Oculomotor control in human and non-human primates

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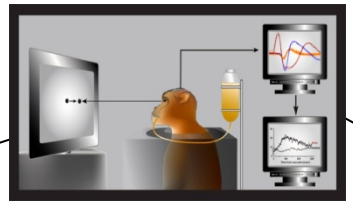
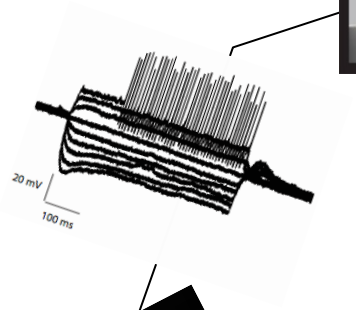
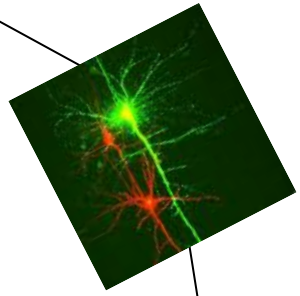
CR-ICM, Paris, France

GT8 Robotique/Neurosciences June 23th 2011

Physiology - Experiments - Anatomy - Neurology -







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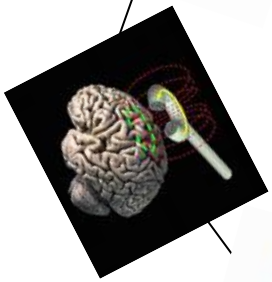
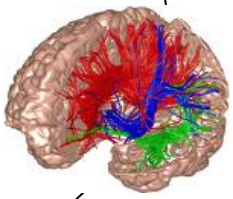
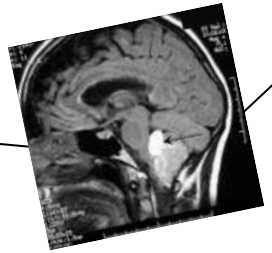






Eye movements are under voluntary control

Yarbus (1967)

Eye movements are under voluntary control

Yarbus (1967)

“Remember the location of objects in the room”

Eye movements are under voluntary control

Yarbus (1967)

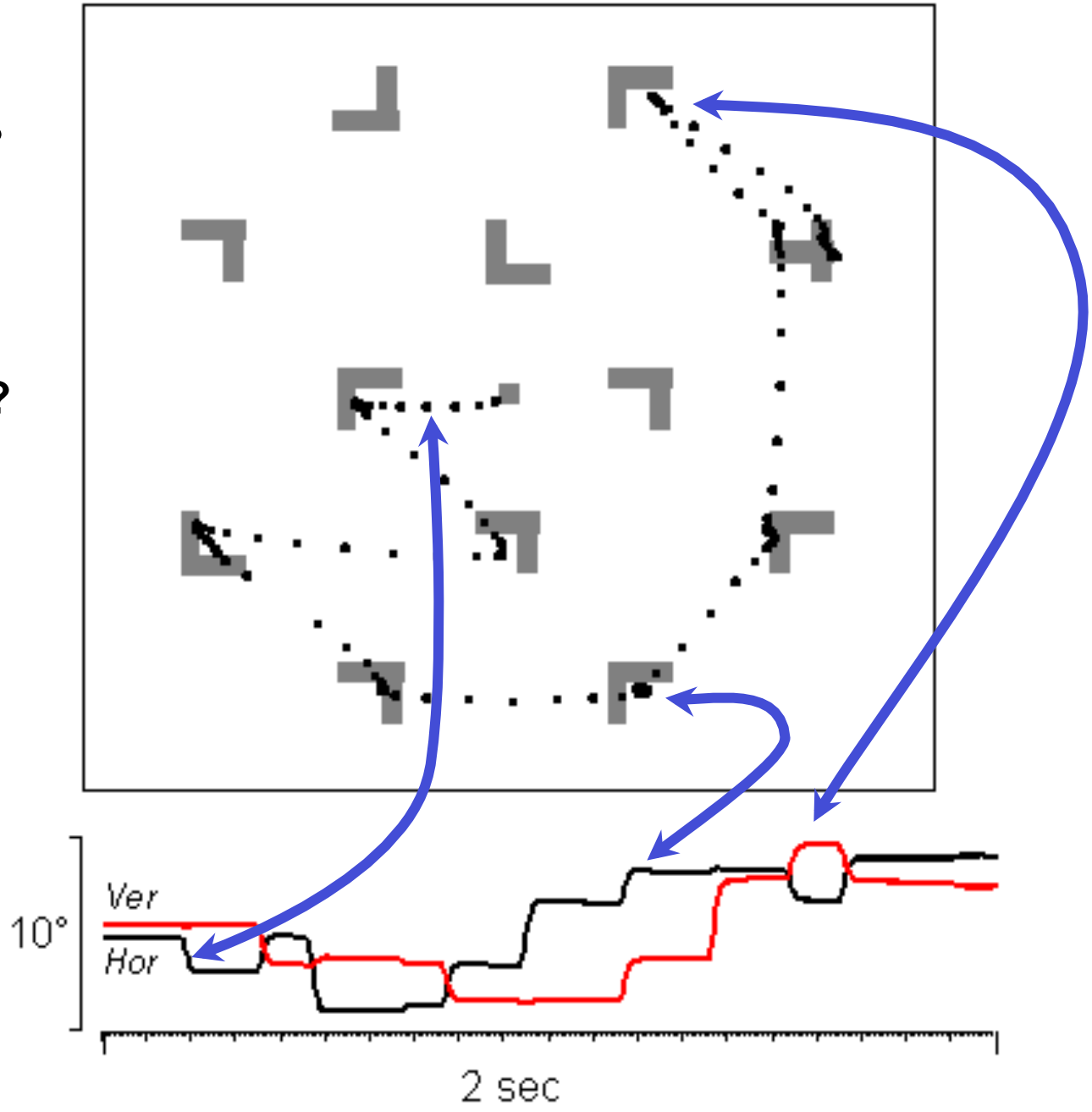
“Remember the location of objects in the room”

“Remember the ages of the people in the room”

How does the brain choose where to look?

How does the brain control when to move?

How does the brain correct errors?



Work on saccadic reaction times in humans seems to suggest that **the brain runs a kind of race between signals representing different possible targets**, with more probable targets starting nearer the finishing post than less probable ones.

There is also a huge random element, rather like a gratuitous random handicap, so that reaction times are very variable even when the stimuli and conditions are absolutely constant.

This may well represent a deliberate mechanism for making sure our behaviour is not too predictable by our predators (and you may like to think of it as **the neural mechanism behind our illusion of 'free will'**.

