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PURSUITS

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THIS CHAPTER INCLUDES A REVIEW OF:

- Facts about Pursuits
- Models of the Pursuit System
- Latency and Pursuit Eye Movements
- Abnormal Pursuits
- Way to Improve Pursuits
- Saccadic Overlay
- Ageing Effects on Pursuits

INTRODUCTION

- Pursuits are the major eye movement involved in tracking objects smoothly in space
  → What types of activities in your life would involve pursuit movement?
- The main goal of this system is to match your eye velocity to target velocity.

Pursuits are also a form of Slow Eye Movements (SEM). The pursuit system can over-ride the vestibular system. A pursuit movement can occur while the head is being turned. Think of football!

FACTS ABOUT PURSUITS

A. GENERAL FACTS

- Conjugate eye movements:

  Motion/movement, and not the target's overall position on the retina, is the stimulus for a pursuit. That is, the pursuit system is more likely to respond to target velocity and acceleration than target position although target position may also drive the system to some extent. The motion of the target causes 'retinal slip'

  - Retinal slip occurs when the images start to slide off of the fovea because the object of regard is moving.
  - This stimulates a pursuit (and, if it is fast and big enough, a saccade, too). But, it is not just the position of the target relative to the fovea (this is more a static thing) that stimulates the pursuit → it is the movement of it and the resulting retinal slippage.
- Pursuits work best with slow target movements and with a velocity of 20-50 degrees per second. If the target is too fast, it creates a large retinal error (i.e. it's too far off of the fovea), which reduces the resolution of the target (how well you see it) and may stimulate a saccade to get things back on track.
- In clinical testing, this is important so that when you are testing pursuits the target should not be moved too fast otherwise saccades would be tested.
- No suppression/omission of information occurs during a pursuit (unlike in saccades) → the goal is to keep the object ON the fovea for clear vision. It is called a continuous control system and samples the target constantly, responding to any small change in position as it goes along.
- Sustained periods of foveal pursuit allow maximal resolution of the moving target, as well as better information-gathering and processing of the fine target details. Evolutionarily, think how important this was for hunting the Woolly mammoth, Saber tooth tiger, etc.
- With retinal peripheral targets, a pursuit can be triggered before a saccade, when the target starts moving over that portion of the retina. Why would this be good for the visual system?

Latency of the pursuit system is 100 msec; this is how long it takes to process the neural signal. Latency is slightly longer for slow targets.

B. FACTS CONCERNING PURSUITS AND PREDICTABLE TARGETS

- If the target is predictable, then the eye will anticipate and start to move even before the target starts to move. (We saw this in the section on saccades and anticipation).
- If the target is still, then anticipatory drifts will not be made unless the person imagines an apparent motion of the target or if the lights are turned off.
- The brain is using some kind of memory in relation to perceived target motion and stopping.
- With training, a person can match pursuit movements almost perfectly with the motion of the target. This may be due to:
  - Memory of the patterned movement
  - The brain's extrapolation of the target's behavior.
    What advantage would there be to be able to match these so well?
- The pursuit system can continue tracking a stimulus for about 190 msec at 60% of the original velocity after the stimulus is gone.
- Smooth pursuit of predictable target motion is superior to that of non-predictable motion. Can you think of ways that this might manifest in a clinical testing situation?

NOTE: Efficiency of pursuits in response to predictable target motion varies with subject, testing protocols, and how the data is analyzed. How might this impact your results when testing a 6 year old child?

MODELS OF THE PURSUIT SYSTEM

A. OPEN AND CLOSED LOOPS	• Open loop systems for control of neurological pathways do not continuously sample the environment; their reactions, instead, rely only on the initial information given to the system. • Closed loops use feedback from within the system and sample data constantly to adjust the outcome. This makes it more precise. Can you think of a closed loop system we've already studied? • The pursuit system is traditionally considered to be a continuous control system. In other words, it continuously samples the environment to make the movements more precise. So is the pursuit system more open or closed loop? • The earliest models of the pursuit system were considered to be only a basic velocity mechanism, i.e. all they did was match eye velocity to target velocity, which reduced retinal slippage and kept the target clear while it was being tracked.
B. COMPONENTS OF THE MODELS	• **A differentiator** converts position information into velocity information. • **A limitor** prevents a motor response to a velocity input that is greater than the patient's preset system level i.e. if the target goes too fast while you track it, then the limitor stops the pursuit from firing so that the saccadic system can take over and track it. • **An open-loop gain** to combine with other things to form a "leaky" neural integrator. • **A processing delay** • **A saturation element** which prevents the response from being too large • **An integrator** (1/s) which converts a velocity signal into an eye position signal - this makes the eye muscles move. • But, there were a few problems associated with this model, so a more complex model was formulated which included an input for target velocity relative to the environment. It also included positive feedback information about retinal velocity and acceleration as the eyes track.

LATENCY AND PURSUIT EYE MOVEMENTS

100 MSEC LATENCY TIME FOR PURSUITS	This is how long it takes to process the neural signal and get the eyes moving. • The initial 20-40 msec presaccadic portion is independent of target stimulus, i.e. it just works to get the eyes moving somewhere. This is considered more open loop, because it doesn't really sample any environmental data, it just tries to get the eyes moving. • The last 60 msec of that 100msec time is considered closed loop, because it is loosely related to target velocity and is under visual feedback control, i.e. the pursuit generated is related to either a real or perceived target velocity. • After that initial 100msec, the pursuit system continues to be closed loop. How will that affect the accuracy of the response? • Details about the flow of information along the pursuit system are less well understood than in the saccadic system.
A. PURSUITS	The magnocellular pathway is likely to be the pathway used. This makes sense because the cerebellum plays a really important part in synthesizing the pursuit signal.

