Brain Intelligence and Artificial Intelligence

人脑智能与机器智能

Lecture 9 – Motor System 2

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Recap Lecture 8 – Motor System 1

- **Muscles:** skeletal muscle; smooth muscle; cardiac muscle
- **Control of movement**: Spinal & Brain
- **The lower motor neuron**
  - Segmental organization of lower motor neurons
  - Alpha Motor neurons
  - Motor Units & Motor Unit Pool
  - Myotatic stretch reflex & Inverse myotatic reflex
  - Reciprocal inhibition
  - Flexor reflex & Crossed-extensor reflex
- **Musculoskeletal model (for simulation)**
- **Bio-inspired Bipedal Robots**
- **Exoskeleton**

Lecture 9 – Motor System 2

- **Brain control of movement:** Voluntary movement; posture & locomotion
- **Descending spinal tracts**
  - Lateral pathway: Voluntary movement
  - Ventromedial pathway: posture & locomotion
- **Brain regions in motor system**
  - M1: Initiation of movement
  - PMA, SMA, Posterial Parietal, Prefrontal
  - Basal Ganglia: feedback
  - Cerebellum: feedback
- **Autonomous vehicles (AVs)**
- **MuJoCo tutorial**

Three hierarchical levels of movement control

Level	Function	Structures
High	Strategy	Association areas of neocortex, basal ganglia
Middle	Tactics	Motor cortex, cerebellum
Low	Execution	Brain stem, spinal cord

- **Strategy**: the goal of the movement and the movement strategy that best achieves the goal
- **Tactic**: the sequences of muscle contractions, arranged in space and time, required to smoothly and accurately achieve the strategic goal
- **Execution**: the activation of motor neurons and interneuron pools that generate the goal-directed movement and make any necessary adjustments of posture

Sensory information is important for motor control!

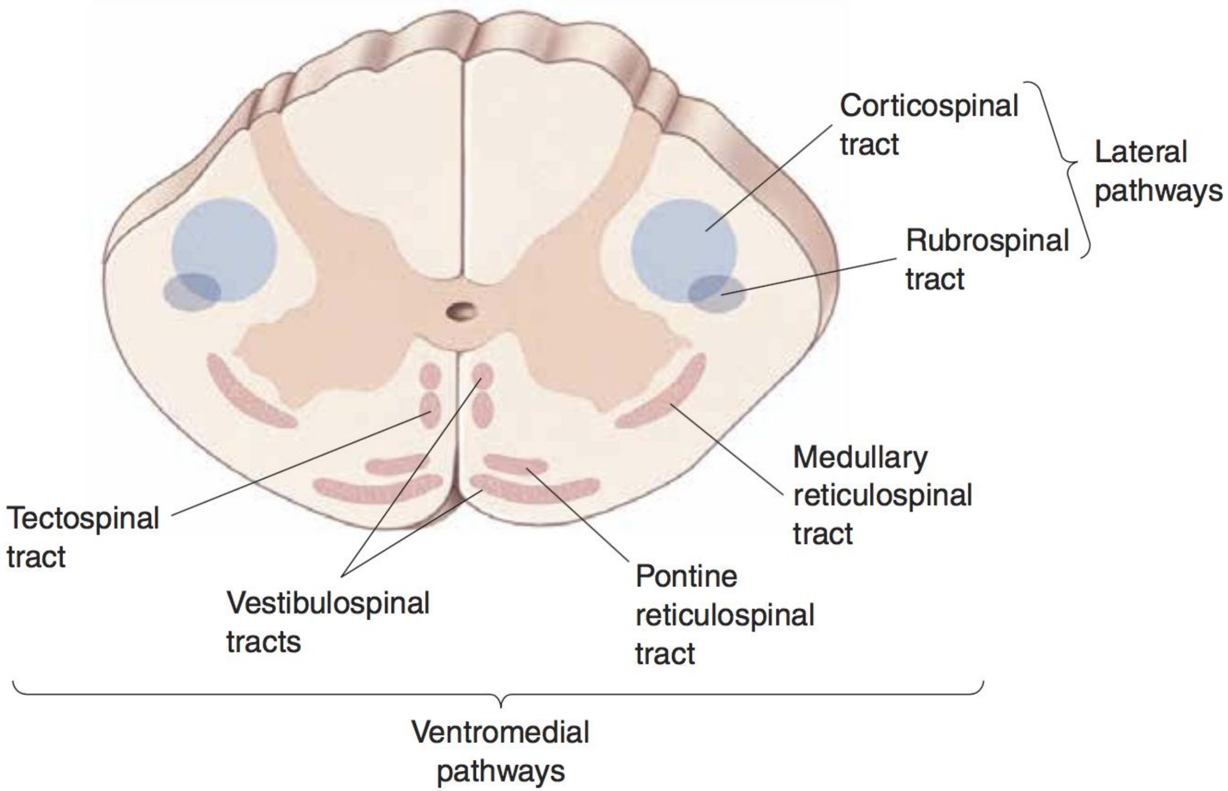
- At the **highest** level, sensory information generates a mental representation of the body and its relationship to the environment.
- At the **middle** level, tactical decisions are based on the memory of sensory information from past movements.
- At the **lowest** level, sensory feedback is used to maintain posture, muscle length, and tension before and after each voluntary movement.

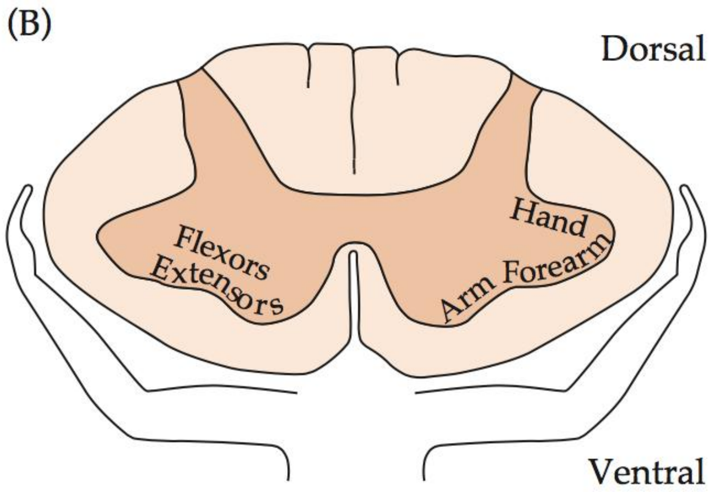
Sensorimotor system

Descending Spinal Tracts

How does the brain communicate with the motor neurons of the spinal cord?

- The **lateral** pathways are involved in voluntary movement（自主运动） of the distal musculature and are under direct cortical control, consisting of the *corticospinal* and *rubrospinal* tracts.
- The **ventromedial** pathways are involved in the control of posture and locomotion（自动运动） and are under brain stem control, consisting of the *vestibulospinal*, *tectospinal*, *medullary reticulospinal*, and *pontine reticulospinal* tracts.

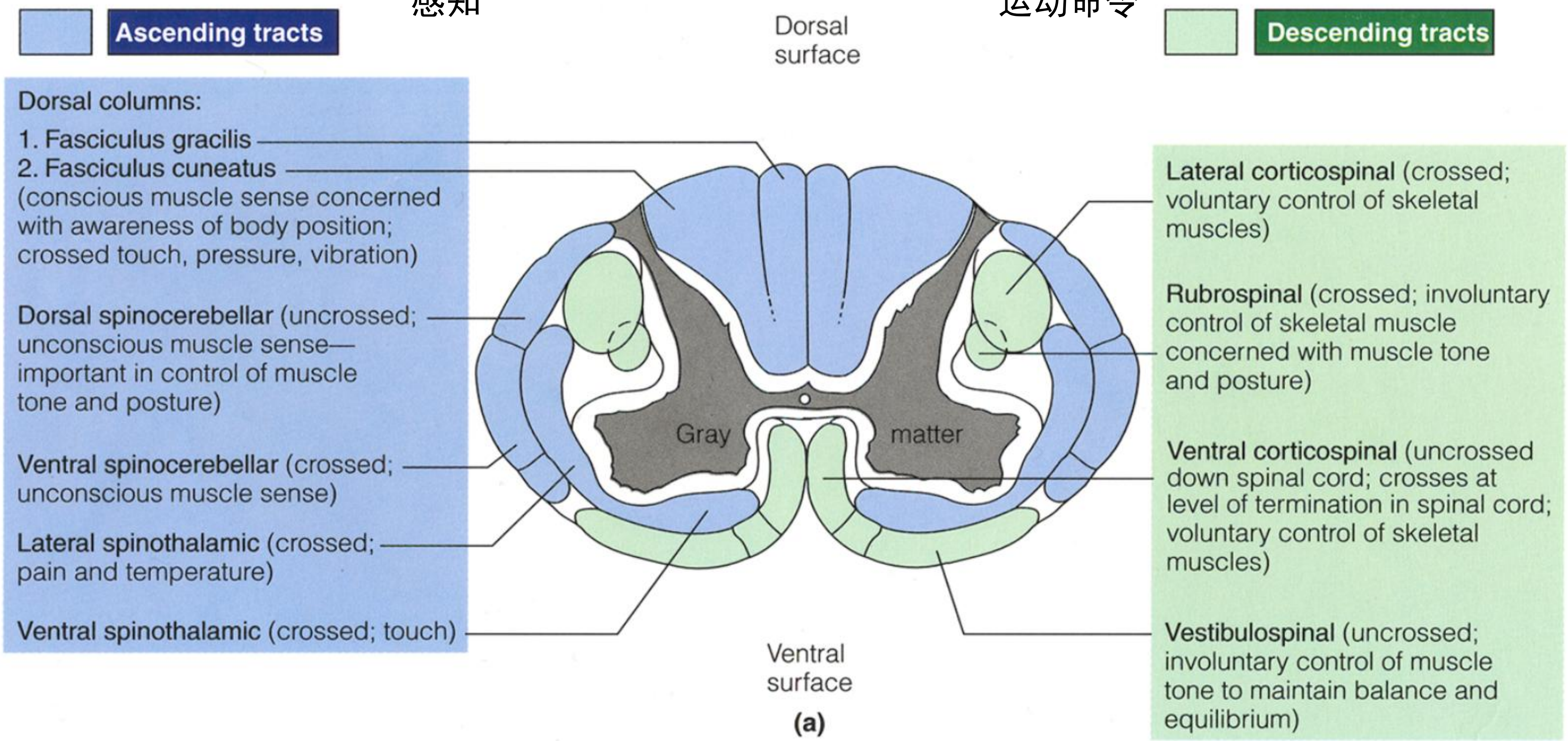




Ascending Tracts and Descending Tracts

感知

运动命令



Lateral pathway (自主运动）

- The **lateral** pathways are involved in voluntary movement of the distal musculature and are under direct cortical control, consisting of the *corticospinal* and *rubrospinal* tracts.

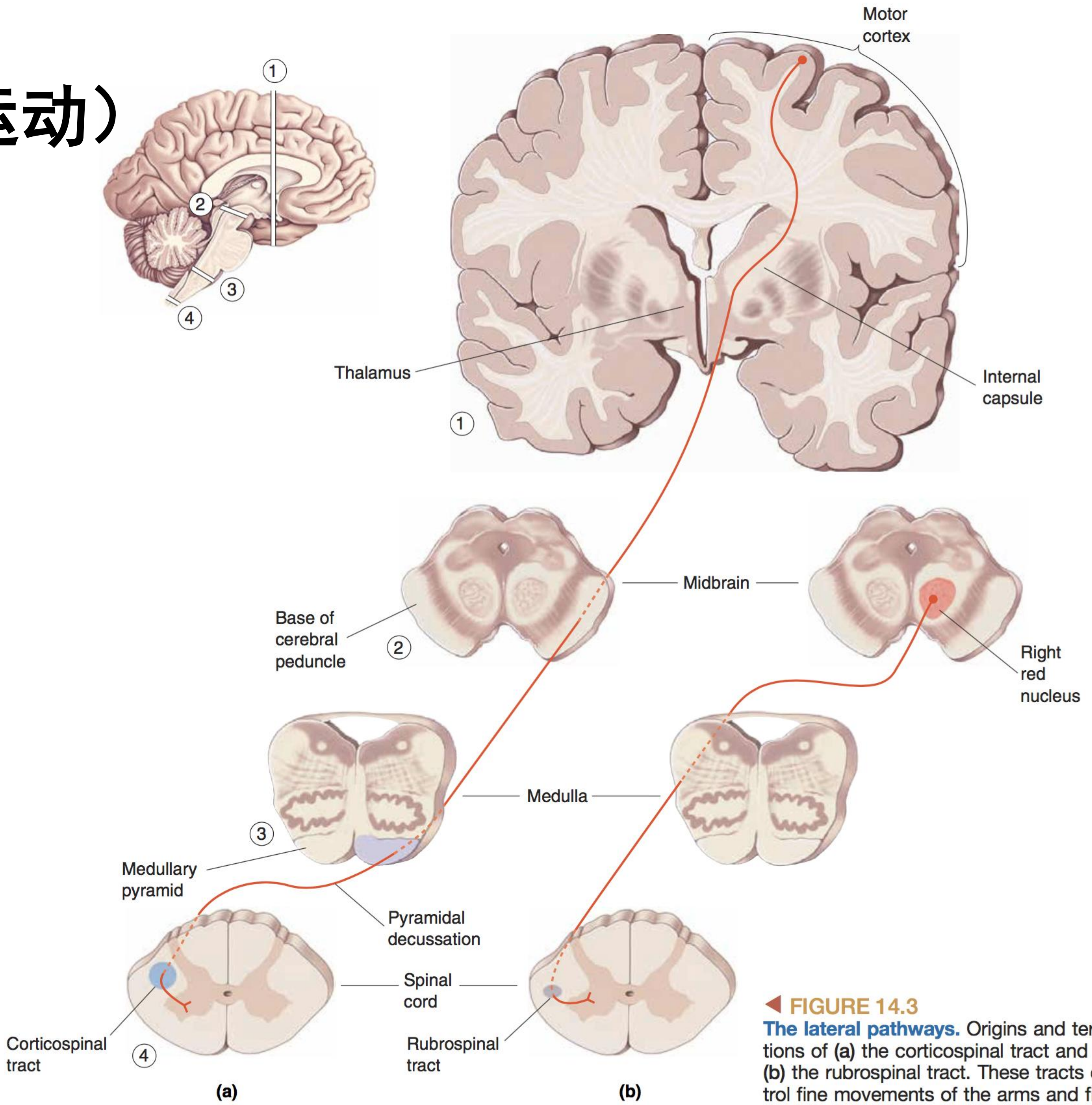


FIGURE 14.3
The lateral pathways. Origins and terminations of **(a)** the corticospinal tract and **(b)** the rubrospinal tract. These tracts control fine movements of the arms and fingers.

The Effects of Lateral Pathway Lesions

Experimental lesions in **both** corticospinal and rubrospinal tracts in monkeys rendered them **unable to make fractionated movements** of the arms and hands.

That is, they could not move their shoulders, elbows, wrists, and fingers independently. For example, they could grasp small objects with their hands but only by using all the fingers at once.

Voluntary movements were also slower and less accurate.

Despite this, the animals could sit upright and stand with normal posture.

Lesions in the monkeys' corticospinal tracts **alone** caused a movement deficit. Interestingly, however, many functions gradually reappeared over the months following surgery.

In fact, the only permanent deficit was some weakness of the distal flexors and an inability to move the fingers independently.

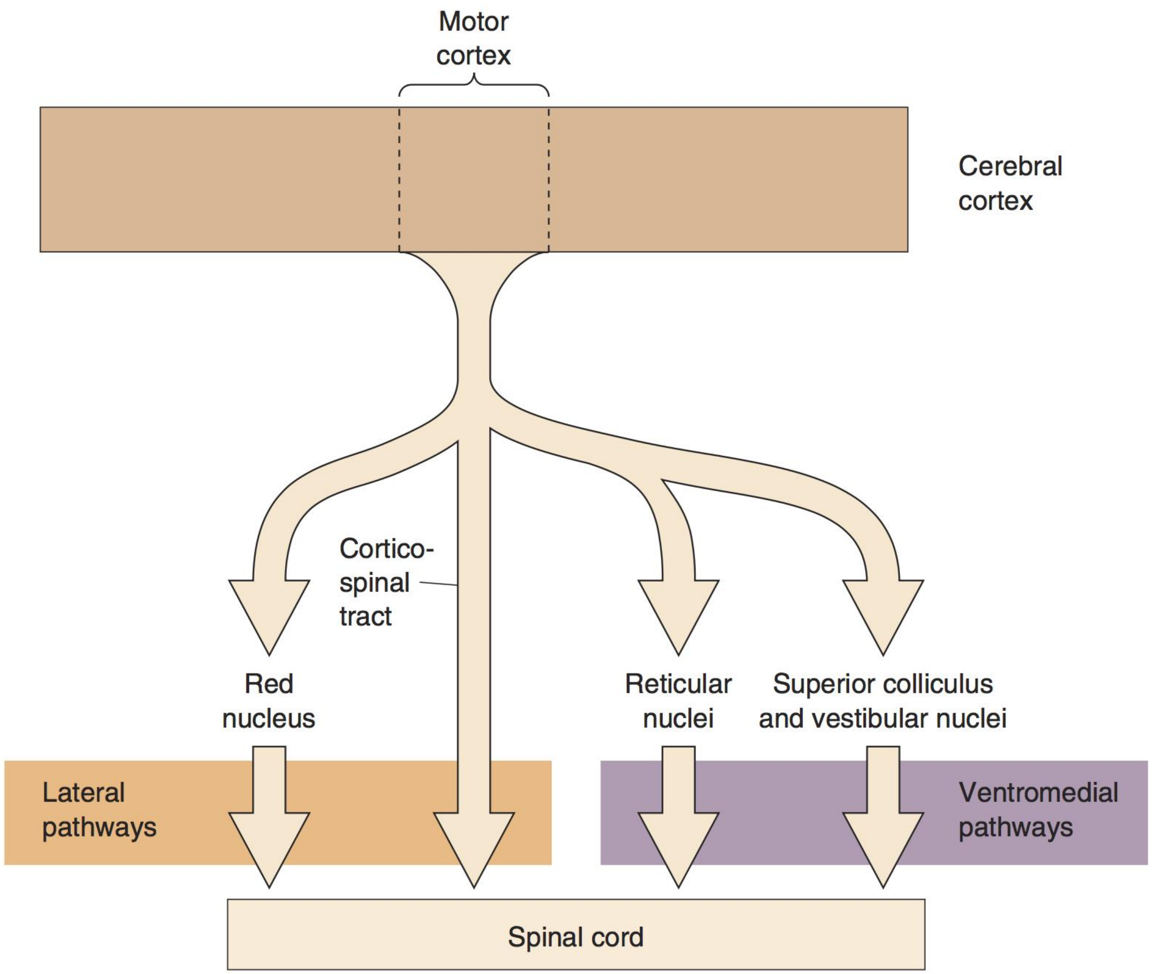
A subsequent lesion in the rubrospinal tract **completely reversed** this recovery.

