4.2 Oculomotor Control

The *Oculomotor Control Assessment* is a quick screening tool that uses a "listen and look" approach. The OT *listens* to the client's complaints of difficulties using their eyes together to focus and locate objects and *looks* for deviations in oculomotor control that may account for these complaints.

4.2.1 Assessment Considerations

4.2.1.1 The OT Role

In our role working with the client to complete occupations, OT is often the first rehab team member to observe the client having difficulty using their eyes together to complete activities. The oculomotor assessment will help the OT link observations of the client's ability to make eye movements to limitations completing daily occupations. Diagnosing the cause of the impairment (e.g., a cranial nerve lesion, convergence insufficiency or other focusing impairment) is the role of the ophthalmologist or optometrist-the professions best qualified to make a differential diagnosis of this complex visual impairment. If our screening suggests oculomotor impairment due to the brain injury, the next step is to seek a referral to these eye doctors for further evaluation.

4.2.1.2 Visual History

It is important to begin the assessment by asking about the client's visual history to identify whether oculomotor impairment occurred from the current brain injury. Adult clients with a childhood history of oculomotor impairment or reduced acuity in one eye (amblyopia) often demonstrate eye movements that deviate from the norm. However, most have adapted to these oculomotor changes and do not experience functional limitations. Therefore, oculomotor deficiencies from early childhood conditions are usually not significant unless they cause a functional limitation. Other clients may have a history of eye injuries (black eye, orbital blow out fracture) or a previous brain injury (concussion). These injuries can also alter eye movements.

4.2.1.3 Room Lighting

Light sensitivity is a common co-impairment in clients with oculomotor impairment. A client with sensitivity may keep the eyes partially or completely closed in rooms with bright, glaring, or fluorescent lighting. The room should be illuminated with a **non-glaring light source** to reduce visual stress. The lighting should be just bright enough to enable you to clearly see the client's eye movements. Avoid shining light directly onto the client's face. Avoid using a penlight as a target and never shine a penlight directly into the client's eye. Doing so will cause visual stress and may agitate the client and reduce their cooperation.

4.2.1.4 Medications

Clients routinely take multiple medications during their recovery from brain injury. Some of these medications may affect the client's visual system and exacerbate visual symptoms. There is little research on the relationship between medications and visual complaints in clients with TBI and stroke. Han et al.[99] compared two groups with vision symptoms from TBI or stroke; one group consumed medications and the other group consumed no medications. The study found that persons taking medications reported a 2-fold increase in light sensitivity, increased complaints of poor depth perception, and dry eye compared to the non-medication group. The most consumed medications in study participants were anti-anxiety/antidepressants, anticonvulsants, opiate/combination analgesics and cardiac/antihypertensives. All of these medications include light sensitivity as a side effect suggesting that the medication may have contributed to the complaints of light sensitivity in this group. Opiate/combination analgesics may have contributed specifically to dry eye. More studies are needed to establish a relationship between medications and visual symptoms in clients with ABI, but the Han study reinforces the importance of reviewing the client's medications and including questions about light sensitivity, depth perception and dry eye in the initial assessment.

4.2.1.5 Arousal/Attention Level

The client's ability to maintain arousal (see section 2.5.1) and attend to a target can directly affect their ability to focus and move their eyes. Evaluate the symmetry of the eyes and eye movements when the client is the most alert, rested, and attentive. If needed, break the assessment into short segments and evaluate the client over several days. Although this is not a long assessment, it can be fatiguing and stressful for a client with oculomotor impairment. Using brightly colored kinetic targets (like a kid's pencil topper that bounces and moves) will engage the client's attention more than a static target as will a target with a face on it. Be creative and **avoid using** your low contrast finger or the very boring tip of your pen as a target.

4.2.1.6 Visual Acuity

Always measure acuity before assessing oculomotor control as a certain level of visual acuity is necessary for visual fixation. Reduced visual acuity may cause visual blur when viewing small details-a common complaint in clients who have age-related eye disease. If the client is unable to see the target, the eyes may wander, creating the impression of oculomotor impairment. Optic atrophy, vitreous hemorrhage and macular scotoma are examples of conditions that may prevent fixation and cause eye movements that mimic paralytic strabismus. If the client has reduced acuity, increase the size and brightness of the target.

4.2.1.7 Client Complaints/Observations

Clients often report and demonstrate specific changes and limitations using their vision for certain activities. These complaints and observations offer insights into the type of oculomotor

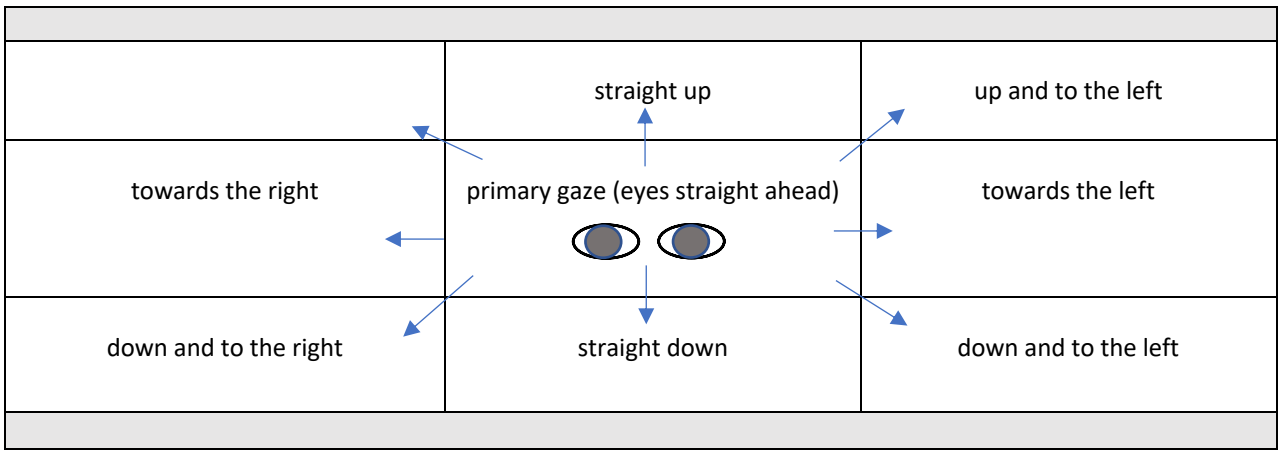
impairment they are experiencing. Table 4.2.1 lists common complaints and observations of clients with difficulty focusing or aligning the eyes.

