Motility Disorders: Overview

Which cranial nerves innervate the extraocular muscles (EOMs)?
Motility Disorders: Overview

CN3  CN6  CN4

Which cranial nerves innervate the extraocular muscles (EOMs)?
Motility Disorders: Overview

What is the name for the collections of neurons that give rise to each of these cranial nerves? (This is not a trick question--the answer is as obvious as it seems.)
Motility Disorders: Overview

What is the name for the collections of neurons that give rise to each of these cranial nerves? (This is not a trick question--the answer is as obvious as it seems.)

CN3 Nucleus  CN6 Nucleus  CN4 Nucleus
(As we shall soon see, this ‘nuclear level’ serves as a useful point around which to organize the EOM-control pathway.)
Motility Disorders: Overview

Um, Dr Flynn, 4 comes before 6. Why are these nuclei listed out of order?

CN3 Nucleus
CN6 Nucleus
CN4 Nucleus
Motility Disorders: Overview

Um, Dr Flynn, 4 comes before 6. Why are these nuclei listed out of order? This will be explained shortly.
Motility Disorders: Overview

With respect to pathology of the EOM control pathways, there are four major ‘locations.’ One of these (the nuclear) has been identified already. What are the other three? (Hint: Their names reflect the relationship each has to the nuclear level.)
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With respect to pathology of the EOM control pathways, there are four major ‘locations.’ One of these (the nuclear) has been identified already. What are the other three? (Hint: Their names reflect the relationship each has to the nuclear level.)

…you may not be with this one, although you’ll agree it makes sense in context. (Further, and importantly, it is used in the BCSC Neuro book.)
With respect to pathology of the EOM control pathways, there are four major ‘locations.’ One of these (the nuclear) has been identified already. What are the other three? (Hint: Their names reflect the relationship each has to the nuclear level.)

…you may not be with this one, although you’ll agree it makes sense in context. (Further, and importantly, it is used in the BCSC Neuro book.)
Motility Disorders: Overview

The *supranuclear pathways* consists of inputs to the nuclei from centers in the cortex, cerebellum, vestibular system, etc.
Motility Disorders: Overview

**Supranuclear**

The *supranuclear pathways* consists of inputs to the nuclei from centers in the cortex, cerebellum, vestibular system, etc. These locations are ‘supra’ in that they carry signals to the nuclei.

**Infranuclear**
Are lesions of the CN3 nucleus commonly encountered in clinical practice?
Are lesions of the CN3 nucleus commonly encountered in clinical practice?
No, they are rare
Motility Disorders: Overview

Are lesions of the CN4 nucleus commonly encountered in clinical practice?
Motility Disorders: Overview

Supranuclear

Nuclear

CN3 Nucleus

CN6 Nucleus

Internuclear

CN4 Nucleus

Are lesions of the CN4 nucleus commonly encountered in clinical practice?
No, these are even rarer
Motility Disorders: Overview

Are lesions of the CN6 nucleus commonly encountered in clinical practice?
Motility Disorders: Overview

Are lesions of the CN6 nucleus commonly encountered in clinical practice?

While not common, they are a well-known clinical entity.
Motility Disorders: Overview

Which two nuclei share an internuclear connection that is of well-established clinical importance?
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Which two nuclei share an internuclear connection that is of well-established clinical importance?
3 and 6 (Apropos a previous question: This is why the nuclei are not in numeric order!)
Motility Disorders: Overview

What is the name of the internuclear pathway connecting the CN3 and CN6 nuclei?
What is the name of the internuclear pathway connecting the CN3 and CN6 nuclei? The medial longitudinal fasciculus (MLF).
The infranuclear pathway consists of everything below the nuclei: the axons as they run from the nuclei to the neuromuscular junction; the junction itself; and finally the EOMs themselves. (There are many subsections in this pathway; we will identify them shortly.)
This slide summarizes the basic organization of EOM control.

When you encounter a pt with a motility issue, your first thought should be: Is this deficit nuclear, supranuclear, internuclear, or infranuclear in origin?
This slide summarizes the basic organization of EOM control. When you encounter a pt with a motility issue, your first thought should be: Is this issue **nuclear**, **supranuclear**, **internuclear**, or **infranuclear** in origin?
Next we will look at each level/pathway in more detail.