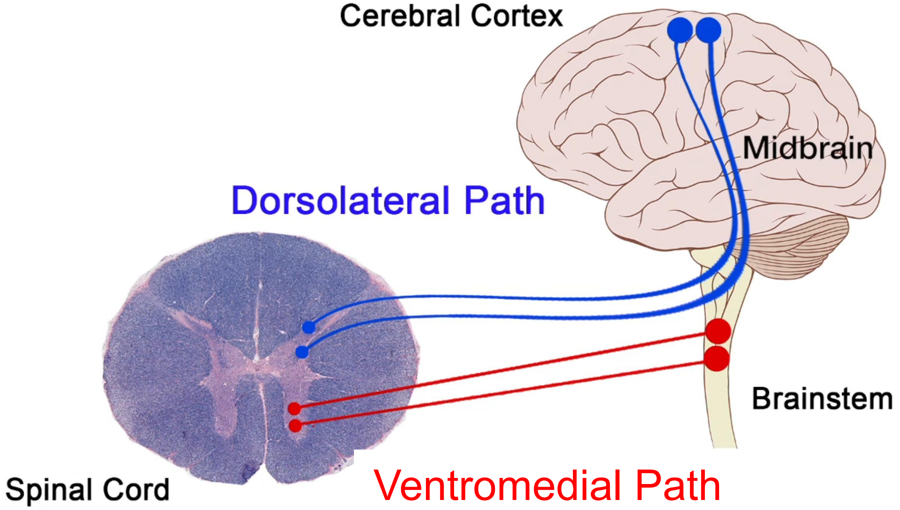
These results suggest that the cortico-rubrospinal pathway was able to partially compensate for the loss of the corticospinal tract input.

The Ventromedial Pathways （姿态维持&自动运动）

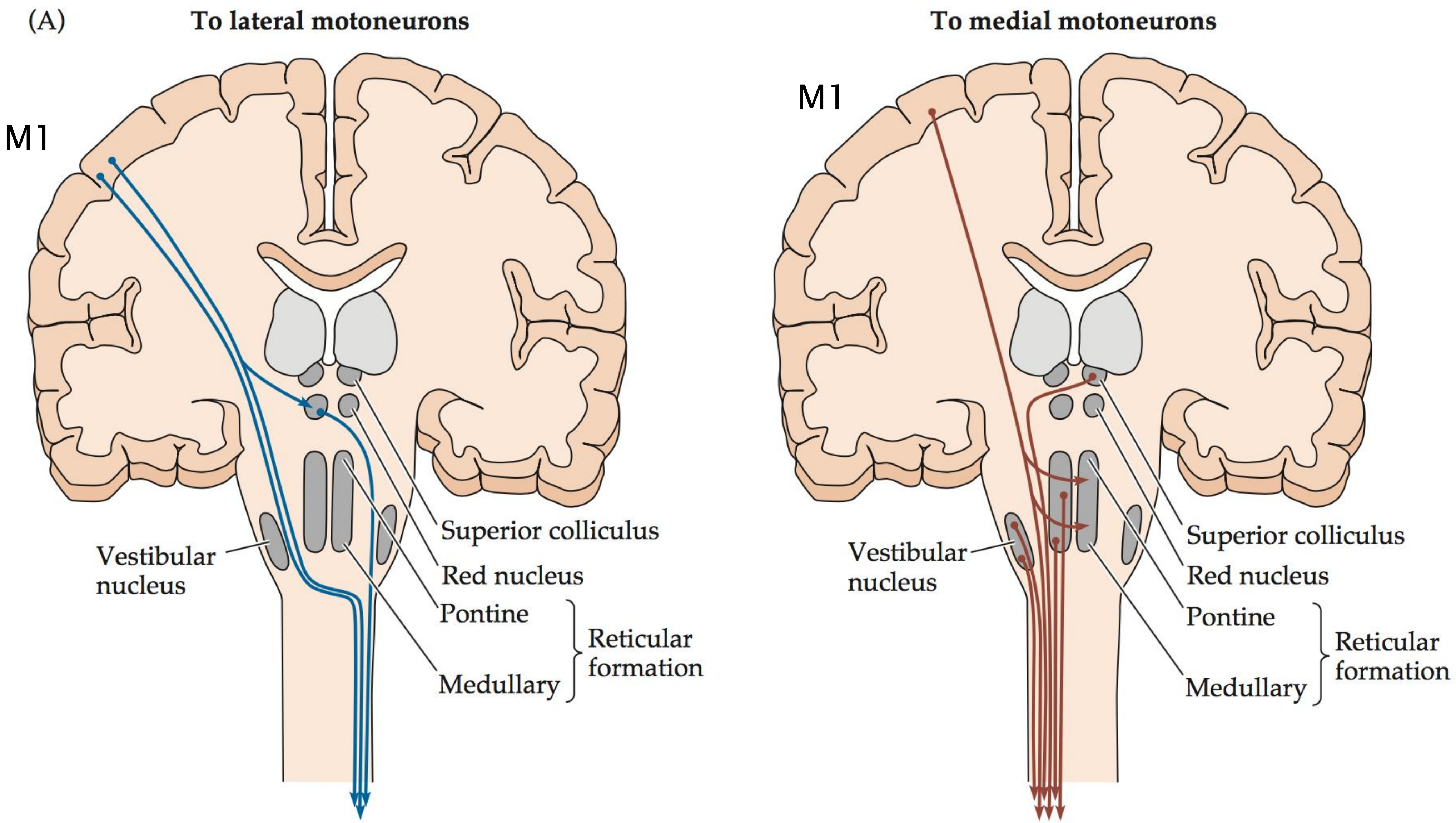
- **The Vestibulospinal Tract:**
  - to keep the head balanced on the shoulders as the body moves through space;
  - to turn the head in response to new sensory stimuli.
- **The Tectospinal Tract:**
  - to direct the head and eyes to move
- **The Pontine Reticulospinal tract:**
  - to enhance the antigravity reflexes of the spinal cord;
  - to maintain a standing posture by resisting the effects of gravity
- **The Medullary Reticulospinal Tract:**
  - to liberate the antigravity muscles from reflex control

Summary of Lateral and Ventromedial Pathways





Summary of Lateral and Ventromedial Pathways



Summary of Lateral and Ventromedial Pathways

Lateral and Ventromedial Pathways 在运动控制中的主要差别是?

在运动控制中，**Lateral Pathways（侧束通路）和Ventromedial Pathways（腹内侧通路）**的主要差别在于它们控制运动的不同功能和身体部位，具体如下：

1. Lateral Pathways (侧束通路)

- **组成部分:**
  - 主要包括**皮质脊髓束**（corticospinal tract，又称金字塔束）和**红核脊髓束**（rubrospinal tract）。
- **功能:**
  - 控制**随意运动**，尤其是远端肢体（手、手指、脚等）的**精细**、**精准的运动**。
  - 在复杂运动、独立手指运动等高度灵活的动作中起重要作用。
- **支配:**
  - 主要支配身体的**远端肌肉**（如四肢的肌肉）。
- **路径特点:**
  - 神经纤维从大脑皮层（尤其是初级运动皮层）起源，通过内囊下行到延髓的锥体区域，在延髓下交叉到对侧，然后进入脊髓，最终与脊髓中的下运动神经元（LMNs）连接，直接控制肌肉。

2. Ventromedial Pathways (腹内侧通路)

- **组成部分:**
  - 包括**前庭脊髓束**（vestibulospinal tract）、**网状脊髓束**（reticulospinal tract）、**顶盖脊髓束**（tectospinal tract）和**前皮质脊髓束**（anterior corticospinal tract）。
- **功能:**
  - 主要负责**维持姿势**、**平衡和自动运动**。这些动作通常是无意识的或较低水平控制的，例如站立时的姿态调节。
  - 参与**躯干和近端肌肉**（肩膀、髋部等）的协调运动，帮助维持身体的平衡、协调和姿态控制。
- **支配:**
  - 支配**近端肌肉和轴向肌肉**（躯干和体干肌肉）。
- **路径特点:**
  - 神经纤维起源于脑干，传递来自前庭器官、顶盖区和网状结构的信息。大部分这些纤维不会像侧束通路那样在延髓交叉，而是双侧或直接下行，通过控制脊髓中的运动神经元来调节姿势和身体的自动性运动。

主要差异总结:

- **Lateral Pathways** 负责控制**远端肢体**的精细随意运动，如手指运动。
- **Ventromedial Pathways** 负责**姿态**、**平衡**的维持，以及控制**近端和轴向肌肉**的自动运动，如站立和行走时的平衡调节。

这些两类运动通路的功能相辅相成，协调实现精确的自主运动和稳定的姿势控制。

Brain regions in motor system

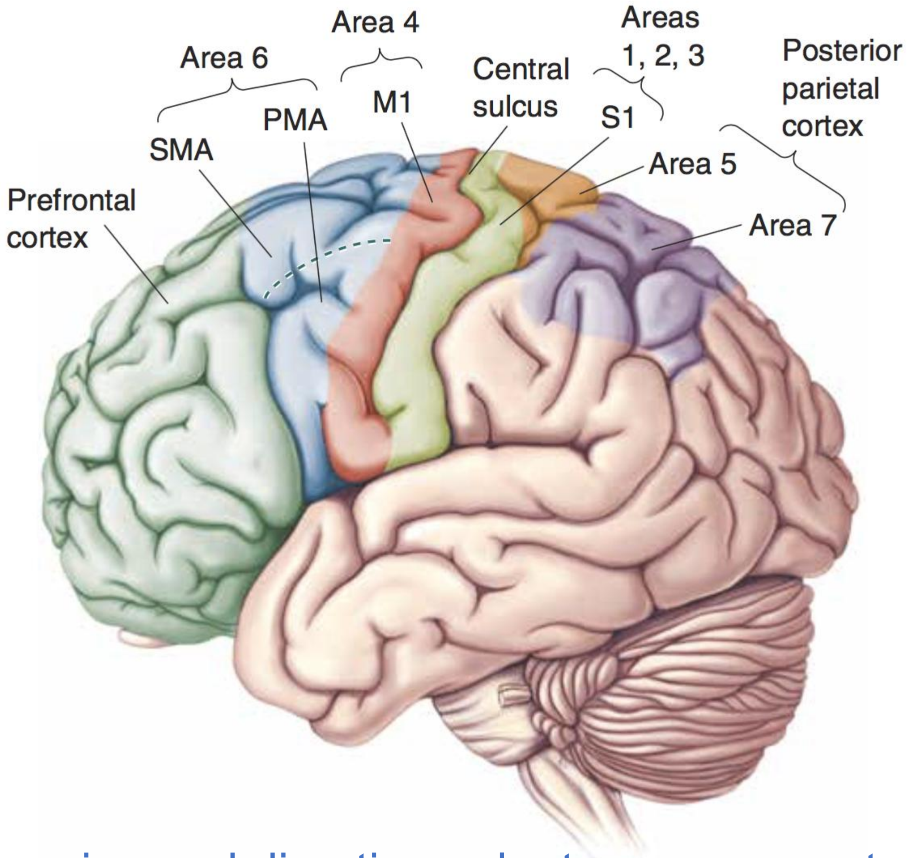
The control of voluntary movement engages almost ALL of the neocortex.

Goal-directed movement depends on knowledge of where the body is in space, where it intends to go, and on the selection of a plan to get it there.

Once a plan has been selected, it must be held in memory until the appropriate time.

Finally, instructions must be issued to implement the plan.

To some extent, these different aspects of motor control are localized to different regions of the cerebral cortex.



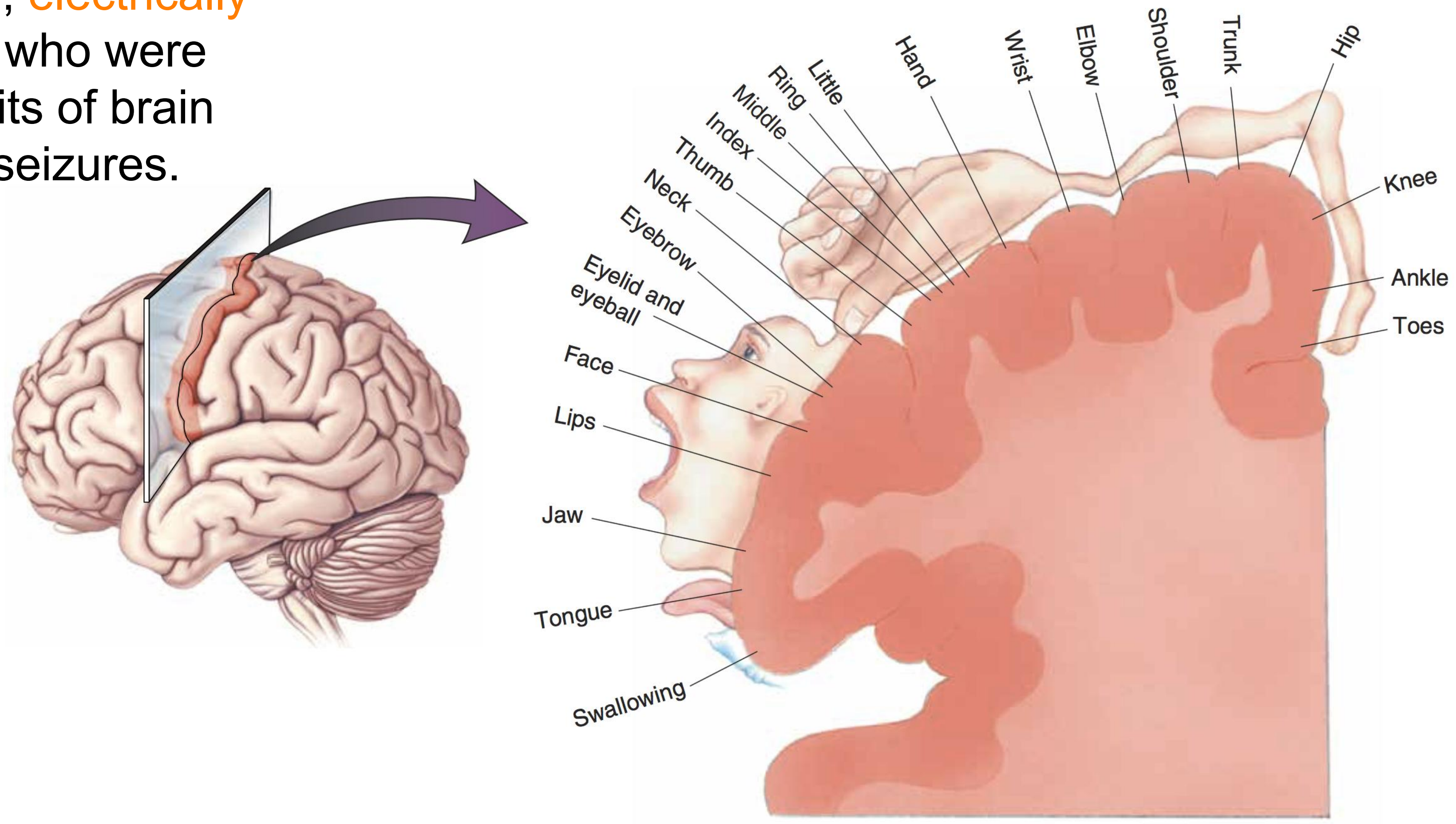
Planning and directing voluntary movements.
These areas of the neocortex are involved in the control of voluntary movement.
Areas 4 and 6 constitute the **motor cortex**.

Somatotopic motor map in M1

Wilder Penfield, a neurosurgeon, electrically stimulated the cortex in patients who were undergoing surgery to remove bits of brain thought to be inducing epileptic seizures.