Table 4.2.1: Common Complaints/Observations: Clients with Difficulty Focusing or Aligning Eyes

Focusing	Eye Alignment
Impairment affects activities that require focusing on close objects and/or sustaining focus at close distances-reading, needlework, device use etc.	*Misalignment affects activities that require viewing and/or focusing on an object at a specific distance or in a specific direction*
Visual blur	Visual blur
Eye fatigue from sustained focusing	Doubling images
Forehead pain or pain surrounding the eye	Crooked/distorted images
Squinting eyes to view near target/object	Ghosting images (like bad TV reception)
Red rimmed eyes, tearing, blinking, rubbing eyes after attempting to focus	Turning head sideways or tilting head up or down to view target
Dry itchy eyes after sustained focusing	Shutting one eye to view a target/object
Leaning back away from object/target to focus	Image disappears when one eye is shut
Complains words break apart, float, change colors, shimmer, disappear when reading	Feeling/being off balance during movement
	Past pointing when reaching for an object

4.2.1.8 The Cardinal Directions of Gaze

The eye muscles work synergistically to move the eye through 9 gaze directions depicted in the diagram below.



4.2.1.9 Characteristics of Cranial Nerve Lesions

Cranial nerves 3,4 and 6 control the extraocular muscles that move the eye (see sections 2.3.2.1, 2.3.3.2). Damage to each CN creates a specific set of limitations described in Table 4.2.2

Table 4.2.2: Eye Movement Changes from CN Lesions 3,4,6

CN 3: Oculomotor Nerve	CN 4: Trochlear Nerve	CN 6: Abducens Nerve
Difficulty making vertical eye movements and moving eye inward towards the nose	Difficulty moving the eye down and out (as when looking at neighbor's test to cheat on exam)	Difficulty making horizontal eye movement-moving eye outward towards the ear
Client may tilt head upward to view a target placed above the head or tilt it downward to view target placed below the chest	Client may tilt head toward lesion side (unilateral CN4 lesion) or tilt head downward (bilateral CN4) to view central target	Client may turn head to view a target placed towards the periphery on the involved side
Eye maybe turned outward (exotropia) when viewing a central target in primary gaze	Eye maybe turned upward (hypertropia) when viewing a central target in primary gaze	Eye may be turned inward (esotropia) when viewing a central target in primary gaze
Eye may be drooped or closed (ptosis); pupil may be dilated		
Client C/O blurred or double vision when reading or completing close work	Client C/O blurred or double vision reading; on curb/step or walking on uneven ground	Client C/O blurred or double vision driving, walking, playing golf, tennis etc.

4.2.1.10 Corneal Reflections

The corneal reflection is the spot of light reflected off the cornea of the eyes from an ambient source or a penlight. Observing the corneal reflections in primary gaze is a quick and accurate method to assess ocular alignment. Facial injuries can distort the appearance of the eyes and may make it appear that they are not aligned with one another. Corneal reflections provide a **true** indication of eye alignment.[137] If the eyes are aligned, the corneal reflections will appear in the center of the eye as the client views a centrally placed target held directly in front of the face (eyes in primary gaze) and the locations of the reflection in each eye will match. If one eye is deviated (positioned outward, inward, up, or down), its corneal reflection will be off-center and appear on the either the inner, outer, upper, or lower rim of the iris instead of the center of the pupil. Persons with significant astigmatism in one eye may have a cornea that is more oblong than round or dimpled rather than smooth. The corneal reflection in the astigmatic eye may be slightly off center and not precisely matched with the other eye, but the client will not show any other signs that the eyes are misaligned.

4.2.1.11 Visual Vestibular Impairment

Clients with visual-vestibular impairment may have trouble stabilizing gaze and experience visual blur during head and body movements. They may also experience shimmering and movement in the peripheral visual field that may be constant or occur with body movement. Because visual stability is a necessary component of postural control, the client may also complain of or demonstrate impaired balance. Referral to a PT or OT trained in vestibular rehabilitation should be made to address the client's limitations.

4.2.1.12 The Best Test Targets

Persons in the early stages of recovery may have difficulty attending to targets. The best targets for clients with low attention are those with interesting designs or motion. Targets with faces (animal or human) are particularly effective because we are inherently drawn to focus on the face. Kinetic targets are also effective as the eye is drawn to movement. The least effective target is your low contrast finger or the tip of your very boring pen. Penlights are useful because they enable us to view the corneal reflections. BUT the intense, bright light may irritate a client with light sensitivity and cause the client to become agitated or shut down. Ambient room lighting is often sufficient to see the client's corneal reflections and eliminate the need for a penlight. If the penlight is required, never shine it directly into the client's eye.

