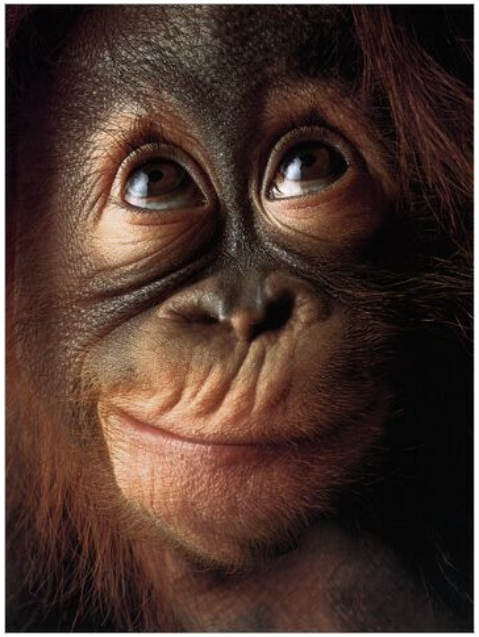
Comment le cerveau contrôle-t-il le mouvement de notre regard ?

How do we know what we know about eye movements?



Pierre Pouget, ICM, CNRS UMR 7225
pierre.pouget@upmc.fr

Oil on canvas by Caravaggio: *Fortune Teller* (1594). Rome, Capitoline Museums

Certains mouvements du regard nécessitent plus de contrôle…

En situation expérimentale…

Yarbus (1967)

Le contrôle des mouvements du regard

Yarbus (1967)

“Retenir les objets”

Le contrôle des mouvements du regard

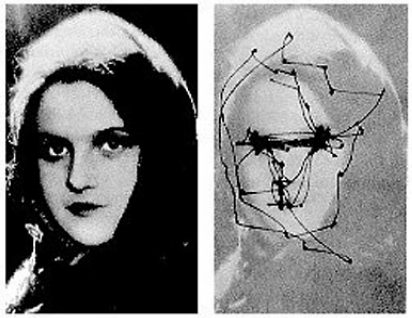
Yarbus (1967)

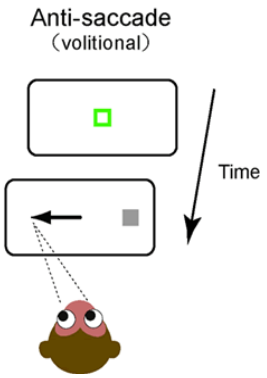
“Retenir les objets”

“Retenir les âges des personnages”

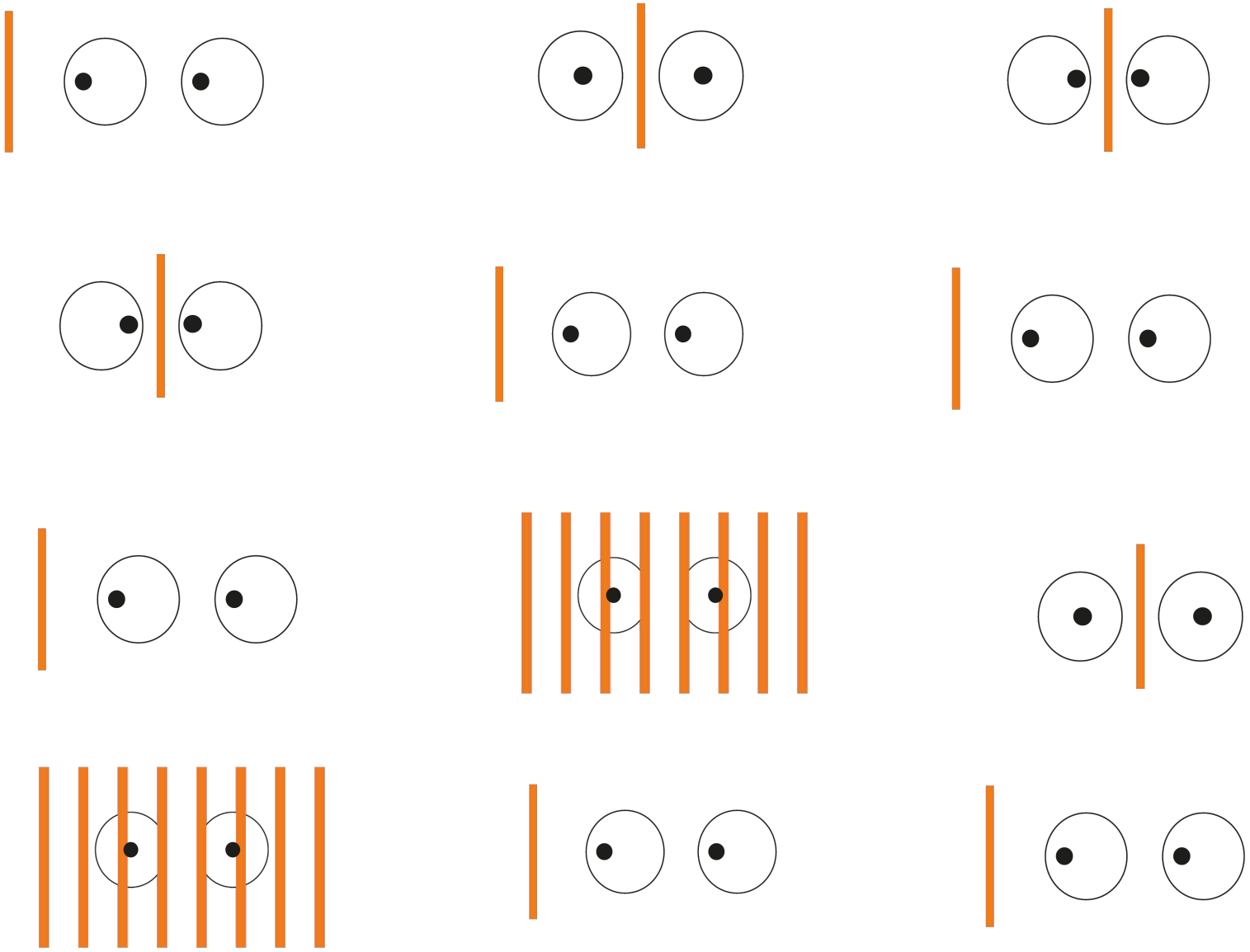
Le contrôle des mouvements du regard

Réflexif / Volontaire





Différents types de mouvements oculaires.



Plan:

- Pourquoi déplaçons-nous notre regard ? / Why do we move our eyes?
- Explorer son propre regard. Seeing the unseen
- Etudes en neurosciences
- *L'art est dans le regard…*

Pourquoi déplaçons-nous notre regard ?

Fixer ce point 

D

2014

E

A

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D

2014

E

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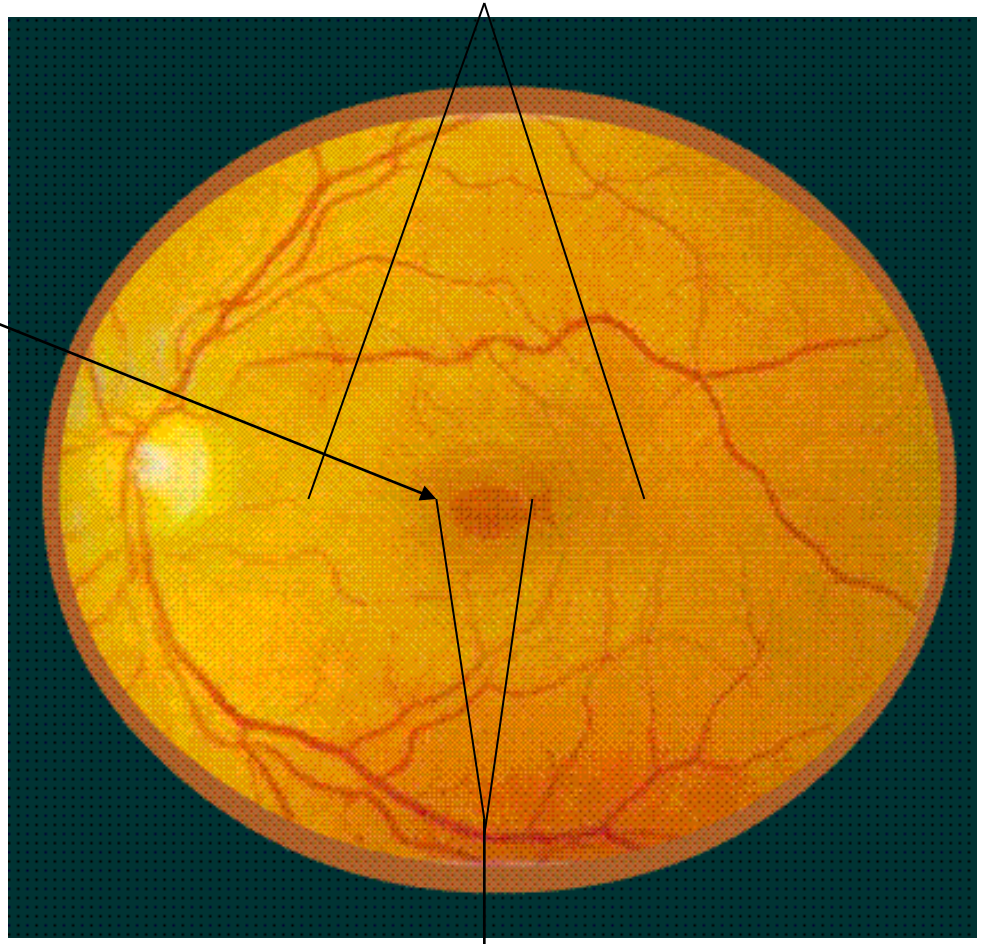
N

S

Zone peri-foveal (10°)

Fovea



Foveal region (2°)

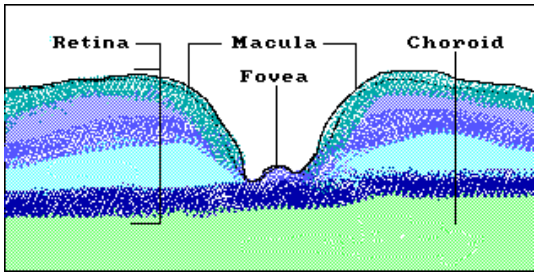
Peripheral Vision

Peripheral Vision

Nous déplaçons nos yeux pour mieux percevoir.

We move our eyes to see better.

Eye movements place the image of the object of interest on the part of the retina (fovea) with the highest acuity.



Nous déplaçons notre regard pour maintenir une image stable d'un objet qui se déplace mais également pour "compenser" les mouvements de notre propre corps.

Eye movements also keep the image on the eye stationary in spite of movement of the object or movements of one's head.

Lire ce petit texte devient
très difficile lorsque celui-ci
se déplace sur la rétine.

Reading is difficult
when the text is moving on the retina

Vision Res. Vol. 2, pp. 69–80. Pergamon Press 1962. Printed in Great Britain.

