

The caudal fastigial nucleus and the control of gaze orientation :

lessons from perturbation experiments in the cat and monkey.

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CNRS

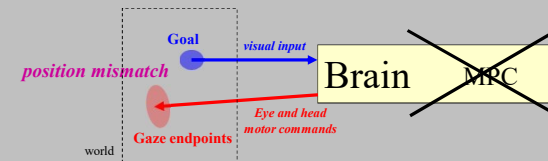
DYVA

Institut de Neurosciences Cognitives de la Méditerranée
Marseille, France

The medio-posterior cerebellum (MPC)

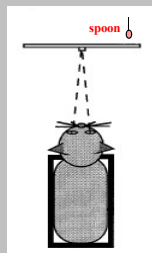
Dysfunction of MPC leads to gaze **dysmetria** i.e. it alters the spatial congruence between :

- the location of a visual event
- the endpoint of gaze shifts towards it

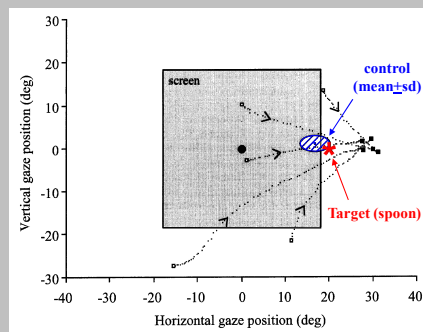


Studies in the head unrestrained cat

Experimental protocol



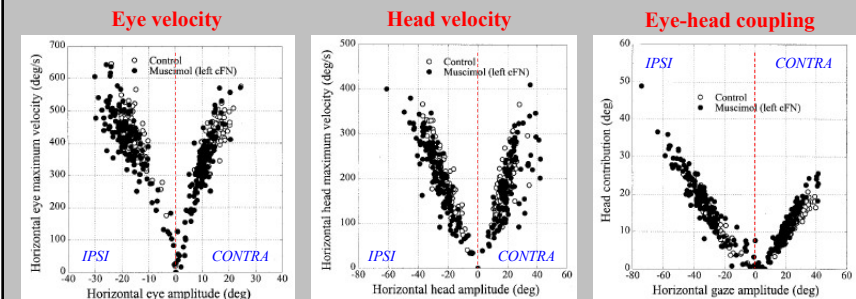
Muscimol injection in the right cFN (0.3 µg)



modified from Goffart & Pélisson JNP 1998

Studies in the head unrestrained cat

No sign of change in movement execution

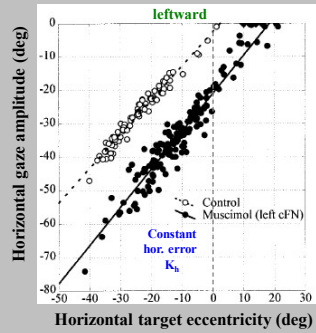


modified from Goffart Pélisson & Guillaume JNP 1998

Studies in the head unrestrained cat

Dysmetria of the horizontal component of gaze shifts

Ipsilesional movements

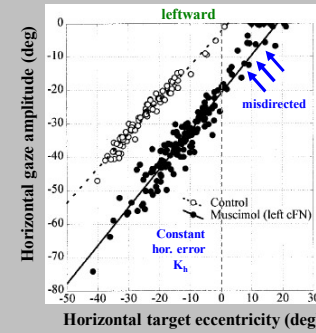


modified from Goffart & Pélisson JNP 1998

Studies in the head unrestrained cat

Dysmetria of the horizontal component of gaze shifts

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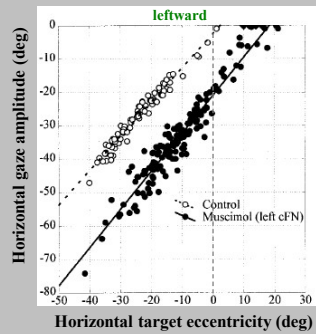


modified from Goffart & Pélisson JNP 1998

Studies in the head unrestrained cat

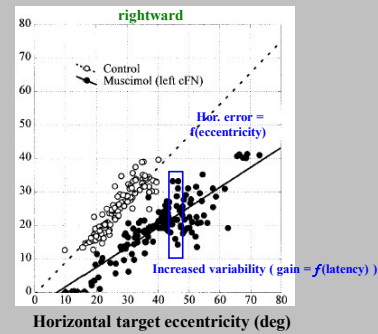
Dysmetria of the horizontal component of gaze shifts

