NEUR 3001; Advanced Visual Neuroscience
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Professor Glickstein
Visual Guidance of Movement

DEMO: CATCH A SMALL OBJECT

There are two major systems in the brain controlling movement;
Basal ganglia and cerebellum. For much of the brain the two systems remain separate. A fundamental question is to understand their differential role in motor control.

The systems when they work properly, are often beautiful to see; a ballet dancer or a gymnast. But is not just human movement that can be beautiful.

Film: Gibbons

It can be tragic when one of system goes completely wrong.

Film; Ivan shaking while dressing

I want to show some instances in which understanding the differences in the two independent systems can be helpful in understanding the symptoms in someone afflicted with a disease.

We can distinguish several classes of movement

Whole body; running; riding a bicycle
Driving; landing an airplane
Arms, legs etc. (catching a cricket ball/baseball; kicking a football)
Fingers and wrist (threading a needle; sight-reading a musical score).
Eyes: On the categories of voluntary eye movements conjugate vs. vergence
Smooth pursuit vs saccade;
Why has so much attention been paid to eye movements?

General problem of load compensation in limbs;
Eyes always weigh the same

One more aspect of visuo-motor control to consider is predictive control. Is the traffic slow enough for me to cross the road?

Brief side look into history. The discovery of the motor and visual cortex

SLIDE 1: 1870s; FRITSCH AND HITZIG WITH DOG'S BRAIN

Electrical stimulation produces movement on the *opposite* side of the body

SLIDE 2: 1880s: MUNK: OCCIPITAL LESIONS CAUSES HEMIANOPIA

SLIDE 3: 1890s SALOMON HENSCHEN "HEMIANOPISCHE FÄLLE"

"KEINE HEMIANOPSIE"

By the end of the nineteenth century, the identity and location of the primary visual and motor areas of the human and monkey cerebral cortex were clear. Less was understood about further processing of the visual signal.

SLIDE 4: BRODMANN LATERAL VIEW

The circuits for visuo-motor control start at the primary visual cortex. There are circuits that further process the visual signal; a lateral one involving the temporal; lobe, and a medial system, the parietal lobe. **I**n the old literature these were often lumped together as "Association areas".

Parietal Lobe Lesions Cause Visuo- Motor Impairment

SLIDE 5: FERRIER: "TEMPORARY COMPLETE ...."
So profound that he misinterpreted the deficit as due to blindness

SLIDE 6: BALINTS CASE

SLIDE 7: BALINTS DESCRIPTION

How do visual cortical areas connect to motor cortical areas?

Assumption of direct cortico-cortical links

Direct cuts of cortico-cortical fibres do not block visual guidance of the hand and arm.

While some movements may be controlled by cortico-cortical links, there are two subcortical routes whereby visual cortex may be linked to motor cortex for sensory guidance of movement; Basal ganglia and Cerebellum

BASAL GANGLIA

A very brief revue of the basal ganglia pathway Cortex-caudate /putamen-via external globus pallidus to internal; globus pallidus ; via thalamus to cortex

It is the virtually complete loss of this system that results in the deficits seen in

Parkinson's disease.

CEREBELLLUM

The visual input to the cerebellum originates in parietal lobe visual areas. Fibres link the parietal lobe visual areas by way of the internal capsule and cerebral peduncle to pontine nuclei.

SLIDE 8: HUMAN CERBRAL PEDUNCULE

The major target of the peduncle fibres is the pontine nuclei

SLIDE 9: HUMAN BRAINSTEM PARASAGITTAL SECTION TO SHOW PONS

How does the cerebral Cortex Connect to the Pontine Nuclei?

Two related questions;
1) Which Cells ? 2) Which Areas?

Inject pontine nuclei with a retrograde tracer; Identify labelled cortical cells

SLIDE 10: TREE SHREW

All cortico-pontine cells are Layer V pyramidal cells

SLIDE 11: MONKEY: SOURCE OF CORTICO PONTINE VISUAL FIBRES

Visual corticopontine pathways originate in parietal lobe

Pontocerebellar Pathway
- **Cerebellar afferent fibres**
- **Mossy vs. climbing fibres**
- **3 peduncles**

SLIDE12: MIDDLE PEDUNCLE

middle > (inferior and superior)
nearly all from n. pontis.
Contralateral and ipsilateral projection in the middle cerebellar peduncle: Possible solution to some old problems.

SLIDE13: INFERIOR OLIVE (HUMAN)

Climbing fibre input to the cerebellum.
Accessory optic system dorsal cap of the inferior olivary nucleus. Flocculus and adjacent flocculus.

On the difference between mossy fibre and climbing fibre visual afferents to the cerebellum. The climbing fibre as teacher?

The distinction between basal ganglia and cerebellum in the control of movement is reflected in instances of skilled movement in Parkinson patients

Preservation of skilled movement in Parkinson's disease

Ivan running Cambridge
Ivan in Edinburgh Catching a ball
Ivan in Edinburgh kicking ball

Dutch patient showing symptoms, and then cycling

I suggest that these instances of preservation of skilled movements can be interpreted on the basis of the character of the visual stimulus. Response properties of pontine visual cells. Textured regions in lower visual field looming objects; all would activate pontine visual cells.

In addition to direct involvement in visuomotor control, the cerebellum is also critical for some forms of plasticity.

1. Plasticity of the VOR
2. Saccadic Adaptation
2. Prism adaptation
3. Nictitating membrane conditioning

References

Eye Movements

Robinson, D.A. (1981) Control of eye movements in (V. Brooks, Ed.). American Physiological Society Handbook of Physiology Section 1. The Nervous System, Volume II Motor Cortical, Ch. 28, 1275-1320.

Carpenter, R.H.S. (1988) Movements of the Eyes. London: Pion.

Lee, R.J., and Zee, D.S. (1999) The Neurology of Eye Movements New York; Oxford University press

Also, several chapters on eye movements on Chalupa and Werner, cited above.