Lesson 10

ELECTROOCULOGRAM (EOG) I

Eye Movement
Saccades and Fixation during Reading
I. INTRODUCTION

What do these three things have in common?

- Two young lovers whose eyes meet across a crowded room
- The final scene of *Casablanca*
- A Michael Crichton novel

Regardless of what else they have in common, all involve the muscular control of eye movements in your field of view. One of the most important functions your eyes can perform is to “fix” or “lock” on specific objects. When you “fix” on an object, you position your eyes so that the image of the object is projected onto your retina at the area of greatest acuity, the fovea. Muscular control of your eyes works to keep the image on your fovea, regardless of whether the object is stationary or moving.

There are two primary mechanisms used to fixate on objects in your **visual field**, defined as the field of view without moving your head:

1. **Voluntary fixation mechanism** — Voluntary fixation allows you to direct your visual attention and lock onto the selected object.
2. **Involuntary fixation mechanism** — Involuntary fixation allows you to keep a selected object in your visual field once it has been found.

In voluntary types of eye movements, you can fixate on another person from across a crowded room. Voluntary fixation involves a conscious effort to move the eyes. This mechanism is used to initially select objects in your visual field, and once selected, your brain “hands off” the task to involuntary fixation.

Even when you fixate on a stationary object, your eyes are not still but exhibit tiny, involuntary movements. There are three types of involuntary movements: tremors, slow drifts, and flicking:

- **Tremors** — a series of small tremors of the eyes at about 30-80 Hz (cycles/sec).
- **Slow drifts** — involuntary movements that result in drifting movements of the eyes. This drift means that even if an object is stationary, the image drifts across the fovea.
- **Flicking movements** — As the image drifts to the edge of the fovea, the third involuntary mechanism causes a reflex flicking of the eyeball so that the image is once again projected onto the fovea.

The drifting movements and flicking movements will be in opposite directions. If the drifting movement is to the left, the flicking movement will be to the right, although it may not be 180° opposite of the drifting movement.

When you wish to follow a moving object, you use large slow movements or *tracking movements*. So, as you watch Humphrey Bogart walk away during the final scene of *Casablanca*, your eyes are following an apparently smooth motion and tracking an object in your visual field. Although you have voluntarily directed your eyes to Humphrey Bogart, tracking movements are involuntary.

Another set of motions is used when you read or when objects are streaming past you, e.g., when you watch the world go by while riding in a train. Rather than a smooth tracking motion, reading usually involves voluntary, larger movements, known as **saccades**, or fixating on a series of points in rapid succession. When this happens, your eye jumps from point to point at a rate of about three jumps per second. During the jumps or saccades, the brain suppresses visual images, so you don’t “see” the transitional images between the fixation points.

Typically, the eye will spend about 10% of the time moving from fixation point to fixation point, with the other 90% of the time fixating on words, although there is much variation.

Eye movement can be recorded as an **electrooculogram**, a recording of changes in voltage that occur with eye position. Electrically, the eye is a spherical “battery,” with the positive terminal in front at the cornea, and the negative terminal behind at the retina of the eyeball. The potential between the front and back of the eyeball is about 0.4-1.0 mV. By placing electrodes on either side of the eye, you can measure eye movement up to ±70°, where 0° is in front and ±90° is directly lateral or vertical to the eyes. The electrodes measure the changes in potential as the cornea moves nearer or further from the recording electrodes. When the eye is looking straight ahead, it is about the same distance from either electrode, so the signal is essentially zero. When the front of the eyeball, the cornea, is closer to the positive electrode, that electrode records a positive difference in voltage.
II. EXPERIMENTAL OBJECTIVES

1) Compare eye movements while fixated on a stationary object and tracking objects.
2) Measure duration of saccades and fixation during reading.
3) Instructor’s option: Record spatial position of eye movements during visual examination of materials.

III. MATERIALS

- BIOPAC electrode lead set (SS2L), Qty-2
- BIOPAC disposable vinyl electrodes (EL503), 6 electrodes per subject
- BIOPAC electrode gel (GEL1) and abrasive pad (ELPAD) or skin cleanser or alcohol prep
- Adhesive Tape (TAPE 2)
- Computer system
- Biopac Student Lab 3.7
- BIOPAC data acquisition unit (MP36, MP35, or MP30 with cable and power)

IV. EXPERIMENTAL METHODS

For further explanation, use the online support options under the Help Menu.