Ipsilesional movements



modified from Goffart & Pélisson JNP 1998

Contralesional movements

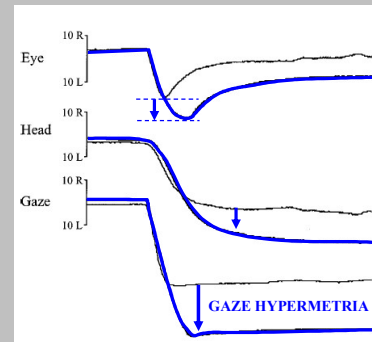


Goffart & Pélisson
J Physiol (London) 1997

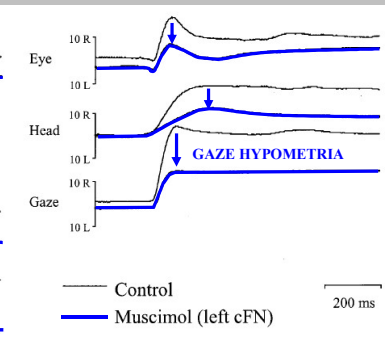
Studies in the head unrestrained cat

Dysmetric movements of the eyes and the head

Ipsilesional movements



Contralesional movements



modified from Goffart Pélisson & Guillaume JNP 1998

HYPOTHESIS (CAT) :

The dysmetria is due to an impaired specification of the goal for gaze shifts prior to their initiation

HYPOTHESIS (MONKEY) :

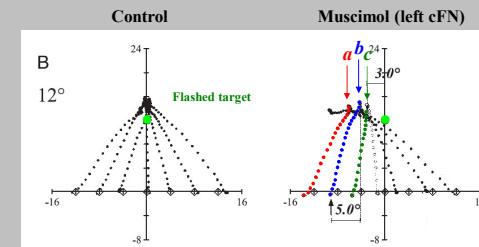
The dysmetria is due to an impairment in saccade execution (after their initiation)

(impaired acceleration / drive for contralesional saccades and impaired deceleration / brake / choke for ipsilesional ones)

Studies in the head restrained monkey

Dysmetria of the horizontal component of saccades

Contralesional saccades : hor. hypometria



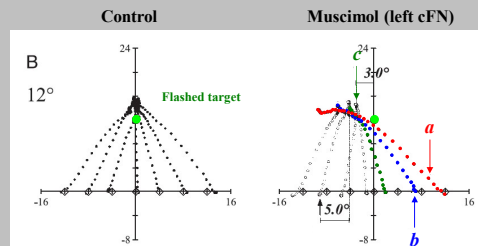
modified from Goffart, Chen & Sparks JNP 2004

Studies in the head restrained monkey

Dysmetria of the horizontal component of saccades

Contralesional saccades : hor. hypometria

Ipsilesional saccades : hor. hypermetria (non constant error)



modified from Goffart, Chen & Sparks JNP 2004

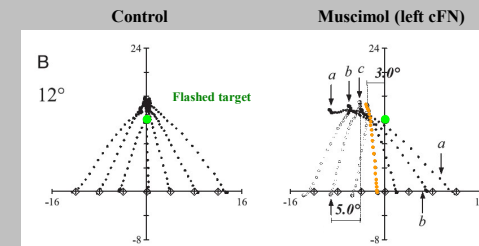
Studies in the head restrained monkey

Dysmetria of the horizontal component of saccades

Contralesional saccades : hor. hypometria

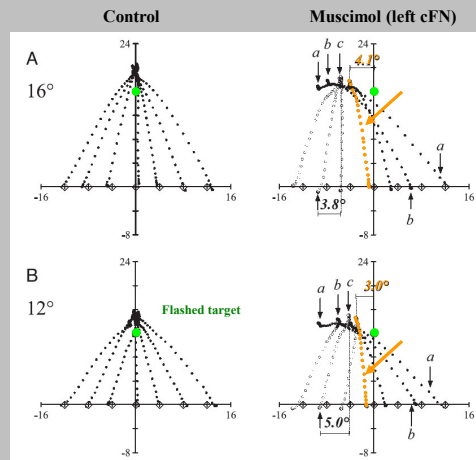
Ipsilesional saccades : hor. hypermetria (non constant error)

Vertical saccades : ipsipulsion



modified from Goffart, Chen & Sparks JNP 2004

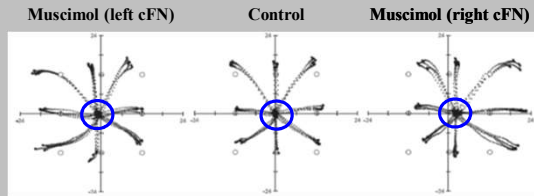
Studies in the head restrained monkey



modified from Goffart, Chen & Sparks JNP 2004

Studies in the monkey

target LEDs @ 145 cm : 0.25° visual angle, mesopic conditions



Goffart, Chen & Sparks, JNP 2004

Ipsilesional shift in the scatter of eye position during fixation = fixation offset (approx. 1°)

