

## Association of Technical Personnel in Ophthalmology (ATPO)

### *CE on the Internet Article*

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### **PUPIL EVALUATION & COLOR VISION**

Deborah Diggins, COMT, CRA

#### **Pupil Evaluation**

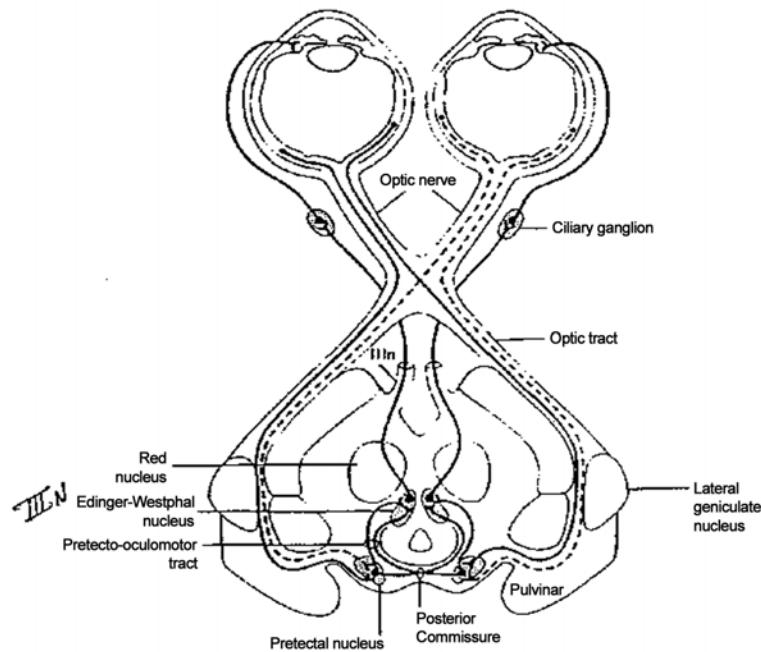
Pupil evaluation is an important part of the complete eye exam, as well as the neurological eye exam.

Evaluation of the pupils should always be performed before instilling dilating drops. This provides valuable information to the ophthalmologist. Pupils are evaluated for size, symmetry or anisocoria (asymmetric pupil size), shape, and response to direct and indirect light stimulation.

**Pupils** – The pupil's functions are to control the amount of light entering the eyes and provide the best visual function under varying degrees of light intensity. The normal diameter of a pupil is 3 – 4 mm under average lighting conditions. In dim lighting the pupil size is larger and in bright light it is smaller. Pupils are usually larger in children and smaller in the elderly. Twenty percent of fibers in the optic tract are for pupillary function.

**Near Reflex** – The pupil also changes when focusing on near objects. With accommodative effort, caused either by a blurred retinal image or conscious visual fixation on a near object of regard, a “near synkinesis” is evoked, including increased accommodation of the lens, convergence of the visual axes of the eyes, and pupillary constriction or miosis.

**Light Reflex** – *The diagram below shows the path of the pupillary light reflex. When light first enters the eye, the light reflexes are mediated through axons from ganglion cells in the retina. These impulses pass back in the optic nerve and decussate, cross or intersect, in the chiasm with the other visual fibers. Pupillary fibers then leave the optic tract just before the lateral geniculate body, synapse (the point at which a nervous impulse passes from one neuron to another) at the pretectal area of the midbrain, and then synapse bilateral Edinger-Westphal (E-W) nuclei. The impulse then leaves the midbrain via the third cranial to the ciliary ganglion, which is a small junction of nerves within muscle cone behind the eyeball. After synapsing in the ciliary ganglia, the post-ganglionic fibers innervate the pupillary sphincter muscles to constrict the pupils.*



Stimulation of one eye by a bright light produces an equal constricting response in both eyes due to the direct and consensual light reflexes. Transfer of the light to the fellow eye will maintain the same constriction and tone on this pupil. However, if an asymmetrical lesion in the pathway on one side exists, the light transfers from the good eye to the bad eye, which results in less neuronal stimulation of the E-W nucleus from that eye and a comparative dilation of both pupils, and vice versa. This is seen as an alternating constriction and dilation of each pupil as the light is swung from eye to eye. A relative afferent pupillary defect (RAPD), or optic disk pallor, are the only objective clinical signs of disease of the afferent visual system.