A. SET UP

FAST TRACK Set Up

1. Turn the computer ON.
2. Make sure the BIOPAC MP3X unit is turned OFF.
3. Plug the electrode leads (SS2L) in as follows:
   - Horizontal lead — CH 1
   - Vertical lead — CH 2

4. Turn the MP3X Data Acquisition Unit ON.

Detailed Explanation of Set Up Steps

The desktop should appear on the monitor. If it does not appear, ask the laboratory instructor for assistance.

Electrode lead sets (SS2L)

Fig. 10.1
5. Place 6 electrodes on the **Subject** as shown in Fig. 10.2.

**IMPORTANT**
For accurate recordings, attach the electrodes so they are horizontally and vertically aligned.

6. Attach the vertical electrode lead set (SS2L) from Channel 2 to the electrodes, following Fig. 10.3.

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Fig. 10.2 Proper electrode placement

Attach one electrode above the right eye and one below, such that they are aligned vertically.

Attach one electrode to the right of the right eye and one to the left of the left eye, such that they are aligned horizontally.

The other two electrodes are for ground, and it is not critical that they are aligned.

**Note:** For optimal electrode adhesion, the electrodes should be placed on the skin at least five minutes before the start of the Calibration procedure.

*Note:* Because these electrodes are attached near the eye, be very careful if using alcohol to clean the skin.

Follow Fig. 10.3 to ensure that you connect each colored cable to the proper electrode. It is recommended that the electrode leads run behind the ears, as shown, to give proper cable strain relief.
7. Attach the horizontal electrode lead set (SS2L) from Channel 1 to the electrodes, following Fig. 10.4.

Follow Fig. 10.4 to ensure that you connect each colored cable to the proper electrode. It is recommended that the electrode leads run behind the ears, as shown, to give proper cable strain relief.

8. Have the Subject adjust the seating position such that his/her eyes are in line with the center of the computer screen.

The Subject should be positioned to see the computer screen easily without moving his/her head. Supporting the head to minimize movement is recommended.

Connect the electrode cable clip (where the cable meets the three individual colored wires) to a convenient location (can be on the Subject's clothes). This will relieve cable strain.

The Subject should not be in contact with nearby metal objects (faucets, pipes, etc.), and should remove any wrist or ankle bracelets.

9. Note the distance from the eyes to the computer screen.

Note the distance from the eyes to the computer screen, as it will be needed in Recording Step 26.

10. Start the BIOPAC Student Lab Program.


12. Type in your filename.

13. Click OK.

This ends the Set Up procedure.
B. CALIBRATION

The Calibration procedure establishes the hardware’s internal parameters (such as gain, offset, and scaling) and is critical for optimum performance. **Pay close attention to the Calibration procedure.**

### FAST TRACK Calibration

1. Make sure the **Subject** is seated in the same position as directed in Set Up Step 8.
2. Click **Calibrate**.
3. Prepare for the next step.
4. Click **OK**.
5. **Subject** should follow the dot on the screen with eyes only.
6. **Check** the calibration data:
   - **If similar**, proceed to Data Recording.
   - **If different**, **Redo Calibration**.

### DETAILED EXPLANATION OF CALIBRATION STEPS

**Note:** It is very important that the **Subject** does not move his/her head during the calibration procedure.

After the **Calibrate** button is pressed, a new window will be established and a dialog box will pop up (Fig. 10.5).

![Fig. 10.5](image)

The journal will be hidden from view during calibration.

In the next step, after the OK button is pressed, a dot will begin a counterclockwise rotation around the screen. **The Subject is to track the dot with his/her eyes without moving his/her head.**

This will begin the Calibration procedure.

The **Subject** should follow the dot around the screen with eyes only and should not move his/her head.

This procedure will continue for about 10 seconds and will stop automatically.

At the end of the 10-sec calibration recording, the screen should resemble Fig. 10.6.