Roger Carpenter: http://babylon.acad.cai.cam.ac.uk/people/rhsc/oculo.html

A race between signals representing different possible targets…

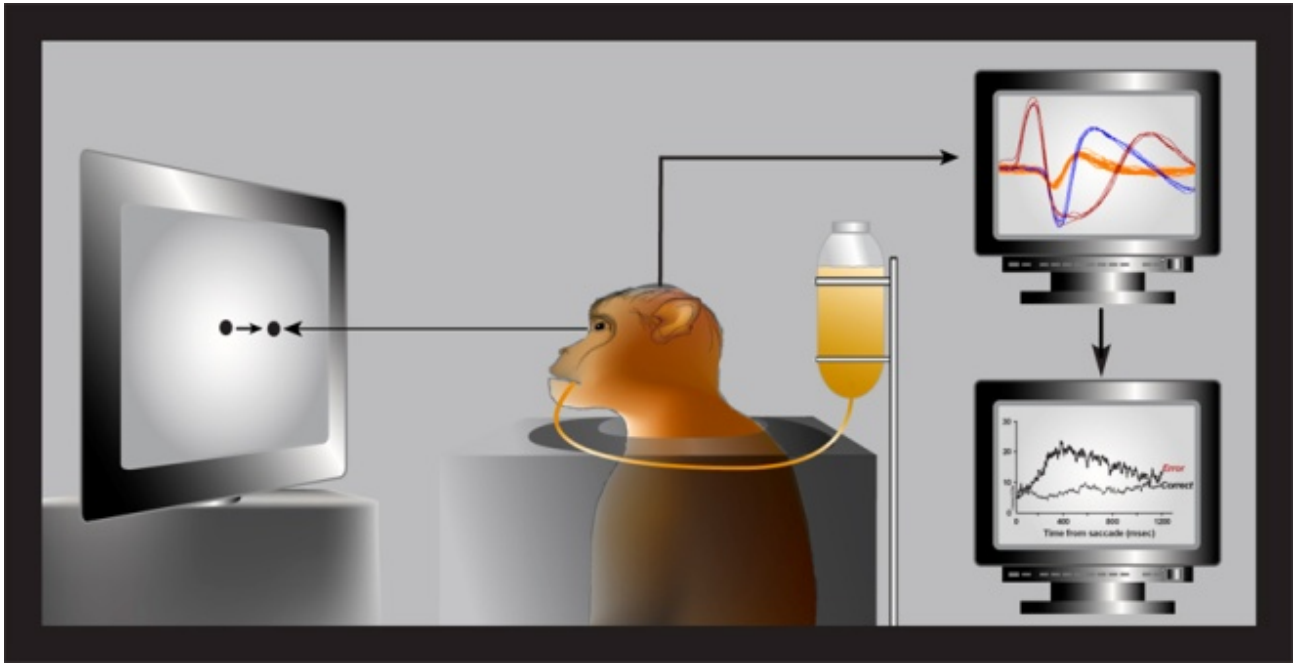
Théodore Géricault, 1791-1824

How to stop the race?

