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Axonal arbor plasticity of the developing neocortex

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The formation of the neocortex in the developing mammalian brain is one of the most exciting processes in nature. So far it is hardly understood how the construction of the cortex is controlled. Understanding the mechanisms how cells divide, mature to neurons and form axons and dendrites will give major insight into brain physiology and pathophysiology. Experiments in which the structure of the neocortex can be altered in a controlled manner may help to understand these mechanisms. The process how the brain reacts to changes of the environment is called plasticity. A well established system to study neocortical plasticity is the facial whisker system of the rodent. Rodents use the whisker system to explore their surrounding just like humans use their hands to explore objects in close distance. Thereby, the whiskers form an array of tactile sensors. Each whisker is represented on the cortical surface. Neighboring whiskers are represented in neighboring cortical areas. Thereby, the whisker array system forms a cortical map on the surface of the brain in a topology-preserving manner. Interestingly, trimming of the whiskers during a critical period of development leads to an alteration of this map.

In this work a simple trimming protocol was used to investigate if and how the axonal morphology of layer 2/3 pyramidal neurons is altered. This protocol has previously been shown to have a significant effect on the functional receptive field. Layer 2/3 neurons of the D2 column were labeled by lentiviral mediated gene transfer and subsequent expression of green fluorescent protein (GFP). This technique allows a controlled and selective labeling. Two groups of animals were investigated: One control group and one group with whiskers rows A, B and C trimmed (DE-row pairing) during a critical period of development (postnatal day 7 to 15). In brief, the findings were: The control group showed an approximately symmetrical projection of axons into neighboring cortical areas (to the C and E row side). This was true for the supra- and infra-granular layers. In contrast, DE pairing in the experimental group led to a higher density of axons projecting towards the spared E-row columns than towards the deprived C-row columns. Further testing showed that this was due to a reduced projection into deprived cortical areas in supragranular layers. Interestingly there was no change in projection in infragranular layers. This work shows an anatomical substrate for functional changes in the receptive field map of layer 2/3 neurons and supports the hypothesis that active cortical areas tend to be connected stronger than deprived cortical areas.