This slide summarizes the basic organization of EOM control. When you encounter a pt with a motility issue, your first thought should be: Is this issue **nuclear**, **supranuclear**, **internuclear**, or **infranuclear** in origin?
From where to where do the fascicles of the MLF run?

**Motility Disorders: Overview**

**Supranuclear**

**Nuclear**

**Infranuclear**

CN3 Nucleus  \[\text{MLF}\]  CN6 Nucleus

**From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus**

**What purpose does the MLF serve?**

To allow coordinated lateral gaze of both eyes

**How does the MLF facilitate lateral gaze coordination?**

By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into ipsilateral lateral gaze together
Motility Disorders: Overview

Supranuclear

From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the CN3 nucleus

Nuclear

MLF

CN3 Nucleus → CN6 Nucleus

ipsi- v contralateral

Infranuclear

CN4 Nucleus
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the contralateral CN3 nucleus
From where to where do the fascicles of the MLF run? From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its subnucleus.
From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus.
From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus

What purpose does the MLF serve?
From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus

What purpose does the MLF serve?
To allow coordinated lateral gaze of both eyes
Motility Disorders: Overview

**Supranuclear**

**Nuclear**

**Infranuclear**

---

**From where to where do the fascicles of the MLF run?**
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus.

**What purpose does the MLF serve?**
To allow coordinated lateral gaze of both eyes.

**How does the MLF facilitate lateral gaze coordination?**
**Motility Disorders: Overview**

**Supranuclear**

**Nuclear**

**Infranuclear**

**From where to where do the fascicles of the MLF run?**
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus

**What purpose does the MLF serve?**
To allow coordinated lateral gaze of both eyes

**How does the MLF facilitate lateral gaze coordination?**
By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together
Motility Disorders: Overview

**Supranuclear**

- From where to where do the fascicles of the MLF run?
  - "So if the depicted CN6 nucleus is on a pt’s left side, the depicted MLF runs to her right MR subnucleus."

**Nuclear**

- How does the MLF facilitate lateral gaze coordination?
  - "By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together."

**Infranuclear**

- What purpose does the MLF serve?
  - "To allow coordinated lateral gaze of both eyes."
From where to where do the fascicles of the MLF run?

So if the depicted CN6 nucleus is on a pt’s left side, the depicted MLF runs to her right MR subnucleus. When the pt endeavors to look to her left, the left CN6 nucleus causes the left LR to contract while also sending impulses (via the MLF) to her right MR subnucleus, which in turn causes the right MR to contract simultaneously—and both eyes shift into left gaze in coordinated fashion.

By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together.
Motility Disorders: Overview

Supranuclear

Nuclear

From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus.

What effect does a lesion of the MLF have on lateral gaze?
If the MLF is bagged, the impulse intended to result in the firing of the contralateral MR is affected…but the impulse to the ipsilateral lateral rectus (LR) gets through unscathed. Thus, attempted lateral gaze results in appropriate abduction of the ipsilateral eye, but impaired adduction of the contralateral eye.

What purpose does the MLF serve?
To allow coordinated lateral gaze of both eyes.

How does the MLF facilitate lateral gaze coordination?
By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together.
**Motility Disorders: Overview**

**Supranuclear**

**Nuclear**

**Infranuclear**

*From where to where do the fascicles of the MLF run?*

From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus.

*What effect does a lesion of the MLF have on lateral gaze?*

If the MLF is bagged, the impulse intended to result in the firing of the contralateral MR is affected...

*How does the MLF facilitate lateral gaze coordination?*

By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together.

**CN3 Nucleus**

**CN6 Nucleus**

**CN4 Nucleus**

**MLF**

**LR**

**MR**
From where to where do the fascicles of the MLF run? From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus.

What effect does a lesion of the MLF have on lateral gaze? If the MLF is bagged, the impulse intended to result in the firing of the contralateral MR is affected…but the impulse to the ipsilateral LR gets through unscathed. Thus, attempted lateral gaze results in appropriate abduction of the ipsilateral eye, but impaired adduction of the contralateral eye.