He discovered that a weak electrical stimulation of **area 4** (Primary motor area, M1) in the ***precentral gyrus*** would elicit a twitch of the muscles in a particular region of the body on the contralateral side.

→ Somatotopic map

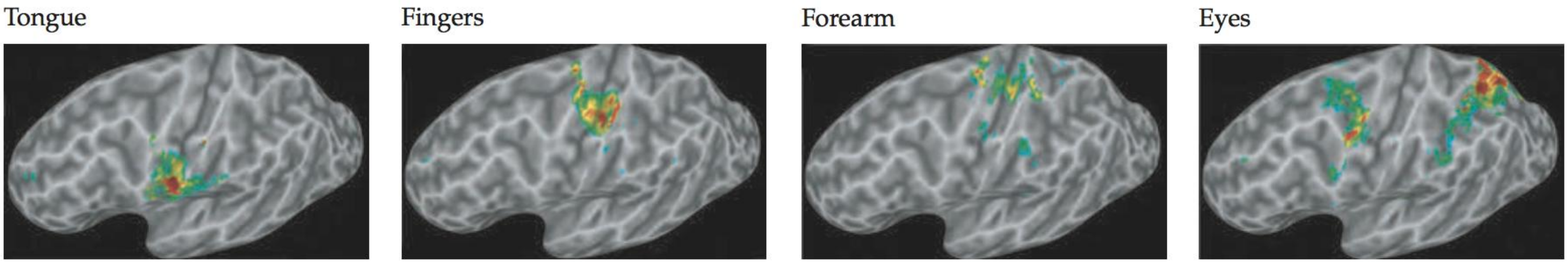


▲ FIGURE 14.8
A somatotopic motor map of the human precentral gyrus. Area 4 of the precentral gyrus is also known as *primary motor cortex* (M1).

Somatotopic motor map in M1: from fMRI

Unit recordings, fMRI, and transcranial magnetic electrical stimulation have shown that the map of motor cortex is *plastic* and changes following peripheral lesions or as consequence of practicing to acquire a novel skill.

Hence, motor maps in M1 or in premotor cortex are ***not*** immutable, with each mini area always controlling one discrete and well defined group of muscle fibers.



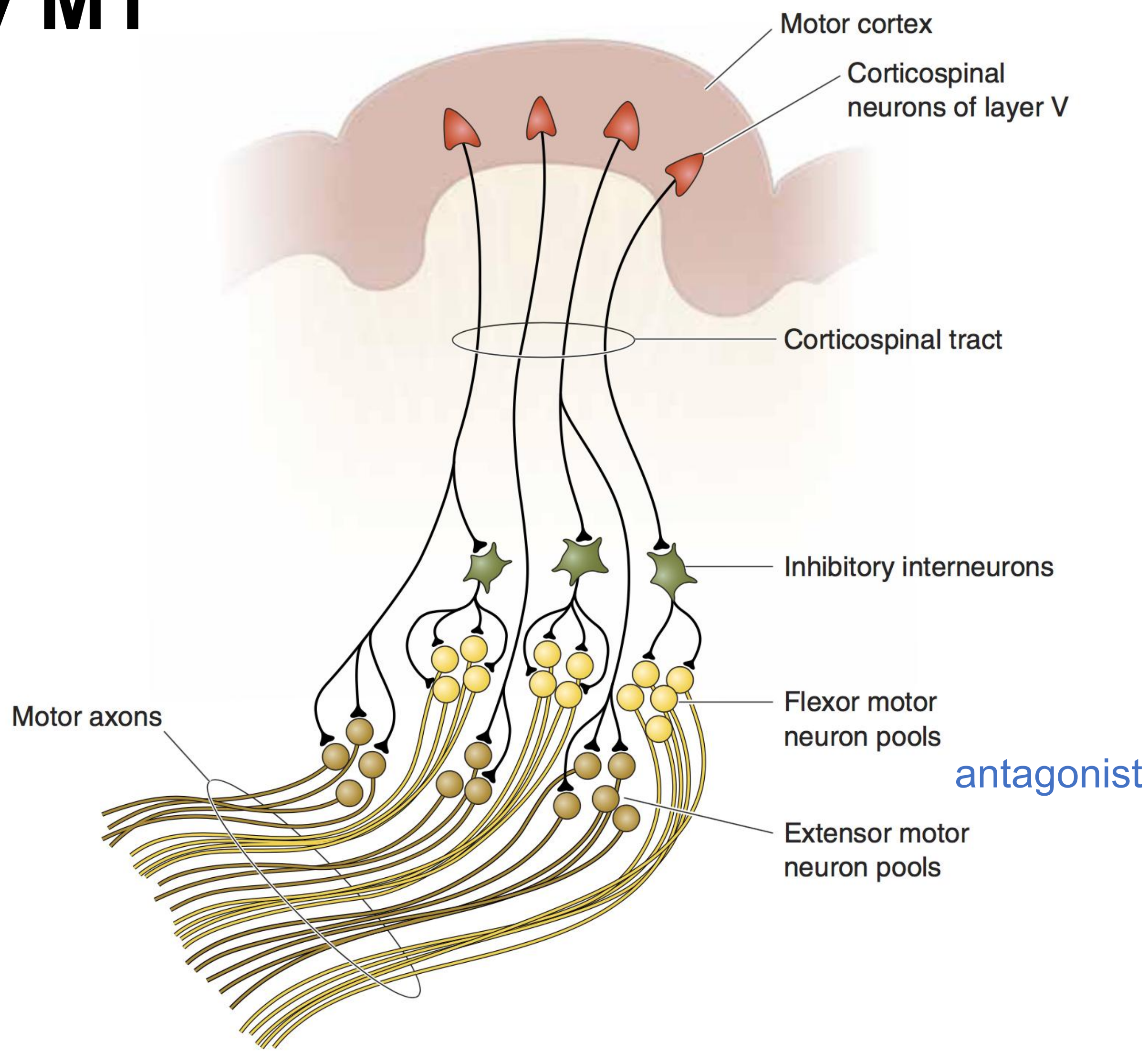
The initiation of movement by M1

The pathway by which motor cortex activates lower motor neurons originates in cortical **layer V in M1**. **Layer V** has a population of pyramidal neurons, some of which can be quite large (soma diameters approaching 0.1 mm).

In humans, many of the large corticospinal cells of **layer V** project to pools of *lower motor neurons* and excite them monosynaptically.

A single corticospinal neuron may generate coordinated effects on antagonist muscles.

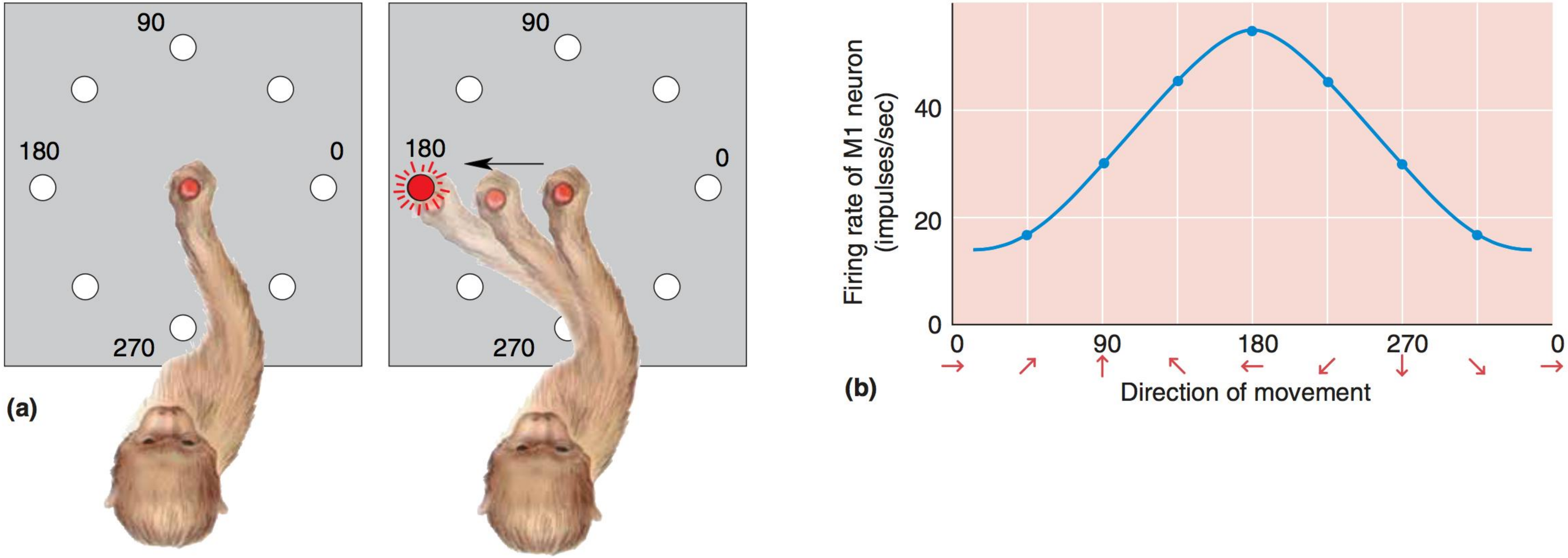
The layer V pyramidal cells in M1 receive their inputs primarily from two sources: **other cortical areas** and the **thalamus**.



Corticospinal tract axons control pools of motor neurons

The coding of movement in M1

Recordings from **M1 neurons** in behaving animals have revealed that a burst of activity occurs immediately before and during a voluntary movement, and that this activity appears to encode **two** aspects of the movement: force and direction.

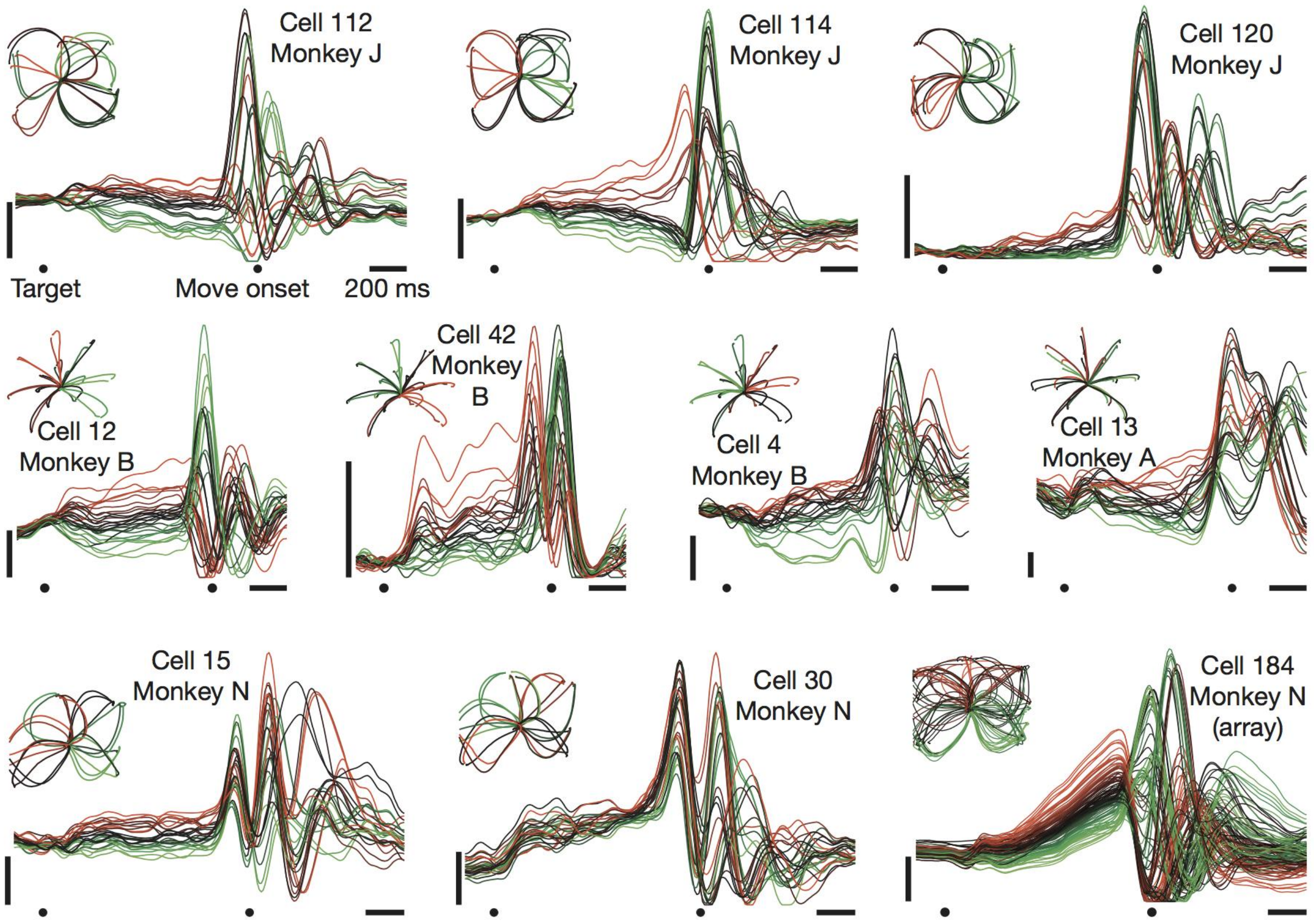


The population coding of movement in M1

Single-neuron responses in motor cortex are complex, and there is marked disagreement regarding which movement parameters are represented.

Single neuron --> population coding

Population coding in the motor system implies that groups of neurons are broadly tuned for the properties of movements.



Firing rate versus time for ten example neurons, highlighting the multiphasic response patterns.

