

Lecture Notes



**Scroll to
the bottom!**

Don't Miss This: Binocular Vision Emergencies

Ryan Capouch, OD, FCOVD

Financial Disclosure

- I own Lumen Vision, an optometry practice in Fargo, ND.
- Specialties: pediatrics, vision therapy, and vision rehabilitation
- We provide services to patients with the conditions mentioned in this lecture.



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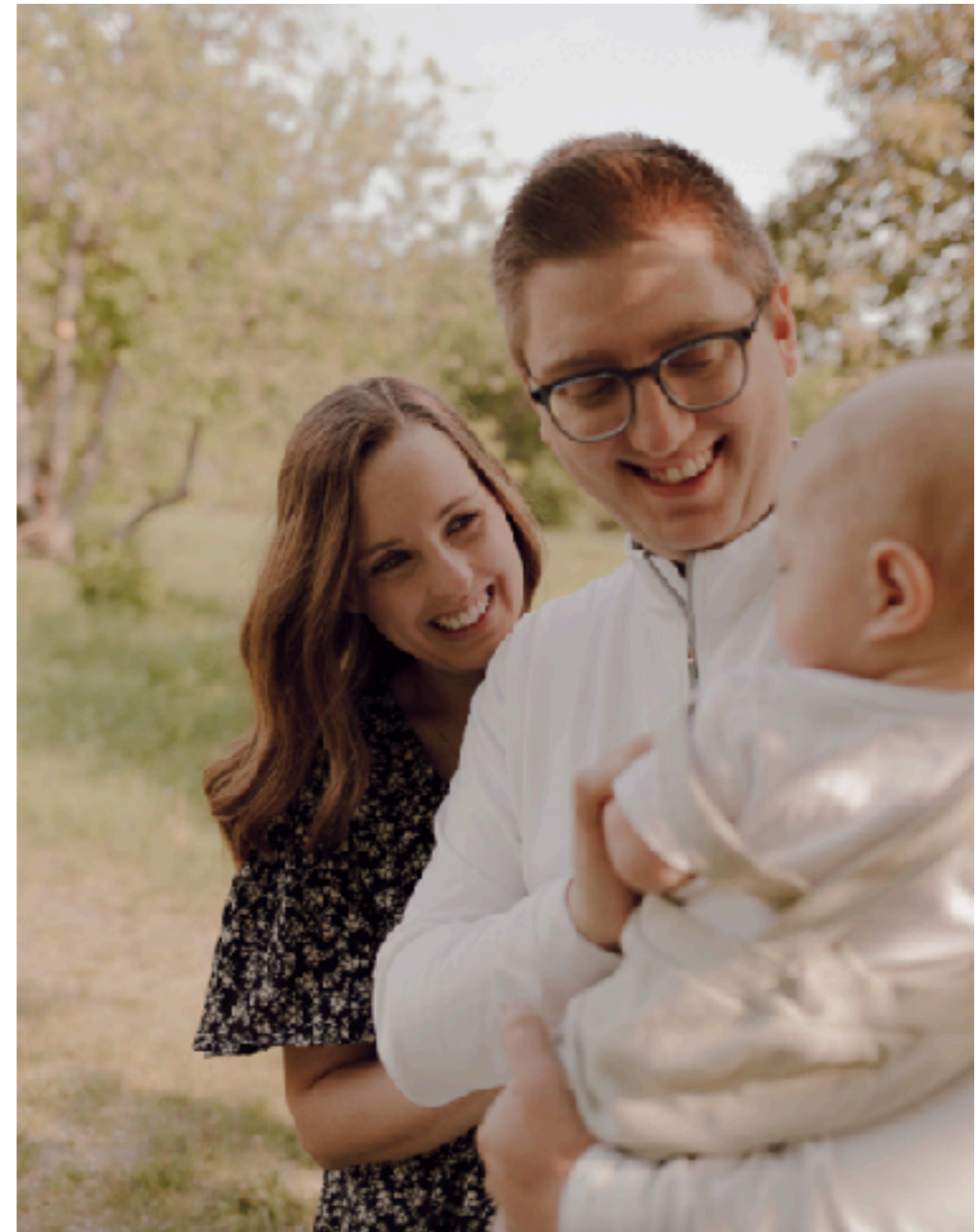
Changing eyes, changing
lives.

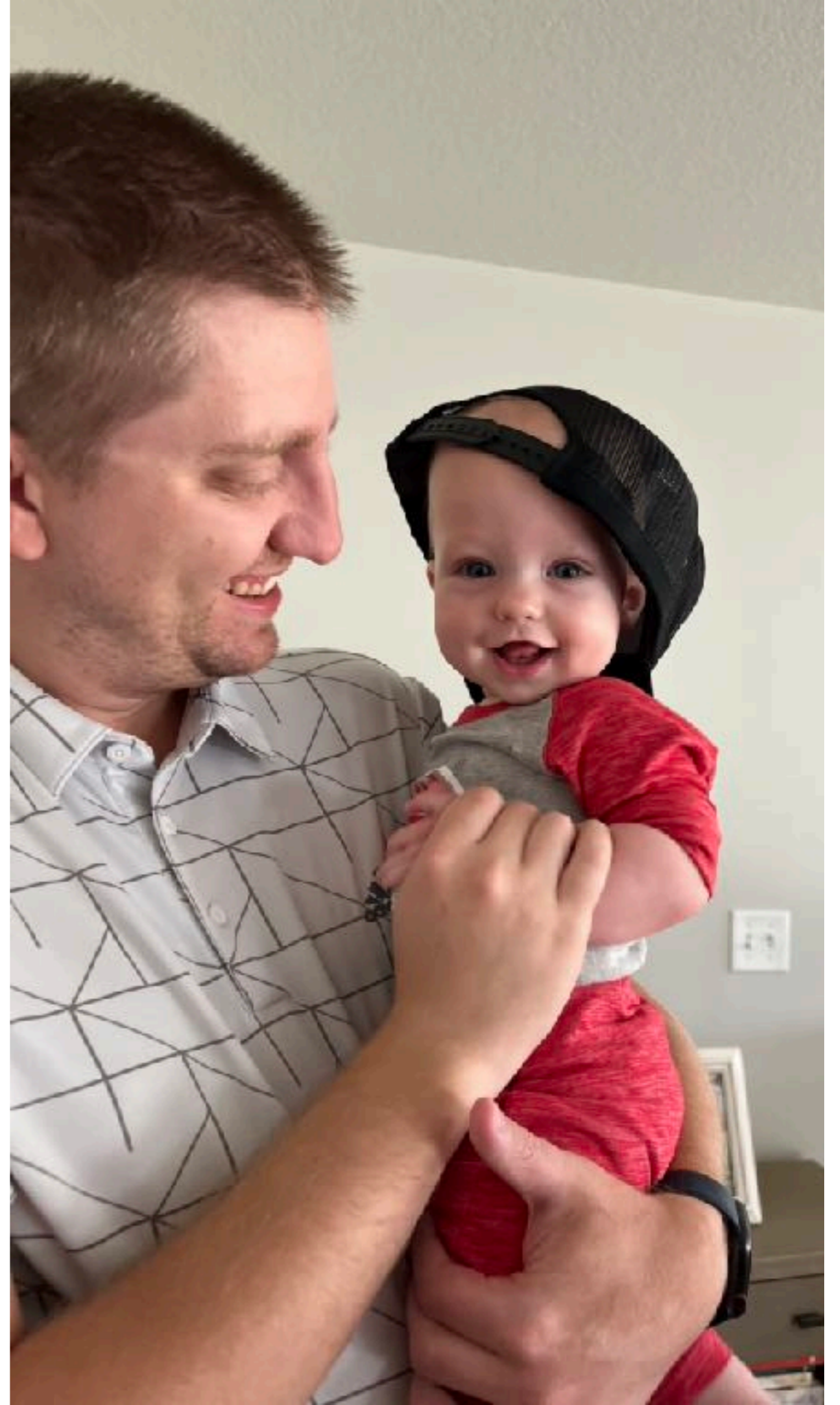
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Ryan Capouch, OD, FCOVD

- **University of Mary (2014)**
 - BA, Biology
 - Minors: Chemistry, Theology
- **Arizona College of Optometry (2018)**
 - Pediatrics
 - Developmental Optometry
- **Fellowship (2022)**
 - College of Optometrists in Vision Development
- **Memberships**
 - Catholic Medical Association
 - College of Optometrists in Vision Development
 - American Optometric Association
 - North Dakota Optometric Association





Outline

- **Binocular Vision Crash Course**
- Know the Horses
- Find the Zebras

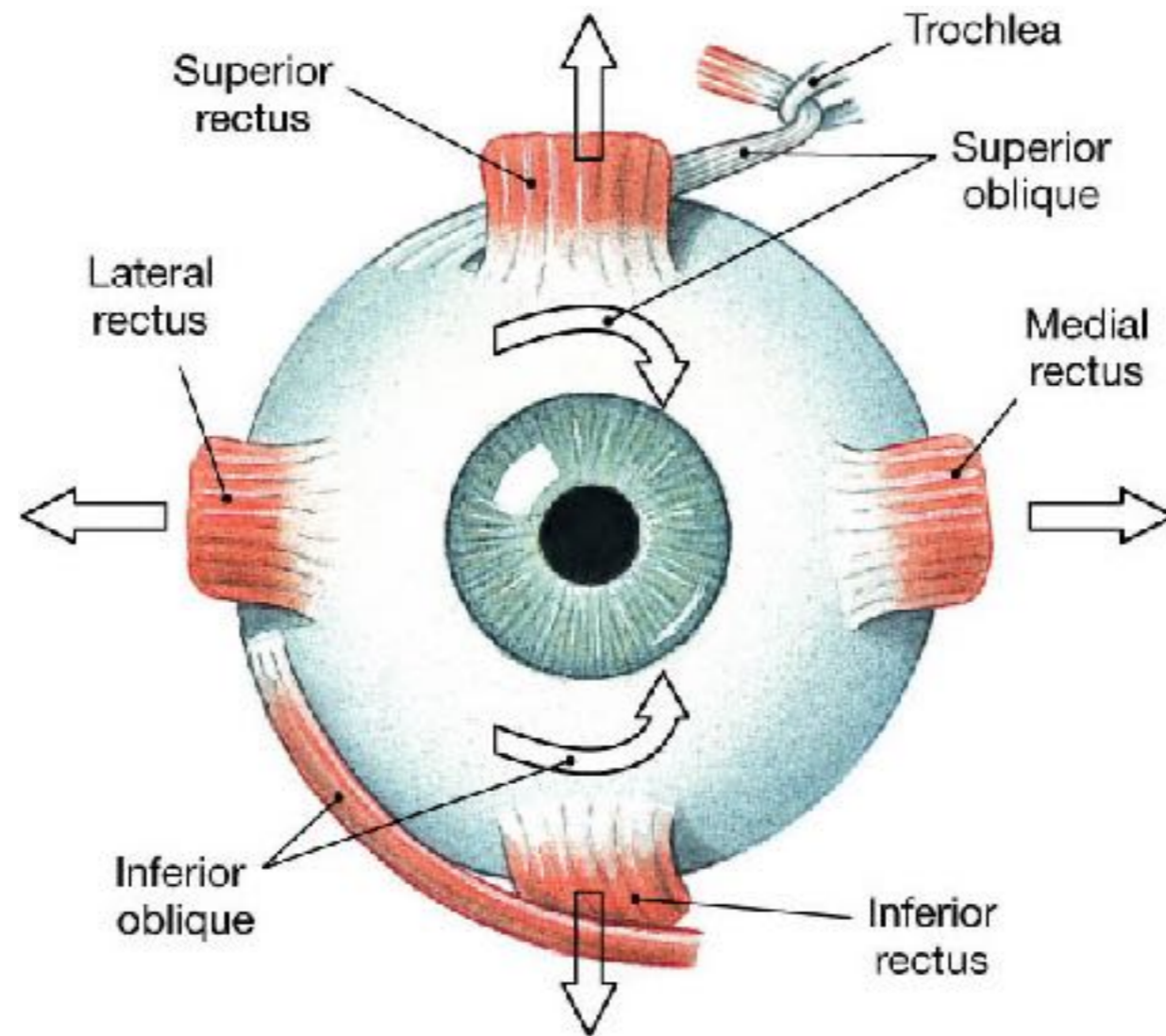
When you hear hoofbeats...



Binocular Vision 101

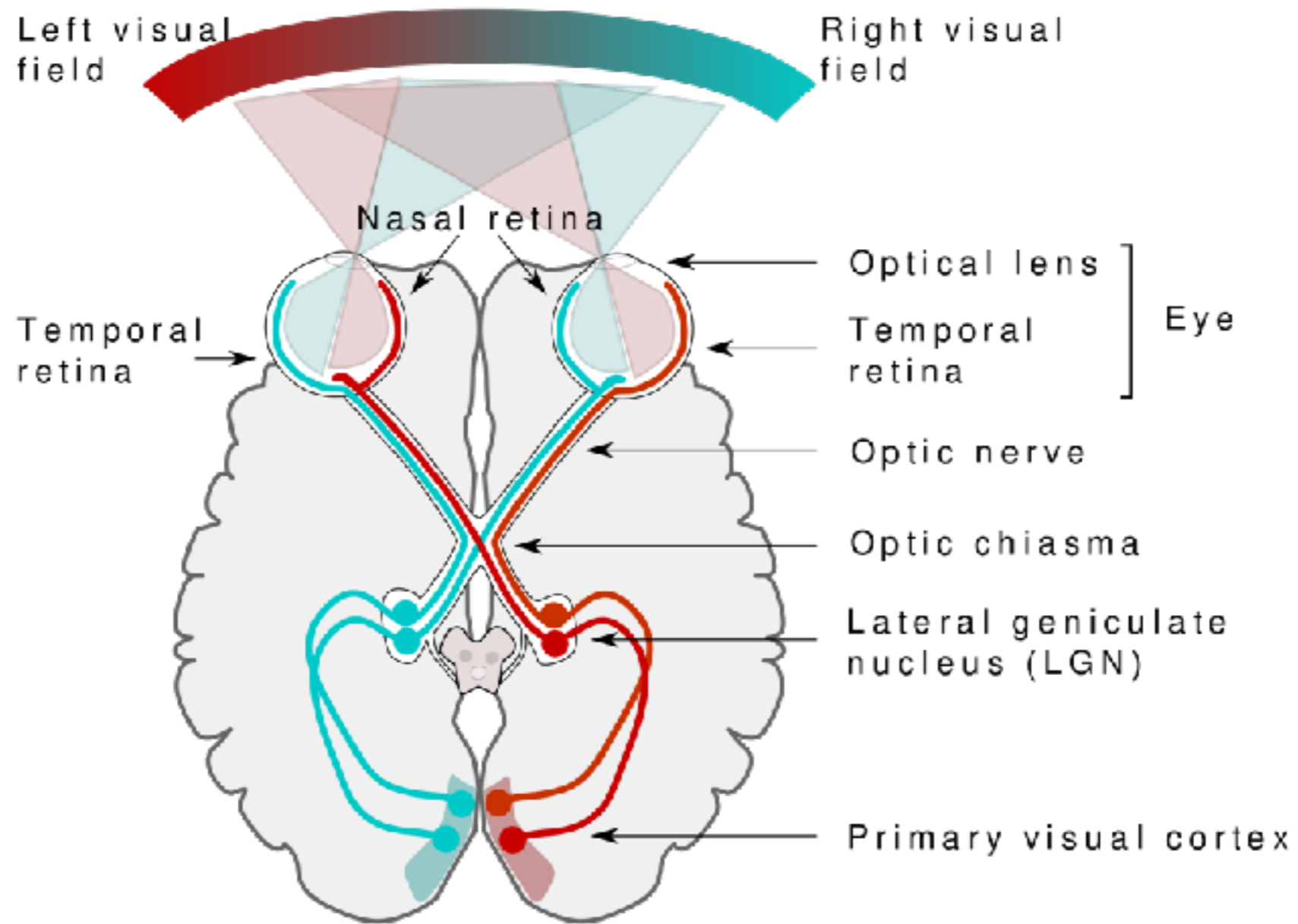
- There are two components to Binocular Vision:
 - Motor - neuromuscular
 - Sensory - neural pathway

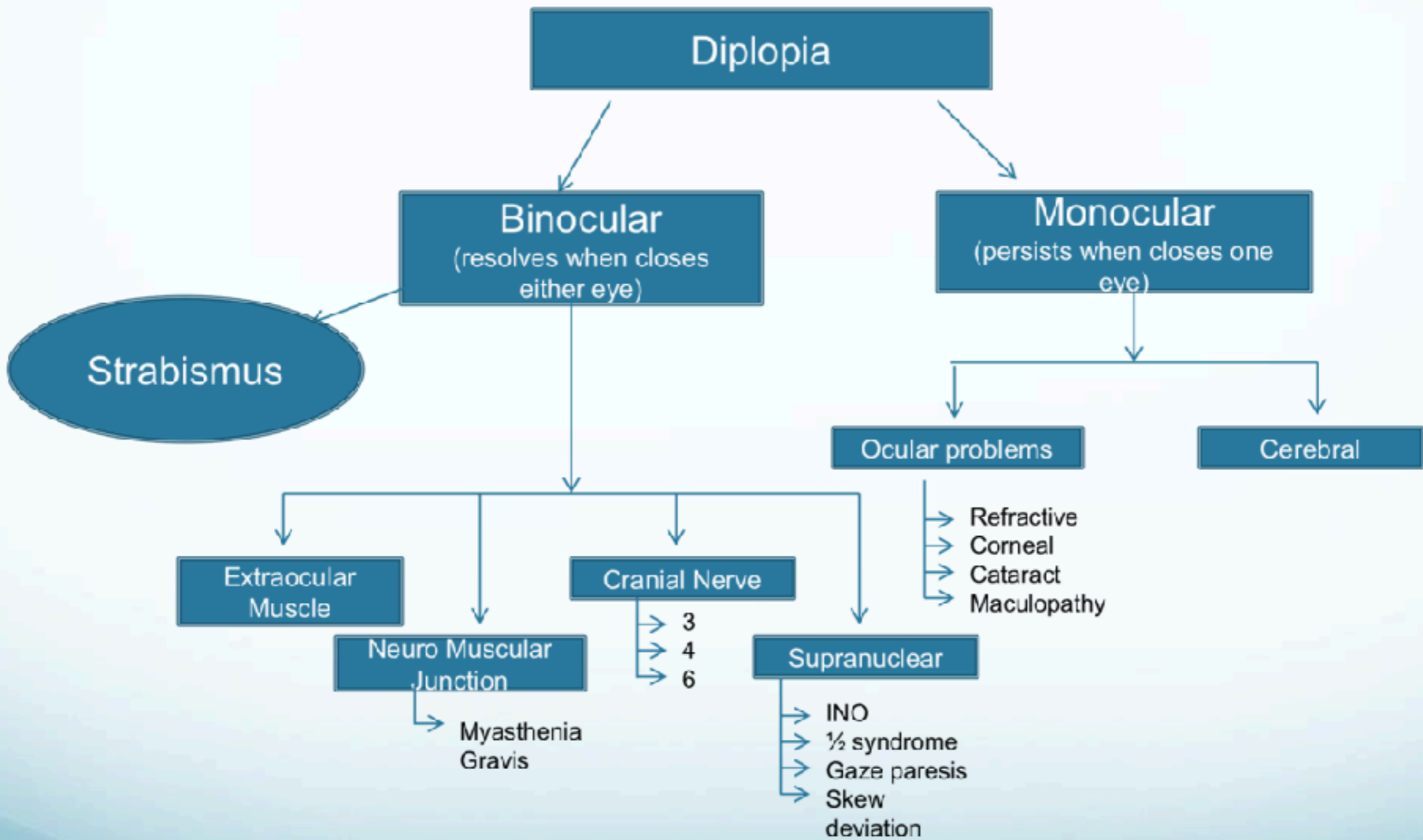
Motor Fusion



(c) Anterior view, right eye

Sensory Fusion





Double Vision

Does it go away when you close one eye?