THE EVOLUTIONARY HISTORY OF EYE MOVEMENTS[1]

G. L. WALLS

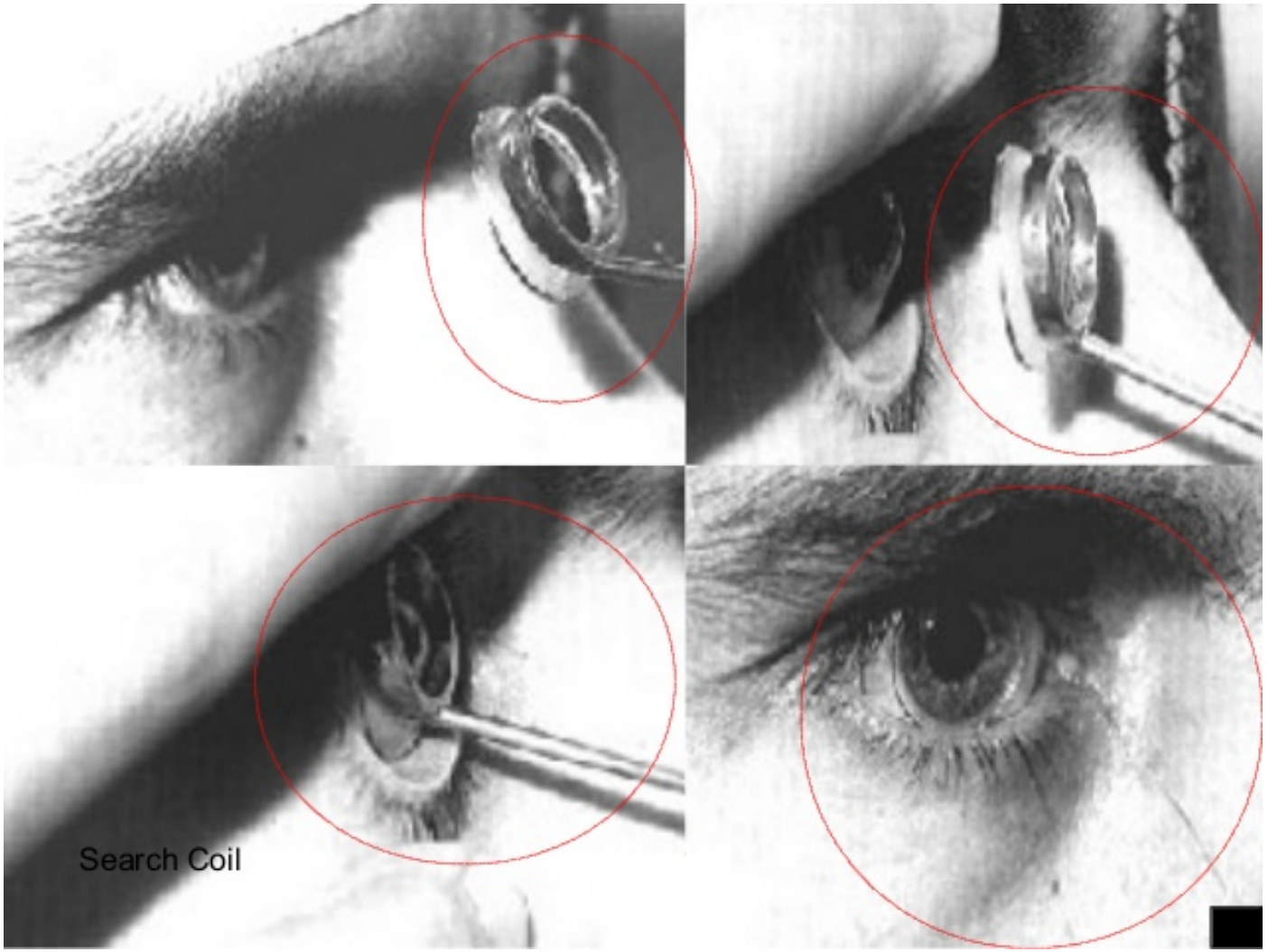
School of Optometry, University of California, Berkeley

(*Received 22 August 1961*)

Quels sont les outils de mesure des mouvements oculaires?

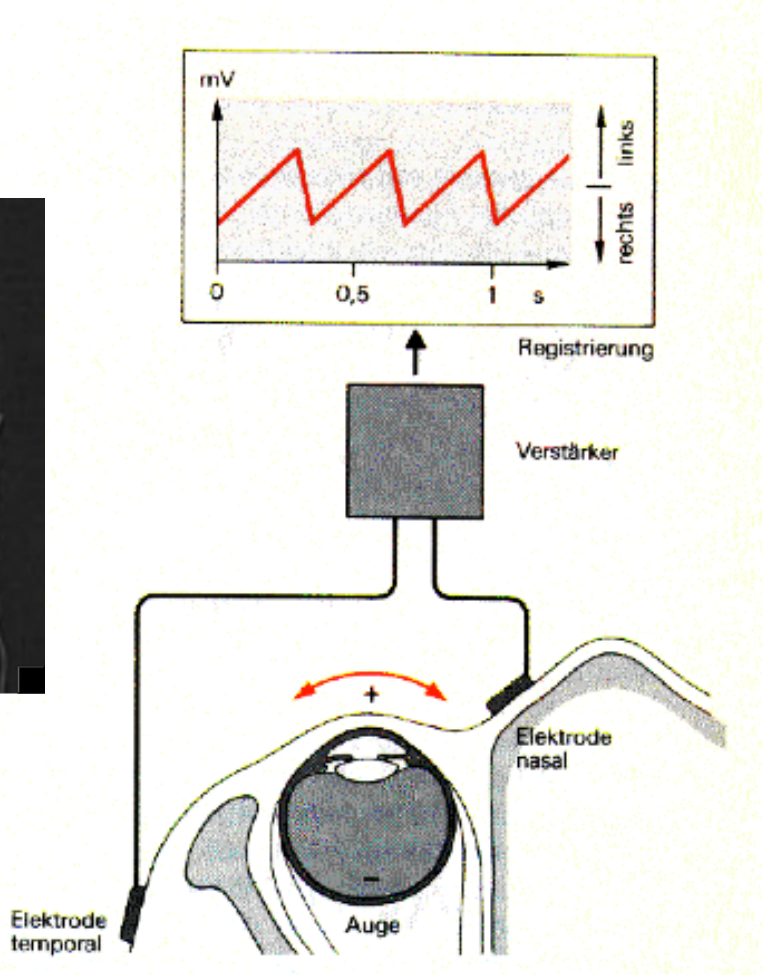
How do we know what we know about eye movements?

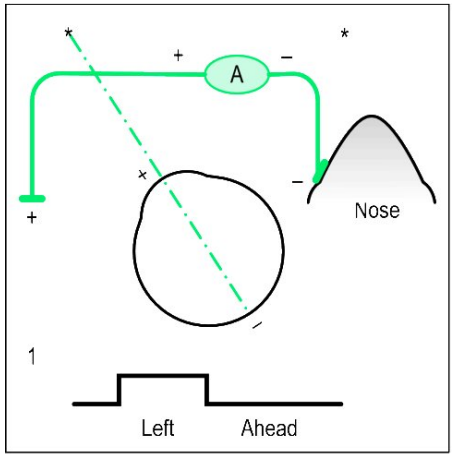
Modulation d'un champs magnétique par une micro-bobine placée dans une lentille de contact.

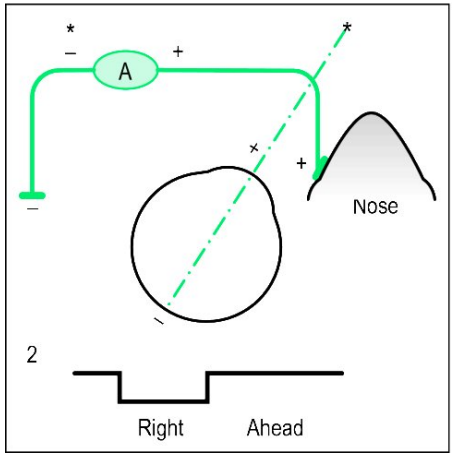


Electro-oculogram: EOG


A picture wearing the EOG apparatus



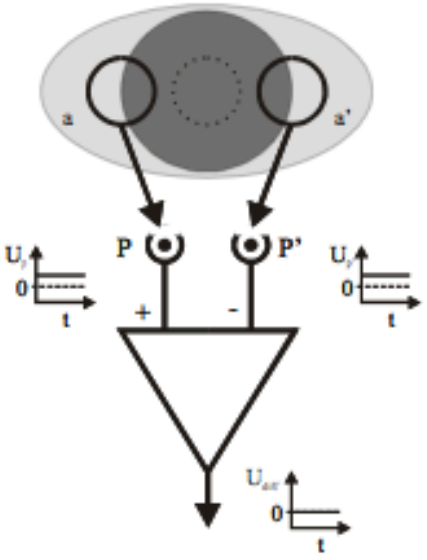




The cornea is approximately 6 * positive with respect to the retina, which changes with differing retinal illumination.

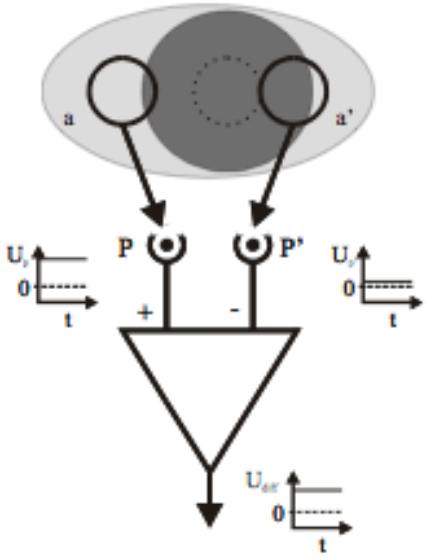
L'estimation du déplacement de la limbe sclérotique