### A Guide to Evaluating Pupils

The testing conditions for evaluating pupils include:

- Evaluating pupils in dim illumination
- Having the patient fixate at a distance
- Using bright light (a good penlight or fixation light)
- Noting size; anisocoria (unequal pupil size), and corectopia (irregular shaped pupil)

In watching the eye receiving the direct light, you can then determine the direct response by:

- Shining the penlight directly in OD, note response (brisk, sluggish)
- Repeating OS

If the pupils are normal, they will react equally reactive to the direct light.

For assessing the indirect response, utilize the swinging flashlight test by

- Placing the penlight in front of the OD and swinging it in front of OS. The examiner watches that eye for a direct response and the other eye for a consensual response.
- Next, placing the penlight in front of the OS and swinging it in front of OD. The examiner watches that eye for a direct response and the other eye for a consensual response.

The normal pupil will constrict to the direct light as the light swings back and forth, and the normal pupil will also constrict to indirect light, having a consensual response. RAPD constricts to consensual light, and not to direct light.

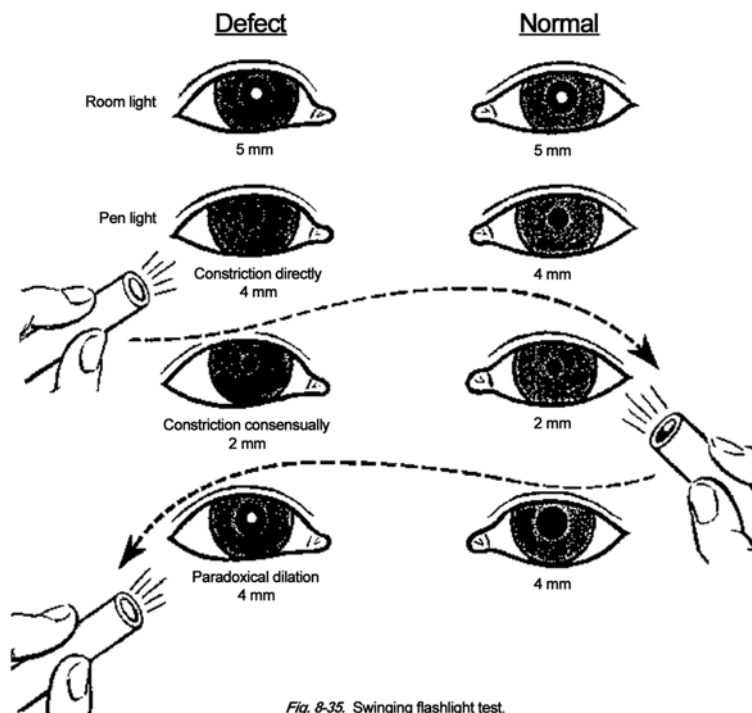


Fig. 8-35. Swinging flashlight test.

## Abnormalities of the Pupil and Their Characteristics

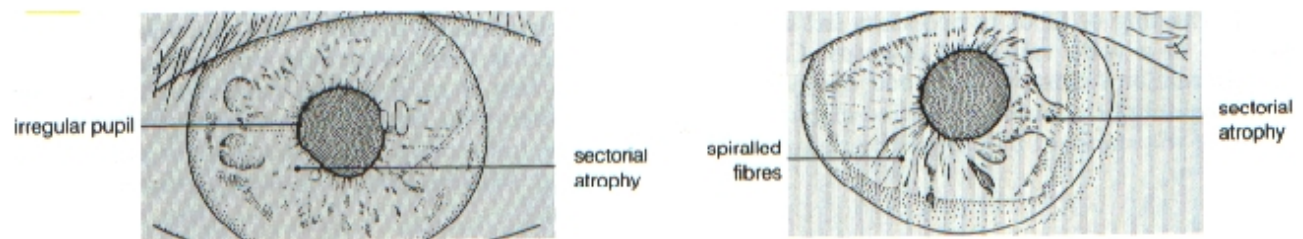
### Relative Afferent Pupillary Defect (RAPD) – also referred to as APD and Marcus-Gunn Pupil

- Objective sign of an asymmetrical lesion of the anterior visual pathway (retina, optic nerve, chiasm, or optic tract)
- Seen with major retinal lesions or neurological lesions of the anterior visual pathway.

The presence of a RAPD and the absence of gross ocular disease indicate a neurological lesion in the anterior visual pathway and the importance of this physical sign cannot be over emphasized.