Yes - Binocular

No - Monocular

Next available. Not an emergency.

Has it gotten worse since you first noticed it?

Stayed the same

Worse

Urgent. May be sight or life threatening.

How long ago did you notice the double vision?

Today

2-5 days

>5 days

Urgent. May be sight or life threatening.

Can be urgent, but generally ok as next available.

Next available. Not an emergency.

Double Vision

Split image

double vision can look like this:

double vision
double vision
double vision
double vision
double vision
double vision

"Ghosting"

This is how I
see
EVERYTHING
without my
glasses...



**Where do the eyes aim
when there is nothing to
look at?**

In the absence of a visual stimulus, the eyes will:

- Remain correctly aligned: **Orthophoria**
- Turn in: **Esophoria**
- Turn out: **Exophoria**
- Vertically misalign: **Hyperphoria**

**What if the eye muscles
can't compensate for our
natural alignment?**

If the eye muscles cannot compensate while looking at a target, the eyes can:

- Turn in: **Esotropia**
- Turn out: **Exotropia**
- Vertically misalign: **Hypertropia**
- This is also called **strabismus**



Fig. 1 Large-angle infantile-onset esotropia.



Fig. 2 Child with exotropia of the right eye.



**How can we measure a
person's natural eye
alignment?**

Cover Test

- Determines presence of tropia or phoria
- Determines magnitude of deviation
- You will need:
 - Occluder
 - Target for patient (near or distance)
 - Prism bars

Cover Test



```
graph LR; A[Cover Test] --> B[1. Unilateral Cover Test (UCT)]; A --> C[2. Alternating Cover Test (ACT)];
```

1. Unilateral Cover Test (UCT)

-Determines if deviation is a tropia

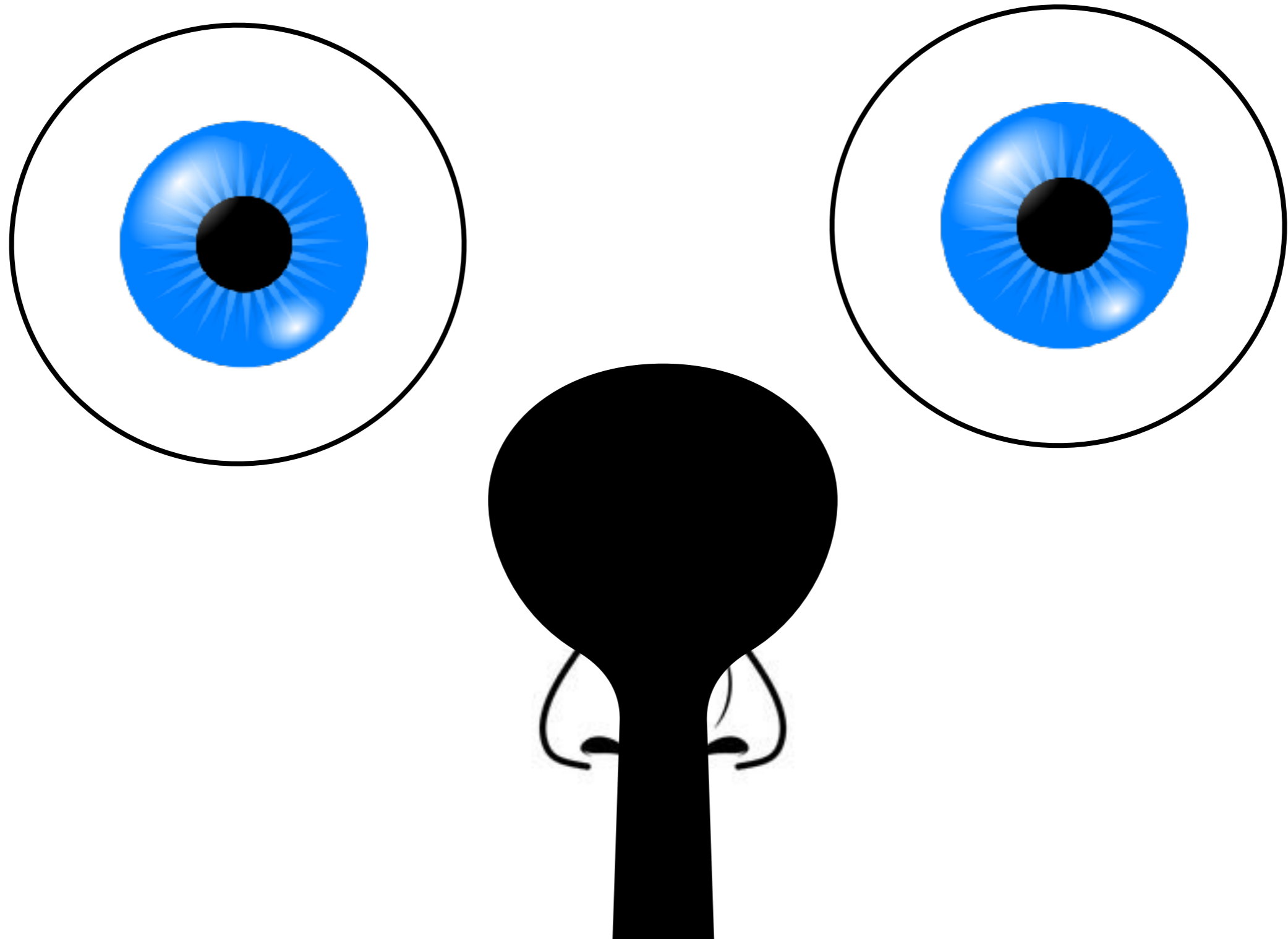
2. Alternating Cover Test (ACT)

-Determines direction and magnitude of deviation

Unilateral Cover Test

- Begin with occluder at patient's nose.
- Move occluder to right eye, and **watch the left eye.**
- Move occluder back to nose.
- Move occluder to left eye, and **watch the right eye.**

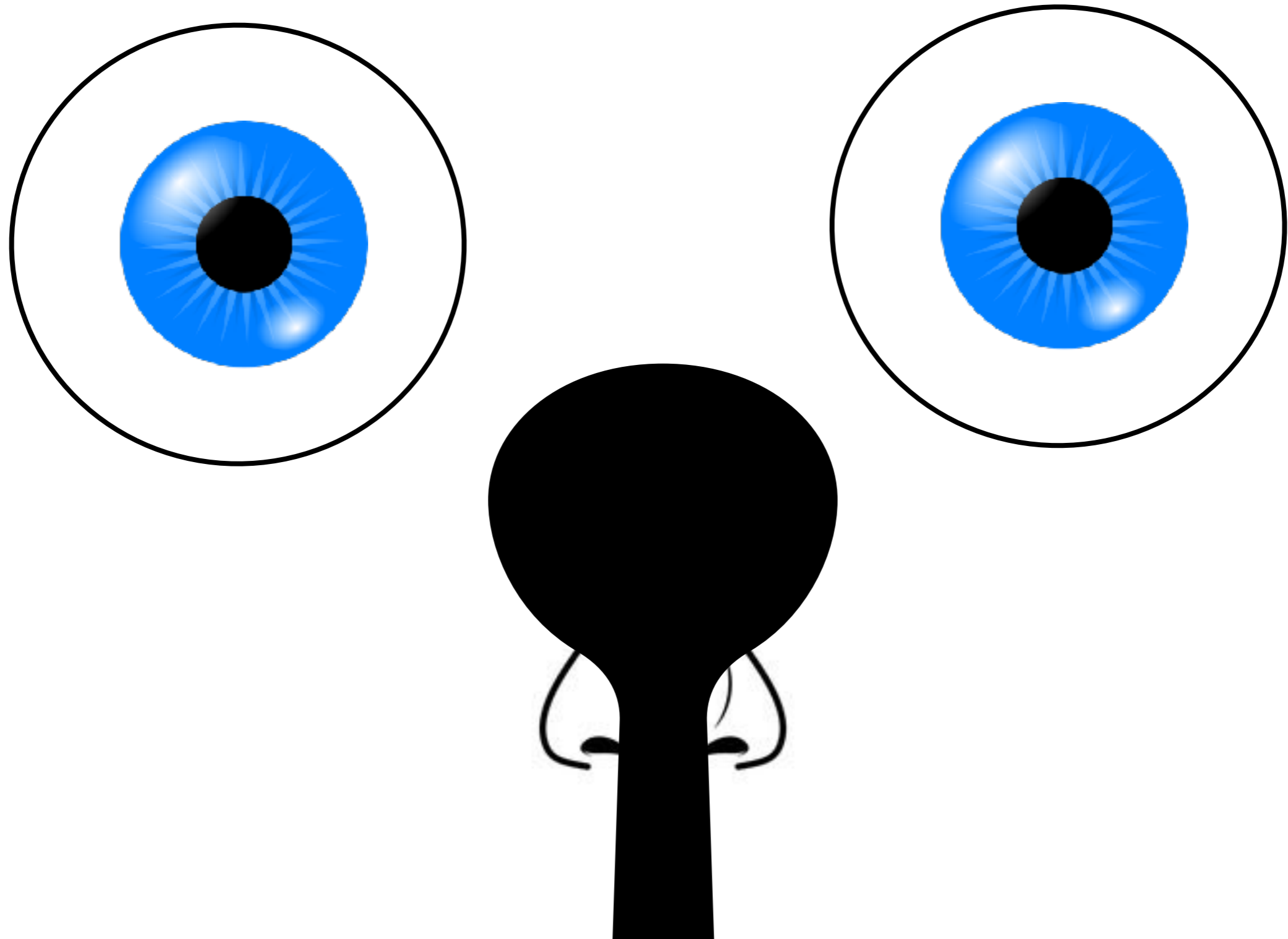
Unilateral Cover Test



Alternating Cover Test

- Do this IMMEDIATELY AFTER UNILATERAL COVER TEST
- Begin with occluder at patient's nose.
- Move occluder QUICKLY to right eye, and **watch the left eye.**
- Move occluder QUICKLY to left eye, and **watch the right eye.**
- **Repeat 3-5x**

Alternating Cover Test

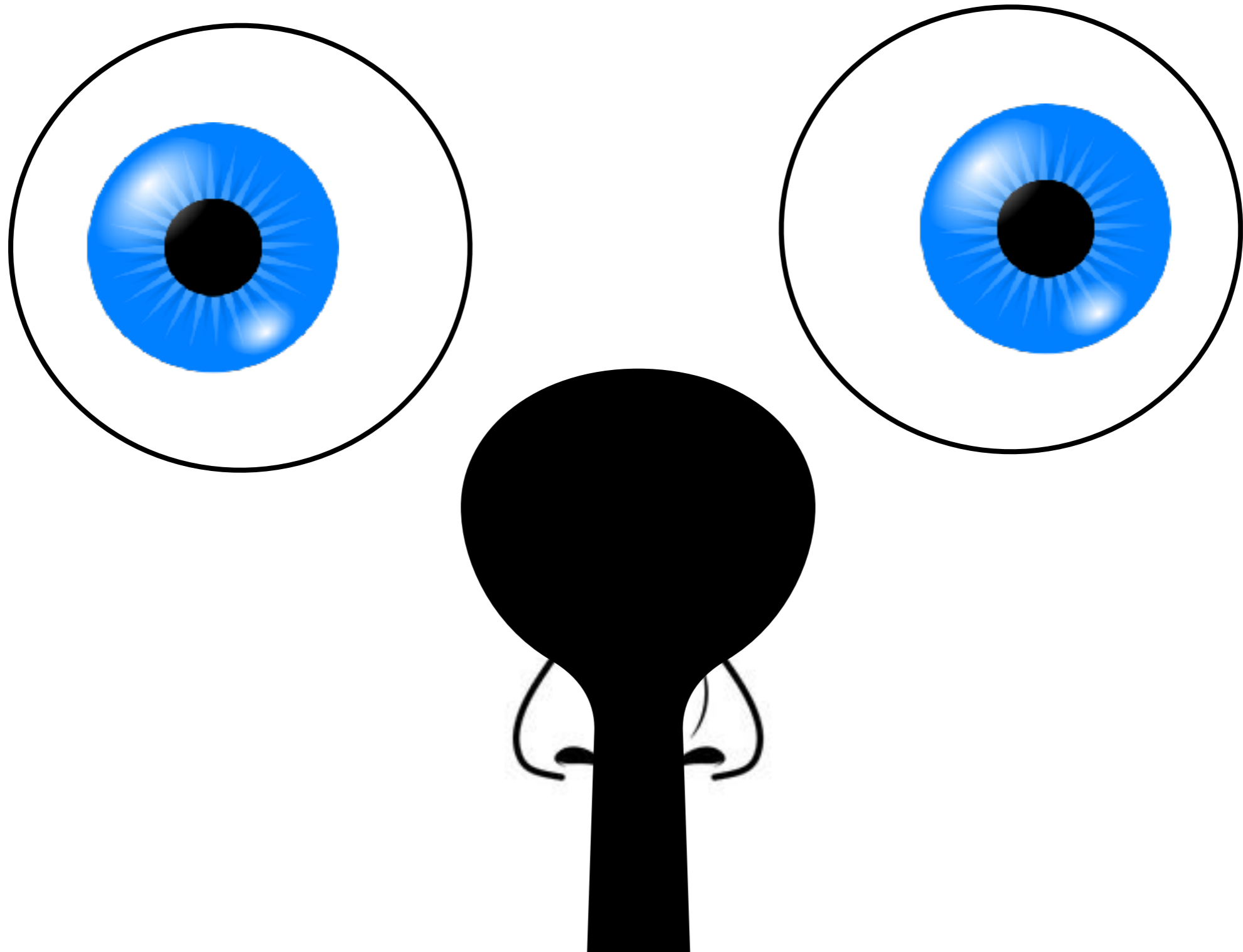


Determining Alignment

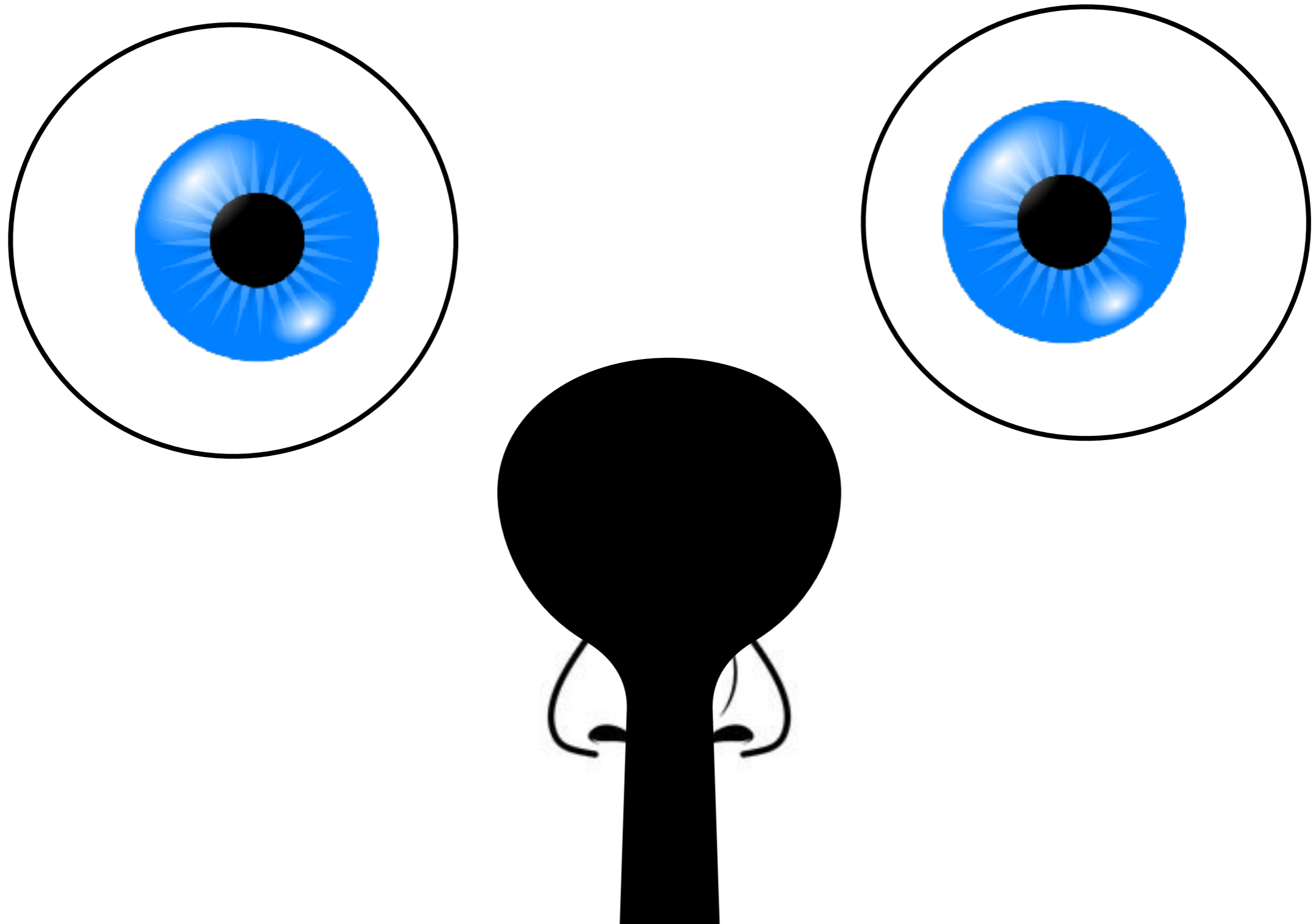
Rules for Interpretation

- If the eye moves out, it was turned IN to begin with (**ESO**)
- If the eye moves in, it was turned OUT to begin with (**EXO**)
- If the eye moves down, it was turned UP to begin with (**HYPER**)

