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

Which cranial nerves innervate the extraocular muscles (EOMs)?

CN3  CN6  CN4
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

CN3 Nucleus

CN6 Nucleus

CN4 Nucleus

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

(As we shall soon see, this ‘nuclear level’ serves as a useful point around which to organize the EOM-control pathway.)
Um, Dr Flynn, 4 comes before 6. Why are these nuclei listed out of order?
Um, Dr Flynn, 4 comes before 6. Why are these nuclei listed out of order? This will be explained shortly.
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.)
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.)
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.)

…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

Supranuclear

Internuclear

Nuclear CN3 Nucleus CN6 Nucleus CN4 Nucleus

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.)

Infranuclear

…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

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.

**Supranuclear**

**Internuclear**

**Infranuclear**

Nuclear

- CN3 Nucleus
- CN6 Nucleus
- CN4 Nucleus
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
Are lesions of the CN4 nucleus commonly encountered in clinical practice?
Motility Disorders: Overview

Supranuclear

Nuclear

CN3 Nucleus

CN4 Nucleus

CN6 Nucleus

Internuclear

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

Infranuclear
Are lesions of the CN6 nucleus commonly encountered in clinical practice?
Are lesions of the CN6 nucleus commonly encountered in clinical practice? While not common, they are a well-known clinical entity.
Which two nuclei share an internuclear connection that is of well-established clinical importance?
Motility Disorders: Overview

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

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

The MLF runs 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

Nuclear

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

Motility Disorders: Overview

Supranuclear

Nuclear

Infranuclear

CN3 Nucleus → MLF → CN6 Nucleus

CN4 Nucleus

CN3 Nucleus

CN6 Nucleus

CN4 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
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?
**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.
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.

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

Infraocular

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.

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.

Nuclear

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...

Inf

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.
From 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.

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.

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?
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.

Nuclear

How does the MLF facilitate lateral gaze coordination?
By causing the contralateral MR to fire simultaneously with the
lateral gaze together

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

Supranuclear

Nuclear

Internuclear

CN3 Nucleus → CN6 Nucleus

MLF

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

Internuclear

Fascicular

CN3 Nucleus ➔ CN6 Nucleus

MLF

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 2ndry 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
This is a rendering of a cranial nerve **fascicle** (in this case, CN3). Like the cranial-nerve proper, a fascicle is the bundle of axons that left their nucleus headed toward the target tissue; however, we don’t start calling this bundle a ‘nerve’ until it breaks out of the substance of the brainstem and into the subarachnoid space.
This is a rendering of a cranial nerve fascicle (in this case, CN3). Like the cranial-nerve proper, a fascicle is the bundle of axons that left their nucleus headed toward the target tissue; however, we don’t start calling this bundle a ‘nerve’ until it breaks out of the substance of the brainstem and into the subarachnoid space. Note that on its course, the fascicle runs through and near important CNS structures, and one can envision how damage at such locations would result in a set of S/S some of which stem from damage to the CN, and others from damage to the anatomically related CNS structure; these sets of S/S constitute the fascicular syndromes.
This is a rendering of a cranial nerve **fascicle** (in this case, CN3). Like the cranial-nerve proper, a fascicle is the bundle of axons that left their nucleus headed toward the target tissue; however, we don’t start calling this bundle a ‘nerve’ until it breaks out of the substance of the brainstem and into the subarachnoid space. Note that on its course, the fascicle runs through and near important CNS structures, and one can envision how damage at such locations would result in a set of S/S some of which stem from damage to the CN, and others from damage to the anatomically related CNS structure; these sets of S/S constitute the fascicular syndromes. (While you’re at it, take note of the CN nuclei themselves, and imagine how a similar clinical circumstance could arise from damage at their locations.)
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Infranuclear

Speaking of fascicular syndromes: The Neuro book describes four involving the CN3 fascicle

CN3 fascicular syndromes:
--?
--?
--?
--?
Speaking of fascicular syndromes: *The Neuro book describes four involving the CN3 fascicle*

**CN3 fascicular syndromes:**
-- Weber syndrome
-- Benedikt syndrome
-- Claude syndrome
-- Nothnagel syndrome
Motility Disorders: Overview

Speaking of fascicular syndromes: The Neuro book describes four involving the CN3 fascicle…and three involving CN6.

