Georg Köhr

Head of Research Group
Physiology of Neuronal Networks

1. Narrative academic profile

Following 2 years of postdoctoral training in cellular electrophysiology, and studying mechanisms of epilepsy at Stanford University (1990/91), I conducted 15 years of basic research on glutamate receptor function in Heidelberg; structural and functional analyses of NMDA receptors in heterologous systems at the Center for Molecular Biology, and later on, in transgenic mice at the Max-Planck-Institute (MPI) for Medical Research. In mice, my contribution focused on synaptic plasticity of glutamatergic synapses in acute slices of several brain regions (hippocampus, cerebellum and cortex).

From 2007 until 2012, I headed a research group at the MPI which focused on interactions of glutamate receptors with neuromodulator systems which release transmitters in the CNS depending on the behavioral state. My interest focused on noradrenaline and dopamine, the latter being released during novelty detection or attentional processes. To address the timing and context of endogenous dopamine, which is critical for information processing and computation, and can be altered in pathological conditions, the dopaminergic system was activated electrically, pharmacologically or optogenetically while NMDA receptor-dependent synaptic plasticity was induced with behaviorally-relevant electrical stimulations in acute brain slices and in freely moving mice.

To perform systems physiology in rodents during operant behavior, the relocation of my research group in 2013 from Heidelberg to the Central Institute of Mental Health (ZI) in Mannheim made the envisaged impact to start transdisciplinary research. Collaborations within the Institute of Psychopharmacology allowed us to study neural correlates of addictive behavior (e.g., cocaine, alcohol) in rats during operant conditioning and extinction. Collaborations with the Department of Theoretical Neuroscience allowed computational analysis of operant behavior and neural activity that my research group had acquired longitudinally up to 6 weeks. Collaborations and interactions with the Emmy-Noether group Developmental Biology of Psychiatric Disorders stimulated technical and topical achievements. Finally, collaborations with the biochemical laboratory in the Department of Psychiatry allowed one to electrophysiologically characterize induced pluripotent stem cell (iPSC) derived neurons, the work of which has been ongoing since 2018 with the Hector Institute for Translational Brain Research at the ZI, where I am still a guest scientist. Current iPSCs originate from patients with bipolar disease or schizophrenia and from individuals carrying a single nucleotide polymorphism in the BDNF gene. The goal is to study disease-relevant mechanisms in these human cells.

To this day, I supervised 10 PhD and 2 MD students, 6 being international, jointly creating a young and global atmosphere that I enjoy very much. In contrast, I worked only with 3 postdocs, indicating my preference to educate junior researchers. Offering practical courses to Heidelberg University PhD students of the IZN (Interdisciplinary Center for Neurosciences), taking part in recruitment sessions of the Heidelberg graduate school HBIGS and being an examiner of Neuroscience Masters and PhD students are diverse activities that I enjoy partaking in.

Following habilitation in Pharmacology and Toxicology in 1996, I was a voluntary lecturer for Pharmacology at Heidelberg University, teaching Pharmacy students for 4 years, and shortly after, a lecturer for Physiology, teaching medical students for 12 years. Since 2019, I am an appointed lecturer for Physiology teaching students at the Medical Faculty Mannheim and for the remaining time, I am a researcher in the Department of Neurophysiology, where we study animal models of chronic pain electrophysiologically in acute spinal cord slices and in collaboration with Neurology to investigate gene expression with single-nucleus RNA-sequencing.

All in all, I feel my personality and my activities are in very good hands at the Mannheim Center for Translational Neuroscience.

2. Key output of the years 2020-2022

Studying and understanding neural correlates of behavior has been a long-term goal of mine. To reach this goal, different disciplines were integrated at the ZI with me being the driving coordinator (Russo et al., 2021):

When our project started, previously published manipulations (pharmacological inactivation, optogenetic stimulation) had highlighted the role of the medial prefrontal cortex (mPFC) in the extinction of reward-seeking responses. However, the neural dynamics driving extinction were largely unknown. Our transdisciplinary research approach now demonstrated a temporal coordination across the whole rat mPFC in anticipation of behavioral extinction. The Institute of Psychopharmacology provided the know-how of operant reward-seeking behavior in rats. My research group trained the animals, stereotactically implanted a custom-built flexDrive containing eight tetrodes (4-wire electrodes) into the mPFC of each rat and performed chronic recordings of multiple single-units during behavior. And the Department of Theoretical Neuroscience applied a novel statistical model of binary choice behavior that captured the response-probability dynamics of an animal (i.e. learning curve) by a weighted sum of sigmoids. The center of each sigmoid corresponded to a behavioral change point which was related to neural change points on the population and single-unit level. Though multiple labs had reported that global shifts in mPFC population activity precede switching between behavioral strategies, our study was the first to demonstrate this for the extinction of learned associations.