Neurosciences et interdisciplinarité : l'exemple des sciences du mouvement

UNIVERSITÉ PARIS SUD
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Michel-Ange Amorim
Séminaire du Centre d'Alembert – 28 janvier 2016

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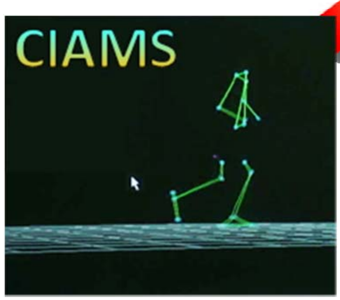
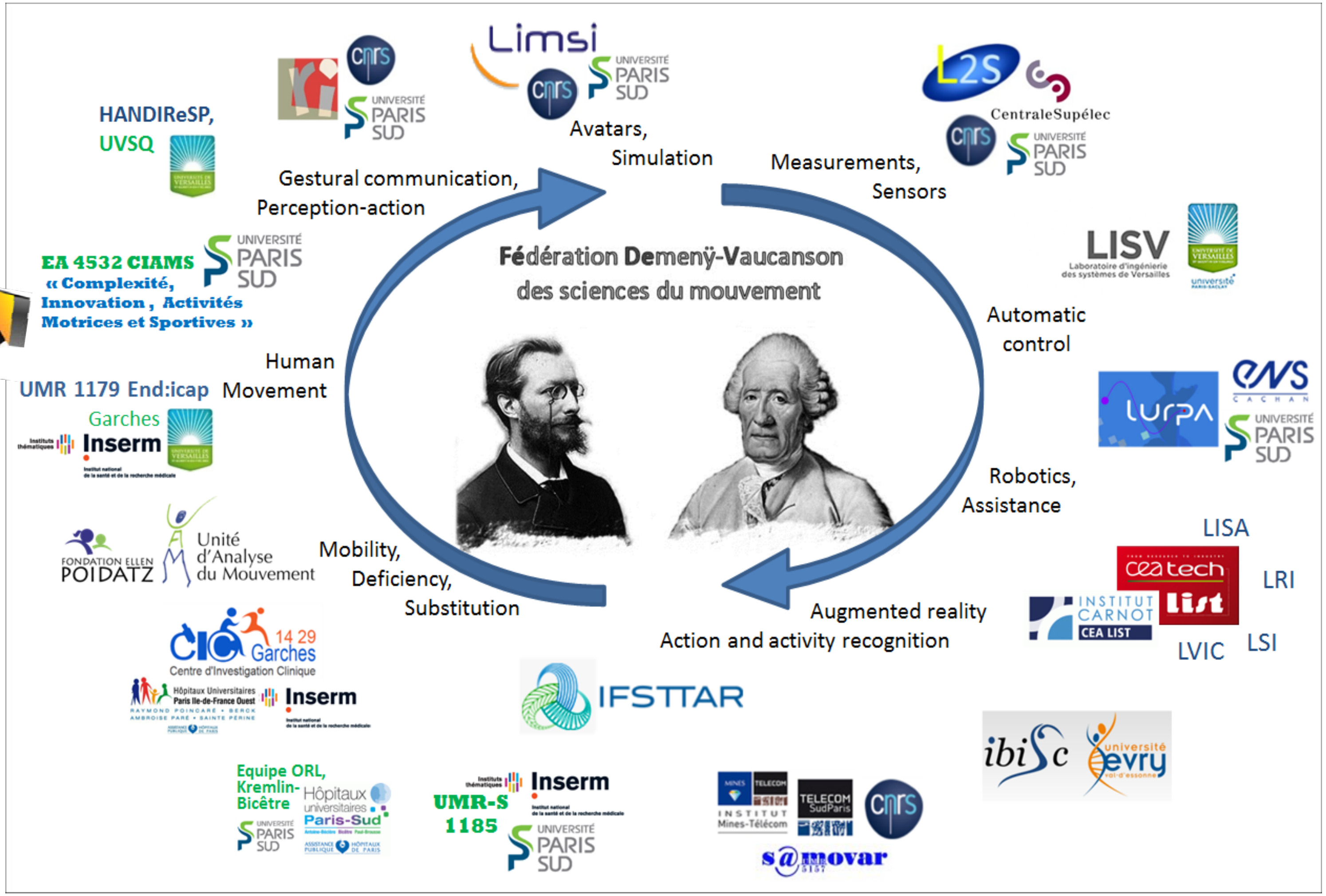
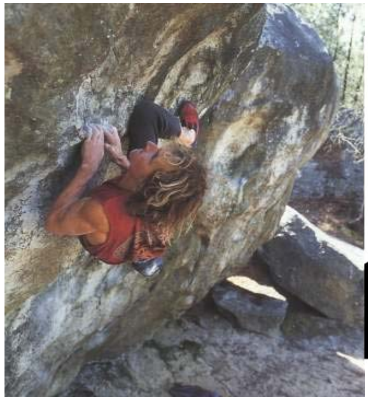
FéDeV

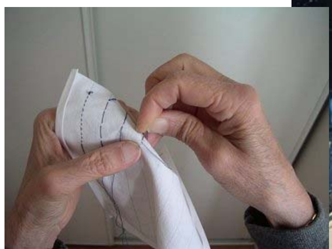




Neurosciences et sciences du mouvement








Les différents domaines des neurosciences principalement concernés par les sciences du mouvement :

Neurosciences cognitives étudient comment le cerveau crée et contrôle la pensée, le langage, la résolution de problèmes et la mémoire.

Neurosciences computationnelles s'appliquent à découvrir les principes computationnels (calculatoires) des fonctions cérébrales et de l'activité neuronale, c'est-à-dire des algorithmes génériques qui permettent de comprendre l'implémentation dans notre système nerveux central de nos fonctions cognitives.

Neurosciences comportementales examinent les liens structure(s)-fonction(s) qui sous-tendent le comportement des animaux et des humains.

Neurosciences cliniques implique des neurologues et psychiatres utilisant des résultats de recherche de neurosciences fondamentales pour découvrir comment traiter et prévenir les troubles neurologiques et réhabiliter les patients dont le système nerveux a été endommagé ou blessé.

Apprendre tout au long de la vie

ELSEVIER

Neurobiology of Aging 26 (2005) 883–890

NEUROBIOLOGY OF AGING

www.elsevier.com/locate/neuaging

Memories that last in old age: motor skill learning and memory preservation

C.D. Smith[a,b,d], A. Walton[b], A.D. Loveland[b], G.H. Umbe
R.J. Kryscio[c,d], D.M. Gash[b,*]

[a] Department of Neurology, University of Kentucky College of Medicine, Lexington, KY 405:
[b] Department of Anatomy and Neurobiology, University of Kentucky College of Medicine, Lexington,
[c] Department of Statistics and Public Health, University of Kentucky College of Medicine, Lexington,
[d] Sanders-Brown Center on Aging, University of Kentucky College of Medicine, Lexington, KY 4

Received 1 April 2004; received in revised form 30 June 2004; accepted 3 August 200

5 essais avec main gauche et 5 essais avec main droite pour chaque tâche

315 femmes and 188 hommes âgés de 18 à 94 years

« Tâche double-S »

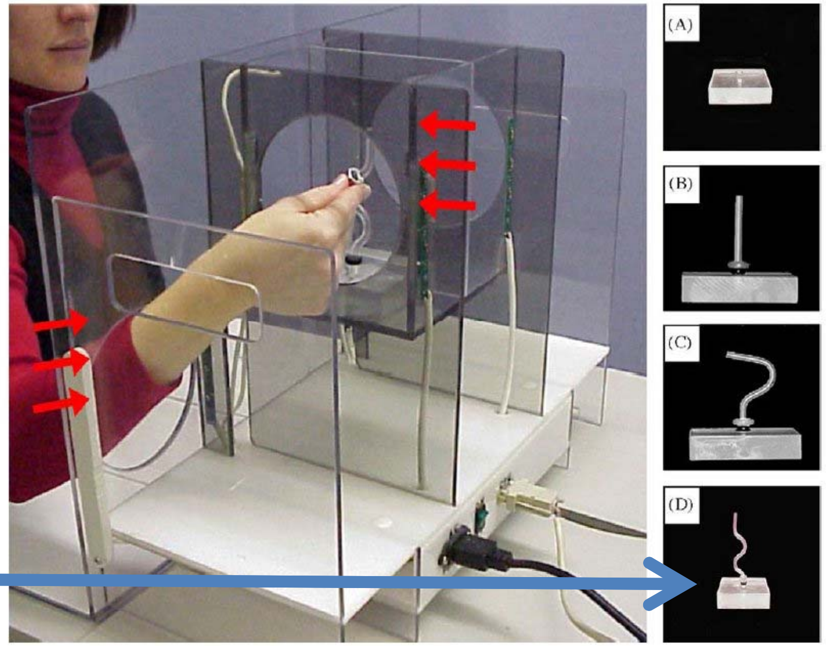


Fig. 1. The hMAP consists of a transparent plexiglas vertical plate with left and right arm portals through which the individual reaches to gain entry to an inner chamber divided into left and right halves. Time measurements are based on interruption of a light beam across the entrance to the inner chamber. Four separate motor tasks of hand and wrist are completed within the inner chamber: platform, straight rod, question mark, and double-S. The subject removes a 14-mm steel nut from each level. The rods are unthreaded and smooth, and the nut slides easily over the rods with minimal resistance.

Apprendre tout au long de la vie

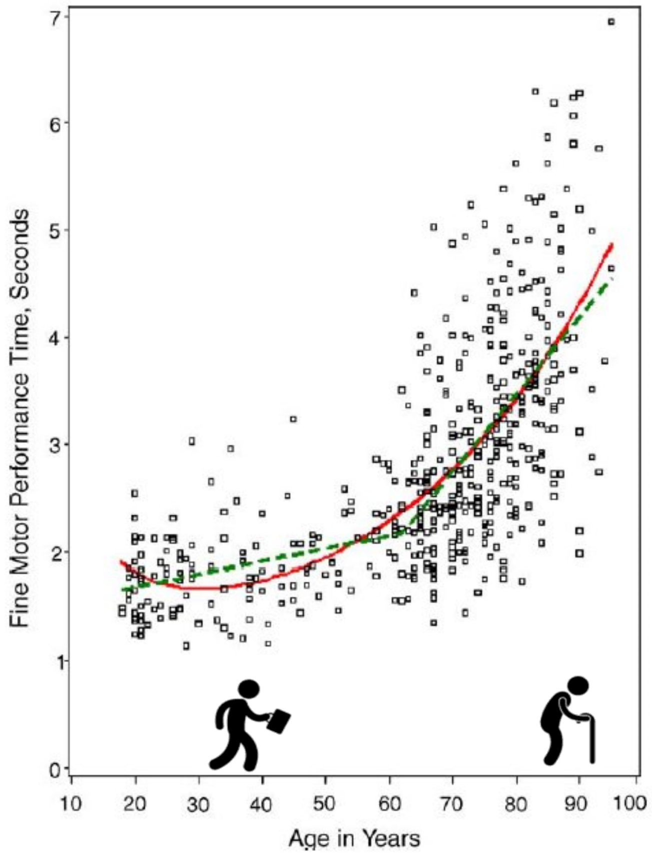
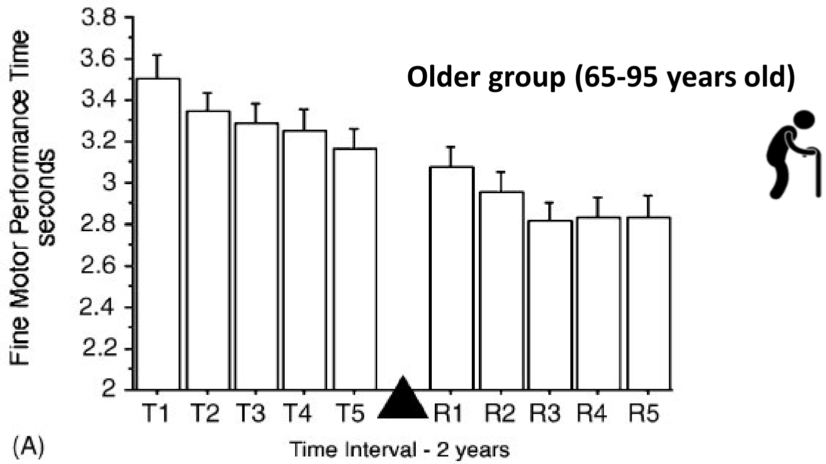
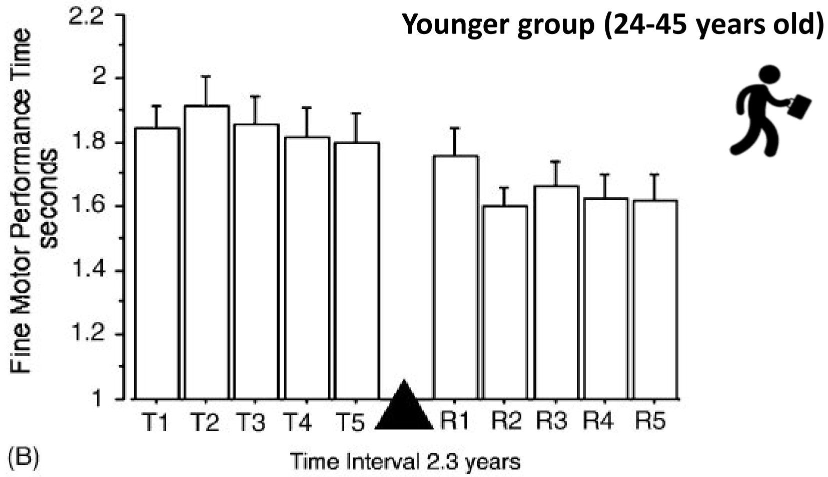