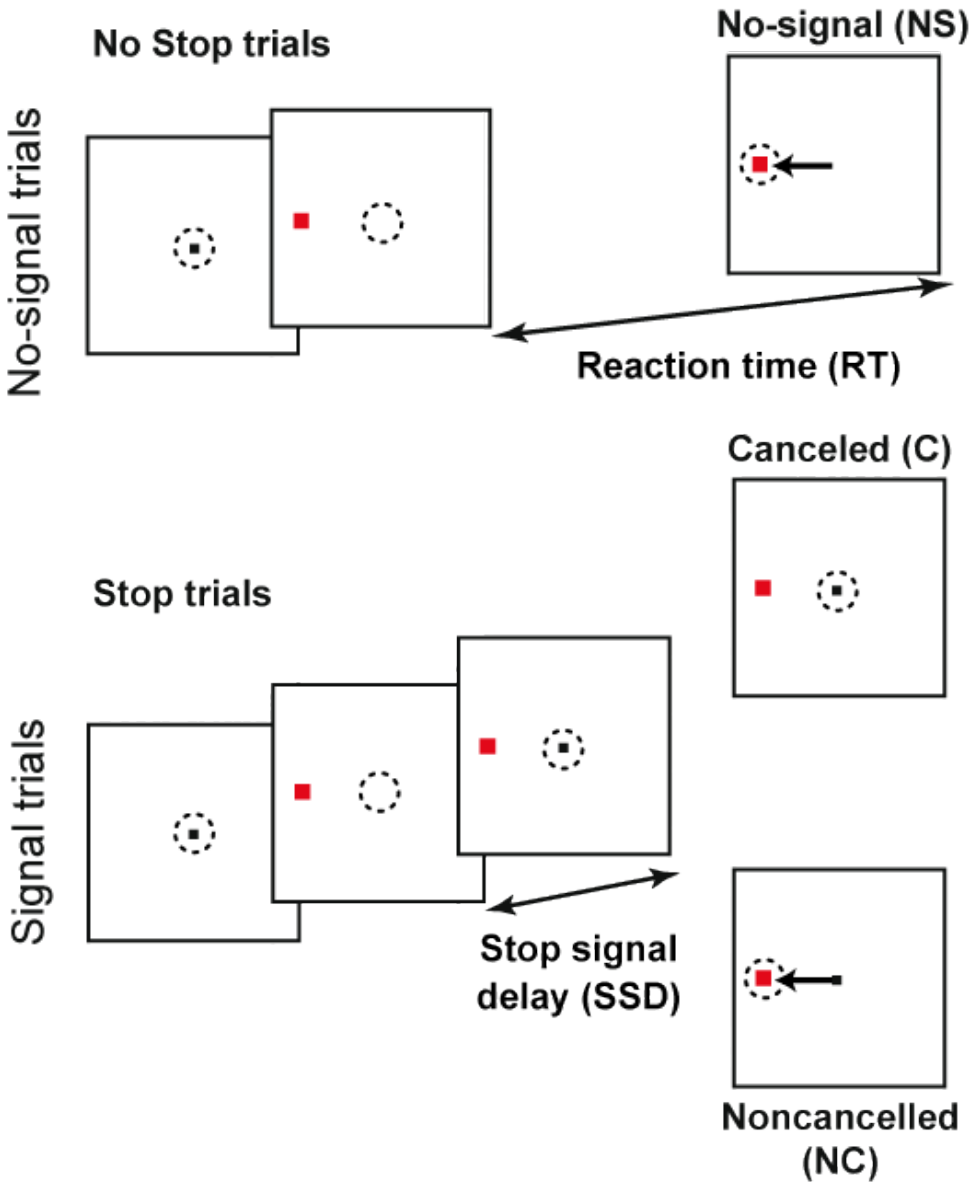
Théodore Géricault, 1791-1824

Stopping oculomotor plans in human and non-human primates

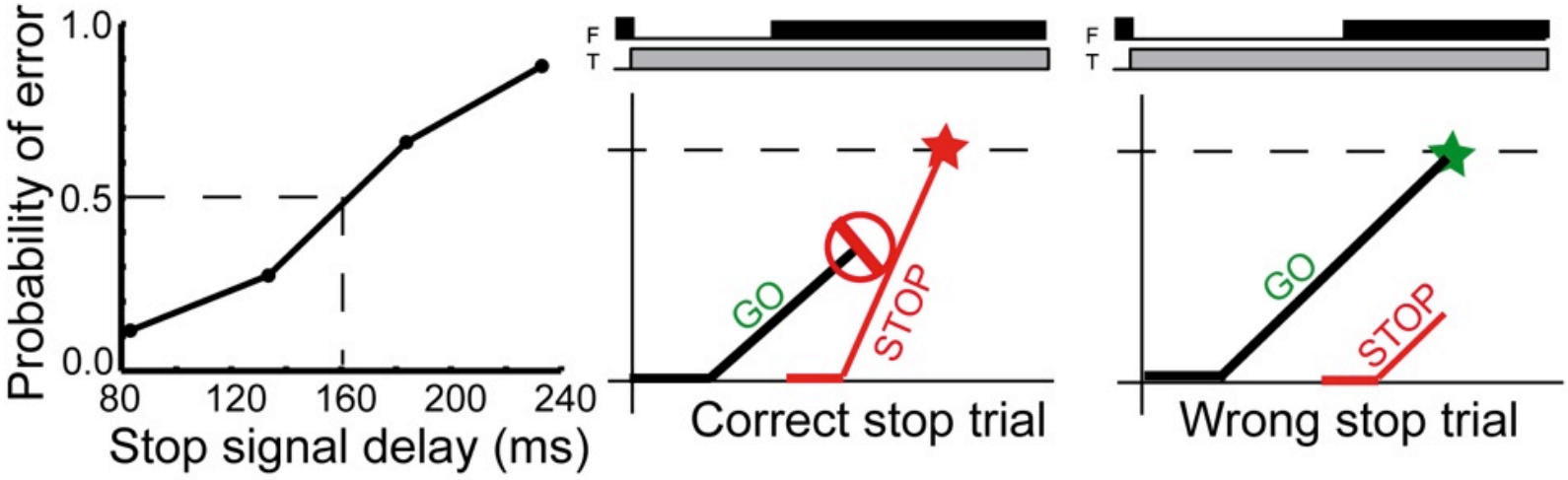
Stopping oculomotor plan



Countermanding Task

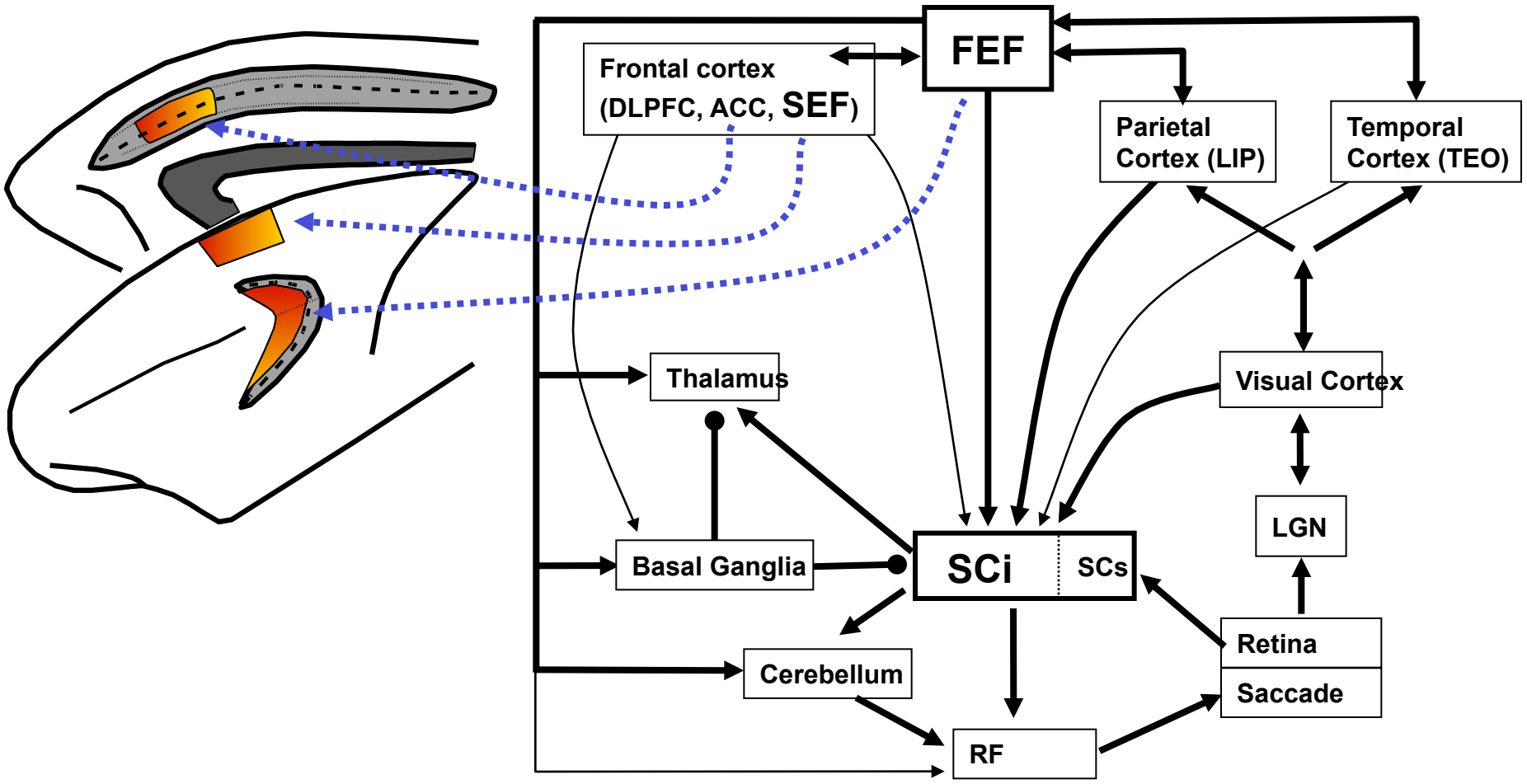


Race model of behavior



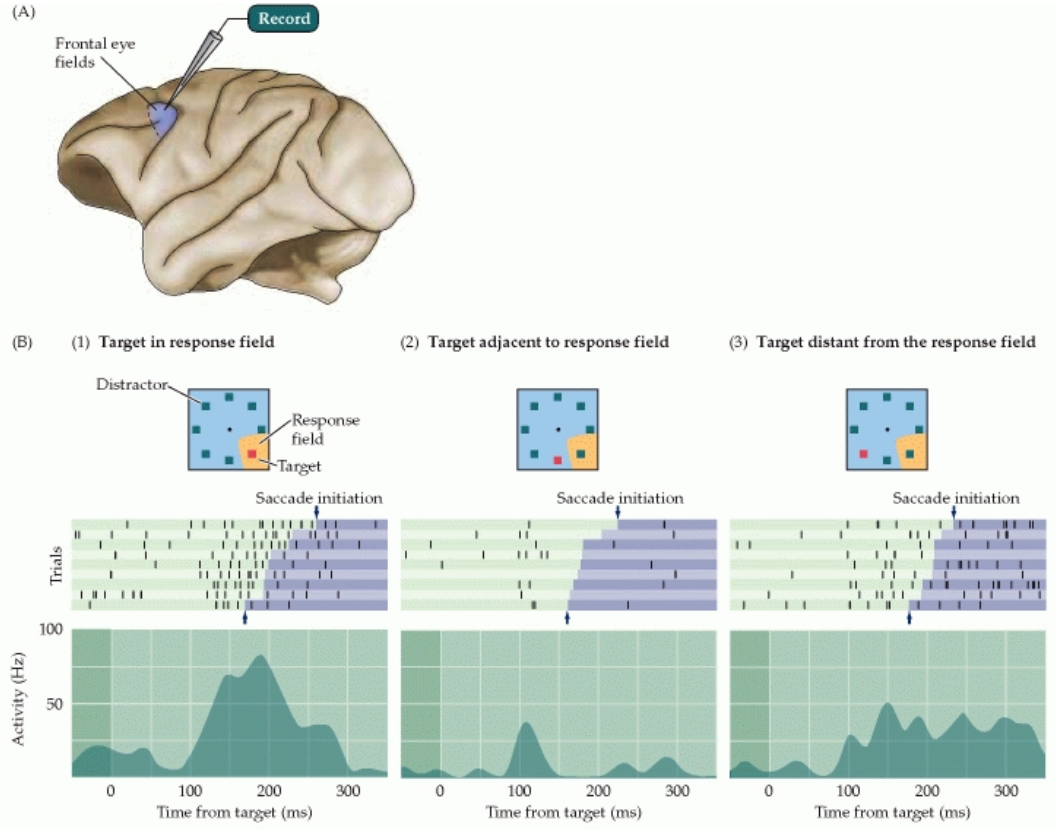
(Logan and Cowan, 1984)

