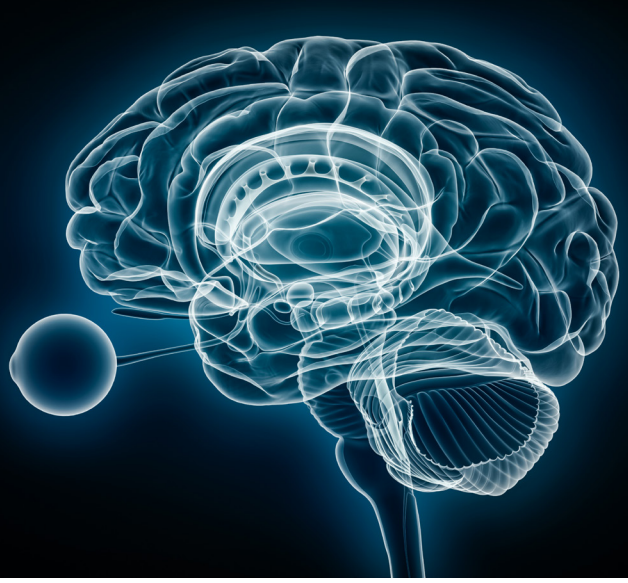
NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

I Can't See Things Clearly: Disruption of the Visual Pathway



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Preparation

Complete the second column of Table 1 below by describing the purpose of each eye assessment test. This information will be reviewed in Part III of this case study.

Table 1. Eye assessment tests.

Test	*Purpose of Test: What Is Measured?*
Autorefractor	
Entrance tests: • Visual acuity test	
• Extraocular muscle function test	
• Vision field test	
• Color vision test	
• Pupillary light reaction test	
Slit lamp examination	
Dilated fundus examination	
Intraocular pressure (IOP) test	

Part I – I Can't See!

On a sunny Sunday morning in July, 70-year-old Mrs. Silva woke up early to spend the day with her grandson Lucas. They decided to go to the park for a walk to catch up on life and to discuss Lucas' academic plans. Lucas shared with her that he would be attending college the following spring. Mrs. Silvia reacted with a big smile, but that big smile was followed by a misstep as she grabbed her grandson's arm.

"Oh, I'm sorry," said Mrs. Silva. "I don't know what happened, but my vision blurred for a split second. I guess I didn't get enough sleep yesterday."

Lucas became worried and asked her if she was okay. However, Mrs. Silva struggled to respond as her face took on a pained expression. Lucas immediately ended the walk, hailed a cab, and took his grandmother home.

At home, Mrs. Silva complained of having a headache, feeling nauseous, and discomfort in moving her eyes. While these resolved, the blurry vision persisted for five days. The family was worried, so Ana, Mrs. Silva's daughter, decided to spend the day at her mother's house to ensure her safety as she booked an appointment with her ophthalmologist, Dr. Wang.

Questions

1. When light enters Mrs. Silvia's eyes, what are the structures that the light passes through? Fill in the blanks:

   Cornea → _____ → _____ → _____ → Retina (rods and cones)

2. How does light reach the rods and cones after passing through the vitreous humor? Once the light energy is transduced to electrical energy, what is the direction of electrical transmission? (*Hint:* list cellular layers.)

3. List the pathway nerve impulses travels from the retina to the brain.
   a) Label A–D on the diagram below (see Figure 1, next page) to show how the information received by the eye is mapped to the visual cortex.
   b) Circle where crossing over occurs on Figure 1.
   c) Which visual cortex receives information from the left eye, and which cortex receives information from the right eye? (*Hint:* consult Figure 1.)

4. Which cranial nerves are involved in vision?

5. Eight years ago Mrs. Silva was diagnosed with type II diabetes and hypertension. Since that time she has taken metformin to treat her condition. Based on this medical history, describe any additional reasons that might explain her blurry vision.