How does the MLF facilitate lateral gaze coordination? By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together.
Motility Disorders: Overview

Supranuclear

Nuclear

From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus.

What effect does a lesion of the MLF have on lateral gaze?
If the MLF is bagged, the impulse intended to result in the firing of the contralateral MR is affected…but the impulse to the ipsilateral LR gets through unscathed. Thus, attempted lateral gaze results in normal ABduction of the ipsilateral eye, but impaired ADduction of the contralateral eye.

How does the MLF facilitate lateral gaze coordination?
By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together.
Motility Disorders: Overview

Supranuclear

From where to where do the fascicles of the MLF run?
From the CN6 nucleus to the contralateral CN3 nucleus—specifically, to its medial rectus (MR) subnucleus.

What purpose does the MLF serve?
To allow coordinated lateral gaze of both eyes.

How does the MLF facilitate lateral gaze coordination?
By causing the contralateral MR to fire simultaneously with the ipsilateral lateral rectus (LR), thus ensuring both eyes turn into lateral gaze together.

What effect does a lesion of the MLF have on lateral gaze?
If the MLF is bagged, the impulse intended to result in the firing of the contralateral MR is affected...but the impulse to the ipsilateral LR gets through unscathed. Thus, attempted lateral gaze results in normal abduction of the ipsilateral eye, but impaired adduction of the contralateral eye.

This is an internuclear ophthalmoplegia (INO; see slide-set N20)
Next we will turn our attention to the \textit{infranuclear pathway}, which proceeds in an ordered fashion from the nuclei to the extraocular muscles themselves.
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

The first portion of the nerve as it leaves the nucleus, but before leaving the substance of the brainstem
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

The first portion of the nerve as it leaves the nucleus, but before leaving the substance of the brainstem
The cranial-nerve nuclei and their fascicles are located within the brainstem. Given this, it shouldn’t come as a surprise that, generally speaking, lesions of the nuclei and/or fascicles do not present with isolated EOM abnormalities; ie, the ophthalmoparesis is almost always accompanied by nonocular signs and symptoms of CNS damage.
The cranial-nerve nuclei and their fascicles are located within the brainstem. Given this, it shouldn’t come as a surprise that, generally speaking, lesions of the nuclei and/or fascicles do not present with isolated EOM abnormalities; ie, the ophthalmoparesis is almost always accompanied by nonocular signs and symptoms of CNS damage.

*What general term is used to describe conditions presenting with motility dysfunction secondary to fascicle damage + non-ocular CNS findings?*
The cranial-nerve nuclei and their fascicles are located within the brainstem. Given this, it shouldn’t come as a surprise that, generally speaking, lesions of the nuclei and/or fascicles do not present with isolated EOM abnormalities; ie, the ophthalmoparesis is almost always accompanied by nonocular signs and symptoms of CNS damage.

What general term is used to describe conditions presenting with motility dysfunction 2ndry to fascicle damage + non-ocular CNS findings?

Fascicular syndrome
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

CN3 Nucleus

CN6 Nucleus

CN4 Nucleus

MLF

Speaking of fascicular syndromes… the Neuro book describes four involving the CN3 fascicle, and two for the CN6. Name them.

CN3 fascicular syndromes:
--
--
--
--
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Fascicular

Speaking of fascicular syndromes... the Neuro book describes four involving the CN3 fascicle, and two for the CN6. Name them.

CN3 fascicular syndromes:
-- Weber syndrome
-- Benedikt syndrome
-- Claude syndrome
-- Nothnagel syndrome
Speaking of fascicular syndromes…the Neuro book describes four involving the CN3 fascicle, and two for the CN6. Name them.

CN3 fascicular syndromes:
--Weber syndrome
--Benedikt syndrome
--Claude syndrome
--Nothnagel syndrome

CN6 fascicular syndromes:
--
--
Speaking of fascicular syndromes...the Neuro book describes four involving the CN3 fascicle, and two for the CN6. Name them.

**CN3 fascicular syndromes:**
--Weber syndrome
--Benedikt syndrome
--Claude syndrome
--Nothnagel syndrome

**CN6 fascicular syndromes:**
--Foville syndrome
--Millard-Gubler syndrome
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Fascicular

Speaking of fascicular syndromes... the Neuro book describes four involving the CN3 fascicle, and two for the CN6. Name them.