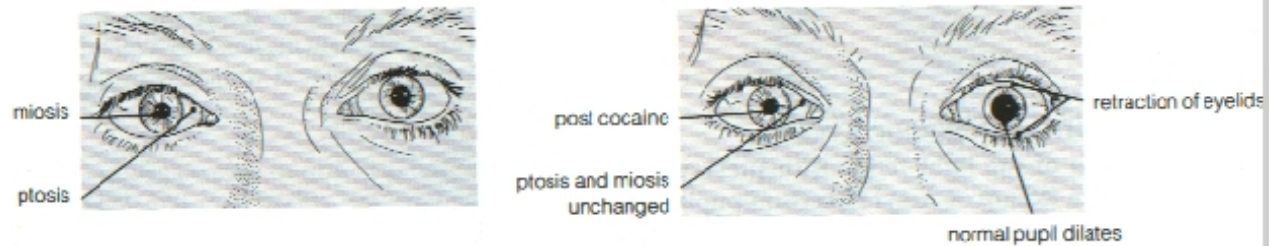
### Adie's Syndrome – also referred to as Tonic Pupil

- Variable presentation of dilated pupil (sector to complete palsy of sphincter muscle)
- Caused by lesion of the ciliary ganglion
- Typically young female, unilateral involvement
- Frequent absence of deep tendon reflexes
- Absent or retarded constriction of pupil to light
- May be diagnosed by instilling 0.1% pilocarpine drop in eye. In Adie's Syndrome, the pupil will constrict, the normal pupil will not.



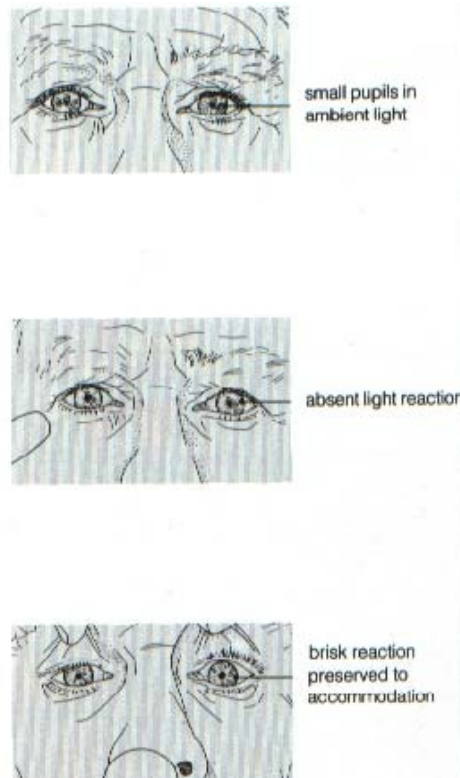
### Horner's Syndrome

- Caused by lesion of sympathetic pathway in the brain stem, upper spinal cord, or peripheral sympathetic chain.
- Ipsilateral (same side) ptosis, miosis (small pupil), and anhydrosis (lack of sweating)
- Diagnosed with 4% cocaine – Horner's will dilate poorly (normal will dilate)



### Argyll-Robertson Pupil

- Frequently associated with neurosyphilis, a sexually transmitted disease
- Irregular, miotic pupils
- Dilate poorly with mydriatics (dilating drops)
- Usually bilateral, may be asymmetric
- Light-near dissociation has a sluggish or no response to light, but has preservation of near response, meaning the pupil still constricts to near targets



### Color Vision

Recognizing color is part of our every day world. However, not everyone sees color the same way.

#### Physiology & Theory

Color discrimination assumes the presence of three cone populations in different regions of the visible spectrum, which provides the brain with the information to interpret a world of color. Disturbances in color recognition may be caused by ocular media color changes, deficiencies, or absences of one or more cone populations, or from changes in neural integration at the level of transmission or interpretation in the central nervous system.

Light is defined as that portion of the electromagnetic spectrum that stimulates human retinal receptors.

The visible part of the electromagnetic spectrum is as follows:

Red	650 – 750 nanometers (wavelength)
Orange	592 – 650 nanometers (wavelength)
Yellow	560 – 592 nanometers (wavelength)
Green	500 – 560 nanometers (wavelength)
Blue	446 – 500 nanometers (wavelength)
Violet	400 – 446 nanometers (wavelength)

The retina contains rods and cones. Rods are achromatic without color; cones mediate color vision. Cones require a greater intensity of light to be stimulated than rods require; therefore, we are unable to

distinguish color in dim illumination. Cones are concentrated primarily centrally, but present throughout the retina.