Fixation centrale

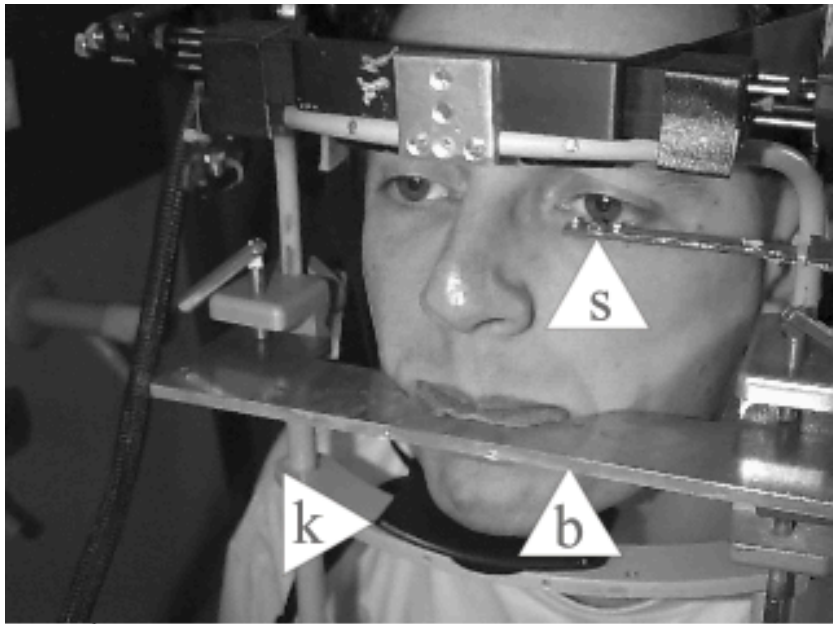


Output

Déplacement à gauche

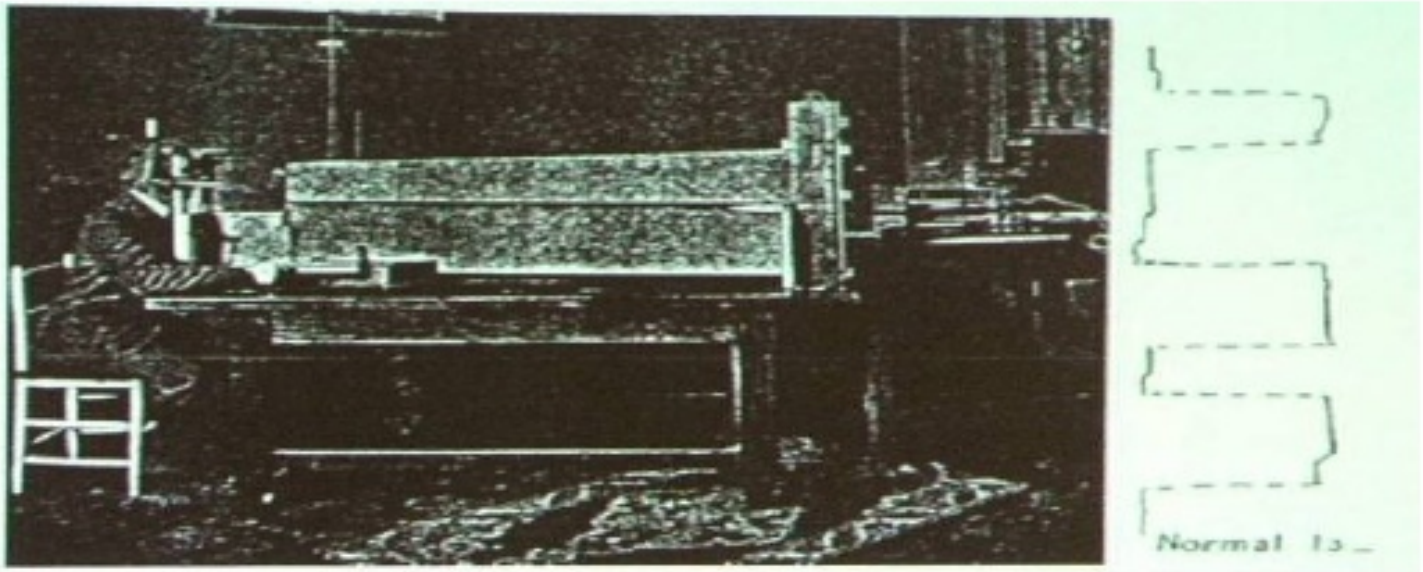


Output

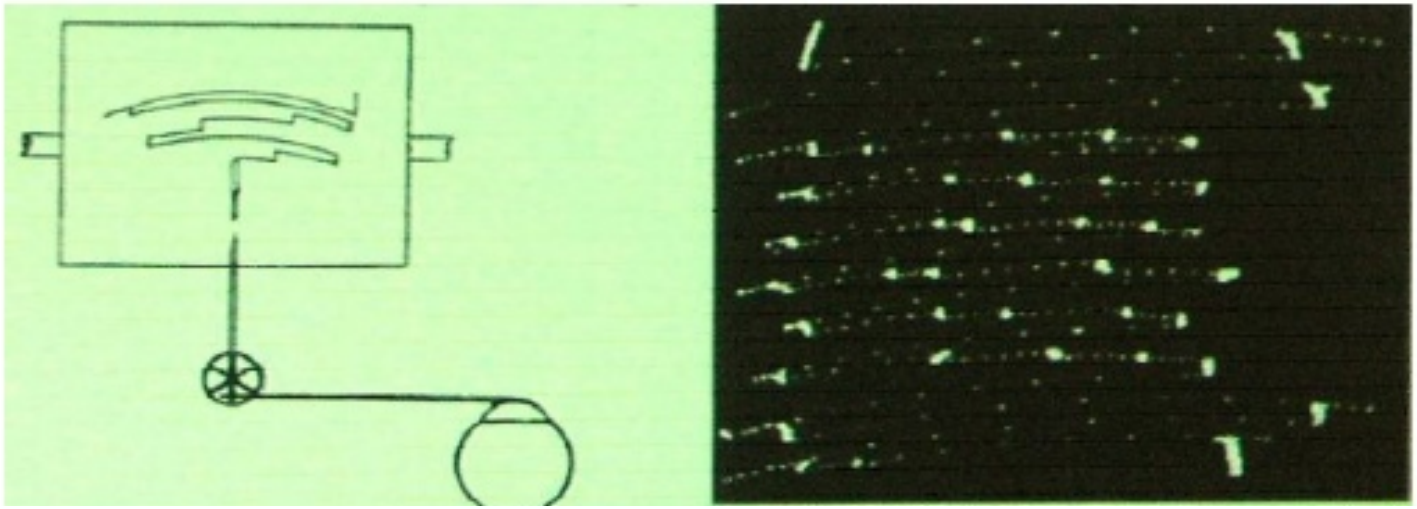


Optical-based method:

R. Dodge (1901)

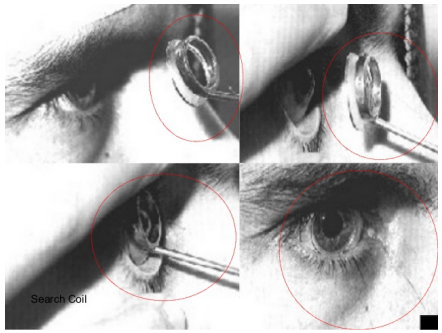


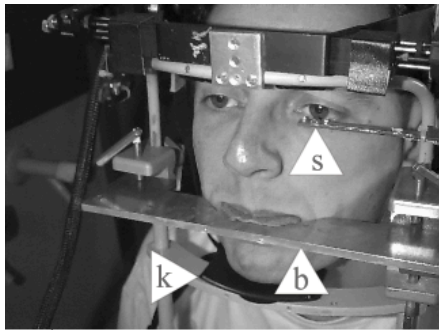
E.Delabarre (1898)

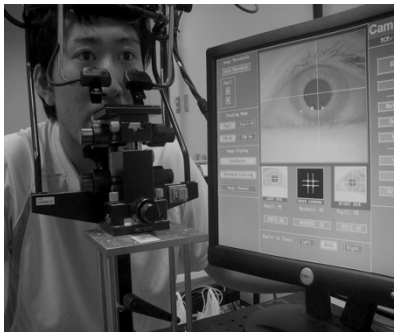


E. Huey (1898)

Pour qui n’a qu’un marteau tout ressemble à un clou.





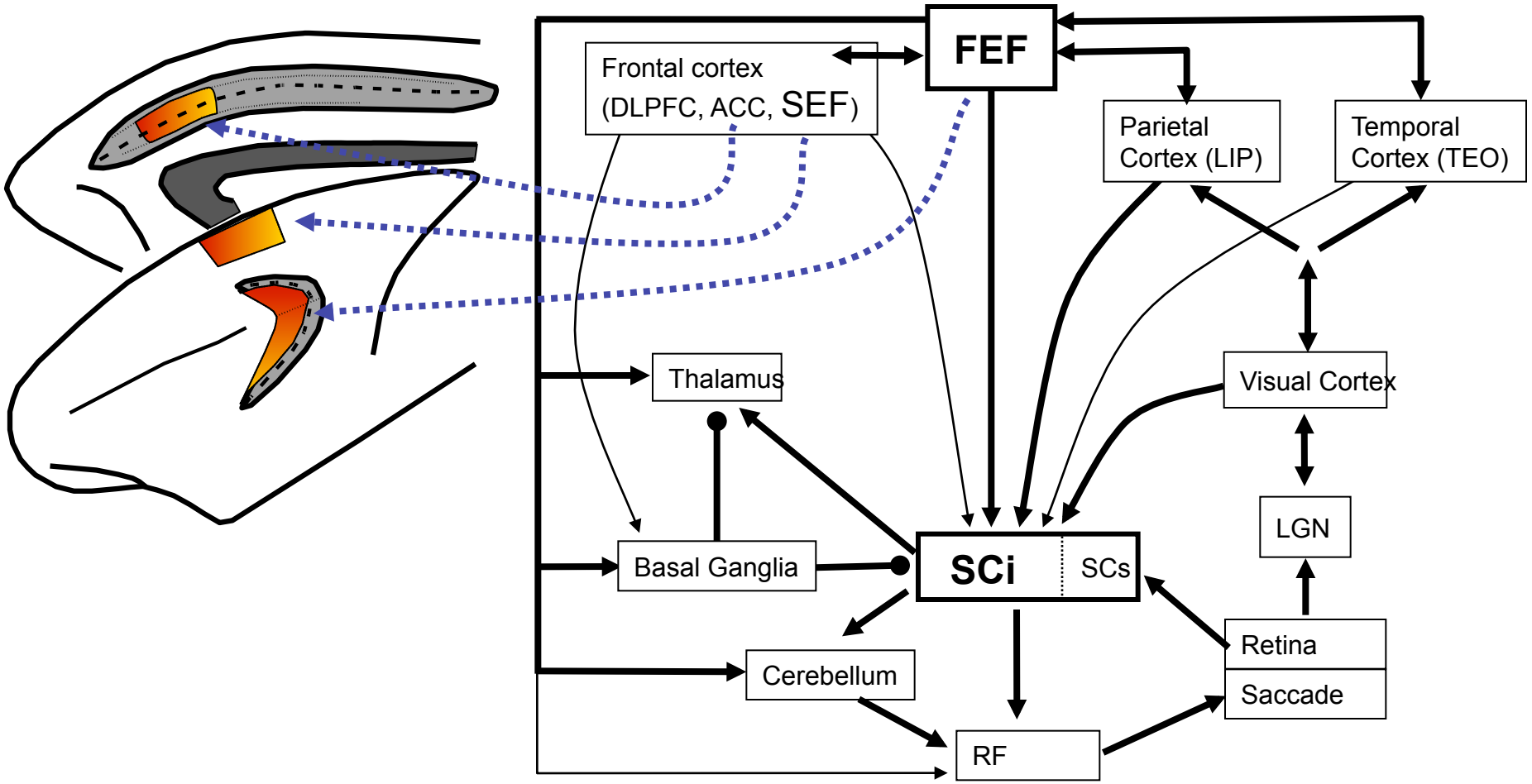


Quelle est la fonction des mouvements oculaires?