CN3 fascicular syndromes:
--Weber syndrome
--Benedikt syndrome
--Claude syndrome
--Nothnagel syndrome

CN6 fascicular syndromes:
--Foville syndrome
--Millard-Gubler syndrome

The fascicular syndromes are addressed in detail in their own slide-set (N14)
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Fascicular

The next portion commences once the fascicles exit the brainstem--now they’re a nerve. Named for the space in which the nerves travel.
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

The next portion commences once the fascicles exit the brainstem--now they’re a nerve. Named for the space in which the nerves travel.
Which cause of ophthalmoplegia, common among vasculopathies, is attributed to damage occurring to the subarachnoid segments?
Which cause of ophthalmoparesis—common among vasculopathies—is attributed to damage occurring to the subarachnoid segments? 

**Ischemic palsies** (i.e., a so-called ‘diabetic third’ or ‘diabetic sixth’)
The nerves then leave the subarachnoid space by diving into a space of a very different sort. This portion is named for the space entered into.
The nerves then leave the subarachnoid space by diving into a space of a very different sort. This portion is named for the space entered into.
What is the hallmark of ophthalmoplegia secondary to a cavernous sinus process?
What is the hallmark of ophthalmoplegia secondary to a cavernous sinus process? The involvement of two or more cranial nerves simultaneously.
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

CN3 Nucleus ───────────────────────────────────── CN6 Nucleus
MLF

Fascicular

Subarachnoid

Infranuclear

Cavernous sinus

What is the hallmark of ophthalmoplegia 2ndry to a cavernous sinus process? The involvement of two or more cranial nerves simultaneously

Which nerves may be involved?

- 
- 
- 
- 
- 
- 
- 
- 
-
What is the hallmark of ophthalmoplegia 2ndry to a cavernous sinus process? The involvement of two or more cranial nerves simultaneously

Which nerves may be involved?

- Involvement manifests as
- Involvement manifests as
What is the hallmark of ophthalmoplegia 2ndry to a cavernous sinus process?
The involvement of two or more cranial nerves simultaneously

Which nerves may be involved?
--
  -- Involvement manifests as ophthalmoplegia
  -- Involvement manifests as facial hypoesthesia
  -- Involvement manifests as Horners
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Infranuclear

Fascicular

Subarachnoid

Cavernous sinus

What is the hallmark of ophthalmoplegia secondary to a cavernous sinus process?
The involvement of two or more cranial nerves simultaneously

Which nerves may be involved?
--CN3
--CN4
--CN6
--V_1
--V_2
--Sympathetics

Involvement manifests as ophthalmoplegia
Involvement manifests as facial hypoesthesia
Involvement manifests as Horner's
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Fascicular
Subarachnoid
Cavernous sinus

Getting pretty close now. Post-cavernous sinus, another well-defined space.
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Fascicular

Subarachnoid

Cavernous sinus

Orbital

Getting pretty close now. Post-cavernous sinus, another well-defined space.
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

CN3 Nucleus \[\xrightarrow{MLF}\] CN6 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Orbital

The answer *superior orbital fissure* is just as good here (if not better, as the *Neuro* book breaks out the fissure as a separate structure in the pathway).
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Likewise, the answer *orbital apex* would also be reasonable at this junction.
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Motility disorders secondary to pathology in these areas are addressed in detail in their own slide-set (N19)
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Fascicular
Subarachnoid
Cavernous sinus
Orbital
Where the journey ends for the nerves.
**Motility Disorders: Overview**

Supranuclear

Nuclear

Infranuclear

- Fascicular
- Subarachnoid
- Cavernous sinus
- Orbital
- Neuromuscular junction

Where the journey ends for the nerves.
Motility Disorders: Overview

Per the Neuro book, what is the “prototypical” disease of the neuromuscular junction?
Per the Neuro book, what is the “prototypical” disease of the neuromuscular junction?
Myasthenia gravis
Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

Fascicular
Subarachnoid
Cavernous sinus
Orbital
Neuromuscular junction

MLF

And finally…Don’t forget pathology here when evaluating motility disorders!
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Orbital

Neuromuscular junction

Extraocular muscle

And finally…Don’t forget pathology here when evaluating motility disorders!
Motility Disorders: Overview

What sorts of conditions are included here?