4.2.1.13 Testing Eyes Separately or Together

Just as it is more difficult to move the upper extremities together than to move one arm at a time, binocular movement of the eyes is more difficult to produce than monocular eye movement. Deviations in eye movements are more readily observed on a binocular test that requires the eyes to move together to track a target through the 9 cardinal points of gaze (see diagram in section 4.2.1.8). The assessment focuses on the client's ability to produce controlled eye movement through the **mid-range of motion** directly in front of the face. Tracking a target in this area should be easy and effortless as we repeatedly make eye movements within this range during a typical day. If a wider eye movement is needed to locate a target, eye movement is combined with head movement as it is more efficient to use the head and eyes together.

4.4.1.14 Eye Turns, Head Turns, Head Tilts

Persons with eye misalignment may only be able to eliminate the double image by assuming a head position that avoids the action of the paretic muscle.[202] For example, a client with a left lateral rectus palsy (CN 6 lesion) may turn the head toward the left to avoid the need to abduct the eye; a client with paralysis of the right superior oblique muscle (CN 4 lesion) may tilt the head to the right to avoid the downward action of that muscle.[201, 202] In some clients, the altered head position is a functional adaptation the client uses to obtain single vision and not a result of neck or trunk instability. For this client altering their head position to minimize or eliminate diplopia may impair their postural control and mobility.

Clients with significant paralysis of an eye muscle may show an eye turn when viewing the target in primary gaze (see Table 4.2.2 and section 2.3.2.1). *Tropia* is the suffix applied when there is a noticeable deviation in the position of one eye as the client focuses on a target. *Phoria* is the suffix used when the eye muscle is weak, but deviation of the eye prevented by the brain's need for sensory fusion and is not noticeable when the client is focusing on an object. These terms are combined with a prefix that indicates the direction of the deviation. There are four prefixes used: *eso*-meaning the eye turns inward towards the nose; *exo*-the eye

turns outward towards the temple/ear; *hypo*-the eye turns downward *hyper*-the eye turns upward. *Esotropia,* for example, indicates an observable, inward, deviation of the eye commonly described as "crossed eyes" whereas, *esophoria* indicates the eye drifts inward when the client is not focusing on an object but aligns with the other eye when the client focuses on an object.

Clients with phorias usually complain of intermittent diplopia that appears when the client is tired or not feeling well. Although the client can maintain single vision by forcing the eyes to work harder to stay aligned, the client pays the price in visual stress that can manifest as headaches, eye strain, or decreased concentration. If a phoria is suspected, ask the client about visual stress during activities that require sustained focus such as reading, needlework, watching television or working on their computer.

4.2.1.15 Near Point of Convergence

The near point of convergence (NPC) is the nearest point in space that a person can focus on an object and maintain a single image.[165, 208] It is an important measure of the person's ability to accommodate and eye doctors pay close attention to it when assessing the client's focusing ability. The near point of convergence in a typical adult is approximately 2-4 inches (6-10 cm) from the bridge of the nose. However, several factors influence this distance including age, refractive errors, the pupil's ability to contract, visual acuity and so on. Eye doctors consider all of these factors when interpreting the NPC in their diagnosis of an accommodative disorder. Without this depth of knowledge, the OT is unable to determine whether a client's NPC is significant; therefore, taking time to measure it provides little value. The OT acquires more valuable information about the client's focusing ability by observing how easily the client converges the eyes over several repetitions. Convergence is a very practiced skill-we converge our eyes every time we read or look at our phone or computer. A person with normal focusing abilities should be able to track a target in and out multiple times without any sign of visual stress (e.g., blinking, eyes watering, eyes reddening, shutting an eye). *Any sign* of stress during convergence strongly indicates a focusing deficiency and the client should be referred to an eye doctor for a more thorough evaluation.

4.2.1.16 Diplopia Testing

Diplopia testing is completed only when the client complains of or demonstrates diplopia. It is used to determine the severity of the diplopia and whether it is due to a tropia or a phoria. Diplopia testing is based on the principle that the eye uses the fovea to view objects in order to see them clearly-a process known as foveation (see section 2.3.1). If an eye that is not fixating on a target is suddenly required to foveate, it will achieve foveation by moving the eye towards the target. Therefore, if both eyes fixated the target, neither eye will move when one eye is covered but if the eyes are **not** aligned, the deviating eye will move to take up fixation when the other eye is covered. Clients with phoria can align the eyes for short periods of time to fixate on a target but can't maintain that alignment without experiencing significant stress

(headache, eye pain, fatigue). To uncover a phoria, the occluder must cover the eye for **at least 2 seconds** to break fusion and allow the eye to drift, then quickly be moved to the other eye.

If movement of the eye is observed on either of the tests, seek a referral to an eye doctor for further evaluation and diagnosis. To quantify the severity of the diplopia, the eye doctor places prisms of increasing power (measured in diopters) over the deviating eye and repeats the cover test until no eye movement is observed. The doctor records the dioptric strength of the neutralizing prism to quantify the extent of the deviation and determines whether to prescribe prism to assist the client to achieve and maintain single vision. The application of temporary Fresnel prisms to improve sensory fusion can reduce visual stress during recovery and improve the client's ability to participate in fully in their rehabilitation program.

