TRAMA — TRAining in Motion Analysis

First Course "Basics in Motion analysis"
TRAMA Project
September 10 -12 th 2007

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ALFA
EUROPEAID CO-OPERATION OFFICE

Objectives
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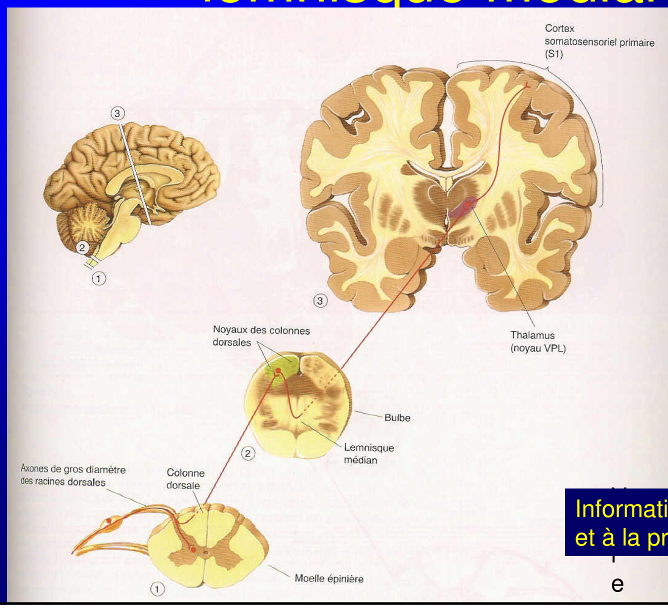
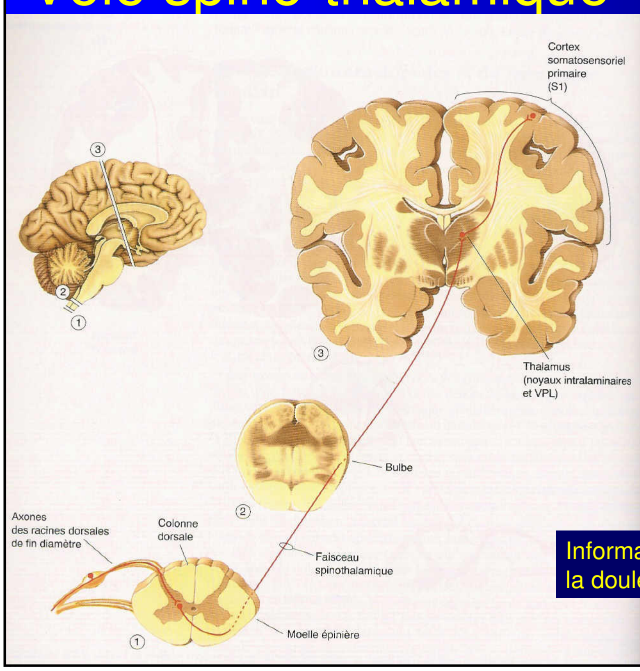
Voies des colonnes dorsales-lemnisque médian



Information relatives au toucher et à la proprioception.

Voie spino-thalamique



Informations relatives à la douleur et à la température

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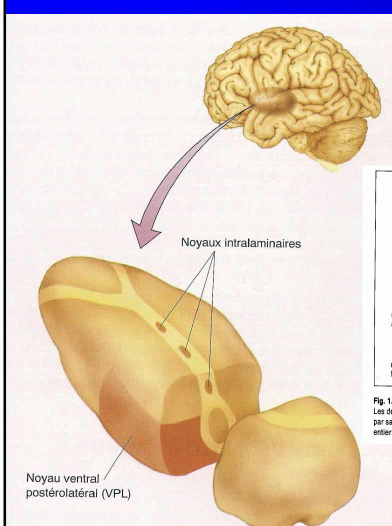
Organisation du thalamus



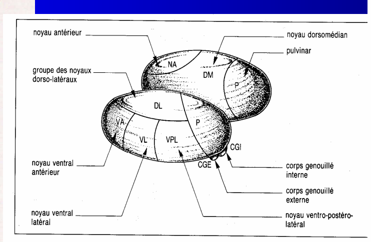


Fig. 1.14 Vue d'ensemble des deux thalamus (gauche et droit) et de leurs subdivisions.
Les deux thalamus sont représentés en les isolant par la pensée du reste du cerveau. Le thalamus gauche est vu par sa face externe, le thalamus droit par sa face interne. Le nom des différents noyaux constitutifs est indiqué en entier et par le sigle correspondant (voir fig. 1.15).

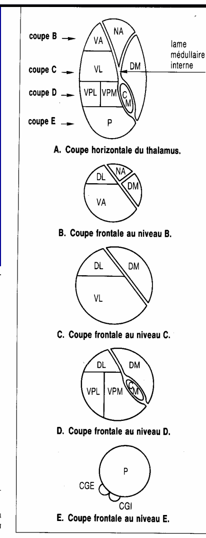


Fig. 1.15 Topographie des différents noyaux du thalamus.
Le thalamus est représenté par une coupe horizontale et par une série de coupes frontales passant par les niveaux indiqués par des flèches sur la coupe horizontale. Les subdivisions anatomiquement les plus évidentes sont celles qui sont dues à la présence d'une lame de substance blanche, la lame médullaire interne. NA = noyau antérieur ; VA = noyau ventral antérieur ; VL = noyau ventrolatéral ; VPL = noyau ventro-postéro-latéral ; VPM = noyau ventro-postéro-médian ; DM = noyau dorsomédian ; CM = centre médian ; DL = groupe des noyaux dorso-latéraux ; CGE = corps genouillé externe ; CGI = corps genouillé interne ; P = pulvinar.