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

**CN6 fascicular syndromes:**
--?
--?
--?
Motility Disorders: Overview

Speaking of fascicular syndromes: The Neuro book describes four involving the CN3 fascicle…and three involving CN6.

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

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

Supranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Infranuclear

Fascicular

Speaking of fascicular syndromes: The Neuro book describes four involving the CN3 fascicle…and three involving CN6.

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

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

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

Supranuclear

Nuclear

Internuclear

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

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Subarachnoid

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

Infranuclear
Which cause of ophthalmoparesis--common among vasculopathies--is attributed to damage occurring to the subarachnoid segments?
Which cause of ophthalmoparesis—common among vasculopaths—is attributed to damage occurring to the subarachnoid segments? Ischemic palsies (ie, 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.
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

Fascicular

Subarachnoid

Infranuclear

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

Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

Fascicular

Subarachnoid

Infranuclear

Cavernous sinus

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Nuclear

Infranuclear
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?

- 
- 
- 
- 
-
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

Fascicular

Subarachnoid

Infranuclear

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?

- Involvement manifests as [ ]
- Involvement manifests as [ ]
- Involvement manifests as [ ]
- Involvement manifests as [ ]

MLF
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
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
- V1
- V2
- Sympathetics
  - Involvement manifests as facial hypoesthesia
  - Involvement manifests as Horner's syndrome
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Getting pretty close now. Post-cavernous sinus, another well-defined space.

?
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

Fascicular

Subarachnoid

Cavernous sinus

Orbital

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

Supranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Superior orbital fissure

Orbital

Infranuclear

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

Supranuclear

Infranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Superior orbital fissure

Orbital apex

Orbital

Motility disorders 2ndry to pathology in these areas are addressed in detail in their own slide-set (N19)
Motility Disorders: Overview

Supranuclear

Nuclear

Internuclear

Fascicular
Subarachnoid
Cavernous sinus
Orbital
?
?

Where the journey ends for the nerves.

Infranuclear

CN3 Nucleus

CN4 Nucleus

MLF

CN6 Nucleus
Motility Disorders: Overview

**Supranuclear**

**Nuclear**

**Infranuclear**

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

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

Supranuclear

Nuclear

Internuclear

CN3 Nucleus

MLF

CN6 Nucleus

CN4 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Orbital

Infranuclear

Neuromuscular junction

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

Supranuclear

Nuclear

Internuclear

CN3 Nucleus  \( \rightarrow \) MLF  \( \rightarrow \) CN6 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

Orbital

Infranuclear

Neuromuscular junction

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

- **Supranuclear**
- **Nuclear**
- **Infranuclear**

**Supranuclear**

**Nuclear**

**Infranuclear**

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

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

Supranuclear

Nuclear

Internuclear

Fascicular
Subarachnoid
Cavernous sinus
Orbital
Neuromuscular junction

Infranuclear
Extraocular muscle

And finally…Don’t forget pathology here when evaluating motility disorders!
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

Internuclear

CN3 Nucleus \rightarrow MLF \rightarrow CN6 Nucleus

Fascicular

Subarachnoid

Cavernous sinus

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.
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.

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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.

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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. 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.

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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. 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.
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. 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 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

Motility Disorders: Overview
1) The **ocular fixation system** is responsible for maintaining a high-quality image of a stationary object when the head is still.

**Supranuclear**

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

**Internuclear**

**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. 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.
Motility Disorders: Overview

**Supranuclear**

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

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
Motility Disorders: Overview

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** 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
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.
Motility Disorders: Overview

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**

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
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Supranuclear

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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

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Motility Disorders: Overview
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** are responsible for holding an image steady during head rotations—either brief and rapid (VOR) or slower and sustained (OKN).
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Internuclear

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Motility Disorders: Overview

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

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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.

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

Motility Disorders: Overview

Supranuclear

Internuclear

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**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.
Supranuclear

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

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Orbital

Neuromuscular

Extraocular muscle

*Motility Disorders: Overview*

Why don’t most pts with supranuclear disorders have 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.

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

Motility Disorders: Overview

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5) The **saccadic system**

6) 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.

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Each of these is addressed in detail in other slide-sets—check the ToC.
Motility Disorders: Overview

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

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