- Restrictive (e.g., thyroid eye dz)
- Inflammatory (e.g., orbital myositis)
- Myopathies (e.g., chronic progressive external ophthalmoplegia)

Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Extraocular muscle
**Motility Disorders: Overview**

**Supranuclear**

**Nuclear**

**Infranuclear**

What sorts of conditions are included here?
Restrictive (eg, thyroid eye dz); inflammatory (eg, orbital myositis); myopathies (eg, chronic progressive external ophthalmoplegia)

Extraocular muscle
Before discussing supranuclear lesions, we need to define the role of the efferent (ie, motor) component of the visual system. But before we do that, we have to define the role of the afferent system.
Before discussing supranuclear lesions, we need to define the role of the efferent (ie, motor) component of the visual system. But before we do that, we have to define the role of the afferent system.

In primates, vision has two purposes: 1) to detect objects of interest (eg, things you may want to eat, or may want to eat you), and 2) to scrutinize objects of interest (ie, to determine definitively whether it's an eat-er vs an eat-ee).
Before discussing supranuclear lesions, we need to define the role of the efferent (ie, motor) component of the visual system. But before we do that, we have to define the role of the afferent system.

In primates, vision has two purposes: 1) to detect objects of interest (eg, things you may want to eat, or may want to eat you), and 2) to scrutinize objects of interest (ie, to determine definitively whether it’s an eat-er vs an eat-ee). It follows from this that the efferent visual system has two jobs: 1) Keep both foveas pointing at the current object of regard; and 2) rapidly redirect both foveas to a new object when one is detected in the periphery.
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But let’s consider what it takes to accomplish these tasks. Scrutinizing an object requires steady bifixation—but not too steady, or the photoreceptors (PRs) will fatigue and the image will disappear.
Before discussing supranuclear lesions, we need to define the role of the efferent (ie, motor) component of the visual system. But before we do that, we have to define the role of the afferent system.

In primates, vision has two purposes: 1) to detect objects of interest (eg, things you may want to eat, or may want to eat you), and 2) to scrutinize objects of interest (ie, to determine definitively whether it’s an eat-er vs an eat-ee). It follows from this that the efferent visual system has two jobs: 1) Keep both foveas pointing at the current object of regard; and 2) rapidly redirect both foveas to a new object when one is detected in the periphery.

But let’s consider what it takes to accomplish these tasks. Scrutinizing an object requires steady bifixation—but not too steady, or the photoreceptors (PRs) will fatigue and the image will disappear. Further, the object might be moving, meaning the efferent system has to precisely track it. Further still, the primate’s head might be moving, also necessitating object-tracking.
Before discussing **supranuclear lesions**, we need to define the role of the efferent (ie, motor) component of the visual system. But before we do *that*, we have to define the role of the *afferent* system.

In primates, vision has two purposes: 1) to **detect** objects of interest (eg, things you may want to eat, or may want to eat you), and 2) to **scrutinize** objects of interest (ie, to determine definitively whether it’s an eat-er vs an eat-ee). It follows from this that the *afferent* visual system has two jobs: 1) Keep both foveas pointing at the current object of regard; and 2) rapidly redirect both foveas to a new object when one is detected in the periphery.

**But let’s consider what it takes to accomplish these tasks.** Scrutinizing an object requires steady bifixation—but not *too* steady, or the photoreceptors (PRs) will fatigue and the image will disappear. **Further, the object might be moving,** meaning the efferent system has to precisely track it. **Further still,** the primate’s *head* might be moving, also necessitating object-tracking. In order to rapidly refixate both foveas on a peripheral image, the efferent system must first produce just enough torque to overcome inertia and rotate the eyes to this image, then it must ‘ramp down’ the amount of torque to the level needed to maintain gaze in this new direction.
Supranuclear

The *supranuclear pathways* consist of six systems in the primate CNS that deal with these fixation-related issues. Thus, lesions of a supranuclear pathway manifest as difficulties with either the **maintenance** or **acquisition** of bifixation.

