Activity Dependent Mechanisms of Sensory Map Development

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In the brains of mammals, birds and invertebrates, the sensory world is organized into regular neuronal arrays or maps. Common examples are the map of body surface in somatosensory cortex (the so called "homunculus") and the representation of oriented bars or edges in visual cortex. In these maps, neighboring cells respond to similar features of stimuli in the sensory periphery, and there is usually an orderly progression of the optimal stimulus across the array of neurons. We are interested in understanding how genes ('nature') interact with the environment ('nurture') to guide the development of these neuronal maps. For example, it is well established in the vertebrate that molecular/genetic mechanisms guide sensory afferents to their appropriate target brain structure. Neuronal activity, shaped by sensory experience, is then thought to refine the arrangement of afferent synapses in order to accurately reflect the pattern of sensory input from the periphery. We are currently focused on the development of the sensory pathways in rodents, particularly the visual and somatosensory system, because they allow for the relatively easy and rapid investigation of developmental mechanisms, but they are similar in many respects to analogous neuronal circuits in the human. We specifically use the maps of the retina and eye segregation in the visual system and the 'barrel' map of facial whiskers in the somatosensory cortex of the mouse to investigate mechanisms responsible for the development of topographic maps. Here, we will review experiments examining the role of activity in shaping the development of neural circuits for vision and somatosensation. In particular, we will make a 'comparison and contrast' analysis of the role of neural activity in the formation of topographic maps in the two sensory modalities, looking for unifying features that will allow us to identify fundamental mechanisms underlying neural circuit development in the mammalian forebrain.