Churchland et al, (2012) Neural population dynamics during reaching, *Nature*

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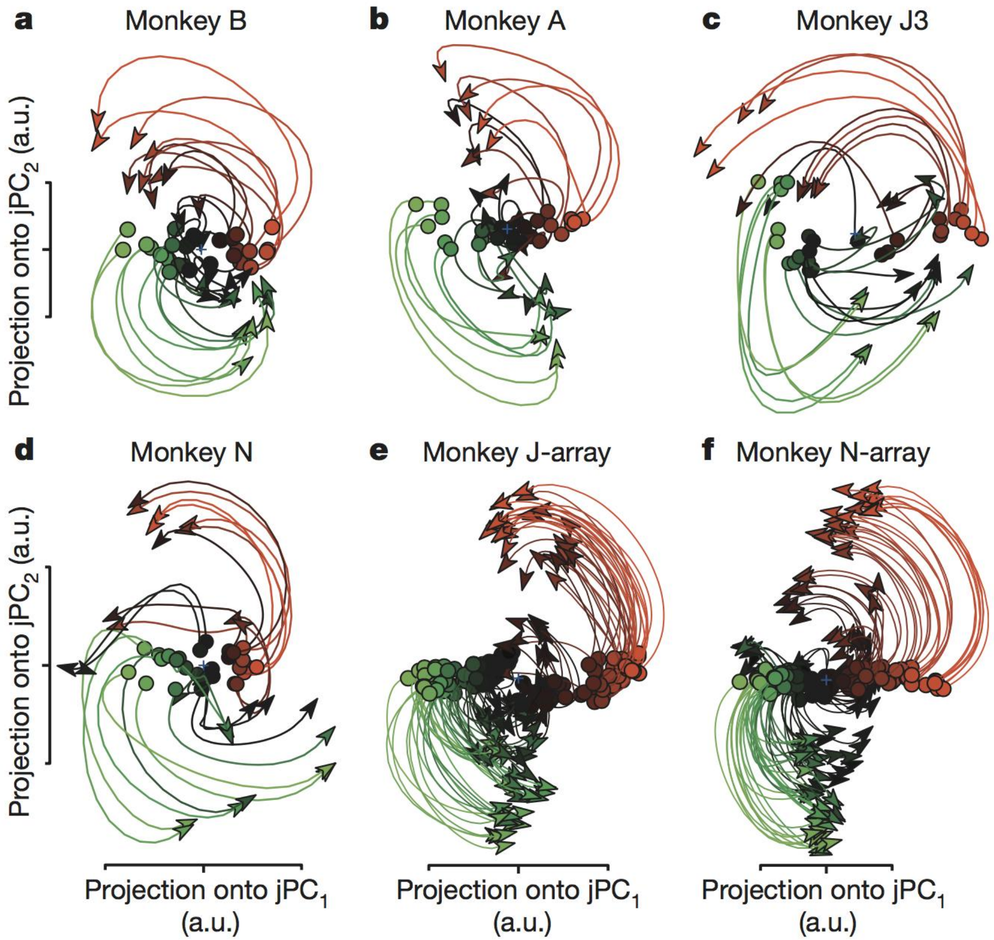
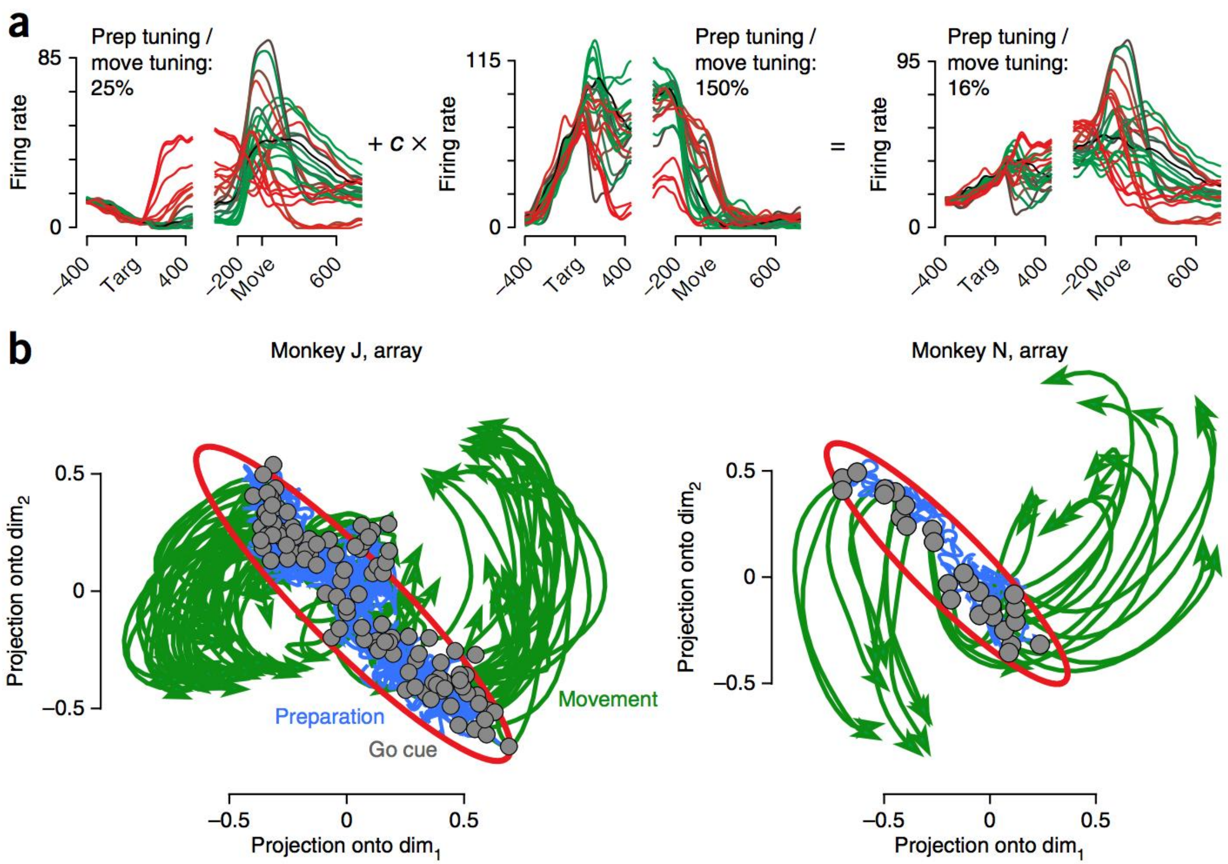
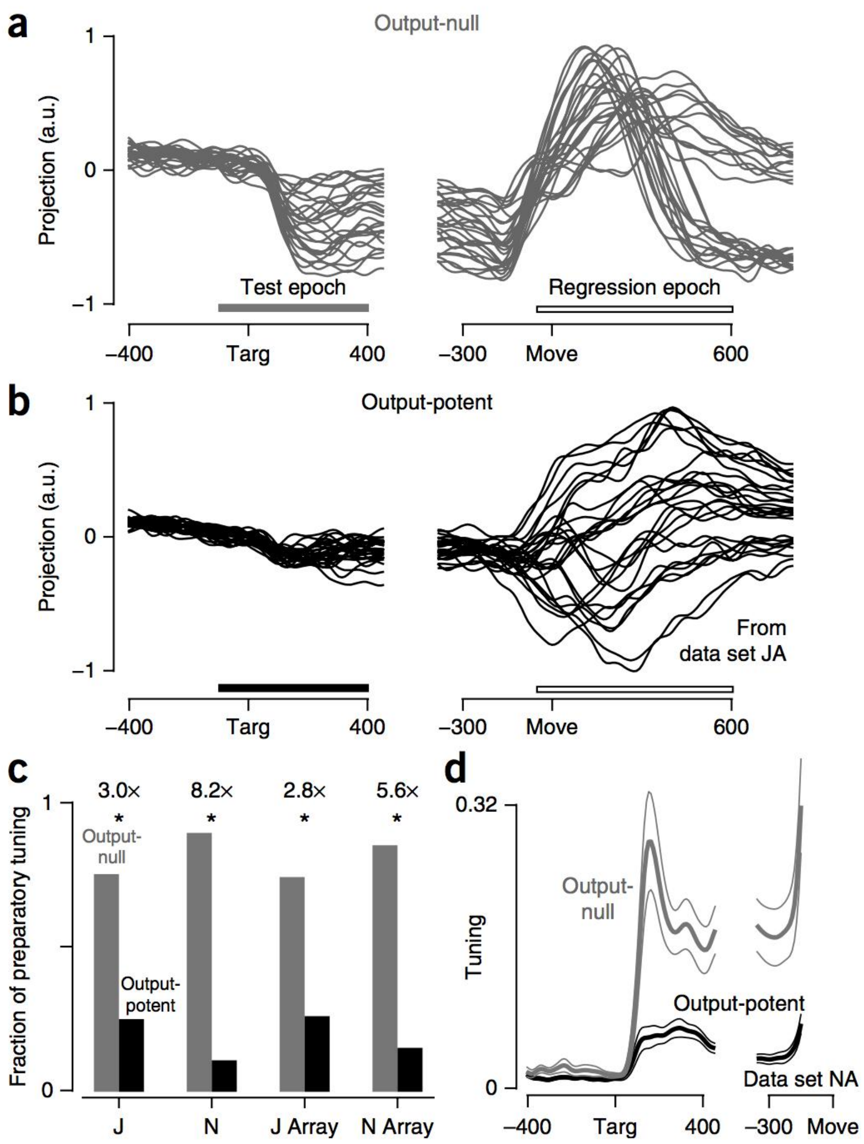


Projections of the neural population response.
200ms of movement-related activity

Churchland et al, (2012) Neural population dynamics during reaching, *Nature*

The population activity in the null space



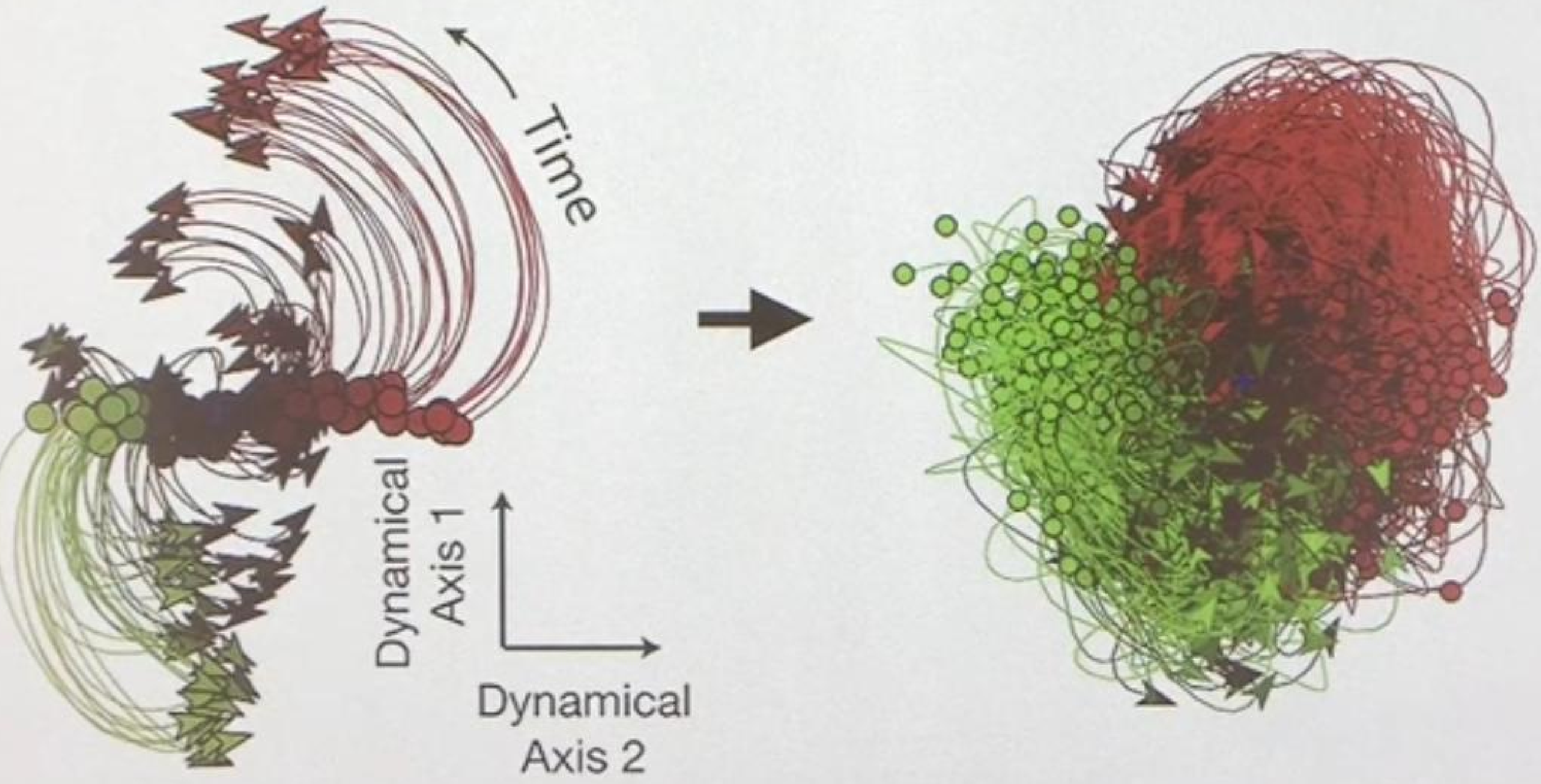


Kaufman and Churchland et al, (2013) Cortical activity in the null space: permitting preparation without movement, *Nature Neuroscience*

Challenge: these representations are difficult to extract on a moment-to-moment basis

Condition-averaged
Each trace is a behavioral condition
(requires averaging over many repeats)

Single trial
Low-D representation is very noisy on a
moment-to-moment basis



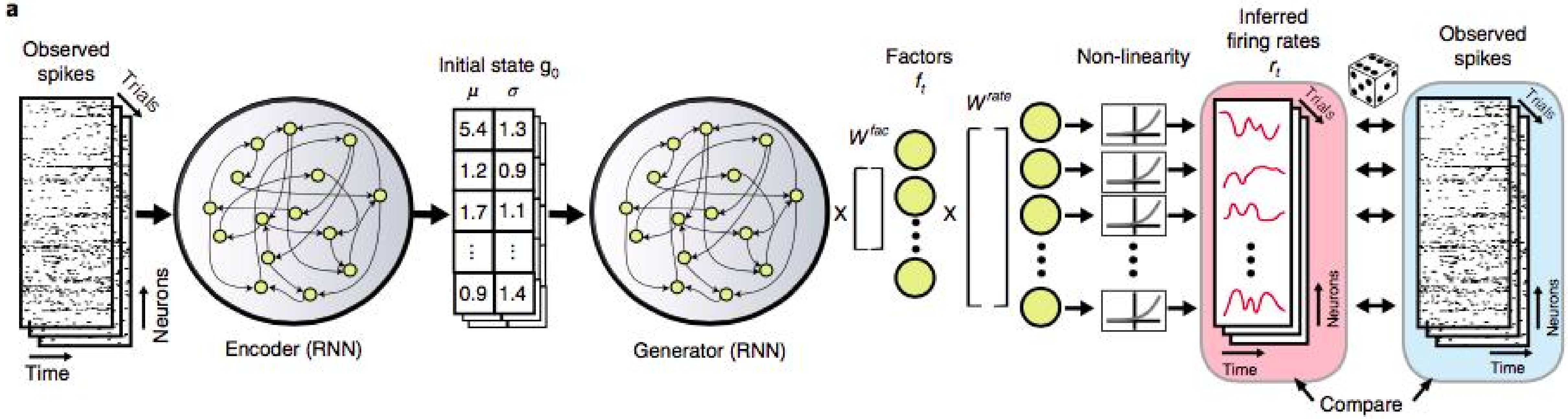
Churchland*, Cunningham* et al., *Nature* 2012

LFADS: Latent factor analysis via dynamical systems

$$\dot{\mathbf{x}}(t) = \mathbf{F}(\mathbf{x}(t),\ \mathbf{u}(t))$$

$$\dot{\mathbf{x}}(t) = \mathbf{F}(\mathbf{x}(t))$$

x(t): state
x(0): initial condition
u(t): input
F: vector-value function



https://www.youtube.com/watch?v=08xa7bE5iTQ

Pandarinath et al (2018). Inferring single-trial neural population dynamics using sequential auto-encoders, *Nature Methods*

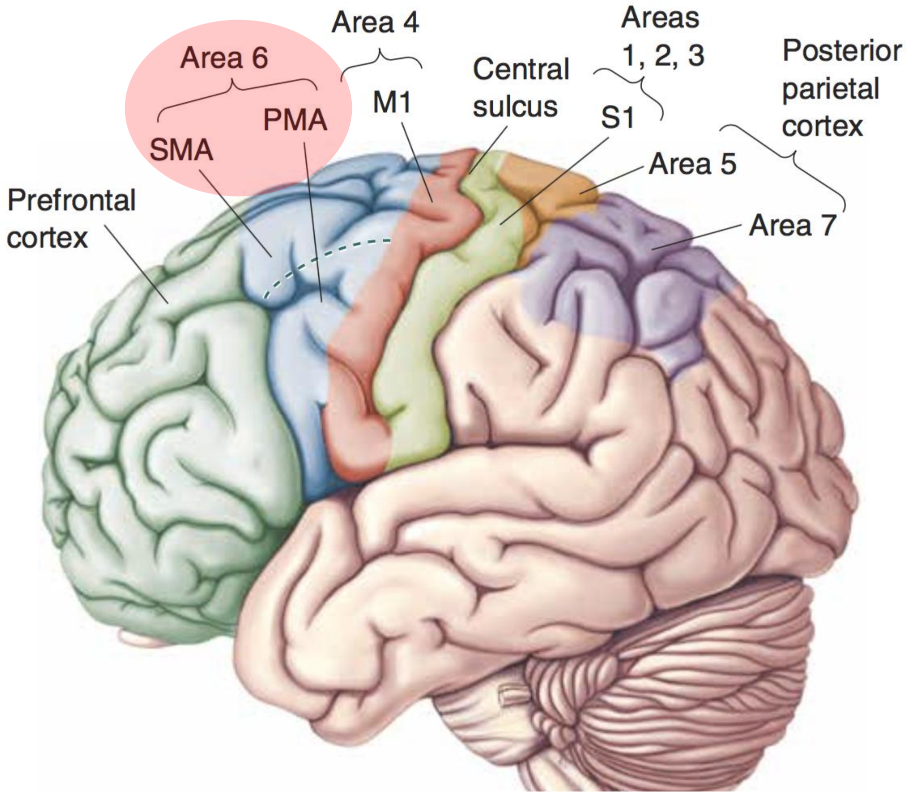
Premotor area (PMA) and Supplementary motor area (SMA)

Is there a ‘higher’ motor area in humans specialized for skilled voluntary movement?

Yes. Electrical stimulation of **area 6** (PMA and SMA) could evoke complex movements of either side of the body.

These two areas appear to perform **similar** functions but on **different** groups of muscles.

- **SMA** sends axons that innervate distal motor units directly.
- **PMA** connects primarily with reticulospinal neurons that innervate proximal motor units.



Article | Open Access | Published: 04 February 2020

Direct electrical stimulation of the premotor cortex shuts down awareness of voluntary actions

Luca Fornia, Guglielmo Puglisi, Antonella Leonetti, Lorenzo Bello, Anna Berti, Gabriella Cerri & Francesca Garbarini

Nature Communications **11**, Article number: 705 (2020) | Cite this article

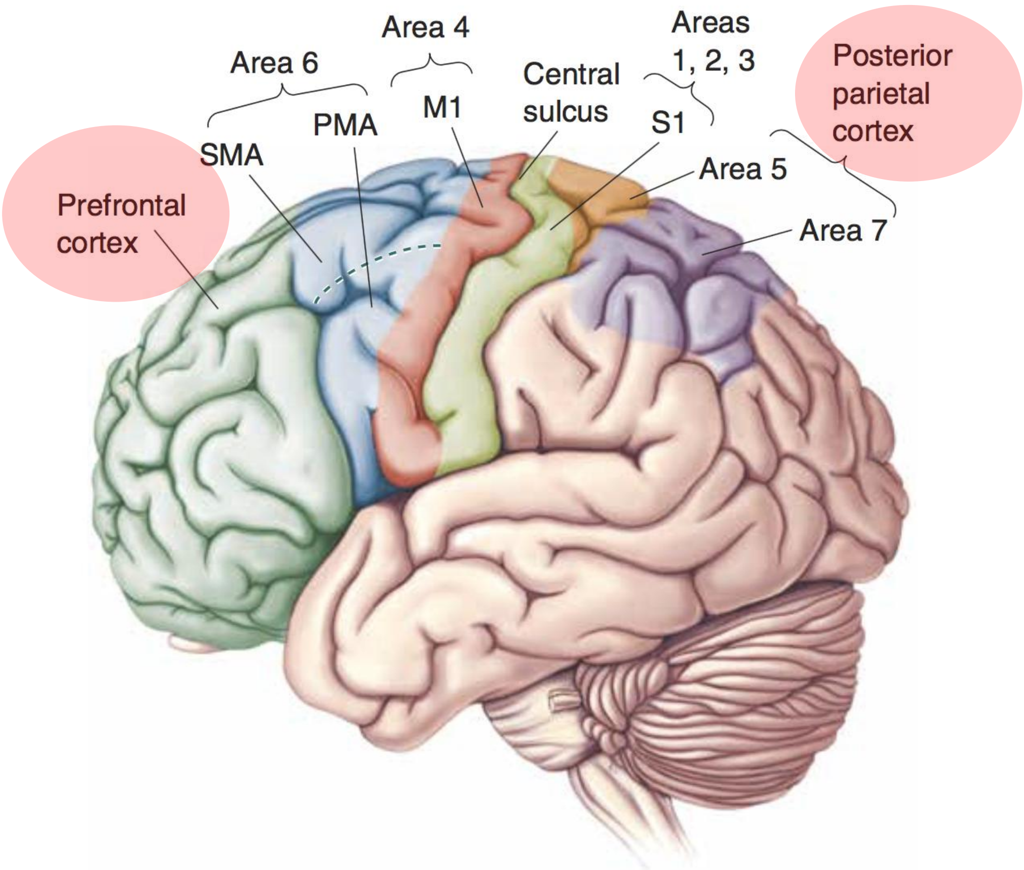
Posterior Parietal and Prefrontal Cortex

Posterior parietal cortex

- *Area 5* gets inputs from Areas 3, 1, and 2 (sensory cortex)
- *Area 7* get inputs from high-order visual areas (such as MT).