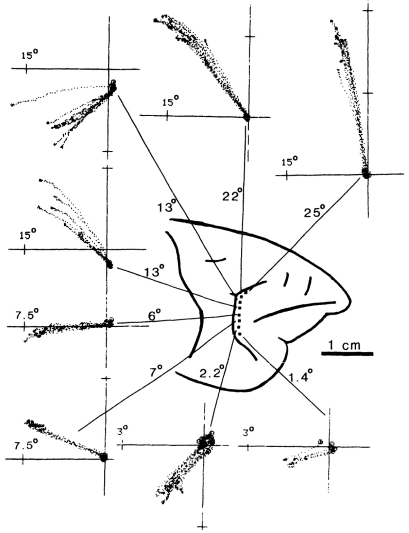
Saccades are produced by a distributed network

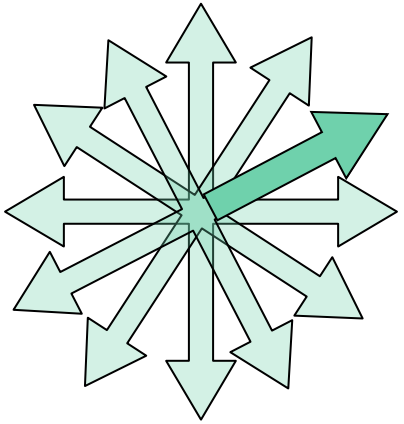


Spatial selectivity of the motor signal

- **Movement activity is spatially tuned.**

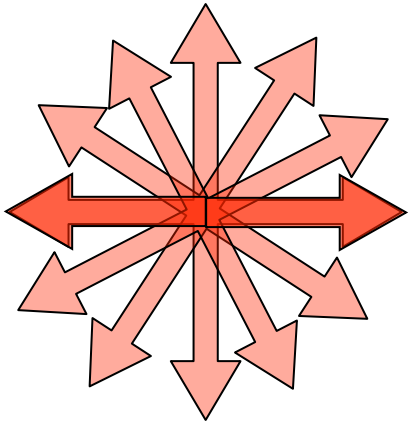






(e.g. Russo and Bruce, 1993)

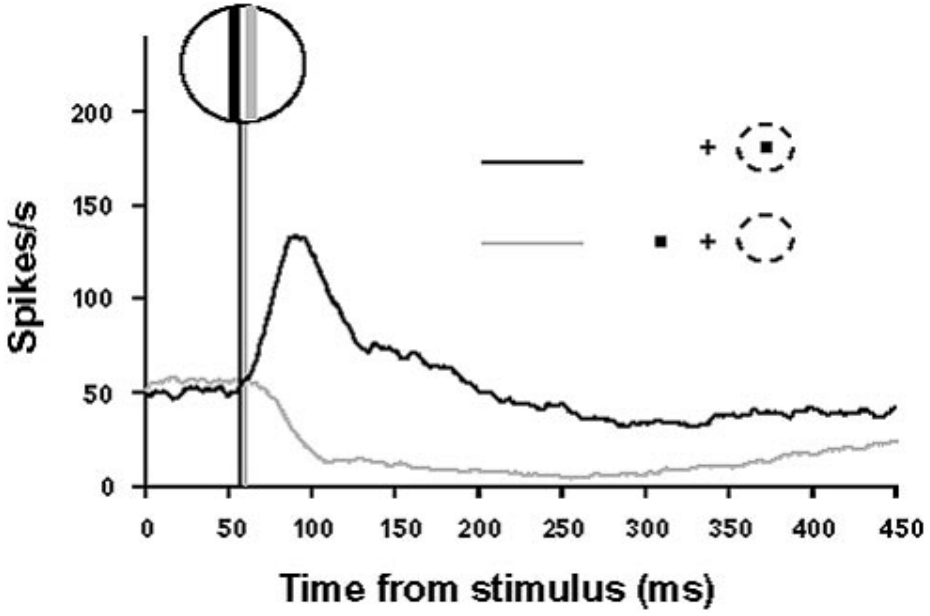
Selectivity of the inhibitory signal

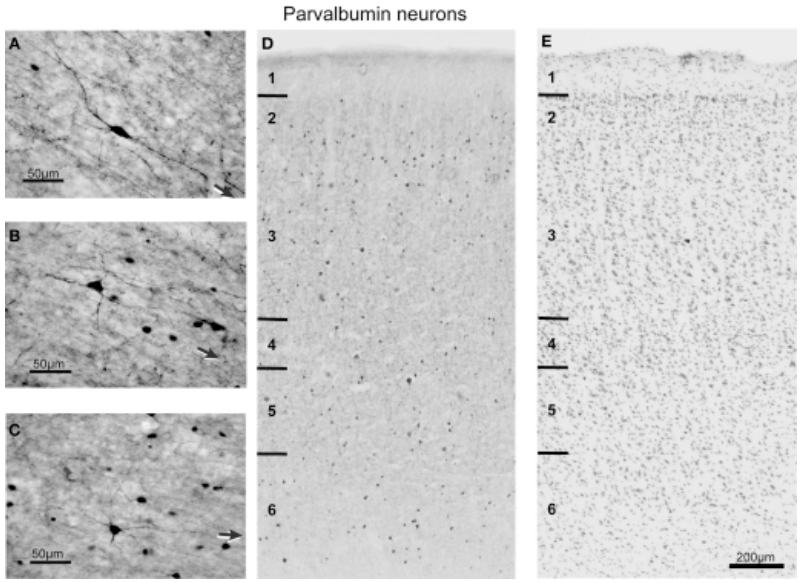


- **How selective is the inhibitory signal?**

Contralateral visual inhibition.
Inhibitory local connections.