Fig. 2. Double-S performance time (y-axis; seconds) vs. age (x-axis; years). The smooth curved line represents the fit using Hoerl's function. The dotted line represents the segmented regression model ($R^2 = 0.51$, $p < 0.0001$). There is a marked increase in the variance and the rate of fine motor slowing around age 62.

après un intervalle de rétention d'au moins 2 ans…

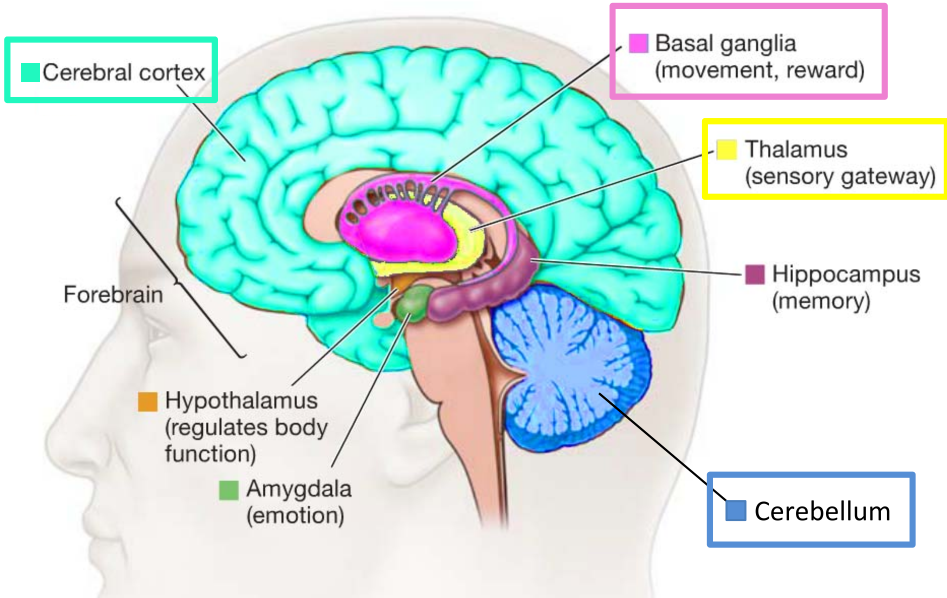




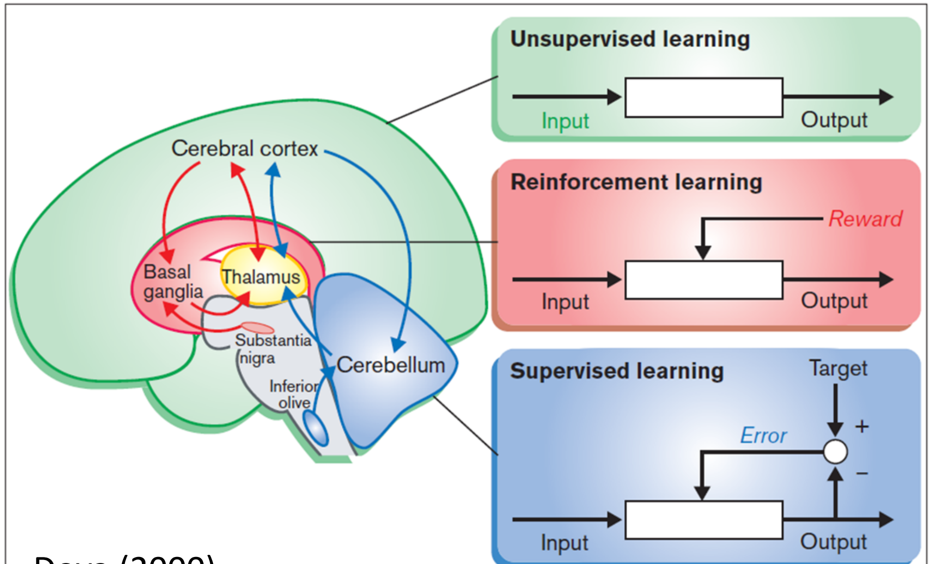
lemondefr

lemondefr Un jeune palestinien fait une démonstration de "parkour" dans une rue de Gaza, le 15 janvier. --
A Palestinian youth demonstrates his parkour skills on a street in Gaza City January 15, 2016.
--
Photo : @reuters
#Gaza #Parkour

Les bases neurofonctionnelles du mouvement



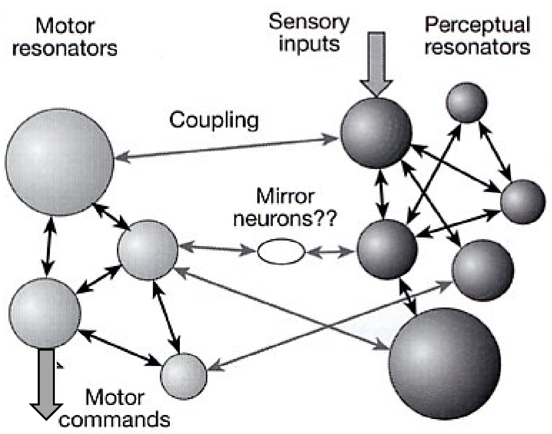
Specialization of the cerebellum, the basal ganglia, and the cerebral cortex for different types of learning [24••]. The cerebellum is specialized for supervised learning, which is guided by the error signal encoded in the climbing fiber input from the inferior olive. The basal ganglia are specialized for reinforcement learning, which is guided by the reward signal encoded in the dopaminergic input from the substantia nigra. The cerebral cortex is specialized for unsupervised learning, which is guided by the statistical properties of the input signal itself, but may also be regulated by the ascending neuromodulatory inputs [80].

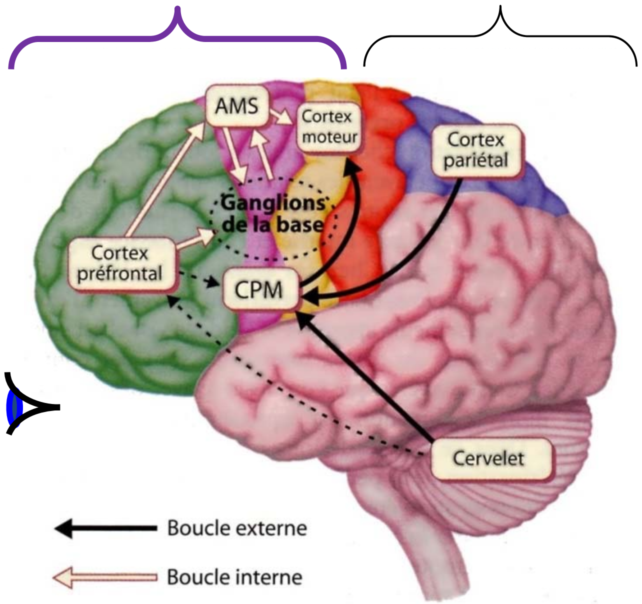


Doya (2000)

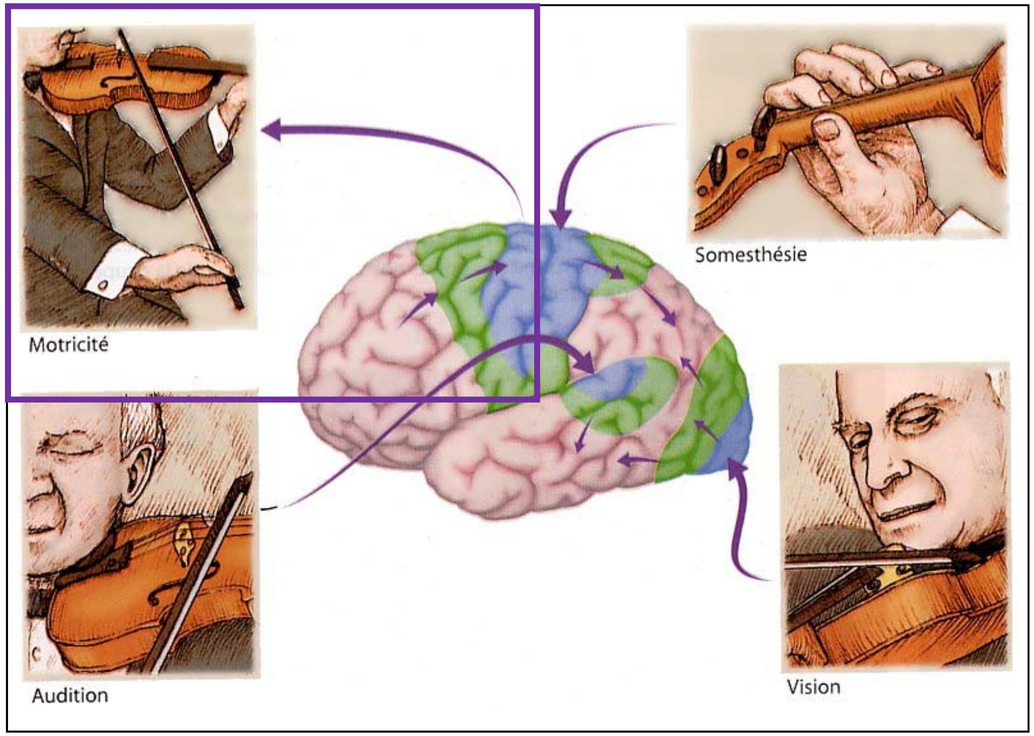
Cortex cérébral : apprentissage non supervisé
Ganglions de la base : apprentissage par renforcement (via la substance noire)
Cervelet : apprentissage supervisé (via l'olive inférieure)

Les bases neurofonctionnelles du mouvement

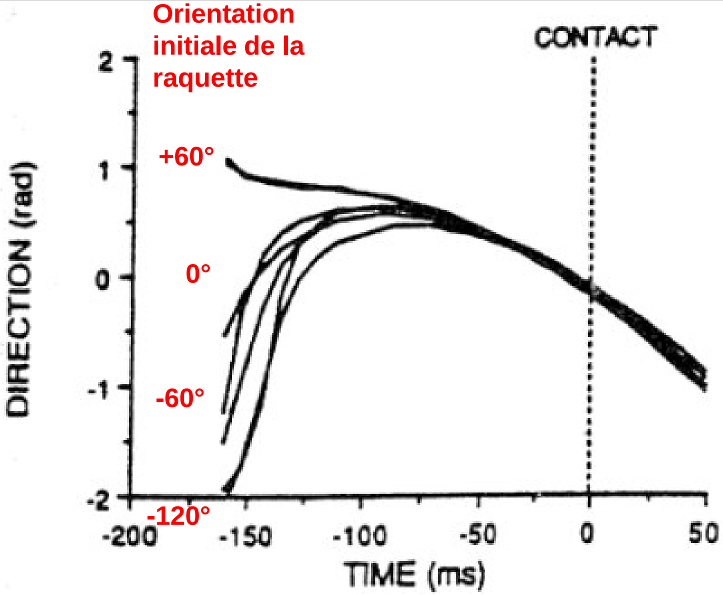




Un couplage perception-action



Interagir avec un environnement en mouvement



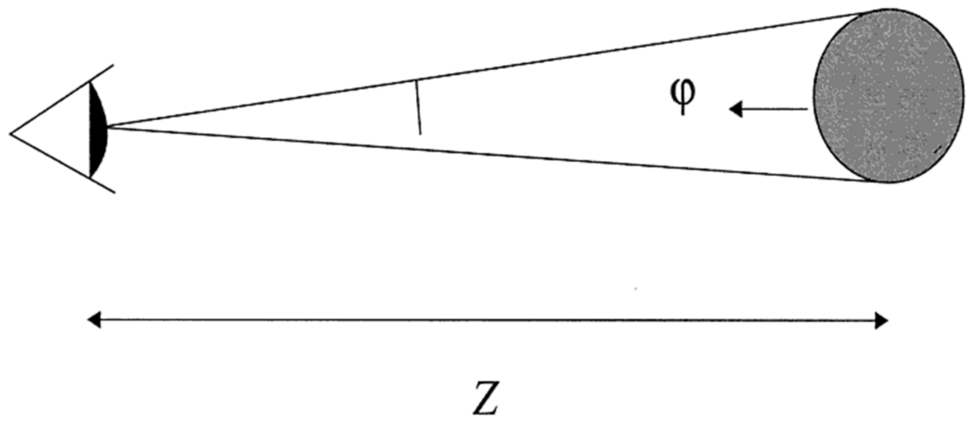
Wieringen & Bootsma (1990)