In primates, vision has two purposes: 1) to **detect** objects of interest (eg, things you may want to eat, or may want to eat you), and 2) to **scrutinize** objects of interest (ie, to determine definitively whether it’s an eat-er vs an eat-ee). It follows from this that the *afferent* visual system has two jobs: 1) Keep both foveas pointing at the current object of regard; and 2) rapidly redirect both foveas to a new object when one is detected in the periphery.

**But let’s consider what it takes to accomplish these tasks.** Scrutinizing an object requires steady bifixation—but not *too* steady, or the photoreceptors (PRs) will fatigue and the image will disappear. *Further, the object might be moving, meaning the efferent system has to precisely track it.* *Further still, the primate’s head might be moving,* also *necessitating object-tracking.* In order to rapidly refixate both foveas on a peripheral image, the efferent system must first produce just enough torque to overcome inertia and rotate the eyes to this image, then it must ‘ramp down’ the amount of torque to the level needed to maintain gaze in this new direction.
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

Internuclear

1) The two words system is responsible for maintaining a high-quality image of a stationary object when the head is still.

Infranuclear

- Fascicular
- Subarachnoid
- Cavernous sinus
- Orbital
- Neuromuscular junction
- Extraocular muscle
1) The **ocular fixation system** is responsible for maintaining a high-quality image of a stationary object when the head is still.
1) The **ocular fixation system** is responsible for maintaining a high-quality image of a stationary object when the head is still. It does this via continuous *microsaccadic refixation movements*, which produce a constant shifting among the PRs regarding which are responsible for the retinal image. This shifting prevents PR fatigue (and subsequent image loss) from occurring.
**Supranuclear**

six systems in the primate CNS that deal with these fixation-related issues

1) The **ocular fixation system**

2) The **two words system** is responsible for maintaining fixation on a moving object. When it is impaired, pursuit movements may either lag behind the object or jump ahead of it.

**Infranuclear**

- Fascicular
- Subarachnoid
- Cavernous sinus
- Orbital
- Neuromuscular junction
- Extraocular muscle
Supranuclear

1) The **ocular fixation system**

2) The **smooth-pursuit system** is responsible for maintaining fixation on a moving object. When it is impaired, pursuit movements may either lag behind the object or jump ahead of it.

Internuclear

Infranuclear

- Fascicular
- Subarachnoid
- Cavernous sinus
- Orbital
- Neuromuscular junction
- Extraocular muscle

six systems in the primate CNS that deal with these fixation-related issues
1) The **ocular fixation system** is responsible for maintaining a high-quality image of a stationary object when the head is still. It does this via continuous microsaccadic refixation movements, which prevent PR fatigue (and subsequent image loss) from occurring.

2) The **smooth-pursuit system** is responsible for maintaining fixation on a moving object. When it is impaired, pursuit movements may either lag behind the object or jump ahead of it. **Of note, this is the only supranuclear pathway that is activated voluntarily.**

---

**Supranuclear**

Six systems in the primate CNS that deal with these fixation-related issues.

**Internuclear**

1) The **ocular fixation system**

2) The **smooth-pursuit system**

**Infranuclear**

- Fascicular
- Subarachnoid
- Cavernous sinus
- Orbital
- Neuromuscular junction
- Extraocular muscle
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

1) The **ocular fixation system**

2) The **smooth-pursuit system**

3) The **system** is responsible for maintaining fixation on an object that is moving toward or away from the eyes, thus necessitating they converge or diverge.

Infranuclear

- Subarachnoid
- Cavernous sinus
- Orbital
- Neuromuscular junction
- Extraocular muscle
**Supranuclear**

六系统在灵长类大脑皮层中处理这些与固定相关的问题。

<table>
<thead>
<tr>
<th>Internuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) The <strong>ocular fixation system</strong></td>
</tr>
<tr>
<td>2) The <strong>smooth-pursuit system</strong></td>
</tr>
<tr>
<td>3) The <strong>vergence system</strong> is responsible for maintaining fixation on an object that is moving toward or away from the eyes, thus necessitating they converge or diverge.</td>
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<thead>
<tr>
<th>Infranuclear</th>
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<tbody>
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<td>Subarachnoid</td>
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<td>Cavernous sinus</td>
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<td>Neuromuscular junction</td>
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<td>Extraocular muscle</td>
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Supranuclear

With these fixation-related issues, six systems in the primate CNS that deal

1) The **ocular fixation system**

2) The **smooth-pursuit system**

3) The **vergence system** is responsible for maintaining fixation on an object that is moving toward or away from the eyes, thus necessitating they converge or diverge. Many forms of vergence dysfunction can occur, including *convergence insufficiency, divergence insufficiency, accommodative esotropia*, and *spasm of the near*.