4.2.2 Test Instructions

General Instructions to the Client:

> *"I am going to give you some tests to see how well you can move your eyes together to clearly see objects. Using the eyes together is important for good balance, reading and eye hand coordination. Sometimes a brain injury damages the centers that control eye movements."*

4.2.2.1 Visual History and Key Client Complaints/Observations

Test Item:

Oculomotor Control Assessment form

Procedure:

1. Use the key client complaints/observation checklists embedded throughout the assessment to identify potential limitations and strengths using eye movements to complete activities. Begin making these observations during your first encounters with the client and as you work with them on ADLs. Use the checklist with family members and other team members to verify your observations and obtain a different perspective on the client's abilities.
2. Be sure to observe for light sensitivity as this is a very common co-impairment with oculomotor impairment and causes significant visual stress.
3. Obtain a basic visual history using the first section of the form as a guide. Ask a family member to supply the information if it is not possible to obtain it from the client.
4. Look for patterns in the client's responses that suggest limitations in a specific aspect of oculomotor control. Note whether the client's complaints of fatigue and concentration appear to be related to activities that require sustained focusing. Pay attention to whether the client's visual difficulty seems to change with focal length or direction of eye movement.

4.2.2.2 General Appearance

Test items:

Oculomotor Control Assessment form
Interesting distant target-large enough to be seen easily at 6 plus feet

Environment*:* well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source is not shining directly into the client's eyes.

Procedure*:*

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they need to wear them for this assessment.
2. Observe the client's eyes as they focus on a distant target placed directly in front of the face at eye level.
3. Complete the checklist on the form. Record asymmetries in eyelid function, eye position and head position.

Instructions to the Client:

"I am going to look at your eyes to see if they look the same. Please look straight ahead and keep your eyes fixed on the [target]as I check your eyes."

4.2.2.3 Corneal Reflections

Test Items:

Oculomotor Control Assessment form
Penlight (if needed)
Interesting distant target large enough to be seen easily at 6 plus feet
Interesting near target

Environment: well-lighted room with a non-glaring light source directed from behind the client; lower the room illumination if you have difficulty seeing the client's corneal reflections.

Procedure:

1. Seat the client comfortably wearing prescription eyeglasses if typically worn. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If the client's eye position is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape for the short duration of the test.
3. Hold or place an interesting target directly in front of the client at eye level.
4. Begin with a distant target.
5. Instruct the client to focus on the target.
6. Check to see if you can view the client's corneal reflections using just the ambient room lighting-if not use the penlight to view the reflection.

7. If using the penlight-center it in front of the client's face approximately 12 inches from the tip of the nose. If the client exhibits any sign of light sensitivity, tip the penlight vertically to slightly direct the light upward so it does not directly shine into the eyes.
8. Observe the corneal reflection in each eye as the client fixates the target and record the position of the reflection on the form.
9. Repeat using a near distance target.

Instructions to the Client:

"I am going to look at your eyes to see if they line up together. [If using a penlight-include *I am going to use this penlight so I can look at the light reflect off your eyes to see if it is in the same place on both eyes*]. *Please look straight ahead and keep your eyes fixed on the [target] as I check your eyes."*

4.2.2.4 Eye Movements

4.2.2.4.1 Tracking Eye Movements

Test Items:

Oculomotor Control Assessment form
Interesting target (see section 4.2.1.12)

Environment: well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source does not shine directly into the client's eyes.

Procedure:

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape for the short duration of this test.
3. Instruct the client to focus on the target.
4. Try to keep the target approximately 20 inches from the face and move it at a steady pace-not too fast and not too slow-through the 9 cardinal directions of gaze (see section 4.2.1.8)
    - *Primary Gaze*: Hold the target directly in front of the bridge of the nose.
    - *Horizontal-Right/Left*: Start with the target in front of the nose, move the target towards the right shoulder, then back towards left shoulder. The total excursion of the target should not exceed 15 inches.
    - *Vertical-Up/Down*: Start with the target in front of the nose; move the target vertically towards the top of the head, then down towards the Adam's apple. The total excursion of the target should not exceed 15 inches.
    - *Diagonal-Left/Right*: Start with the target by the left shoulder; move the target diagonally towards the top of the right side of the head. Stop when the target is

slightly above the right shoulder. Reverse directions. The total excursion of the target should not exceed 15 inches.

- *Diagonal-Right/Left*: Start with the target by the right shoulder; move the target diagonally towards the top of the left side of the head. Stop when the target is slightly above the left shoulder. Reverse directions. The total excursion of the target should not exceed 15 inches.

5. **Again-do not move the target more than 15 inches in any direction**. This enables you to test the client's control of eye movements within the mid-range where they typically occur.
6. Observe whether both eyes stay on the target as it moves. Key observations:
    - Both eyes move an equal distance in each direction.
    - The corneal reflections match in both eyes as they move in each direction.
    - The proportion of iris to sclera [white of eye] is equal in both eyes as they move in each direction.
7. Observe the client's ability to execute controlled eye movements. Key observation:
    - The eyes stay on target with minimum jerking movement as the client tracks the target through the mid-range.
8. Observe for signs of visual stress. Key observations:
    - Blinking, squinting, tearing, eyes reddening, shutting eyes while tracking the target.

Instructions to the Client:

"I am going to look at how well you can move your eyes together by having you follow this [target] as I move it in different directions. It's important to keep your eyes on the [target] as I move it."

4.2.2.4.2 Convergence

Test Items:

Oculomotor Control Assessment form
Interesting target

Environment: well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source does not shine directly into the client's eyes.