Spécification optique du temps de pré-contact

$V = \Delta d / \Delta t$ ➔ $t = \Delta d / \Delta V$

si d est une taille d'objet (angulaire) correspondant à un angle optique = φ

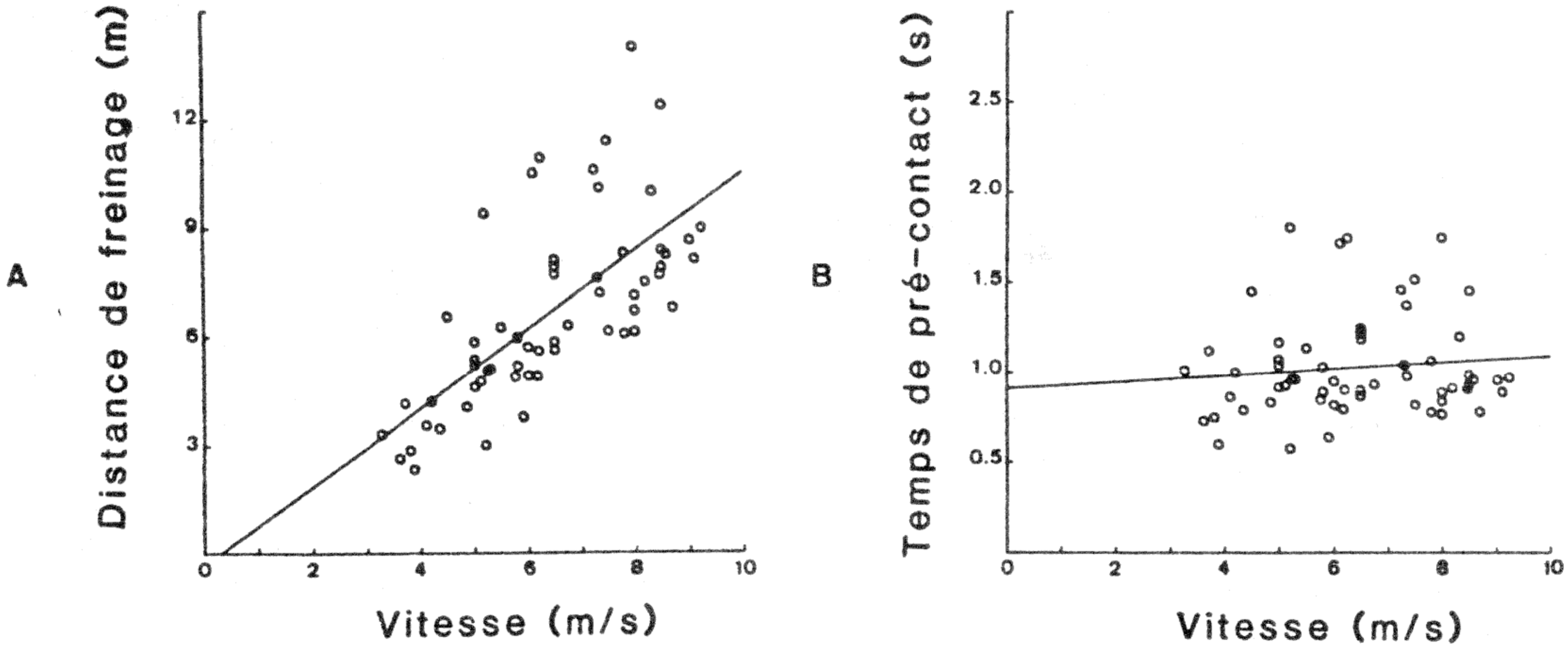
➔ $\tau = \Delta\varphi / (\Delta\varphi/dt)$



$$\tau = \varphi / (d\varphi / dt) = -Z / (dZ / dt) = TC_1$$

Exemple d'une balle qui approche directement le point d'observation à vitesse constante. Si l'on appelle tau (τ) l'inverse de la vitesse relative d'expansion des contours du mobile $\varphi/(d\varphi/dt)$, alors tau spécifie le temps de pré-contact de premier ordre (TC_1). Avec : Z : distance courante séparant la balle du point d'observation ; φ : angle courant sous-tendu au point d'observation par les contours du mobile.

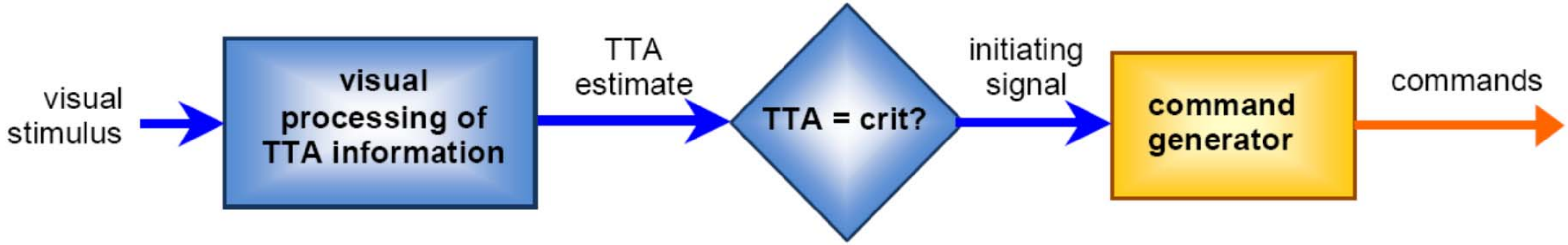
Spécification optique du temps de pré-contact



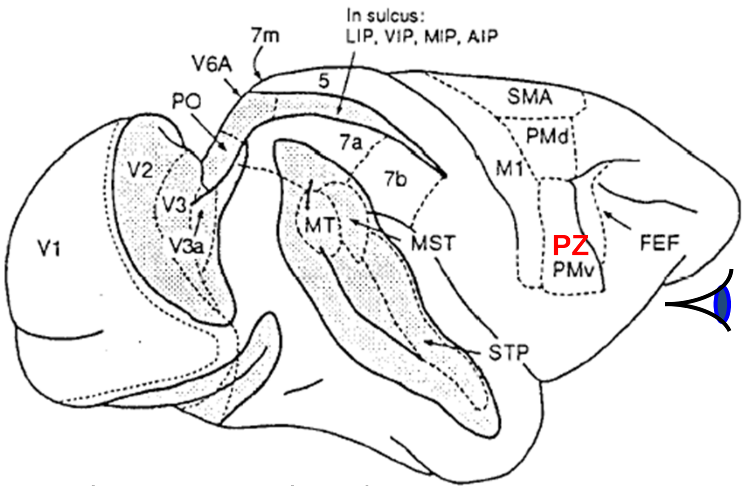
Relation entre la distance de freinage et la vitesse de course (A) et entre le temps de pré-contact mesuré (TC) et la vitesse de course (B) (d'après Laurent, 1987).

Spécification optique du temps de pré-contact

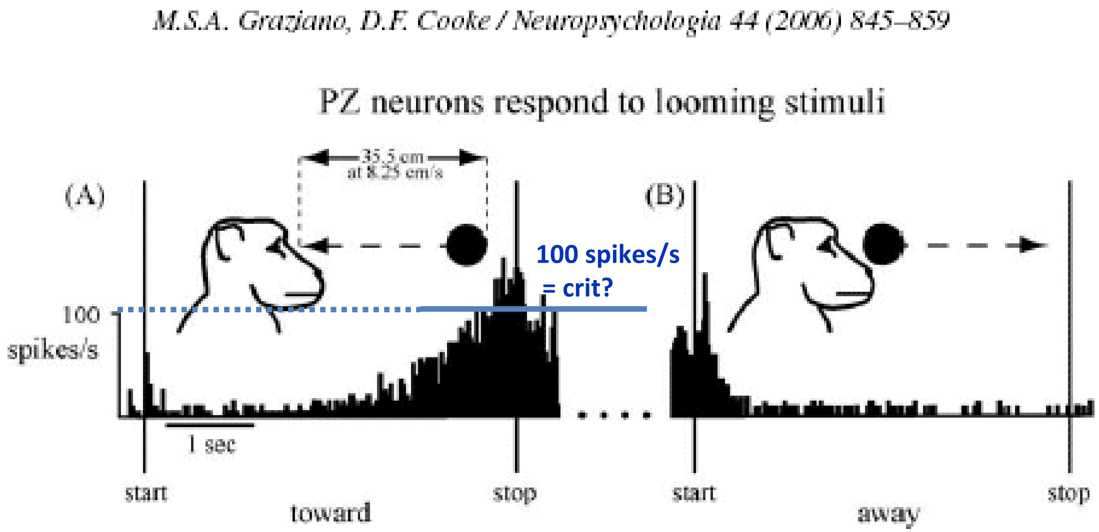
TTA = Time To Arrival



Bases neurofonctionnelles

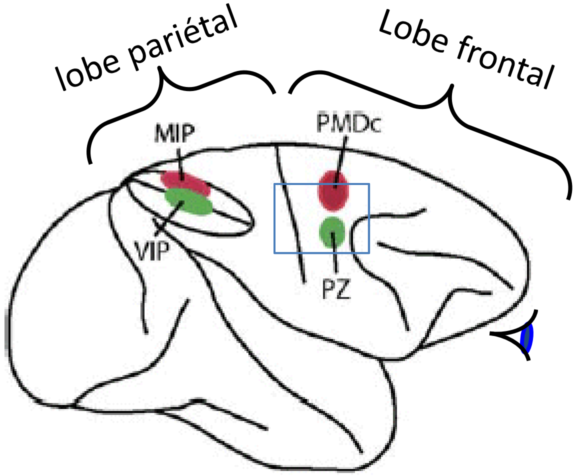


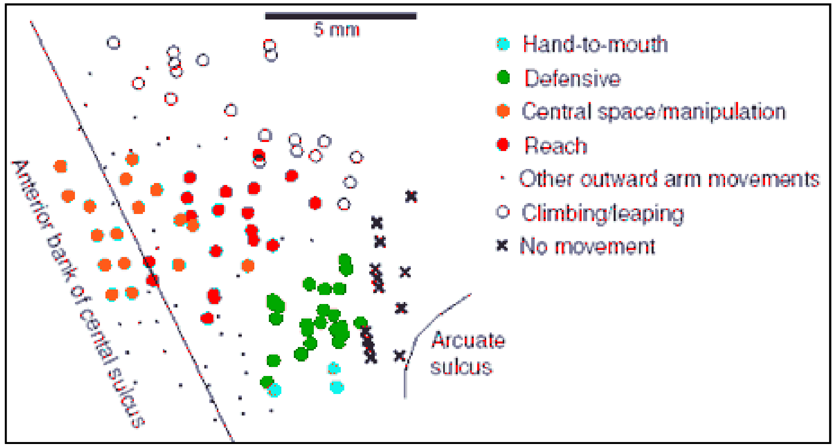
Graziano & Gross (1998)

