Lecture X. Brain Pathways: Movement

Bio 3411
Monday
September 28, 2009

Readings (background only)

Neuroscience 4th ed

Page(s) Feature
423-451 Upper motor control of Brain Stem and Spinal Cord

The Brain Atlas 3rd ed

Page(s) Feature
198-199 Vestibular Pathways
200-201 Direct Corticospinal tract
202-203 Rubrospinal and Tectospinal tracts
204-205 Reticulospinal Pathways

References

†Gleeson, J. G., Keeler, L. C., Parisi, M. A., Marsh, S. E., Chance, P. F., Glass, I. A., Graham Jr, J. M., Maria, B. L., Barkovich, A. J., & Dobyns, W. B. (2004). Molar tooth sign of the midbrain-hindbrain junction: occurrence in multiple distinct syndromes. *Am J Med Genet A, 125A*(2), 125-134; discussion 117.

†Sicotte, N. L., Salamon, G., Shattuck, D. W., Hageman, N., Rub, U., Salamon, N., Drain, A. E., Demer, J. L., Engle, E. C., Alger, J. R., Baloh, R. W., Deller, T., & Jen, J. C. (2006). Diffusion tensor MRI shows abnormal brainstem crossing fibers associated with ROBO3 mutations. *Neurology, 67*(3), 519-521.

†Tovar-Moll, F., Moll, J., Bramati, I. E., de Souza, A. S., Andreiuolo, P. A., & de Oliveira-Souza, R. (2007). The human pyramidal syndrome Redux. *Neuroreport, 18*(14), 1417-1421.

†Vulliemoz, S., Raineteau, O., & Jabaudon, D. (2005). Reaching beyond the midline: why are human brains cross wired? *Lancet Neurol, 4*(2), 87-99.

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† Posted on class web site.

What the last Lecture was About

Sensory Transduction
Receptive Fields
Adaptation
Feature Detection
Maps
Sensory Integration

Overview

Corticospinal Tract: Activation & Somatotopy
Activity of Motor Cortex Neurons Directs Movement: Force & Direction
Four Other Motor Pathways to Spinal Cord
Role(s) of Descending Pathways in Movement Control
Effects of Corticospinal Tract Lesion
Why is left right, and right left?

Corticospinal (Pyramidal) Pathway.

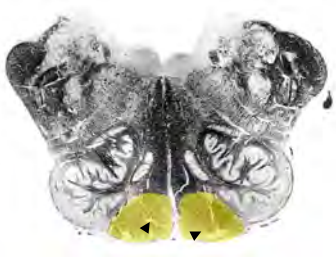
This is the direct connection from the cerebral cortex for control of fine movements in the face and distal extremities, e.g., buttoning a jacket or playing at trumpet.

THE BRAIN ATLAS 3rd, pp. 36, 43

Corticospial Tract (Pyramid) at Medulla

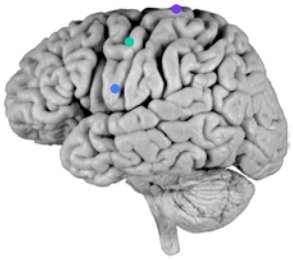
THE BRAIN ATLAS, 3rd ed., p. 147

Cross Section Through Human Medulla



Pyramidal Tracts

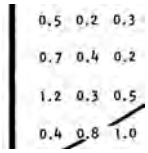
THE BRAIN ATLAS 3rd ed, pp. 20, 201



Normal Pyramid

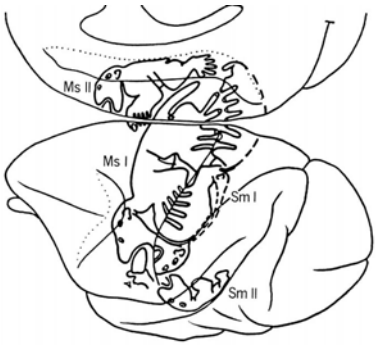
Electrical stimulation of different points in motor cortex with small currents (thresholds) causes different movements

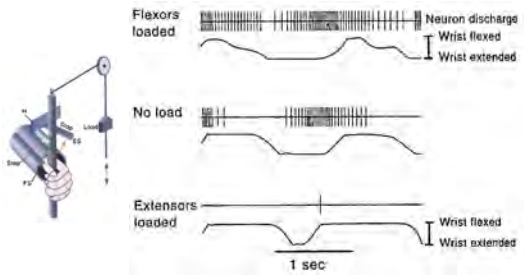
Cartoons of movements evoked by direct cortical stimulation. The shading indicates the joint(s) moved.