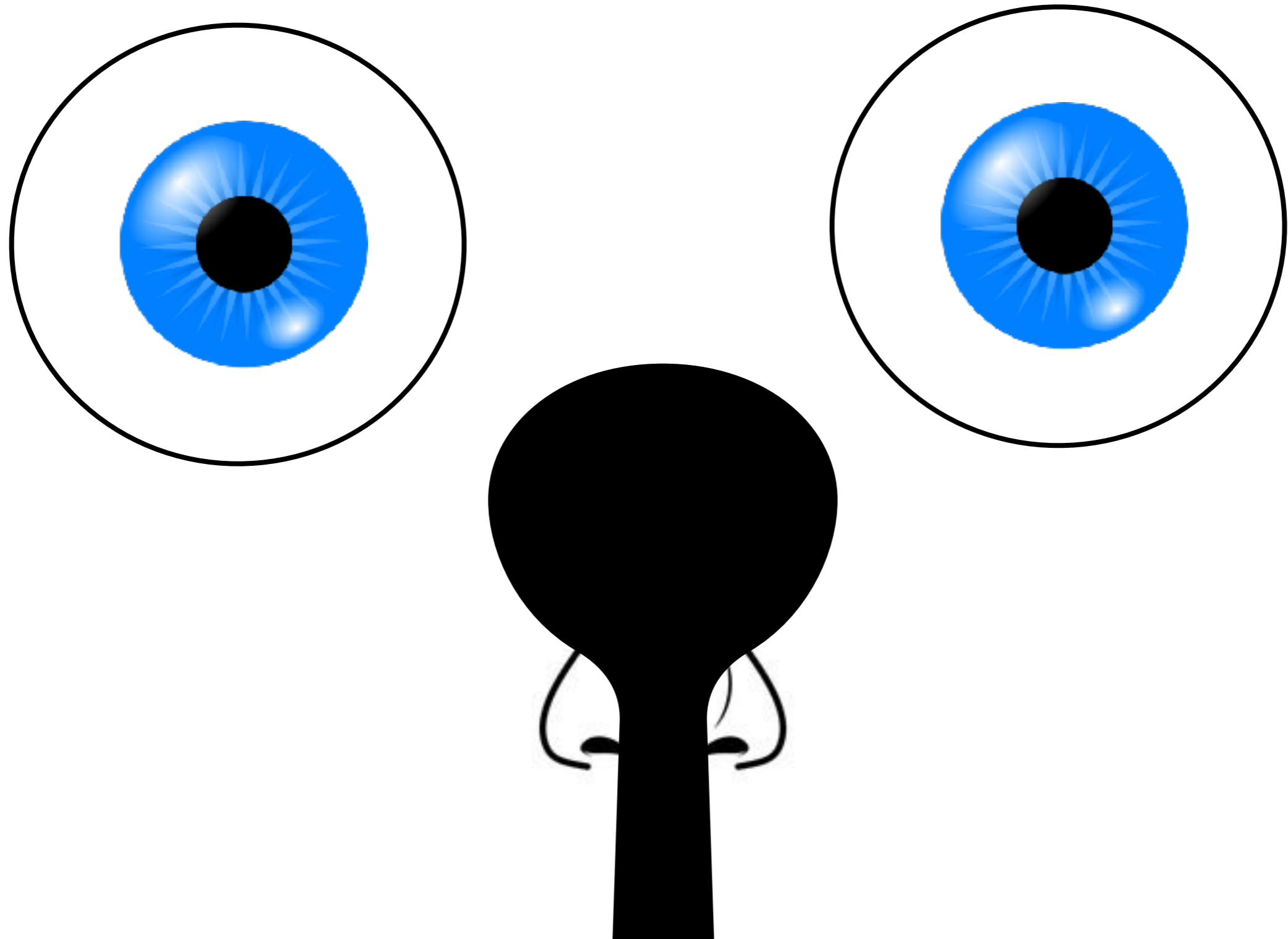
Exophoria



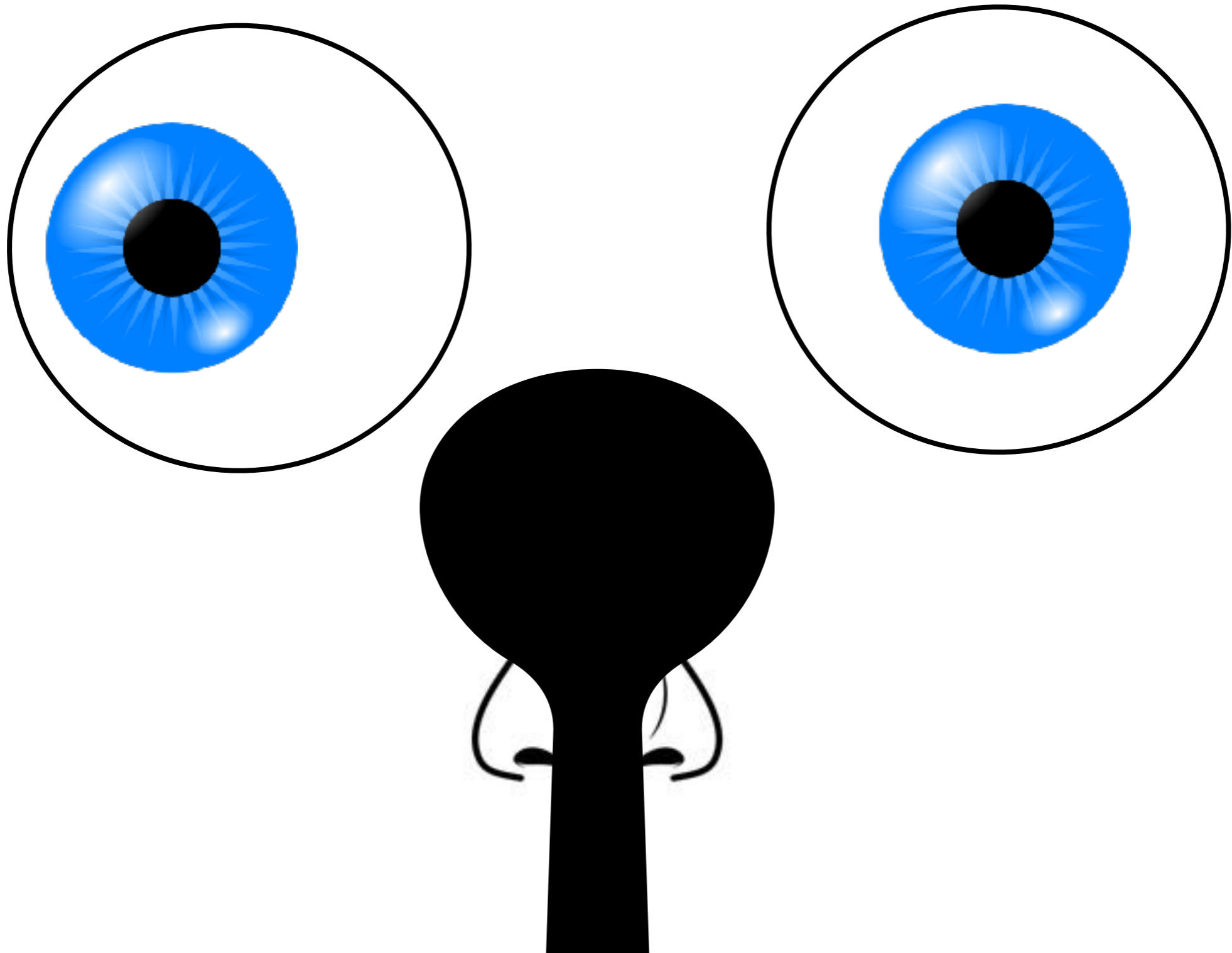
Esophoria



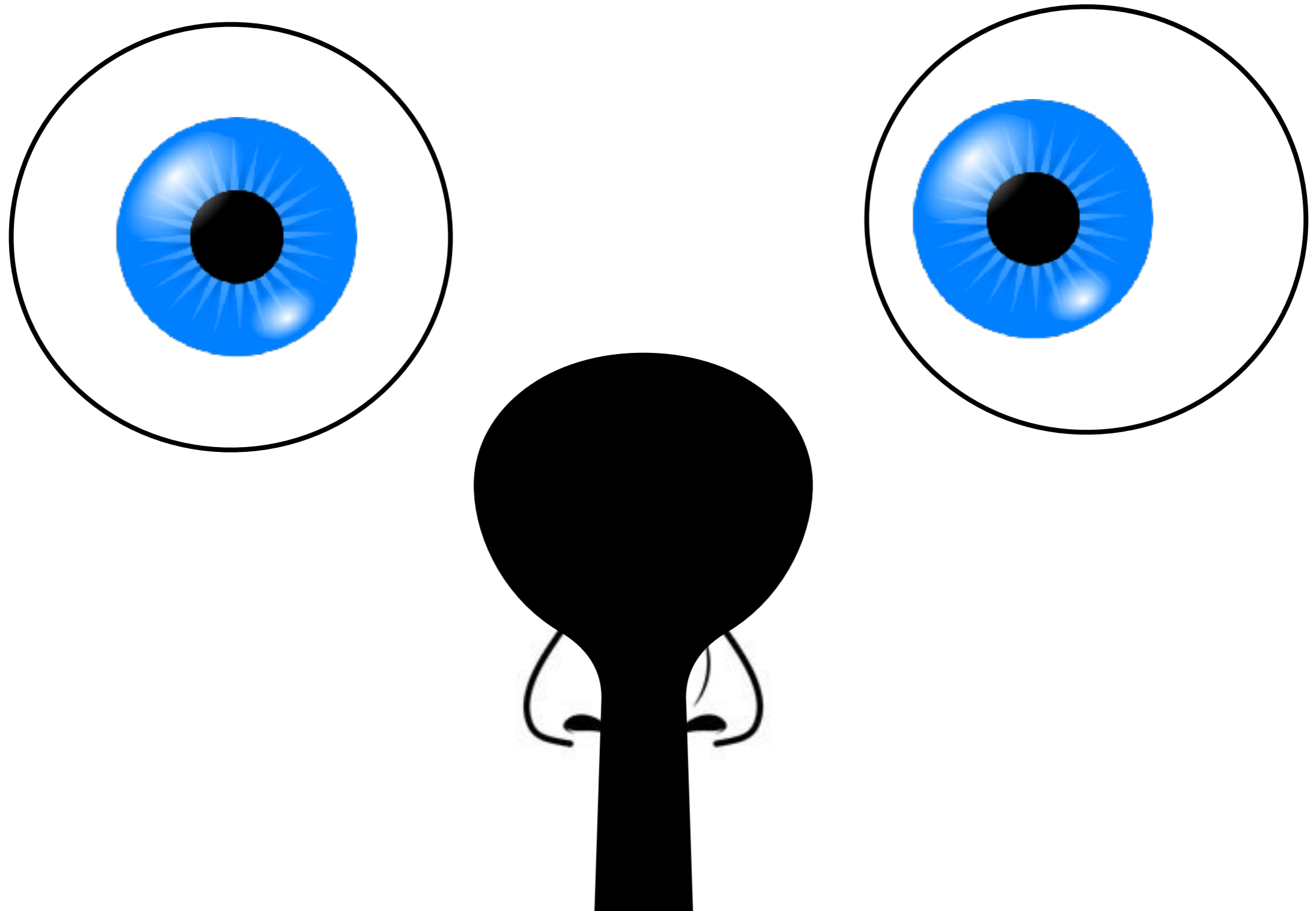
Right Hyperphoria



Right Exotropia



Left Esotropia



Nomenclature

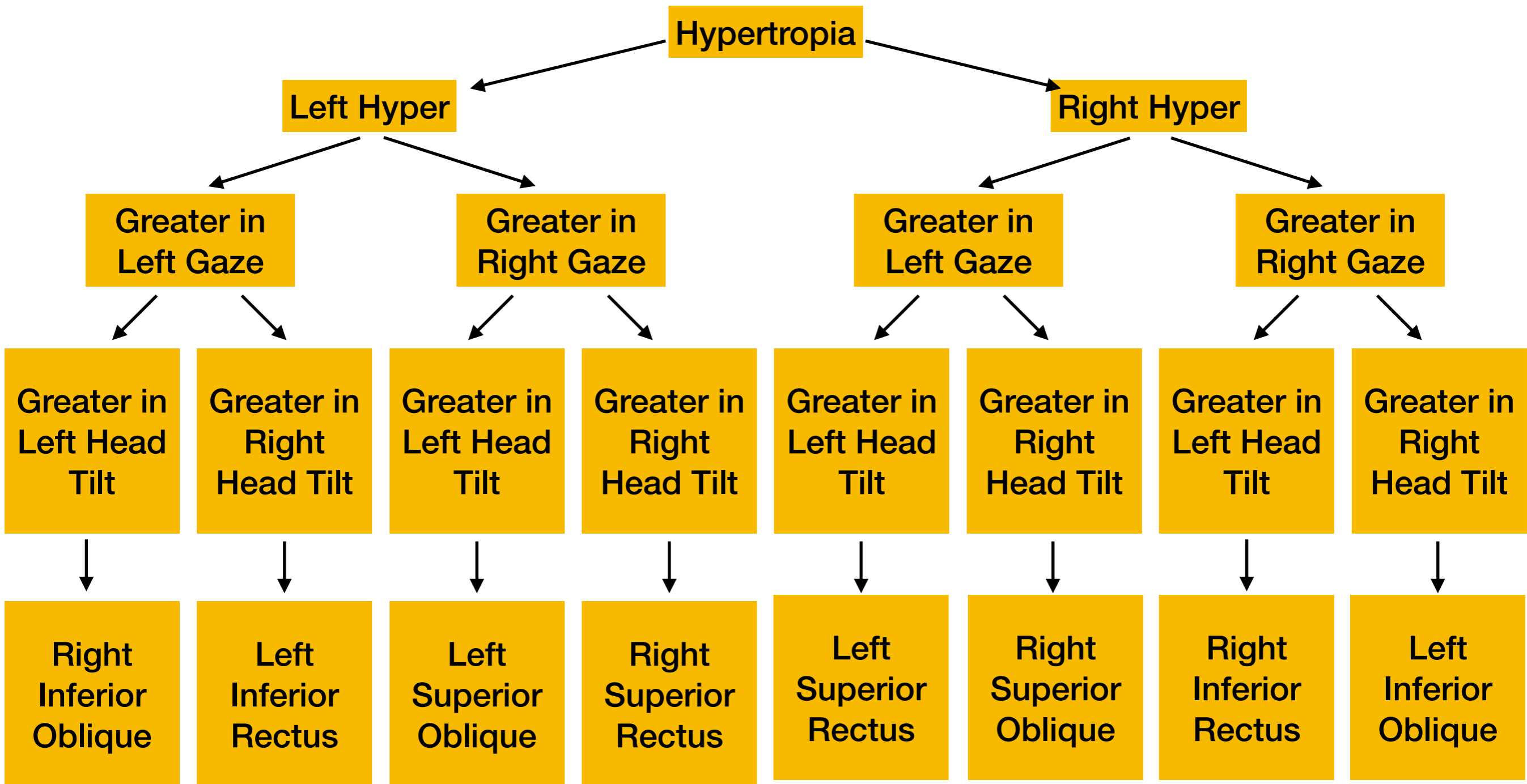
- XP = exophoria at distance
- EP' = esophoria at near
- IRXT' = intermittent right exotropia at near
- CAET = constant alternating esotropia at distance
- CLHyperT' = constant left hypertropia at near

**Vertical? Isolate the
problematic muscle!**

Park's Three Step

- Step 1: Determine **which eye is higher** than the other in primary position (looking straight ahead). This is the hypertropic eye. For example, if the right eye is higher than the left eye, this is called right hypertropia.
- Step 2: Determine whether the hypertropia increases on **right or left gaze**. This indicates which muscle is involved. For example, if the right hypertropia increases on left gaze, this means that either the right superior oblique or the left inferior oblique muscle is weak or paralyzed.
- Step 3: Determine whether the hypertropia increases on **right or left head tilt**. This indicates which side of the muscle is involved. For example, if the right hypertropia increases on right head tilt, this means that the right superior oblique muscle is weak or paralyzed.

Vertical? Isolate the problem!



Park's Three Step

Which Eye + Which Gaze + Which Head Tilt = Which Muscle

• RRR = LIO

• RRL = RIR

• RLR = RSO

• RLL = LSR

• LRR = RSR

• LRL = LSO

• LLR = LIR

• LLL = RIO

Park's Three Step

OD

OS

SR

IO

IO

SR

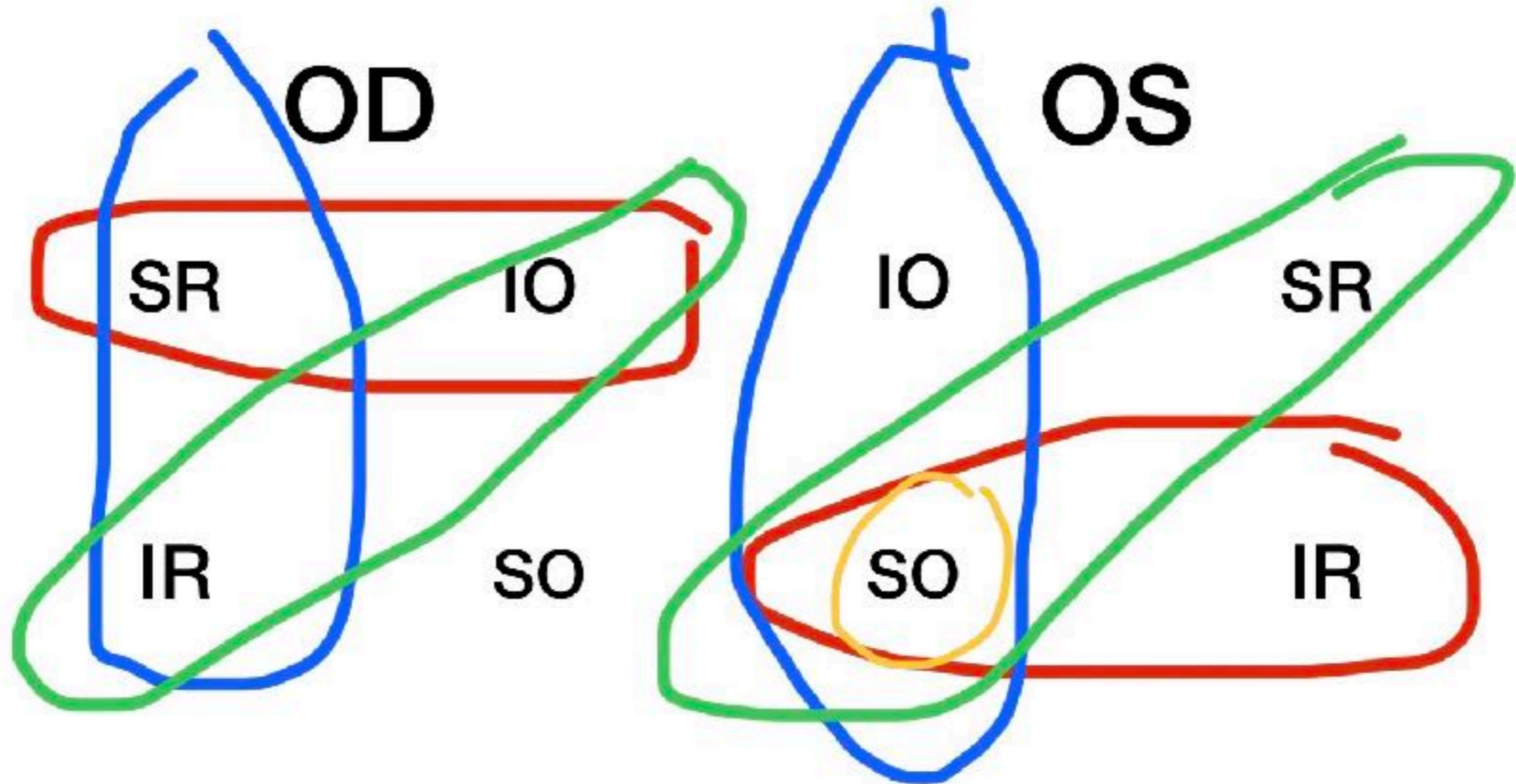
IR

SO

SO

IR

Park's Three Step



- **Left Hyper**, Worse in **right gaze**, worse in **left head tilt**



Vezzini's final scene in The Princess Bride

Outline

- Binocular Vision Crash Course
- **Know the Horses**
- Find the Zebras
- Know the Difference

When you hear hoofbeats...