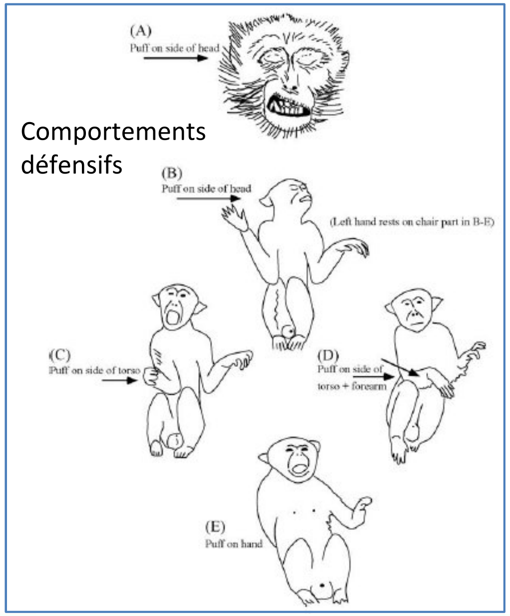


Bases neurofonctionnelles du lien perception-action

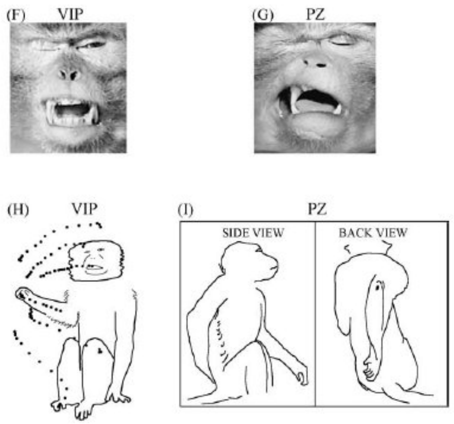
Gestes d'atteinte ou défensifs





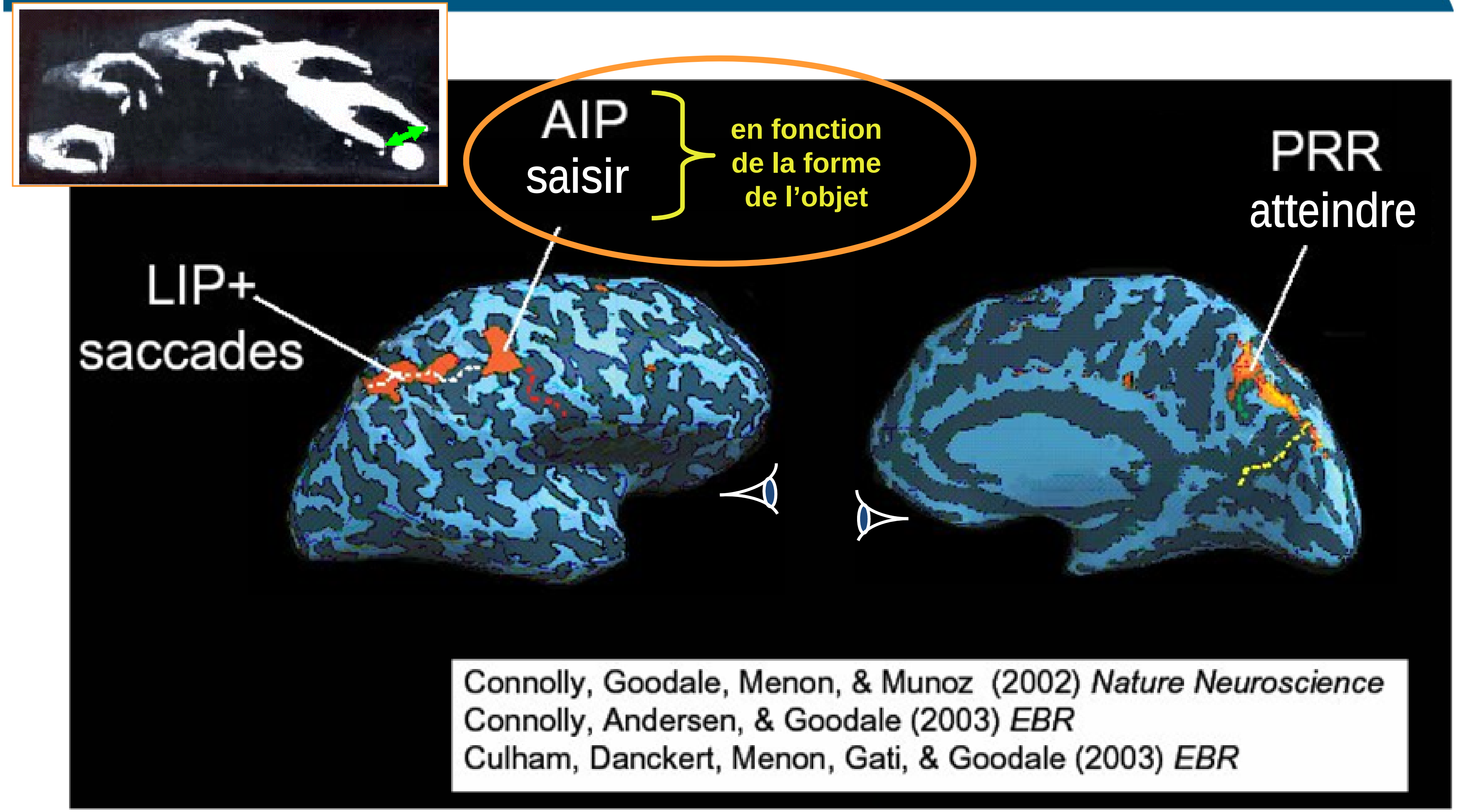


...par stimulation électrique cérébrale

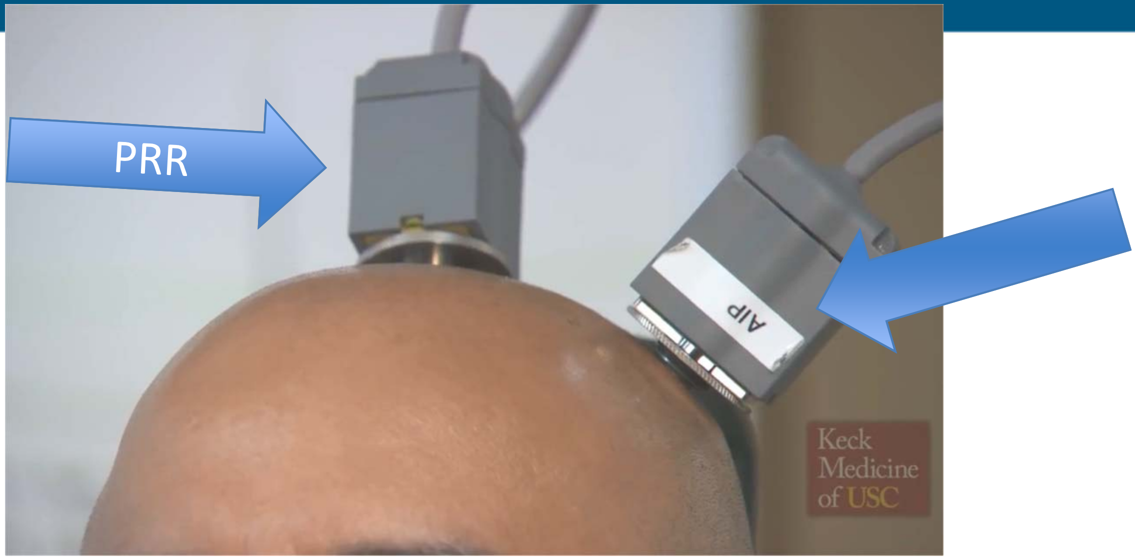


Graziano & Cooke (2006)

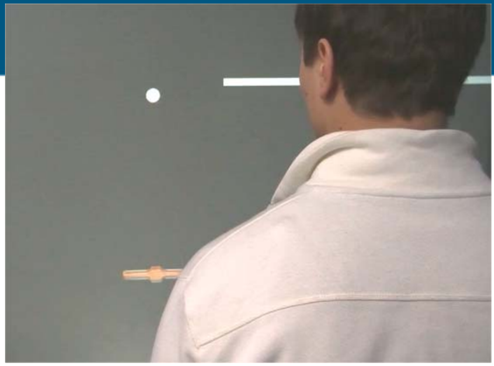
Bases neurofonctionnelles du lien perception-action

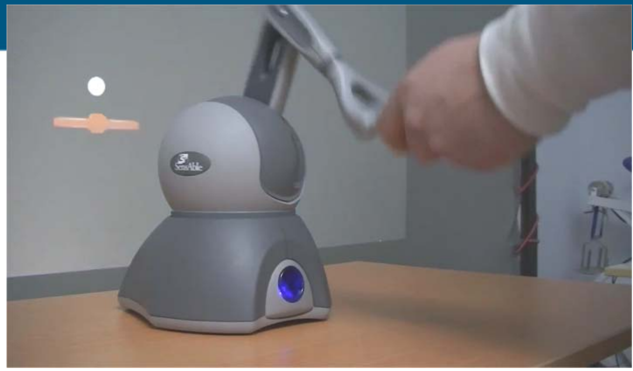


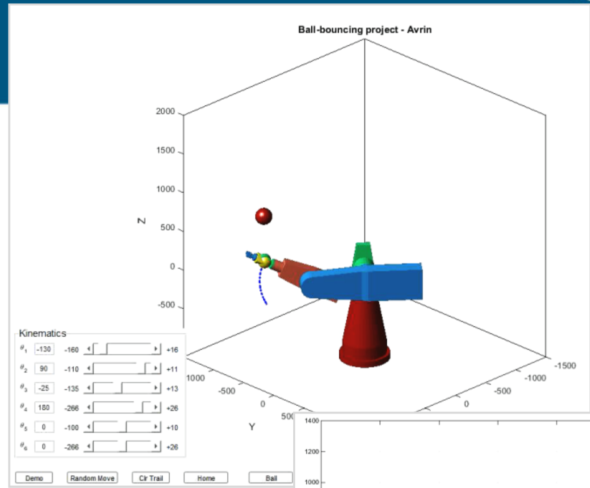
Bases neurofonctionnelles du lien perception-action

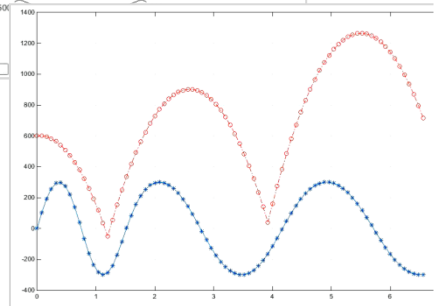


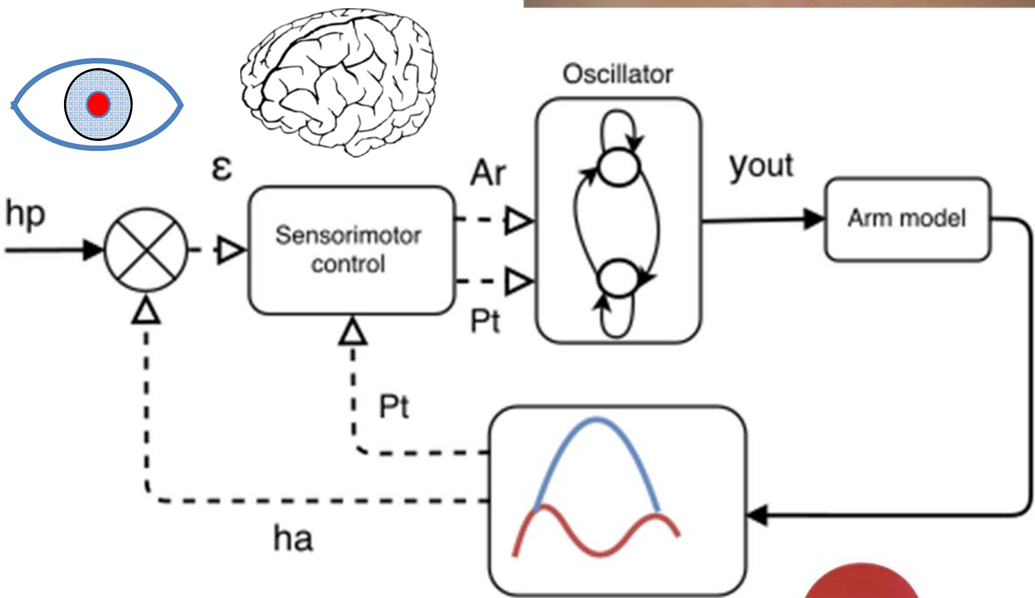
Neurosciences computationnelles du lien perception-action

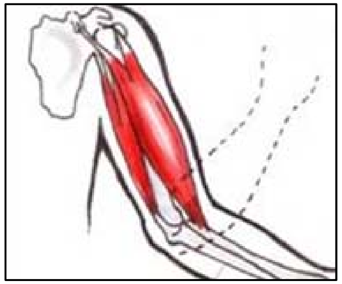












Travail de thèse de G. Avrin
(en cours)