The purposes of eye movements

- **Conserver l'objet sur la fovéa / Keep an object on the fovea**
  - Fixation
  - Poursuite lisse / Smooth pursuit
- **Conserver la fixation du regard lorsque la tête bouge / Keep the eyes still when the head moves**
  - Réflexe vestibulo-oculaire / Vestibulocular reflex
  - Réflexe optocinétique / Optokinetic reflex
- **Déplacer son regard d'un objet à un autre / Move the fovea from one object to another**
  - Saccade
  - ….Vergence

Saccades are produced by a distributed network



Munoz DP, Schall JD (2003) Concurrent distributed control of saccade initiation in the frontal eye field and superior colliculus. In *The Oculomotor System: New Approaches for Studying Sensorimotor Integration*. Edited by WC Hall, AK Moschovakis. CRC Press, Boca Raton, FL. Pages 55-82.

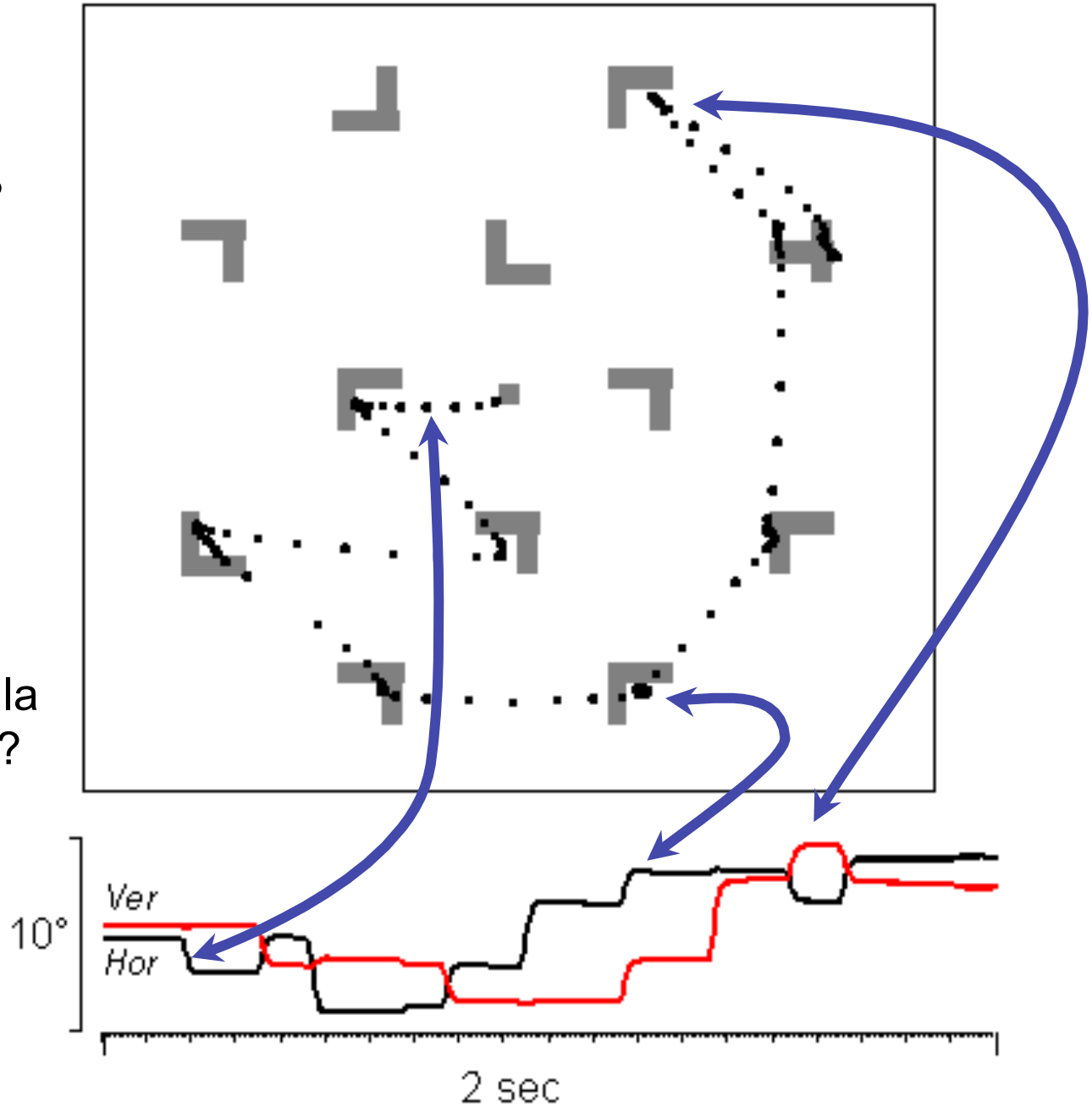
Control of Saccades

- Superior colliculus drives the reticular formation to make contralateral saccades.
- The frontal eye fields and the parietal cortex drive the colliculus.
- The parietal cortex provides an attentional signal and the frontal eye fields a motor signal.
- The substantia nigra inhibits the colliculus unless
- It is inhibited by the caudate nucleus
- Which is, in turn, excited by the frontal eye field.

Comment le cerveau sélectionne-t-il le déplacement du regard?

Comment le cerveau sélectionne-t-il la commande motrice appropriée ?

Comment le cerveau détecte-t-il et corrige-t-il la production d'une erreur ?

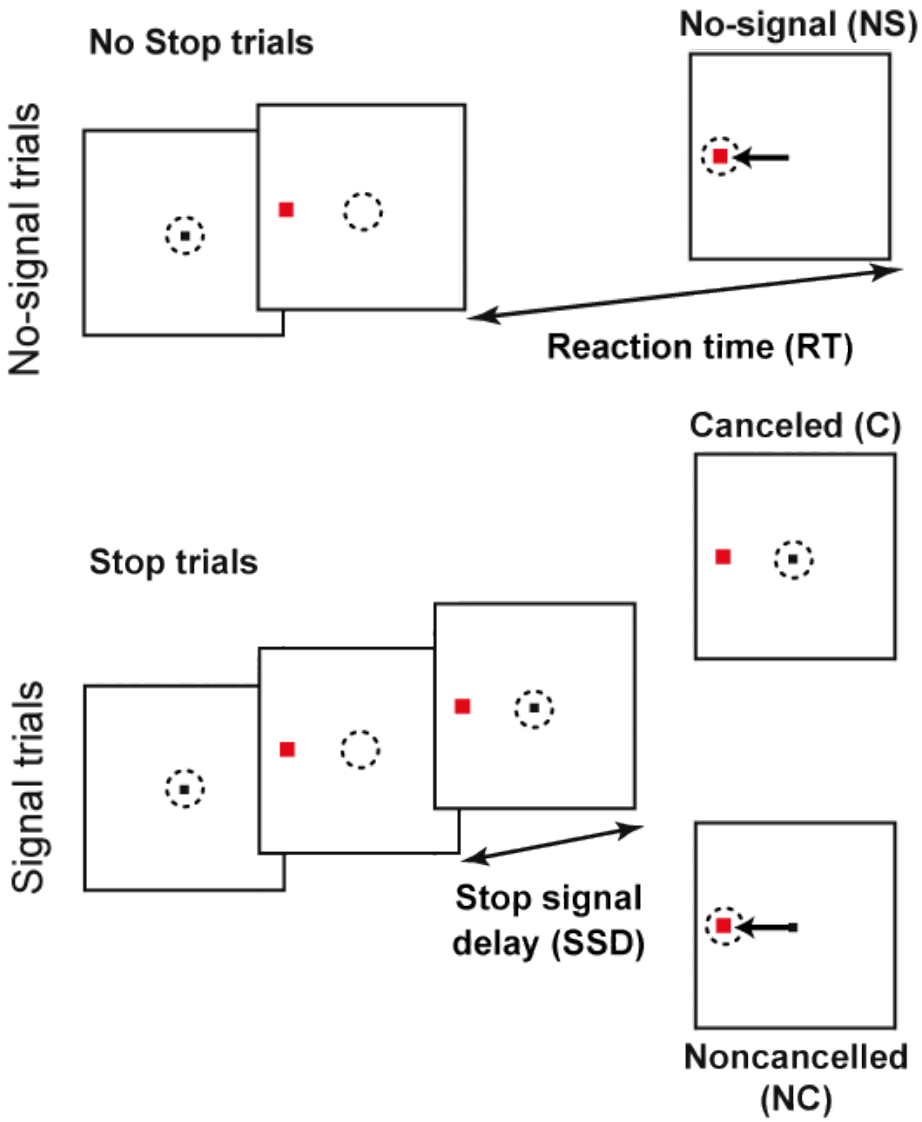


Contrôle et inhibition du mouvement

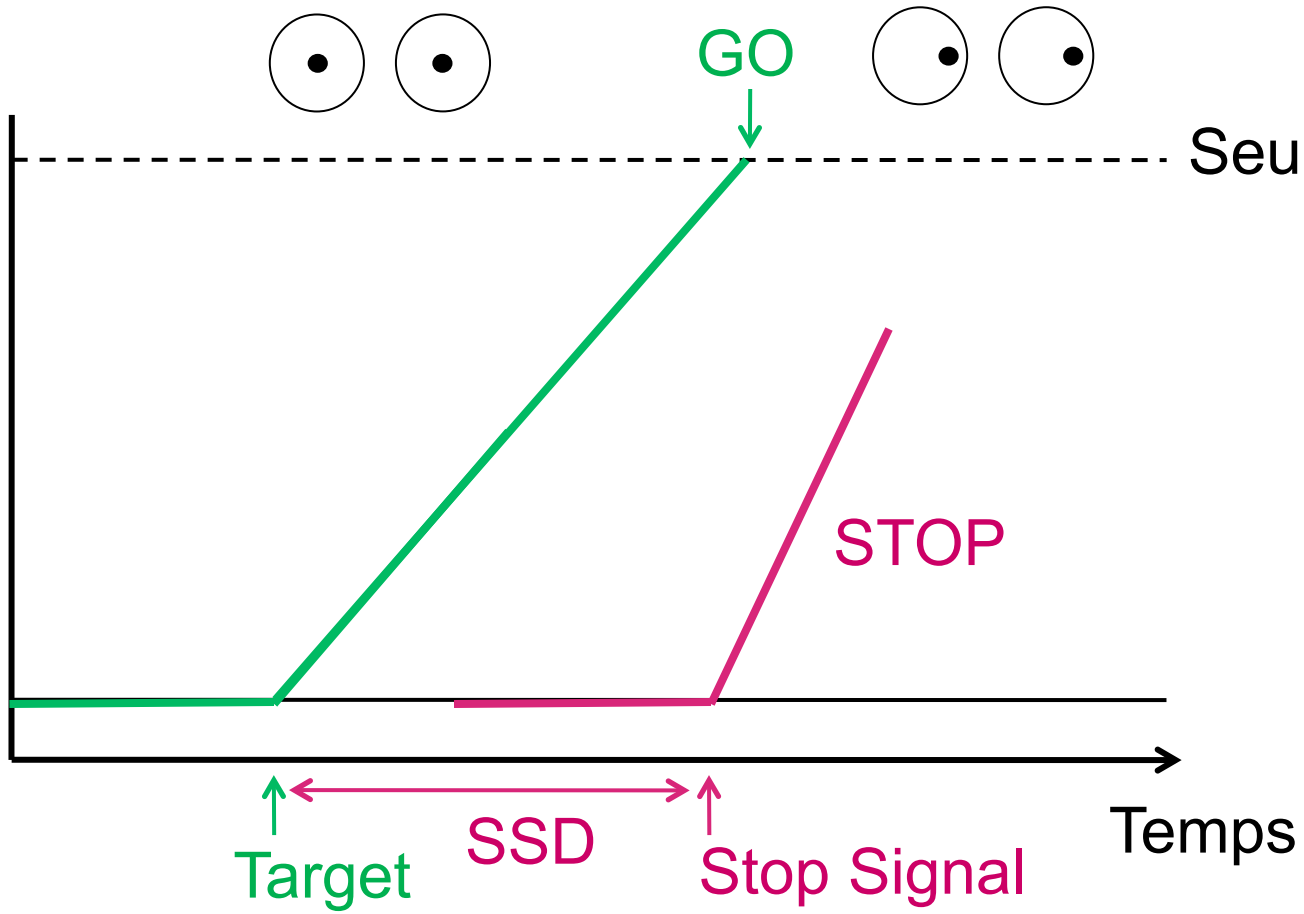
Quel est le temps nécessaire pour inhiber un mouvement (oculaire) / How long does it take to inhibit an eye movement?