![Fig. 10.6](image)

There should be fluctuation in the data for each channel. If your data resembles Fig. 10.6, proceed to the Data Recording section.

If the **Subject** did not follow the dot on the screen or blinked, giving large data spikes or jitter, or if an electrode “peeled up,” giving large baseline drift, then you should redo the calibration by clicking on the **Redo Calibration** button and repeating the entire calibration sequence.
### C. RECORDING LESSON DATA

#### FAST TRACK Recording

<table>
<thead>
<tr>
<th>Step</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Prepare for the recording.</td>
</tr>
<tr>
<td>2.</td>
<td>Subject and Director should face each other.</td>
</tr>
<tr>
<td>3.</td>
<td>Director should hold a pen in front of the Subject.</td>
</tr>
<tr>
<td>4.</td>
<td>Subject should pick a focal point on the pen so that the eyes remain horizontal.</td>
</tr>
</tbody>
</table>

#### Detailed Explanation of Recording Steps

In order to work efficiently, read this entire section so you will know what to do before recording.

Check the last line of the journal and note the total amount of time available for the recording. Stop each recording segment as soon as possible so you don’t use an excessive amount of time (time is memory).

**Hints for obtaining optimal data:**

- a) Always track the object with your eyes and not your head.
- b) **Subject** should focus on one point of the object, and maintain that focus while following it around.
- c) The **Subject** needs to sit so that head movement is minimized during recording.
- d) There should be enough space near the **Subject** so that an object can be moved around the head at a distance of about 10” (25 cm).
- e) When moving the object, the **Director** should try to keep it at the same distance from the **Subject’s** head.
- f) During recording, the **Subject** should not blink. If unavoidable, the **Recorder** should mark the data.
- g) Make sure electrodes do not “peel up.”
- h) The larger the monitor, the better the data results from the eye tracking portion of this lesson.

**Subject** should not be looking at the computer screen.

The **Director** should hold a pen in front of the **Subject’s** head at a distance of about 10” (25 cm). The pen should be centered with the **Subject’s** head, so that the **Subject’s** eyes are looking straight ahead.

The **Subject’s** eyes should not move up or down. Ideally, they will only move laterally to follow the object.

Recording continues…
Segment 1

5. Click **Record**.

6. Record for 20 seconds.
   - **Subject** fixates and tracks object.
   - **Director** holds object center and still for about 5 seconds, then moves object laterally ±70° and back to center in about 3 seconds.
   - **Recorder** inserts event markers with each change of direction:
     - \( \nabla \) ‘L’ for left
     - \( \nabla \) ‘R’ for right

7. Click **Suspend**.

8. Review the data on the screen.
   - If correct, go to **Step 10**.

   - If incorrect, go to **Step 9**.

9. If data was incorrect, click **Redo**.

   When you click **Record**, the recording will begin and an append marker labeled “Eyes tracking horizontal” will automatically be inserted “.

   The **Subject** should fixate and track the object. **Subject** should try not to blink during recording, though it may be unavoidable.

   **Director** should hold object 10” (25 cm) in front of **Subject** for about 5 seconds, then move the object laterally to **Subject’s** left, then right, then back to center in about 3 seconds.

   **Director** should verbalize the directions so that the **Recorder** knows when to place markers and what direction to label them.

   To insert **Markers**, press the F9 key. Markers and labels can be edited after the data is recorded.

   The recording will halt, and you can review the data.

   If all went well, your data should look similar to Fig. 10.7.

   ![Fig. 10.7 End of Segment 1 (Horizontal tracking)](image)

   a) Data should show that the horizontal EOG (CH 1) had large deflections, and the vertical EOG (CH 2) had very little deflection.
   
   b) Data should show a positive peak when **Subject** looked right, and a negative peak when the **Subject** looked left.

   The data would be **incorrect** if:

   a) Channel connections were incorrect.
   b) Lead connections were incorrect (i.e., red lead was not connected to the **Subject’s** right temple.)
   c) The **Suspend** button was pressed prematurely
   d) An electrode peeled up, giving a large baseline drift
   e) The **Subject** looked away or the head moved.