The retina has approximately 120 million rods and six million cones. The retina has three types of cones, each with a different photosensitive pigment in their outer segments. The cones are cyanolabe (blue), chlorolabe (green), and erythrolabe (red). Each absorbs light of a definite wavelength, according to their period of vibration. These cones overlap; therefore, a given light elicits different degrees of response in each type of cone. Light causes a chemical change that breaks the pigments down into products which electrochemically stimulate the photoreceptors to discharge a nervous impulse, which is transmitted through the optic nerve.

The dimensions of color are:

- Brightness – luminance, intensity
- Hue – dependent on wavelength of light
- Saturation – index of purity of the color, such as red-highly saturated, pink-less saturated

### Color Defects

Approximately 8% of males and 0.4% of females have some degree of color deficiency. Congenital color blindness is the most common type; it is X-linked recessive (only males affected, transmitted through female carriers to half of the sons, no father to son transmission). It is usually bilateral, symmetric, and non-progressive. Patients may be tested binocularly.

Acquired color blindness may be caused by poisoning, optic nerve or retinal disease. It may be unilateral, bilateral, asymmetric, and progressive. Patients should be tested monocularly.

Different categories of color vision and color vision deficiency exist:

- **Trichromatism** is normal with all three types of cones functioning
- **Anomalous Trichromatism** is an irregular deviation from natural order. It is the largest group of color defects, and uses abnormal amounts of primaries for color matches. Anomalous Trichromatism shows only partial sensitivity to certain colors.
  - Protanomaly uses more red than normal
  - Deuteranomaly uses more green than normal
  - Tritanomaly uses more blue than normal
- **Dichromatism** has only two of the three cones functioning, and the individual will have protanopes, deuteranopes, or tritanopes. Those with
  - Protanopes are red-blind and insensitive to deep red
  - Deuteranopes are green-blind and confuse shades of red, green, and yellow
  - Tritanopes are blue-blind and confuse blue and green shades
- **Monochromat** is an individual who cannot distinguish colors and either has only one type of cone functioning or lack of all cone function. Monochromat is very rare.

### Color Vision Testing Methods

Color vision is the perception of color and results from stimulation of red, green, and blue cone receptors in the retina.<sup>1</sup> The following color vision testing methods are a few of the foremost procedures.

- **Pseudo-isochromatic Plates: Ishihara, Stilling, & Hardy-Rand-Rittler** – The plates consist of primary color dots printed on a background of similar dots in a confusion of colors. Dots are set in patterns, such as numbers, letters, or shapes, which will be indiscernible to individuals with color deficits. Ishihara Plates are arranged as numbers or patterns, Stilling Plates are arranged as letters, and Hardy-Rand-Rittler Plate are arranged as geometric figures, such as triangles, squares, or circles.

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<sup>1</sup> *Dictionary of Eye Terminology* (B. Cassin, S. Solomon, S, Third Edition, 1997, Triad Publishing Company)

- **Farnsworth D-15 – Macbeth Easel Lamp** – Macbeth Easel Lamp (6.740 degrees Kelvin, “average daylight”) is used with room lights dim, lamp above color chips. Patient arranges 15 colored caps in order according to color. A substitute for the Macbeth Easel Lamp is a 100-watt bulb with a Kodak Wratten 78AA filter mounted in spectacles.
- **Farnsworth-Munsell 100 Hue** – Lighting is the same as D-15. Test consists of four cases, with a total of 93 caps; each case has two fixed reference caps, leaving 85 removable caps. With one box at a time, the patient arranges caps in order of color. The order in which the patient arranged the caps is recorded and the test is scored. This test is the most time consuming and detailed.
- **Anomaloscope** – An anomaloscope is used to detect red-green color deficiencies. The patient matches a red monochromatic wavelength light and a green monochromatic wavelength in color and brightness on a yellow background.