The Horses

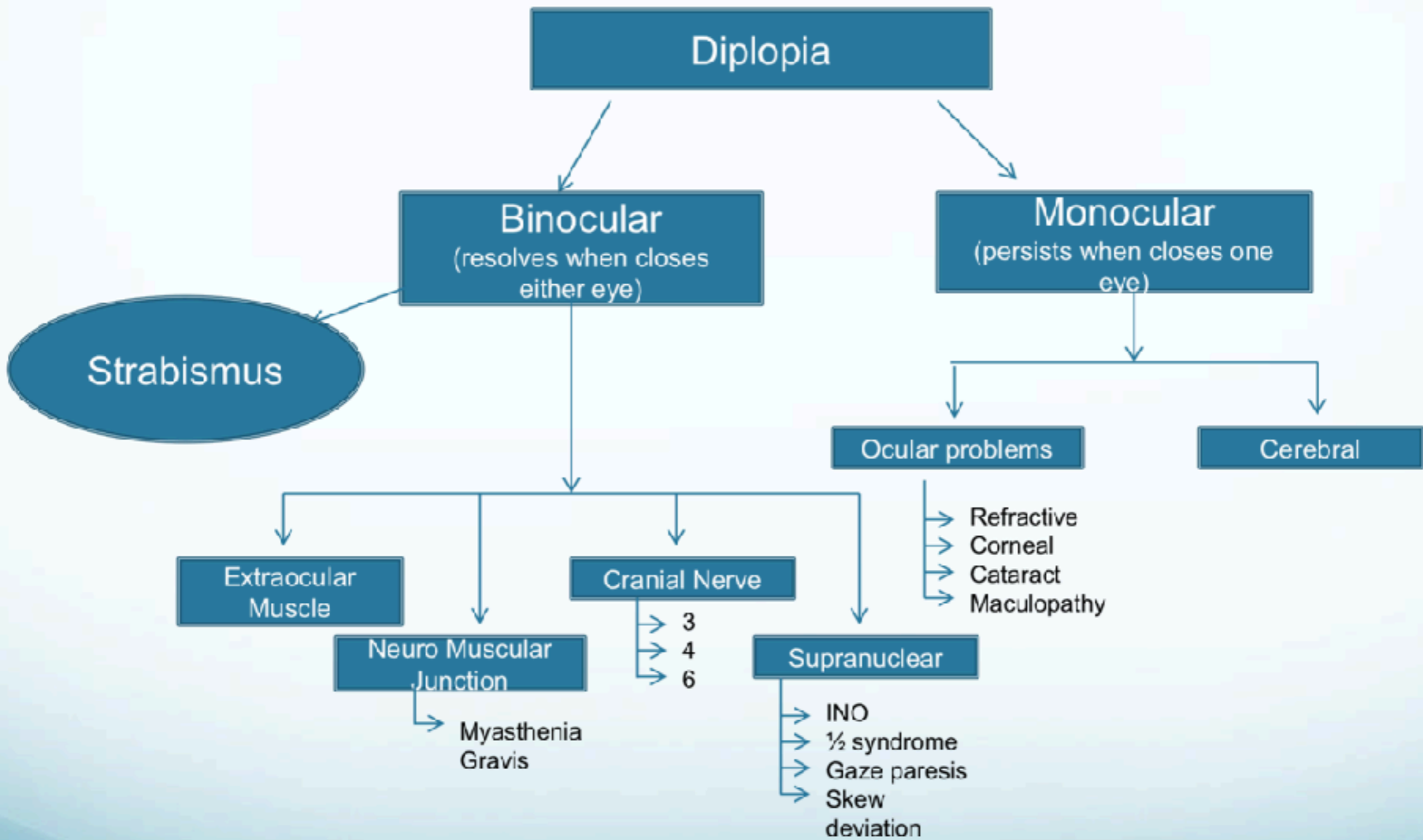
- Refractive Error
- Vergence Disorders
- Oculomotor Dysfunction
- Accommodative Disorders
- Comitant Strabismus
- Amblyopia



| Condition | Cover Test | Calc. AC/A | AA | Vergences | NRA/PRA | Flippers | MEM | 1° Treatment | 2° Tx |
|------------------------------------|----------------------------|------------|-----------------------|--|-----------|-------------------------|-----------------------|--|------------------------------------|
| Convergence Insufficiency | High exo at near | Low | ↓ NPC | ↓ BO (PRV) | ↓ NRA | Fail (+) BAF | Low lead | VT | BI prism at near |
| Divergence Insufficiency | High eso at distance | Low | | ↓ BI (NRV) at distance | | | | BO prism overall or at distance only | VT |
| Convergence Excess | High eso at near | High | | ↓ BI (NRV) | ↓ PRA | Fails (-) BAF | Large lag | (+) lenses at near & BO overall if eso at distance | BO prism VT |
| Divergence Excess | High exo at distance | High | | ↓ BO (PRV) at distance ↓ BI (NRV) at near | | | | VT | (-) lenses at distance BI prism |
| Basic Esophoria | Eso similar at near & dist | | | ↓ BI (NRV) | ↓ PRA | Fails (-) BAF | Large lag | BO prism overall | (+) lenses VT |
| Basic Exophoria | Exo similar at near & dist | | | ↓ BO (PRV) | ↓ NRA | Fails (+) BAF | Low lead | VT | BI prism overall |
| Vergence Dysfunction | | | | ↓ BI & BO | ↓ NRA/PRA | Fails (+)/(-) BAF | | | |
| Accommodative Insufficiency | | | ↓ AA | ↓ BO (PRV) at near (?) | ↓ PRA | Fails (-) B&M | Large lag | (+) lenses | VT |
| Ill-Sustained Accommodation | | | ↓ AA with multiple PU | ↓ BO (PRV) at near (?) | ↓ PRA | Fails (-) B&M over time | Large lag if fatigued | (+) lenses | VT |
| Accommodative Infacility | | | | ↓ BO & BI at near (?) | ↓ NRA/PRA | Fails (+)/(-) B&F | | VT | (+) lenses |
| Accommodative Spasm | | | | ↓ BI (NRV) at near (?) | ↓ NRA | Fails (+) B&M | Low lead | VT | (+) lenses Cycloplegic |

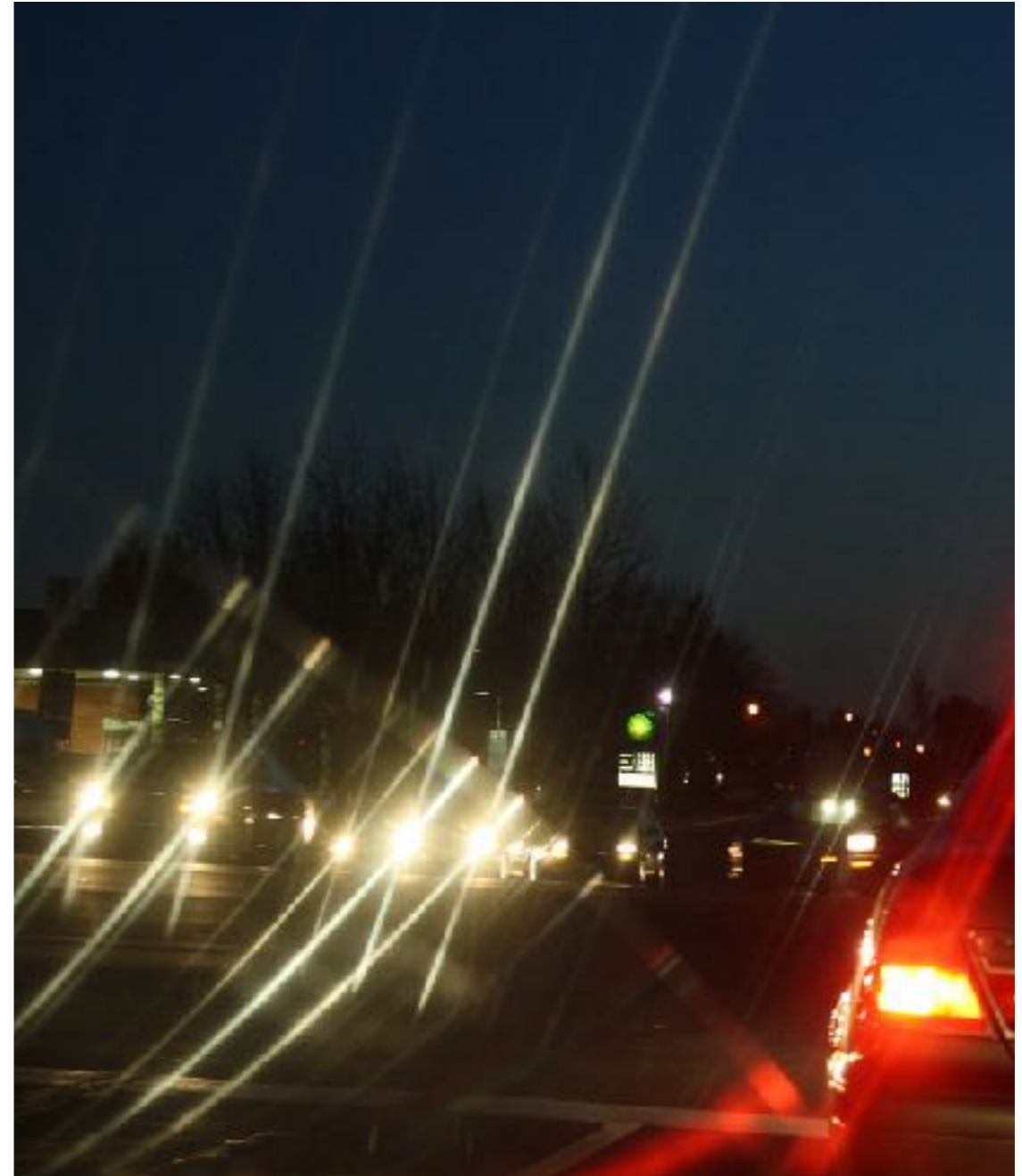
Morgan's Norms

- BO (PFV) 9/19/10
- BI (NFV) x/7/4
- BO' (PFV') 17/21/11
- BI' (NFV') 13/21/13
- PRA -2.37 +/- 1.00
- NRA +2.00 +/- 0.50
- BCC (FCC) +0.50 +/- 0.50



Refractive Error!

- Correct the refractive error!
- Patient education & reassurance



Vergence Disorders

Four children in every classroom see print this way. They can't control their eye movements at close distances, making reading and attention almost impossible. As the print blurs and moves, they stumble over words, lose their place, and can't comprehend. Out of desperation, they give up and quit. Is it any wonder they struggle in school?

the words move or jump

Assessing Vergence

- **Objective measurements**
 - Posture (Alignment) - cover test, vonGraefe phoria
 - Amplitude: Positive/Negative Relative Vergence (PRV/NRV)
 - Facility: 12BO/3BI Flipper
- **Subjective measurements**
 - Near Point of Convergence (NPC)
- When in doubt, ***refer!***



Vergence Disorders

- **Convergence Insufficiency**
- Divergence Insufficiency
- Convergence Excess
- Divergence Excess
- Vertical Heterophoria

Convergence Insufficiency (CI)

- Asthenopia/headaches with near tasks
- Intermittent blur
- Intermittent diplopia
- Words move on page
- Decreased reading comprehension over time
- Slow reading
- Covers one eye
- Avoids near work
- **Asymptomatic**



Convergence Insufficiency (CI)

- Low XP, greater XP'
- Reduced PFV & PFV'
- Intermittent suppression at near
- **Receded NPC**
- Normal accommodative amplitude
- Fails binocular accommodative facility
- Plano or lead (-) on BCC/MEM
- Low NRA
- Reduced prism facility in BO direction
- Low AC/A

Treating CI

- **Root Problem: Vision Therapy**
 - Most effective treatment method for vergence disorders.
 - Virtual reality, 3D TV, vectograms, tranaglyphs, stereoscope, prism goggles
- **Crutch: Prism**
 - Contoured Prism (Neurolens)
- **Not Helpful: Lenses**
 - Due to low AC/A

Pseudo-CI

- Exact same signs/symptoms, but patients **accept plus at near**
- (Primary issue is accommodative)
- **Active Treatment:** Vision Therapy
- **Passive Treatment:** Anti-fatigue lenses



Divergence Insufficiency (DI)

Symptoms

- Asthenopia/headaches with **distance** tasks
- Intermittent blur (distance)
- Intermittent diplopia (distance)
- Sensitivity to light
- Dizziness/vertigo

Signs

- $EP > EP'$ (can be ET)
- Reduced NFV, high PFV
- Low AC/A

Treating DI

- **Root Problem: Vision Therapy**

- Most effective treatment method for vergence disorders.
- Virtual reality, 3D TV, vectograms, tranaglyphs, stereoscope, prism goggles (**distance emphasis**)

- **Crutch: Prism**

- Base-Out (prefer distance-only but can be at all distances)
 - (Additional BO at near can be helpful due to high PFV')

- **Not Helpful: Lenses**

- Due to low AC/A

Convergence Excess (CE)

- Asthenopia/headaches with near tasks
- Intermittent blur
- Intermittent diplopia
- Words move on page
- Decreased reading comprehension over time
- Slow reading
- Covers one eye
- Avoids near work
- **Asymptomatic**



Convergence Insufficiency (CI)

- Asthenopia/headaches with near tasks
- Intermittent blur
- Intermittent diplopia
- Words move on page
- Decreased reading comprehension over time
- Slow reading
- Covers one eye
- Avoids near work
- **Asymptomatic**



Convergence Excess (CE)

- Asthenopia/headaches with near tasks
- Intermittent blur
- Intermittent diplopia
- Words move on page
- Decreased reading comprehension over time
- Slow reading
- Covers one eye
- Avoids near work
- **Asymptomatic**



Convergence Excess (CE)

- Mild-moderate EP, large EP'
- Reduced NFV'
- Intermittent suppression at near
- **Low PRA, High NRA**
- Normal accommodative amplitude
- Fails binocular accommodative facility
- High lag (+) on BCC/MEM
- **High plus acceptance**
- High AC/A

Treating CE

- **First Line: Plus Lenses**
 - Push plus at near (anti-fatigue, FT-28)
- **Root Problem: Vision Therapy**
 - Virtual reality, 3D TV, vectograms, tranaglyphs, stereoscope, prism goggles (**near BI emphasis**)
- **Not Helpful: Prism**
 - (Mostly because plus lenses are so helpful)

Divergence Excess (DE)

Symptoms

- Asthenopia/headaches with **distance** tasks
- Intermittent blur (distance)
- Intermittent diplopia (distance)
- Sensitivity to light (**closes one eye to bright light**)
- Dizziness/vertigo
- Cosmetic eye turn
- **Asymptomatic**

Signs

- $XP > XP'$ (frequently XT)
- Reduced NFV, normal/high PFV
- High AC/A
- Poor stereopsis at distance

Treating DE

- **Root Problem: Vision Therapy**
 - Most effective treatment method for vergence disorders.
 - Virtual reality, 3D TV, vectograms, tranaglyphs, stereoscope, prism goggles (**distance emphasis, watch for suppression!**)
- **Crutch: Minus Lenses**
 - Over-minus with younger patients will reduce
 - (Additional minus at near can be helpful due to low PFV’)
- **Not Helpful: Prism**
 - Due to suppression

Vertical Heterophoria

Symptoms

- Asthenopia/headaches
- Intermittent blur
- Diplopia (vertical or diagonal)
- **Dizziness/vertigo**
- Car/motion sickness
- Inability to concentrate during sustained visual tasks

Signs

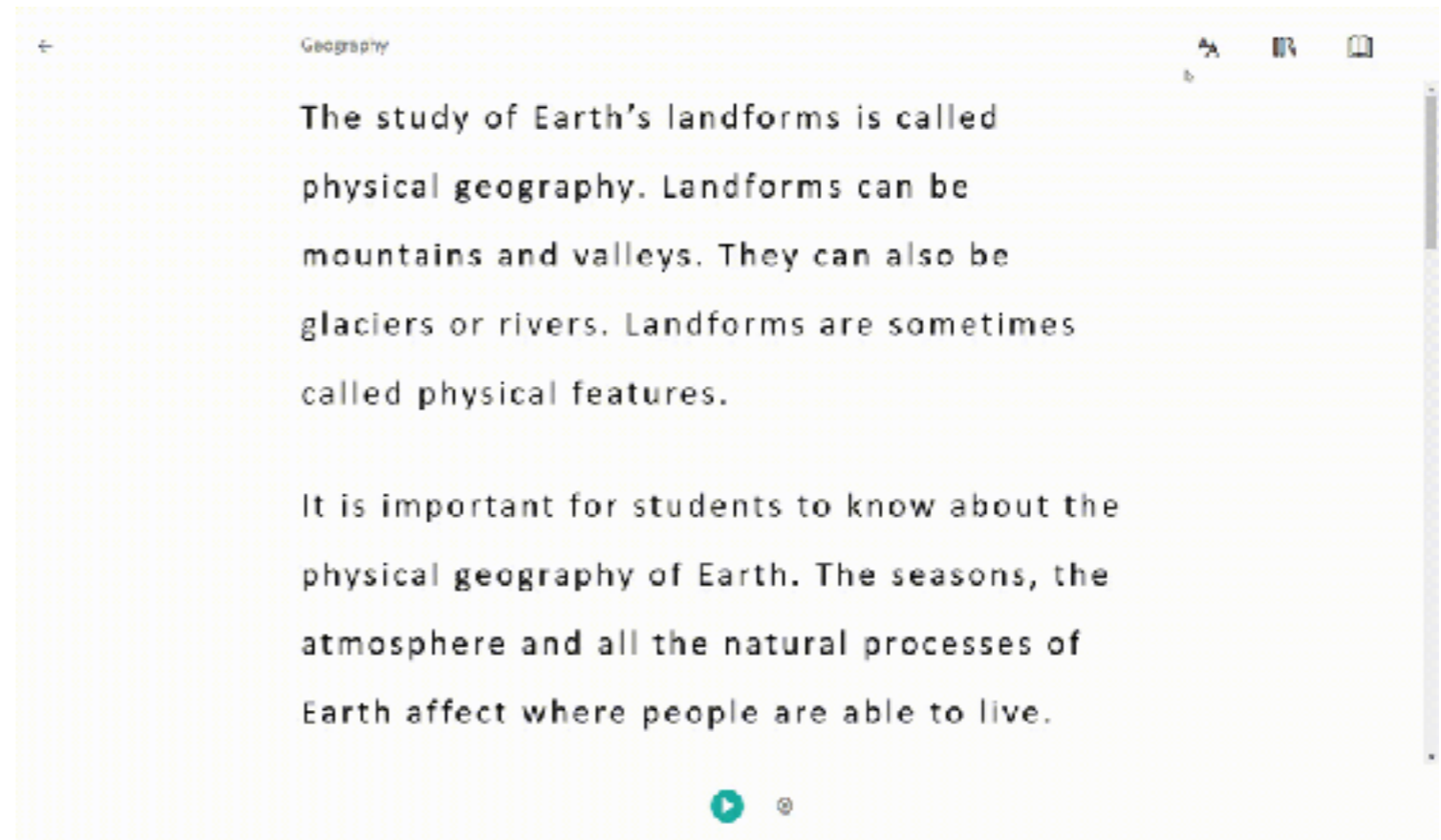
- **Head tilt**
- HP or HT (distance or near)
- **Reduced vergence ranges in all directions/distances**
- Poor stereopsis

Treating Vertical Heterophoria

- **First Line: Prism**
 - **Base opposite deviation!**
 - Example: RHyper gets treated with BD OD
- **Root Problem: Vision Therapy**
 - Improving **horizontal vergence ranges** improves vertical deviation.
 - Virtual reality, 3D TV, vectograms, tranaglyphs, stereoscope, prism goggles
- **Not Helpful: Lenses**

Tracking (Oculomotor)

Henry looked to the right. He looked to the left. He looked up, and he looked down. Where had Frog gone? Henry did not like being alone in the forest. "Frog, where are you?" Henry called. "Please come back!"



