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Developmental changes in electrophysiological properties and a transition from electrical to chemical coupling between excitatory layer 4 neurons in the rat barrel cortex

Valiullina F., Akhmetshina D., Nasretdinov A., Mukhtarov M., Valeeva G., Khazipov R., Rozov A.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2016 Valiullina, Akhmetshina, Nasretdinov, Mukhtarov, Valeeva, Khazipov and Rozov. During development, sensory systems switch from an immature to an adult mode of function along with the emergence of the active cortical states. Here, we used patch-clamp recordings from neocortical slices in vitro to characterize the developmental changes in the basic electrophysiological properties of excitatory L4 neurons and their connectivity before and after the developmental switch, which occurs in the rat barrel cortex in vivo at postnatal day P8. Prior to the switch, L4 neurons had higher resting membrane potentials, higher input resistance, lower membrane capacity, as well as action potentials (APs) with smaller amplitudes, longer durations and higher AP thresholds compared to the neurons after the switch. A sustained firing pattern also emerged around the switch. Dual patch-clamp recordings from L4 neurons revealed that recurrent connections between L4 excitatory cells do not exist before and develop rapidly across the switch. In contrast, electrical coupling between these neurons waned around the switch. We suggest that maturation of electrophysiological features, particularly acquisition of a sustained firing pattern, and a transition from the immature electrical to mature chemical synaptic coupling between excitatory L4 neurons, contributes to the developmental switch in the cortical mode of function.

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Keywords

Barrel cortex, Critical period, Development, Excitation, Gap junctions