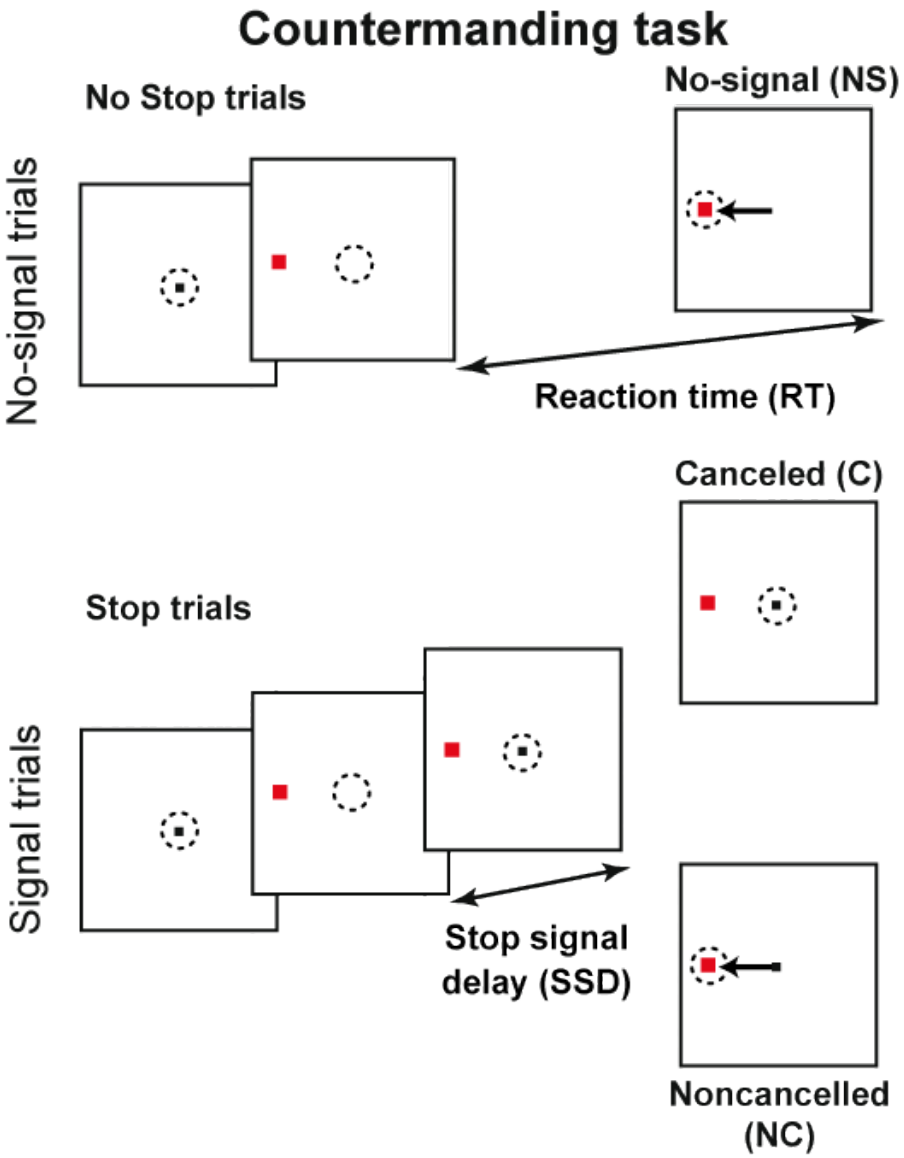
- **How flexible is the inhibitory signal?**



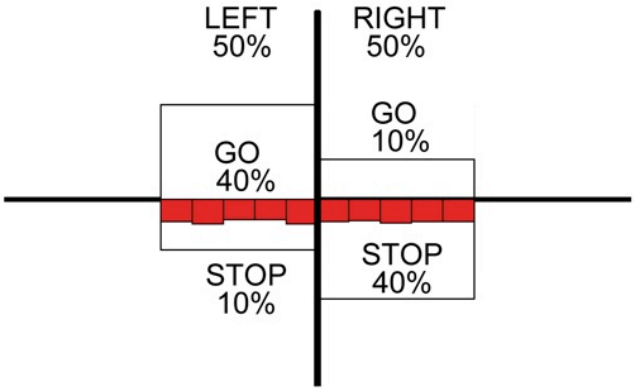


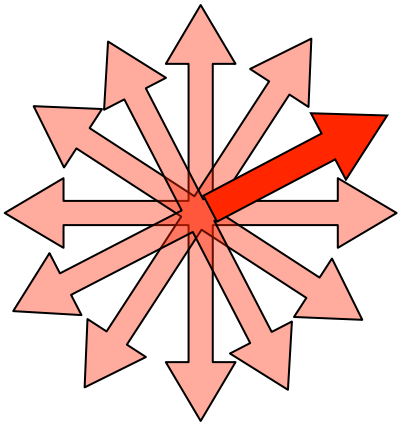
(Pouget et al., 2005, 2009)

Spatial selectivity of inhibitory signal(s)



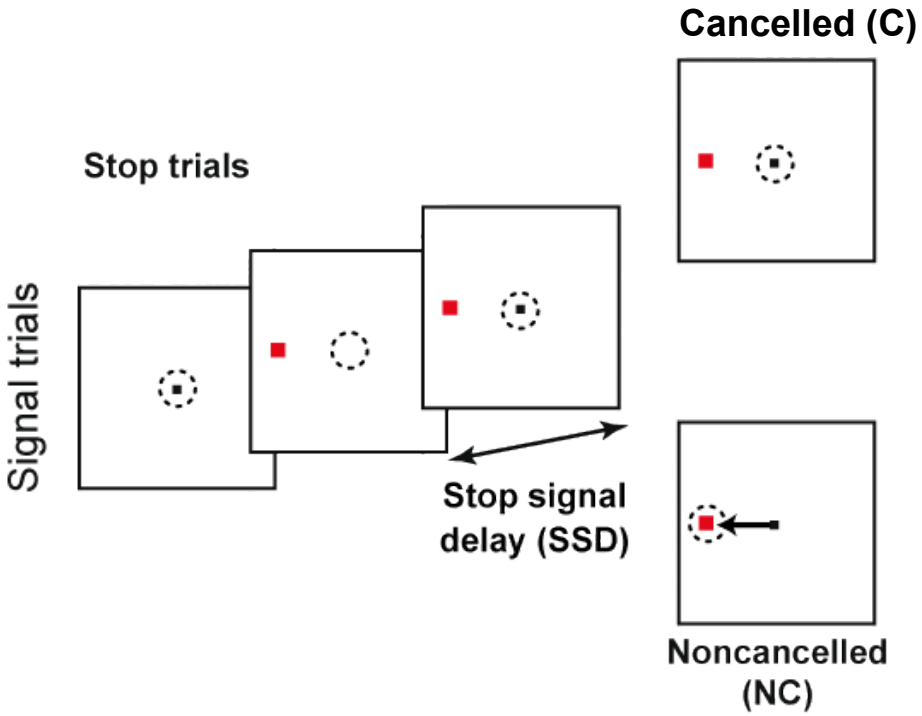
Total probability of STOP trials: 50%
Lateralized stop probability: 20 % left / 80% right