Oculomotor Dysfunctions

- **Deficient Saccadic Eye Movements**
 - Oculomotor component (CN III)
- **Deficient Smooth Pursuit Eye Movements**
 - Vestibular component (CN VIII)

Tracking: Symptoms

- Slow reader
- Lots of head movement!
- Loses place or uses finger excessively to read



Assessing Oculomotor

- **Objective Measurements**

- Visual tracking equipment

- EyeSync

- RightEye

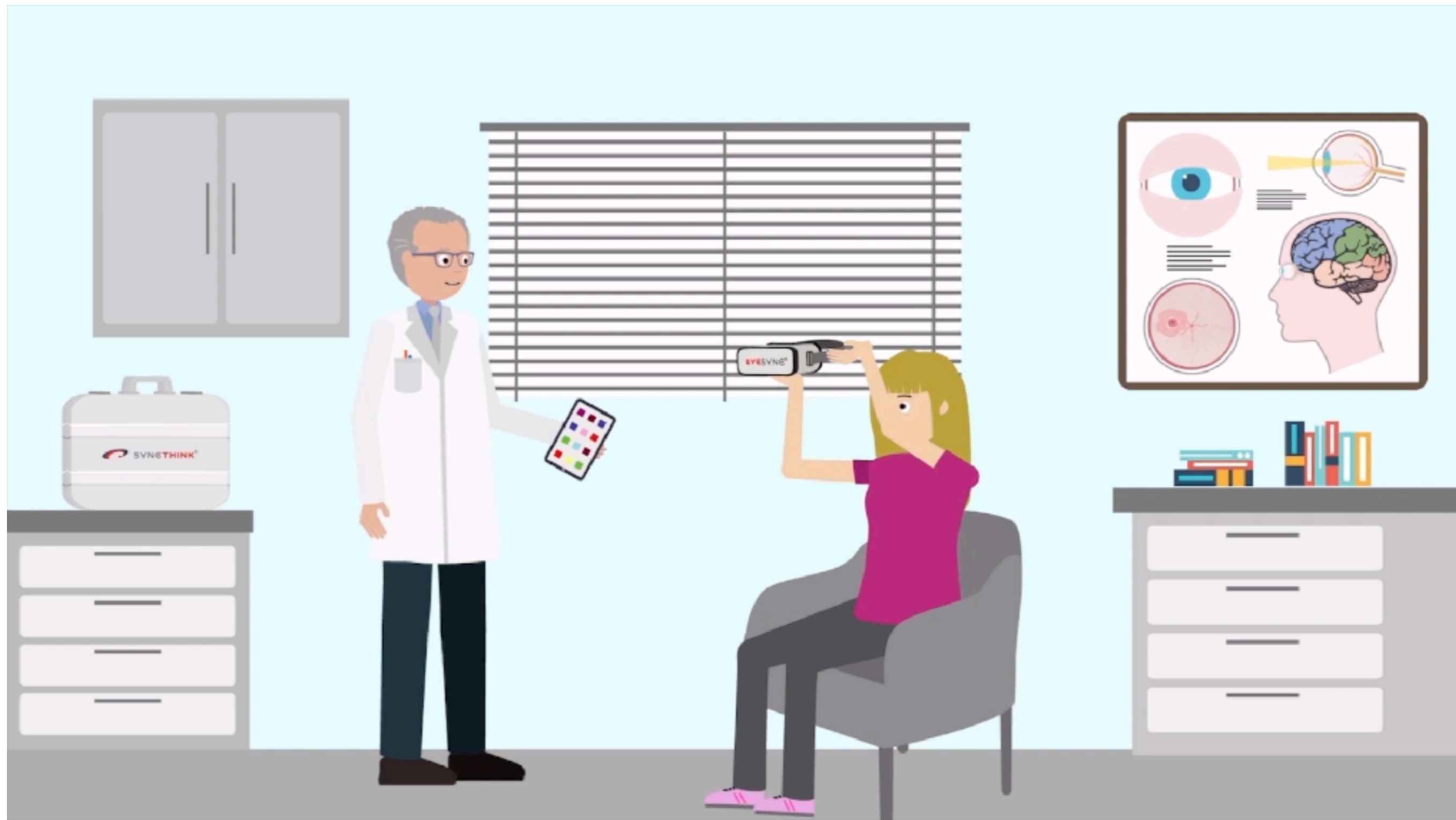
- OpticsTrainer

- **Subjective Measurements**

- NSUCO Method

- Ability, accuracy, head movement, body movement

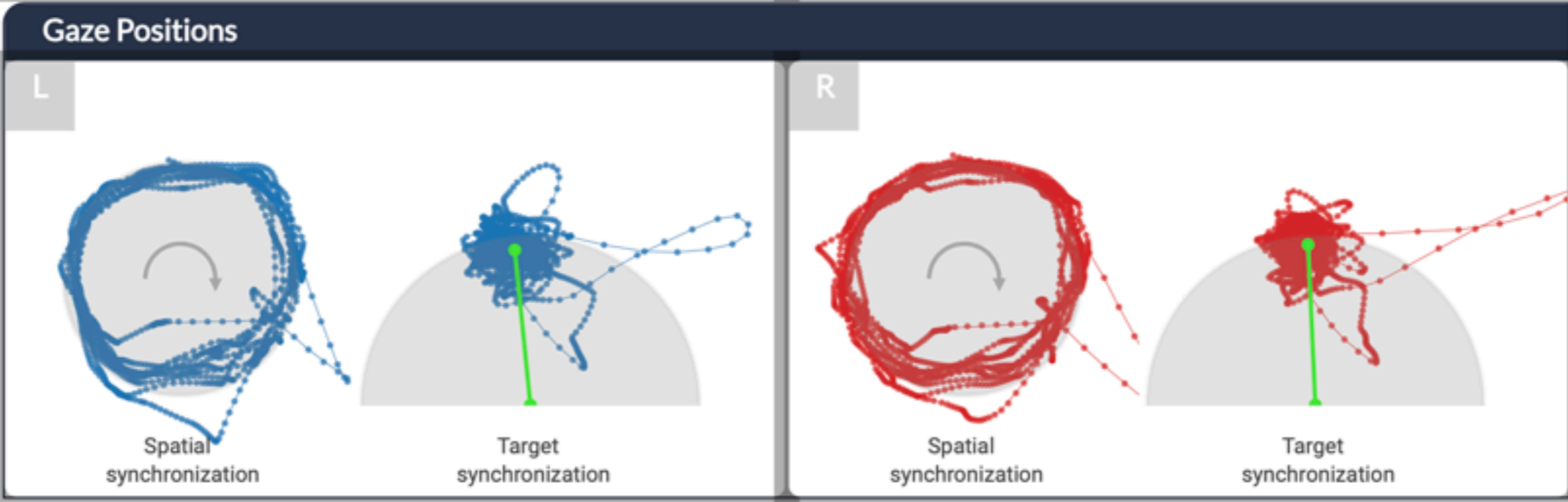
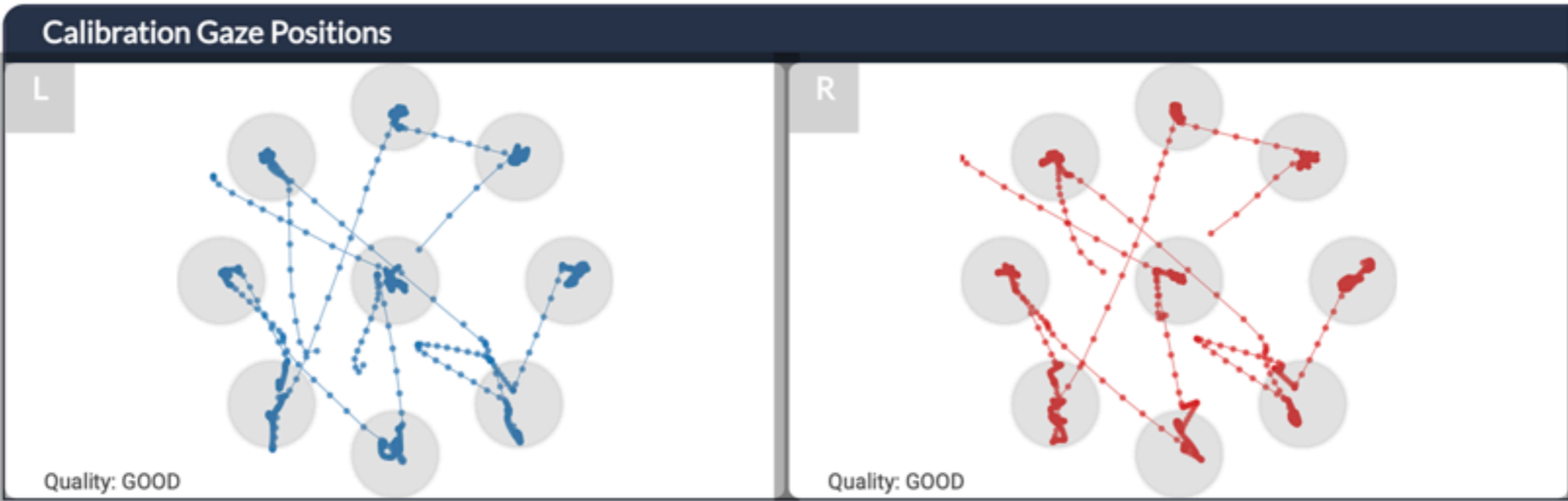
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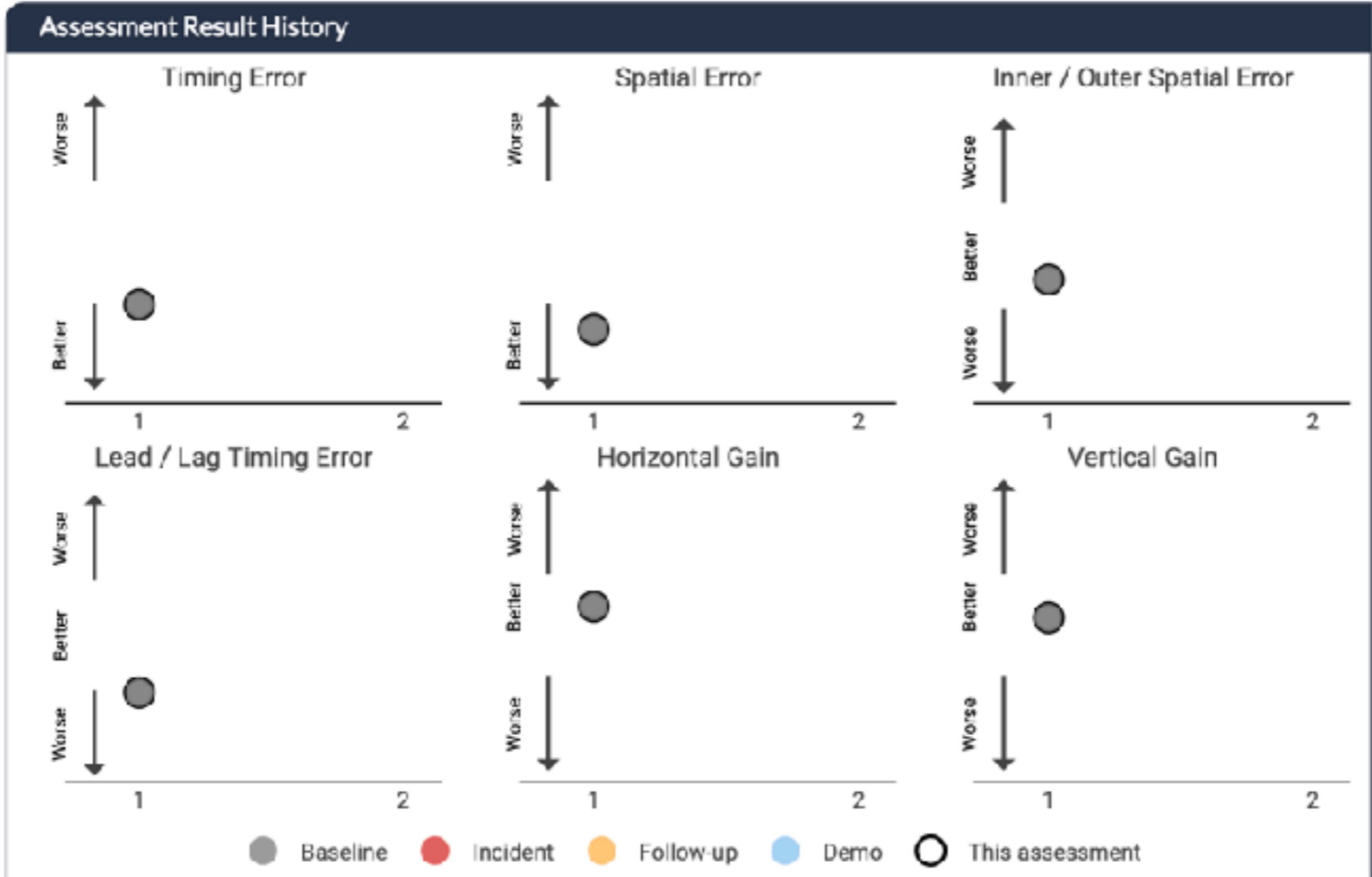
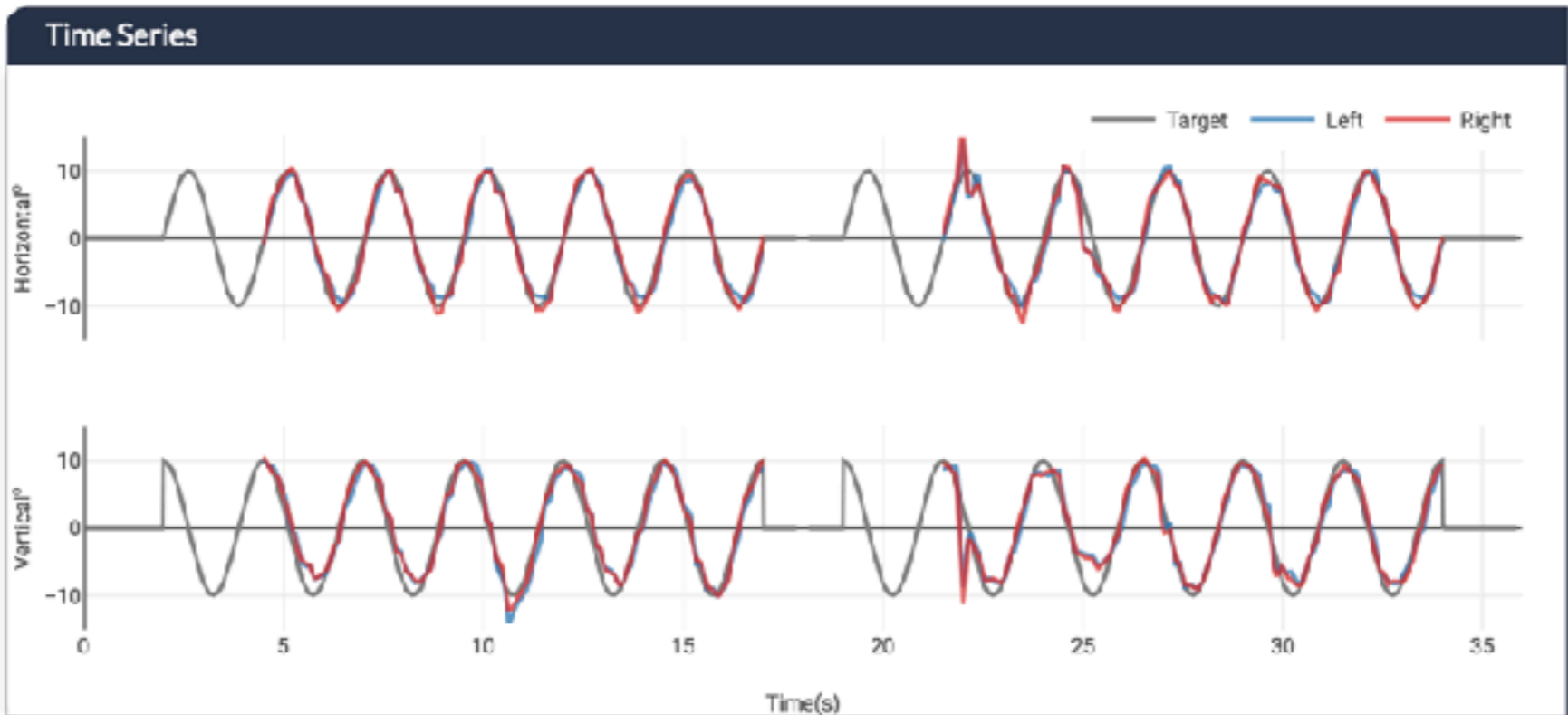
Pursuit Report

| EYE-SYNC Metrics | | |
|-----------------------------|----------|-----------|
| Smooth Pursuit | Left Eye | Right Eye |
| Timing Error | 1.69 | 1.54 |
| Spatial Error | 1.27 | 1.37 |
| Lead / Lag Timing Error | -5.75 | -2.61 |
| Inner / Outer Spatial Error | -0.75 | -0.47 |
| Horizontal Gain | 0.90 | 0.99 |
| Vertical Gain | 0.85 | 0.87 |