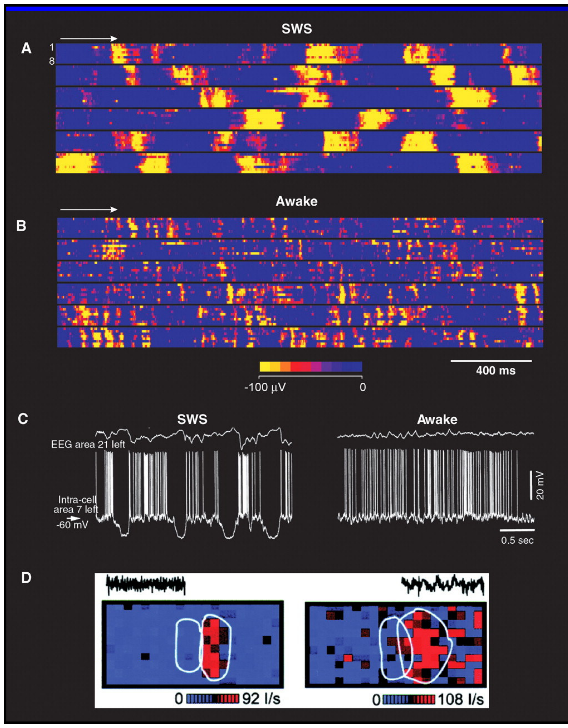
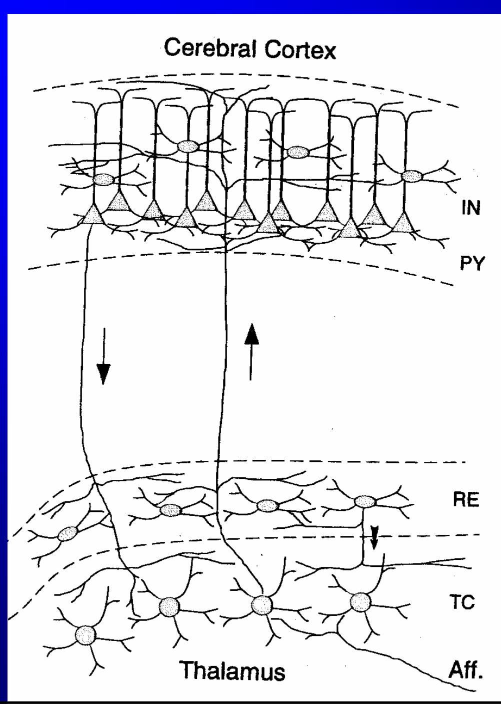


Fig. 1. Complex spatiotemporal patterns of ongoing network activity during wake and sleep states in neocortex. (**A**) Spatiotemporal map of activity computed from multiple extracellular local field potential (LFP) recordings in a naturally sleeping cat during slow-wave sleep (SWS). The activity consists of highly synchronized slow waves (in the frequency range, 1–4 Hz), which are irregular temporally but coherent spatially. (**B**) Same recording arrangement when the animal was awake. In this case, the ß frequency–dominated LFPs (15–30 Hz) are weakly synchronized and very irregular both spatially and temporally. [(A) and (B) modified from (*73*)] (**C**) Intracellular recordings during these two states show slow oscillations during slow-wave sleep (SWS, left), and a sustained depolarized state with intense fluctuations during wakefulness (Awake, right). [Courtesy of Igor Timofeev, Laval University] (**D**) Network state–dependent responsiveness in visual cortex. Cortical receptive fields obtained by reverse correlation in simple cells for ON responses. The procedure was repeated for different cortical states, by varying the depth of the anesthesia (EEG indicated above each color map). (Left) Desynchronized EEG states (light anesthesia); (right) synchronized EEG states with prominent slow oscillatory components (deeper anesthesia). Receptive fields were always smaller during desynchronized states. Color code for spike rate (see scale). [Modified from (*12*)]

Destexhe &Contreras,2006 Science

Relation thalamo-corticale et cortico-thalamique



(Destexhe, 2000, J. Physiol)

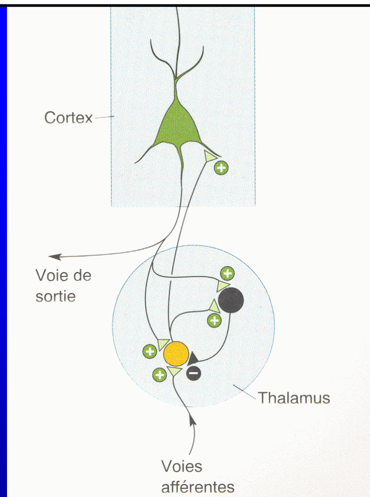


Figure 17.9

Les rythmes thalamiques pilotent les rythmes corticaux. Le thalamus peut générer une activité rythmique grâce aux propriétés intrinsèques de ses neurones et à leurs interconnexions spécifiques. Les neurones figurés en jaune représentent des populations cellulaires excitatrices, les neurones inhibiteurs étant figurés en noir.

Relation thalamo-corticale
et cortico-thalamique

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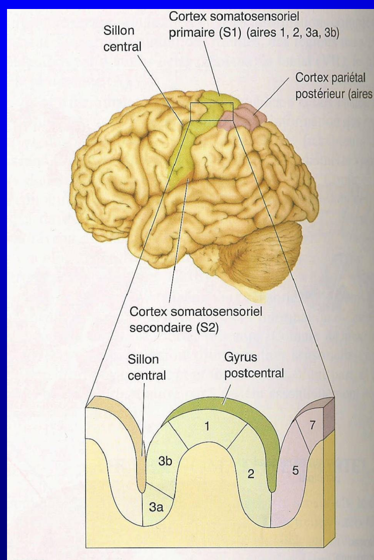
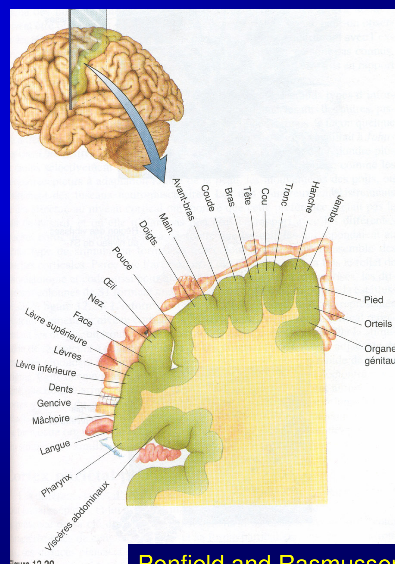
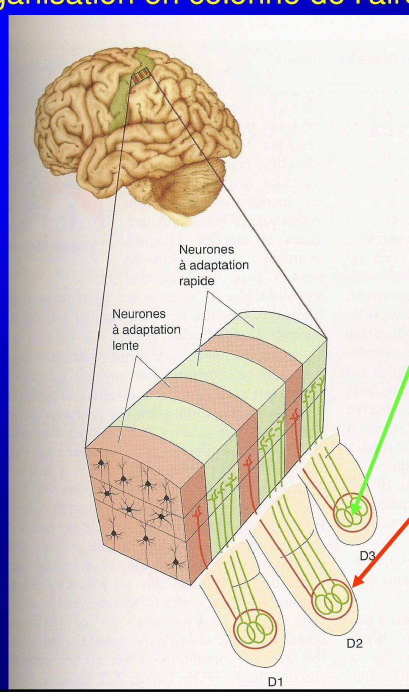
Organisation du cortex somatosensoriel





