# Med's Neurophysiology

## Eye Movements

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### Introduction

We move our eyes to **see better**.

**1)** the retina is not uniform. Only the fovea has high acuity. We make saccades to place and keep the image of the object of interest on the part of the retina with the highest acuity, the **fovea**. Try to read a page of text without moving your eyes. How much of this sentence can you make out while fixating a single word?

**2)** the retina is like the camera with a slow shutter speed. The image must be still on the retina to see it clearly. We used the vestibular ocular reflex to keep the image on the **whole retina** stationary in spite of movements of one's head. Try shaking your head from side to side while reading this page. Can you make out what it says? If you can, your VOR is working.

### There are 5 types of eye movements.

### 1) Saccades

- Saccades are used to point the **fovea** to objects of interest like the words in this sentence.
- Get a partner. Watch your partner's eyes while reading a page. What pattern of eye movements do you see? Place one finger to the right and the other to the left. Ask your partner to saccade back and forth from one to the other every second or so.
- Notice how the eyes rotate **so fast** that it is hard to see them move. You are nearly **blind** during a saccade. To minimize this blind period saccades are **very fast**, the fastest your body can make.
- Notice how they get to your other finger **accuratel**y in one or two saccades.
- Check if the two eyes rotate at the same speed, in the same direction and by the same amount (**conjugate)**. If the speed, direction, or amount is different, something is abnormal.
- Unlike a limb movement, you **cannot** will yourself to make a **slow** saccade. Ask your partner to make a slow saccade. They cannot. The speed is **preset** by the PPRF.

### 2) Vergence

- Vergence directs the **two foveae** at the same object. They prevent you from seeing double (strabismus). Ask your partner to look at your finger while you move it up, down, right, left. If Vergence works the two eyes should pointing at your finger in all these positions and your partner should see only one finger.
- Convergence occurs when looked from far to near and divergence when looking from near to far.
- How do saccadic and vergence eye movements differ? Get a partner to make these movements by placing one finger **very close** to the eye and the other far, but at the **same height**. (If they are not at the same height a rapid vertical saccade will accompany vergence)
- Notice that vergence movements are much **slower** than saccades.
- Also during saccades both eyes rotate in the same direction. During vergence, they rotate in opposite directions **(disconjugate)**.

### 3) Pursuit

- When an object moves, the image is kept still on the **fovea** by means of a pursuit eye movement.
- Move a finger **slowly** to the right and left. Watch the subject make smooth pursuit eye movements.
- If you move your fingers **more quickly,** saccades will be used to catch up to the finger.
- You cannot will yourself to make pursuit eye movements in the absence of a **moving stimulus**? Ask a partner to try and watch their eyes. You will see a series of saccades, not a smooth pursuit movement.

### 4) Vestibular ocular reflex (VOR)

- If we move our head, an eye movement **very similar to pursuit** is elicited whose function is to keep the image still on the **whole retina**. However, in spite of the fact that the movement looks similar, it is generated by a different neural circuit, the vestibular ocular reflex (VOR).
- The VOR responds much **faster** than the pursuit system. Notice that you can read a page of text while you shake your head quickly from side to side. To activate the pursuit system, take a page of text and try reading it while you shake the page as quickly from side to side. Notice that it is much more difficult to make out the words while shaking the page than when shaking your head. This is because the reflex loop for pursuit is long, through primary visual cortex (V1) and the middle temporal motion area (MT), while that of the VOR is short.
- Ask your partner to make a **large slow** head rotation from side to side while looking at the room. Notice that the smooth VOR movements in one direction are interrupted by saccades in the other direction. This is **nystagmus**.
- Also unlike the pursuit system, the VOR does not need a visual stimulus. It works in the **dark**. Rotate your head with your eyes closed. Feel your eyes move with your finger tips. If you make small rotations of the head, you will feel smooth eye movements generated by the VOR. If you make large rotations of the head you will feel the smooth movements interrupted by jerks. This again is nystagmus.

### 5) Optokinetic Reflex (OKR)

- The VOR does not work well for slow, prolonged movements. In this case vision, through the OKR, assists the VOR. The OKR is activated when the image of the world slips on the **whole retina** and produces a sense of self motion (e.g. when sitting in a car stopped at a light and a car beside you starts to move, you sometimes feel like you are moving).
- In the clinic this is tested with a large rotating stripped drum. When this drum is rotated in front of the subject **optokinetic nystagmus** is generated.

### Note that each type of eye movement

- 1) serves a unique function &
- 2) has properties particularly suited to that function.
- 3) the first 3 types are concerned with **A)** keeping the image stable on the **fovea** and the last two with **B)** keeping the image stable on the **whole retina**.