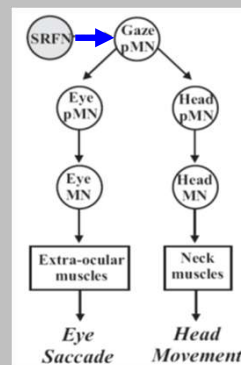
Magnitude of offset is similar in the head unrestrained monkey (see Quinet & Goffart JNP 2005)

IN THE CAT : larger magnitude of fixation offset (4.9 +/- 2.7°)

Is the dysmetria a disorder in orienting gaze?

- Disorder in gaze-related commands ?
 - > dysmetria eye + head **YES**
 - > eye-head coupling unchanged **YES**

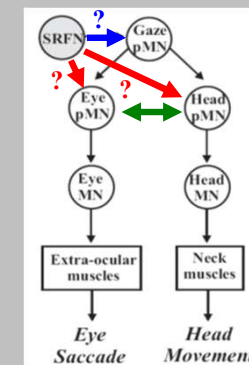
Studies in the cat *Goffart & Pélisson JNP 1998*
Goffart et al. JNP 1998



Is the dysmetria a disorder in orienting gaze or in orienting eye + head ?

- Disorder in gaze-related commands ?
 - > dysmetria eye + head **YES**
 - > eye-head coupling unchanged **YES**

Studies in the cat *Goffart & Pélisson JNP 1998*
Goffart et al. JNP 1998



Limitations :

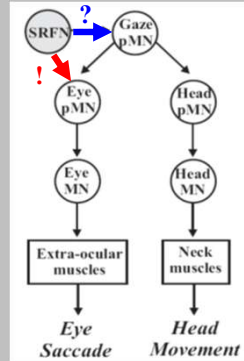
- spoon of food = target for the mouth
→ dysmetria for orienting the head
- Eye-head coupling preserved because unaffected by cFN inactivation

Studies in the head unrestrained monkey

Orienting toward a LED (target for the fovea)

- Disorder in gaze-related commands ?
 - > dysmetria eye + head ? **NO**
 - > eye-head coupling unchanged ? **NO**

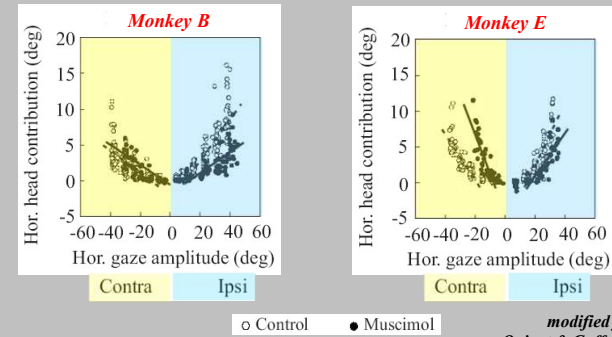
- Disorder in eye-related commands ?
 - > eye dysmetria only **YES**
 - > eye-head coupling changed **YES**
 - > Modifications affecting the eye and not the head **YES**



Quinet & Goffart JNP 2005
Quinet & Goffart JNP 2007

Eye-head coupling is modified

Ipsi : head contributes less
Contra : head contributes more

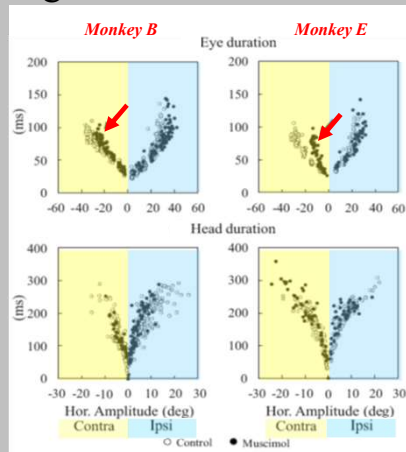


modified from
Quinet & Goffart JNP 2007

Slowing of contralesional eye saccades No change in head movement velocity

EYE

HEAD



modified from
Quinet & Goffart JNP 2007

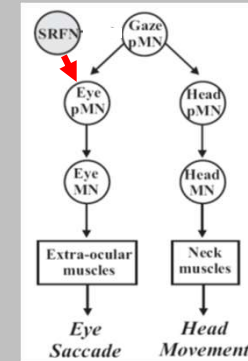
The saccade-related neurons in cFN exert an eye-related function in the primate