Prefrontal cortex

- The *parietal lobes* are extensively interconnected with regions in the *anterior frontal lobes* that in humans are thought to be important for abstract thought, decision making, and anticipation of the consequences of action.



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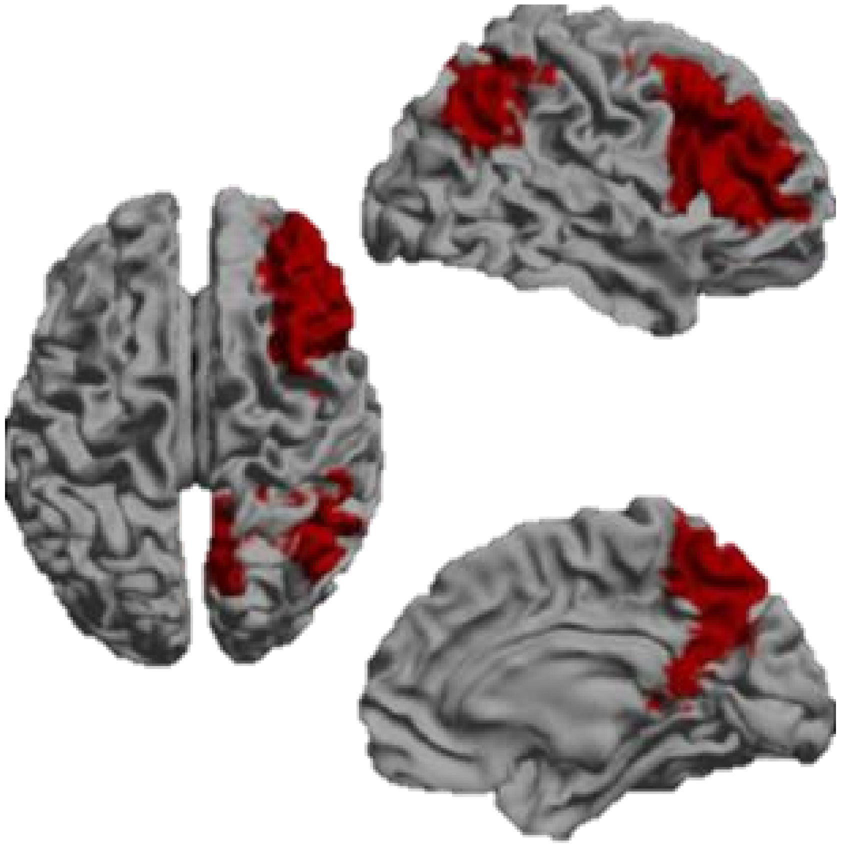


Frontoparietal network from resting fMRI data

Neuronal Correlates of Motor Planning

Area 6 (SMA and PMA) plays an important role in the planning of movement, particularly complex movement sequences of the distal musculature.

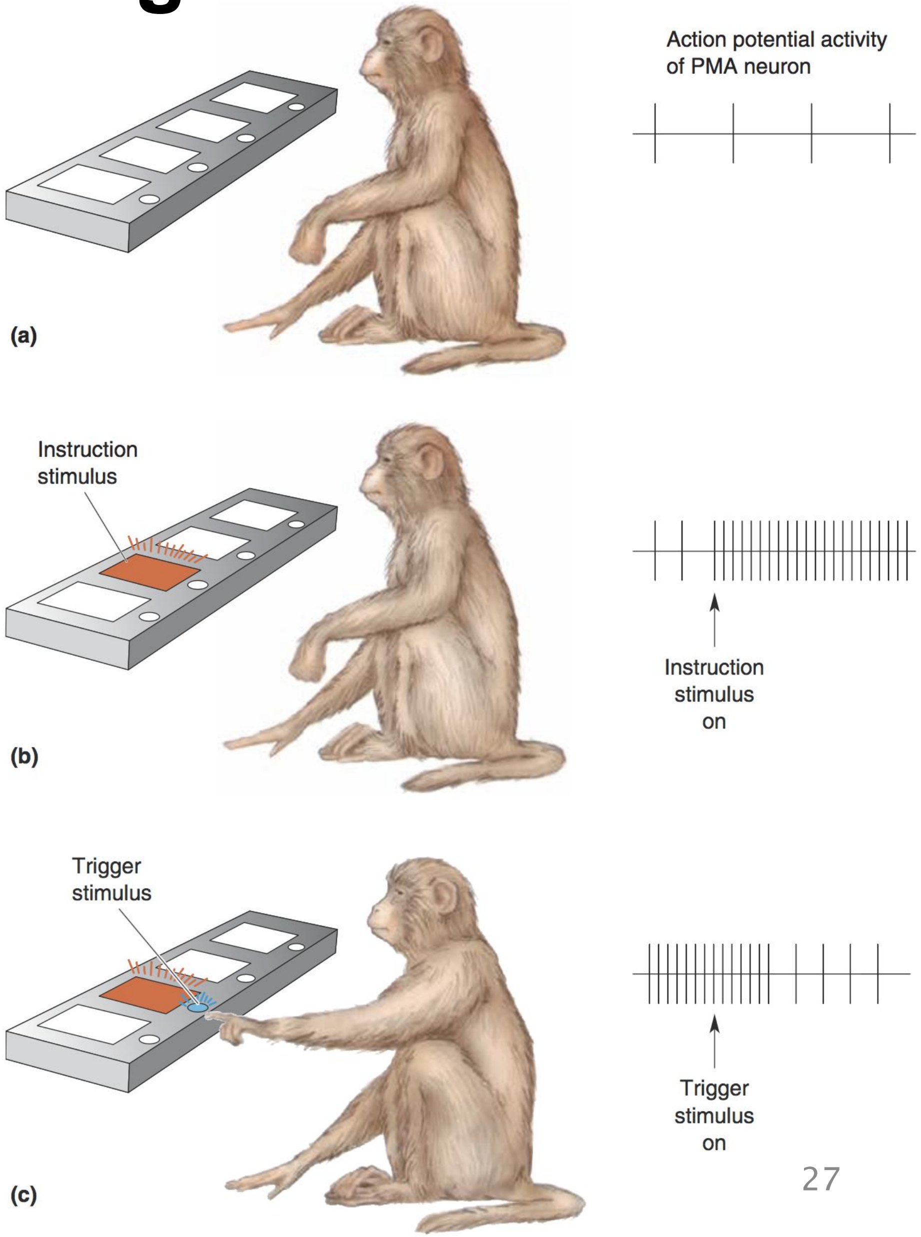
A “ready-set-go” task

(a) **Ready**: to wait for an instruction stimulus

(b) **Set**: The instruction stimulus (one of the square red lights) occurs, resulting in firing of the neuron in PMA.

(c) **Go**: A trigger stimulus (a blue light in one of the but- tons) tells the monkey when and where to move. Shortly after the movement is initiated, the PMA cell ceases firing.

Weinrich and Wise, (1982) *Journal of Neuroscience*



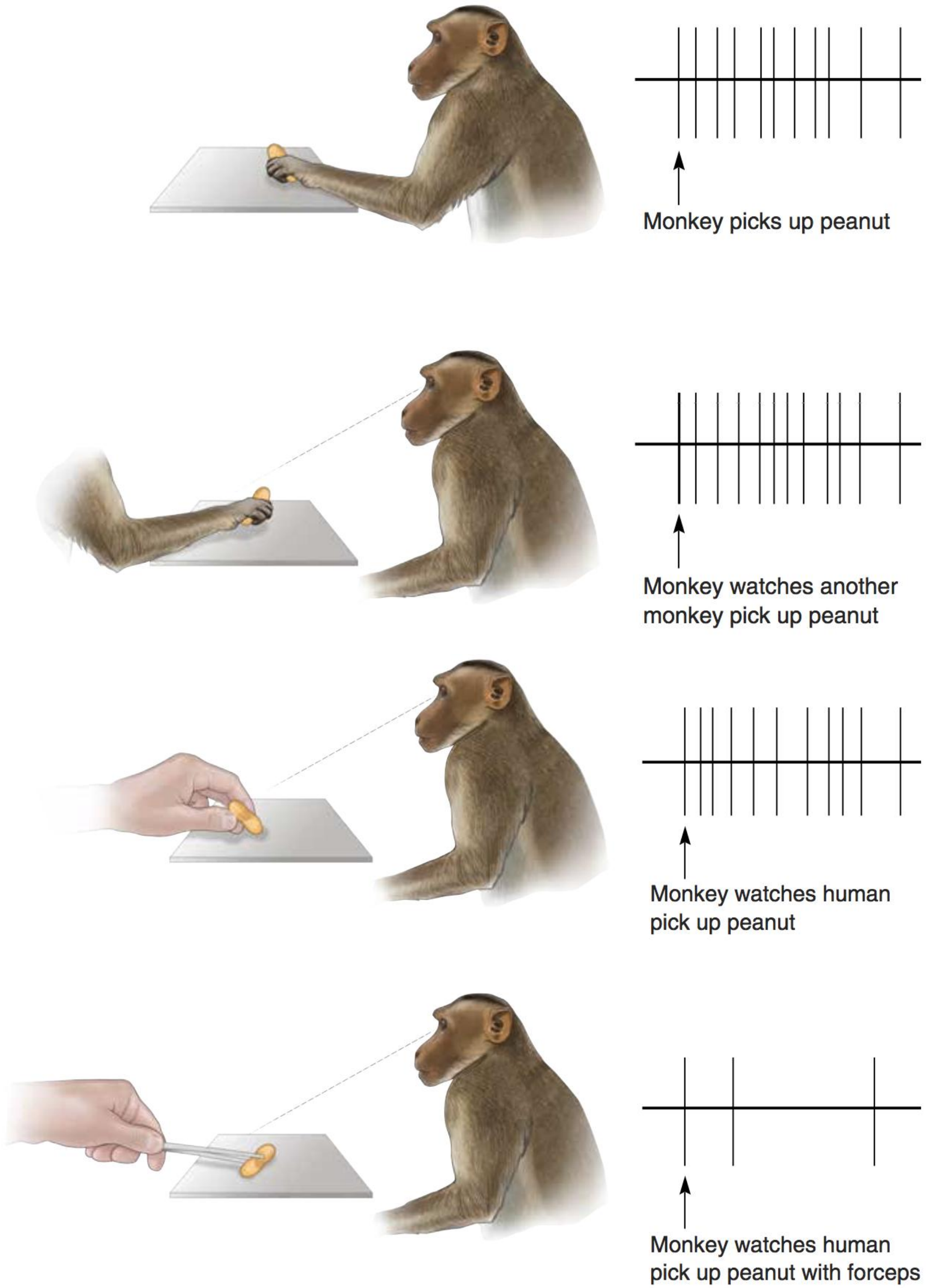
Mirror Neurons

A mirror neuron is a neuron that fires **both** when an animal acts, and when the animal observes the same action performed by another.

Action recognition in the premotor cortex
V Gallese, L Fadiga, L Fogassi, G Rizzolatti - Brain, 1996 - academic.oup.com
We recorded electrical activity from 532 neurons in the rostral part of inferior area 6 (area F5) of two macaque monkeys. Previous data had shown that neurons of this area discharge during goal-directed hand and mouth movements. We describe here the properties of a …
Cited by 6542 Related articles All 16 versions

[PDF] Premotor cortex and the recognition of motor actions
G Rizzolatti, L Fadiga, V Gallese, L Fogassi - Cognitive brain research, 1996 - Citeseer
In area F5 of the monkey premotor cortex there are neurons that discharge both when the monkey performs an action and when he observes a similar action made by another monkey or by the experimenter. We report here some of the properties of these'mirror'neurons and …
Cited by 6594 Related articles All 19 versions

AI: Imitation learning?



The function of mirror neurons are still debating.

In humans, brain activity consistent with that of ***mirror neurons*** has been found in the *premotor cortex*, the *supplementary motor area*, the *primary somatosensory cortex*, and the *inferior parietal cortex*.

The function of the mirror system in humans is a subject of much **speculation**, including **understanding** the actions of other people, for **learning** new skills by *imitation*, **language**, **empathy**, **theory of mind**….

Birds have been shown to have imitative resonance behaviors and neurological evidence suggests the presence of some form of mirroring system.

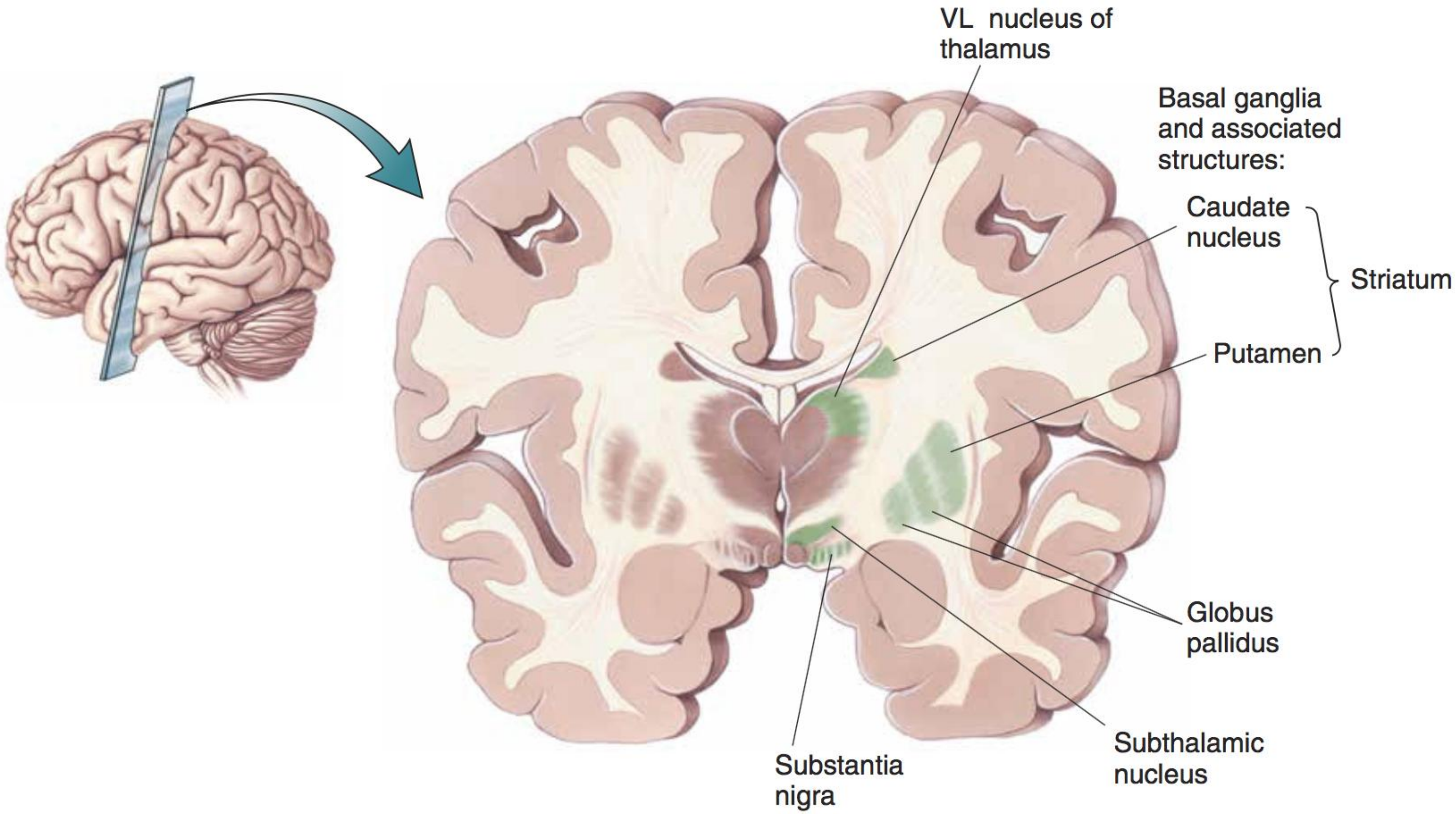
To date, no widely accepted neural or computational models have been put forward to describe how mirror neuron activity supports cognitive functions.

