saccades

training vision= training movement

tracking

- fixation
- saccades
- (smooth) pursuits
- central/peripheral integration

perception

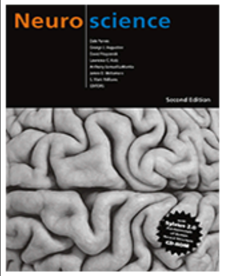
- visual discrimination
- visual spatial relations
- visual closure
- visual memory
- sequential memory
- figure ground
- form constancy

teaming

- Convergence
- Divergence

focusing

- accommodation



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Types of Eye Movements and Their Functions

There are four basic types of eye movements: saccades, smooth pursuit movements, vergence movements, and vestibulo-ocular movements. The functions of each type of eye movement are introduced here; in subsequent sections, the neural circuitry responsible for three of these types of movements is presented in more detail (see Chapters 14 and 19 for further discussion of neural circuitry underlying vestibulo-ocular movements).

Saccades are rapid, ballistic movements of the eyes that abruptly change the point of fixation. They range in amplitude from the small movements made while reading, for example, to the much larger movements made while gazing around a room. Saccades can be elicited voluntarily, but occur reflexively whenever the eyes are open, even when fixated on a target (see Box A). The rapid eye movements that occur during an important phase of sleep (see Chapter 28) are also saccades. The time course of a saccadic eye movement is shown in Figure 20.4. After the onset

Tracking: Saccades

Saccades refer to the eye's ability to quickly and accurately shift from one target to another. This is a critical skill in reading, involving very specific eye movements. The eyes must move left to right along a straight line without deviating up or down to the lines above or below. In addition, when we reach the end of a line, our eyes must make a difficult reverse sweep back to the beginning of the next line. If a child cannot control these eye movements, he'll

How Saccade Intrusions Affect Subsequent Motor and Oculomotor Actions

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In daily activities, there is a close spatial and temporal coupling between eye and hand movements that enables human beings to perform actions smoothly and accurately. If

Introduction

Daily life requires an almost infinite number of actions that require eye-hand coordination (Engel and Soechting, 2003; Vercher et al., 2003; Crawford et al., 2004). For example, there is a close spatial and temporal coupling between the eyes and hand movements when subjects point to a peripheral target (Abrams et al., 1990; Helsen et al., 2000; Neggers and Bekkering, 2000, 2001; Ren et al., 2006). Similarly, in natural settings such as object manipulation, we first turn our gaze (central vision) to the object, and the hand subsequently reaches out to grasp it (Biguer et al., 1982; Prablanc and Martin, 1992).

This coordination of eye and hand movements has several advantages. First, by directing eye movements toward an object and foveating on it (i.e., placing it in the center of vision), the eyes provide spatial information for the hands (Crawford et al., 2004). Furthermore, pointing in general is more accurate when the gaze is fixed on the intended target, thereby avoiding the added processing of spatial updating for gaze shifts during pointing (Crawford et al., 2004). In some situations, gaze and arm movements appear to be guided by a common drive signal (Engel et al., 2000), and saccades are faster when accompanied by a coordinated arm movement (Epelboim et al., 1995; Snyder et al., 2002).