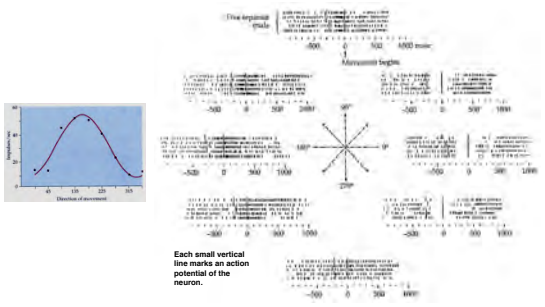
Currents required to just provoke the above movements (threshold).

The left hemisphere of the monkey brain - Motor (Ms) and Somatosensory (Sm) Maps





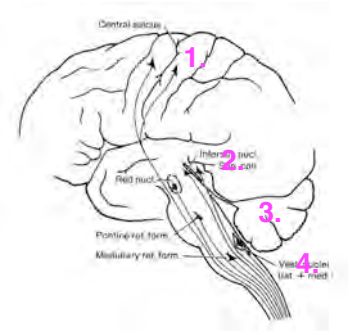
A neuron in the motor cortex of of an awake behaving monkey fires when the wrist is extended (red arrow in diagram above). It fires more when more force is required (flexors loaded) and not at all if no contraction is needed to extend the rest (extensors loaded).



A neuron in the motor cortex of of an awake behaving monkey fires in relation to the direction of the movement (see "tuning" curve - left).

Sources of Descending Pathways for Movement Control

1. **Forebrain (Cortex)**
2. **Midbrain (Red Nucleus & Superior Colliculus)**
3. **Pons (Reticular Formation)**
4. **Medulla (Reticular Formation and Vestibular Nuclei)**



THE BRAIN ATLAS, 3rd ed, p. 203

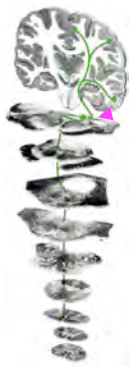
Rubrospinal Pathway.

This pathway (from the red nucleus) mediates voluntary control of movements, excepting the fine movements of the fingers, toes and mouth.

THE BRAIN ATLAS, 3rd ed, p. 203

Tectospinal Pathway.

This pathway (from the superior colliculus) mediates head and body orientation in response to localized visual, auditory and tactile stimuli, often from the same source.



THE BRAIN ATLAS, 3rd ed, pp. 199, 205

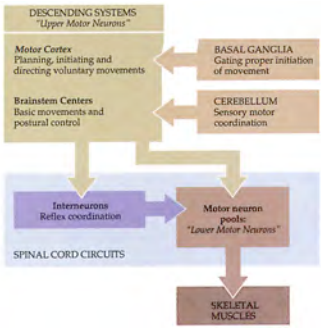
Vestibulospinal Pathways.

These pathways (from the vestibular nuclei) mediates head and body orientation in response to changes in head linear and angular velocity and with respect to gravity .

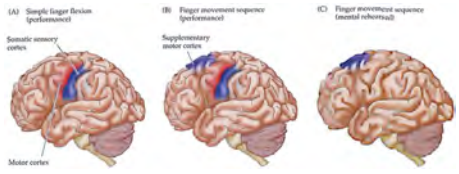
Reticulospinal Pathways.

These pathways carry information from the brain stem reticular formation to the spinal cord to stabilize movement on uneven surfaces.

Descending systems from the brain influence cells in the spinal cord to create movements. The cerebellum and the basal ganglia indirectly influence movements as indicated schematically here.