The subject of mirror neurons continues to generate intense **debate**.

https://en.wikipedia.org/wiki/Mirror_neuron

Basal Ganglia

ventral lateral (VL) nucleus



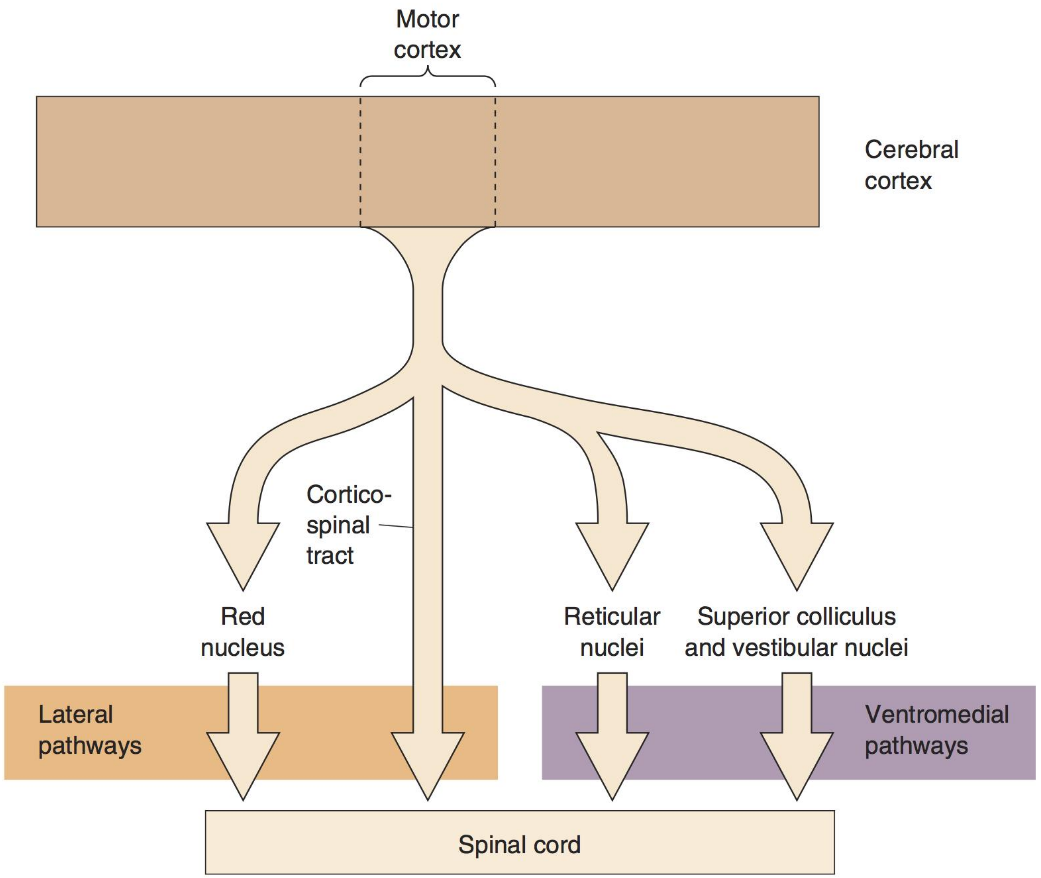
▲ FIGURE 14.12
The basal ganglia and associated structures.

The basal ganglia consist of

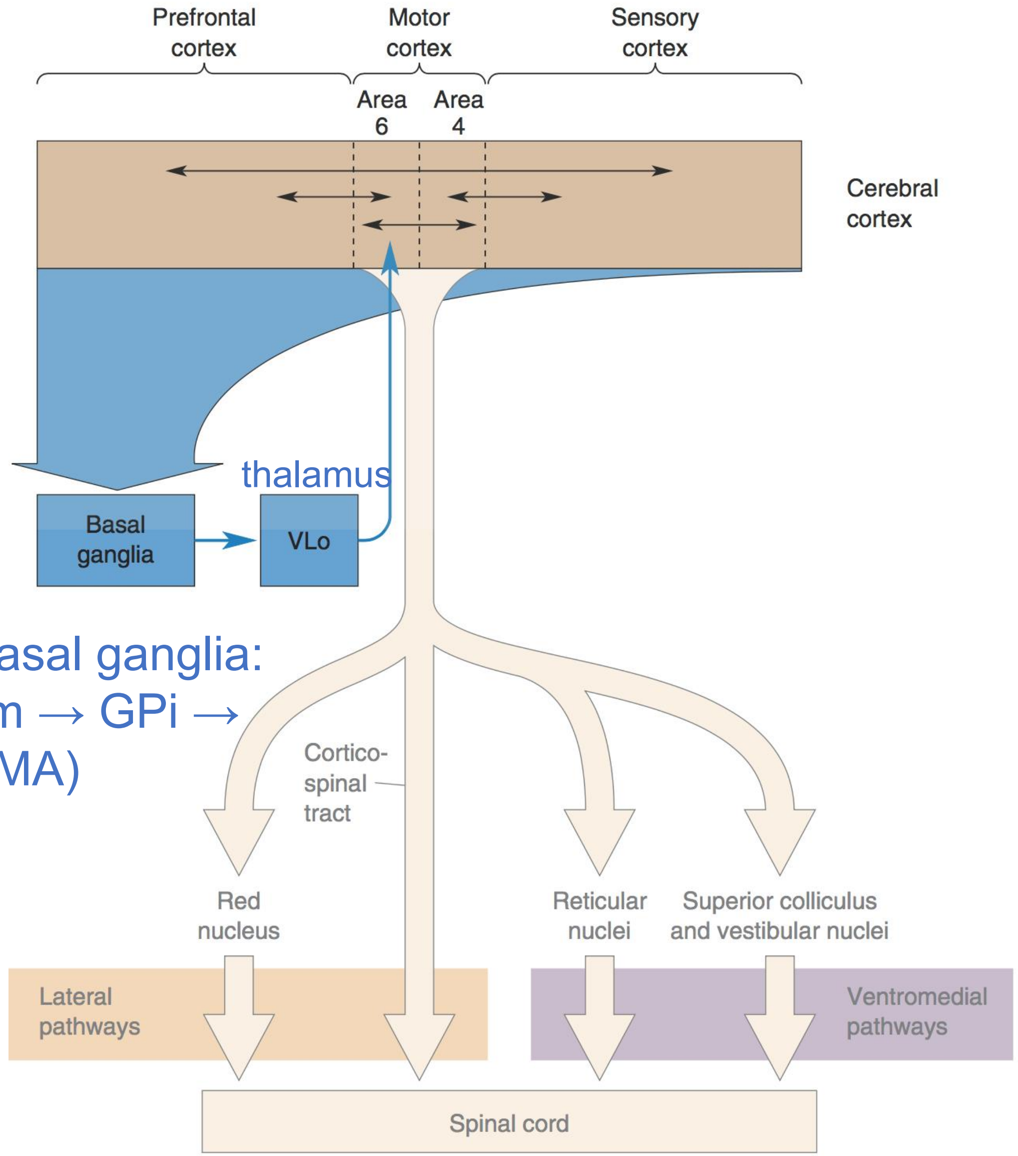
- the caudate nucleus,
- the putamen,
- the globus pallidus (consisting of an internal segment, GPi, and an external segment, GPe),
- the subthalamic nucleus.

In addition, we can add the substantia nigra, a midbrain structure that is **reciprocally connected** with the basal ganglia of the forebrain.

Summary of movement control



A loop through basal ganglia:
Cortex → Striatum → GPi →
VLo → Cortex (SMA)

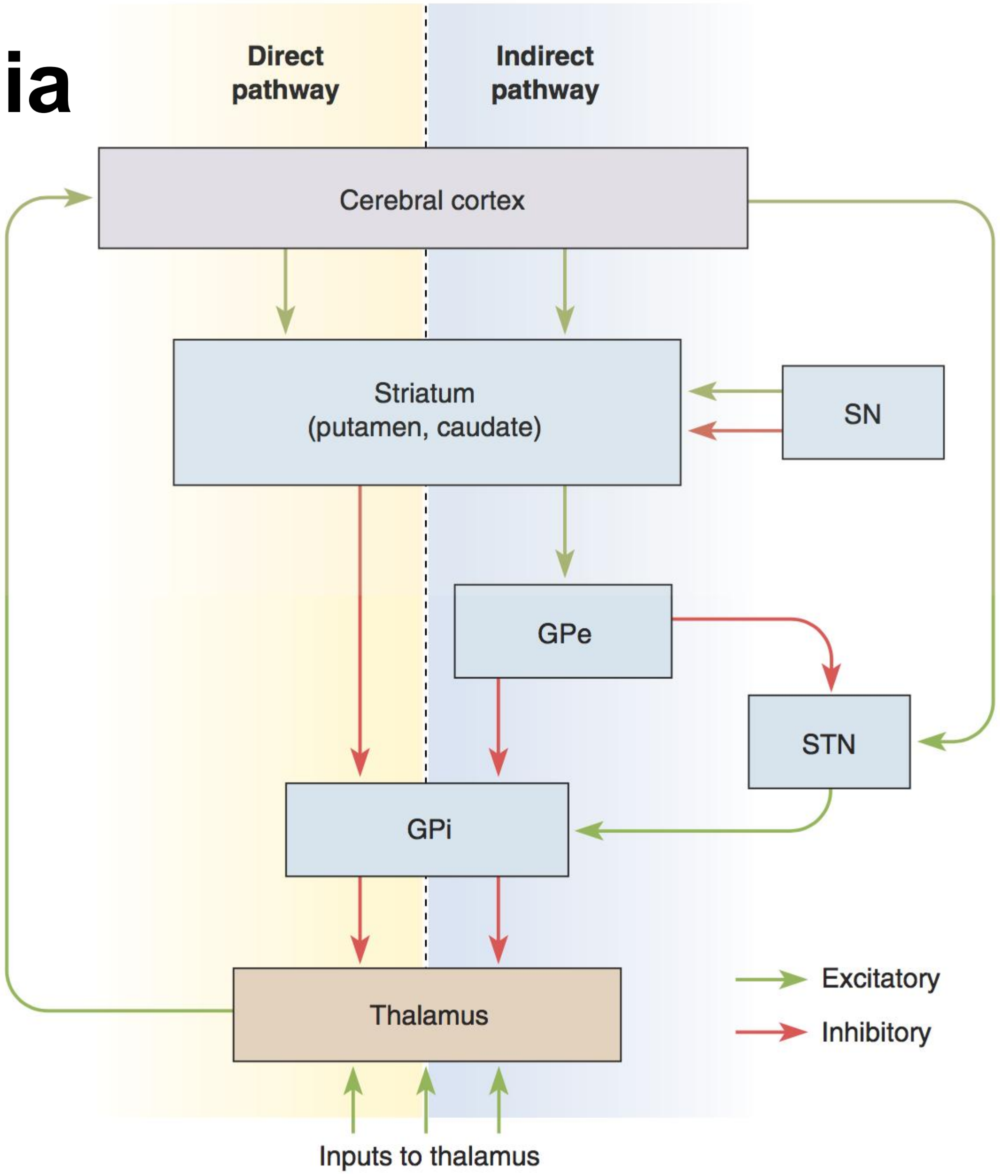


Pathways through Basal Ganglia

Dopaminergic neurons of the substantia nigra (SN) modulate the putamen and caudate nucleus.

Activation of the **direct pathway** by the cortex tends to facilitate the thalamus and information passing through it, while activation of the **indirect pathway** by the cortex tends to inhibit the thalamus.

The direct pathway may help to select certain motor actions, while the indirect pathway simultaneously suppresses competing, and inappropriate, motor programs.



▲ FIGURE 14.14
The direct and indirect pathways through the basal ganglia. Dopaminergic neurons of the substantia nigra (SN) modulate the putamen and caudate nucleus. The GPe and the subthalamic nucleus (STN) are part of the indirect pathway."

Basial Ganglia Disorders

Studies of several human diseases have supported the view that the direct motor loop through the basal ganglia functions to facilitate the initiation of willed movements.

According to one model, increased inhibition of the thalamus by the basal ganglia underlies ***hypokinesia***, a paucity of movement, whereas decreased basal ganglia output leads to *hyperkinesia*, an excess of movement.

Parkinson's disease exemplifies the ***hypokinesia***.

It affects about **1%** of all people over age 60.

Symptoms: slowness of movement (bradykinesia), difficulty in initiating willed movements (akinesia), increased muscle tone (rigidity), and tremors of the hands and jaw, which are most prominent at rest when the patient is not attempting to move.

Pathology: a degeneration of certain ***substantia nigra neurons*** and their inputs to the striatum. These inputs use the neurotransmitter, ***dopamine*** (DA).

DA can enhance the cortical inputs to the direct pathway, and DA inhibits the neurons in the striatum that send inhibitory outputs, via the indirect pathway, to the GPe.

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Huntington's disease is a hereditary, progressive, inevitably fatal syndrome characterized by ***hyperkinesia*** and *dyskinesias* (abnormal movements), *dementia* (impaired cognitive abilities), and *a disorder of personality*.

5–10 people per 100,000 worldwide

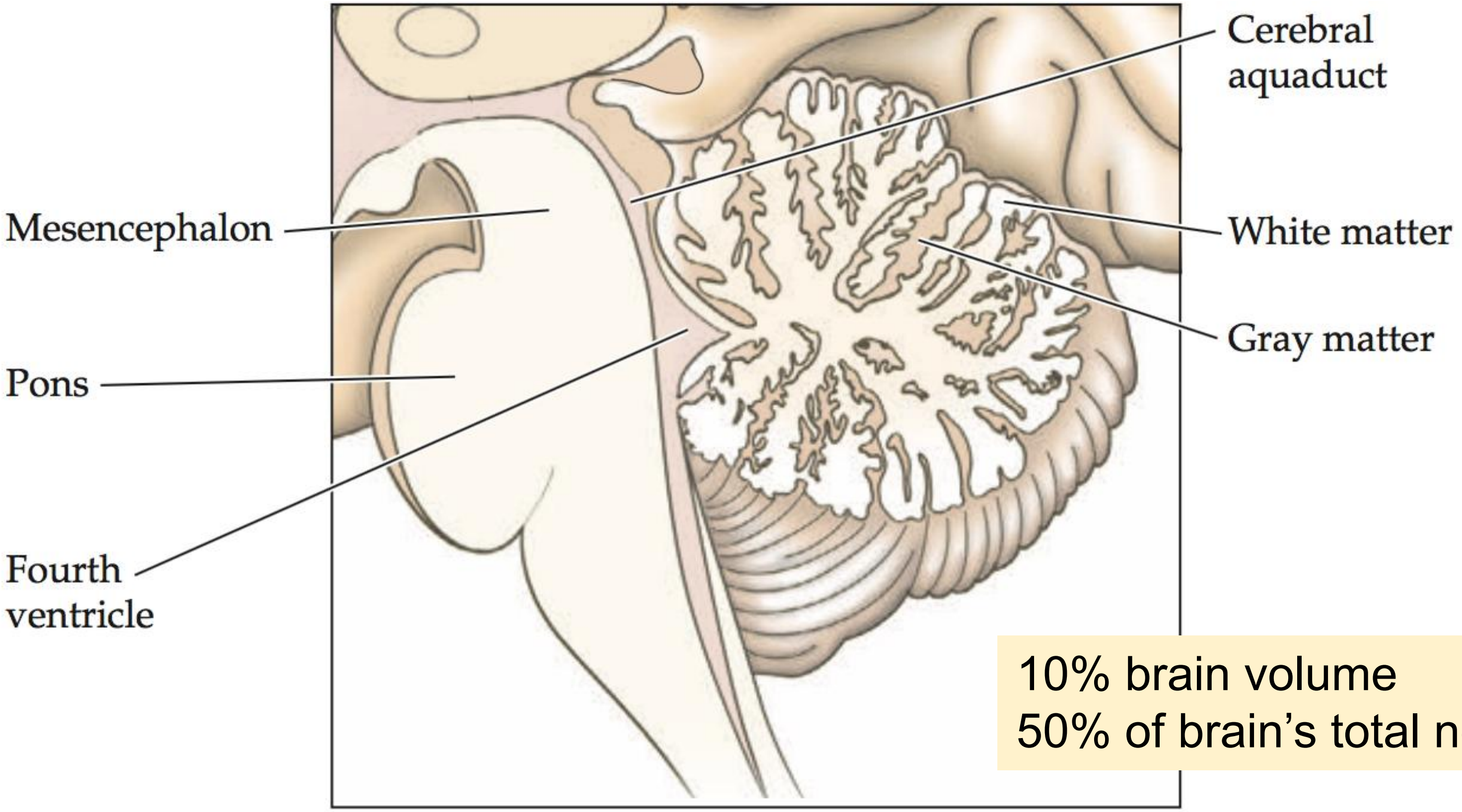
Symptoms: changes in mood, personality, and memory. The most characteristic sign of the disease is *chorea* — spontaneous, uncontrollable, and purposeless movements with rapid, irregular flow and flicking motions of various parts of body.