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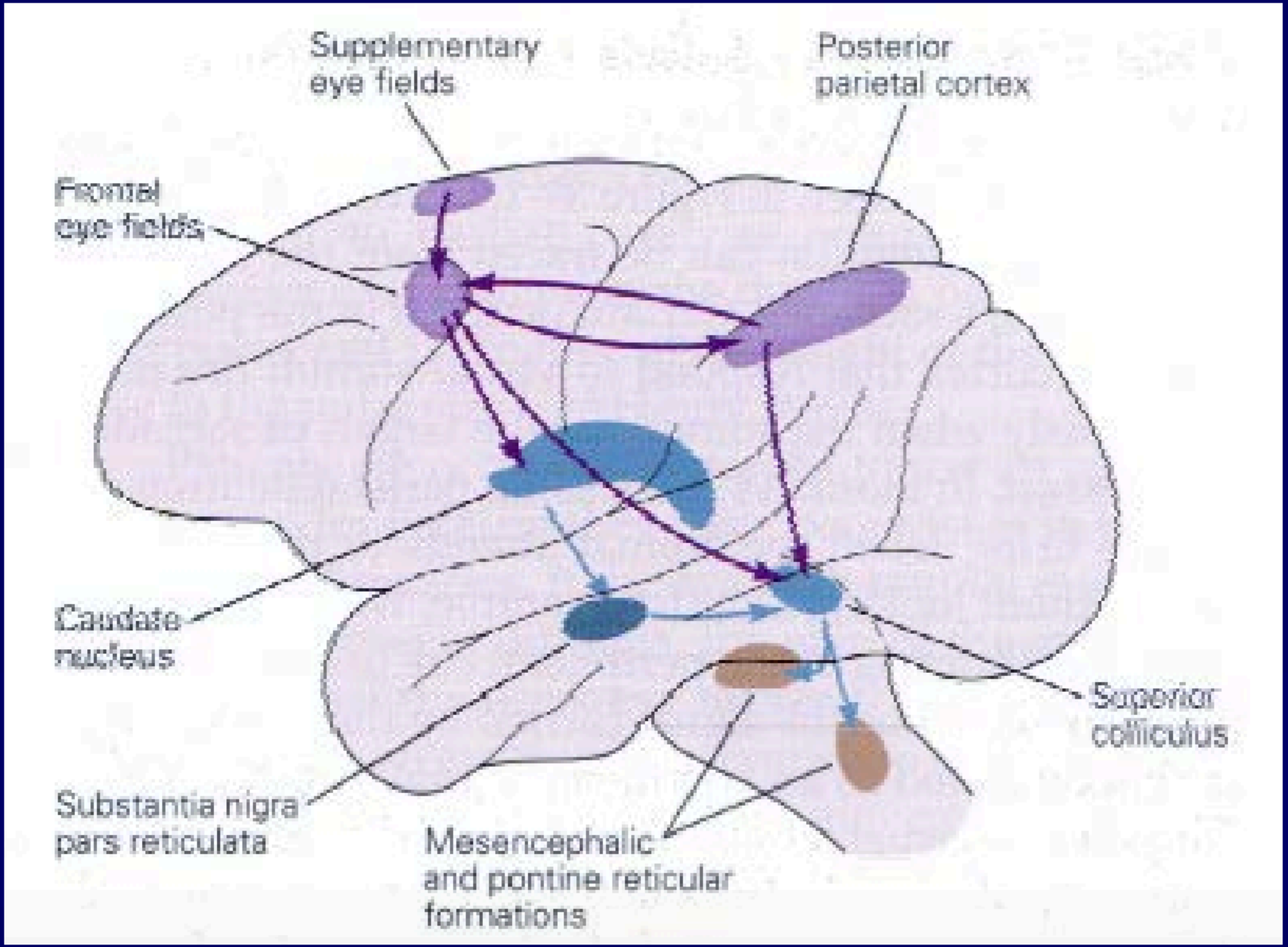
The Brain controls how the eyes move by processing information in multiple well delineated cortical regions called eyes fields.