Results in the head unrestrained monkey

Pharmacological inactivation
Quinet & Goffart JNP 2005, 2007

Electrical microstimulation
Quinet & Goffart in revision

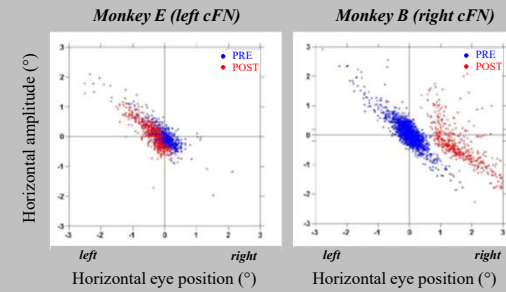
Anatomical studies
Robinson, Phillips & Fuchs JCN 1994



Fixation offset and **dysmetria** :

- > Two different deficits ?
- > One same deficit ?
(dysmetria of fixational saccades) ?

Fixational saccades are inaccurate



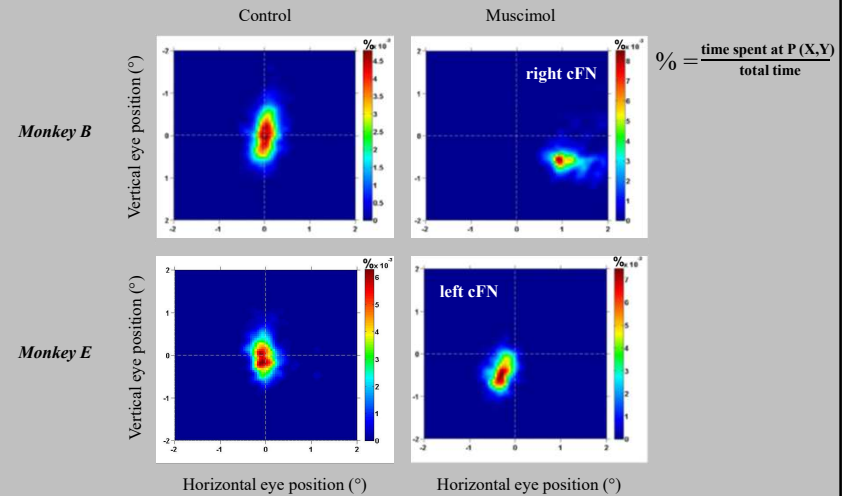
Guerrasio, Quinet, Büttner & Goffart
in preparation