**CE on the Internet Quiz**

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**PUPIL EVALUATION & COLOR VISION**

1. What is (are) the function(s) of the pupils?
  - a. Controls the amount of light entering the eyes
  - b. Provides the best visual function under varying degrees of light intensity
  - c. Gives the eye its color
  - d. a & b
  
2. Pupils are best evaluated under which condition?
  - a. Bright room light
  - b. Dim room light
  - c. Outside
  - d. After dilation
  
3. An afferent pupillary defect
  - a. Constricts to consensual light
  - b. Does not constrict to direct light
  - c. Is also known as a Marcus-Gunn pupil
  - d. All of the above
  
4. Which of the following is characterized by ipsilateral ptosis, miosis, and anhydrosis?
  - a. Argyll-Robertson Pupil
  - b. Horner's Syndrome
  - c. Adie's Syndrome
  - d. Marcus Gunn Pupil
  
5. The visible part of the electromagnetic spectrum in nanometers is
  - a. 500-700
  - b. 400-750
  - c. 200-800
  - d. 0-1000
  
6. \_\_\_\_\_ is the highest visible part of the electromagnetic spectrum at 650-750 nanometers, and \_\_\_\_\_ is the lowest visible part of the electromagnetic spectrum at 400-446 nanometers.
  - a. Red; violet
  - b. Orange; blue
  - c. Yellow; green
  - d. Red; blue
  
7. \_\_\_\_\_ mediate color vision and require a greater intensity of light to be stimulated.
  - a. Cones
  - b. Rods
  - c. Retina
  - d. Cyanolabe
  - e.
  
8. \_\_\_\_\_ are achromatic and respond more efficiently in low light situations.
  - a. Cones
  - b. Rods
  - c. Retina
  - d. Trichromat

9. Approximately \_\_\_\_\_ rods and \_\_\_\_\_ cones are in the retina.
  - a. 20 million; 1 million
  - b. 120 million; 6 million
  - c. 6 million; 120 million
  - d. None of the above
  
10. Cones are concentrated primarily in the \_\_\_\_\_.
  - a. iris
  - b. sclera
  - c. pupil
  - d. macula
  
11. Someone who is red-blind is described as a:
  - a. Protanope
  - b. Deuteranope
  - c. Tritanope
  
12. Someone who is green-blind is described as a:
  - a. Protanope
  - b. Deuteranope
  - c. Tritanope
  
13. Someone who is blue-blind is described as a:
  - a. Protanope
  - b. Deuteranope
  - c. Tritanope
  
14. A \_\_\_\_\_ is an individual who cannot distinguish colors and either has only one type of or lack of all cone function.
  - a. Monochromat
  - b. Dichromatism
  - c. Trichromatism
  - d. Anomalous Trichromatism
  
15. A \_\_\_\_\_ is used to detect red-green color deficiencies by a patient matching a red monochromatic wavelength light and a green monochromatic wavelength in color and brightness on a yellow background.
  - a. Macbeth Easel Lamp
  - b. Munsell 100 Hue
  - c. Anomaloscope
  - d. Pseudo-isochromatic Plates
  
16. What percent of the nerve fibers in the optic tract are for pupillary function?
  - a. 10
  - b. 5
  - c. 20
  - d. 25

**CE on the Internet Answer Sheet**

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Place your answers to each question in the appropriate space adjacent to the question number.

- |          |           |           |
|----------|-----------|-----------|
| 1. _____ | 7. _____  | 13. _____ |
| 2. _____ | 8. _____  | 14. _____ |
| 3. _____ | 9. _____  | 15. _____ |
| 4. _____ | 10. _____ | 16. _____ |
| 5. _____ | 11. _____ |           |
| 6. _____ | 12. _____ |           |

By filling in the above spaces and signing your name, you agree that:

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I attest that I have completed this quiz on my own. \_\_\_\_\_  
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Score	Pass	Fail
Notified Quiz Taker	_____	

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Please read each question carefully. Your feedback is **important** to us. Thank you!

1. How long have you been employed in the field of ophthalmology? \_\_\_\_\_ years
2. This written article was designed at a level right for me. (circle one) YES NO
3. Please read the following statements. Then, circle the number corresponding to the degree to which you agree with each statement.

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
a. The material was organized and presented in a clear and efficient way.	5	4	3	2	1
b. The information will be useful/relevant to me.	5	4	3	2	1
c. The material was presented at a level appropriate to my background and level.	5	4	3	2	1
d. Overall, I was satisfied with the article.	5	4	3	2	1

4. What part of the article was **most useful** to you?

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5. What part of the article was **least useful** to you?

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6. What suggestions do you have for improving this article?

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