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The binocular offset and tuning of retinal and cortical hemi representations

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The corpus callosum is the major interhemispheric fibre bundle in the mammalian brain which mostly connects homologous cortical areas bilaterally. Early visual experience seems to influence callosal projections. In cats, bilateral occlusion eliminates most of the visual callosal axons while early strabismus halts the normal pruning process. Furthermore, a callosotomy shortly after birth will cause strabismus. We investigated these pathways in humans and developed a model which might explain both the sensory and motor aspects of infantile strabismus. In order to investigate visual interhemispheric fibers, tractography was used in subjects with infantile esotropia (IE) and control subjects with normal binocularity. In human callosal agenesis, normal binocularity could be explained by different interhemispheric connections via the anterior commissure. In subjects with infantile esotropia, the analyses from the primary visual area on one side appeared different from the analysis from the other side. The distribution areas are asymmetrical. Binocularity and alignment not only rely on correspondence between crossed and uncrossed hemi-representations but in addition the corpus callosum seems important in this respect. Its role in the development of the visual pathways is like the tuning of an orchestra. If correspondence is possible between hemi-representations of crossed and uncrossed pathways on both sides of the cortex, the uncrossed pathway projects via the corpus callosum towards the contralateral hemi-representation. A vertical midline comes out of this process. Meanwhile, however, the other uncrossed pathway strives to find the vertical midline of the other eye. Early in development the interhemispherical pathways seek to bring both vertical midline representations and the correspondence in both hemispheres in line. A failure to do so will result in crossed dominance after V1. Consequently, the normal binocular development of the brainstem, i.e. the not and superior colliculus, will not take place and latent nystagmus as well as dissociated horizontal and or vertical divergence may ensue.

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