UKE Paper of the Month März 2017

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Layer-specific optogenetic activation of pyramidal neurons causes beta–gamma entrainment of neonatal networks

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ABSTRACT:

Coordinated activity patterns in the developing brain may contribute to the wiring of neuronal circuits underlying future behavioural requirements. However, causal evidence for this hypothesis has been difficult to obtain owing to the absence of tools for selective manipulation of oscillations during early development. We established a protocol that combines optogenetics with electrophysiological recordings from neonatal mice in vivo to elucidate the substrate of early network oscillations in the prefrontal cortex. We show that light-induced activation of layer II/III pyramidal neurons that are transfected by in utero electroporation with a high-efficiency channelrhodopsin drives frequency-specific spiking and boosts network oscillations within beta–gamma frequency range. By contrast, activation of layer V/VI pyramidal neurons causes nonspecific network activation. Thus, entrainment of neonatal prefrontal networks in fast rhythms relies on the activation of layer II/III pyramidal neurons. This approach used here may be useful for further interrogation of developing circuits, and their behavioural readout.

STATEMENT:

In the paper we introduce a novel optogenetics-based approach for interrogation of developing neuronal circuits. By its use we elucidate the cellular substrate of coordinated patterns of electrical activity in the immature brain. These findings open new perspectives (i) for understanding the role of electrical activity early in life for the behavioural performance at adulthood and (ii) for identifying the key players of network miswiring in neurodevelopmental disorders."

BACKGROUND:

This work was performed at the research group Developmental Neurophysiology (head: Ileana Hanganu-Opatz), Institute of Neuroanatomy, in collaboration with the Institute for Synaptic Physiology (head: Thomas Oertner), Center for Molecular Neurobiology. It is part of the PhD theses of Sebastian H. Bitzenhofer and Joachim Ahlbeck. The project was funded by the ERC (Consolidator Grant 681577 "Psychocell" to I. Hanganu-Opatz) and DFG (SPP 1665, SFB 936 and FOR 2419). Both groups have strong interests in understanding the development and plasticity of neuronal networks by combining electrophysiology and optogenetics.