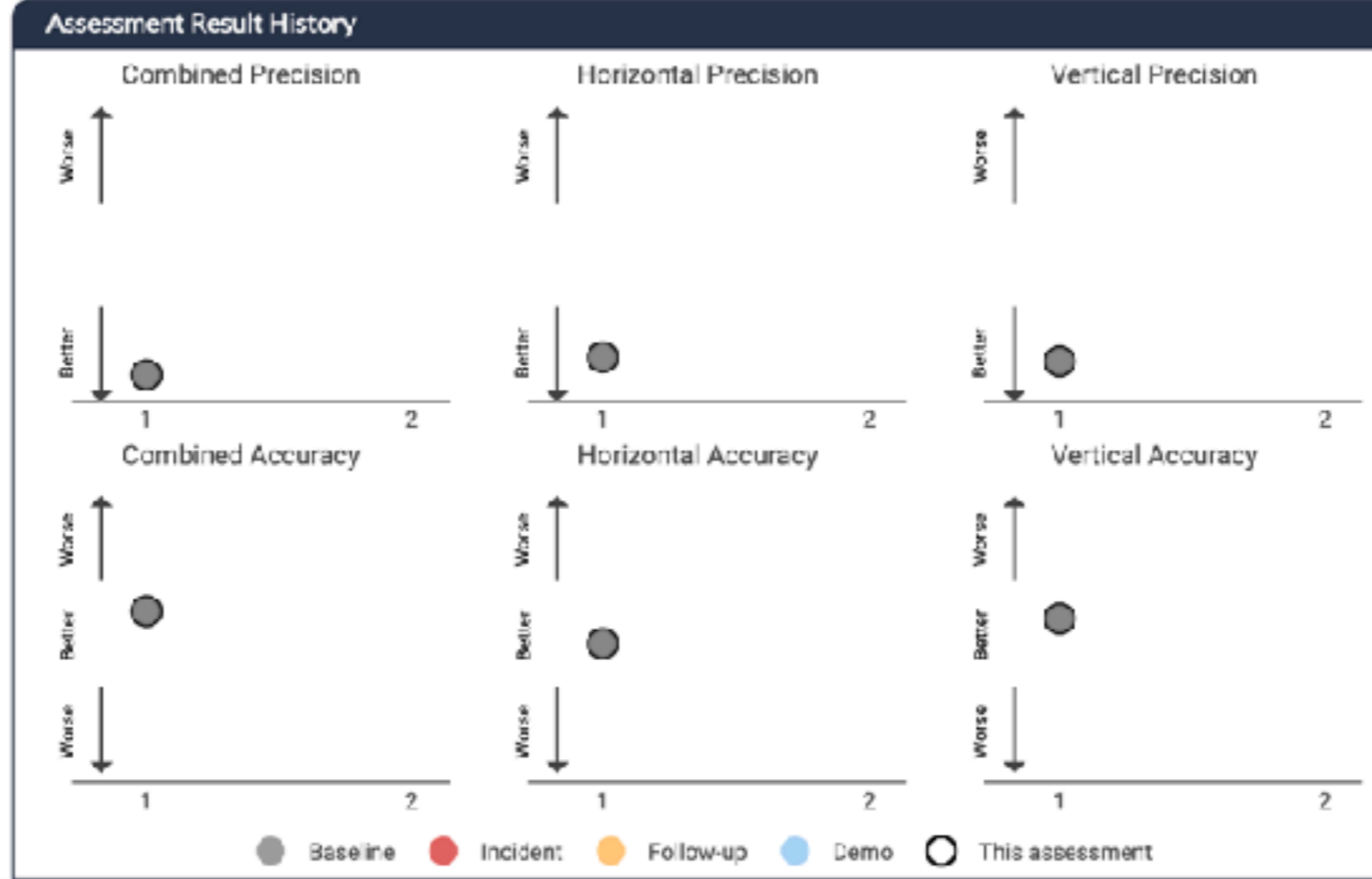
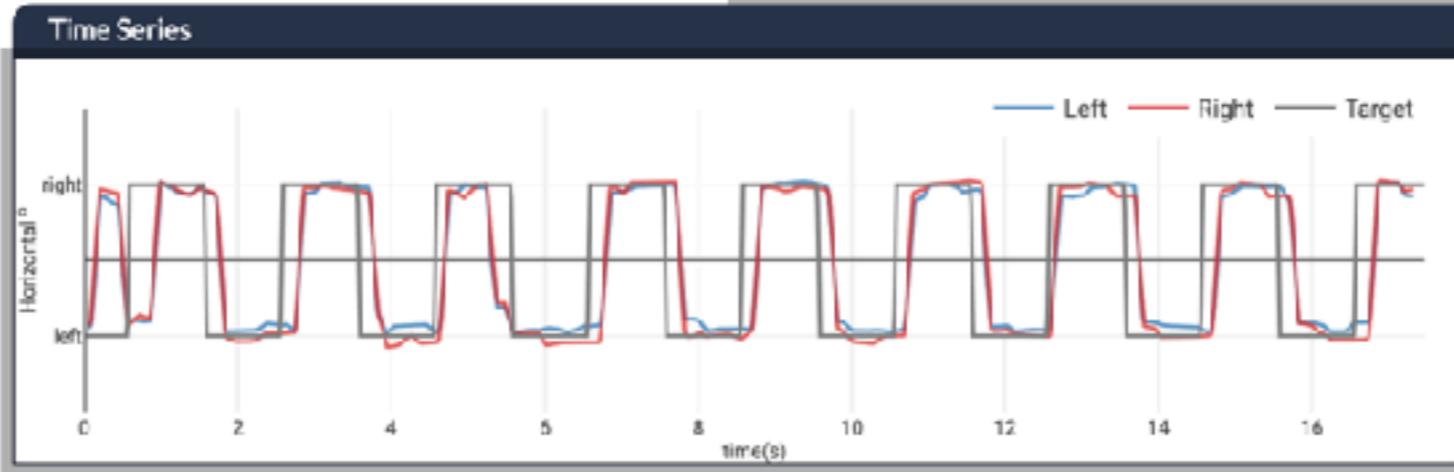
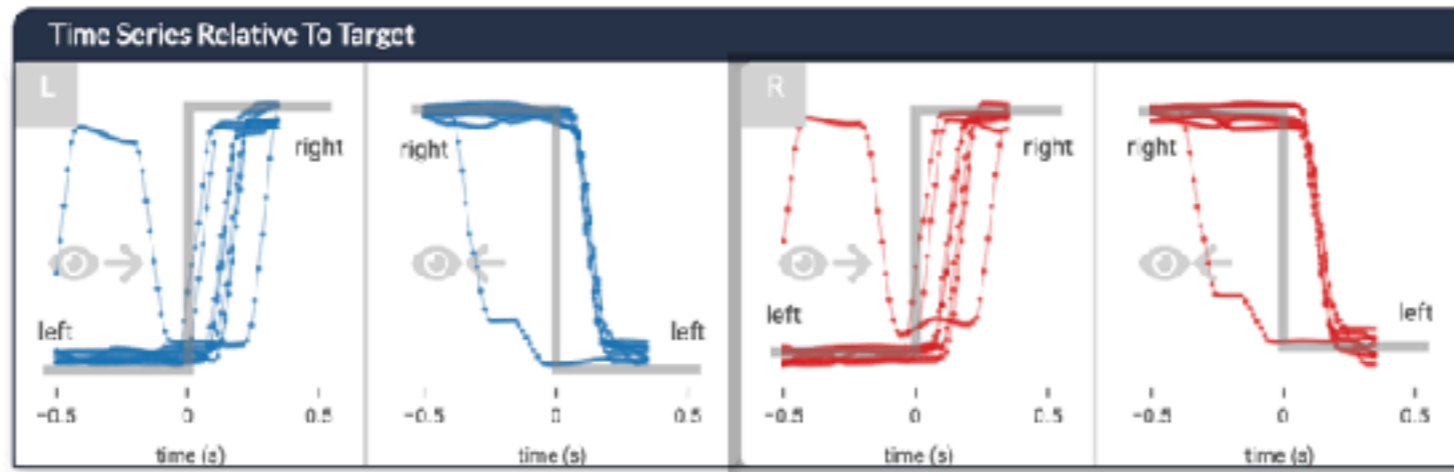
| Induced Symptoms | | | |
|---------------------|-----|------|------------|
| Assessment Symptoms | Pre | Post | Difference |
| Headache | 0 | 1 | 1 |
| Dizziness | 0 | 0 | 0 |
| Nausea | 0 | 0 | 0 |
| Fogginess | 0 | 0 | 0 |



Pursuit Report



Saccade Report



Saccade Report

| EYE-SYNC Metrics | | |
|----------------------|----------|-----------|
| Saccade | Left Eye | Right Eye |
| Combined Precision | 0.31 | 0.28 |
| Horizontal Precision | 0.78 | 0.46 |
| Vertical Precision | 0.21 | 0.42 |
| Combined Accuracy | 1.01 | 0.83 |
| Horizontal Accuracy | 0.34 | -0.26 |
| Vertical Accuracy | -0.61 | 0.58 |

| Induced Symptoms | | | |
|---------------------|-----|------|------------|
| Assessment Symptoms | Pre | Post | Difference |
| Headache | 1 | 0 | -1 |
| Dizziness | 0 | 0 | 0 |
| Nausea | 0 | 0 | 0 |
| Fogginess | 0 | 0 | 0 |



NSUCO Method

Pursuits

- Patient is STANDING
- Target is held 40 cm from patient at maximum or a minimum of the harmon distance
- Pursuit path is in a circle, 20 cm in diameter
- Minimum of 2 rotation clockwise and 2 counterclockwise
- Test OD, OS, and OU
- Performance in 4 categories
 - Ability
 - Accuracy
 - Body Movement
 - Head Movement
- Score is used to determine performance based on age and gender

Saccades

- Patient stands for this test
- Similar to gross saccadic testing, but standardized and strict criterion for administration
- Performance rated in 4 categories on a 1-5 scale
 - Ability
 - Accuracy
 - Body Movement
 - Head Movement
- Patient score is used to determine performance based on age and gender
- If the patient fails the test, OMD is very likely
- Passing the test does not rule out the existence of OMD

Pursuits: Male **Pursuits: Female**

| Age | A | A | HM | BM | Age | A | A | HM | BM |
|-----|---|---|----|----|-----|---|---|----|----|
| 5 | 4 | 2 | 2 | 3 | 5 | 5 | 3 | 3 | 4 |
| 6 | 4 | 2 | 2 | 3 | 6 | 5 | 3 | 3 | 4 |
| 7 | 5 | 3 | 3 | 3 | 7 | 5 | 3 | 3 | 4 |
| 8 | 5 | 3 | 3 | 4 | 8 | 5 | 4 | 3 | 4 |
| 9 | 5 | 3 | 3 | 4 | 9 | 5 | 4 | 3 | 4 |
| 10 | 5 | 4 | 4 | 4 | 10 | 5 | 4 | 4 | 5 |
| 11 | 5 | 4 | 4 | 4 | 11 | 5 | 4 | 4 | 5 |
| 12 | 5 | 4 | 4 | 5 | 12 | 5 | 4 | 4 | 5 |
| 13 | 5 | 5 | 4 | 5 | 13 | 5 | 4 | 4 | 5 |
| 14 | 5 | 5 | 4 | 5 | 14 | 5 | 4 | 4 | 5 |

Saccades: Male **Saccades: Female**

| Age | A | A | HM | BM | Age | A | A | HM | BM |
|-----|---|---|----|----|-----|---|---|----|----|
| 5 | 5 | 3 | 2 | 3 | 5 | 5 | 3 | 2 | 4 |
| 6 | 5 | 3 | 2 | 3 | 6 | 5 | 3 | 3 | 4 |
| 7 | 5 | 3 | 3 | 3 | 7 | 5 | 3 | 3 | 4 |
| 8 | 5 | 3 | 3 | 4 | 8 | 5 | 3 | 3 | 4 |
| 9 | 5 | 3 | 3 | 4 | 9 | 5 | 3 | 3 | 4 |
| 10 | 5 | 3 | 3 | 4 | 10 | 5 | 3 | 4 | 4 |
| 11 | 5 | 3 | 3 | 4 | 11 | 5 | 3 | 4 | 5 |
| 12 | 5 | 3 | 3 | 4 | 12 | 5 | 3 | 4 | 5 |
| 13 | 5 | 3 | 3 | 5 | 13 | 5 | 3 | 4 | 5 |
| 14 | 5 | 4 | 3 | 5 | 14 | 5 | 3 | 4 | 5 |

NSUCO

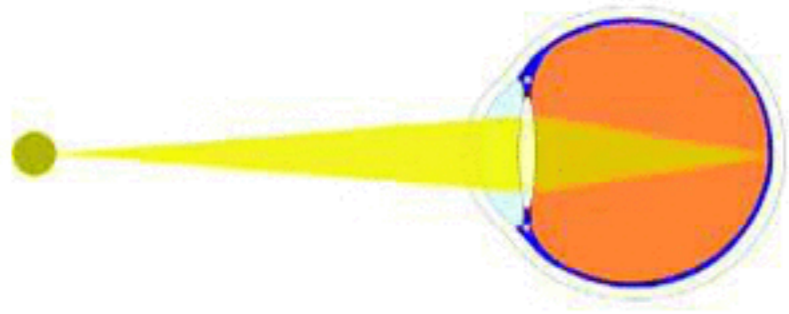
| | Score | 1 | 2 | 3 | 4 | 5 |
|-----------------|----------|------------------------------------|----------------------------------|--|---|-------------------------------------|
| Pursuits | Ability | Cannot complete ½ rotation CW/CCW | Completes ½ rotation CW/CCW | Completes 1 rotation in either direction | Completes 2 rotations but not both ways | Completes 2 rotations both CW & CCW |
| | Accuracy | No attempt to follow >10 re-fix | Re-fixates 5-10 times | Re-fixates 3-4 times | Re-fixates <2 times | No re-fixations |
| | Movement | Large head (body) at any time | Moderate head (body) at any time | Slight head (body) >50% | Slight head (body) <50% | No head or body movement |
| Saccades | Ability | <2 round trips | Completes 2 round trips | Completes 3 round trips | Completes 4 round trips | Completes 5 round trips |
| | Accuracy | Large over/under shooting | Moderate over/under 1+ times | Constant slight over/under >50% | Intermittent slight over/under <50% | No over/under noted |
| | Movement | Large head (body) at any time | Moderate head (body) at any time | Slight head (body) >50% | Slight head (body) <50% | No head or body movement |

Treating Oculomotor Dysfunction

- Saccadic Eye Movements are best treated in a **vision therapy** setting
 - Most effective treatment method for saccadic disorders
 - Infrared tracking software (OpticsTrainer), saccadic workbooks, Hart charts
- Pursuit eye movements, independent of other visual diagnoses, are best addressed in a **physical therapy** setting
 - “Astronaut program”
 - Balance/coordination
- Exception: VOR/VORx

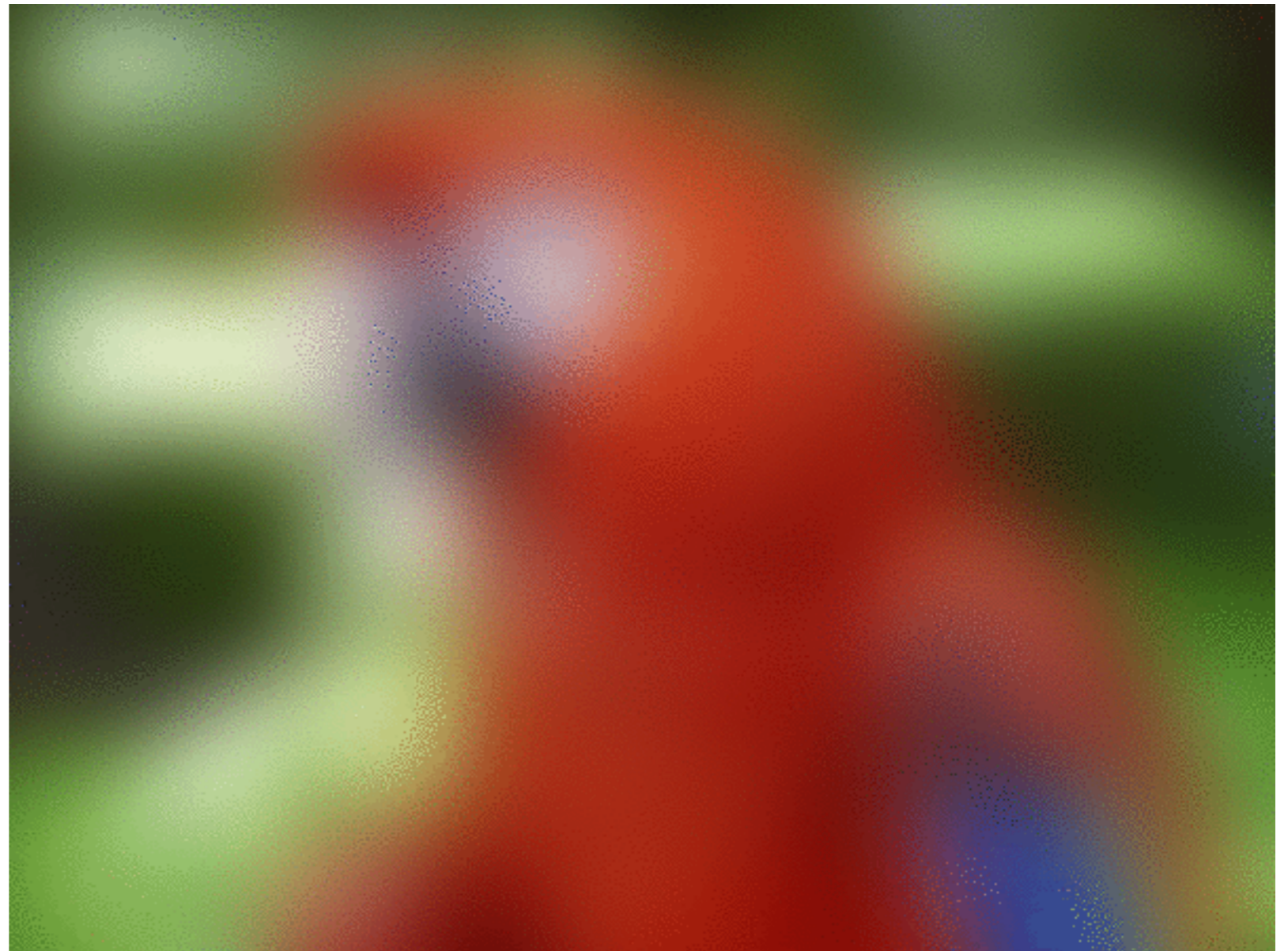
Accommodative Disorders

“Focusing”



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Accommodative Dysfunctions

- Paresis of accommodation
- Paralysis of accommodation
- Spasm of accommodation

- Do not confuse with **presbyopia!**

Symptoms

- Squinter, even with glasses
- Slow note-taker
 - Shift (far > near > far)
- Lots of blinking!



Assessing Accommodation

- **Objective Measurements**

- Posture: Binocular Cross-Cylinder (BCC)
- Facility: +/-2.00 Rock
- Amplitude: Minus Lens amplitude
- Binocular: Positive/Negative Relative Accommodation (PRA/NRA)

- **Subjective Measurements**

- Monocular push-up
 - Monocular pull-away
- When in doubt, ***refer!***

Treating Accommodative Dysfunction

- Passive therapy
 - Anti-fatigue lenses
 - General rule of thumb: prescribe $\frac{1}{2}$ the **BCC value**
- Active vision therapy
 - Most effective treatment method for accommodative disorders.
 - Flippers, lens sorting, etc.
 - Free space accommodative activities
 - Bullseye target, near/far chart

Comitant Strabismus

- What's the goal?
- What does the deviation look like?
- What is the sensory fusional ability?
- What is the visual potential?
- What has been done in prior treatment?

Comitancy

- Comitant: the magnitude of the deviation is the same in all directions of gaze
 - General rule of thumb: <5 pd difference between highest and lowest deviation
 - Examples: decompensating phoria, congenital strabismus
- Noncomitant: the magnitude of the deviation varies in different directions of gaze
 - Most commonly: muscle or nerve problem (acquired)

Comitant Strabismus: What's the goal?

- Cosmesis?
- Acuity?
- Stereopsis?
- Getting out of prism?
- Normal binocular vision?

Strabismus: Deviation

- **Frequency**
 - Intermittent > Constant
- **Direction**
 - XT > ET > HT
- **Magnitude**
 - Smaller is better (except constant microtropes)
- **Laterality**
 - Amblyopia, eccentric fixation
- **Comitancy**
 - May not achieve BV in all fields of gaze
- **Accommodative Component**
 - Non-accommodative: more consistent prognosis

Strabismus: Sensory Fusion

- **Amblyopia**
 - Often best to treat amblyopia first
- **Suppression**
 - Guarded prognosis for deeper suppression
- **Retinal Correspondence**
 - AC is less favorable
- **Stereopsis**
 - Better prognosis with 2nd & 3rd degree fusion

Strabismus: Visual Potential

- **Age of onset**
 - $> 3-5$ years is more favorable
- **Age of treatment**
 - Early treatment = faster improvement

Strabismus: Prior Treatment

- **Details, details, details!**
 - Surgery, patching, drops, VT, homeopathic
- **How compliant was the patient?**
- **What is current motivation?**

Strabismus: Assessment

- Cover Test
- Monocular acuities
- **Eccentric Fixation**
 - Direct Ophthalmoscopy (Visuoscopy)
- **Anomalous Correspondence**
 - Cover Test, Worth 4 Dot, Cover Test

Strabismus: Treatment Options

- Prism
- Surgery
- Occlusion
- Vision Therapy
- Combination

Prism

Good Idea

- Previous incidence of stereopsis
- No prism adaptation
- Elderly patients
- Limited financial resources

Bad Idea

- No previous stereopsis of any kind
- Prism adapter
- Young patients
- Patients with anomalous retinal correspondence

Strabismus Surgery

Good Idea

- Stereopsis (virtual or real space)
- No anomalous retinal correspondence
- No eccentric fixation
- Large deviations
 - > 20 XT
 - > 10 ET
 - > 5 HT

Bad Idea

- No previous stereopsis of any kind
- Unharmonious anomalous retinal correspondence
- Eccentric fixation > 2 DD
- Small deviations
- Surgical intervention without sensory fusion therapy

~~Occlusion Therapy~~

Good Idea (??)