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape for the short duration of the test.
3. Instruct the client to focus on the target.
4. Begin approximately 20 inches from the face, move the penlight at steady pace-not too fast-not too slow-towards the bridge of the client's nose.

5. Both eyes should stay fixed on the target and move inward to follow it.
6. At some point as the target nears the bridge of the nose, the client will reach the near point of convergence (see section 4.2.1.15) and be unable to continue to converge the eyes. At this point, the client may report double or blurred vision, or you may observe one or both eyes move off the target.
7. Move the target back to starting position and repeat the test several more times.
8. Carefully observe the client's performance using the checklist on the form.

Instructions to the Client:

"I am going to see how long you can stay focused on this [target] as I move it towards your nose. As the [target] gets close to your nose, you may feel eye strain, and the target may double or get blurry. Please let me know as soon as this happens. I will stop and move the target back to where it started. Keep your eyes on the target as I move it back towards the starting position. I am going to repeat this test several times to see if you can easily stay on the target."

4.2.2.5 Diplopia Testing

4.2.2.5.1 Cover/Uncover Test

Complete this test when you observe an eye turn, or head turn/tilt and suspect the client may have a tropia (see sections 4.2.1.14 and 4.2.1.16).

Test Items:

Oculomotor Control Assessment form
Interesting distant and near targets
Handheld plastic occluder

Environment: well-lighted room with a non-glaring light source directed from behind the client onto the target; ensure that the light source is not shining directly into the client's eyes.

Procedure:

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape during short duration of the test.
3. Instruct the client to focus on the target. The target should be positioned at eye level and at midline and behind the examiner so that it is more than 30 inches away from the client's face. The client's eyes should be in primary gaze as they focus on the target.
4. While the client fixates the target, use the occluder to **quickly cover the eye that appears to have intact oculomotor control.**
5. As you cover the eye, observe the **uncovered** eye to see if it moves to fixate on the target.

6. If eye movement is observed, record the direction that the eye moved using the checklist or diagram on the assessment form.
7. Repeat the test **several times** to confirm your observation of whether the uncovered eye moved and the direction it moved.
8. Repeat the test this time observing the movement of the other eye.
9. If neither eye moves on the test, repeat the test on both eyes using a near distance-target placed 16 inches (40cm) from the eye.
10. If neither eye moves when tested at the far or near distance, complete the alternate cover/uncover test to check for a phoria.

Instructions to the Client:

"I am going to see if your eyes can stay focused on the [target] as I cover and uncover each eye. It is important that you keep your eyes focused on the [target] during the test."

4.2 2.5.2 Alternate Cover Test

Complete this test when the client's complaints suggest eye misalignment and you didn't observe movement on the cover/uncover test-suggesting the client may have a phoria (see sections 4.2.1.14 and 4.2.1.16).

Test Items:

Oculomotor Control Assessment form
Interesting distant and near targets
Plastic handheld occluder

Environment: well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source is not shining directly into the client's eyes.

Procedure:

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape during short duration of the test.
3. Instruct the client to focus on the target. The target should be positioned at eye level and at midline and behind the examiner so that it is more than 30 inches away from the client's face. The client's eyes should be in primary gaze as they focus on the target.
4. Quickly switch the occluder back and forth between the eyes while the client fixates on the target. **HOLD** the occluder over the eye for **a full *2 seconds*** before switching**.**
5. Observe whether the eye ***under cover*** moves to take up fixation when the occluder is removed and record the direction that the eye moved on the assessment form using the checklist or diagram.
6. Repeat the test several times to confirm your observation of whether the eye moved and the direction it moved.

7. Repeat the test observing the movement of the other eye.
8. If neither eye moves on the test, repeat the test on both eyes using a near distance target placed 16 (40cm) from the eye.
9. If neither eye moves at the far or near distance, but you still suspect a phoria, repeat the test several more times to fatigue the eye-repetition can sometimes unmask a phoria.

Instructions to the Client:

"I am going to see if your eyes can stay focused on the [target] as I cover and uncover each eye. It is important that you keep your eyes focused on the [target] during the test."

4.2.3 Interpreting the Client's Performance on the Assessments

Eye doctors are the most qualified professionals to diagnose, prescribe and provide an intervention plan for the client with oculomotor impairment. The client's performance on the OT screening should be used to request and justify a referral to the eye doctor for further evaluation, diagnosis, and treatment.

4.2.3.1 Visual History

The client's responses can reveal much about the type and severity of their oculomotor impairment. Use this information to determine the assessments to include in your evaluation.

***The client reports history of childhood strabismus, lazy eye, or amblyopia*.** Wearing a patch, having had eye surgery, and completing eye exercises as a child all suggest the presence of a congenital (not acquired) strabismus. A client with this history may have long-standing deficiencies in oculomotor control. Most persons adapt to oculomotor deficiencies that occur early in life and they do not interfere significantly reading and other tasks. The client with longstanding childhood acuity or oculomotor impairment in one eye, may be more likely to perceptually suppress visual information from the "lazy"eye. This client may not complain of blurred or doubling vision even when there is an obvious eye turn or mismatch between the corneal reflections. This client's oculomotor issues are more subtle and complex and require an eye doctor's evaluation.