Comment peut-on estimer le temps d'un évènement qui ne va pas se produire? How do we give a valid time estimate of something that is *not* going to happen?

Tâche de contre-ordre / Countermanding Task



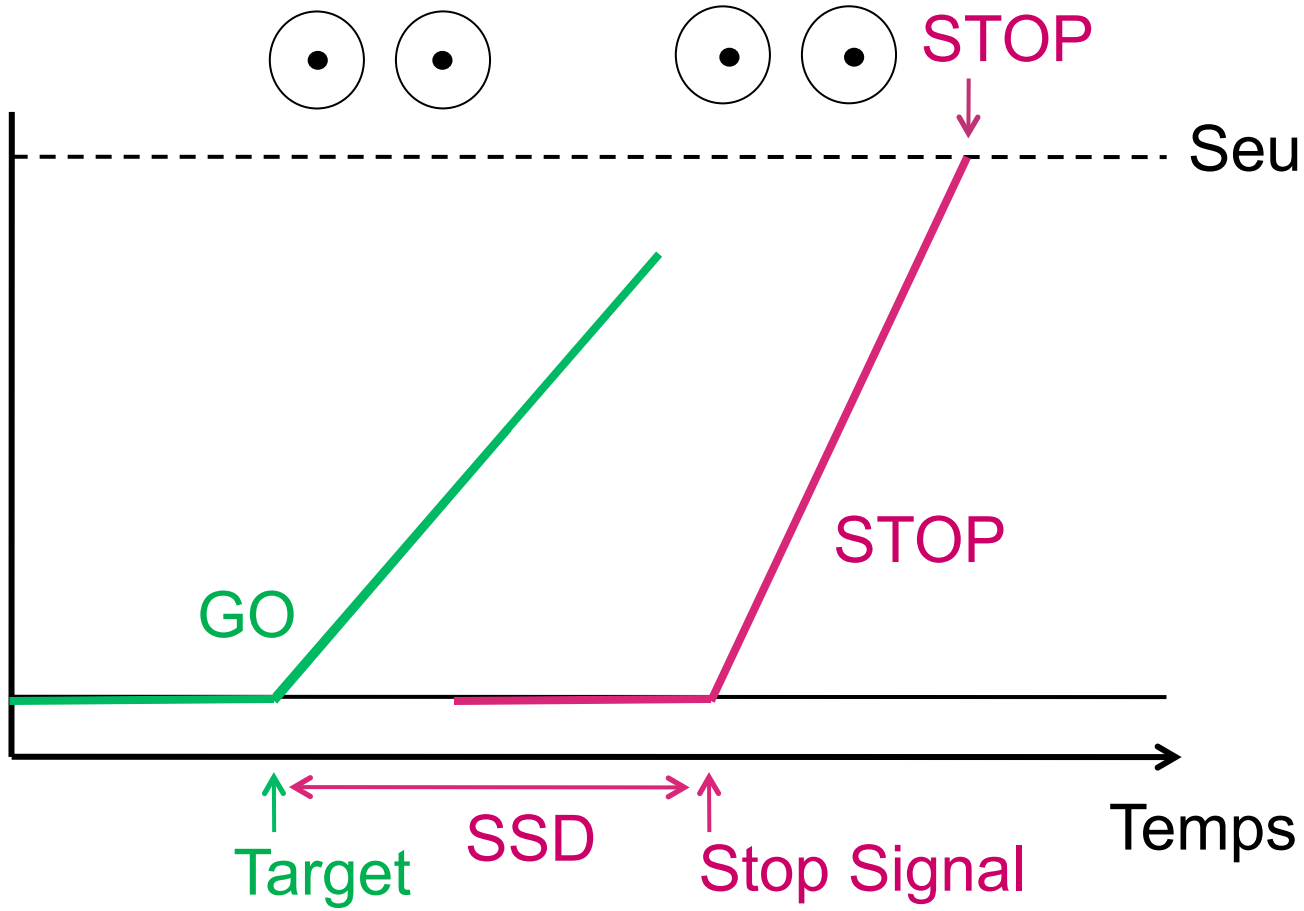
Une course entre deux processus : GO et STOP



➢La saccade est déclenchée

(Logan & Cowan, 1984)

Une course entre deux processus : GO et STOP

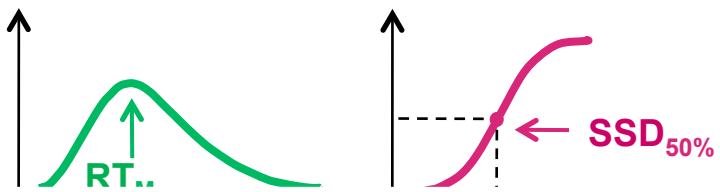


➢La saccade est inhibée

(Logan & Cowan, 1984)

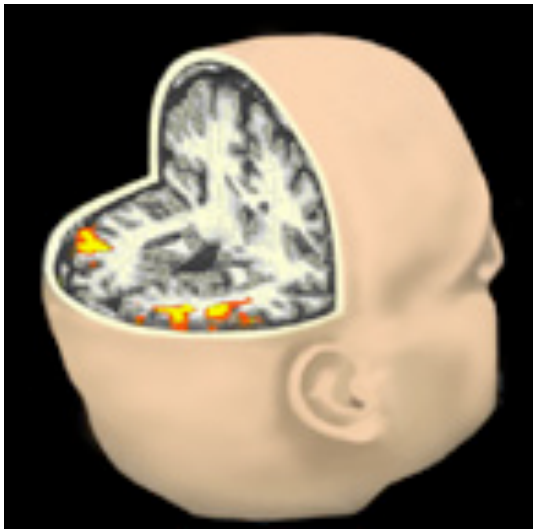
Quel est le temps nécessaire pour inhiber un mouvement **(SSRT) ?**

$$SSRT = RT_M - SSD_{50\%}$$

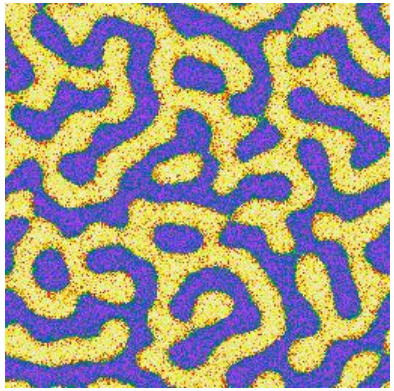


Une METHODE pour estimer le temps d'un évènement qui ne va pas se produire? How do we give a valid time estimate of something that is *not* going to happen?

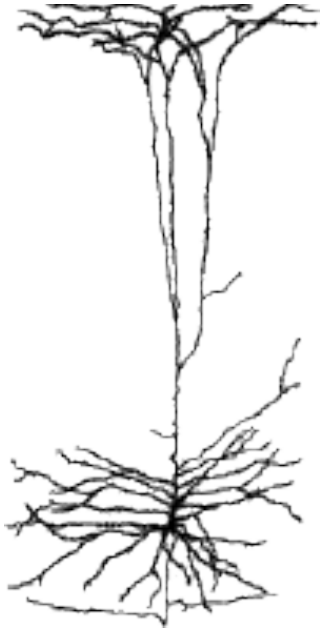
Systèmes?



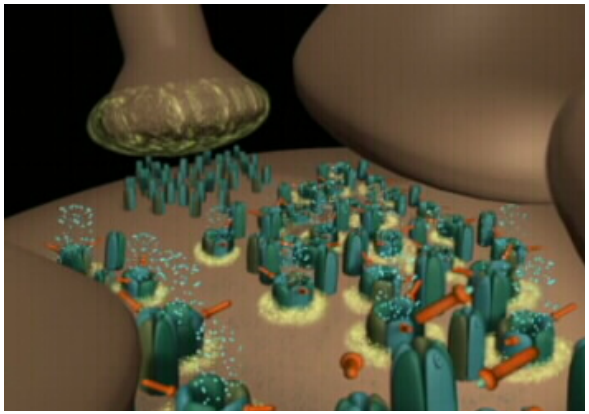
Circuits?



Cellules?



Synapses?

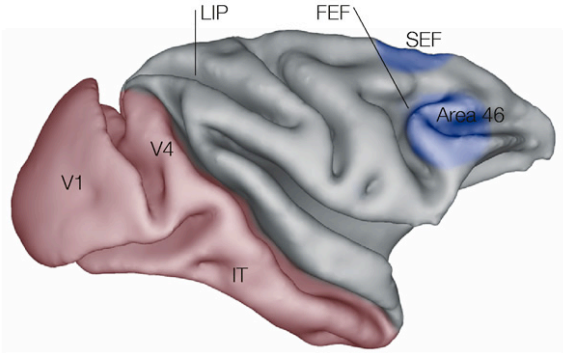


Etude expérimentale à partir de lésions

Pourquoi et comment déplace-t-on notre regard ?

Yarbus 1967.

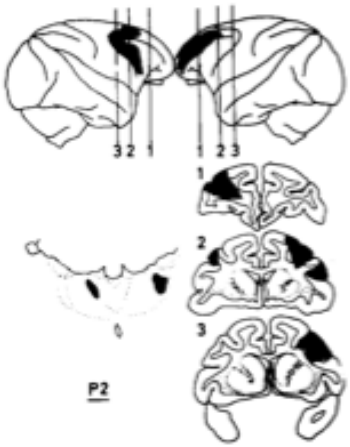
Quelle région de notre cerveau contrôle le déplacement de notre regard ?