Fixational saccades are inaccurate

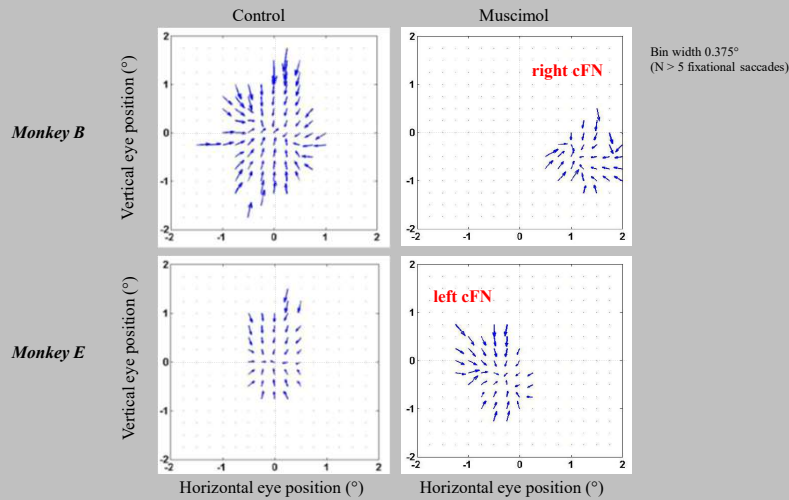
BUT

there are additional observations

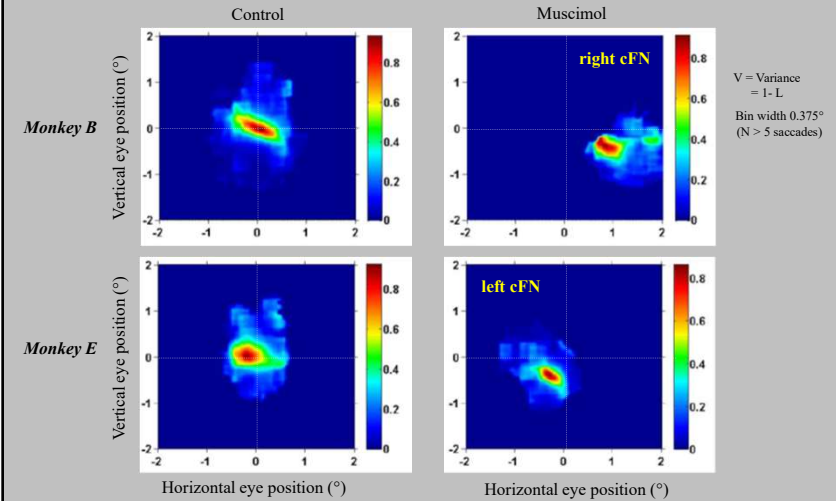
Fixation offset : spatio-temporal map



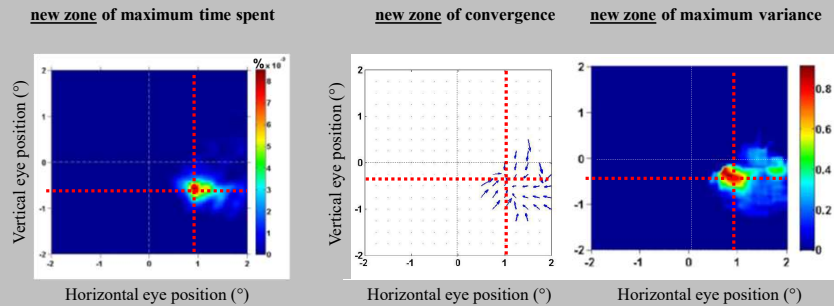
Directional field of fixational saccades



Directional field : zone of maximum variance

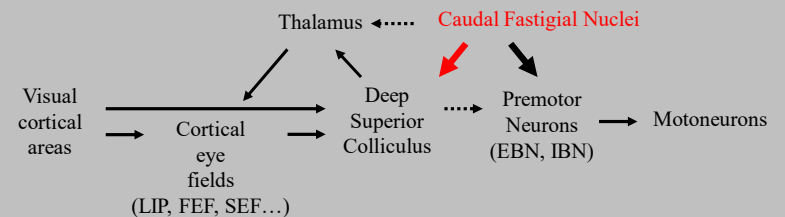


Fixational saccades become inaccurate BUT



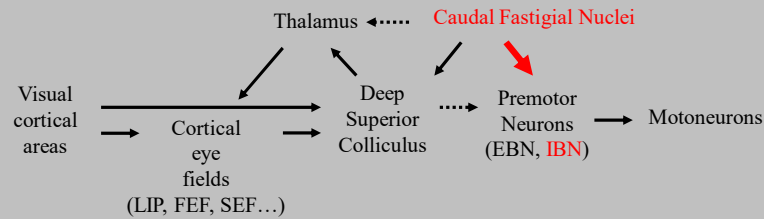
→ a new oculomotor encoding of the foveal target ?

Fastigio-tectal projections could participate in the oculomotor encoding of foveal targets



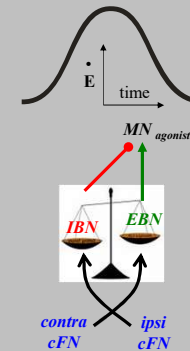
1. *May, Hartwich-Young, Nelson, Sparks & Porter Neuroscience 1990*
The **fastigiotectal pathway** is derived from cells in the caudal fastigial nucleus and projects bilaterally to the rostral end of the intermediate gray layer.
2. *Quinet & Goffart JNP 2005*
Magnitude of fixation offset (~1°) is similar between the **head restrained** and **head unrestrained** conditions → gaze offset
3. *Hafed, Goffart & Krauzlis JN 2008*
Muscimol injection in the **rostral** portion of the deep Superior Colliculus leads to a **fixation offset**

Fastigio-reticular projections would participate in the control of the horizontal amplitude of saccades



1. *Barton, Nelson, Gandhi & Sparks JNP 2003*
Partial inactivation of the paramedian pontine reticular formation (EBN region) does not alter saccade accuracy
2. *Kojima & Iwamoto, Robinson, Noto & Yoshida JNP 2008*
During saccade adaptation (change in amplitude), IBN discharge during off-direction saccades change
3. *Does partial inactivation of the IBN region alter saccade accuracy?*

Fastigial control of the balance between EBNs and IBNs



For every saccade, the bilateral cFN activity regulates the balance of activity between EBNs and IBNs innervating agonist MN (van Gisbergen, Robinson & Gielen JNP 1981)

IBNs are not part of (downstream from) the feedback control of saccade amplitude (Goffart, Chen & Sparks JNP 2004).

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