   **Note**: A few blinks may be unavoidable in the data and would not necessitate redoing the recording.

   Click **Redo** and repeat Steps 2-8. Note that once you press **Redo**, the data you have just recorded will be erased.
Segment 2

10. **Subject** and **Director** should face each other.

11. **Director** should hold a pen in front of the **Subject**.

12. **Subject** should pick a focal point on the pen so that the eyes are looking straight ahead (not up or down).

13. Click **Resume**.

14. Record for 20 seconds.
   - **Subject** should follow object with eyes only.
   - **Director** should hold object stationary and center, then move object up, down, and return to center.
   - **Recorder** should insert event markers:
     - \( \nabla \) “U” Object moved up
     - \( \nabla \) “D” Object moved down

15. Click **Suspend**.

16. Review the data on the screen.
   - If correct, go to **Step 18**.
   - If incorrect, go to **Step 17**.

17. If data was incorrect, click **Redo**.

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**Subject** should not be looking at the computer screen.

The **Director** should hold a pen in front of the **Subject’s** head at a distance of about 10” (25 cm). The pen should be centered with the Subject’s head, so that the **Subject’s** eyes are looking straight ahead.

**Subject** may need to blink before resuming recording.

When you click **Resume**, the recording will continue and an append marker labeled “Eyes tracking vertically” will be automatically inserted.

The **Subject** should follow the object with his/her eyes without moving his/her head. **Subject** should try not to blink during the recording, although it may be unavoidable.

The **Director** should begin with the object about 10” (25 cm) in front of the **Subject** for 5 seconds, and move the object vertically to the edge of the **Subject’s** field of vision.

To insert **Markers**, press the F9 key. Markers and labels can be edited after the data is recorded.

The recording should halt, giving you time to review the data.

If all went well, your data should look similar to Fig. 10.8.

![Fig. 10.8 Segment 2 Vertical Tracking](image)

- a) Data should show that the vertical EOG (CH 2) recording had large deflections, and the horizontal EOG (CH 1) had very little deflection.
- b) Data should show a positive peak when **Subject** looked up and a negative peak when the **Subject** looked down.

The data would be **incorrect** for the reasons from Step 8.

Click **Redo** and repeat Steps 10-16. Note that once you press **Redo**, the data you have just recorded will be erased.
**Segment 3**

18. **Prepare** for Segment 3 reading:
   - **Director** selects reading and positions it in front of **Subject**.
   - **Subject** prepares to read.

19. Click **Resume**.

20. **Subject** should read for about 20 seconds.
   - **Optional:** **Recorder** can insert a marker when **Subject** starts reading each line.

21. Click **Suspend**.

22. Review the data on the screen.
   - If correct, go to **Step 24**.
   - If incorrect, go to **Step 23**.

23. If data was incorrect, click **Redo**.

24. Click **Stop**.

A sample reading is provided at the end of the lesson. Hold the page in front of the **Subject** at a distance of about 10” (25 cm), centered within his/her line of sight.

When you click **Resume**, the recording will continue and an append marker labeled “Reading” will be automatically inserted.

**Subject** should read silently to minimize EMG artifact.

Optional: The **Subject** may signal the **Recorder** (verbally or with hand signals) when starting each new line and the **Recorder** can insert event markers.

To insert **Markers**, press the **F9** key. Markers and labels can be edited after the data is recorded.

The recording should halt, giving you time to review the data.

If all went well, your data should look similar to Fig. 10.9.

Fig. 10.9 Segment 3

The data would be incorrect for the reasons from Step 8.

Click **Redo** and repeat Steps 18-22. Note that once you press **Redo**, the data you have just recorded will be erased.

When you click **Stop**, a dialog box comes up, asking if you are sure you want to stop the recording. Clicking “yes” will end the data recording and automatically save the data. Clicking “no” will bring you back to the **Resume** or **Stop** options. This is simply one last chance to confirm you don’t need to redo the last recording segment.
25. If you want to see an example of eye tracking, go to **Step 26**.

   or
   
   If you want to end the recording, go to **Step 31**.