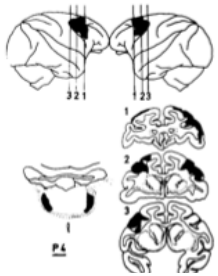


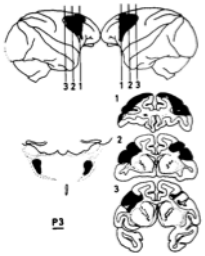
Sugrue et al. 2005.

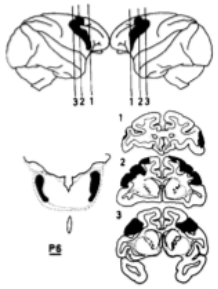
Etude de lésions des régions du FEF chez le macaque:

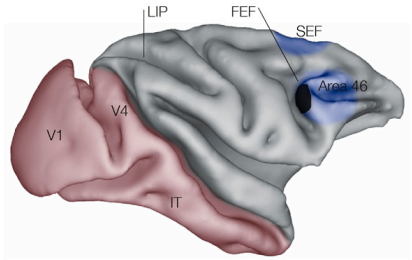
Cortical lesions made by sub-pial aspiration

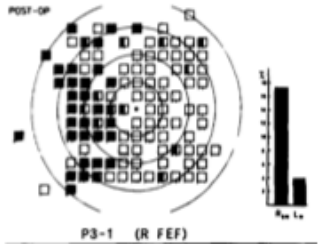


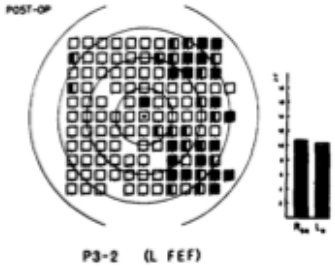


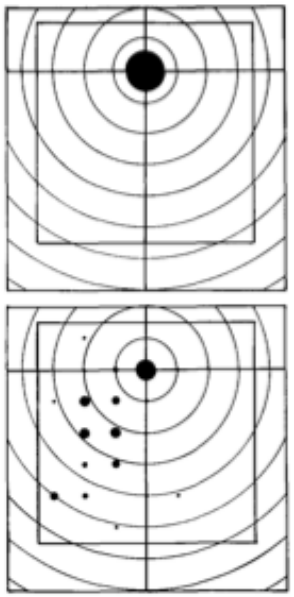






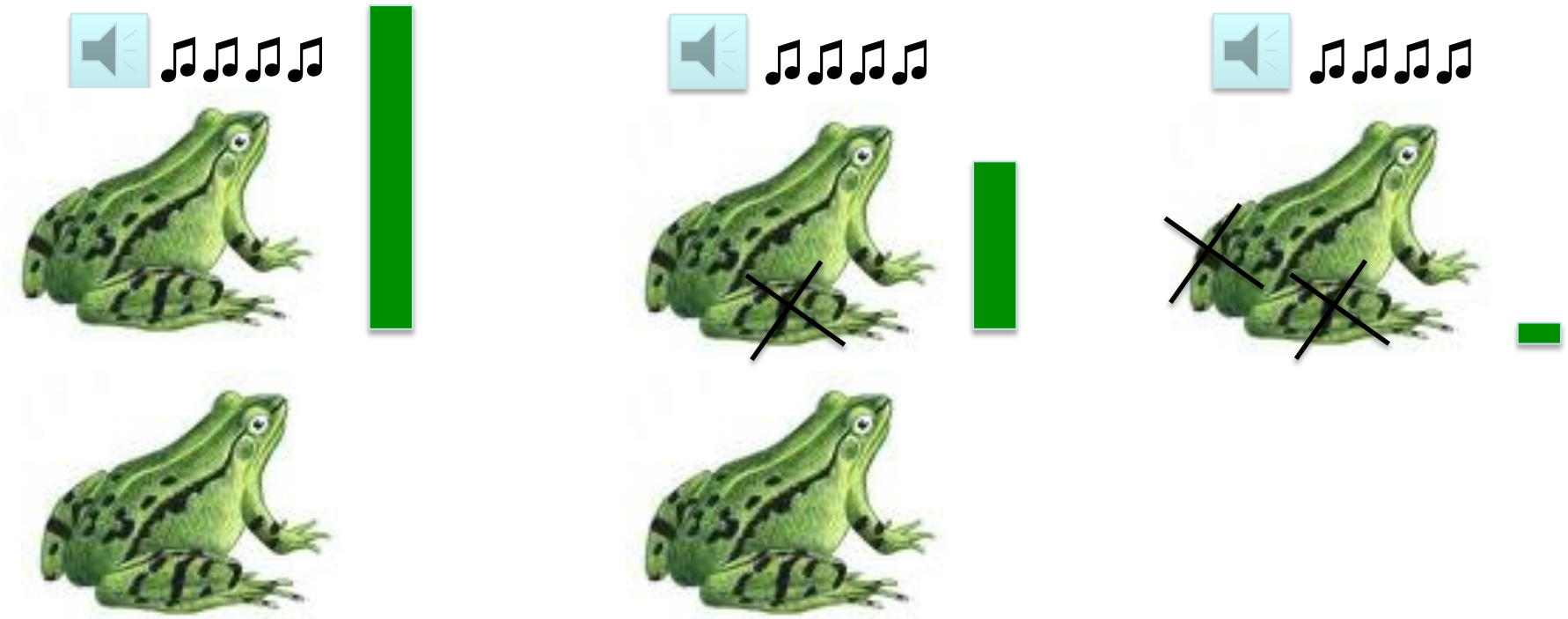






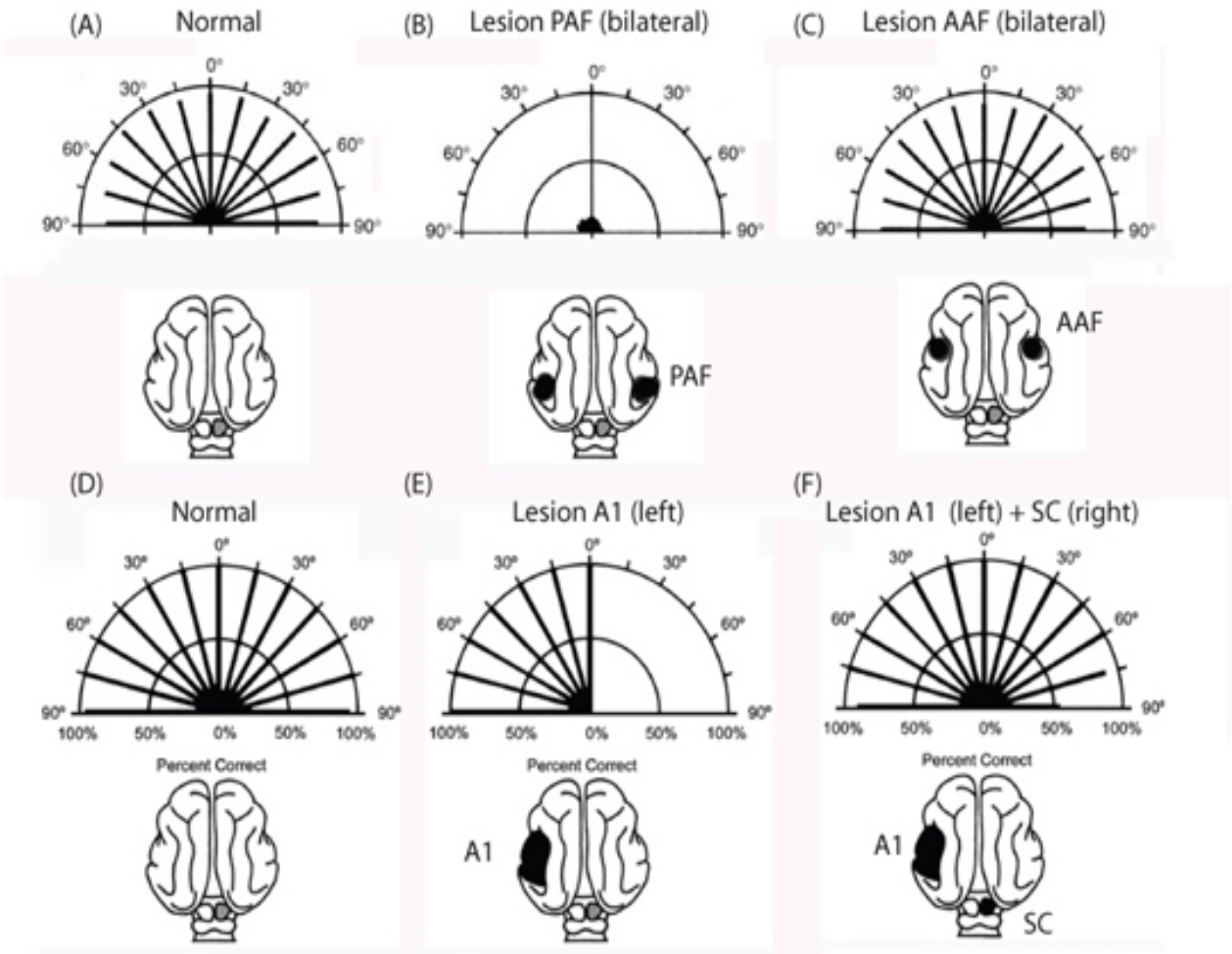
Latto and Cowey, 1971.

La méthodologie lésionnelle: la question de la spécificité



Les organes auditifs de la grenouille se trouvent dans les membres inférieurs!

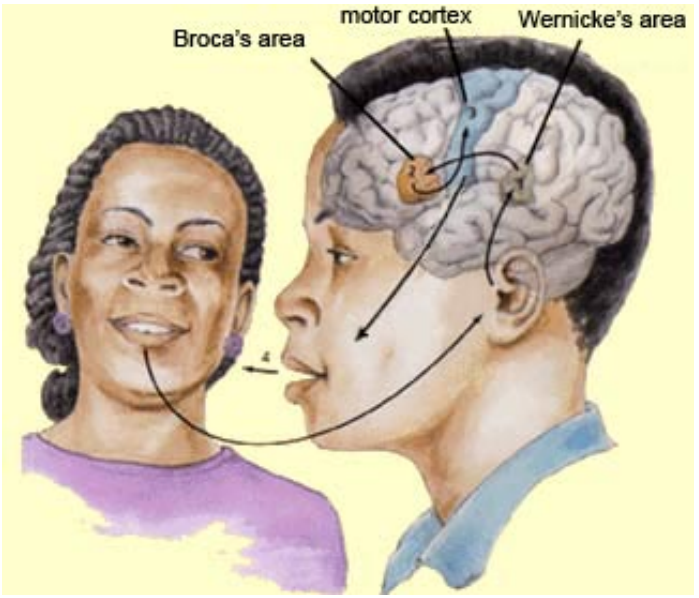
L'effet Sprague

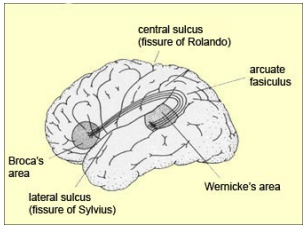


Figures from Lomber et al., 2007.