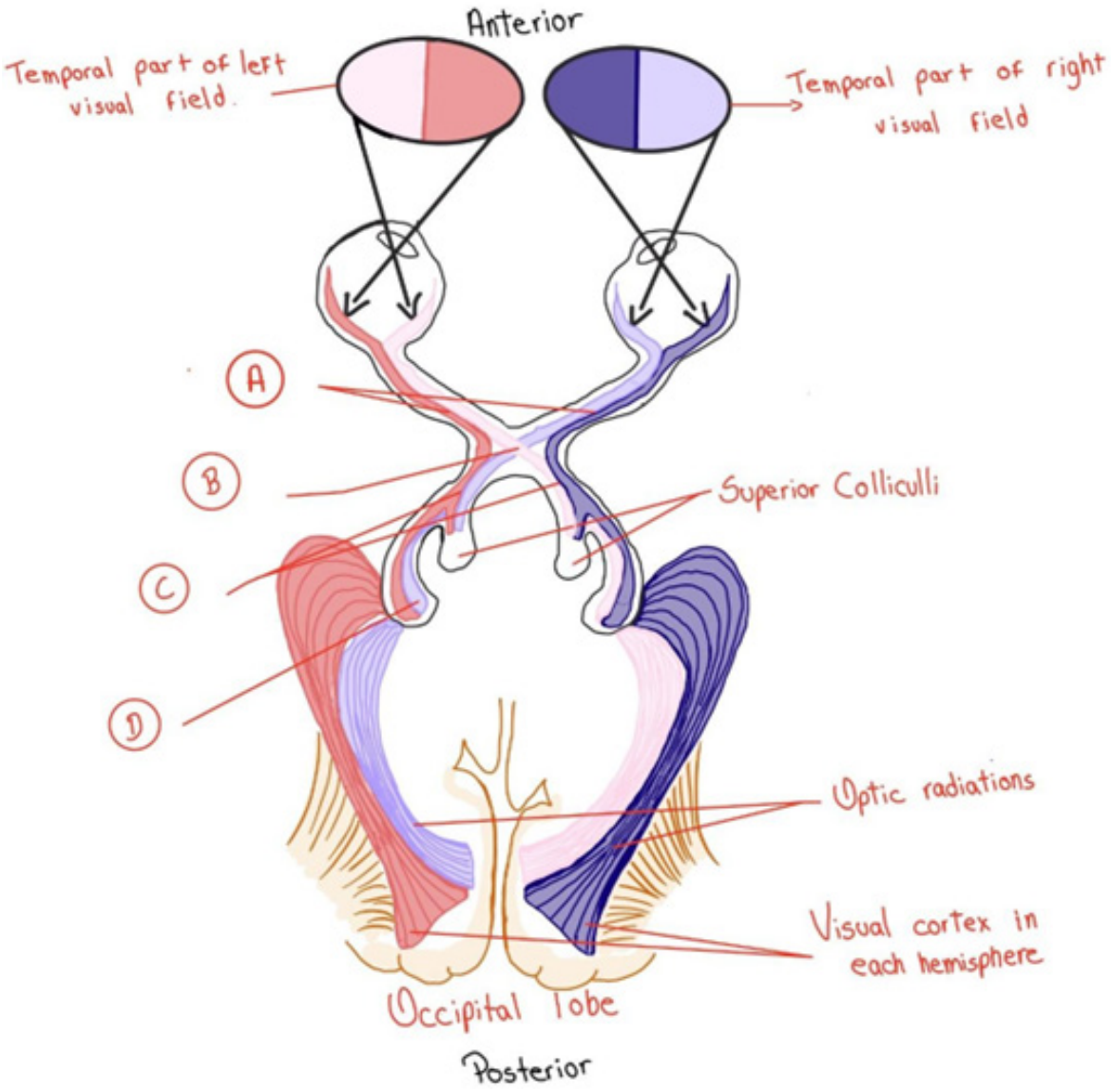

Figure 1. Visual pathway, the route that transmits visual information from retina to the brain.

Part II – A Bit of Light Reading

Mrs. Silva's daughter, Ana was a nurse who worked at St. Antonio Hospital and was familiar with patients experiencing cataracts, especially those who are diabetic. She was aware that women who are diabetic are at greatest risk of developing this condition. Ana spent the evening reviewing information on type II diabetes and how it may affect her mom. She planned to ask their ophthalmologist Dr. Wang about cataracts and continued to read about how visual information is mapped to the visual cortex.

Questions

1. What are cataracts?

2. How does type II diabetes cause cataracts?

Part III – How Does It Work?

