THE BRAIN’S CONTROL OF HORIZONTAL SACCADIC EYE MOVEMENTS

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The Brain controls how the eyes move by processing information in multiple well delineated cortical regions called eyes fields.

http://www.inma.ucl.ac.be/EYELAB/neurophysio/perception_action/saccades.html
Six Cortical Eye Fields

Frontal eye field - FEF
Parietal eye field - PEF
Supplementary eye field - SEF
Medial superior temporal area - MST
Prefrontal eye field (DLPFC) - PFEF
Precuneus region (7m in the monkey)
Each EF is interconnected to all the other EFs and each has direct connections to the brainstem oculomotor system.

http://www.inma.ucl.ac.be/EYELAB/neurophysio/perception_action
EFs participate in other functions

Higher cognitive function such as memory
Decision-making
Remapping of sensory signals
Modulation of attention
Planning of actions
Cortical Activity

At the cortical level potential targets for gaze are analyzed and selected and a decision is made to execute a saccadic eye movement from one target to another or a pursuit eye movement to follow a moving target.
Cortical function is linked to the functions of the superior colliculus, thalamus, basal ganglia, cerebellum and other subcortical structures.
Functional imaging permits analysis of the cortical network

Two fMRI studies directly compared cortical activation during saccadic and smooth pursuit eye movements and found common cortical activation in the FEF, SEF, PEF, the Precuneus and MT/MST for saccade and pursuit eye movements.
Types of Saccades affected by Cortical Lesions

Intentional – volitional, purposeful
Reflexive – saccades to unexpected stimuli
Express – short latency saccades to a novel stimulus after the fixation stimulus has gone
Memory-guided – saccades to a previously presented target (i.e. visual memory)
Predictive – anticipatory saccades to a specific location
Antisaccades – after instruction to look in the opposite direction of a suddenly appearing target.
FEF controls a hierarchy of functions

Intentional saccades to visual targets
Reflexive saccades
Memory-guided saccades
Antisaccades
PEF initiates

Visuo-spatial attention by triggering visually guided reflexive saccades and disengaging fixation
SEF plays a prominent role in directing voluntary sequences of saccades to specific positions.
Oculomotor Structures

- SC
- SEF
- PEF
- FEF
- MST
- Mes
- RF
- 3
- 4
- PPRF
- 6
- Med
- RF
- MV
- PH
- N/F
- FOR
- Uvula
- PF
- Dorsal Vermis
Brainstem Machinery

Midbrain V-T, VERGE

Pons HORIZ

Medulla HOLDING
Base Sections from DeArmond – Structure of the Human Brain
### Horizontal Muscle Actions

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superior oblique</td>
<td>Abduct</td>
</tr>
<tr>
<td>Levator palpebrae superioris</td>
<td>Addduct</td>
</tr>
<tr>
<td>Superior rectus</td>
<td>Lateralize</td>
</tr>
<tr>
<td>Lateral rectus</td>
<td></td>
</tr>
<tr>
<td>Medial rectus</td>
<td></td>
</tr>
<tr>
<td>Inferior rectus</td>
<td></td>
</tr>
<tr>
<td>Inferior oblique</td>
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</tbody>
</table>

Hypothesis

There is increasing evidence that eye movement control and visuo-spatial attention share a common network.

The anatomical overlap supports the hypothesis that attentional and oculomotor processes are tightly integrated at the neural level.
Observations

Watch the patient’s random eye movements when he/she is talking to you

The co-ordination of head movements with movement of the eyes

Time the latency period for the initiation of a voluntary saccade after the command to look right or left. A delay greater than 200 msec is significant

The speed of the saccade. Is it slow, too fast or normal?
Observations

Is the saccade accurate, right on target or hypometric, short of the target or hypermetric, overshoot the target

(A)

(B)

(C)
Is the new position of gaze holding stable or are the eyes drifting back to the midline and then making a quick corrective saccade back resulting in gaze-evoked nystagmus
Horizontal Leftward Voluntary Saccade ("Look to the left")

1. R Frontal Eye Field
2. R saccade center
3. L horiz. gaze center
4. L 6th nucleus (L eye out)
5. R MLF
6. R 3rd nucleus (R eye in)
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Frontotemporal Dementia
Pick body

Bielschowsky

Ubiquitin positive

Tau positive

Tau
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