Problème de spécificité et du rapport structure/fonction

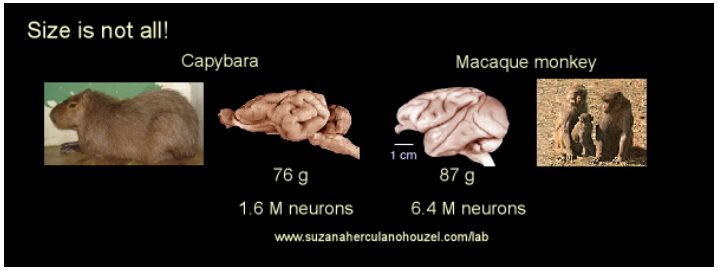
Relation entre la manière dont « une partie » est composée (structure) et le rôle qu'elle a à remplir pour cet organisme (fonction).

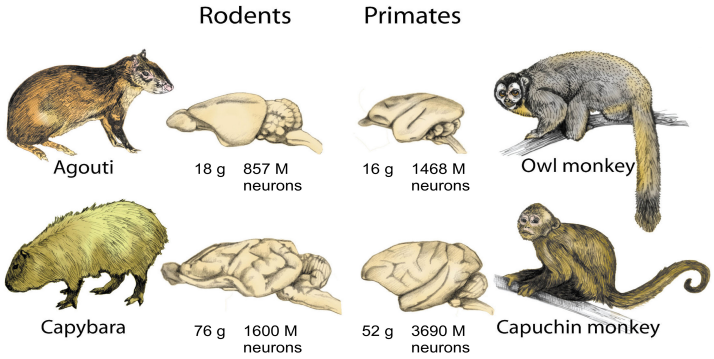




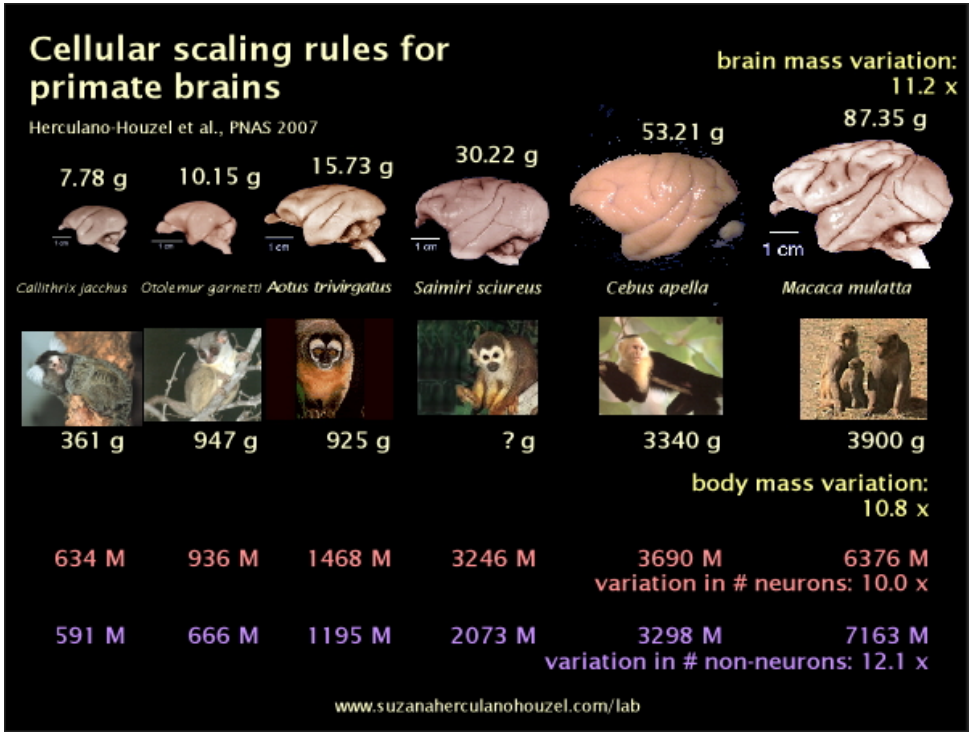
Problème de spécificité et du rapport structure/fonction

Inter-espèces



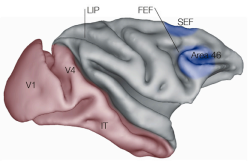


Intra-espèce

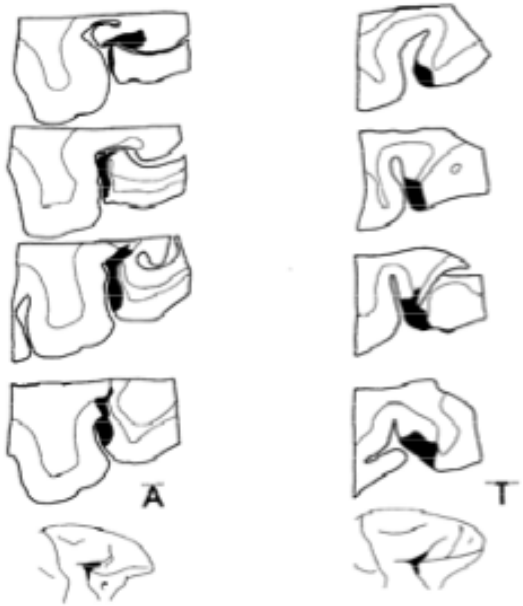


Herculano-Houzel et al., 2008.

Inactivation pharmacologique



Muscimol binds on the $GABA_A$ receptor complex as GABA itself



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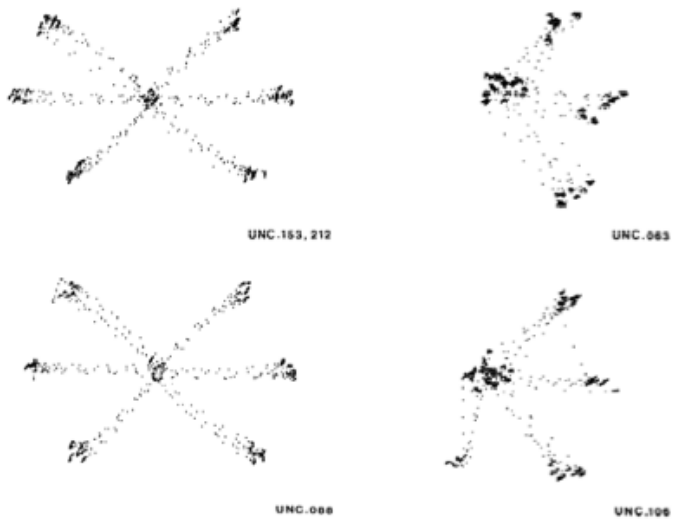
Vol. 57, No. 4, April 1987. Printed in U.S.A.

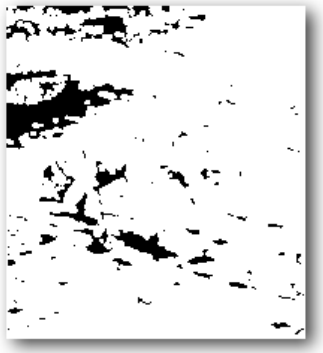
The Effect of Frontal Eye Field and Superior Colliculus Lesions on Saccadic Latencies in the Rhesus Monkey

PETER H. SCHILLER, JULIE H. SANDELL, AND JOHN H. R. MAUNSELL

Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

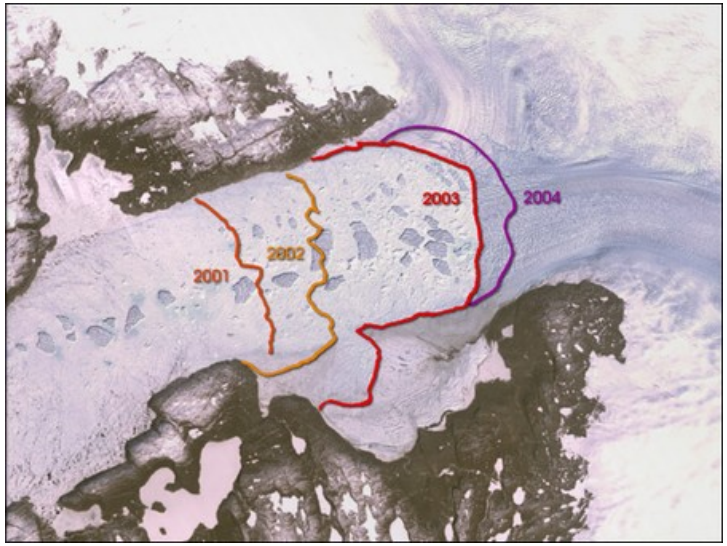


La question de la réversibilité

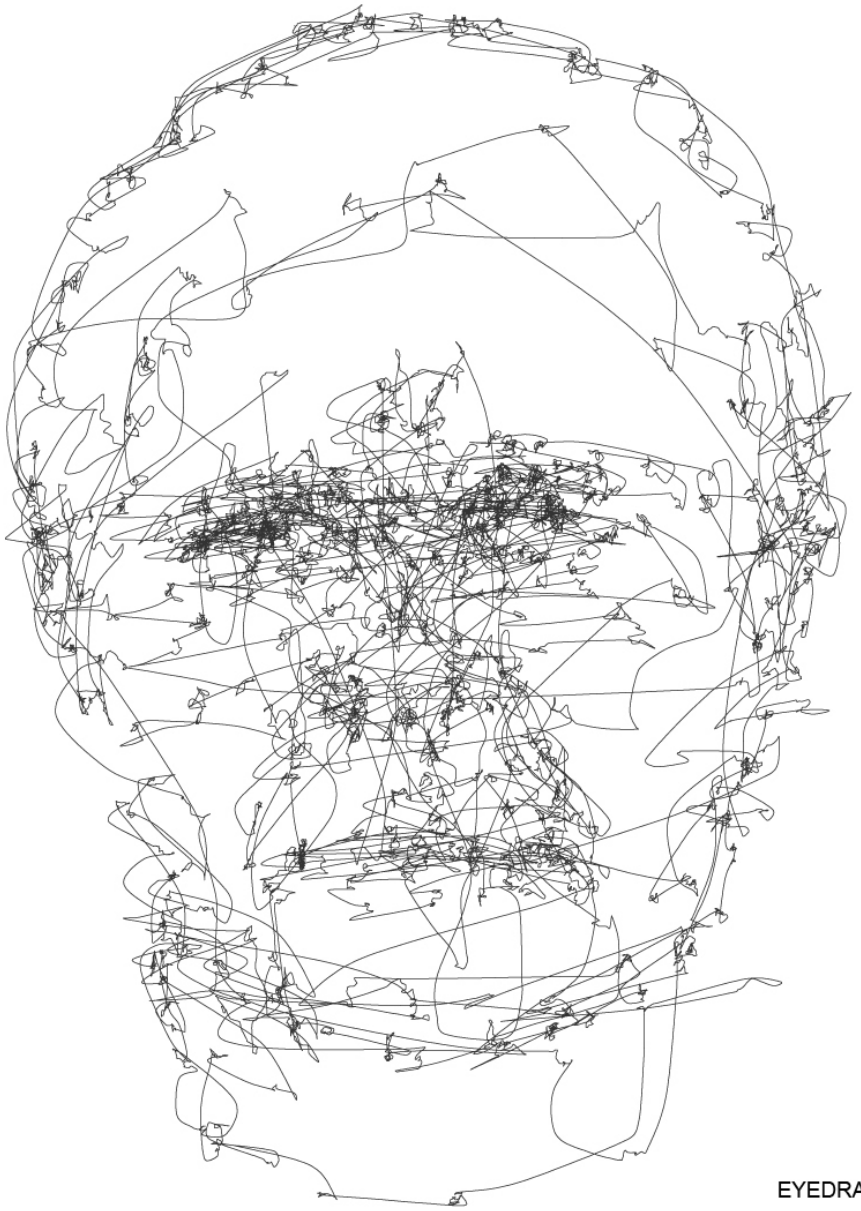


La question de la réversibilité

L’inactivation pharmacologique est-elle réversible ?