***The client reports trauma to the eye or orbit*.** Damage to the eye or orbit from the current-or even a past injury-may cause several visual deficits. Extraocular muscles can be entrapped in the orbital fracture that restricts eye movement and causes pain during eye movement. A blow to the eye can cause a retinal detachment or damage the optic nerve that sometimes causes a severe reduction in acuity. Poor acuity can cause dis-coordinate eye movement. Clients with orbital/eye trauma should have had an ophthalmology exam following the injury. A client who has not had a thorough eye exam should be referred to an eye doctor to rule out a vision threatening condition.

4.2.3.2 Key Client Complaints/Observations

4.2.3.2.1 Focusing Difficulty

Clients with focusing impairment must put much more effort into seeing clearly at near distances. Many of their complaints reflect fatigue and eye strain from this extra effort. Difficulty reading is the number one voiced complaint of persons with focusing impairment.

***The client complains of visual blur and inability to keep objects in focus*.** Visual blur is the most reported complaint of persons with focusing issues. But it is also important to remember that persons with reduced acuity or central scotoma (common in macular degeneration) also report visual blur and difficulty keeping objects in focus. Be especially sure you have measured acuity and obtained an accurate visual history from an older client that includes asking about age-related eye disease.

***The client complains of difficulty reading*.** Difficulty reading is the number 1 complaint of persons with focusing issues. But it is also a common complaint of persons with reduced acuity hemianopia and other visual field deficits that affect the central visual field, and also persons with light sensitivity. Be sure to assess these areas of visual performance when the client complains of difficultly reading.

The client complains of eye fatigue, eye strain, and headache when completing tasks that require sustained focusing. These complaints suggest that the client must put more effort into completing the task. The complaints are most likely to be made when questioned about reading -the most common daily activity dependent on sustained focusing. Persons with reduced acuity also must put more effort into near distance tasks like reading because of their difficulty seeing small and low contrast details. Clients are also more likely to experience eye fatigue, strain, and headache when fitted with total occlusion (e.g., a pirate patch) to eliminate double vision because they are forced to use one eye at a time for reading and near tasks. Consider using partial occlusion instead of total occlusion (see section 5.7.1.2).

The client complains of dry, itchy eyes after a period of sustained focusing. These complaints are associated with dry eye-a common condition where the tears don't sufficiently lubricate the surface of the cornea. There are many causes of dry eye including aging, allergies, medications, diseases (Parkinson's Disease and rheumatoid arthritis are common causes). Be sure to follow up with questions about whether the client has been diagnosed with dry eye and if it is a new or longstanding condition. We also blink less when concentrating on a task, which can cause the eyes to feel dry and itchy after a period of sustained focusing. When a younger client without risk factors or an identified cause of dry eye, complains of dry itchy eyes, it suggests that client is putting extra effort into focusing and is blinking less as a result.

***The client complains of difficulty sustaining concentration during reading and other near vision tasks*.** Clients with acquired brain injury often have limited attentional reserves. The

increased effort required to maintain focusing may drain these reserves and limit their ability to sustain concentration during a task.

***The client blinks excessively, eyes water, or become red-rimmed during or after focusing on targets*.** These are clear signs that the client is experiencing visual stress completing the activity. They are often observed in the client with convergence insufficiency or another accommodative disorder after a period of sustained focusing.

The client complains that images break apart, float, change color, shimmer, disappear after a period of sustained focusing). This complaint is frequently due to muscle fatigue during reading and suggests convergence insufficiency (see section 2.3.3.1). As the eye muscles fatigue from the exertion of sustaining convergence during reading, the person's ability to fuse images breaks down and the client may experience these odd visual phenomena.

The client leans back to focus on a near task. Moving away from a task is usually done to relieve accommodative stress by increasing the focal distance. It suggests convergence insufficiency or another accommodative disorder. It is also a common reading adaptation used by persons with presbyopia who have not yet invested in a pair of reading glasses.

The client squints to focus on a near target. A person usually squints to see more clearly or to reduce light sensitivity. It may suggest difficulty focusing, reduced acuity in one eye compared to the other, or visual stress. But remember that a squint can also be a facial tic.

The pattern of the client's complaints suggest difficulty completing activities that require a sustained focus in near vision. This suggests difficulty with one of the components of accommodation, the presence of convergence insufficiency, or eye misalignment from 3rd or 4th cranial nerve involvement.

The pattern of the client complaints suggests a difference in ability to perform activities at different focal lengths. This suggests difficulty with accommodation if the client is experiencing problems with near distance or a muscle imbalance due to paralytic strabismus from damage to CN 3 or 4. If the client has no complaints about reading but complains of difficulty seeing clearly at a distance, it may suggest a muscle imbalance due to paralytic strabismus from CN 6 damage or reduced distance acuity.

4.2.3.2.2 Visual Vestibular Impairment

The client experiences blurring vision with head movement. This suggests that the client is unable to keep images stable on the fovea when the head/body is moving. It suggests visuo-vestibular dysfunction.

The client complains of shimmering/visual motion in the peripheral visual field. This may suggest increased sensitivity to visual motion which is a common complaint in persons who

have had a TBI (see section 2.3.2.2). Optometrists trained in vision therapy may use bi-nasal occlusion or prism to reduce the perception of motion in the visual field.[48, 194]

4.2.3.2.3 Diplopia

The client reports images that are doubled, blurred, ghosting (like bad TV reception), crooked. These all suggest that the brain is unable to completely fuse the image to achieve single vision and suggest eye misalignment due to CN 3,4,6 lesions.

The client experiences past pointing or reaching. This may suggest that the strabismic eye is the dominant eye.