Penfield and Rasmussen, 1952

Organisation en colonne de l'aire 3b du cortex S1



Récepteurs adaptation rapide (Meissner, Johansson)

Récepteurs adaptation lente (Merkel, Ruffini)

(Kaas et al, 1981)

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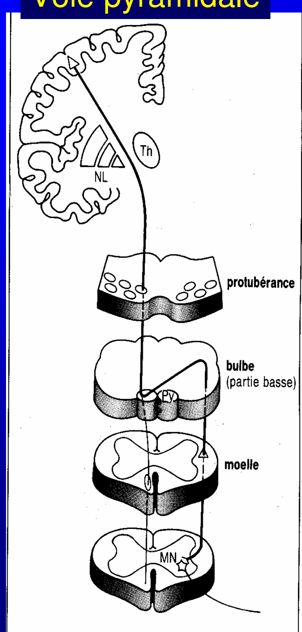
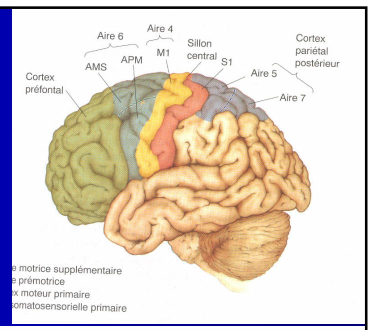
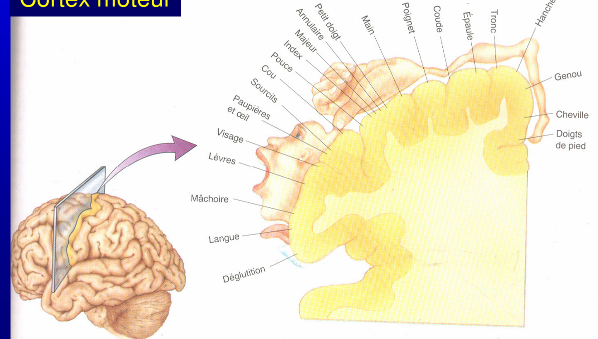
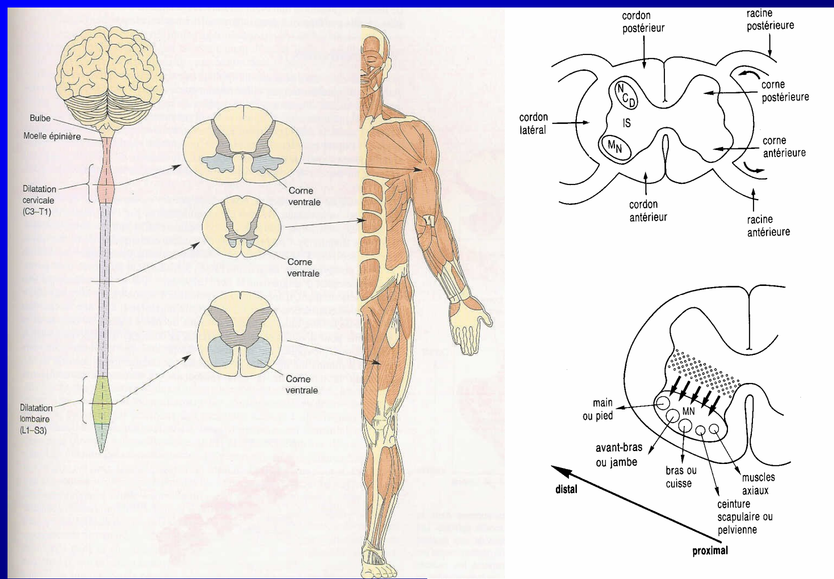
Voie pyramidale





Cortex moteur





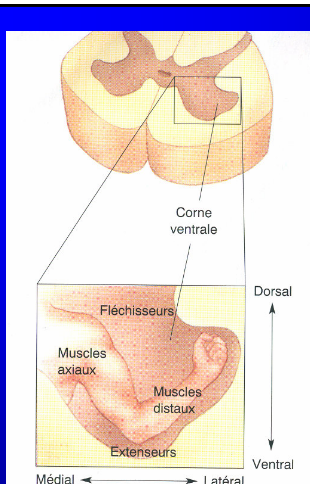
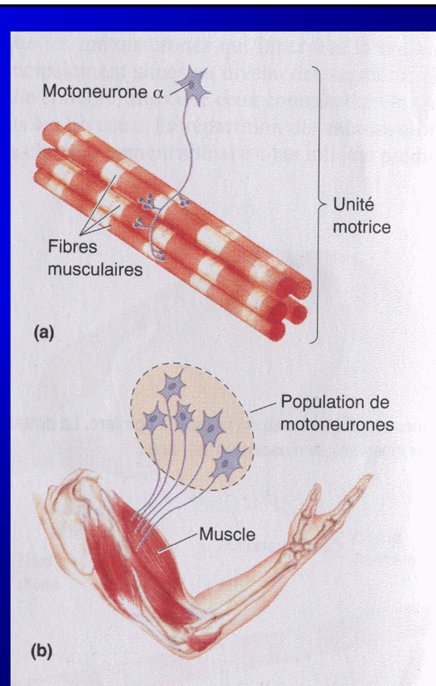


Figure 13.5

Distribution des motoneurones dans la corne ventrale de la moelle épinière. Les motoneurones de commande des muscles fléchisseurs occupent une position dorsale par rapport à ceux commandant les muscles extenseurs. Par ailleurs, les motoneurones de commande de la musculature axiale sont situés dans des régions plus médianes par rapport à ceux contrôlant la musculature distale.