At the ophthalmologist's office, Dr. Wang performed a series of tests (Table 1 above) including the visual acuity test and conducted an exam using the slit lamp and ophthalmoscope on Mrs. Silvia. For the visual acuity test, Dr. Wang asked Mrs. Silva to cover one eye and read the Snellen visual acuity test chart. He also examined the anterior structures of the eye using a yellow dye (fluorescein) followed by the slit lamp. He told Mrs. Silva he would dilate the pupil to see the internal posterior structures. He administered the anesthetic drops and gave her 10 minutes to relax. Dr. Wang performed the examination by flashing an intense bright light into her eye with the ophthalmoscope. Mrs. Silva blinked in reaction to being a little shocked by the bright light. Dr. Wang found some abnormalities in Mrs. Silva's eye. When the Doctor looked at Mrs. Silva to give her the diagnosis, he noticed tears running down her cheeks. He asked if she was okay, and she answered "Yes, I don't know why my eyes are so watery."

Questions

1. What specific structures of Mrs. Silvia's eye will be examined using the yellow dye and slit lamp? What are their functions?

2. How did Dr. Wang examine the posterior compartment of the eye? What specific structures did he look at and what are their functions?

3. Why is the intraocular pressure test of significance for Mrs. Silvia? (*Hint:* think of Mrs. Silvia's pre-existing condition.)

4. At the end of the procedure, Mrs. Silva's cheeks were wet. Why is she tearing up? Which structures of the eye are being stimulated during the procedure?

5. During the muscle function test, Dr. Wang asked Mrs. Silvia to move the eye in eight specific directions without moving her head. [Hint, keep track of which eye is moving] Which muscles contract when she:
   - Looks up (both eyes):
   - Looks down (both eyes):
   - Looks left
     Right eye:

     Left eye:

- Looks right
  Right eye:

  Left eye:

- Rolls the eyes left and up
  Right eye:

  Left eye:

- Rolls the eyes right and up
  Right eye:

  Left eye:

- Rolls the eyes left and down
  Right eye:

  Left eye:

- Rolls the eyes right and down
  Right eye:

  Left eye:

6. Use each of the muscles you identified in Question 5 to label Figure 2 below.

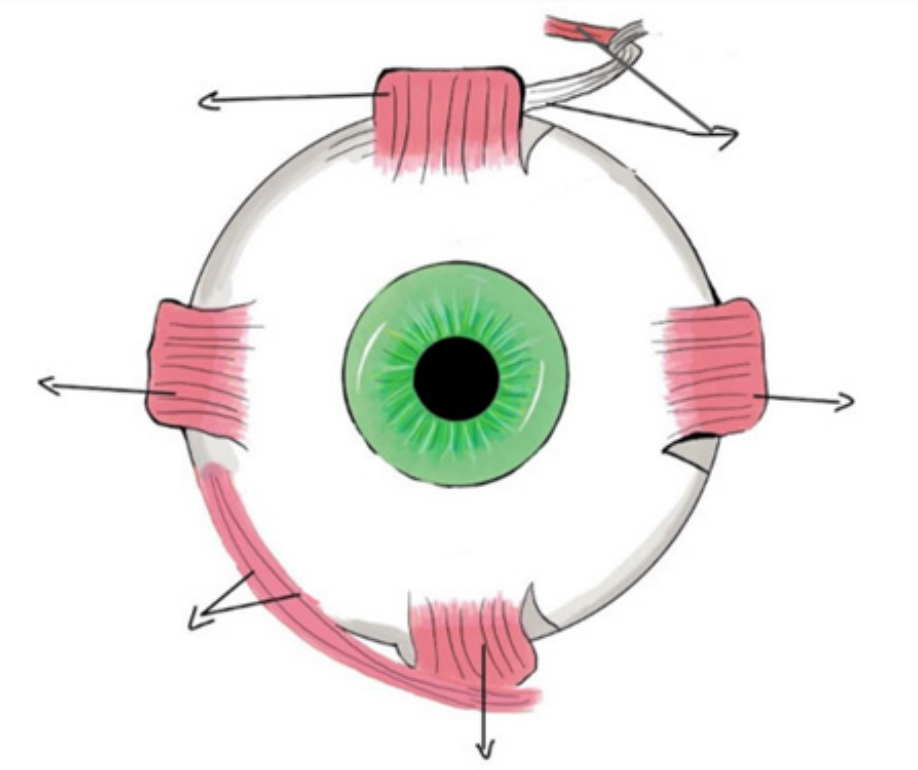

Figure 2. Eye muscles.