- Amblyopia

Bad Idea

- No amblyopia present

Vision Therapy

Good Idea

- Stereopsis (virtual or real space)
- No anomalous retinal correspondence
- No eccentric fixation
- Small deviations
 - < 20 XT
 - < 10 ET
 - < 5 HT

Bad Idea

- No previous stereopsis of any kind
- Unharmonious anomalous retinal correspondence
- Eccentric fixation > 2 DD
- Large deviations
- Known neurologic paresis of CN III, IV, or VI

Combination Treatment

- **Step 1: Vision Therapy**
 - Establish sensory fusion virtually or in real space
 - Determine prismatic correction that provides the best stereopsis
- **Step 2: Strabismus Surgery**
- **Step 3: Vision Therapy**
 - Establish fusional ranges within (or close to) Morgan's Norms
 - Monitor closely to determine changes in sensory fusional ability

My BV Testing Sequence

Technician

- History
- Core 4 (pupils/EOMs/CVF/VA)
- Stereopsis
 - W4D
 - Stereo Book
 - Distance Stereo
- Near Cover Test (9 POGs)
- Maddox Rox (distance & near)
- NSUCO Pursuits/Saccades
- EyeSync
 - Pursuits, Saccades, Convergence

Doctor

- Vergence Ranges
 - Distance BO
 - Distance BI
 - Near BO
 - Near BI
 - Vergence Facility (12BO/3BI flipper)
- Accommodation
 - PRA (minus)
 - Minus Lens accommodative amplitude
 - NRA (plus)
 - BCC/MEM

My Screening: Animals On A Stick!!

- NSUCO Pursuits
- NPC
- NSUCO Saccades
- Monocular Push-Up Accommodation



Animals On A Stick!!



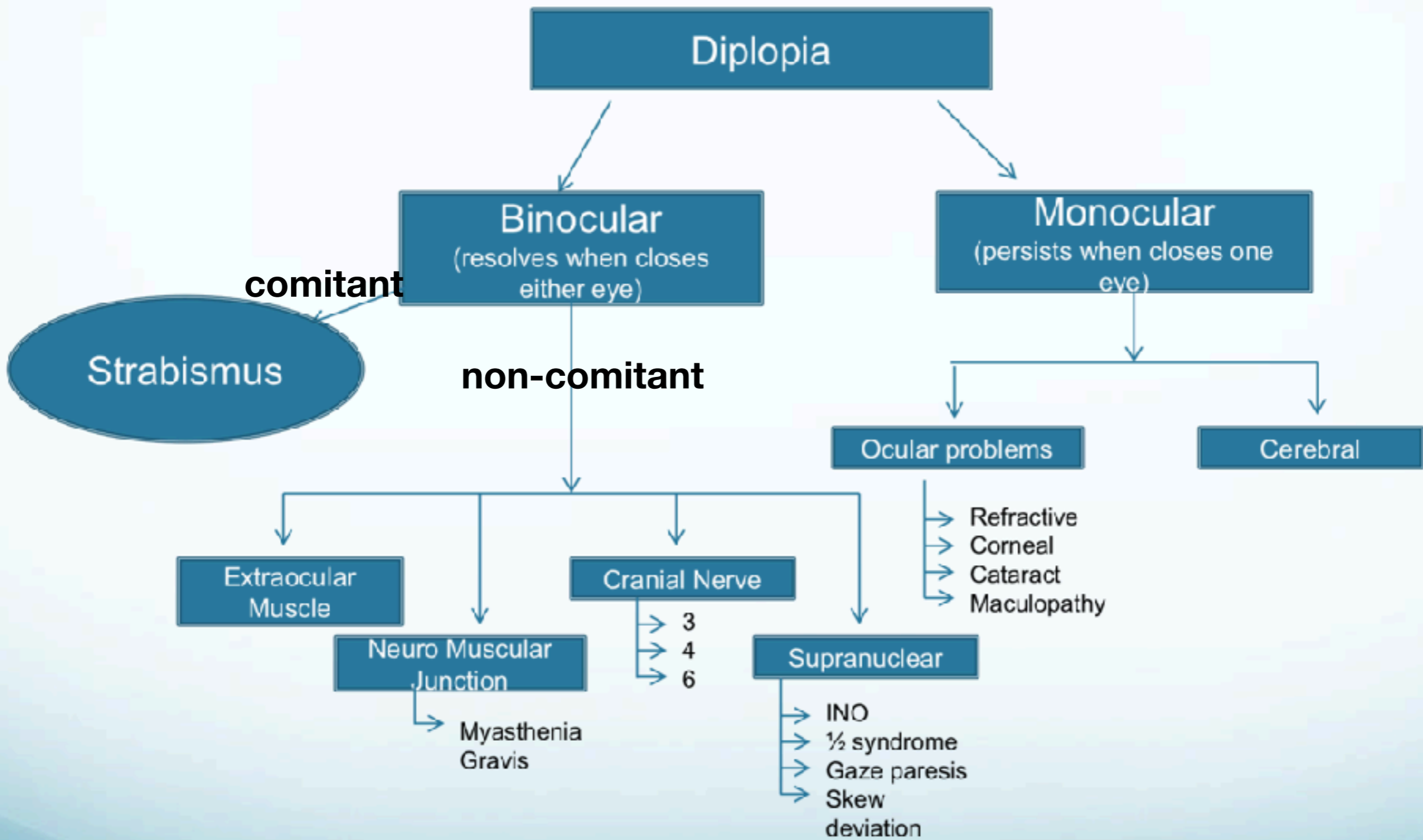
Outline

- Binocular Vision Crash Course
- Know the Horses
- **Find the Zebras**
- Know the Difference

The Zebras

- **Cranial Nerve Palsies**
- Neuromuscular Junction Deficiencies
- Extraocular Muscle Entrapment
- Supranuclear Anomaly

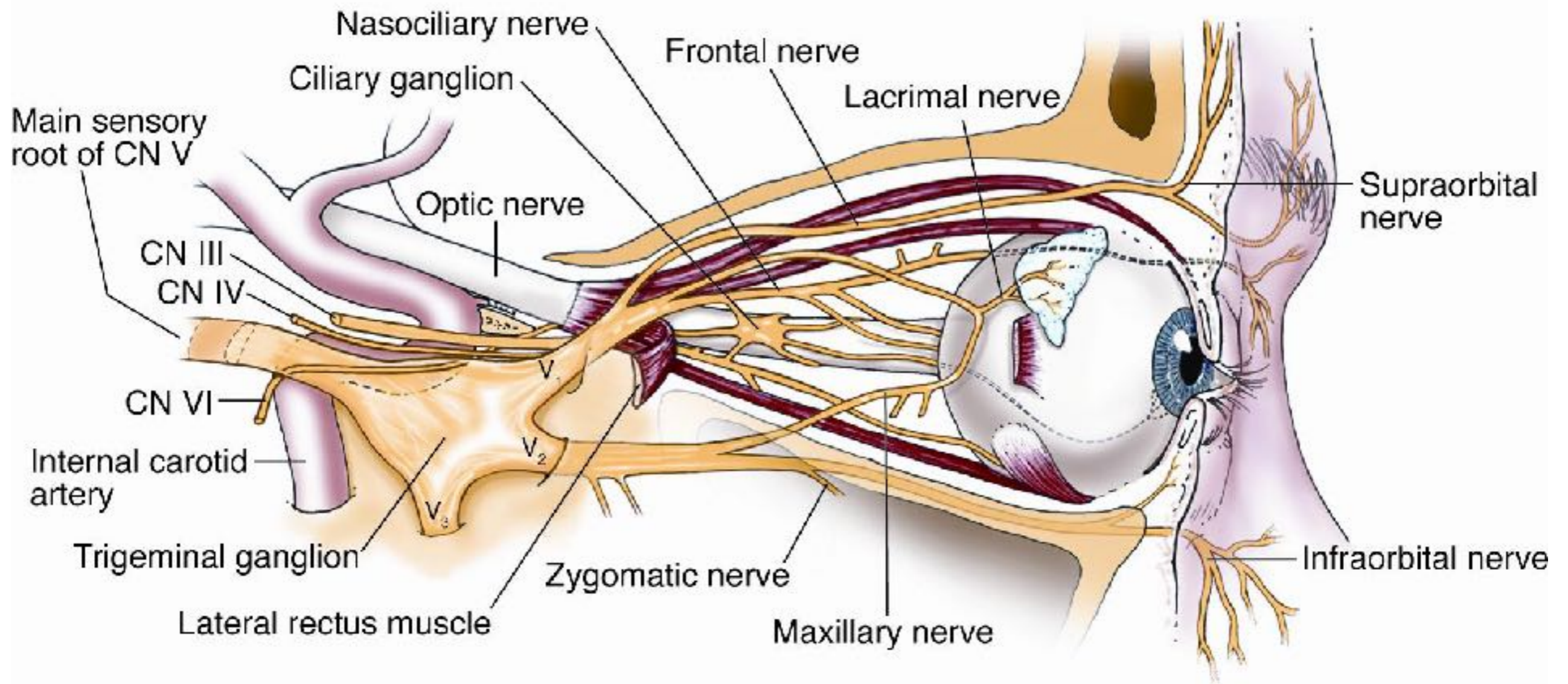




Horizontal or Vertical?

- Horizontal
 - Horses! (CI, CE, DI, DE)
 - 6th Nerve Palsy
 - 3rd Nerve Palsy
 - Internuclear Ophthalmoplegia (INO)
 - Myasthenia Gravis
 - Multiple Sclerosis
- Vertical
 - 4th Nerve Palsy
 - Thyroid-associated ocular disease
 - Myasthenia Gravis
 - 3rd Nerve Palsy
 - Multiple Sclerosis
 - Skew Deviation

QUICK ANATOMY CHECK-IN



Muscles and Nerves!

| | Primary movement | Secondary movement | Tertiary movement | Innervation |
|------------------|------------------|--------------------|-------------------|-------------|
| Superior Rectus | Elevate | Intort | Adduct | 3 |
| Inferior Rectus | Depress | Extort | Adduct | 3 |
| Lateral Rectus | Abduct | | | 6 |
| Medial Rectus | Adduct | | | 3 |
| Superior Oblique | Intort | Depress | Abduct | 4 |
| Inferior Oblique | Extort | Elevate | Abduct | 3 |

Cranial Nerve Palsies

- 3rd
- 4th
- 6th



CN III Palsy

- **Complete**

- ALL muscles innervated by CN III involved
- Eye “down & out”
- + ptosis
- Patients are usually not diplopic (due to complete ptosis)

- **Partial**

- Involvement of one or more muscles innervated by CN III (mild to severe)
- + or - ptosis (mild to severe)
- May cause horizontal, vertical, and/or oblique diplopia

CN III Palsy

- **Pupil-Sparing**

- Pupils are symmetric in size & reactive to light

- **Pupil-Involved**

- Larger pupil on the side of the palsy
- Poorly reactive to light

CN III Etiology

- Ischemic/Vascular
 - Compressive
 - Aneurysm/Neoplasm
 - Traumatic
 - Inflammatory
 - MS
 - Infectious
 - Meningitis
- Most life-threatening: Aneurysm
 - Best prognosis: Ischemic
 - Most common cause in adults: Ischemic (HTN, DM, etc)
 - Most common acquired cause in children: Trauma
 - Most likely pupil-sparing: Ischemic

Ischemic CN III Palsies

- Age: >40 years old
- Medical history: HTN, DM, atherosclerosis, smoking (microvascular)
- Timing: Sudden onset
- Exam: complete palsy with ptosis, normal pupil, no other CN involvement, no other neurologic signs/symptoms
- Work-up (excluding HTN/DM): BP, CBC, RPR, FTA-Ab, ANA, ESR, CRP, glucose tolerance test
- Prognosis: resolves within 3-4 months
- Treatment: Manage systemic risk factors

Compressive CN III Palsies

- Aneurysm
 - Most commonly at junction of internal carotid and posterior communicating artery
 - Acute onset, pupil involvement, persisting severe pain
 - **DON'T MISS THIS. THIS IS AN EMERGENCY.**
- Neoplasm
 - A slow-progressing pupil-involved palsy
 - Primary tumors of oculomotor nerve: Neurinomas and Schwannomas
 - Tumors adjacent to nerve: Pituitary apoplexy, sphenoid wing meningioma
- Bottom line: PUPIL INVOLVEMENT = EMERGENCY. Refer for imaging.

CN IV Palsy

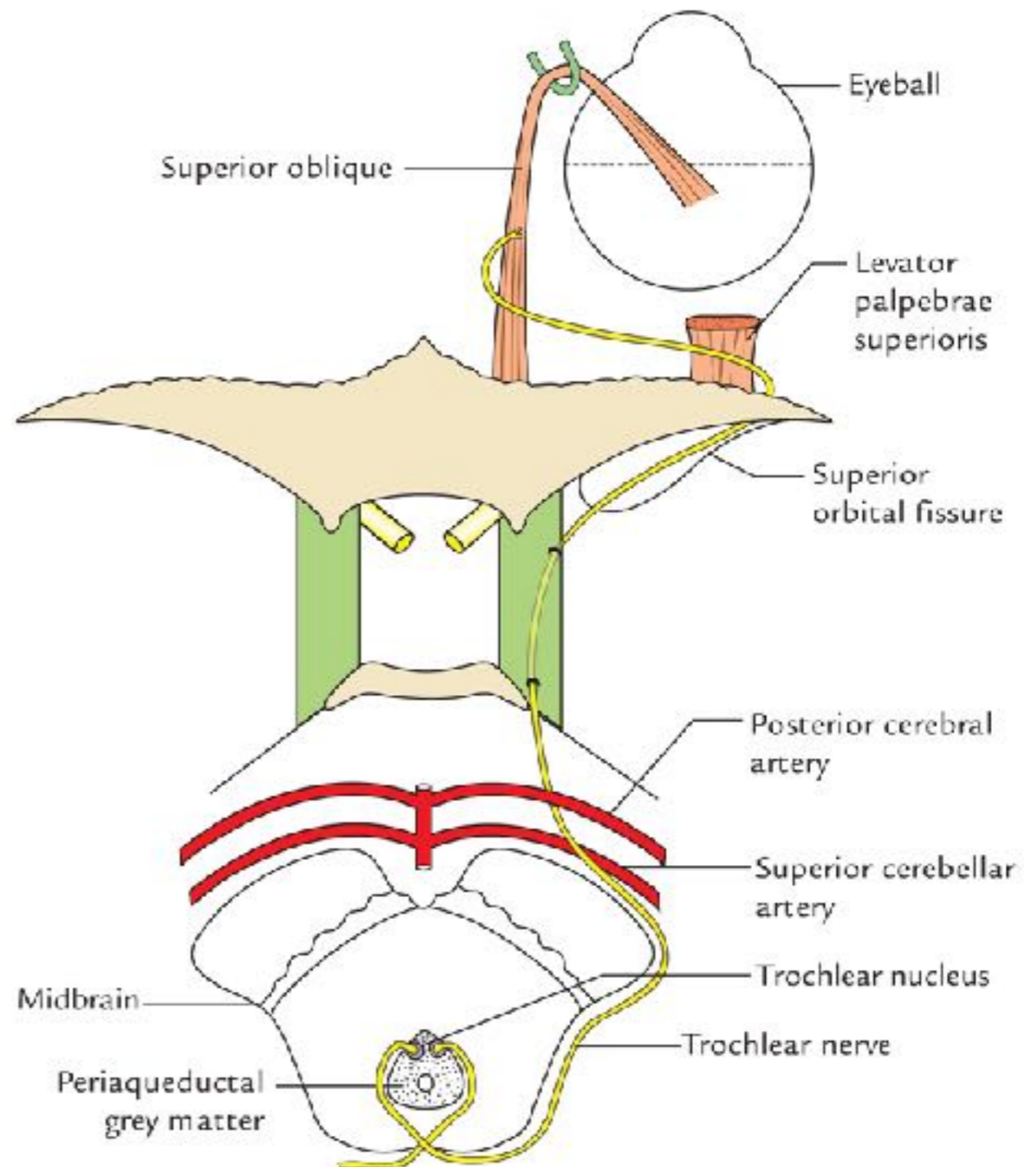
- **Most common palsy**

- Common etiologies:

- Traumatic
- Congenital
- Ischemic

- Less common:

- Neoplasm
- Aneurysm
- Inflammatory



Traumatic CN IV Palsies

- Most vulnerable nerve because it has the longest course
- Unilateral or bilateral
- Neuroimaging is indicated to rule out other causes
- Prognosis: partial or complete resolution
- Management: treat residual diplopia with prism

Congenital CN IV Palsies

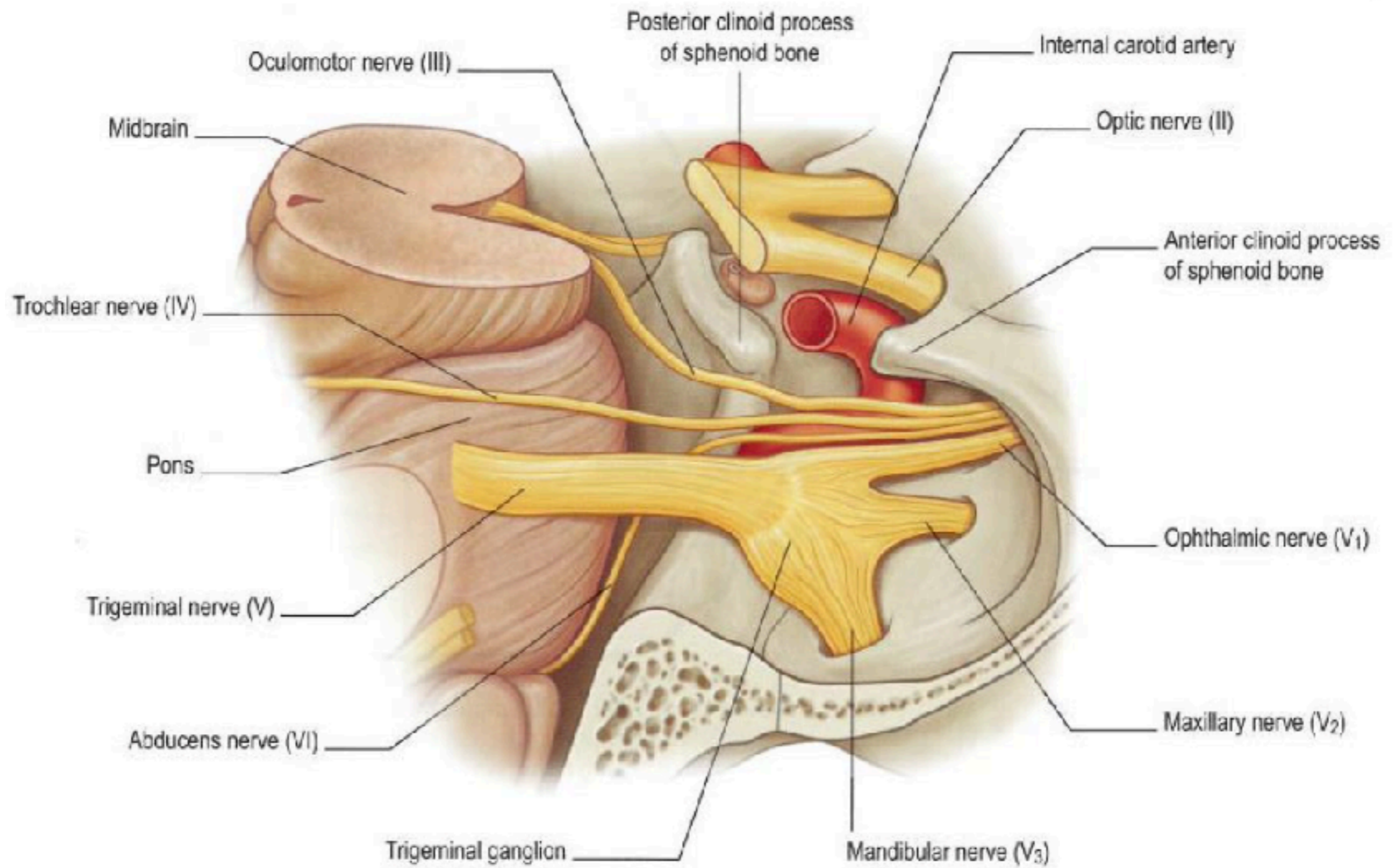
- Can present in childhood or decompensate later
- No progression of deviation
- No other CN involvement or neurologic signs
- Pro tip: look at old pictures!
- Management: vertical prism

Ischemic CN IV Palsies

- Age: >40 years old
- Medical history: HTN, DM, atherosclerosis, smoking (microvascular)
- Timing: Sudden onset (with torsion), no progression
- Exam: normal fusional ranges, no other CN involvement, no other neurologic signs/symptoms
- Work-up (excluding HTN/DM): BP, CBC, RPR, FTA-Ab, ANA, ESR, CRP, glucose tolerance test.
- Imaging: MRI brain/orbits w/ fat suppression & gadolinium; special attention to course of 4th nerve: midbrain, pituitary gland, orbital apex
- Prognosis: resolves within 3-6 months
- Treatment: Manage systemic risk factors

CN VI Palsy

- Ipsilateral horizontal gaze palsy
- Ipsilateral facial weakness
- Neither eye can look in direction of lesion
- Particularly vulnerable as it climbs over the petrous apex of the temporal bone
 - Elevated ICP, mastoid infection, skull fracture, tumor
- Etiologies:
 - Ischemic (HTN/DM)
 - Neoplasm
 - Traumatic
 - Elevated intracranial pressure
 - Aneurysm
 - Inflammatory
 - Meningitis



Isolated CN VI Palsy

- Age: >40 years old
 - If <40, refer to neurology (mass lesions or MS)
- Medical history: HTN, DM, atherosclerosis, smoking (microvascular)
- Timing: Sudden onset
- Exam: esotropia in primary gaze, unilateral restriction of abduction, diplopia, no other neurologic signs/symptoms
- Work-up (excluding HTN/DM): BP, CBC, RPR, FTA-Ab, ANA, ESR, CRP, glucose tolerance test.
- Prognosis: resolves within 3-6 months. If no resolution, refer to neurology
- Treatment: Manage systemic risk factors
 - If >55, giant cell arteritis should be considered (ESR+CRP)
- **CLINICAL PEARL: A microvascular CN VI palsy is most often nonarteritic**

BILATERAL 6th Palsy??