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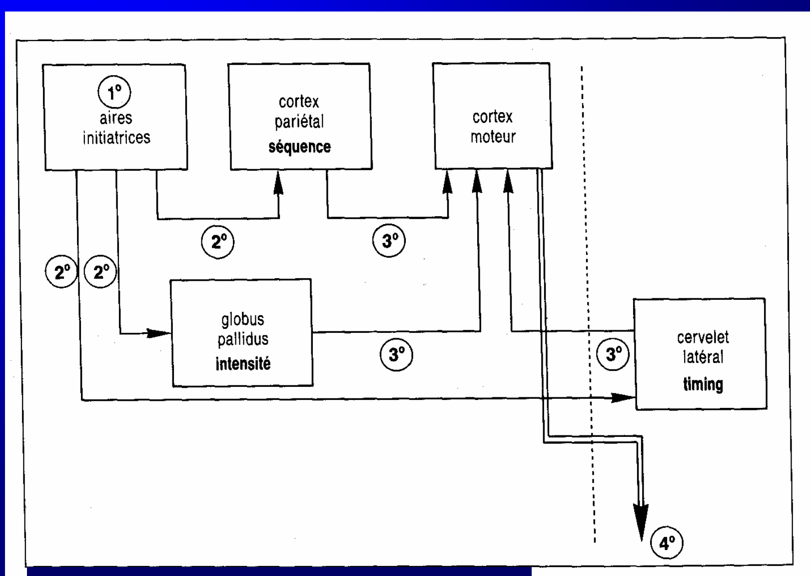
Synthèse:élaboration de la commande motrice



(Godaux et Cheron, 1989, Medsi McGrawHill)

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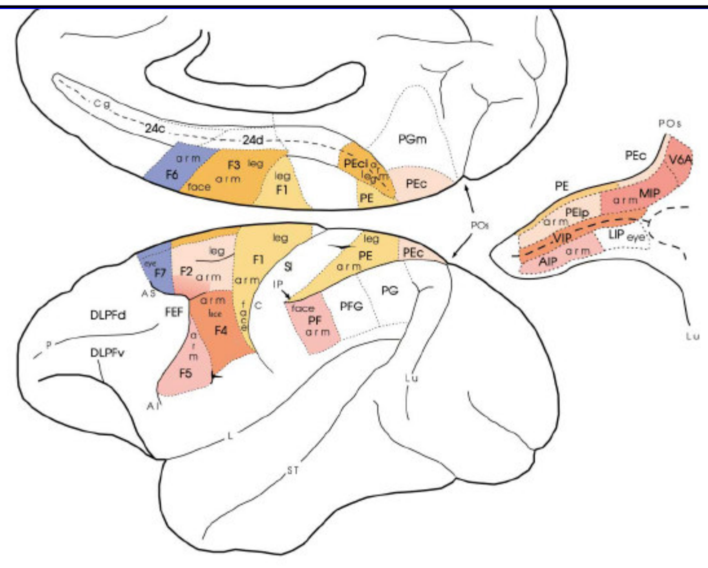


Figure 1. Mesial and Lateral Views of the Monkey Brain Showing the Parcellation of the Motor Cortex, Posterior Parietal, and Cingulate Cortices
The areas located within the intraparietal sulcus are shown in an unfolded view of the sulcus in the right part of the figure. For the nomenclature and definition of motor, posterior parietal, and cingulate areas, see Rizzolatti et al. (1998). The parieto-dependent motor areas and the parietal areas that are the source of their major cortical afferents are indicated with the same color. Prefronto-dependent areas are indicated in blue. AI, inferior arcuate sulcus; AS, superior arcuate sulcus; C, central sulcus; Cg, cingulate sulcus; DLPFd, dorsolateral prefrontal cortex, dorsal; DLPFv, dorsolateral prefrontal cortex, ventral; L, lateral fissure; Lu, lunate sulcus; P, principal sulcus; POs, parieto-occipital sulcus; ST, superior temporal sulcus.

(Rizzolatti and Luppino, 2001, Neuron)

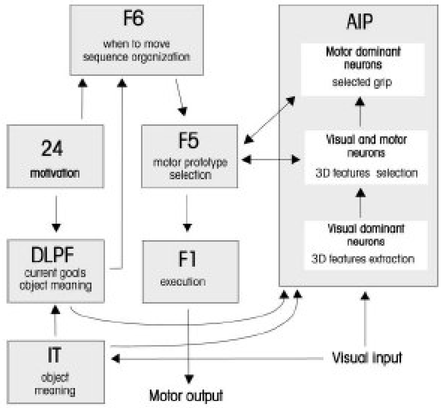
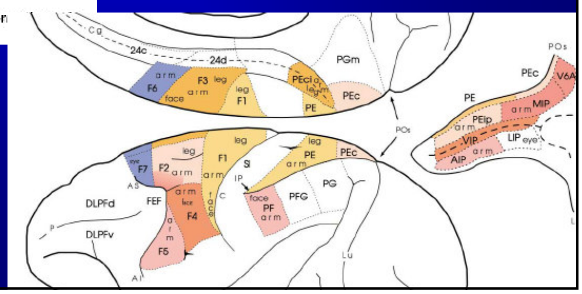
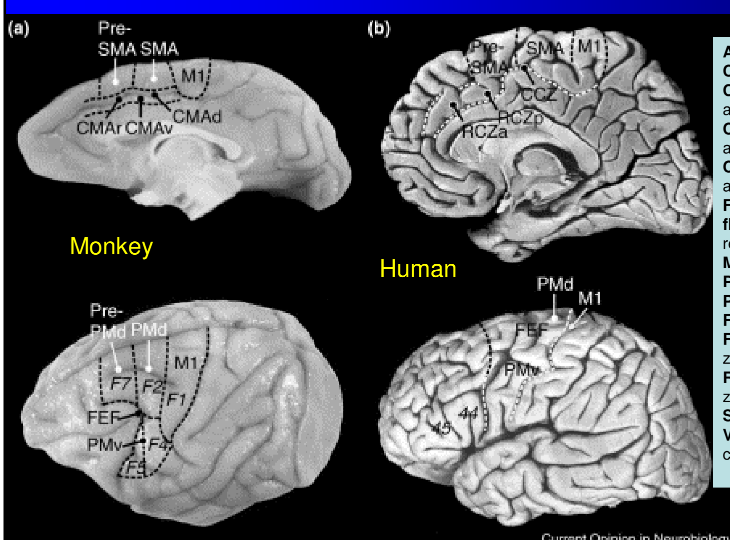


Figure 7. Schematic Model of Visuomotor Transfon
Grasping



(Rizzolatti and Luppino, 2001)



Abbreviations
CCZ caudal cingulate zone
CMAd dorsal cingulate motor area
CMAr rostral cingulate motor area
CMAv ventral cingulate motor area
FEF frontal eye field
fMRI functional magnetic resonance imaging
M1 primary motor cortex
PMd dorsal premotor cortex
PMv ventral premotor cortex
RCZ rostral cingulate zone
RCZa anterior rostral cingulate zone
RCZp posterior rostral cingulate zone
SMA supplementary motor area
VCA line level of the anterior commissure