Cortical Activity

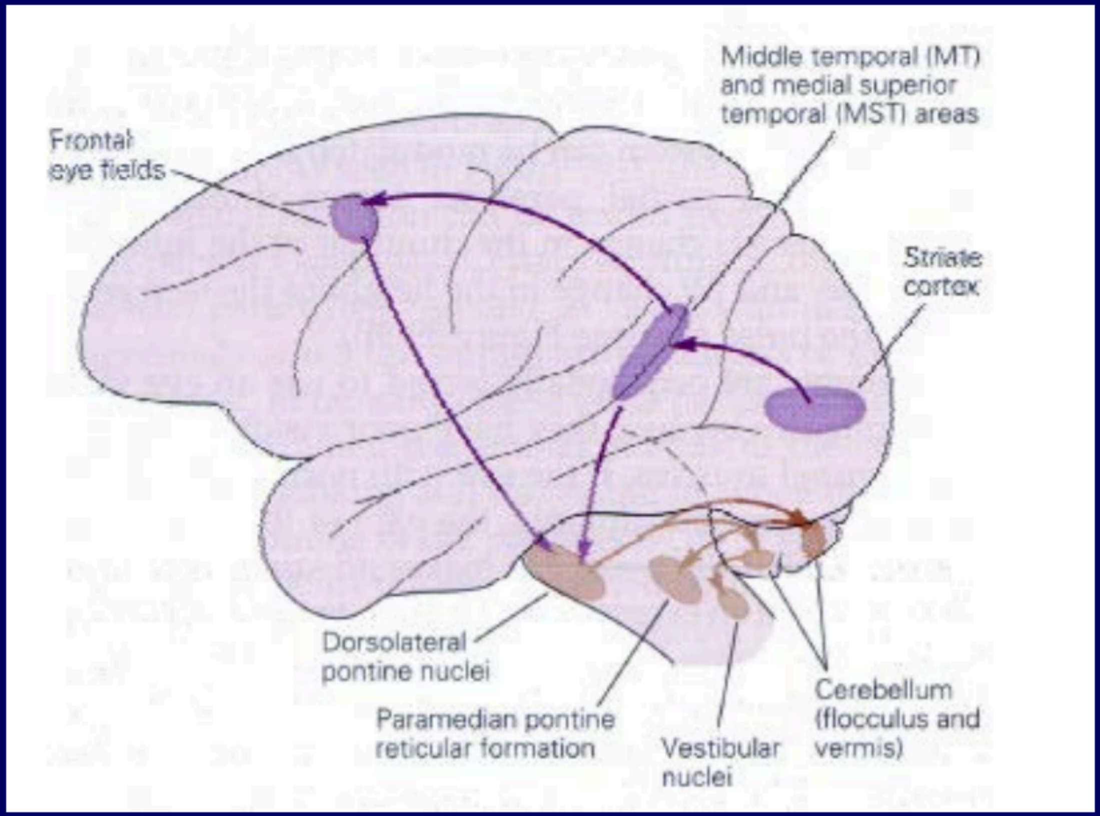
At the cortical level potential targets for gaze are

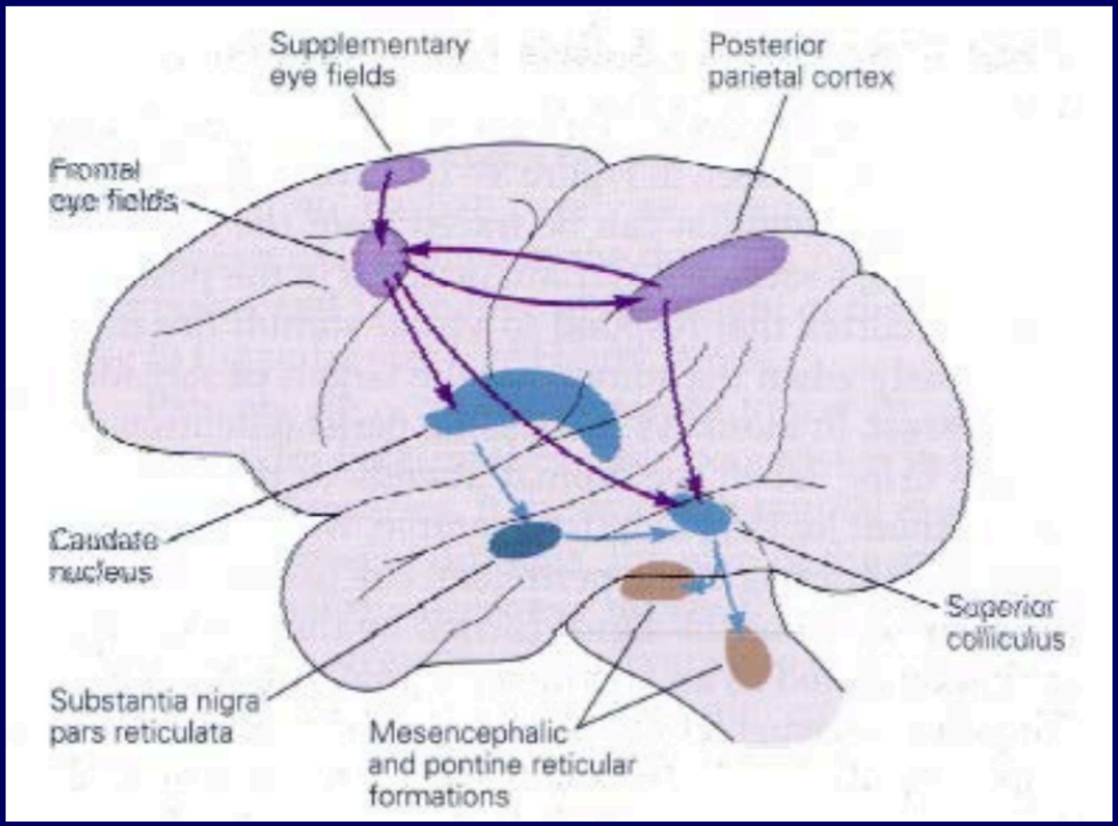
analyzed and selected and a decision is made to

execute

a saccadic eye movement from one target to another
or
a pursuit eye movement to follow a moving target

Interconnections





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

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.