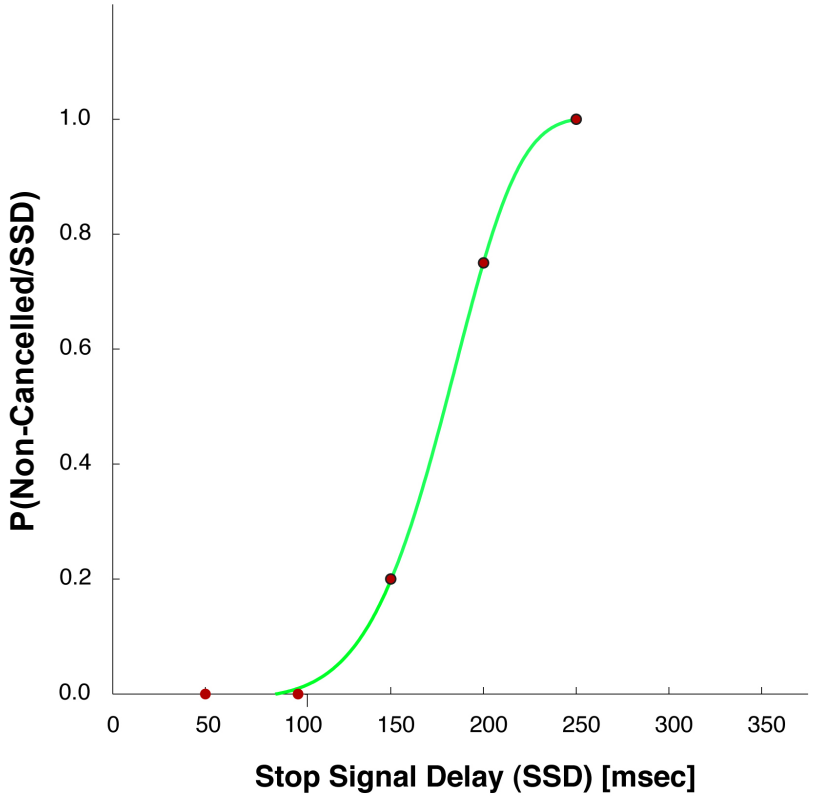




Inhibition function

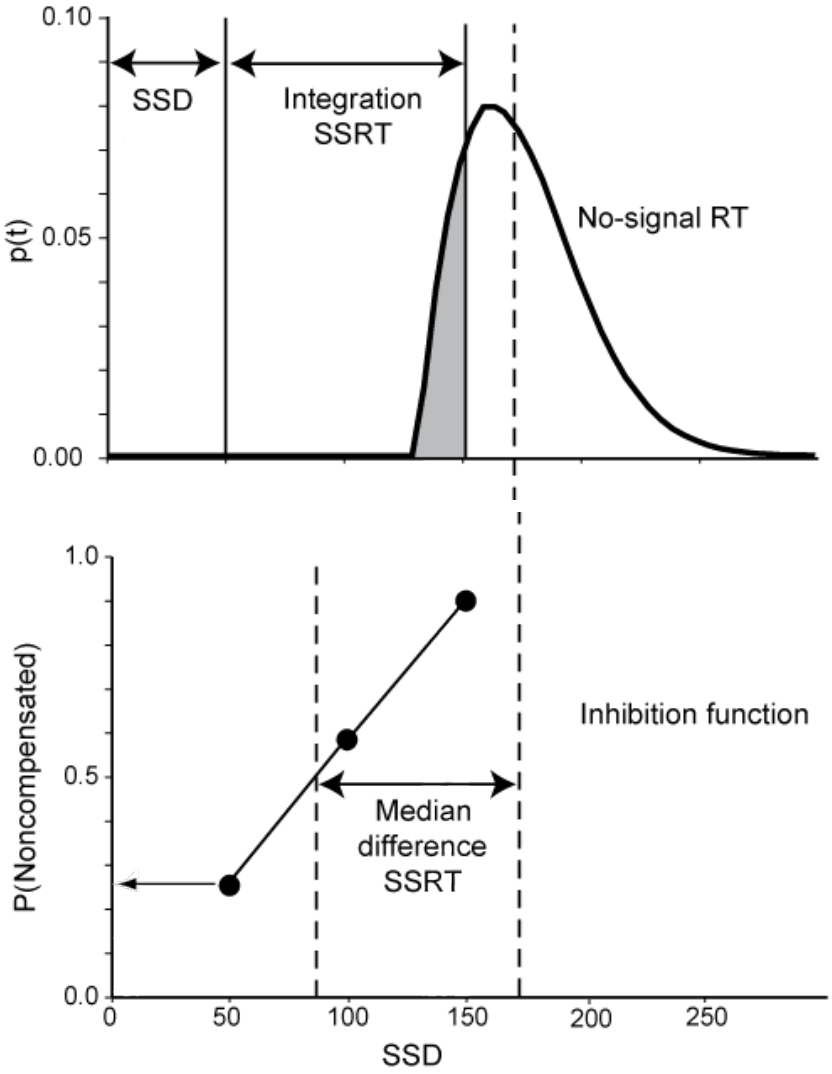
- How to calculate the inhibition function?

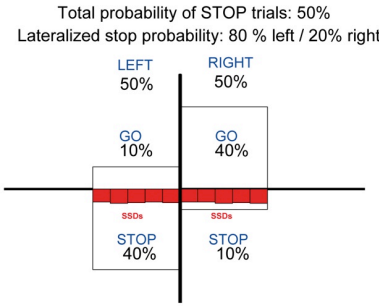




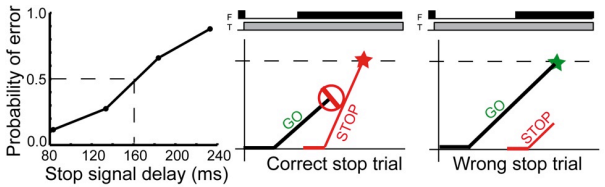
Stop Signal Reaction Time

- **Estimate the Stop Signal Reaction Time (SSRT)**





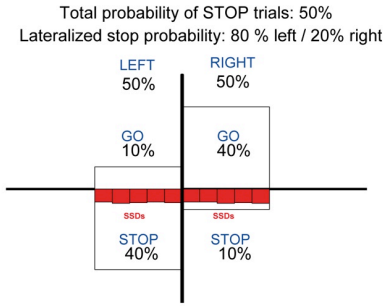
Race model of behavior



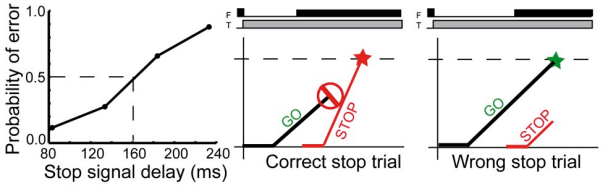
SSRT is the delay before, which saccades are cancelled and after, which saccades are produced…

Spatial selectivity of the inhibitory signal

- **How flexible is the inhibitory signal?**

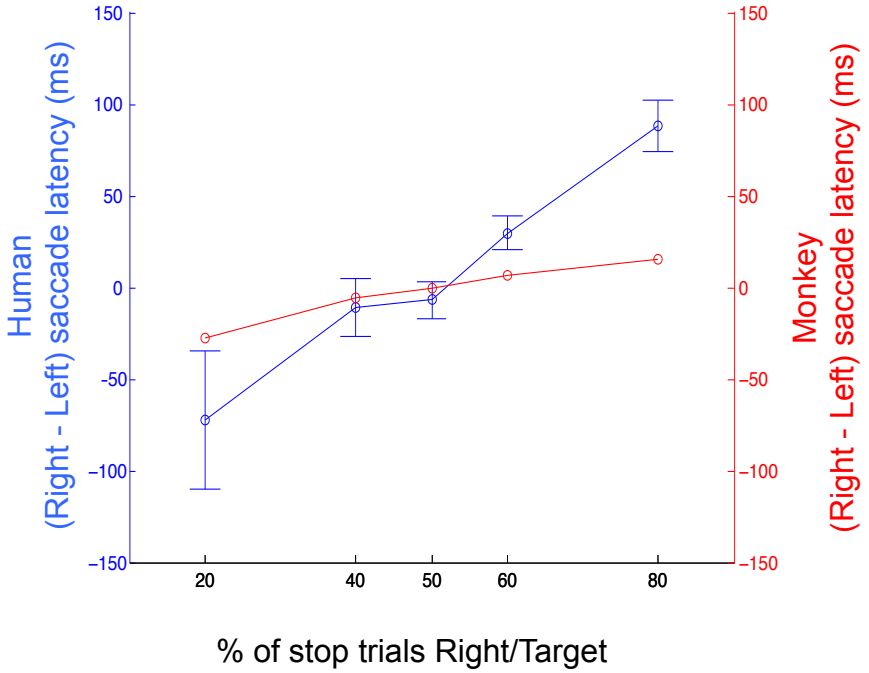


Race model of behavior



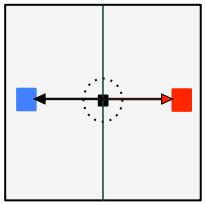
Selectivity of the inhibitory signal

Reaction times increase as function as the lateralized probability of stop trials increases