The client feels off balance when walking or displays impaired balance. This may suggest a 4th or 6th cranial nerve lesion. If the client's balance issues only occur when descending steps, it may indicate a 4th CN lesion; other balance issues may be related to a 6th CN lesion or visual vestibular impairment (see section 2.3.2.2).

The diplopia disappears when one eye is closed. This suggests that the diplopia is due to a muscle imbalance from acquired paralytic strabismus or another condition.

The diplopia does NOT disappear when one eye is closed. This suggests that the diplopia is due to damage to the structures of the eye or the retina. The client should be referred to an ophthalmologist or optometrist for an eye exam.

The diplopia is characterized by objects splitting side to side (horizontally). This suggests either 3rd or 6th cranial nerve involvement.

The diplopia is characterized by objects splitting one on top of the other (vertically). This suggests 4th cranial nerve involvement.

The diplopia is present only in near vision. This suggests either 3rd or 4th cranial nerve involvement.

The diplopia is present only in distant vision. This suggests 6th cranial nerve involvement.

The diplopia is constantly present. This suggests the presence of a tropia.

The diplopia comes and goes throughout the day. This suggests the presence of a phoria.

The diplopia is present only with gaze in one direction. This suggests that the diplopia is due to muscle paresis from a CN 3,4,6 lesion or muscle impingement if the client has experienced an orbital blow out fracture.

The diplopia is present in all directions of gaze. If this occurs with one eye covered, this may suggest that the diplopia is due to damage to the structures of the eye or the retina. The client should be referred to an ophthalmologist or optometrist for an eye exam.

The client with symptoms that suggest the presence of diplopia can fuse and perceive one image at a specific distance from the face. This suggests that some binocular capability is present. If the client's injury is recent (less than 6 months) it suggests that the muscle paresis may be resolving.

4.2.3.3 General Appearance

***The client has a dilated pupil or lowered eye lid (ptosis)*.** These are characteristics of a complete 3rd cranial nerve lesion. Fixed dilation of the pupil reduces accommodation and may increase visual blur when focusing on tasks in near space. Ptosis reduces the available superior visual field and can interfere with navigation and driving. Ptosis may also prevent diplopia by occluding vision in one eye.

Noticeable deviation in the position of one eye with complaint of diplopia*.* This suggests a tropia most likely due to eye misalignment from paralytic strabismus.

Noticeable deviation of the eye without complaint of diplopia. This may suggest reduced acuity in the eye severe enough to prevent the client's ability to fixate on a target (without fixation, the eye may deviate). Complete an acuity test to determine if the client has sufficient acuity to see and fixate a target. It may also suggest the presence of a long-standing strabismus that the client has adapted to by perceptually suppressing vision in one eye. Suppression is common in long-standing or congenital strabismus, but most adults with *newly acquired* paralytic strabismus are unable to suppress visual information and must use an altered head position to eliminate the diplopia.

The client assumes a deviated head position to view the target. This suggests paralytic strabismus and diplopia due to tropia. A "chin down" position suggests bilateral 4th cranial nerve involvement; the head turned toward the left or right suggests a 6th cranial nerve lesion; head tilt towards a shoulder suggests a unilateral 4th cranial nerve lesion. Use of a deviated head position will eliminate diplopia but may interfere with the client's postural adaptation and mobility-be sure to observe balance and ask about falls.

Nystagmus is observed (quivering of the eyes). This may suggest cerebellar and/or brainstem involvement but there are many causes of nystagmus. If the nystagmus occurred following the brain injury and is present in primary gaze, the client may experience blurred vision.

4.2.3.4 Corneal Reflections

The position of the corneal reflections indicates whether the eyes are aligned when focusing on an object. The reflections should match in location; asymmetry in the position of the reflections between the two eyes may suggest a tropia and paralytic strabismus. Remember persons with an irregularly shaped cornea in one eye may have unequal corneal reflections despite normal ocular alignment (see section 4.2.1.10). Therefore, mis-matched corneal reflections are not significant without other signs of misalignment such as diplopia or deviations in eye position and movement. When the corneal reflections indicate that eyes are misaligned, but the client denies diplopia, possible causes include a congenital or long-standing strabismus with sensory suppression of the deviating eye or very poor acuity in one eye that prevents fixation.

The corneal reflection is positioned on the outer (lateral) rim of the iris in one eye. This suggests that the eye is turned inward (esotropic) and a possible 6th cranial nerve lesion.

The corneal reflection is positioned on the inner (medial) rim of the iris in one eye. This suggests that the eye is turned outward (exotropic) and a possible 3rd cranial nerve lesion.

The corneal light reflection is positioned on the upper rim of the iris in one eye. This suggests hypotropia.

The corneal reflection is positioned on the lower rim of the iris in one eye. This suggests hypertropia and a possible 4th cranial nerve lesion.

4.2.3.5 Tracking Eye Movements

The primary clinical observation is visual stress combined with difficulty/inability keeping both eyes fixated on the target as it moves through the 9 cardinal directions of gaze.

The client's eyes redden, begin watering, blink repeatedly, squint; the client shows other signs of visual stress when attempting to follow the target through the 9 cardinal directions of gaze. Following a target on its short excursion through the midrange of the 9 cardinal directions of gaze should be easy and effortless as these eye movements are repeatedly made throughout a typical day. Any signs of visual stress when tracking a target is significant. It suggests that the client has difficulty moving the eyes together possibly due to misalignment from a CN 3,4,6 lesion or difficulty coordinating eye movements due to pathway damage.