Picard and Strick, 2001

Separate functional divisions in premotor areas

SMA, PMd, CCZ, → Various aspects of Movement generation and control

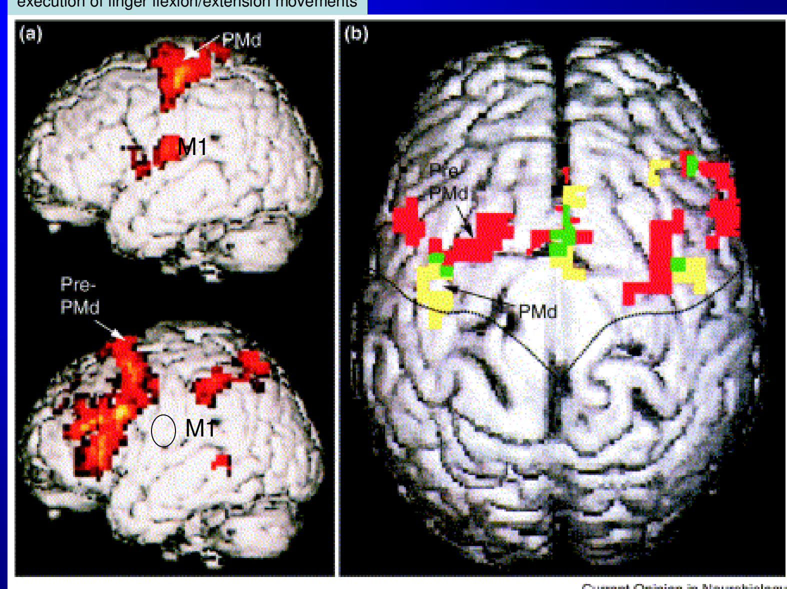
RCZ → Motor and cognitive functions

RCZa=CMAr → Conflict monitoring

RCZp=CMAv → Response selection

pre-SMA → Abstract level, sensory-motor association
Unrelated to motor aspects of the task,
Working memory, shift of attention
to stimuli

activation of the PMd proper during
execution of finger flexion/extension movements



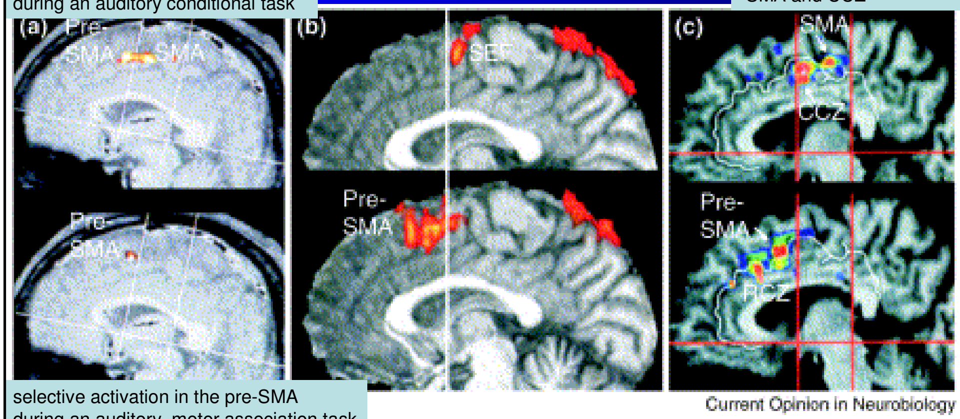
activation of the pre-PMd during
imagined movements of the fingers

Activation of the pre-PMd related to spatial attention/memory is shown in red,
activation of the PMd on the precentral gyrus related to movement preparation
is shown in yellow, and the overlap is shown in green.

activation in the SMA and pre-SMA during an auditory conditional task

Activation in the supplementary eye field (SEF) during visually guided saccades

motor-related activations in SMA and CCZ



selective activation in the pre-SMA during an auditory–motor association task

selective activation of the pre-SMA for a mixed condition of compatible and incompatible (Stroop-like) conditional saccades

sustained activation during working memory delay in the pre-SMA and RCZ

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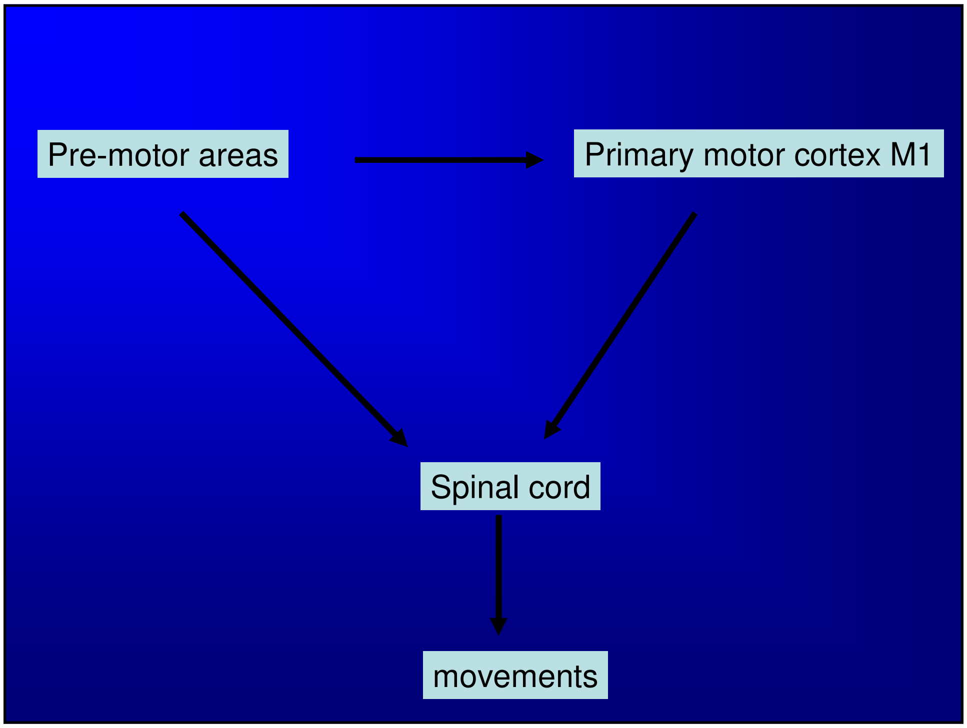

