Current Opinion in Neurobiology Review on Activity in Visual Map Development

* functional - physiological
  + synapse maturation
    - retinocollicular synapse
      * Increased AMPA/NMDA ratios and AMPA quantal amplitudes during first postnatal week [[29]](#fn:29)
      * burst activation in vitro capable of inducing LTP [[29]](#fn:29)
      * delayed maturation and greater LTP at beta2-/- nAchR ko synapses [[29]](#fn:29)
    - retinogeniculate synapse
      * Chinfei Chen work (Hooks and Chen DOI 10.1016/j.neuron.2006.07.007)

Functional synapse maturation at retinogeniculate (Hooks and Chen, 2006) and retinocollicular (Shah and Crair, 2008) synapses is dependent on spontaneous activity. At the retinogeniculate synapse, blockade of spontaneous activity by TTX application to the eye around and before the time of eye opening, prevents the normal developmental increase in synapse strength and arrested synaptic pruning (Hooks and Chen, 2006). Visual deprivation (by delaying eye opening) has no effect. Functional maturation at the retinocollicular synapse is also impaired in 2-nAChR KO (2-/-) mice during the first week after birth (Shah and Crair, 2008), again suggesting that spontaneous retinal activity promotes the maturation of retinogufal synapses before normal vision is possible. (Talk about LTP/LTD at retinocollicular/retinogeniculate synapses here or elsewhere?).

* + retinotopy
    - Retinotopic map refinement requires retinal waves in SC [[25]](#fn:25)
      * beta2 nAchR ko mice, focal DiI tracer injections into retina
      * preferential anatomical terminal zone elongation along nasal-temporal axis
    - Disrupted retinotopic map in beta2 nAchR ko mice in LGN (first order connections) [[30]](#fn:30)
      * using tungsten microelectrode extracellular recordings
      * physiological receptive fields preferentially disrupted (elongated) along nasal-temporal (visual field azimuth) axis
      * Abnormal segregation of on- and off-centered cells in LGN that is not seen in wt
        + *precocious glutamate bipolar cell mediated waves?*
    - Altered retinotopic map in beta2 nAchR ko mice in SC (first order connections) [[31]](#fn:31)
      * using tungsten microelectrode extracellular recordings
      * physiological receptive fields elongated along nasal-temporal axis
    - Altered retinotopic map in beta2 nAChR-/- mice in SC (first order connections) [[32]](#fn:32)
      * using instrinsic signal imaging
      * retinotopic map preferentially disrupted (elongated) along anterior-posterior (nasal-temporal) axis of SC

The development of maps for visual stimulus features, such as retinotopy, ocular dominance and orientation, are also sensitive to the presence of ongoing spontaneous activity before eye opening. Disrupting retinal waves pharmacologically or genetically interferes with the development of both retinotopy and eye specific segregation in the dLGN and SC of mice (McLaughlin et al., 2003; Chandrasekaran et al., 2005). In the SC, of retinocollicular target zones and individual axon arbors are enlarged in 2-/- mice, and preferentially elongated along the nasal-temporal axis of the retina, corresponding the visual field azimuth (Chandrasekaran et al., 2005; Dhande et a., 2011). Functional response properties of SC neurons are correspondingly impacted, with receptive fields dramatically enlarged, particularly along the visual field azimuth (Chadrasekaran et al., 2005; Mrsic-Flogel et al., 2005). In the dLGN, retinal ganglion cell axon arbors are similarly enlarged 2-/- mice (pharmacology done???), but rather than enlarged receptive fields in individual dLGN neurons, the retinotopic map is disrupted because the receptive field location is scattered, particularly along the visual field azimuth (Grubb et al., 2003). Remarkably, in both the dLGN (Grubb et al., 2003) and SC (Chandrasekaran et al., 2005) of 2-/- mice, the organization of response properties associated with on- or off-selectivity, which are not normally observed in mice, emerge. In the dLGN, on- and off-center cells are spatially segregated (Grubb et al., 2003), while in the SC, neurons become selective to either the onset or the offset of light stimulus, when they normally respond equally well to both. Thus, it appears that organization around new response features emerge in the dLGN and SC of 2-/- mice, possibly because of the delayed functional development of retinofugal synapses (Hooks and Chen, 2006; Shah and Crair, 2008) and the precocious presence of Stage III (glutamate receptor mediated) waves in 2-/- mice (Bansal et al., 2000).

* + - Altered retinotopic map in beta2 nAchR -/- mice in V1 (second order connections) [[33]](#fn:33)
      * Intrinsic signal imaging of mouse V1 for visual space map
      * Extracellular microelectrode recordings for single cell receptive fields
      * Preferential disruption (elongation, scatter, response amplitude) along the visual space azimuth (nasal-temporal axis)
      * They speculate that waves regulate ephrinA gradients to explain the nasal-temporal disruption since travelling waves had not been found to have a preferred direction at the time
    - Cortico-collicular alignment of retinotopy (quaternary order connections, L5 –> SC) [[34]](#fn:34)
      * Transgenic mice, tracer injections, intrinsic signal functional mapping
      * Used ephA3ki/ki (knock in) mice crossed with beta2 nAchR -/- mice for the crucial experiment in Figure 6.
      * These mice have duplicated retinocollicular map, but only a single, non-matched corticocollicular projection when no cholinergic waves are present.
  + eye specific segregation
  + ocular dominance columns
    - development of ODCs in ferret [[35]](#fn:35)
      * epibatidine injections and tracer injections
      * ocular dominance bias index with extracellular microelectrode recordings
      * spontaneous cholinergic activity in retina required for cortical ODC formation
    - ODC and orientation selectivity maps in cat independent of visual experience [[2]](#fn:2)
  + orientation selectivity
    - ODC and orientation selectivity maps in cat independent of visual experience [[2]](#fn:2)
    - TODO: Recent Fitzpatrick work?
    - Orientation selectivity develops after retinotopic mapping and eye specific segregation in dLGN and matures after eye opening (see recent reviews [[3]](#fn:3) and [#Huberman:2008a])
    - Mice have no orientation columns but individual V1 neurons are highly selective [#Niell:2008] and prefer matched orientations through both eyes ([#Wang:2010b]; [[4]](#fn:4))
    - Binocular matching of orientation preference depends on vision in mice [[4]](#fn:4), but significant ON-OFF subregion binocular correspondence develops completely independent of visual experience [[4]](#fn:4)
      * adult mice either normally reared or dark reared from birth or P11. single unit recordings (FHC high impedance tungsten) in V1 under urethane anesthesia. Spike triggered averaging (STA) with sinusoidal gratings. Also did flashed spots and PSTH analysis, same results.
      * Fig 5 nice model showing how subregion correspondence gives rise to binocular matching positive or negative sign overlap and their results fit the postive sign overlap model for binocular matching
      * Fig 6 shows subregion correspondence in absence of any light exposure
        + distribution of binocular differences in RF orientation not uniformly distributed, even with DR (also no difference between DR0 DR11, thus any melanopsin not important for orientation maps) and centered around 0º difference
        + large scale orientation maps and matching experience-independent [[2]](#fn:2) and develops in absence of coordinated binocular activity [#Godecke:1996]
  + direction selectivity
    - Recent Konnerth peri-eye opening calcium imaging paper [[36]](#fn:36)
      * calcium imaging in vivo
      * L2/3 neurons mouse visual cortex
      * early direction selectivity in orientation selective cells independent of visual experience
      * unmodified by dark rearing
      * authors conclude dev dir sel distinctly different in in mice from ferrets
    - TODO: Recent Fitzpatrick work (the reprogramming of selectivity)