- **Chiari Malformations**

- Headache (often with exercise)

- Dizziness

- Diplopia from unilateral or **bilateral** 6th nerve palsy (sometimes masquerades as divergence insufficiency)

- Downbeat nystagmus



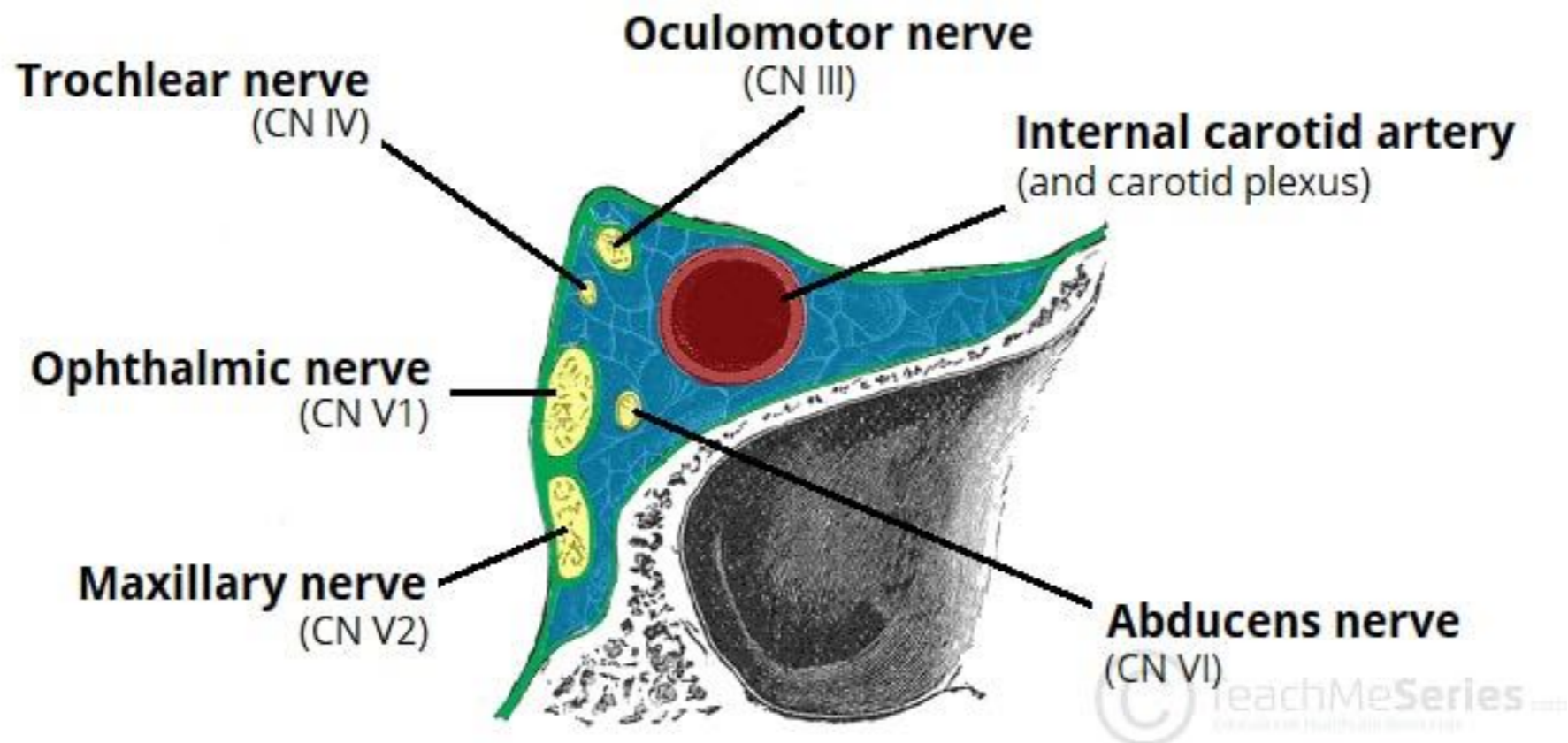
Multiple Cranial Nerves

Rule of 4's

- 3 & 4: **Midbrain**
- 5, 6, 7, 8: **Pons**
- 9, 10, 11, 12: **Medulla**

Cavernous Sinus

- Any combination of 3, 4, 5 (V1 & V2), 6, or Horner's syndrome
- Normal optic nerve function
- Causes: **neoplasms**, carotid cavernous fistula, aneurysm, fungal infection, inflammation Tolosa-Hunt



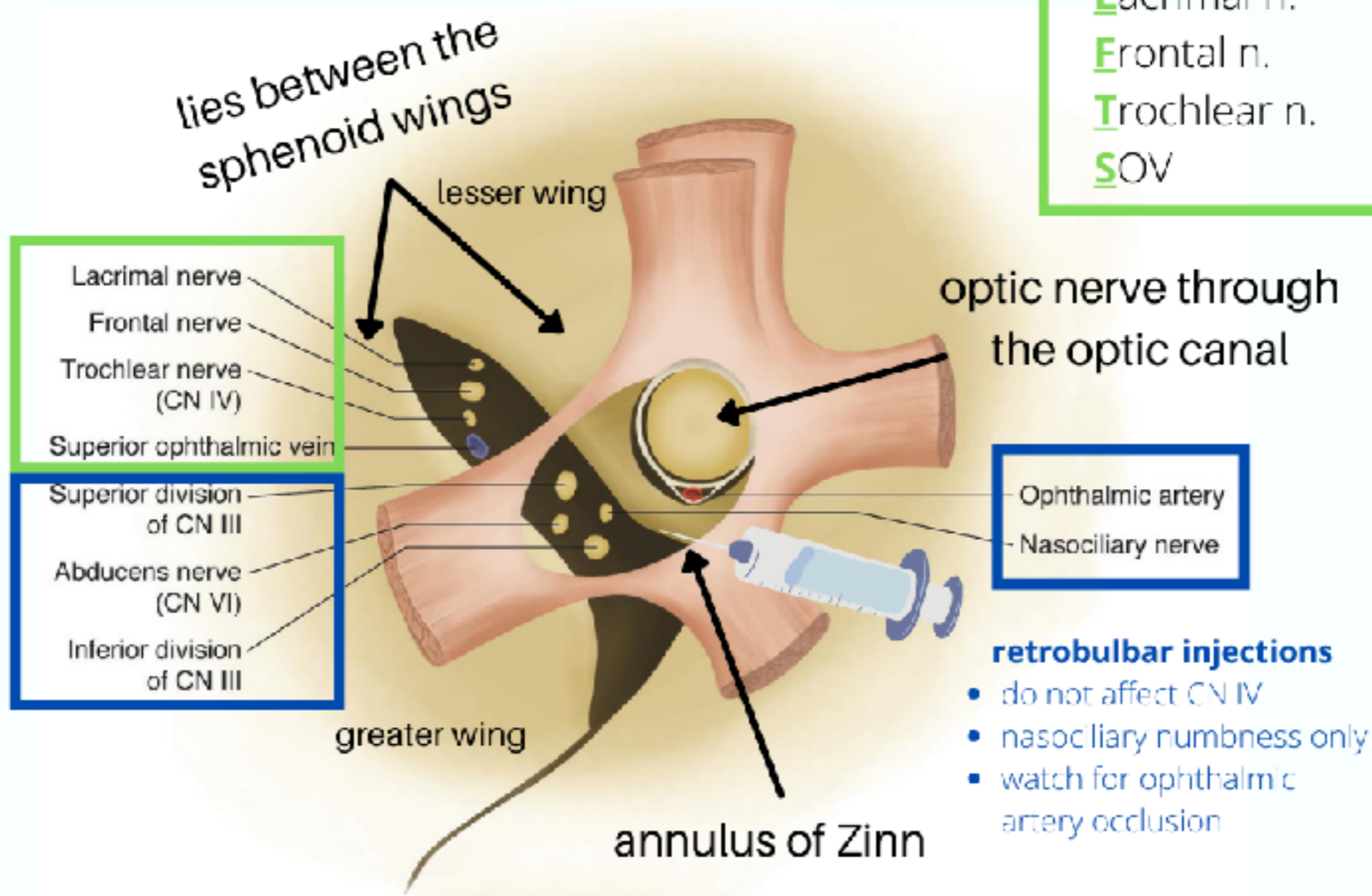
Orbital Apex Syndrome

- Any combination of 3, 4, 5 (V1), 6, or Horner's syndrome
- Optic nerve dysfunction
- Pain & V1 sensory loss (corneal sensation)
- Imaging necessary
- Causes: **neoplasms**, fungal infection, inflammation

Superior Orbital Fissure & Orbital Apex

elevated
LFTS

Lacrimal n.
Frontal n.
Trochlear n.
SOV



Superior orbital fissure syndrome: ophthalmoplegia, ptosis, fixed/dilated pupil, V1 numbness, **normal vision**

Orbital apex syndrome: ophthalmoplegia (**saves SO**), ptosis, fixed/dilated pupil, nasociliary numbness, **vision loss**

Giant Cell Arteritis

- Symptoms: Headache, weight loss, jaw claudication, myalgia, scalp tenderness, neck pain, fatigue
- **Always** consider GCA in elderly patients presenting with intermittent diplopia
- When should I think of GCA? Every patient over 50 years old with...
 - Transient vision loss
 - AION
 - CRAO
 - CN Palsy

Transient Ischemic Attack

- A vertebrobasilar TIA can cause decreased blood flow in the posterior circulation of the brain (brainstem, cerebellum, occipital cortex)
- Can cause transient diplopia
- Typically lasts a few minutes (always less than 24 hours)
- Symptoms: vertigo, facial numbness, hand/leg weakness/numbness, dysarthria

Duane Retraction Syndrome

- Congenital defect of VI innervation to LR, or anomalous III innervation to LR
- Limited abduction (or adduction), retraction of globe on adduction, narrow palpebral fissure on adduction
- Type I: Limited **abduction**
- Type II: Limited **adduction**
- Type III: Limited **abduction and adduction**

Workup for CN Palsies

- MRI - check for compressive lesion
- MRA - check for aneurysm
- Over 50 with symptoms of GCA: ESR, CRP, temporal artery biopsy
- Can also consider additional lab tests: CBC, FTA-Ab, CRP, ESR, RPR, glucose tolerance test

Treatment for CN Palsies

- Treat underlying systemic risk factors
- Adults: reduce diplopia with prism, total occlusion, or sector occlusion
- Children: reduce diplopia with prism (Fresnel or ground-in)
- Surgical resection or Botox injections

The Zebras

- Cranial Nerve Palsies
- **Muscle or Neuromuscular Junction Disorders**
- Extraocular Muscle Entrapment
- Supranuclear Anomaly



Muscle Disorders

Muscle Disorders

- **Weakness**

- Myopathy
 - CPEO
 - Myotonic Dystrophy

- **Restriction**

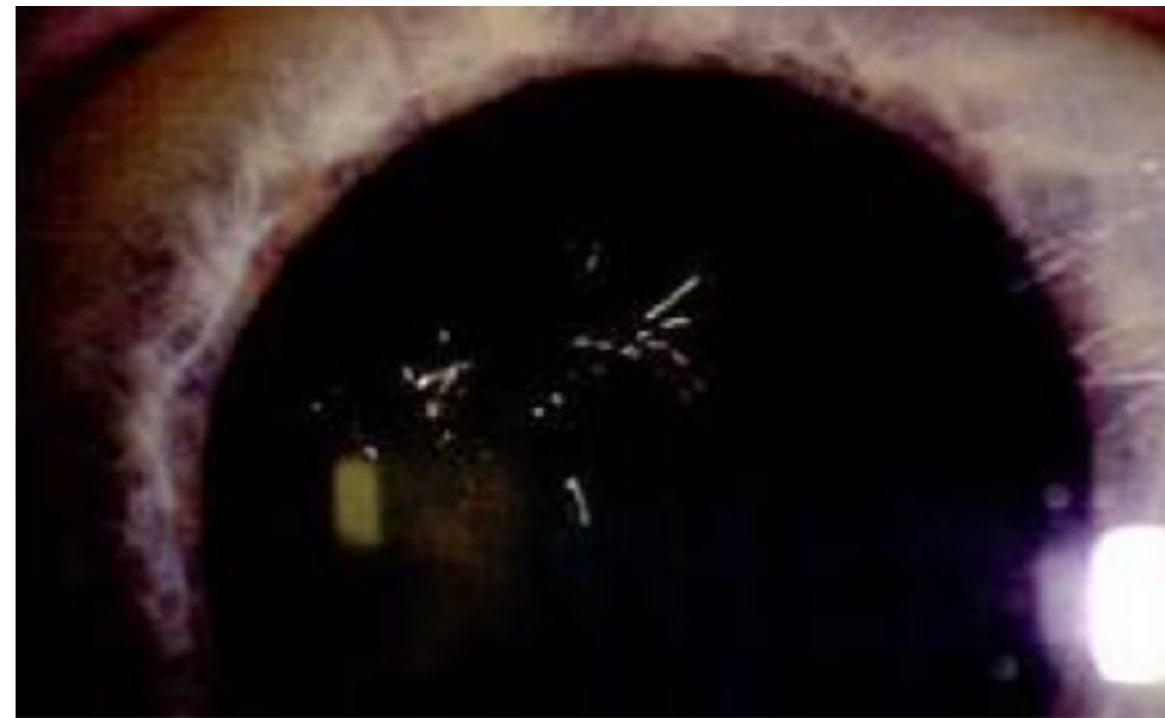
- Muscle entrapment
 - Orbital wall fracture
 - Brown Syndrome
- Enlarged extra ocular muscles
 - Thyroid eye disease
 - Inflammation (orbital pseudotumor)
- Orbital tumor

Chronic progressive external ophthalmoplegia

- Progressive limitation of eye movements (orbicularis weakness)
- Ptosis - bilateral & symmetric
- Eyes are relatively straight in primary gaze
- Findings evident by second decade of life
- Histology: **“ragged red fibers”**
- Major symptom: diplopia while reading (not in primary gaze)
- Clinical Pearl: All patients with ocular myopathy need an **electrocardiogram** (rule out myasthenia gravis)

Myotonic Dystrophy

- Most common adult-onset muscular dystrophy
- Slow relaxation of muscles after voluntary contraction
- Symptoms worsened by excitement, cold, & fatigue
- Bilateral ptosis & progressive ophthalmoplegia
- **Christmas Tree cataract!**



Neuromuscular Junction Disorders

Myasthenia Gravis

- Autoantibodies against acetylcholine receptors destroy or block many of the receptors
 - Less available receptors = less to activate the muscle = quicker muscle fatigue
- Generalized MG can be an **emergency** because patients may develop respiratory distress & swallowing difficulty

Myasthenia Gravis

Ocular Signs

- Any pattern of diplopia (“**great mimicker**”)
 - Ocular motility/diplopia varies from day to day
- Symptoms usually worse at end of day
- **No pupil involvement or pain**
- Ptosis worsened by sustained up gaze
- Cogan’s Lid Twitch (saccade from downgaze to upgaze causes brief over elevation of upper eyelid)
- Orbicularis weakness (easy to force eye open)

The Zebras

- Cranial Nerve Palsies
- Muscle or Neuromuscular Junction Disorders
- **Extraocular Muscle Entrapment**
- Supranuclear Anomaly



Muscle Entrapment

- Orbital “blowout” fractures
- Herniation of orbital contents into the sinuses can cause entrapment, which limits motility (usually in up gaze)
- How to differentiate from nerve palsies: **Forced Duction Test** (restriction vs. paresis)

Brown Syndrome

- Limited elevation in adduction
- Usually due to restricted movement of SO tendon through the trochlea
- Test: Forced Duction
- Typically congenital

Thyroid Eye Disease

- Most common cause of proptosis & restrictive strabismus
- Restricted eye movements (most commonly elevation), and often strabismus (most commonly esotropia)
- EOM enlargement > restricts ocular movement > diplopia
- Lid retraction, lid lag on down gaze, orbital congestion
- Clinical Pearl: The vast majority of patients with enlarged EOMs have TED or idiopathic orbital inflammation (orbital pseudotumor)

Thyroid Eye Disease

Visual Complications

- Compressive optic neuropathy
- Diplopia (especially when patients look up or out)
- Exposure keratopathy
- Increased IOP
- Kocher's sign (spastic retraction of upper lid on fixation)

The Zebras

- Cranial Nerve Palsies
- Muscle or Neuromuscular Junction Disorders
- Extraocular Muscle Entrapment
- **Supranuclear Anomaly**



Internuclear Ophthalmoplegia (INO)

- Signs:
 - Ipsilateral adduction deficit
 - Contralateral abducting nystagmus
 - Convergence may be spared or disrupted
 - INO is named by eye of limited adduction (not which gaze)
- Symptoms:
 - Horizontal diplopia
 - Blurred vision with eccentric gaze
 - Oscillopsia

INO

- Most common causes:
 - Brainstem infarction (**stroke**)
 - Demyelinating disease (**multiple sclerosis**)
- Prognosis: May improve spontaneously over weeks

One and a half syndrome

- INO plus an ipsilateral conjugate gaze palsy
- **Right** “one-and-a-half” = neither eye can look to the right, plus impaired adduction of right eye with abducting nystagmus in left eye
- MS in younger patients, infarction in elderly patients



Skew Deviation

- Binocular vertical diplopia, possibly with torsional component
- Hypertrophic may be comitant or noncomitant
- Symptoms: vertigo, arm/leg numbness or weakness
- Cause: **brainstem** lesions (stroke, tumor, infection, MS)

Summary

- Double Vision: What to do?
 - Recognize & characterize misalignment
 - Type of deviation
 - Quantify deviation
 - Comitant vs. Noncomitant
 - Cranial nerve vs. muscle vs. NMJ
 - Pupils, VAs, fundus evaluation
 - Orbital signs & neurologic signs
- These will help you localize possible lesion, hypothesize mechanism of lesion, and help other specialists obtain imaging & testing to confirm diagnosis.



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