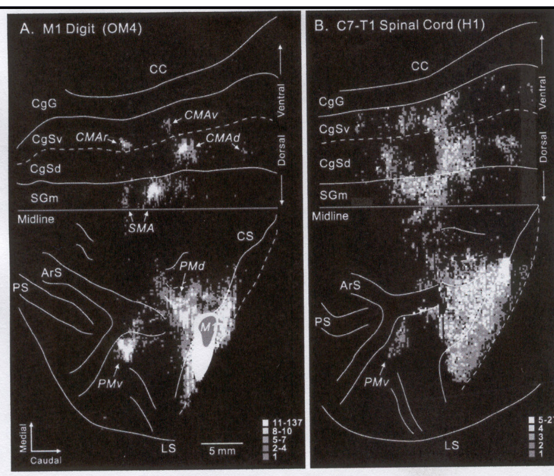

Fig. 1. Identification of premotor areas in the frontal lobe. (A) Premotor areas project to M1. An unfolded map of the frontal lobe depicts the density of labeled neurons after injections of WGA–HRP into the physiologically identified digit representation of M1 in the macaque monkey (animal OM4 from Ref. [24]; for details of the unfolding and the determination of cell density, see Ref. [3]). The medial wall is unfolded and reflected upward from the midline so that it appears upside down. The lip of each sulcus is represented by a *solid line*, and its fundus is indicated by a *dashed line*. The labeled neurons in the PMv (*arrow*) are located in the posterior bank of the arcuate sulcus, and have been projected to the surface to indicate their relative location. However, this projection to the surface artificially increases the displayed density. (B) Premotor areas project to the spinal cord. An unfolded map of the frontal lobe shows the density of labeled neurons after injections of a fluorescent tracer into the C7–T1 segments of the spinal cord. Adapted from Refs. [6,7]. Copyright 1995 by the Society for Neuroscience. Abbreviations: ArS = arcuate sulcus; CC = corpus callosum; CgG = cingulate gyrus; CgSd = dorsal bank of the cingulate sulcus; CgSv = ventral bank of the cingulate sulcus; CS = central sulcus; LS = lateral sulcus; PMd = dorsal premotor area; PMv = ventral premotor area; PS = principal sulcus; SGm = medial superior frontal gyrus.

- Injections de WGA-HRP dans M1
- Injections traceur fluorescent dans segments médullaires C7-T1

(Dum and Strick, 2002)

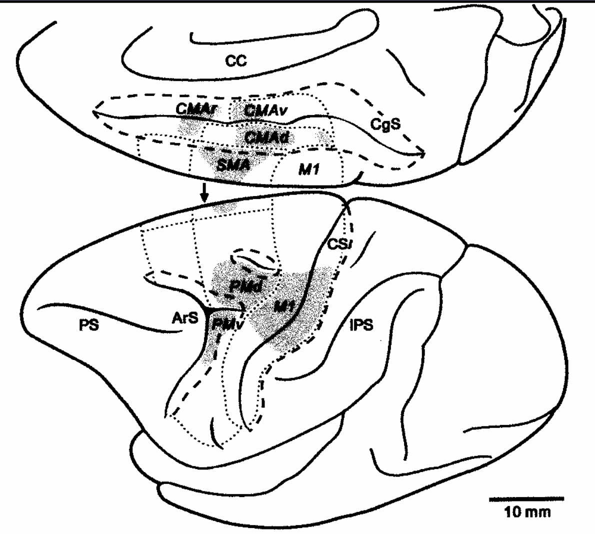

Fig. 2. Motor areas in the frontal lobe of the macaque. *Shaded* regions indicate the location of the origin of corticospinal neurons projecting to the cervical segments of the spinal cord. *Fine dotted lines* indicate cytoarchitectonic borders of each premotor area and M1. Abbreviations: CgS = cingulate sulcus; IPS = intraparietal sulcus; other abbreviations as in Fig. 1.

Terminaisons de M1 au niveau de la moelle

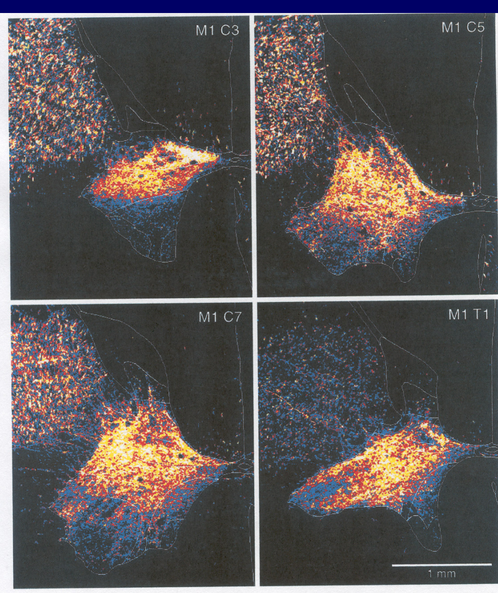

Figure 11. M1 terminations in contralateral cervical segments of animal R4. These images are displayed using the same conventions as in Figure 6. The pattern of M1 terminations at each cervical level is similar to the SMA pattern (Fig. 6), even though the overall density of M1 terminations is higher.

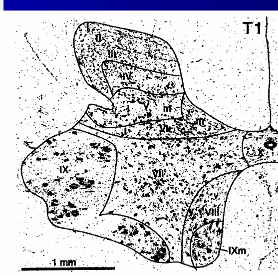

Figure 3. Laminar organization of the cervical spinal cord. Photomi graph of a coronal section of spinal segment T1 of a macaque stained cresyl violet. Laminar borders adapted from the criteria of Rexed (19 and Apkarian and Hodge (1989). *c*, Central; *l*, lateral; *m*, medial.

(Dum and Strick, 1996)

Terminaison de la SMA au niveau de la moelle

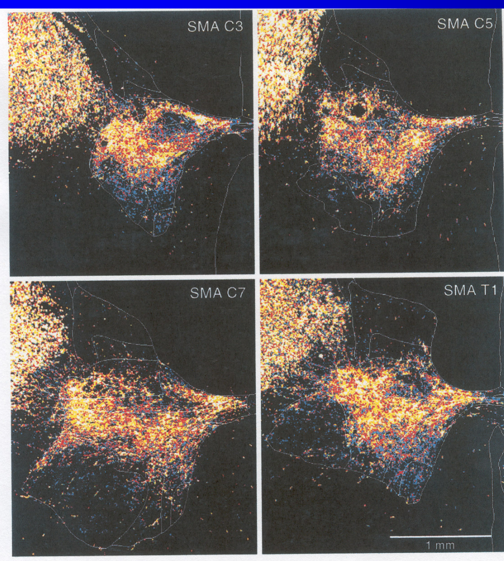

Figure 6. SMA terminations in contralateral cervical segments of animal R3. Each figure shows a gradient density analysis of corticospinal terminations at one of four segmental levels in the cervical spinal cord. Digitally captured images of spinal cord terminations were color-coded: *white* = the most intense 10% of illuminated pixels, *yellow* = 60–90%, *red* = 30–60%, *blue* = the least intense 30%. The pattern of SMA terminations at each segmental level is similar and includes some terminations in dorsolateral lamina IX where motoneurons are located.