***One eye does not move as far as the other eye to stay on the target as the eyes move through the cardinal directions of gaze*.** This suggests restricted movement of one eye in a direction of gaze and suggests paresis/paralysis of the muscle initiating that movement from damage to CN 3,4,6. If the client has had an orbital blow out fracture (see section 4.2.3.1), muscle impingement may be restricting movement and movement usually causes pain.

***The proportion of sclera to iris does not match in the 2 eyes as the eye moves through the 9 cardinal directions of gaze*.** As the eyes track the target the proportion of sclera (white of the eye) to iris should be equal in both eyes. The client should show other signs of paralytic strabismus (e.g., diplopia and functional limitations).

Gaze-evoked nystagmus is observed. This appears as a quivering of the eye when it moves into an eccentric (off-centered) position. It suggests that the client is experiencing difficulty maintaining this position. The appearance of nystagmus can be due to muscle weakness, but it can also be due to age as older adults show more gaze-evoked nystagmus.[137] Its presence during abduction of the eye in conjunction with inability to adduct the other eye may indicate an intranuclear ophthalmoplegia (INO) due to a midbrain lesion (more common in multiple sclerosis).[137] Eye doctors use this symptom for diagnosis-observing it in a younger client may be a reason to refer the client to an eye doctor.

***The eyes jerk as the client tracks the target*.** An eye jerk means that the client was unable to keep the target on the fovea and initiated a saccade to catch up and re-establish fixation (the jerk is the saccadic eye movement). Some jerking of eye movements is normal, especially in children and older adults, and does not impair focusing on the image. Continuous jerking as the eye tracks an object within the mid-range of eye movement disrupts focusing. It may cause visual blur and visual stress.

4.2.3.6 Convergence

The primary clinical observation is difficulty and visual stress when attempting to converge the eyes as the target moves inward towards the nose. The primary client complaint is difficulty reading or completing another task that requires sustained near focusing.

The client follows the target in towards the nose and returns to the starting position 3-5 times without signs of visual stress or effort. This suggests the client has normal convergence (yay!).

***The client shows signs of stress when tracking the target inward: blinking, tearing, eyes reddening, sighing*.** This suggests that the client has difficulty converging the eyes. Convergence should be effortless and never produce stress. Request referral to an eye doctor to address convergence if the client demonstrates any sign of stress.

***The client is only able to follow target inward 1-2 times before fatiguing or showing signs of stress*.** This suggests that the client has difficulty converging the eyes. Convergence should be effortless and never produce stress. Request referral to an eye doctor to address convergence if the client demonstrates any sign of stress.

The client complains of headache or eye irritation after tracking the target inward. This suggests that the client has difficulty converging the eyes. Convergence should be effortless and

never produce stress. Request referral to an eye doctor to address convergence if the client demonstrates any sign of stress.

The client leans or tilts their head backwards to avoid moving the eyes inward **as the target moves towards the nose**. If this occurs as the target begins to move inward, it suggests that the client has difficulty converging the eyes. Request referral to an eye doctor to address the client's ability to converge. If it occurs when the target is close to the bridge of the nose-it suggests that the client reached their near point of convergence.

Only one eye follows the target inward. The client may be unable to move one eye inward due to a 3rd cranial nerve lesion. A central scotoma (from age-related eye disease) may also prevent one eye from seeing the target to follow it inward.

Neither eye follows the target inward. The client may be unable to converge the eyes and will experience significant difficulty completing any near vision task. But it could also suggest that the client misunderstood the directions or is unable to see the target well enough to track it.

4.2.3.7 Diplopia Testing-Cover/Uncover Test

The uncovered eye moves towards the target when the other eye is covered**.** This suggests the presence of a tropia. Clients with a tropia generally complain of constant diplopia when viewing objects.

The uncovered eye moves inward to fixate on the target. This suggests an exotropia and possible 3rd cranial nerve involvement. The client generally complains of blurring or double vision when completing near vision tasks.

The uncovered eye moves outward to fixate on the target. This suggests an esotropia and possible 6th cranial nerve involvement. The client generally complains of blurring or double vision when completing distance tasks such as monitoring the support surface and driving.

The uncovered eye moves downward to fixate on the target. This suggests a hypertropia and possible 4th cranial nerve involvement. The client may experience blurring or double vision when reading or when monitoring the support surface when descending steps or curbs.

The uncovered eye moves upward to fixate on the target. This suggests a hypotropia. The client may experience blurring or double vision when viewing at a distance or when switching viewing distance from near to far as when copying notes from a blackboard.

4.2.3.8 Diplopia Testing-Alternate Cover Test

The eye that was covered moves inward to fixate on the target when the other eye is covered. This suggests exophoria and possible 3rd cranial nerve involvement. The client may experience blurring or double vision when reading, especially after a period of sustained viewing.

The eye that was covered moves outward to fixate on the target when the other eye is covered. This suggests esophoria and possible 6th cranial nerve involvement. The client may experience blurring or double vision when viewing at a distance, especially after a period of sustained viewing.

The eye that was covered moves downward to fixate on the target when the other eye is covered. This suggests hyperphoria and possible 4th cranial nerve involvement. The client may experience blurring or double vision when reading, especially after a period of sustained viewing or when looking downward to monitor the support surface.

The eye that was covered moves upward to fixate on the target when the other eye is covered. This suggests hypophoria. The client may experience blurring or double vision, especially when viewing at a distance or switching viewing distance from near to far as when copying notes from a blackboard.