Pathology: a profound loss of neurons in the caudate nucleus, putamen, and globus pallidus, and elsewhere

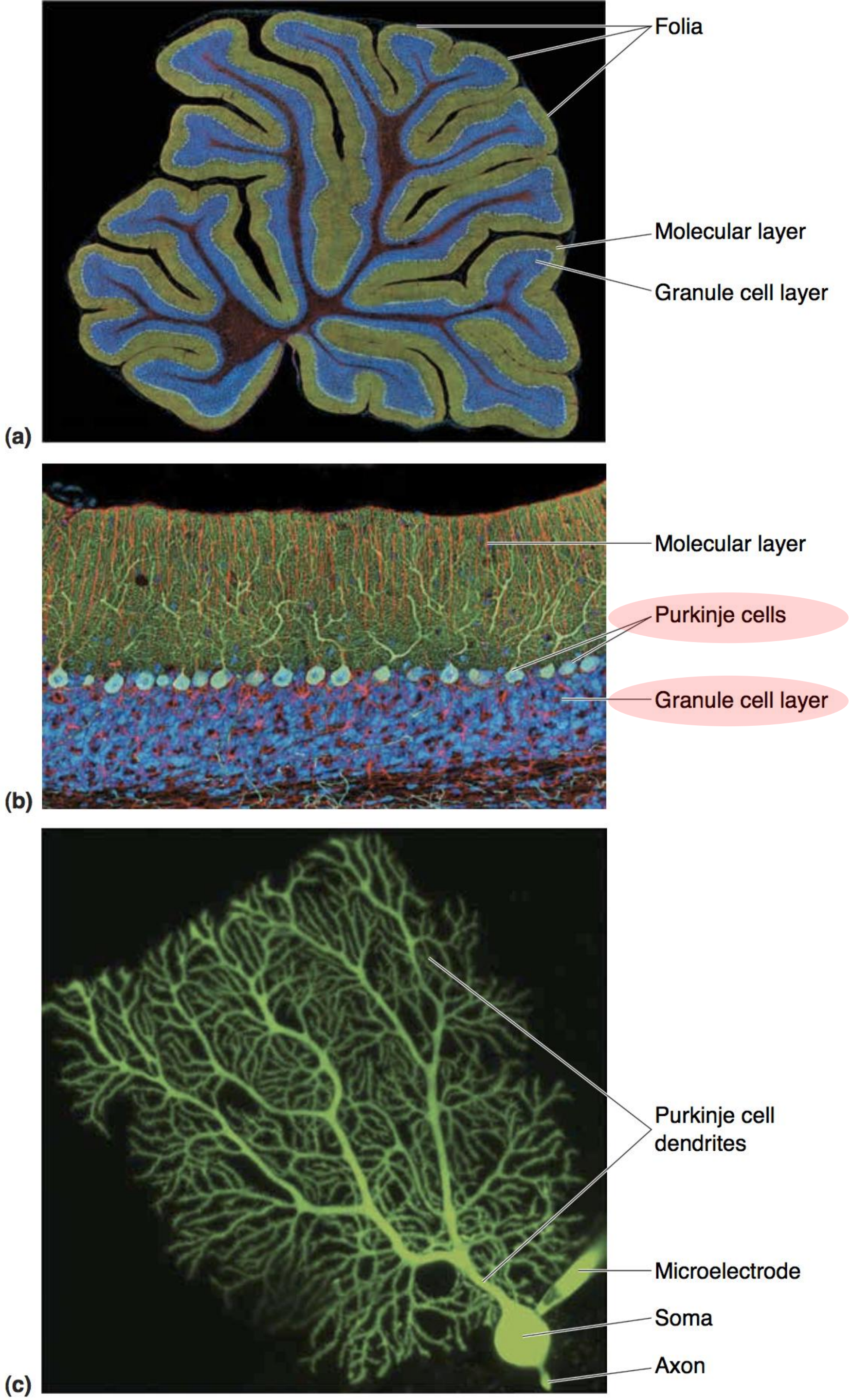
It is *insidious* (do not appear until well into adulthood). Genetic test…

Cerebellum

- Not directly involved in initiation of motor activity
- Fine-tuning of motor control
- Motor learning

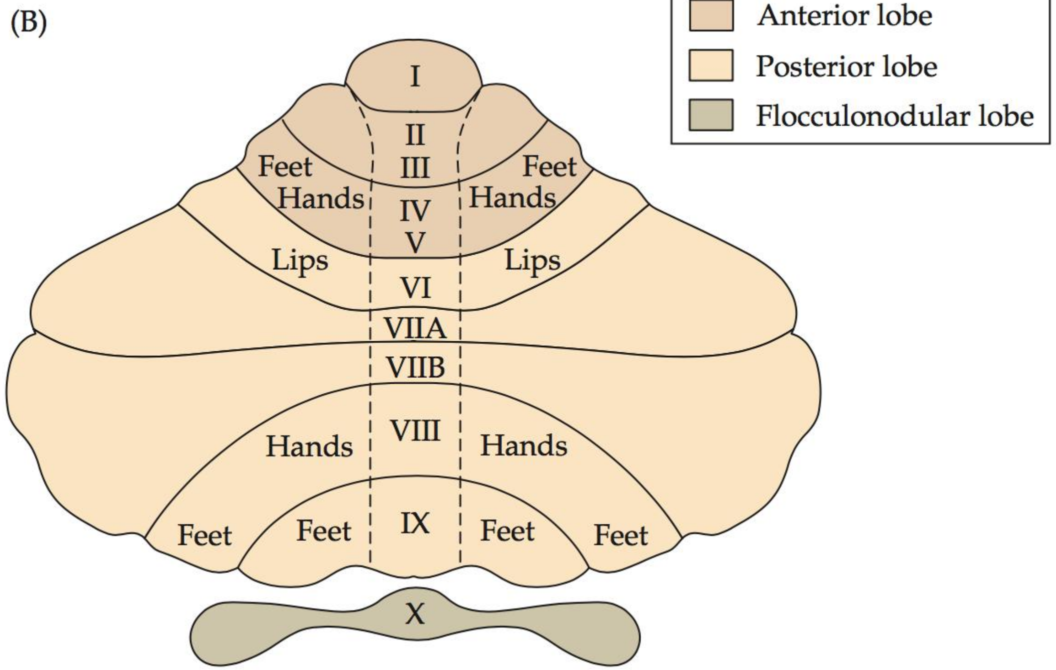


10% brain volume
50% of brain's total neuron

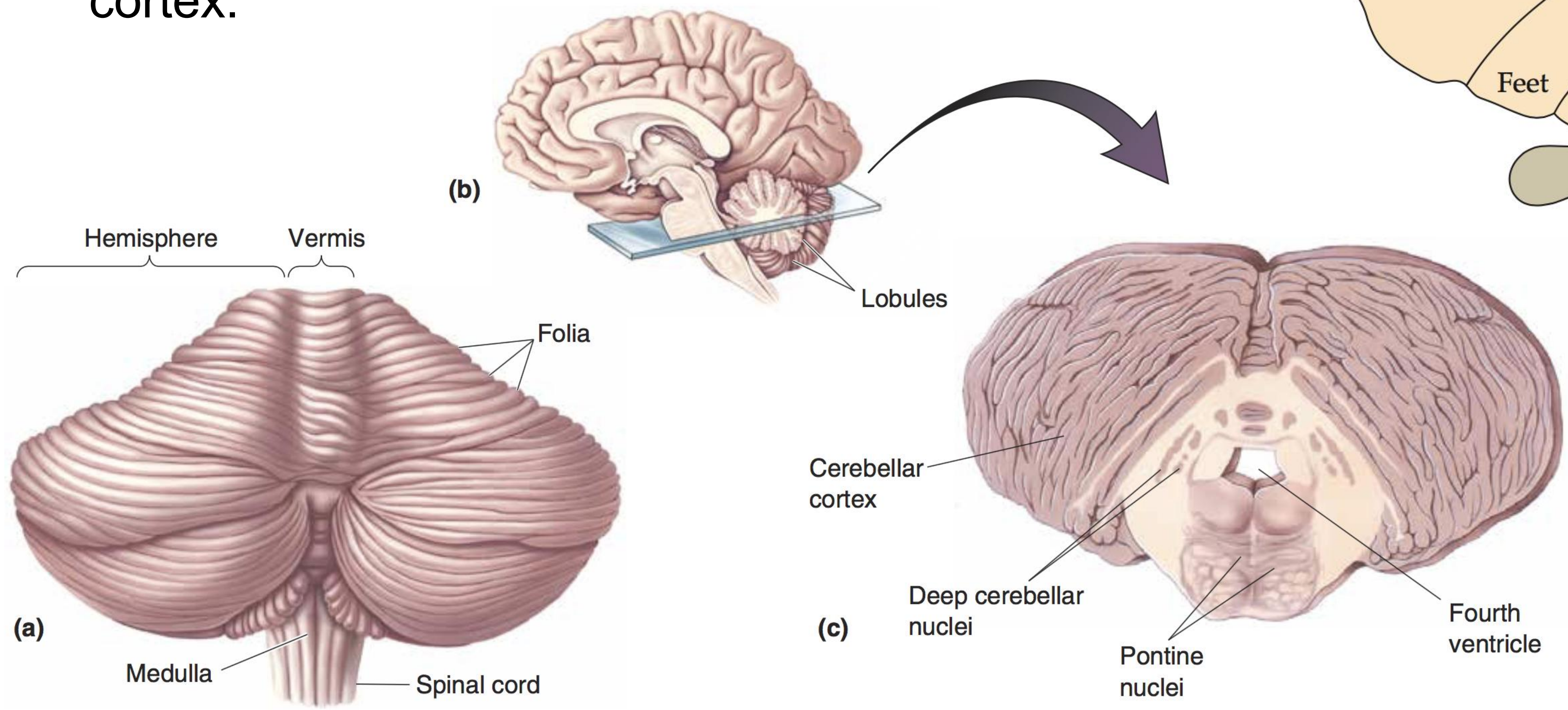


Cerebellum

The cerebellum receives proprioceptive, vestibular, and other sensory inputs from the entire body as well as a massive projection from motor and association cortex.

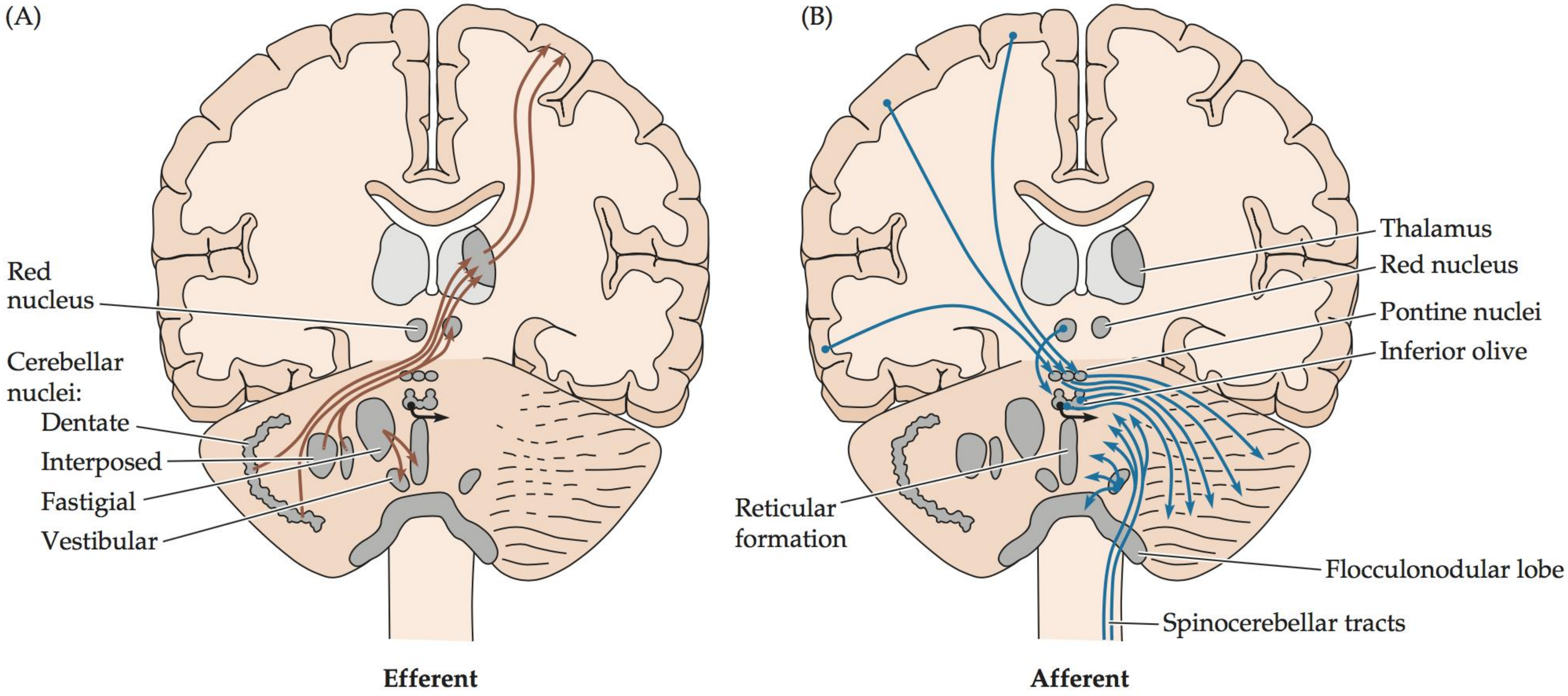


Somatotopic representation of the body in the anterior and posterior lobes of cerebellum



▲ FIGURE 14.20
The cerebellum. **(a)** A dorsal view of the human cerebellum, showing the vermis and hemispheres. **(b)** A midsagittal view of the brain, showing the lobules of the cerebellum. **(c)** A cross section of the cerebellum, showing the cortex and deep nuclei.

Efferent and Afferent Pathways of the Cerebellum



Diseases in Cerebellum

Cerebellar lesions: movements become **uncoordinated** and **inaccurate**, a condition known as **ataxia**.

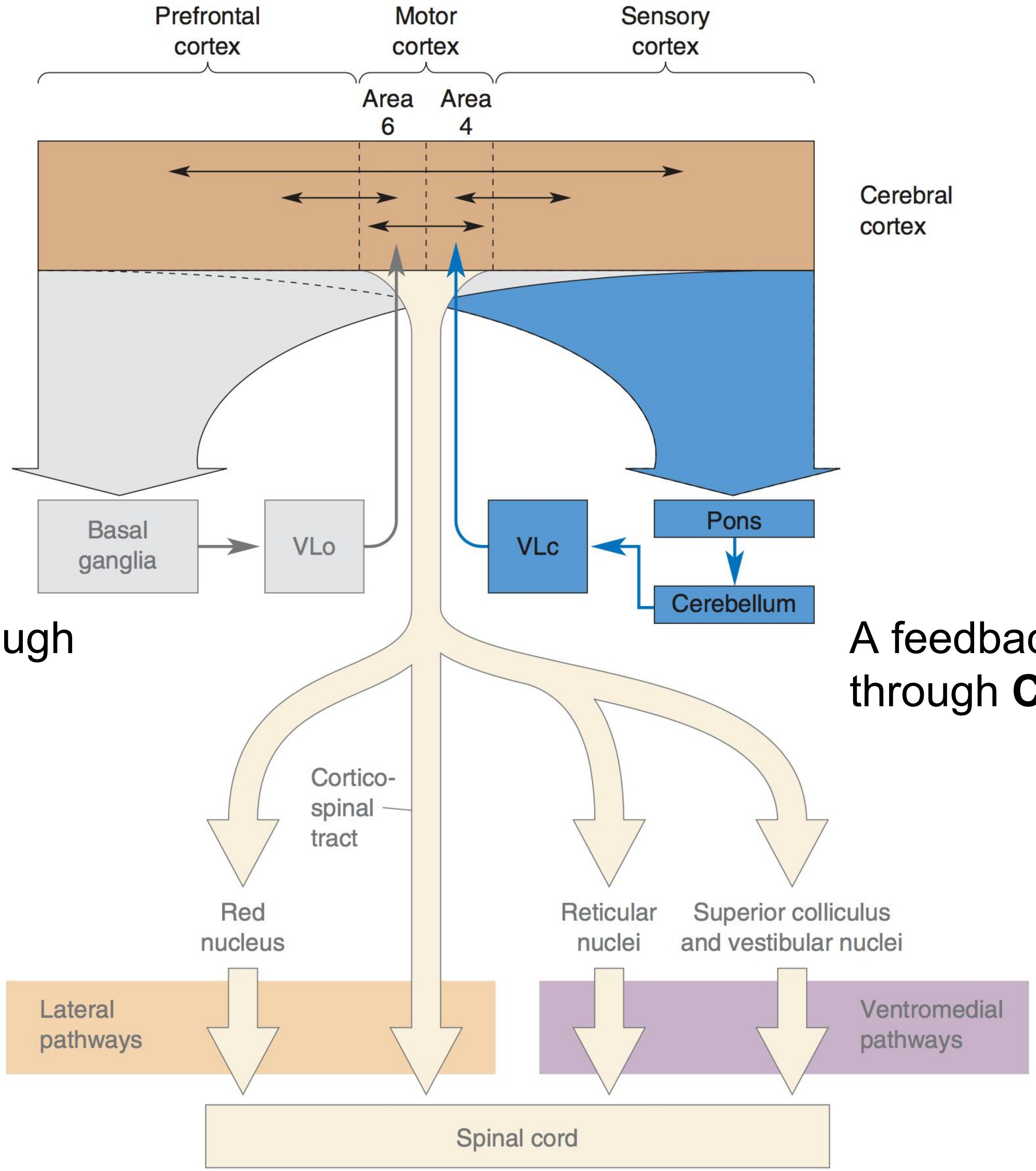
Take this simple test.