Neurosciences computationnelles du lien perception-action

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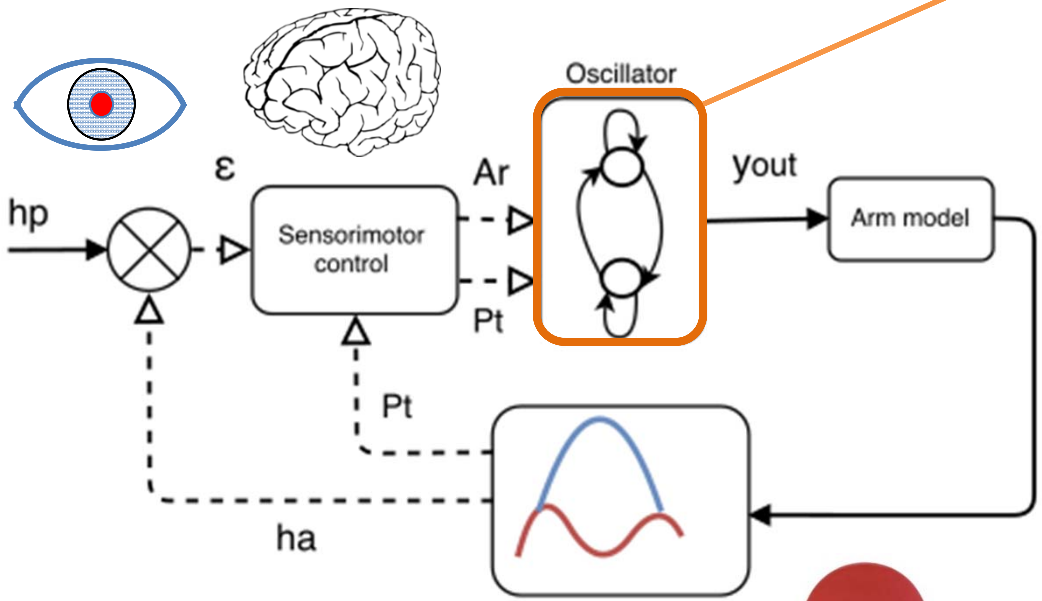
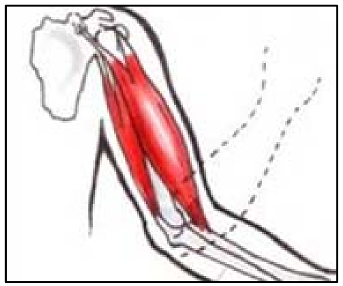
Matsuoka's oscillator:

$$
\begin{aligned}
\tau_r \dot{x}_1 &= -x_1 - \beta v_1 - w y_2 - h[m]^+ + c \\
\tau_a \dot{v}_1 &= -v_1 + y_1 \\
\tau_r \dot{x}_2 &= -x_2 - \beta v_2 - w y_1 - h[m]^- + c \\
\tau_a \dot{v}_2 &= -v_2 + y_2 \\
y_{out} &= max(x_1, 0) - max(x_2, 0) \\
[m]^+ &= max(m, 0), [m]^- = min(m, 0)
\end{aligned}
$$



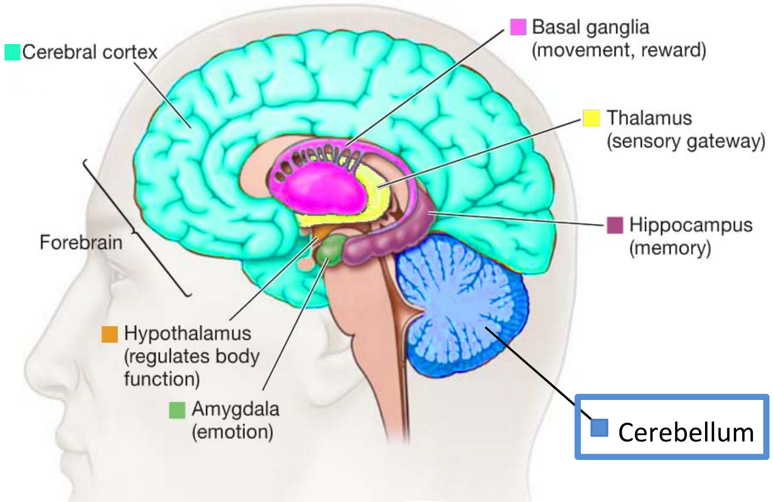


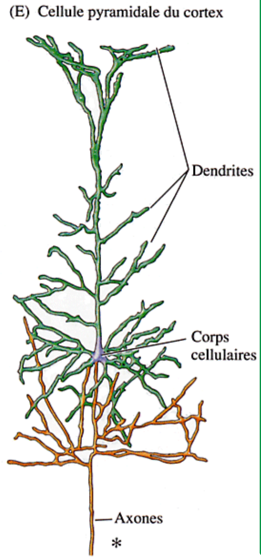
Travail de thèse de G. Avrin (en cours)

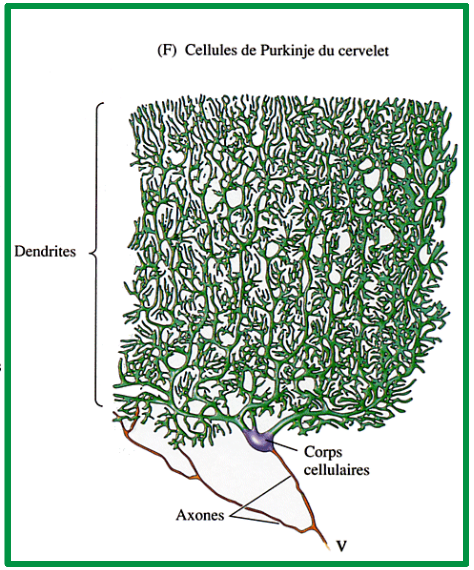
L2S

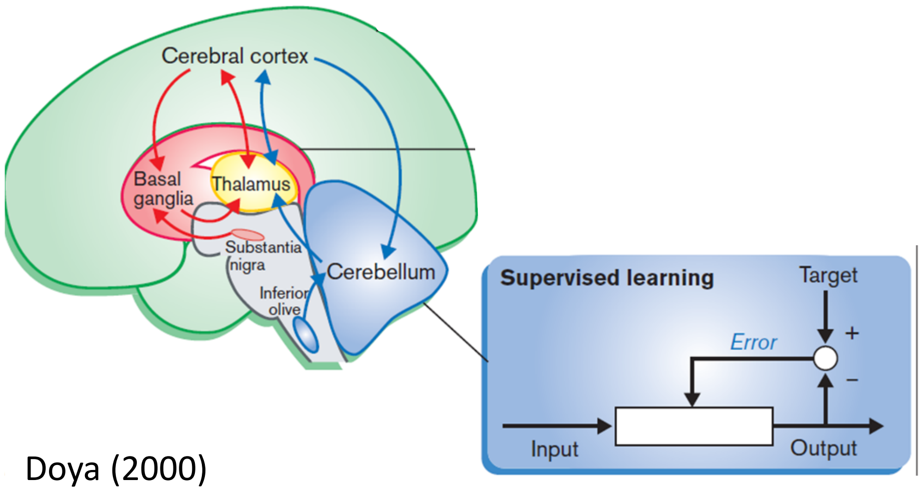
CIAMS

Adaptation sensori-motrice et correction d'erreurs

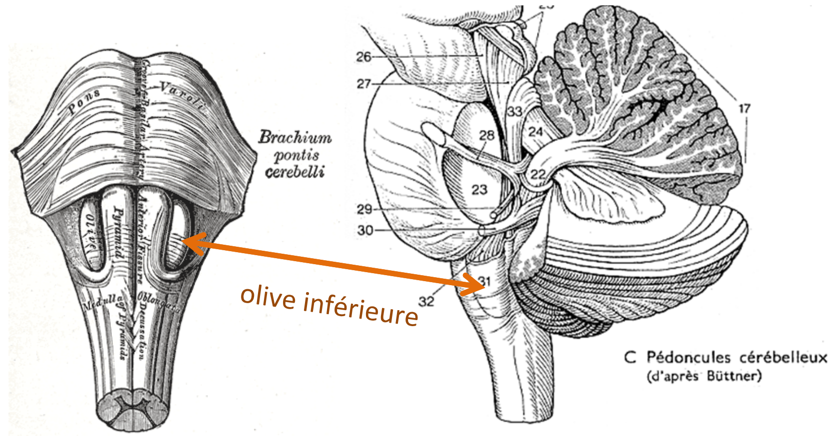








Doya (2000)



Adaptation sensori-motrice et correction d'erreurs

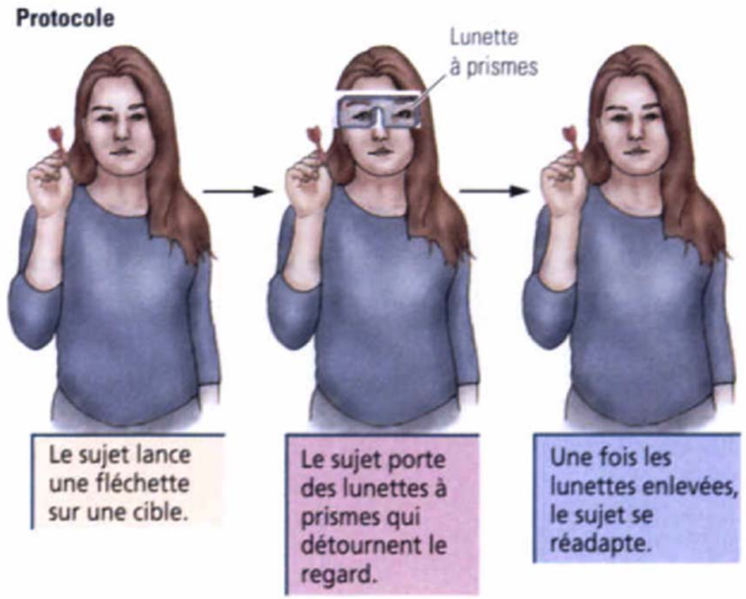
Brain (1996), **119,** 1183–1198

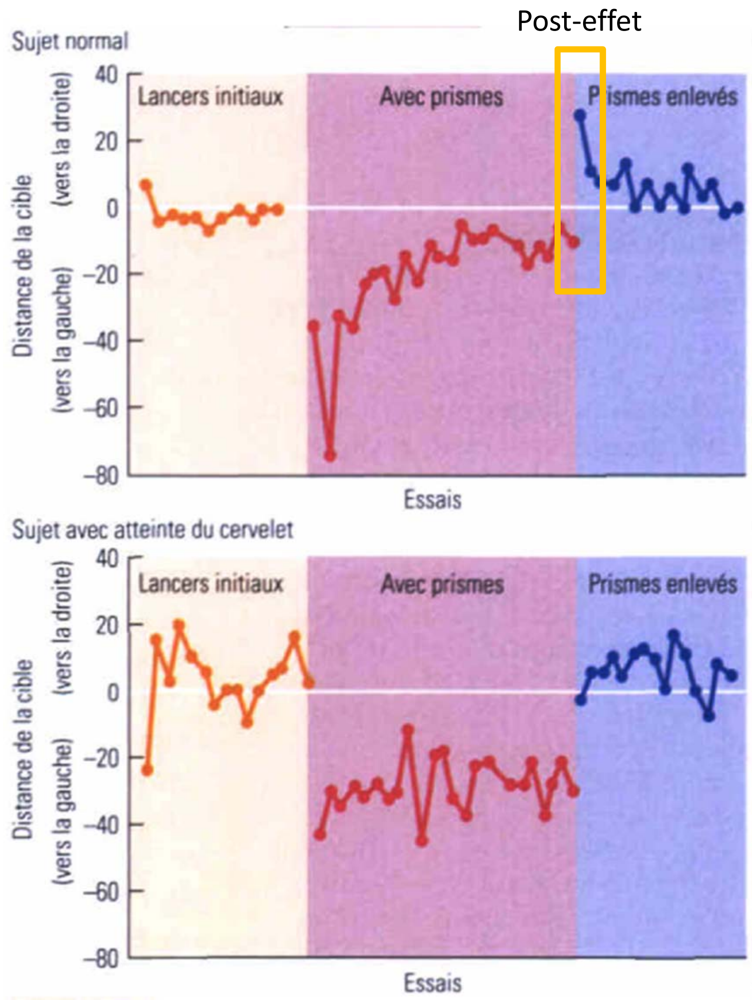
Throwing while looking through prisms
I. Focal olivocerebellar lesions impair adaptation