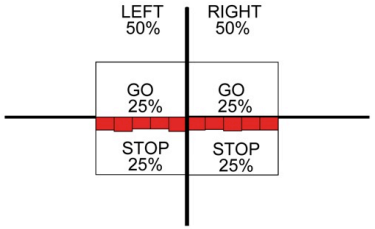


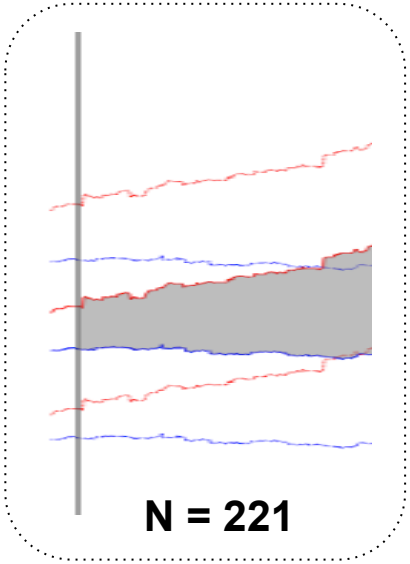
Variations of probability of stop trials are tracked by the inhibitory system. RTs and SSRT can be spatially tuned.

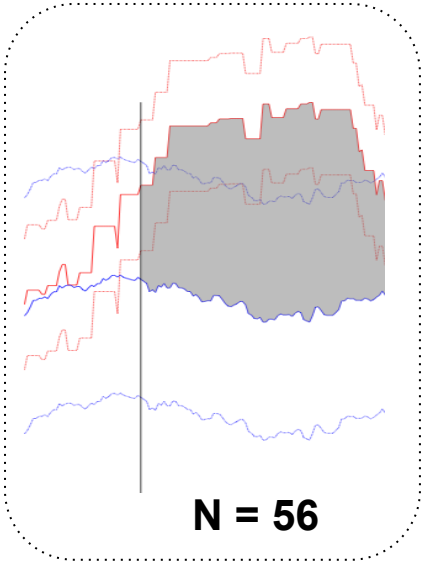
Time course of spatial selectivity…



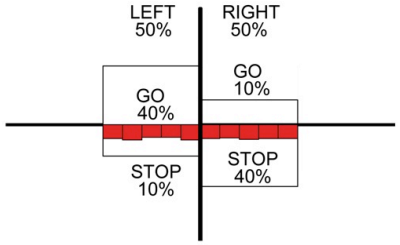
Total probability of STOP trials: 50%
Lateralized stop probability: 50 % left / 50% right





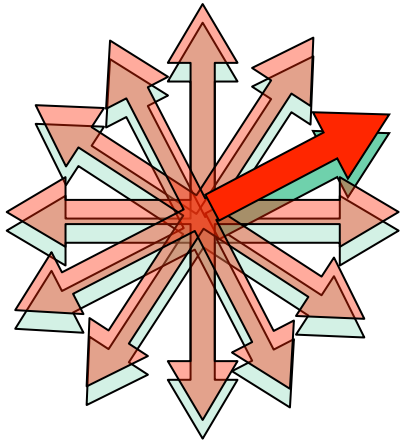


Total probability of STOP trials: 50%
Lateralized stop probability: 20 % left / 80% right



Variations of probability of stop trials are tracked with sub-optimal adjustments of response times...

Selectivity of the inhibitory signal

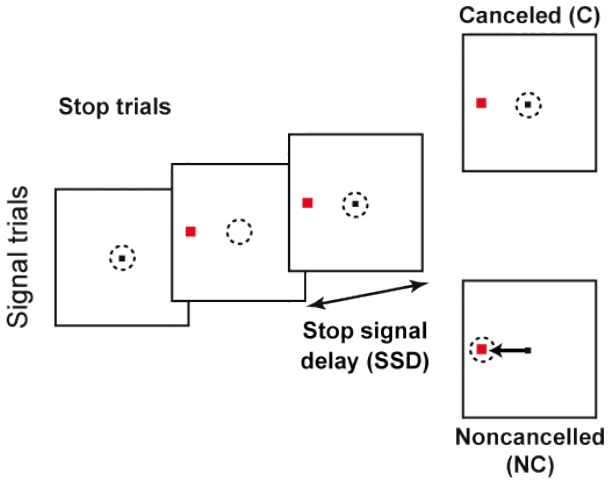


(1) The inhibitory signal is spatially tuned.

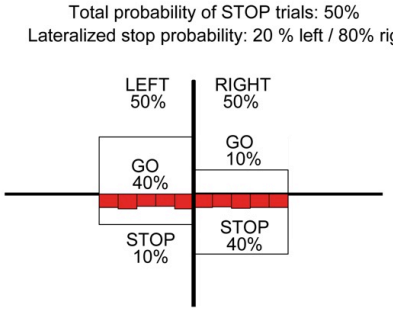
(2) Modest variations of probability of stop trials are tracked by the inhibitory system.

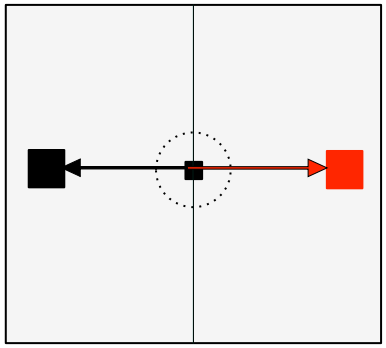
Spatial selectivity of the inhibitory signal

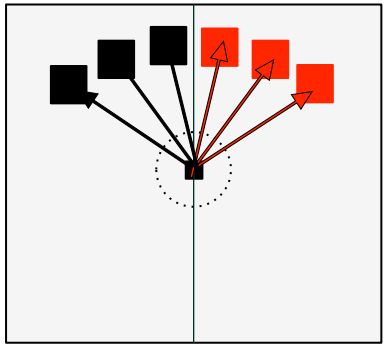
Spatial manipulations of probability of stop trials:

