FUNCTIONAL MRI OF THE SUPERIOR COLLICULUS IN DISSOCIATED VERTICAL DEVIATION

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Background and aim of the project

Dissociated vertical deviation (DVD), first described in 1894, is commonly encountered in the infantile strabismus syndrome. The vertical position of the eyes in DVD depends on fixation effort and luminance differences. The neural mechanism behind DVD is still not clear. Visual and oculomotor pathways in the brainstem are phylogenetically old pathways which in origin are basically monocular: the eye projects to the contralateral brainstem. Cortical visual and oculomotor pathways on the other hand are only found in birds and mammals and are basically binocular: the visual field projects to the contralateral cortex. In primates, stereopsis driven pathways were found to dominate gravity driven brainstem pathways. In early onset strabismus stereopsis fails to develop. The cause of latent nystagmus which also occurs in infantile strabismus syndrome has been tied to a changed hierarchy between cortical and brainstem velocity tracking systems. The same may hold true for DVD. With scleral search coil recordings in individuals with DVD, we showed that motor characteristics in DVD are similar to disparity induced vertical vergence. Vergence is a phylogenetically new system that facilitates binocular vision and is even weaker in cats than in primates. Vergence pathways from the cortex to the superior colliculus are strictly unilateral. The rostral pole of monkey SC projects to omnipause neurons. Both stimulation of the rostral pole of the superior colliculus and stimulation of omnipause neurons result in changes in vertical vergence.

At least for torsional eye movements, it is shown that by equally activating populations of neurons in the right and left interstitial nucleus of Cajal, the head is kept in position. It is likely that disparity induced vertical vergence is realized by weighted activation of right and left omnipause neurons. The nasal bias in ocular dominance columns and interocular suppression found in infantile strabismus may give rise to vertical vergence known as Dissociated Vertical Deviation.

Development of the project

Bielschowsky showed that placing filters of increasing density before the fixating eye makes the hypertropic fellow eye come down incrementally . Interdependance between eyes in DVD resembles a balance: the more intense fixation of one eye is, the less the contralateral eye participates (the higher it is). This interdependance is known in physiology as reciprocal inhibition. Reciprocal inhibition between monocular channels is a quality of the cortical visual pathways (Lateral Geniculate Nucleus and V1). So, it is likely that visual cortical pathways control the 'balance' in DVD. Corticotectal pathways which are unilateral translate the result of reciprocal inhibition between monocular cortical activation into two signals which activate the superior colliculus and omnipause neurons. The hypothesis of this project predicts that the 'balance' in vertical eye position in DVD results from asymmetric stimulation of right and left omnipause neurons.

Functional MRI is a non-invasive imaging technique with which brain functions can be localized and studied. A MRI signal resulting from brain activation is only 1or 2 % stronger than the background signal. It starts about 7 seconds after the beginning of the task. Therefore subjects have to perform tasks in an alternating sequence.
All measurements are performed in a 3 Tesla Siemens MRI scanner of the university hospital Antwerp.
Ten subjects with normal binocularity and normal visual acuity of both eyes are used as controls. Ten subjects with DVD in both eyes and infantile strabismus as well as normal visual acuity in both eyes are tested.
Subjects have to watch checkerboards with different check sizes and different illumination contrast.
The amount of contrast and size difference giving rise to the largest difference in DVD under monocular conditions will be tested clinically.
Then subjects have to watch monocularly, with one eye occluded, during episodes of 30 seconds during which luminance contrast and size of checks is kept constant. Episodes with conditions leading to large amounts of hyperdeviation are compared to episodes eliciting small amounts of hyperdeviation.
The right and left side of both the visual cortex and the tectal area are studied.
By this way, it will be tested whether large dissociated vertical divergence is correlated with large differences in activation between right and left visual cortex and tectum.

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