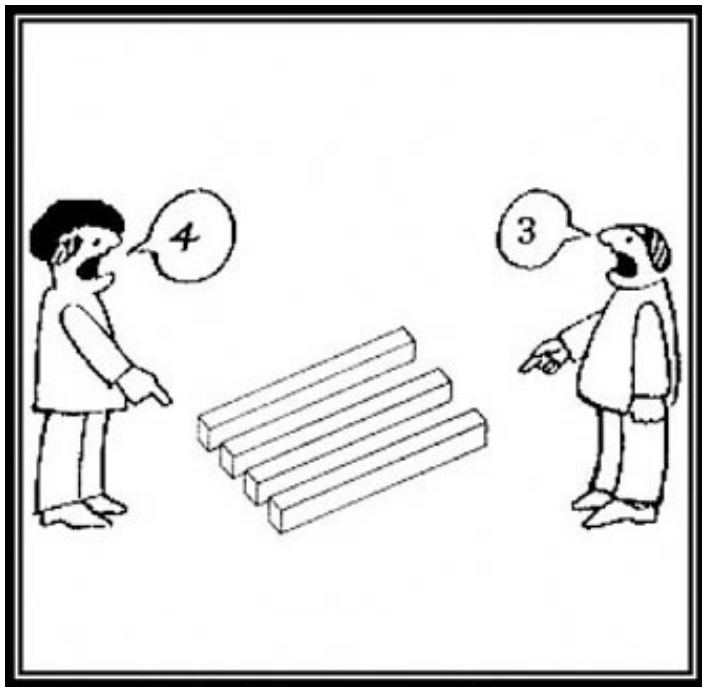
Dansesciences 13 février 2014…

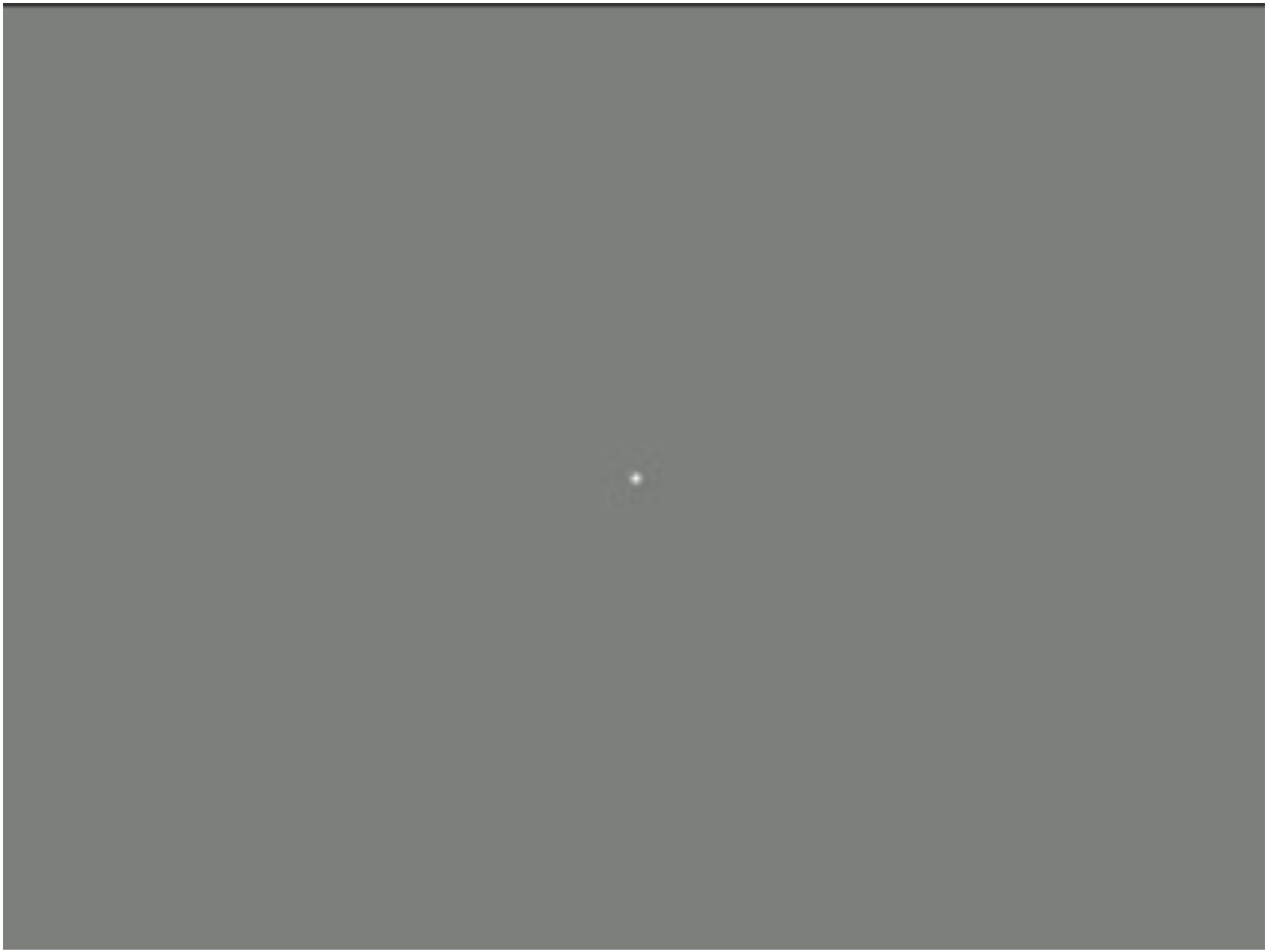


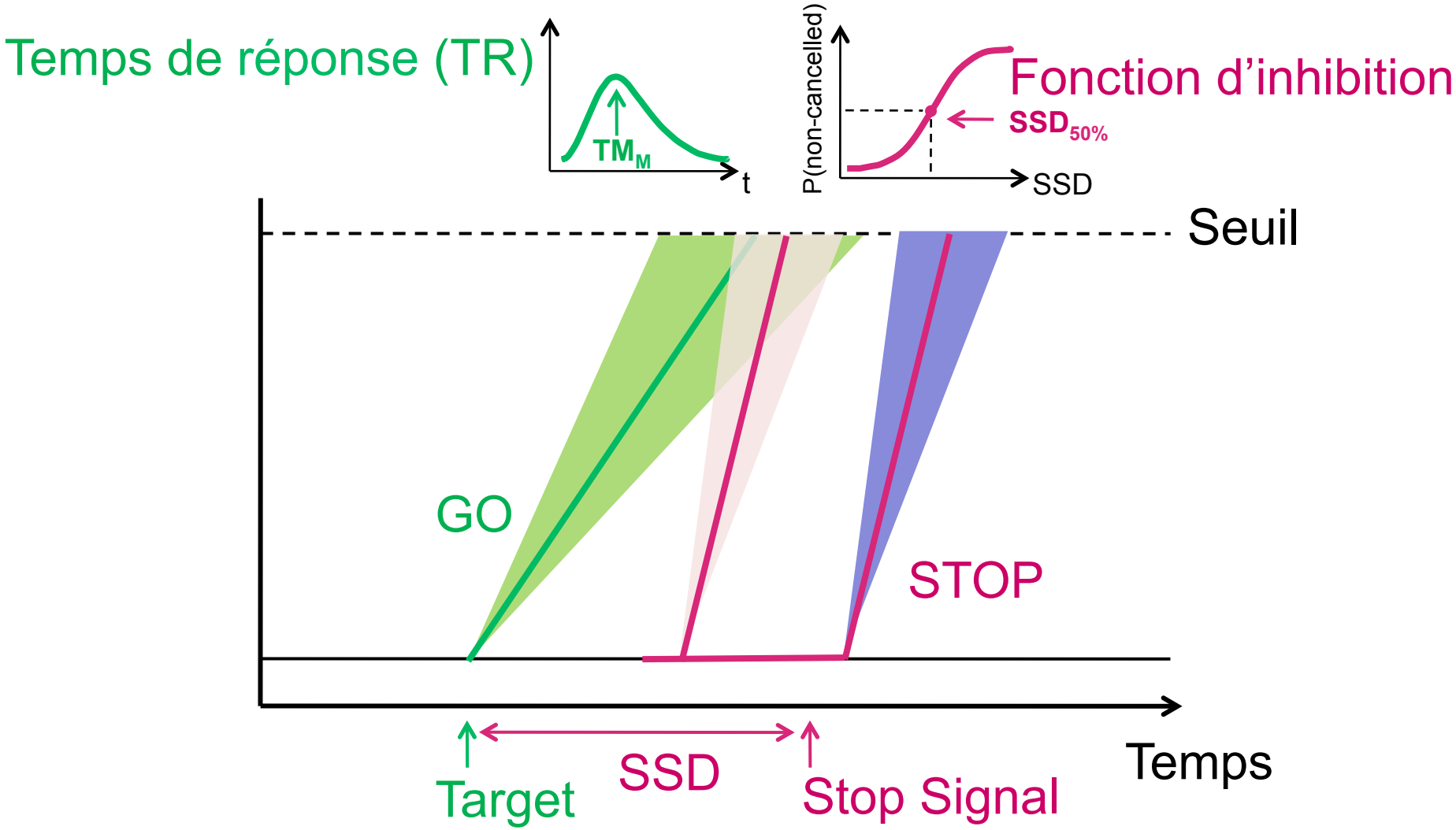
EYEDRAWING

240" AUTOPORTRAIT

Merci de votre attention







- Essai GO : une saccade est déclenchée (TR)
- Essai STOP: la saccade est inhibée ou déclenchée