26. Reposition the **Subject** per Set Up Step 8.

   **IMPORTANT** — The distance from the eyes to the screen must be the same as it was in Set Up.

27. Click **DOT PLOT**.

28. **Subject** should focus on the center of the screen and move his or her head until the dot is also at the center of the screen.

29. **Subject** should look at different points within the data window.

30. Click **Stop**.

31. Click **Done**.

32. Remove the electrodes.

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**Optional Segment 4**

**Tracking demonstration**

**Note:** This part of the recording is for general interest only and data will not be saved. It shows how well the EOG can be used as an eye-tracking device.

Have the **Subject** adjust the seating position such that his/her eyes are in line with the center of the computer screen, and the distance from the eyes to the screen is as recorded.

Refer to the distance noted in Set Up Step 9 to ensure that the distance from the **Subject’s** eyes to the screen is the same as was used for the calibration procedure.

A new window will appear, similar to the calibration window.

**Subject** should maintain this position throughout the **DOT PLOT** segment.

The dot on the screen should track the focal point of the **Subject’s** eyes.

**Subject** should maintain the head position from Step 26, and should look at different points on the screen with eyes only.

Note that because of amplifier limitations, the dot can not hold its position for very long and will tend to move toward the center point.

When you click **Stop**, the screen will change to simultaneously display all the dot positions from the last 30 seconds of the dot plot. This segment of data will not be saved.

You may redo the dot plot by clicking **Redo**.

After you press **Done**, a pop-up window with options will appear. Make your choice, and continue as directed.

If choosing the “Record from another Subject” option:

   a) Attach electrodes per Set Up Steps 5-7 and continue the entire lesson from Set Up Step 11.

   b) Each person will need to use a unique file name

Remove the electrode cable pinch connectors, and peel off the electrodes. Throw out the electrodes (BIOPAC electrodes are not reusable). Wash the electrode gel residue from the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours. This is normal, and does not indicate that anything is wrong.

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**END OF RECORDING**
V. DATA ANALYSIS

**FAST TRACK Data Analysis**

1. Enter the **Review Saved Data** mode.

   Note Channel Number (CH) designation:
   
<table>
<thead>
<tr>
<th>Channel</th>
<th>Displays</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 40</td>
<td>horizontal</td>
</tr>
<tr>
<td>CH 41</td>
<td>vertical</td>
</tr>
</tbody>
</table>

2. Setup your display window for optimal viewing of the first data segment.

3. Set up the measurement boxes as follows:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 40</td>
<td>ΔT</td>
</tr>
<tr>
<td>CH 40</td>
<td>p-p</td>
</tr>
<tr>
<td>CH 40</td>
<td>slope</td>
</tr>
</tbody>
</table>

**DETAILED EXPLANATION OF DATA ANALYSIS STEPS**

- **Enter the Review Saved Data mode from the Lessons menu.**

  The data window should come up the same as Fig. 10.10.

- **Segment 1 data begins at the append marker labeled “Eyes tracking horizontal” at Time 0 and continues to the next append marker.**

- **The following tools help you adjust the data window:**
  
  - Autoscale horizontal
  - Autoscale waveforms
  - Zoom Tool
  - Grids — Turn grids ON and OFF by choosing **Preferences** from the **File** menu.

  The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click on them.

- **Brief definition of measurements:**

  - **ΔT:** The Delta Time measurement is the difference in time between the end and beginning of the selected area, which is the duration of the selected area.
  - **p-p.:** The p-p (peak-to-peak) measurement shows the difference between the maximum amplitude value in the selected range and the minimum amplitude value in the selected range.
  - **slope:** uses the endpoints of the selected area to determine the relative speed of eye movement.

  The “selected area” is the area selected by the **I-beam** tool (including the endpoints).
4. Measure the amplitudes and durations for the data section when looking left and right.

   ![Image](image1.png)

TIP:

5. **Zoom** in on a small section of the first 5 seconds of Segment 1 data (eye fixation).

6. Find a part of the data segment with a small spike or bump, indicating flicking movement (Fig. 10.12) and measure the duration and slope.