(Dum and Strick, 1996)

Terminaisons de M1, de la SMA et du CMA

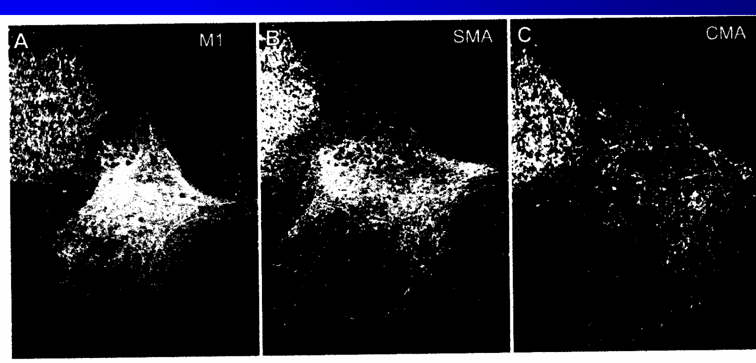

Fig. 3. Pattern of terminations of M1, the SMA, and cingulate motor areas in the spinal cord. Photomicrographs under dark-field/polarized light of the tetramethylbenzidine substrate deposited in the contralateral C7 segment of the spinal cord after injections of WGA–HRP into (A) the arm representation of M1, (B) the SMA, and (C) both the CMAd and the CMAv. The gray matter and its laminar borders are outlined. The intensity of TMB labeling in these digitally captured images was compressed into four density levels that were from darkest to brightest—the 0–30th, 31–60th, 61–90th, and 91–100th percentiles of all the illuminated pixels. Adapted from Ref. [17]. Copyright 1996 by the Society for Neuroscience.

(Dum and Strick, 2002)

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L’organisation des noyaux de la base

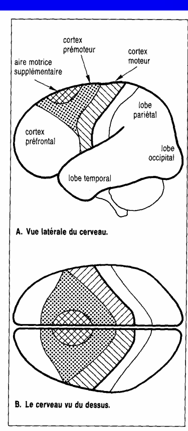
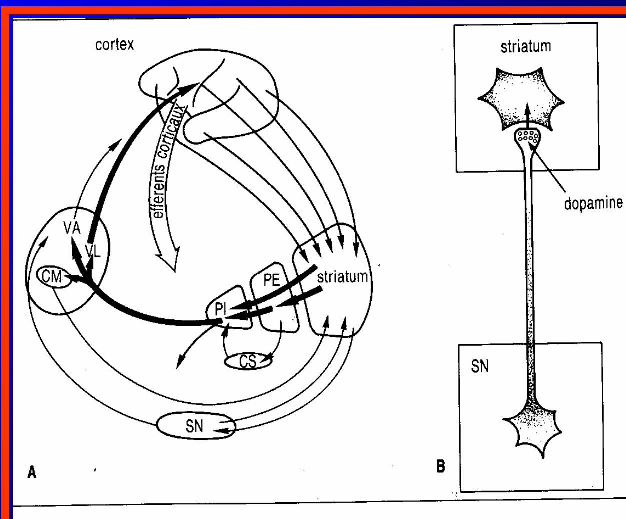


Fig. 1.21 Schéma montrant la localisation des principales aires motrices.
Le cortex moteur, le cortex prémoteur et l’aire motrice supplémentaire.
Le cortex moteur correspond à l’aire 4 de Brodmann, l’ensemble cortex prémoteur-aire motrice supplémentaire à l’aire 6 de Brodmann.



Lésion du globus pallidus

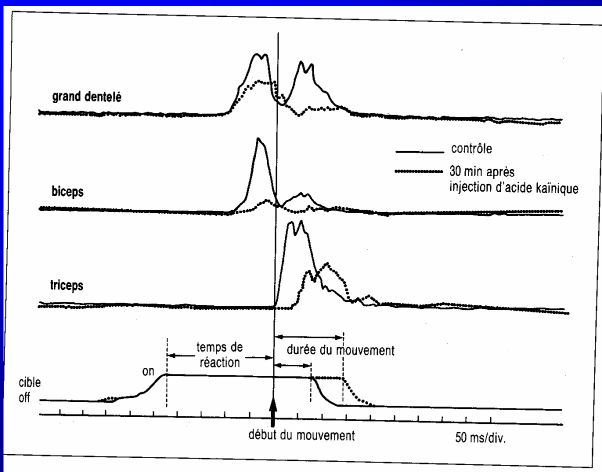


Fig. 2.30 Effet d'une lésion à l'acide kaïnique dans le globus pallidus sur le mouvement rapide vers une cible fixe. Le paradigme expérimental utilisé est illustré aux figures 2.9 et 2.10. Sont ici représentés l'activité EMG des muscles grand dentelé, biceps et triceps ainsi que le temps de réaction et la durée du mouvement avant (traits pleins) et après (traits pointillés) lésion à l'acide kaïnique.
(D'après Horak et Anderson, *J Neurophysiol*, 1984 ; **52 :** 290-304).

Synthèse programmation du mouvement

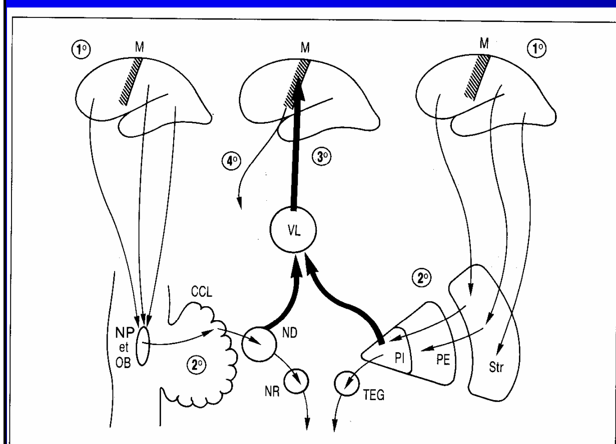


Fig. 2.31 Schéma de synthèse des connexions anatomiques reliant les structures nerveuses qui participent à la programmation du mouvement. Les numéros 1, 2, 3 et 4 indiquent l'ordre dans lequel se déroulent les processus.
M = cortex moteur. NP = noyau pontin. OB = olive inférieure bulbaire. CCL = cortex cérébelleux latéral. VL = noyau ventro-latéral du thalamus. NR = noyau rouge. TEG = tegmentum mésencéphalique. PI = globus pallidus interne. PE = globus pallidus externe. Str = striatum.
(D'après Kemp et Powell, *Phil Trans R Soc Lond B*, 1971 ; **262 :** 441-457).