T. A. Martin,[1] J. G. Keating,[1] H. P. Goodkin,[1] A. J. Bastian[2] and W. T. Thach[1,3,4]

[1]*Department of Anatomy and Neurobiology,* [2]*The Program in Physical Therapy,* [3]*Department of Neurology and Neurological Surgery, and* [4]*The Irene Walter Johnson Institute of Rehabilitation Research, Washington University School of Medicine, St Louis, USA*

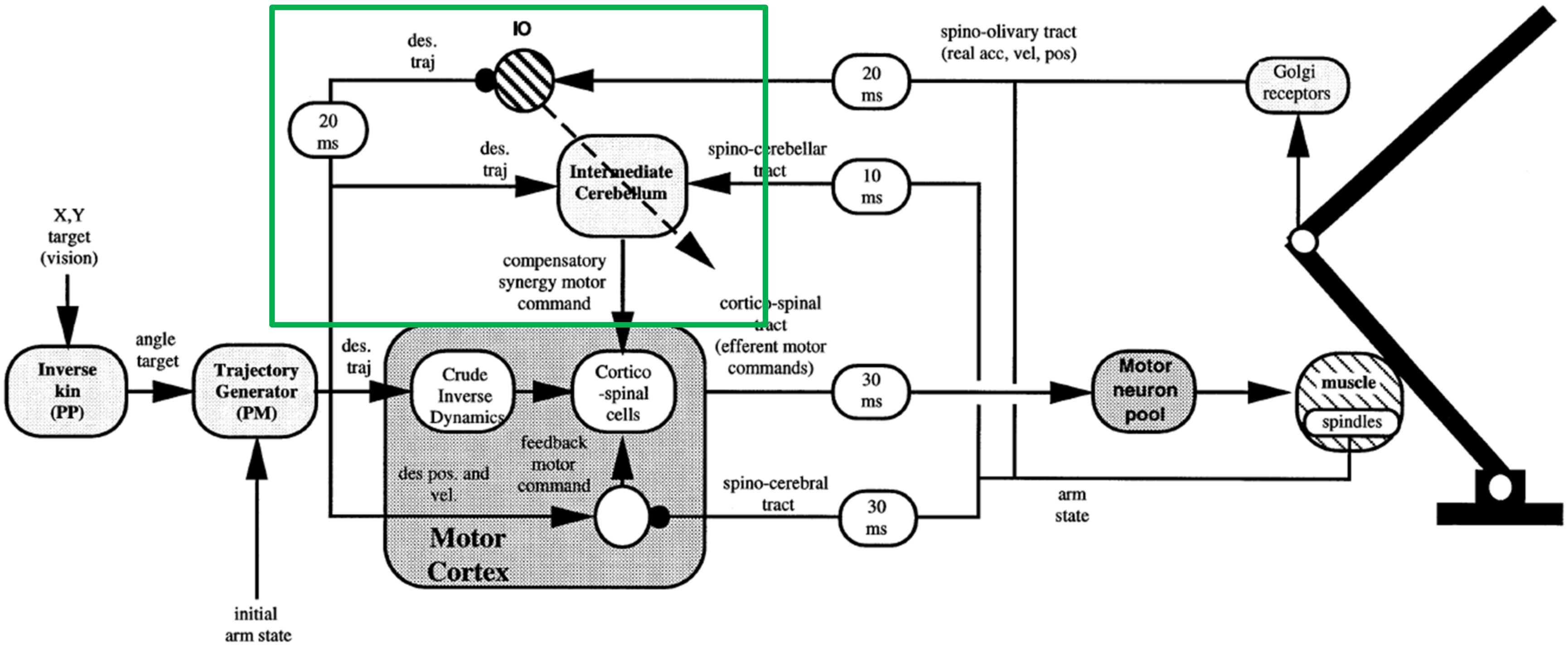
Correspondence to: W. T. Thach, MD, Department of Anatomy and Neurobiology, Washington University School of Medicine, 660 S. Euclid Avenue, Box 8108, St Louis, MO 63110, USA





Adaptation sensori-motrice et correction d'erreurs

Modèle computationnel où l'olive inférieure (IO) informe sur l'erreur motrice



Schweighofer et al. (1998)

Motivation et prise de risque

Baldini 2010 gold medal @ European Fencing Championships in Leipzig

Un cerveau à la recherche de récompense

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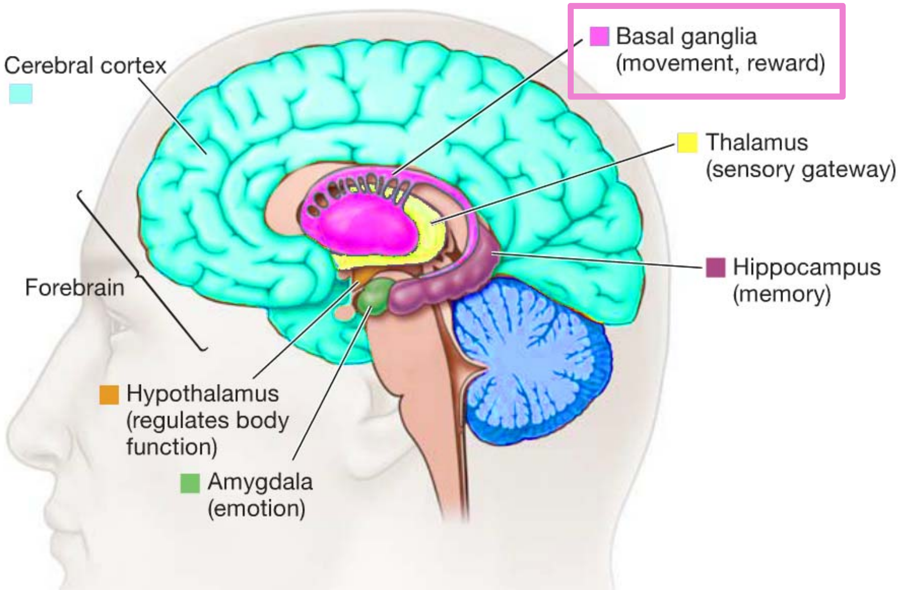
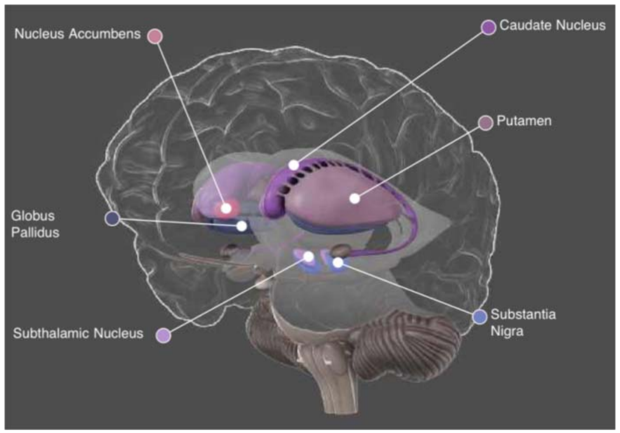
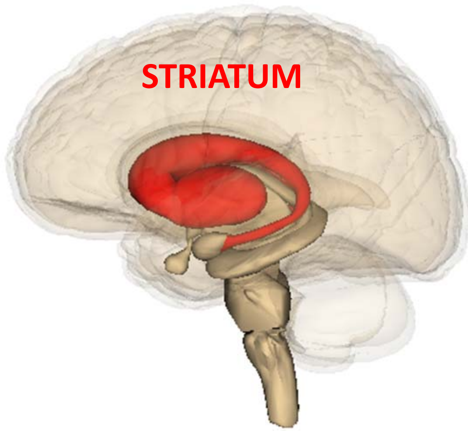
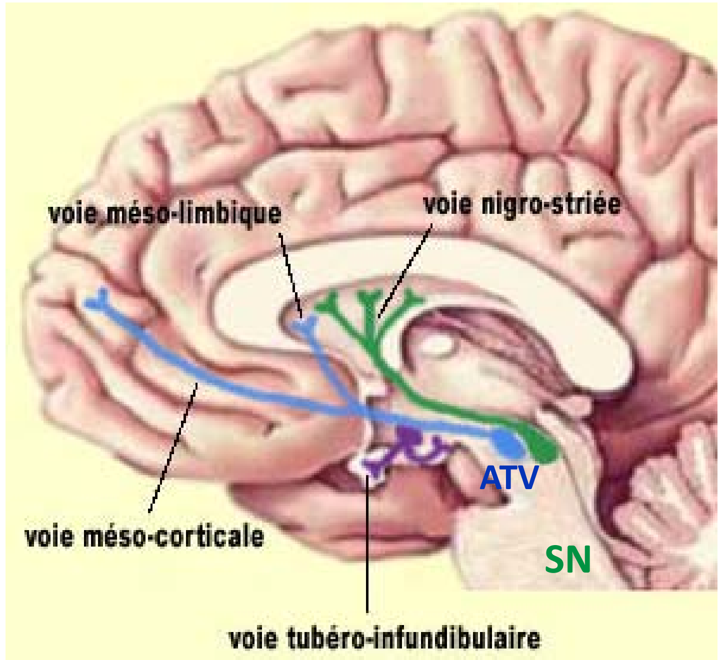




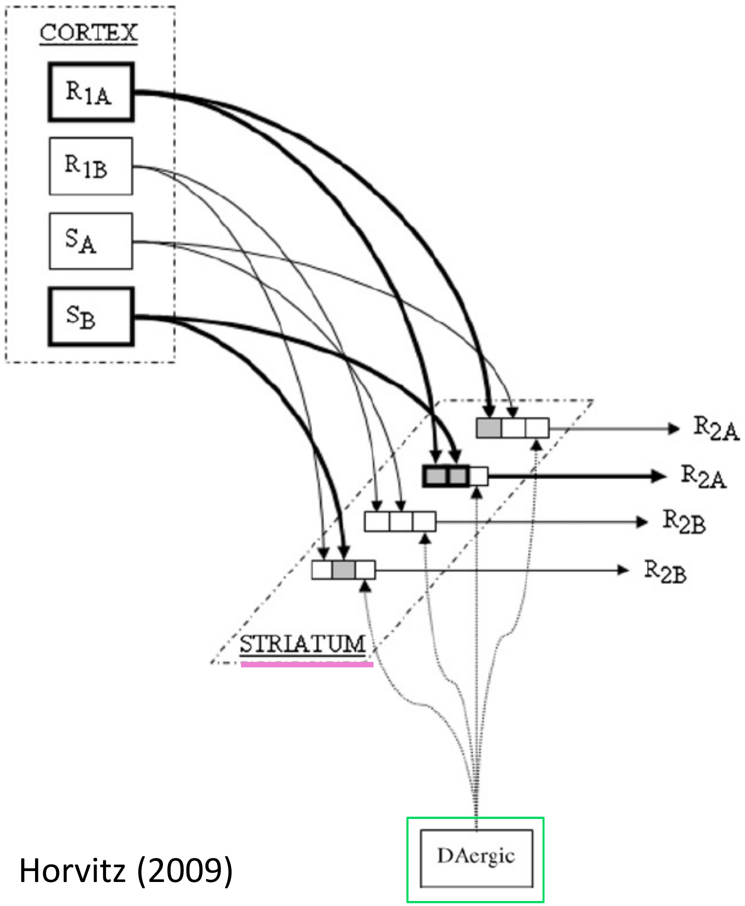


Fournisseurs de dopamine



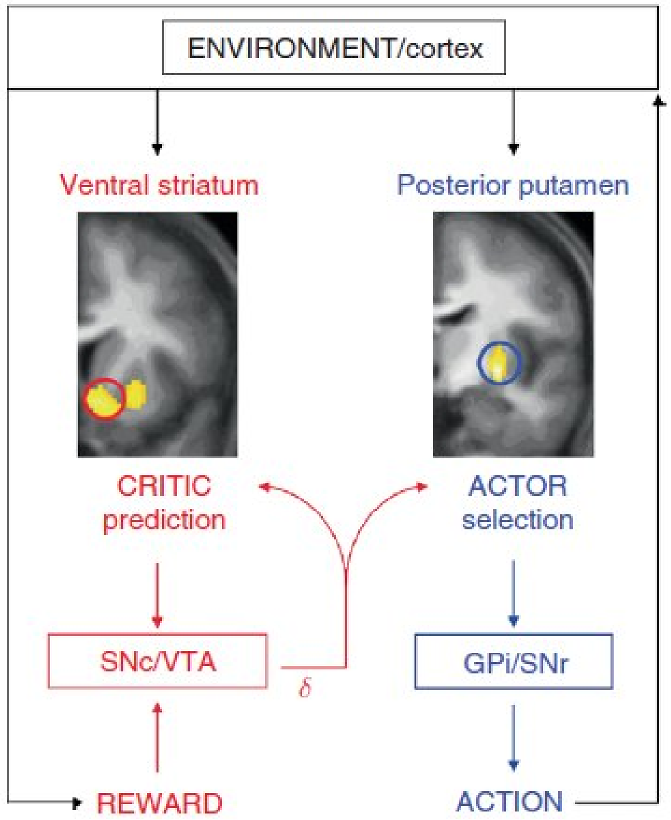
substance noire (**SN**) et
aire tegmentale ventrale (**ATV**)