Lay your arms in your lap for a moment, then touch your nose with one finger. Try it again with your eyes closed. No problem, right?

Patients with **cerebellar damage** are often incapable of performing this simple task. Instead of smoothly and simultaneously moving the shoulder, elbow, and wrist to bring the finger to rest on the nose, they move each joint sequentially—first the shoulder, then the elbow, and finally the wrist. This is called *dyssynergia*, decomposition of synergistic multijoint movement.

Another characteristic deficit shown by these patients is that their finger movement will be *dysmetric*; they will either come up short of the nose or shoot past it, poking themselves in the face.

Updated summary of movement control



A feedback loop through **Basal ganglia**

A feedback loop through **Cerebellum**

Lecture 9 – Motor System 2

- **Brain control of movement:** Voluntary movement; posture & locomotion
- **Descending spinal tracts**
  - Lateral pathway: Voluntary movement
  - Ventromedial pathway: posture & locomotion
- **Brain regions in motor system**
  - M1: Initiation of movement
  - PMA, SMA, Posterial Parietal, Prefrontal
  - Basal Ganglia: feedback
  - Cerebellum: feedback
- **Autonomous vehicles (AVs)**
- **MuJoCo tutorial**

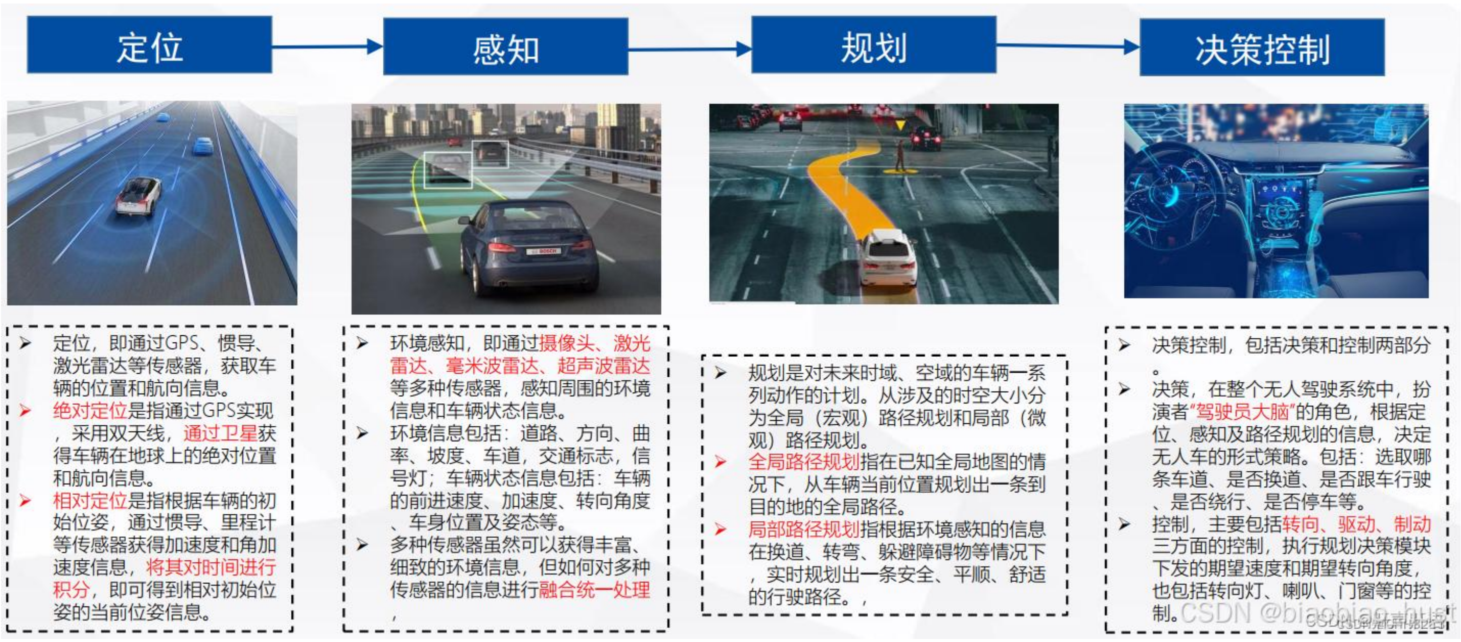
Human movement control & Autonomous Vehicles (AVs)

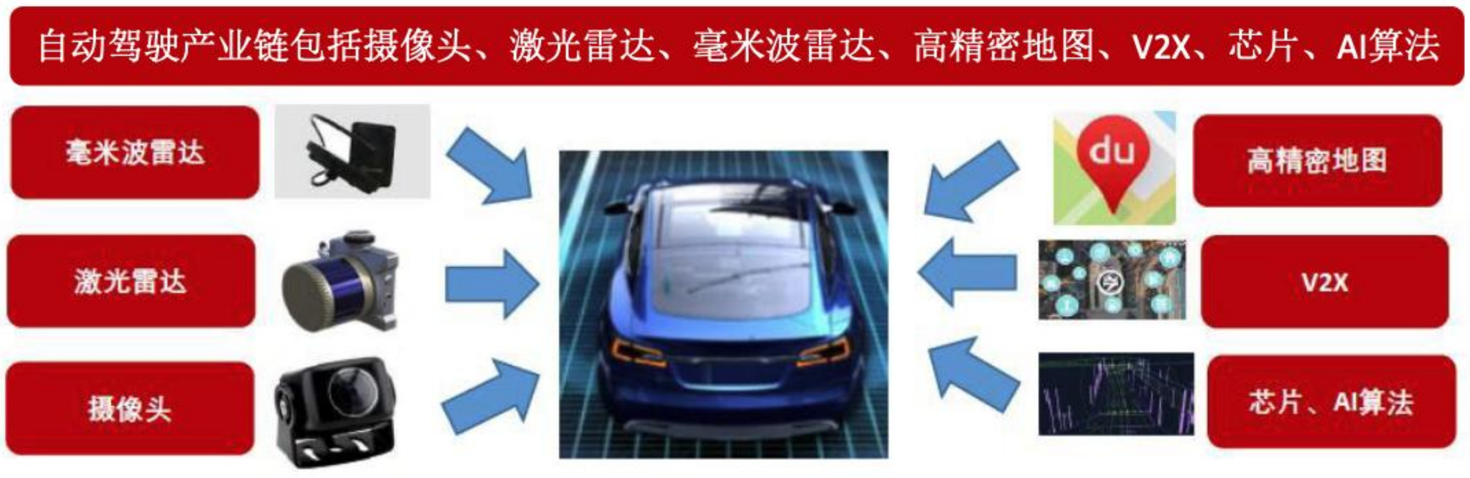
- **Strategy**: the goal of the movement and the movement strategy that best achieves the goal
- **Tactic**: the sequences of muscle contractions, arranged in space and time, required to smoothly and accurately achieve the strategic goal
- **Execution**: the activation of motor neurons and interneuron pools that generate the goal-directed movement and make any necessary adjustments of posture

自动驾驶技术分为多个等级，目前国内外产业界采用较多的为美国汽车工程师协会（SAE）和美国高速公路安全管理局（NHTSA）推出的分类标准。该标准将自动驾驶的概念分为L0~L5，其中L1-L3主要起到辅助驾驶功能。当达到L4级别时，车辆控制权可完全交给系统。从L3开始自动驾驶的主角切换到车辆自动驾驶系统上，可以看出，L3是自动驾驶人机角色重要的分水岭。

自动驾驶分级		名称	定义	驾驶操作	周边监控	接管	应用场景
NHTSA	SAE						
L0	L0	无自动化	没有任何辅助功能及系统完全依靠驾驶员来进行操作	驾驶员	驾驶员	驾驶员	无
L1	L1	驾驶支援	车辆对方向盘和加减速中的一项操作提供驾驶，驾驶员负责其余的驾驶动作	驾驶员和车辆	驾驶员	驾驶员	限定场景
L2	L2	部分自动化	车辆对方向盘和加减速中的多项操作提供驾驶，驾驶员负责其余的驾驶动作	车辆	驾驶员	驾驶员	
L3	L3	有条件自动化	由车辆完成绝大部分驾驶操作，驾驶员需保持注意力集中以备不时之需	车辆	车辆	驾驶员	
L4	L4	高度自动化	由车辆完成所有驾驶操作，驾驶员无需保持注意，但限定道路和环境条件	车辆	车辆	车辆	
	L5	完全自动化	由车辆完成所有驾驶操作，驾驶员无需保持注意力	车辆	车辆	车辆	所有场景

AV技术与产业链


定位
感知
规划
决策控制
定位，即通过GPS、惯导、激光雷达等传感器，获取车辆的位置和航向信息。
绝对定位是指通过GPS实现，采用双天线，通过卫星获得车辆在地球上的绝对位置和航向信息。
相对定位是指根据车辆的初始位姿，通过惯导、里程计等传感器获得加速度和角加速度信息，将其对时间进行积分，即可得到相对初始位姿的当前位姿信息。
环境感知，即通过摄像头、激光雷达、毫米波雷达、超声波雷达等多种传感器，感知周围的环境信息和车辆状态信息。
环境信息包括：道路、方向、曲率、坡度、车道，交通标志，信号灯；车辆状态信息包括：车辆的前进速度、加速度、转向角度、车身位置及姿态等。
多种传感器虽然可以获得丰富、细致的环境信息，但如何对多种传感器的信息进行融合统一处理，
规划是对未来时域、空域的车辆一系列动作的计划。从涉及的时空大小分为全局（宏观）路径规划和局部（微观）路径规划。
全局路径规划指在已知全局地图的情况下，从车辆当前位置规划出一条到目的地的全局路径。
局部路径规划指根据环境感知的信息在换道、转弯、躲避障碍物等情况下，实时规划出一条安全、平顺、舒适的行驶路径。，
决策控制，包括决策和控制两部分。
决策，在整个无人驾驶系统中，扮演者“驾驶员大脑”的角色，根据定位、感知及路径规划的信息，决定无人车的形式策略。包括：选取哪条车道、是否换道、是否跟车行驶、是否绕行、是否停车等。
控制，主要包括转向、驱动、制动三方面的控制，执行规划决策模块下发的期望速度和期望转向角度，也包括转向灯、喇叭、门窗等的控制。
CSDN @biaobiao_hust


自动驾驶产业链包括摄像头、激光雷达、毫米波雷达、高精密地图、V2X、芯片、AI算法
毫米波雷达
激光雷达
摄像头
du
高精密地图
V2X
芯片、AI算法


核心技术
感知定位
雷达
激光雷达
毫米波雷达
超声波雷达
定位
高精地图
高精定位
GPS模组
控制执行
线控底盘
线控转向与制动
线控油门与换挡
线控悬架
底盘域
灯光
动力
决策规划
决策
汽车芯片
智能座舱
软件算法
ADAS系统等
通信
车载通信模组
V2X技术
高速连接器
代表企业
激光雷达
禾赛科技
速腾聚创
大疆览沃
毫米波雷达
博世
大陆集团
安波福
超声波雷达
博世
大陆集团
法雷奥
高精地图
百度
四维图新
易图通
高精定位
拓普康
Septentrio
北斗通信
线控底盘
地平线
黑芝麻智能
均胜电子
汽车芯片
瑞萨电子
恩智浦
英飞凌
智能座舱
四维图新
均胜电子
东软集团
软件算法
Momenta
华为
环宇智行
ADAS系统
博世
大陆集团
电装
车载通信模组
广和通
移远通信
有方科技
V2X技术
百度
华砺智行
大唐移动

BI&AI 2024：Quiz 2

现在的自动驾驶汽车已经基本实现L3级别的自动控制，马斯克最新发布的特斯拉RoboTaxi和RoboVan甚至已经去掉了方向盘、脚踏板、后视镜。

请分析**人的运动控制系统**和**自动驾驶汽车的运动控制系统**的相似和差异之处。以下角度，二选一。

（1）从**感知**、**决策**、**执行**三个层面分析；

（2）从**系统目标**、**软件算法**、**硬件实现**三个层面分析。

特斯拉没了方向盘，
马斯克一夜没了4000亿。。。

BI&AI 2023：Quiz 2

假设你是特种兵，在执行罪犯抓捕任务，你看见罪犯从房顶跳下来逃跑，你估计房高5米、劲风往左吹、罪犯有80%的概率会往左逃跑，你决定往左边冲刺起跳。以下问题**任选其一**：

- **BI方向**：请简要描述以上文字所对应的**你的大脑活动**过程
- **AI方向**：如果我们需要设计一个机器人警察完成这个任务，需要实现什么功能？技术上如何利用**机器视觉**(例如CV)和**自动智能**(例如RL)来实现？
- **BI与AI融合方向**：我们想把你的意图通过**手势、语言、脑机接口等**方式传达给机器人警察，技术上如何实现？

特斯拉的“擎天柱”机器人

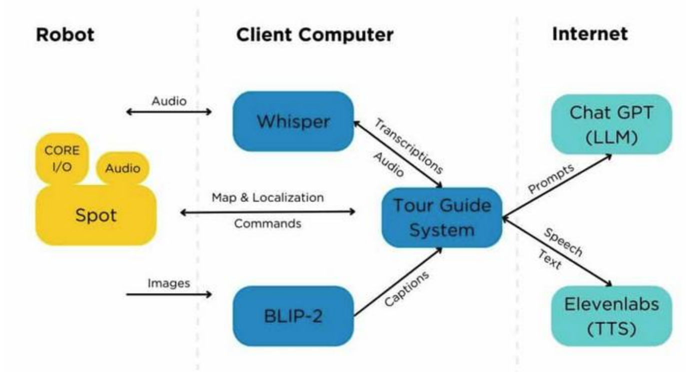
https://www.bilibili.com/video/BV1ua4y1g7Jz/

BI&AI 2022：Quiz 2

假设你是特种兵，在执行罪犯抓捕任务，你看见罪犯从房顶跳下来逃跑，你估计房高5米、劲风往左吹、罪犯有80%的概率会往左逃跑，你决定往左边冲刺起跳。以下问题**任选其一**：

- BI方向：请简要描述以上文字所对应的**你的大脑活动**过程
- AI方向：请简要设计一个机械外骨骼，实现**机器视觉**(例如CV)、**语言指令**(例如LLM)、**人脑控制**(例如BCI)、**自动智能**(例如RL)融合控制，帮助特种兵完成抓捕任务

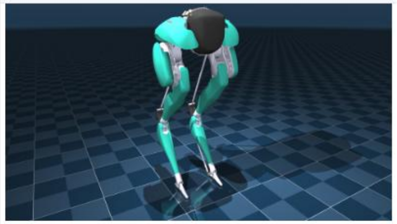
特斯拉的“擎天柱”机器人　https://www.bilibili.com/video/BV1ua4y1g7Jz



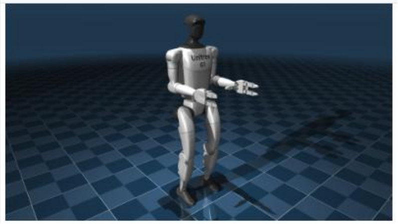
MuJoCo

A physics simulator is only as good as the model it is simulating, and in a powerful simulator like MuJoCo with many modeling options, it is easy to create “bad” models which do not behave as expected. The goal of MuJoCo Menagerie is to provide users with a curated collection of well-designed models that work well right out of the box.

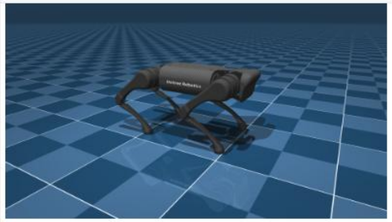
Bipeds

Model	Preview
Agility Cassie	

Humanoids

Model	Preview
Unitree G1	

Quadrupeds

Model	Preview
Unitree A1	

仿真效果：
https://www.bilibili.com/video/BV1rw411T7qw

https://github.com/r

OpenSim

OpenSim Moco produces the optimal motion and muscle behavior for an OpenSim musculoskeletal model, given goals to achieve during the motion and reference data. Moco provides a library of goals, such as minimizing effort, deviation from marker data (or generalized coordinate data), and joint loading. Reference data for the motion (markers or generalized coordinates), external forces (from force places), and muscle activity (from electromyography) are optional.

Reading materials

- *Neuroscience: Exploring the brain* (3rd ed), **Chapter 13 – Brain Control of Movement**, pp482-517
- *From Neuron to Brain* (5th ed), **Chapter 24 – Circuits controlling reflexes, respiration, and coordinated movement**, pp512-527

- **A talk in Simons Institute by David Sussillo**: Inferring Single-Trial Neural Population Dynamics Using Sequential Auto-Encoders https://www.youtube.com/watch?v=08xa7bE5iTQ