmierski, J., Timmermann, B., Twardziok, S., Schneider, S., Machleidt, F., Müller-Redetzky, H., Maier, M., Krannich, A., Schmidt, S., ... Eils, R. (2020). Covid-19 Severity Correlates with Airway Epithelium–Immune Cell Interactions Identified by Single-Cell Analysis. *Nature Biotechnology*, *38*(8), 970–979.
- Eldar, E., Bae, G. J., Kurth-Nelson, Z., Dayan, P., & Dolan, R. J. (2018). Magnetoencephalography Decoding Reveals Structural Differences Within Integrative Decision Processes. *Nature Human Behaviour*, *2*(9), 670–681.
- Eldar, E., Lièvre, G., Dayan, P., & Dolan, R. J. (2020). The Roles of Online and Offline Replay in Planning. *BioRxiv*, 2020.03.26.009571.
- Gärtner, M., Ghisu, E., Herrera-Melendez, A. L., Koslowski, M., Aust, S., Asbach, P., Otte, C., Regen, F., Heuser, I., Borgwardt, K., Grimm, S., & Bajbouj, M. (2021). Using Routine Mri Data of Depressed Patients to Predict Individual Responses to Electroconvulsive Therapy. *Experimental Neurology*, *335*, 113505.
- Jäger, N., Schlesner, M., Jones, D. T. W., Raffel, S., Mallm, J.-P., Junge, K. M., Weichenhan, D., Bauer, T., Ishaque, N., Kool, M., Northcott, P. A., Korshunov, A., Drews, R. M., Koster, J., Versteeg, R., Richter, J., Hummel, M., Mack, S. C., Taylor, M. D., ... Eils, R. (2013). Hypermutation of the Inactive X Chromosome Is a Frequent Event in Cancer. *Cell*, *155*(3), 567–581.
- Liu, Y., Dolan, R. J., Kurth-Nelson, Z., & Behrens, T. E. J. (2019). Human Replay Spontaneously Reorganizes Experience. *Cell*, *178*(3), 640-652.e14.
- Lukassen, S., Chua, R. L., Trefzer, T., Kahn, N. C., Schneider, M. A., Muley, T., Winter, H., Meister, M., Veith, C., Boots, A. W., Hennig, B. P., Kreuter, M., Conrad, C., & Eils, R. (2020). SARS- CoV- 2 Receptor ACE2 and TMPRSS2 are Primarily Expressed in Bronchial Transient Secretory Cells. *The EMBO Journal*, *39*(10), e105114.
- Northcott, P. A., Buchhalter, I., Morrissy, A. S., Hovestadt, V., Weischenfeldt, J., Ehrenberger, T., Gröbner, S., Segura-Wang, M., Zichner, T., Rudneva, V. A., Warnatz, H.-J., Sidiropoulos, N., Phillips, A. H., Schumacher, S., Kleinheinz, K., Waszak, S. M., Erkek, S., Jones, D. T. W., Worst, B. C., ... Lichter, P. (2017). The Whole-Genome Landscape of Medulloblastoma Subtypes. *Nature*, *547*(7663), 311–317.
- Park, S. Q., Kahnt, T., Dogan, A., Strang, S., Fehr, E., & Tobler, P. N. (2017). A Neural Link Between Generosity and Happiness. *Nature Communications*, *8*(1), 15964.

- Rothkirch, M., Tonn, J., Köhler, S., & Sterzer, P. (2017). Neural Mechanisms of Reinforcement Learning in Unmedicated Patients with Major Depressive Disorder. *Brain*, 140(4), 1147–1157.
- Schwarz, E., Alnæs, D., Andreassen, O. A., Cao, H., Chen, J., Degenhardt, F., Doncevic, D., Dwyer, D., Eils, R., Erdmann, J., Herrmann, C., Hofmann-Apitius, M., Kaufmann, T., Koutsouleris, N., Kodamullil, A. T., Khuntia, A., Mucha, S., Nöthen, M. M., Paul, R., ... Meyer-Lindenberg, A. (2020). Identifying Multimodal Signatures Underlying the Somatic Comorbidity of Psychosis: The Commitment Roadmap. *Molecular Psychiatry*, 1–3.
- Sekutowicz, M., Guggenmos, M., Kuitunen-Paul, S., Garbusow, M., Sebold, M., Pelz, P., Priller, J., Wittchen, H.-U., Smolka, M. N., Zimmermann, U. S., Heinz, A., Sterzer, P., & Schmack, K. (2019). Neural Response Patterns During Pavlovian-to-Instrumental Transfer Predict Alcohol Relapse and Young Adult Drinking. *Biological Psychiatry*, 86(11), 857–863.
- Vaghi, M. M., Moutoussis, M., Váša, F., Kievit, R. A., Hauser, T. U., Vértes, P. E., Shahar, N., Romero-Garcia, R., Kitzbichler, M. G., Bullmore, E. T., Consortium, N., & Dolan, R. J. (2020). Compulsivity Is Linked to Reduced Adolescent Development of Goal-Directed Control and Frontostriatal Functional Connectivity. *Proceedings of the National Academy of Sciences*, 117(41), 25911–25922.
- Weilhammer, V., Röd, L., Eckert, A.-L., Stuke, H., Heinz, A., & Sterzer, P. (2020). Psychotic Experiences in Schizophrenia and Sensitivity to Sensory Evidence. *Schizophrenia Bulletin*, 46(4), 927–936.
- Wimmer, G. E., Liu, Y., Vohar, N., Behrens, T. E. J., & Dolan, R. J. (2020). Episodic Memory Retrieval Success Is Associated with Rapid Replay of Episode Content. *Nature Neuroscience*, 23(8), 1025–1033.
- Ziegler, G., Hauser, T. U., Moutoussis, M., Bullmore, E. T., Goodyer, I. M., Fonagy, P., Jones, P. B., Lindenberger, U., & Dolan, R. J. (2019). Compulsivity and Impulsivity Traits Linked to Attenuated Developmental Frontostriatal Myelination Trajectories. *Nature Neuroscience*, 22(6), 992–999.