Infranuclear

- Subarachnoid
- Cavernous sinus
- Orbital
- Neuromuscular junction
- Extraocular muscle
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

1) The **ocular fixation** system

2) The **smooth-pursuit** system

3) The **vergence** system

4) The **vestibulo-ocular reflex (VOR)** system and the 5) **optokinetic nystagmus (OKN)** system are responsible for holding an image steady during head rotations—either brief and rapid (VOR) or slower and sustained (OKN).

Infranuclear

Cavernous sinus
Orbital
Neuromuscular junction
Extraocular muscle
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**Supranuclear**

**Internuclear**

**Infranuclear**

- Cavernous sinus
- Orbital
- Neuromuscular junction
- Extraocular muscle
Supranuclear

With these fixation-related issues, six systems in the primate CNS that deal

1) The **ocular fixation system**
2) The **smooth-pursuit system**
3) The **vergence system**
4) The **vestibulo-ocular reflex (VOR) system** and the 5) **optokinetic nystagmus (OKN) system** are responsible for holding an image steady during head rotations—either brief and rapid (VOR) or slower and sustained (OKN). The VOR is controlled by the vestibular labyrinth, ie, the semicircular canals and otoliths. In contrast, the OKN system is driven by images sweeping across the retina.

Infranuclear

Cavernous sinus
Orbital
Neuromuscular junction
Extraocular muscle
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

1) The **ocular fixation system**
2) The **smooth-pursuit system**
3) The **vergence system**
4) The **vestibulo-ocular reflex (VOR) system** and the 5) **optokinetic nystagmus (OKN) system**
6) The **system** is responsible for rapidly shifting fixation from the current object of interest to a new one located in the visual periphery.

Internuclear

Cavernous sinus
Orbital
Neuromuscular junction
Extraocular muscle
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

1) The **ocular fixation system**

2) The **smooth-pursuit system**

3) The **vergence system**

4) The **vestibulo-ocular reflex (VOR) system** and the 5) **optokinetic nystagmus (OKN) system**

6) The **saccadic system** is responsible for rapidly shifting fixation from the current object of interest to a new one located in the visual periphery.

Infranuclear

Cavernous sinus

Orbital

Neuromuscular junction

Extraocular muscle
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

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4) The **vestibulo-ocular reflex (VOR) system** and the 5) **optokinetic nystagmus (OKN) system**
6) The **saccadic system**

An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it?

Orbital
Neuromuscular junction
Extraocular muscle
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

1) The **ocular fixation** system
2) The **smooth-pursuit** system
3) The **vergence** system
4) The **vestibulo-ocular reflex (VOR)** system and the 5) **optokinetic nystagmus (OKN)** system
5) The **saccadic system**

An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it? It is this: With four important exceptions, supranuclear pts do not complain of diplopia
1) The **ocular fixation** system is responsible for maintaining a high-quality image of a stationary object when the head is still. It does this via continuous microsaccadic refixation movements, which produce a constant shifting among the PRs regarding which are responsible for the retinal image. This shifting prevents PR fatigue (and subsequent image loss) from occurring.

2) The **smooth-pursuit** system is responsible for maintaining fixation on a moving object. When it is impaired, pursuit movements may either lag behind the object or jump ahead of it. Of note, that this is the only supranuclear pathway that is activated voluntarily.

3) The **vergence** system is responsible for maintaining fixation on an object that is moving toward or away from the eyes, thus necessitating they converge or diverge. Many forms of vergence dysfunction can occur, including convergence insufficiency, divergence insufficiency, accommodative esotropia, and spasm of the near.