Un cerveau à la recherche de récompense



Horvitz (2009)

Un cerveau qui prédit la récompense

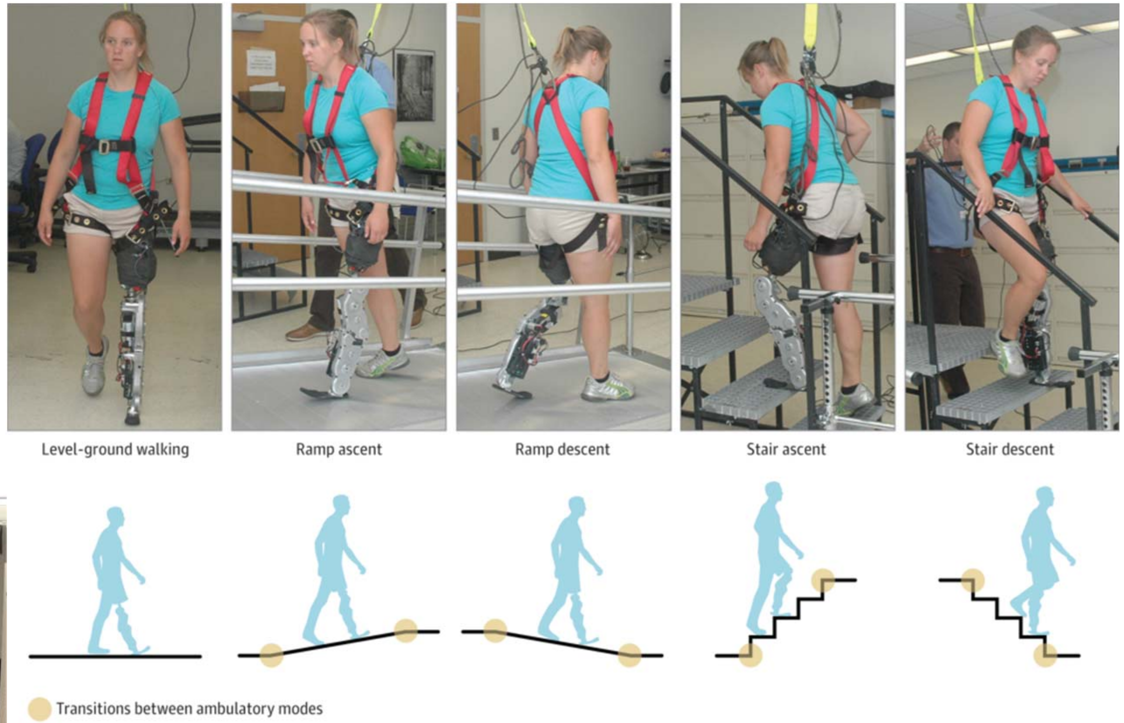


Worbe et al. (2010)

Un cerveau à la recherche de récompense

Assistance au mouvement

Assistance au mouvement

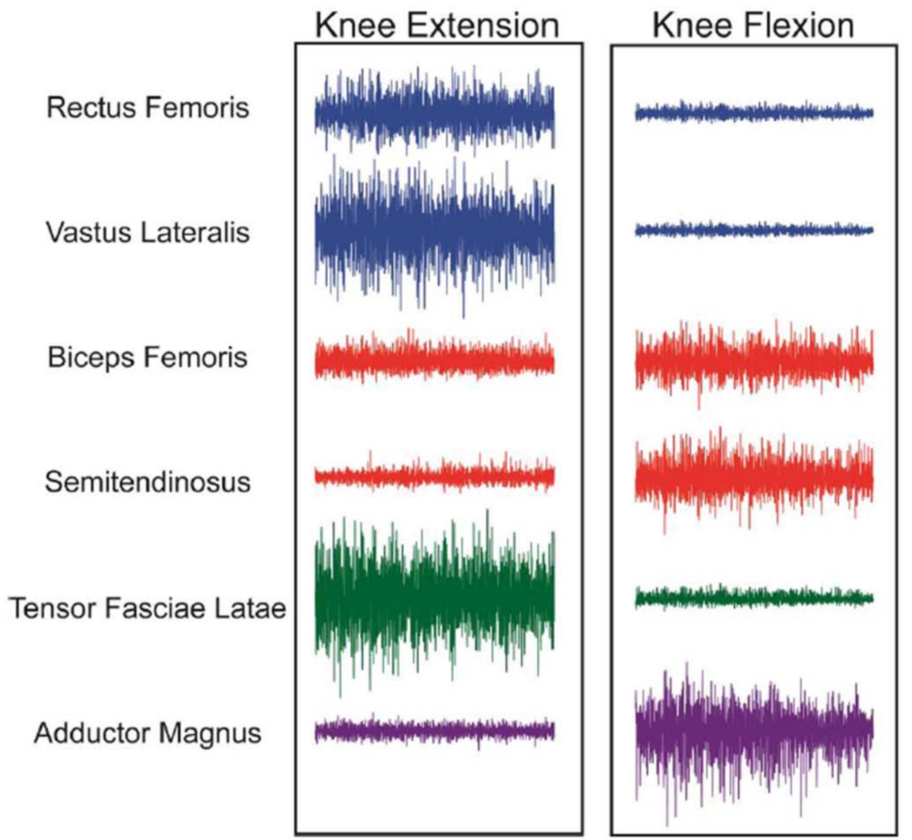


Hargrove et al. (2015, JAMA)

Assistance au mouvement

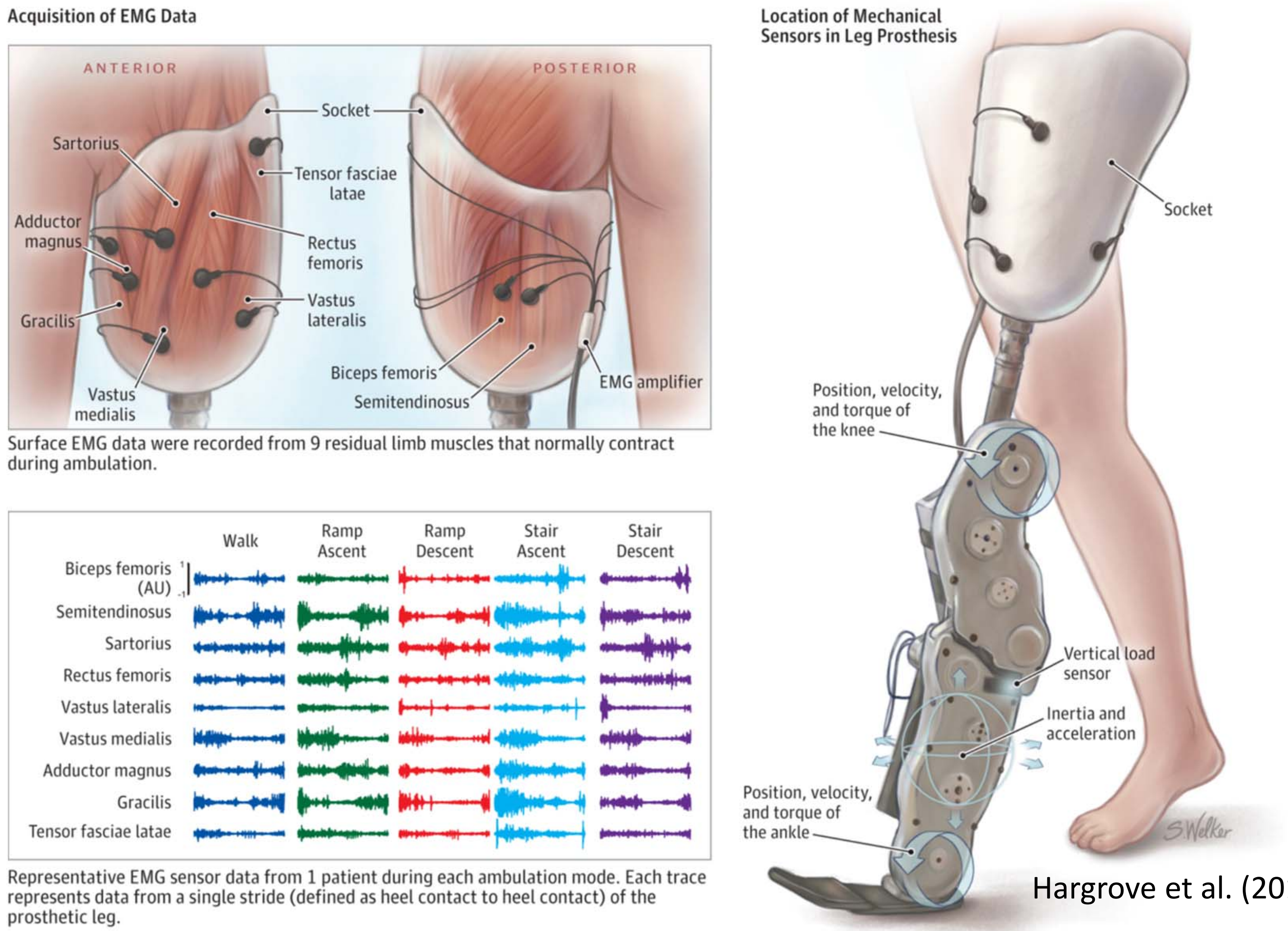
Myoelectric control sites

Embedded electrodes



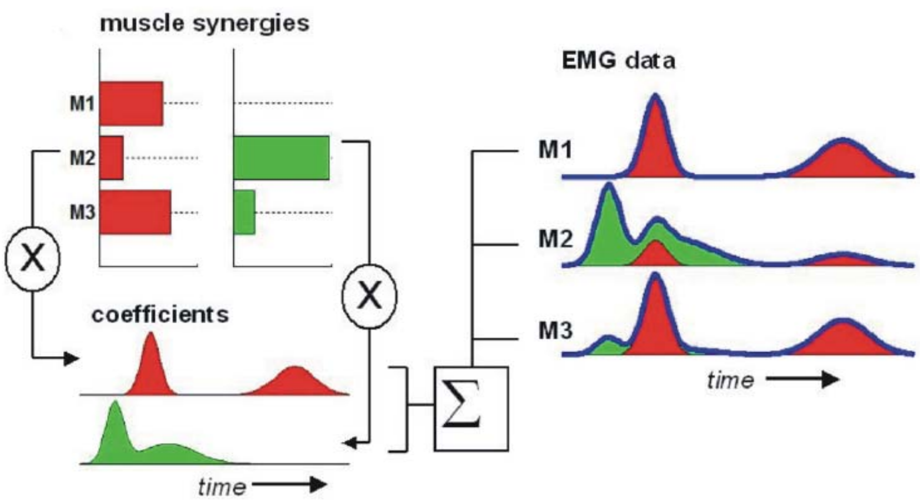
Hargrove et al. (2015, JAMA)

