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In Vivo Visualization of Spontaneous Activity in Neonatal Mouse Sensory Cortex at a Single-neuron Resolution

Nao Nakagawa-Tamagawa[*,1], **Takamitsu Egashira**[*,2,3], **Madhura S. Rao**[2,3,4], **Hidenobu Mizuno**[2,3]

[1] Department of Physiology, Graduate School of Medical and Dental Sciences, Kagoshima University [2] Laboratory of Multi-Dimensional Imaging, International Research Center for Medical Sciences (IRCMS), Kumamoto University [3] Graduate School of Medical Sciences, Kumamoto University [4] Cedars-Sinai Medical Center

[*] These authors contributed equally

Corresponding Authors

Nao Nakagawa-Tamagawa
naonaka@m.kufm.kagoshima-u.ac.jp
Hidenobu Mizuno
hmizuno@kumamoto-u.ac.jp

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Abstract

The mammalian brain undergoes dynamic developmental changes at both the cellular and circuit levels throughout prenatal and postnatal periods. Following the discovery of numerous genes contributing to these developmental changes, it is now known that neuronal activity also substantially modulates these processes. In the developing cerebral cortex, neurons exhibit synchronized activity patterns that are specialized to each primary sensory area. These patterns markedly differ from those observed in the mature cortex, emphasizing their role in regulating area-specific developmental processes. Deficiencies in neuronal activity during development can lead to various brain diseases. These findings highlight the need to examine the regulatory mechanisms underlying activity patterns in neuronal development. This paper summarizes a series of protocols to visualize primary sensory areas and neuronal activity in neonatal mice, to image the activity of individual neurons within the cortical subfields using two-photon microscopy *in vivo*, and to analyze subfield-related activity correlations. We show representative results of patchwork-like synchronous activity within individual barrels in the somatosensory cortex. We also discuss various potential applications and some limitations of this protocol.

Introduction

The cerebral cortex contains several sensory areas with distinct functions. The areas receive inputs originating from their corresponding sensory organs, mostly conveyed through the spinal cord or brainstem and relayed via the thalamus[1]. Notably, neurons in each primary sensory area exhibit uniquely synchronized activity during early developmental stages, which also originate from sensory organs or the lower nervous centers, but essentially differ from the activities observed in the mature cortex[2].

In neonatal rodents, for example, the primary visual area (V1) displays wave-like activity, which originates in the retina