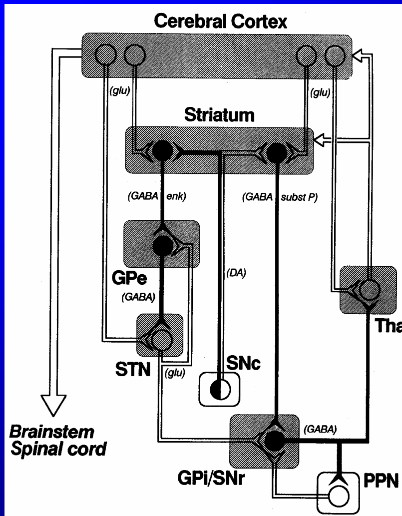


Fig. 2. *Schematic diagram of the circuitry and neurotransmitters of the basal ganglia–thalamocortical circuitry, indicating the parallel 'direct' and 'indirect' pathways from the striatum to the basal ganglia output nuclei. Inhibitory neurons are shown as filled symbols, excitatory neurons as open symbols. Abbreviations: DA, dopamine; enk, enkephalin; GABA, γ-aminobutyric acid; GPe, external segment of globus pallidus; GPi, internal segment of globus pallidus; glu, glutamate; PPN, pedunculopontine nucleus; SNc, substantia nigra pars compacta; SNr, substantia nigra pars reticulata; subst P, substance P; STN, subthalamic nucleus; Thal, thalamus.*

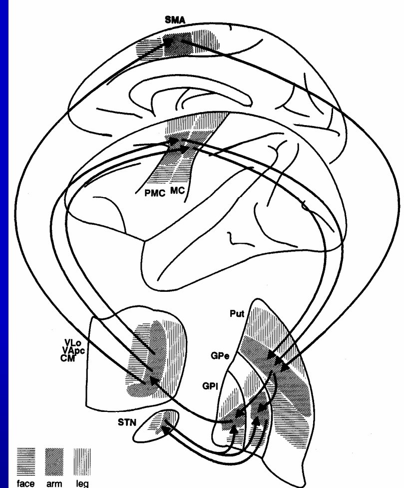


Fig. 4. *Somatotopic organization of the 'motor' circuit. Somatotopic subdivisions of each structure are indicated by differential shading. The arrows indicate the topographically organized pathways that link the respective 'arm' representations at different stages of the circuit. Abbreviations: CM, centromedian nucleus; GPe, external segment of globus pallidus; GPi, internal segment of globus pallidus; MC, primary motor cortex; PMC, premotor cortex exclusive of the arcuate premotor area; Put, putamen; SMA, supplementary motor area; VApc, nucleus ventralis anterior pars parvocellularis; VLo, nucleus ventralis lateralis pars oralis.*

(Alexander and crutcher, TINS, 1990)

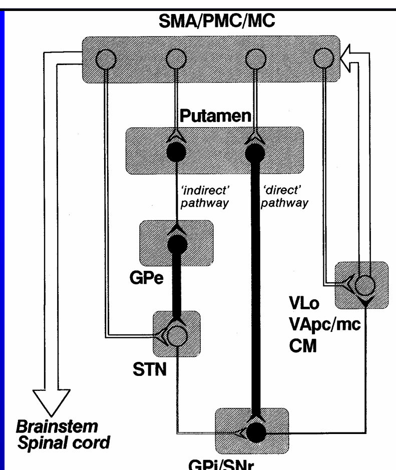


Fig. 2. *Schematic representation of the 'motor' circuit in hyperkinetic disorders. Reduced excitatory projections from the STN to GPi, due either to STN lesions (as in hemiballismus) or reduced striatopallidal inhibitory influences along the indirect pathway (as in Huntington's disease and L-DOPA-induced dyskinesias), lead to reduced inhibitory outflow from GPi/SNr and excessive disinhibition of the thalamus. The overall effect is that of excessive positive feedback to the precentral motor fields engaged by the motor circuit (SMA, PMC, MC), which results in hyperkinetic movements. Abbreviations: CM, centromedian nucleus; GPe, external segment of the globus pallidus; GPi, internal segment of the globus pallidus; MC, primary motor cortex; PMC, premotor cortex; SMA, supplementary motor area; SNr, substantia nigra pars reticulata; STN, subthalamic nucleus; VAmc, nucleus ventralis anterior pars magnocellularis; VApc, nucleus ventralis anterior pars parvocellularis; VLo, nucleus ventralis lateralis pars oralis.*

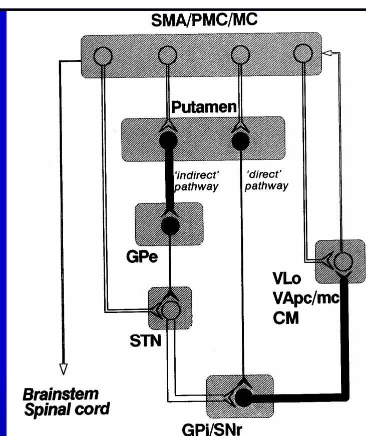


Fig. 1. *Schematic representation of neuronal activity in the 'motor' circuit in hypokinetic disorders. Excessive inhibition of GPe within the indirect pathway leads to disinhibition of the STN, which in turn provides excessive excitatory drive to the basal ganglia output nuclei (GPi/SNr), thus leading to excessive thalamic inhibition. This is reinforced by reduced inhibitory input to GPi/SNr through the direct pathway. Overall, these effects are postulated to result in a reduction in the usual reinforcing influence of the motor circuit upon cortically initiated movements. In this figure and in Fig. 2, inhibitory neurons are represented by filled symbols and excitatory neurons by open symbols. Both figures should be compared with Fig. 3 in the article by G. E. Alexander and M. D. Crutcher, this issue, which represents the operation of the motor circuit under normal conditions. Abbreviations: CM, centromedian nucleus; GPe, external segment of the globus pallidus; GPi, internal segment of the globus pallidus; MC, primary motor cortex; PMC, premotor cortex; SMA, supplementary motor area; SNr, substantia nigra pars reticulata: STN, subthalamic nucleus; VAmc, nucleus ventralis anterior pars magnocellularis; VApc, nucleus ventralis anterior pars parvocellularis; VLo, nucleus ventralis lateralis pars oralis.*

DeLong, TINS, 1990