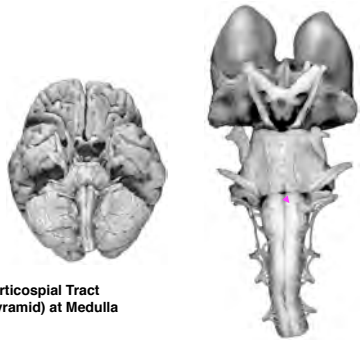


NEUROSCIENCE (1st ed), p. 319, Fig 16.8



Other cortical areas influence the initiation of movements to achieve particular goals through specific sequences, as in playing a scale on the piano. These areas are also activated when a person is instructed to think about performing the sequence without actually moving.

THE BRAIN ATLAS 3rd ed, pp. 36, 43



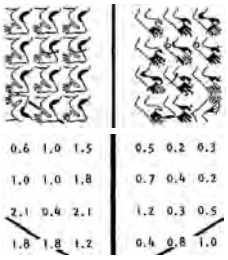
Corticospial Tract (Pyramid) at Medulla

After the pyramid was cut (lesioned) the opposite hand (the right hand) was used to try to get food from a well but all fingers were used. The monkey could not get food from the smallest well.

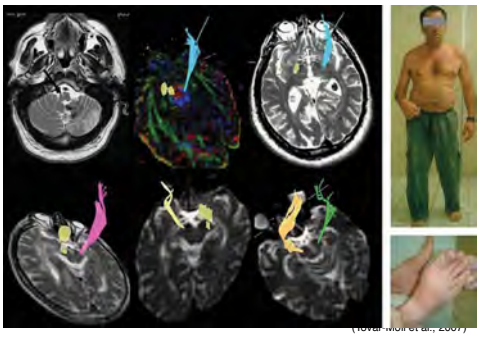
The hand opposite the normal pyramid (the left hand) was used to get food from the small well by opposing the thumb and fore finger. The monkey got the food from the smallest well.

Electrical stimulation of different points in motor cortex with small currents (thresholds) causes different movements

Cut Pyramid Normal Pyramid



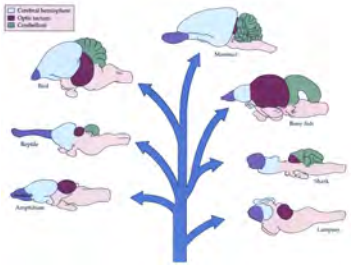
After the pyramid was cut the movements were coarser and the currents required to produce them were larger.



(Nowak, Moll et al., 2007)

The corticospinal (pyramidal) tract controls fine movements particularly of the lips, fingers and toes. When it is cut, other descending pathways such as the rubrospinal pathway can be used for grasping movements. These lack the precision of those activated by the corticospinal pathway and the monkey cannot pickup its food.

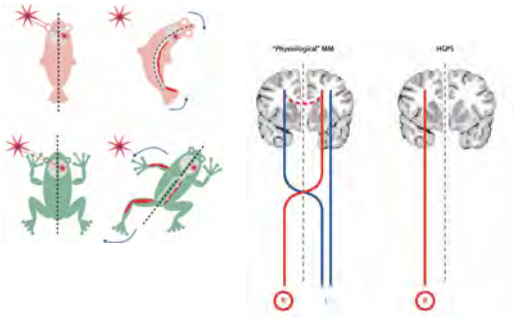
Relative Size of Different Brain Parts In Phylogeny - The forebrain becomes relatively larger as new pathways (functions) are added.



Why are brain pathways "crossed"?

Ramón y Cajal suggested that brain pathways are crossed to preserve the appropriate relationships after optical inversion by the lens as indicated schematically by the arrows in the uncrossed (left) and the crossed (right) visual pathways.

S. Ramón y Cajal, (1911) *Histology of the Nervous System, Volume II.* (English translation by N. & L. Swanson, Oxford: New York pp 309-310, 1995).



(Vulliemoz, Raineteau, & Jabaudon, 2005)

What this Lecture was about

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Activity of Motor Cortex Neurons Directs Movement: Force & Direction

Four Other Motor Pathways to Spinal Cord

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Effects of Corticospinal Tract Lesion

Why is left right, and right left?

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