Part IV – Tests Results

Results from Mrs. Silva's best-corrected visual acuities (BCVA), visual field test, and Ishihara color vision revealed that her vision, vision field, and color vision were bilaterally reduced. Relative afferent pupillary defect (RAPD) was noted for both eyes during the pupillary light reaction test. Funduscopic examination showed swollen optic disks in both eyes. Slit-lamp examination, intraocular pressure, and ocular movement were otherwise normal.

Dr. Wang suspected that Mrs. Silva had optic neuritis (ON) based on these results, especially noting the swollen optic disks.

Questions

1. What is abnormal in Mrs. Silva's eyes? What was normal?

2. Mrs. Silva experiences peripheral and color vision loss. Which cells are responsible? Where are they located?

3. Give a likely reason for Mrs. Silva's pupillary response.

To confirm this diagnosis, Dr. Wang sent Mrs. Silva to get three additional tests. This is documented below in Table 2.

Table 2. Additional tests.

Test	*Normal*	*Mrs. Silva*
Myelin oligodendrocyte glycoprotein (MOG) antibodies	Negative	Positive
MRI (magnetic resonance imaging)	 *Figure 3a*. Normal eye.	 *Figure 3b*. Mrs. Silva's eye.
Mean latency of visual evoke potential (VEP)	Left eye: 88.3 ± 8.8 ms Right eye: 88.7 ± 8.9 ms	Left eye: 134.3 ms Right eye: 135.7ms

Questions

4. Why should a blood test be conducted?

5. The MOG antibodies were present in Mrs. Silvia's blood. What would this antibody's presence signify?

6. On the MRI images:
   a. What sectional plane was imaged?
   b. Use an arrow on the normal image to indicate the optic nerve.
   c. Use an arrow on Mrs. Silva's image to show where her visual information is interrupted.
   d. Do these results correlate with her having blurry vision?

7. What is VEP? What is likely occurring in Mrs. Silvia's eyes?

Part V – Mrs. Silva Seeks Treatment

Dr. Wang confirmed that Mrs. Silva had acute ON, an autoimmune inflammatory condition of unknown cause. Dr. Wang scheduled an appointment to discuss possible treatment options. On the day of the appointment Mrs. Silva arrived at Dr. Wang's feeling anxious and excited. Dr. Wang explained to Mrs. Silva and Ana that there were two options for treatment.

- *Plan A:* intravenous methylprednisolone (IVMP). (If infection occurs, concurrent antibacterial medication is administered.) IVMP is good for immediate therapy. The drug has a short duration of three days resulting in improved short-term performance and increased visual recovery. IVMP is not for long-term treatment. There is a risk of infectious complications due to the immunosuppressive effects of IVMP. Concurrent antibacterial medication may be needed to prevent infections. Additionally, IVMP may have some side effects such as mood changes, increased appetite, weight gain, and fluid retention.
- *Plan B:* intravenous immunoglobulin (IVIg) therapy, followed by plasma exchange (PLEX). IVIg is a treatment for recurrent ON. Treatment decreases MOG antibody associated diseases like ON. IVIg duration is about five weeks. PLEX is thought to rapidly remove plasma antibodies, immune complexes, and cytokines that are involved in demyelination and inflammation. However, IVIg therapy and PLEX are more intensive procedures compared to IVMP. IVIg therapy requires the administration of immunoglobulin through intravenous infusion, which can have potential side effects such as allergic reactions. PLEX involves removing plasma from the blood and replacing it with a substitute, which carries risks associated with the procedure.

Plan B was selected for Mrs. Silva, and after 8 weeks (about 2 months) of treatment, Mrs. Silva's visual acuity had increased, while peripheral and color vision were within normal limits. The funduscopic examination was near normal limit; RAPD grade 1 was documented for the right eye, and left eye pupillary reflex was back to normal.

Questions

1. Why was Mrs. Silva placed on Plan B? Did this treatment plan help her?

2. Are there preventative measures for optic neuritis?