Cerebellar Control of Eye Movements

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Background: The cerebellum plays a central role in the online, real-time control, and long-term modulation of eye movements.

Evidence acquisition: We reviewed the latest (fifth) edition of Leigh and Zee's textbook, The Neurology of Eye Movements, and literature in PUBMED using the following terms: cerebellum, flocculus, paraflocculus, vermis, oculomotor vermis, dorsal vermis, caudal fastigial nucleus, fastigial oculomotor region, uvula, nodulus, ansiform lobule, eye movements, saccades, ipsipulsion, contrapulsion, smooth pursuit, vergence, convergence, divergence, gaze-holding, down beat nystagmus, vestibulo-ocular reflex (VOR), angular VOR, translational VOR, skew deviation, velocity storage.

Results: The cerebellum is vital in optimizing the performance of all classes of gaze-shifting and gaze-stabilizing reflexes. The flocculus-paraflocculus are crucial to VOR gain and direction, pulse-step matching for saccades, pursuit gain, and gaze-holding. The ocular motor vermis and caudal fastigial nuclei are essential in saccadic adaptation and accuracy, and pursuit gain. The nodulus and ventral uvula are involved in processing otolothic signals and VOR responses, including velocity storage.

Conclusions: The cerebellum guarantees the precision of ocular movements to optimize visual performance and occupies a central role in all classes of eye movements both in real-time control and in long-term calibration and learning (i.e., adaptation).

The goal of the efferent visual system is to direct and maintain the angle of gaze on an object of regard, thereby guaranteeing the best possible visual acuity and clarity. Several mechanisms are crucial in attaining this goal: (A) saccades, which direct the eyes to the object of regard; (B) fixation and pursuit tracking, which detects (and corrects for) retinal image drift, and suppresses unwanted saccades; (C) the vestibulo-ocular reflex (VOR) that compensates for head perturbations at short latency to preserve visual acuity during locomotion; and (D) the gaze-holding system, which counteracts the elastic forces of orbital tissue ([1–3]). In species with frontally directed eyes with central foveas, the vergence system enables bifoveal fixation of a single object of regard by correctly aligning the visual axes ([1]). The cerebellum plays a vital role in ensuring the precision and accuracy of ocular movements regardless of changes in head or body positions and is intimately involved in controlling gaze-shifting and gaze-stabilizing reflexes, both in their real-time, immediate modulation, and in their long-term calibration ([1]).

Three cerebellar regions are especially important for ocular motor control (Fig. 1):

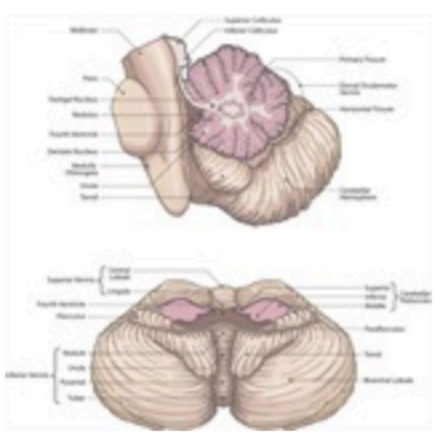

FIG. 1

CONCLUSION

The cerebellum ensures the precision of ocular movements and occupies a central role in all classes of eye movements, both in real-time control and in long-term calibration and learning (i.e., adaptation). The flocculus-paraflocculus are crucial to VOR gain and direction, pulse-step matching for saccades, pursuit gain, and gaze-holding. The OMV-CFN are essential in saccadic accuracy and pursuit gain. The nodulus and ventral uvula are involved in the low-frequency VOR responses (Table 1). The most important, intriguing, and impressive role of the cerebellum in eye movement control is its ability to constantly monitor the brain's performance, detect errors, readjust, and recalibrate its responses to guarantee optimal visual acuity.