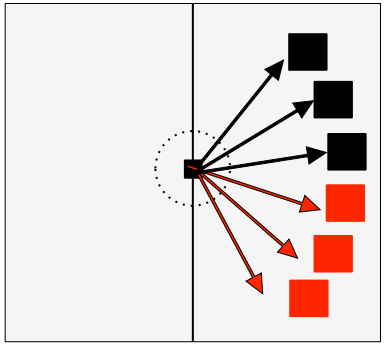


Target 1.5° x 1.5° at 12° eccentricity







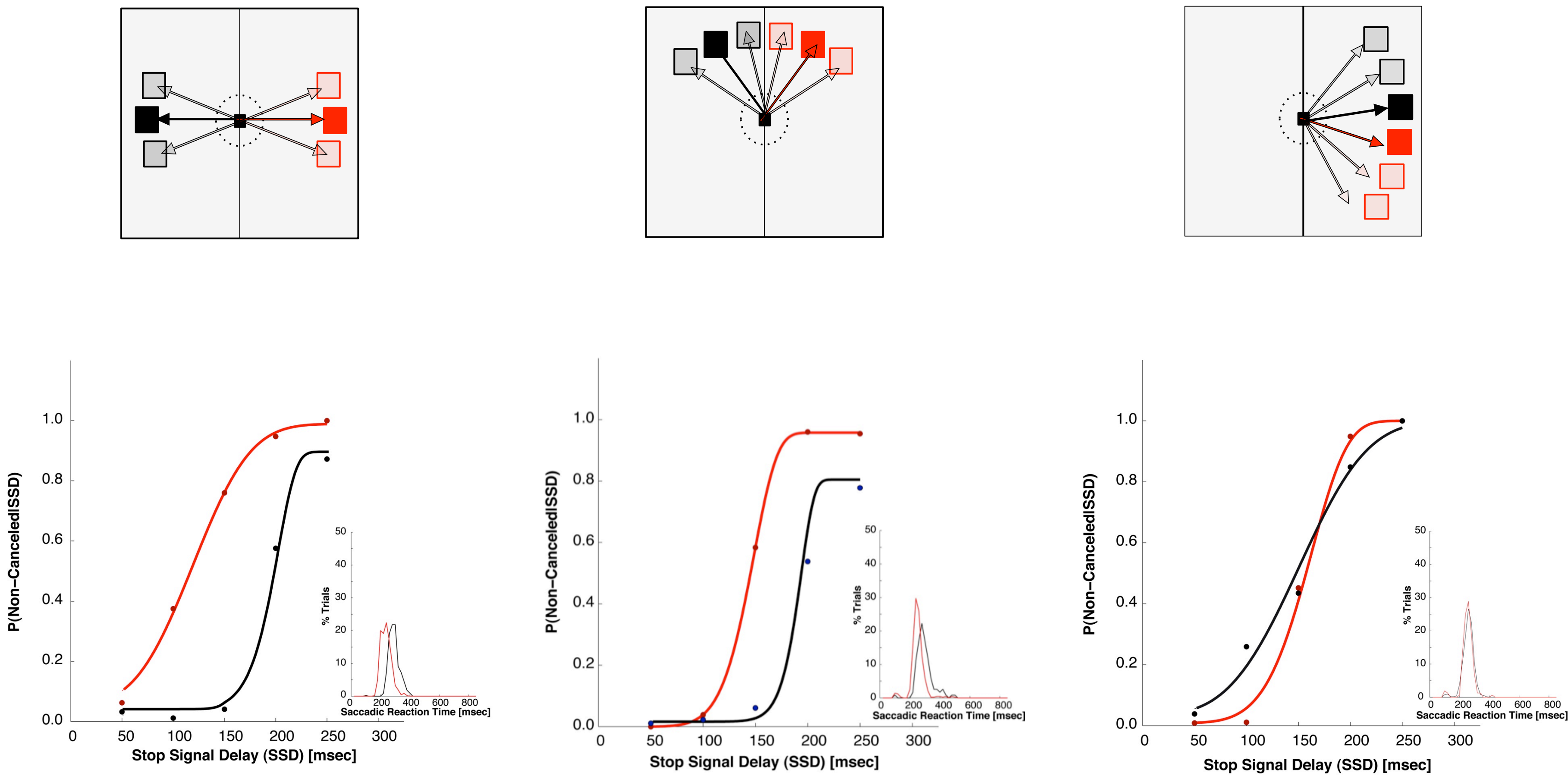


Opposite hemifield: 180°

Opposite hemifield: 30° / 5°

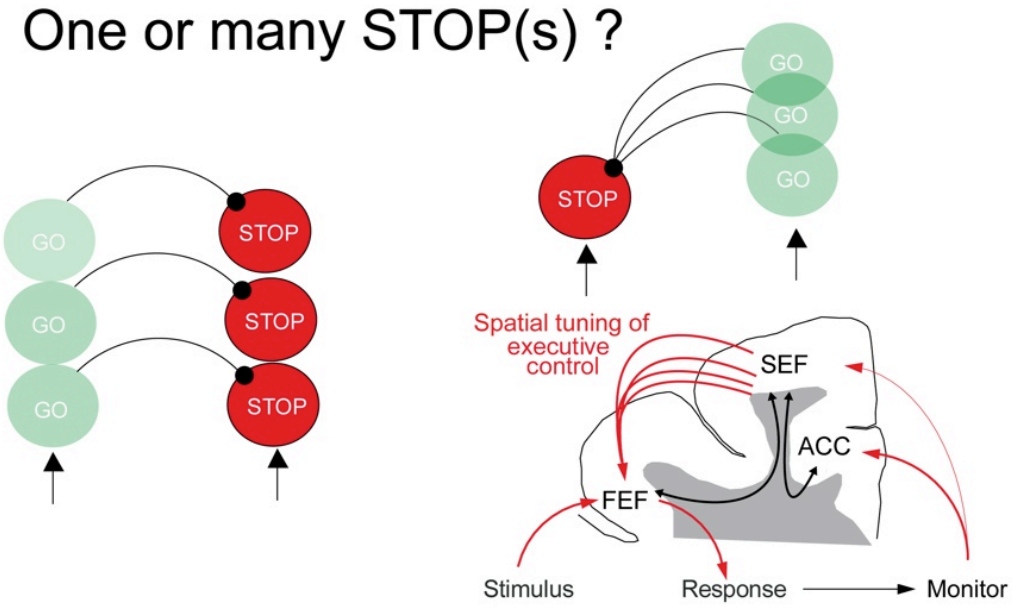
Same hemifield: 30° / 5°

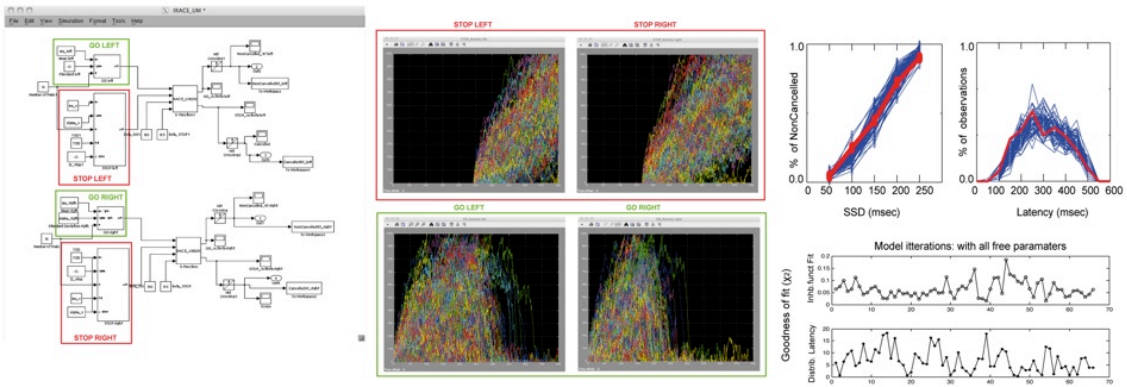
Spatial selectivity of the inhibitory signal



Probabilities of stop trials -associated with each target- are tracked unless targets are separated by less than 10° of visual angle.

What is controlling these inhibitory signals?





(Boucher et al., 2007)


Physiology - Experiments - Anatomy - Neurology -
20 mV
100 ms
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Institut du Cerveau
et de la Moelle épinière

Thank you