Assistance au mouvement

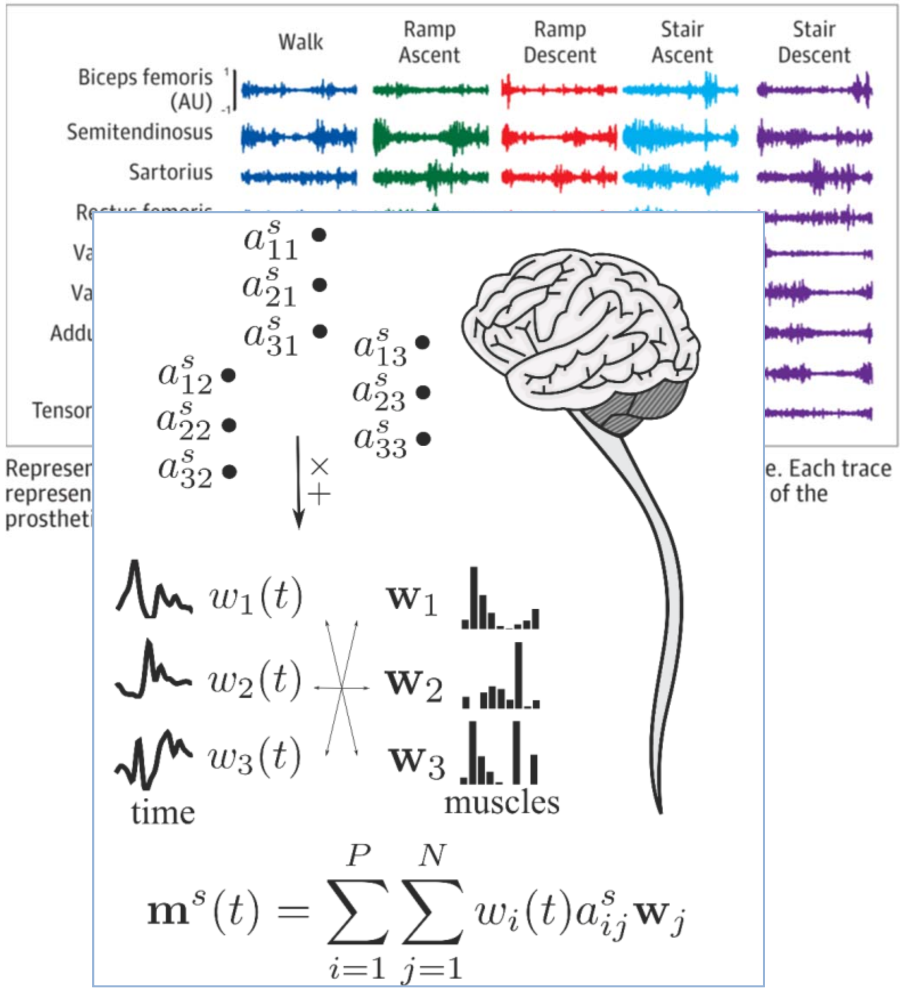


Hargrove et al. (2015, JAMA)

Des synergies musculaires pour faciliter le contrôle moteur

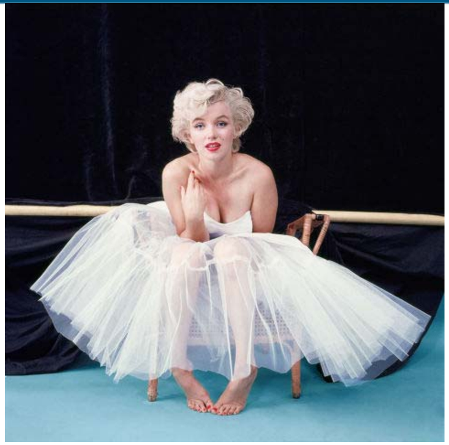


Cheung et al. (2009)



Delis et al. (2014)

La plasticité cérébrale du schéma corporel



Citation: Rouse EJ, Villagaray-Carski NC, Emerson RW, Herr HM (2015) Design and Testing of a Bionic Dancing Prosthesis. PLoS ONE 10(8): e0135148. doi:10.1371/journal.pone.0135148

Editor: Lei Ren, University of Manchester, UNITED KINGDOM

Received: February 4, 2015

Accepted: July 18, 2015

Published: August 18, 2015

RESEARCH ARTICLE

Design and Testing of a Bionic Dancing Prosthesis

Elliott J. Rouse[1], Nathan C. Villagaray-Carski[1,2], Robert W. Emerson[3], Hugh M. Herr[1]*

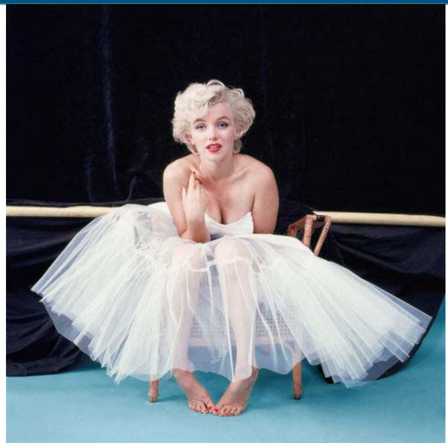
1 Biomechatronics Group, MIT Media Lab, Massachusetts Institute of Technology, Cambridge, Massachusetts, United States of America, **2** Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology, Cambridge, Massachusetts, United States of America, **3** A Step Ahead Prosthetics, Burlington, Massachusetts, United States of America

* hherr@media.mit.edu

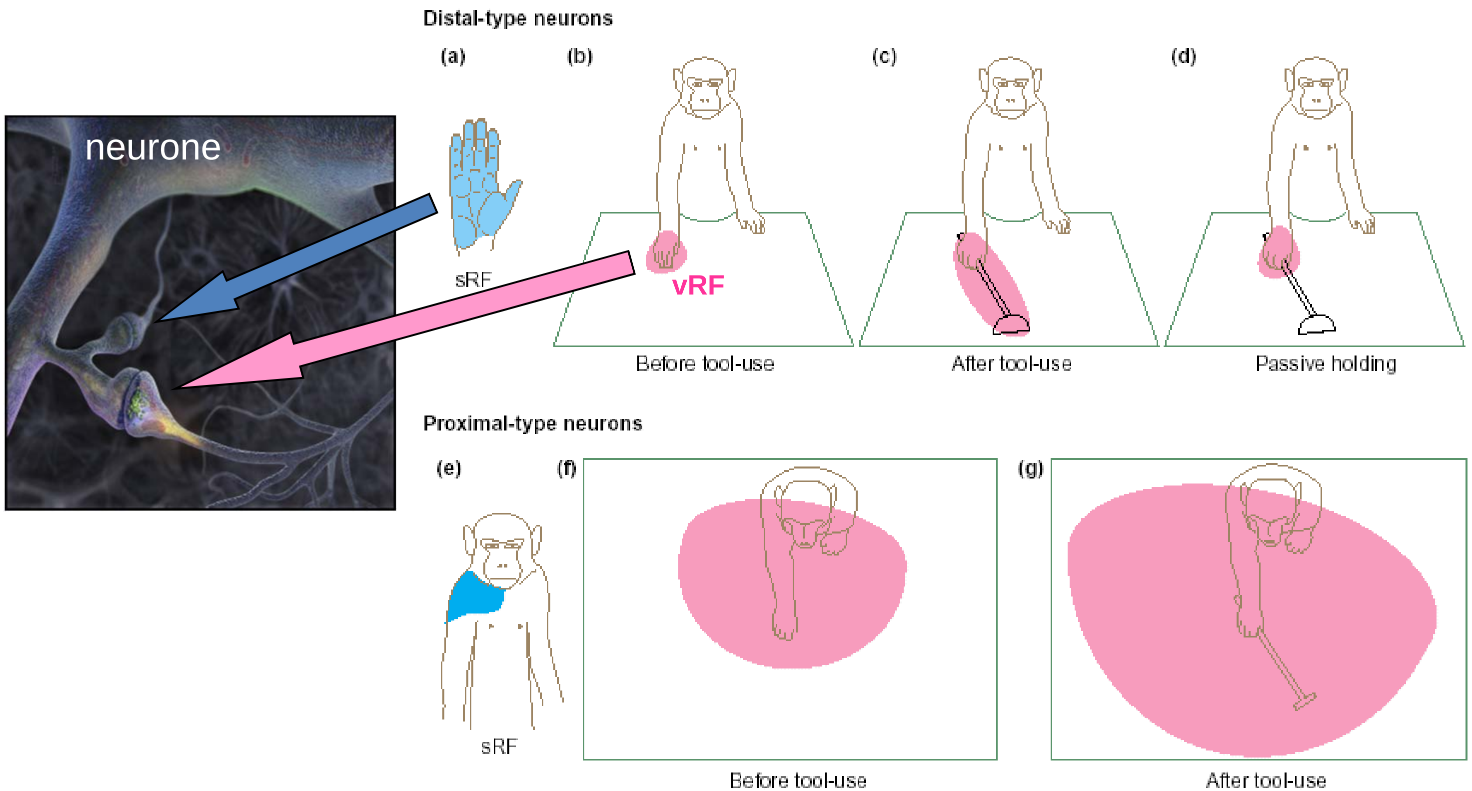
Abstract

Traditionally, prosthetic leg research has focused on improving mobility for activities of daily living. Artistic expression such as dance, however, is not a common research topic and consequently prosthetic technology for dance has been severely limited for the disabled. This work focuses on investigating the ankle joint kinetics and kinematics during a Latin-Ameri-

La plasticité cérébrale du schéma corporel



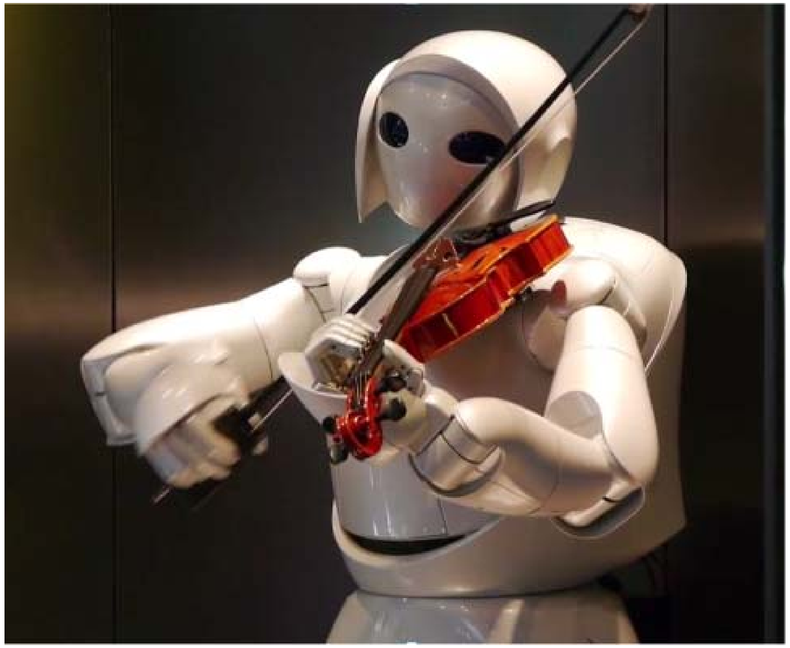
La plasticité cérébrale du schéma corporel

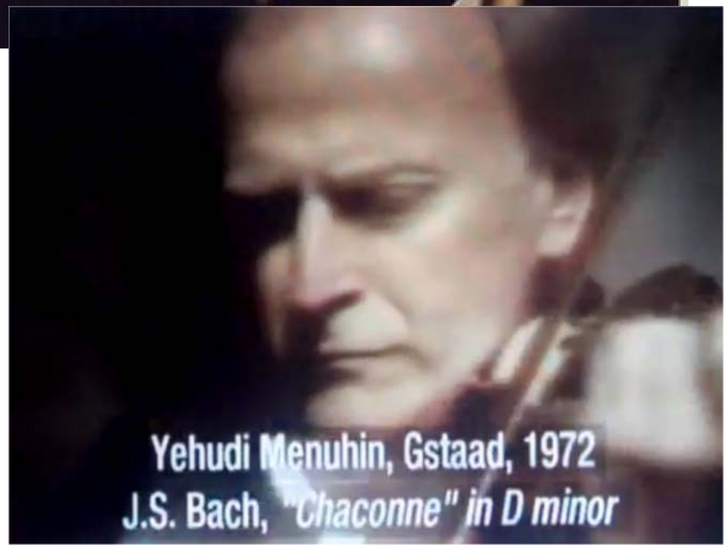


Maravita & Iriki (2004)

« Des *neurones bi-modaux* dans le **cortex prémoteur, pariétal, et le putamen** répondent à la fois à une information somatosensorielle venant d'une région donnée du corps (somatosensory Receptive Field; sRF), et à une information visuelle de l'espace adjacent (visual Receptive Field; vRF) »

Mouvement naturel et artificiel : le jeu des différences





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Nouveaux Masters : un exemple en mouvement

Par Gaëlle Degrez / Publié le 8 janvier 2016

Parmi les principales nouveautés de cette année universitaire, une nouvelle offre de Masters dont plus de 90 % sont désormais mutualisés avec nos partenaires de l'Université Paris-Saclay. C'est une belle opportunité pour offrir de nouvelles formations originales dans le paysage universitaire français. Exemple avec le nouveau Master « STAPS : ingénierie et ergonomie de l'activité physique ».

Les sciences du mouvement et plus particulièrement du mouvement humain ont longtemps été clivées en deux communautés distinctes : d'un côté la communauté des chercheurs en Sciences et Techniques des Activités Physiques et Sportives (STAPS) et de