4) The **vestibulo-ocular reflex (VOR)** system and the 5) **optokinetic nystagmus (OKN)** system are responsible for holding an image steady during head rotations—either brief and rapid (VOR) or slower and sustained (OKN). The VOR is controlled by the vestibular labyrinth, ie, the semicircular canals and otoliths. In contrast, the OKN system is driven by images sweeping across the retina.

6) The **saccadic system** is responsible for rapidly shifting fixation from the current object of interest to a new one located in the visual periphery.

An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it? It is this: With four important exceptions, **supranuclear pts do not complain of diplopia**.

Why don’t most pts with supranuclear disorders have diplopia?
Supranuclear

six systems in the primate CNS that deal with these fixation-related issues

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6) The **saccadic system**

An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it?

It is this: With four important exceptions, **supranuclear pts do not complain of diplopia**

**Why don’t most pts with supranuclear disorders have diplopia?**

Because most supranuclear disorders affect **both** eyes in a **symmetric** fashion
### Supranuclear

**six systems in the primate CNS that deal with these fixation-related issues**

1. **The ocular fixation system**
2. **The smooth-pursuit system**
3. **The vergence system**
4. **The vestibulo-ocular reflex (VOR) system** and the **optokinetic nystagmus (OKN) system**
5. The **saccadic system**

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**An important rule-of-thumb can be stated regarding diplopia—what is it?**

It is this: With four important exceptions, *supranuclear pts do not complain of diplopia*.

**Why don’t most pts with supranuclear disorders have diplopia?**

Because most supranuclear disorders affect **both** eyes in a **symmetric** fashion.

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**What are some of the supranuclear disorders that present typically, i.e., without diplopia?**

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**Supranuclear**

Six systems in the primate CNS that deal with these fixation-related issues:

1) The **oculomotor system**
2) The **smooth-pursuit system**
3) The **vergence system**
4) The **vestibulo-ocular reflex (VOR) system** and the **optokinetic nystagmus (OKN) system**
5) The **saccadic system**

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**Internuclear**

An important rule-of-thumb can be stated regarding **supranuclear motility disorders**—what is it? It is this: With four important exceptions, **supranuclear pts do not complain of diplopia**.

**Why don’t most pts with supranuclear disorders have diplopia?** Because most supranuclear disorders affect both eyes in a **symmetric** fashion.

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**Gaze palsies**, eg, Parinaud syndrome
**Congenital ocular motor apraxia (COMA)**
**Progressive supranuclear palsy (PSP)**
**Saccadic disorders**
### Supranuclear

Six systems in the primate CNS that deal with these fixation-related issues:

1. **Ocular fixation system**
2. **Smooth-pursuit system**
3. **Vergence system**
4. **Vestibulo-ocular reflex (VOR) system** and the **optokinetic nystagmus (OKN) system**
5. **Saccadic system**

An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it?

It is this: With four important exceptions, supranuclear pts do not complain of diplopia.

What are some of the supranuclear disorders that present typically, ie, without diplopia?
- Gaze palsies, eg, **Parinaud syndrome**
- **Congenital ocular motor apraxia** (COMA)
- **Progressive supranuclear palsy** (PSP)
- **Saccadic disorders**

Why don't most pts with supranuclear disorders have diplopia?
Because most supranuclear disorders affect both eyes in a symmetric fashion.

Each of these is addressed in detail in other slide-sets—check the ToC.
1) The ocular fixation system
2) The smooth-pursuit system
3) The vergence system
4) The vestibulo-ocular reflex (VOR) system and the 5) optokinetic nystagmus (OKN) system
6) The saccadic system

An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it? It is this: With four important exceptions, supranuclear pts do not complain of diplopia. Six systems in the primate CNS that deal with these fixation-related issues.

What are the four supranuclear disorders in which pts c/o diplopia? 

An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it? It is this: With four important exceptions, supranuclear pts do not complain of diplopia.
Supranuclear

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An important rule-of-thumb can be stated regarding supranuclear motility disorders and diplopia—what is it? It is this: With **four important exceptions**, supranuclear pts do not complain of diplopia.

What are the four supranuclear disorders in which pts c/o diplopia?--Skew deviation--Divergence insufficiency--Convergence insufficiency--Convergence spasm