ABNORMAL PURSUITS

Errors in pursuit may occur in the following areas:

1. INITIATION	• Latency • Initial 100msec open-loop phase • Maximal eye acceleration
2. REDUCING PURSUIT ABILITY	• Pursuit ability can be reduced by introducing a stationary or moving background, especially if placed near the target plane. Such background clues may cause retinal slip of the background information in the opposite direction of the pursuit movement; this could be a stimulus for OKN. The reduction in gain could be the visual systems effort to cancel out the OKN response triggered in this case. • Accuracy is partially determined by either predictable or unpredictable target movements. • Accuracy can also be reduced by: - Increased target velocity and acceleration - Increased target eccentricity - Increased target unpredictability - Increased age of viewer - Smaller targets - Vertical target movement (versus horizontal) - Moving background distractions - Inattention - Fatigue - Lack of other proprioceptive or auditory cues - Alcohol - Barbiturates - Medication (e.g. diazepam) - Neurological disease (especially those involving the cerebral cortex and cerebellum) - Jerk nystagmus - Amblyopia (due to decreased foveal sensitivity)

NOTE: Pursuit ability is more related to maximal target acceleration than to its velocity; velocities up to 30-40 degrees per second offer the best gain.

2. REDUCING PURSUIT ABILITY	• Patients with pursuit deficiencies do not complain of visual symptoms, they substitute multiple saccades for the pursuit movement. They do not realize that their movements are jerky and not smooth. • Impaired tracking can be an indication of a lesion of the vestibulo-cerebellum region • Parietal lobe lesions may lead to slow pursuit in one direction and a normal pursuit in the opposite. Remember this for OKN; the lesion will be on the same side as the slower pursuit. A lesion in the parietal lobe will often have a contralateral homonymous hemianopsia. To differentiate from an occipital lobe lesion, a parietal lesion will have loss of OKN when the stripes move to the side of the lesion. This is because there is no pursuit to follow and produce OKN.

WAYS TO IMPROVE PURSUITS

WAYS TO IMPROVE PURSUITS	Can pursuits be improved? • Research has found that moderate improvements could be made in velocity matching and correction of positional errors. • In addition, further research has also shown that the accuracy of horizontal and vertical pursuits can be improved. • Athletes with good initial test scores on pursuits could improve to a final level that normal subjects could attain with training.

AGEING EFFECTS ON PURSUITS

AGEING EFFECTS ON PURSUITS	• Reduced closed-loop gain (i.e. pursuit accuracy) of about 25%, which becomes progressively worse as the target velocity increases. It may be due to age-related degradation of the motion information at numerous sites in the visual pathway. The older you get, the worse your pursuit movements are, and the harder it is for you to track moving objects. Think about how this would affect the activities of your daily life; studying, working, watching a football game, driving, etc. All of these can become much harder. • Increased overall saccade frequency. Why? • Reduced overall acceleration → not only is it more difficult to track with a pursuit once you are looking at the target, but it is also harder for your eyes to catch up to it in the first place. • Increased velocity latency → indicative of a delay in processing. • Increased square wave jerks. Increased visual distractibility → i.e. if there is lots of background 'noise', then it is easier to lose your place.

SUMMARY

SUMMARY	Versional Eye movements are yoked movements of the two eyes in the same direction. This occurs in: 1. Vestibulo-optokinetic system 2. Saccadic system 3. Pursuit system These three systems work together with inputs going to the “neural integrator” which sends appropriate signals to the cranial nerve nuclei subnuclei, which in turn signal the extramural muscles to move the globe. The neural integrator is a variety of CNS structures that work together: 1. Cerebellum 2. Pontine reticular 3. Periphypoglossal nuclei
HORIZONTAL VERSIONS	1. The Horizontal Gaze Centre exists within the PONS, near to the sixth cranial nerve nuclei (the Parapontine Reticular Formation, or PPRF, is another name for the “horizontal gaze centre”). 2. The horizontal gaze centres are responsible for the commands which reach the cranial nerve nuclei and produce a horizontal versional movement. 3. The PPRF sends input into the abducens (VI) nerve nucleus Two separate neuron populations within the abducens nucleus respond to the command to execute a horizontal movement 1. Neurons supply the ipsilateral lateral rectus muscle by way of axons within the ipsilateral abducens nerve 2. Neurons supply the contralateral medial rectus muscle by way of the contralateral medial longitudinal fasiculus (MLF) into the oculomotor nerve subnucleus, which then sends an axon up to the oculomotor nerve. 3. The abducens nucleus also receives constant input from the vestibular nerve nuclei, from the periphypoglssal nuclei and from the burst cells of the pons. Thus the abducens nucleus integrates all these inputs.
TESTING PURSUIT	Evaluate pursuit by monitoring patient’s eyes as they follow a small object in vertical and horizontal versions. Observe for catch up saccades or absence of pursuit. Evaluate the patients’ ability to suppress the VOR. Patient is on a rotating stool and fixates thumb. A normal patient can suppress the induced VOR by maintaining fixation on the thumb, even in darkness or with the eyes closed, this may help rule out a malingering patient if they cannot maintain fixation, as even a blind person can.

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