   ![Image](image2.png)

7. Count the number of flicking movements in one-second intervals from 1-4 seconds.

   ![Image](image3.png)

8. Set up the measurement boxes as follows:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 41</td>
<td>ΔT</td>
</tr>
<tr>
<td>CH 41</td>
<td>p-p</td>
</tr>
<tr>
<td>CH 41</td>
<td>slope</td>
</tr>
</tbody>
</table>

Data Analysis continues…
9. Take the measurements on Segment 2 data as needed.

Take measurements in the first five seconds for flicking during fixation.

10. Set up the display window to view Segment 3 “Reading” data.

Segment 3 data begins with the append marker labeled “Reading.” Identify the data section when the Subject moved his/her eyes to read the next line. The horizontal EOG will show the eyes moving left, and at the same time, the vertical EOG will show the eyes moving down.

You can paste measurements into the Journal to record the results of each saccade per line of reading.

11. Find the saccades in the data (Fig. 10.13).

![Fig 10.13]

12. Save or print the data file.

You may save the data to a drive, save notes that are in the journal, or print the data file.

13. Exit the program.

END OF DATA ANALYSIS

END OF LESSON 10

Complete the Lesson 10 Data Report that follows.
ELECTROOCULOGRAM

EOG

DATA REPORT
Student’s Name: ________________________________
Lab Section: __________________________________
Date: _________________________________________

I. Data and Calculations

Subject Profile

Name_________________________________________ Height________
Age___________________________________________ Weight________
Gender: Male / Female

A. Complete Table 10.1 using Segment 1 data.
Be careful to be consistent with units (msec vs secs).

Note: You only need to select one example of a flicking movement.

<table>
<thead>
<tr>
<th>Object Position → Eye Orientation → Measurement [CH #]</th>
<th>Stationary Object Fixation</th>
<th>Moving Object Tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flicking</td>
<td>Left</td>
</tr>
<tr>
<td>ΔT [CH 40]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-p [CH 40]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>slope [CH 40]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Velocity may be represented with a negative ("-"") value because velocity vectors have a magnitude and direction.

B. Complete Table 10.2 using Segment 1 data.

<table>
<thead>
<tr>
<th>Time</th>
<th>Number of Flicking Movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 sec</td>
<td></td>
</tr>
<tr>
<td>1-2 sec</td>
<td></td>
</tr>
<tr>
<td>2-3 sec</td>
<td></td>
</tr>
<tr>
<td>3-4 sec</td>
<td></td>
</tr>
</tbody>
</table>
C. Complete Table 10.3 using Segment 2 data.  

*Note:* You only need to select one example of a flicking movement.

<table>
<thead>
<tr>
<th>Eye Orientation →</th>
<th>Stationary Object</th>
<th>Moving Object Tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Flicking</td>
<td>Up</td>
</tr>
<tr>
<td>ΔT [CH 41]</td>
<td></td>
<td>Down</td>
</tr>
<tr>
<td>p-p [CH 41]</td>
<td></td>
<td>Up</td>
</tr>
<tr>
<td>Slope [CH 41]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D. Complete Table 10.4 with Segment 3 data. (Note: You may not have seven saccades per line.)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>First Line</th>
<th>Second Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of saccades</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of saccade:</td>
<td>#1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#7</td>
<td></td>
</tr>
<tr>
<td>Total duration of saccades/line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total reading time/line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% time of saccades/total reading time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

II. Questions

E. Refer to Table 10.1 data and compare duration (T), relative changes in eye position (Δ), and speed of eye movement (slope) of flicking and tracking movements.

F. What is the stimulus for reflex flicking movements?

G. Refer to Table 10.3 data and compare duration (T), relative changes in eye position (Δ), and speed of eye movement (slope) of flicking and tracking movements.
H. Refer to Table 10.3 data and compare your results with at least three others in your class. What is the range of variation in % time of saccades per line?

I. Describe three types of involuntary movements during fixation on a stationary object.

J. Explain how an electrooculogram is recorded.

K. Define visual field.

L. Define saccade.

End of Lesson 10 Data Report
Saccadic movements jump from place to place.

Alas, poor Yorick, I knew him well.

What do these three things have in common?
Two young lovers whose eyes meet across a crowded room.
A Michael Crichton novel.
The final scene of Casablanca.