Today's topics:

- **Eye movements in reading**
- **Extracting visual information from text**

Background:

- Rayner, Pollatsek, Ashby, & Clifton (2012), Ch 4, "The work of the eyes"

0. Key points today

- Eye movement patterns
  - fixation, saccade, regression
- Fixation duration
  - What this tells us about cognitive processes
- Some methodologies and their results
  - What/how “preview” information is used

1. Basics of vision and eye movement

Eye movement patterns during reading:

- **Fixation**
- **Saccade** [səkɑd]
- **Regression**
- **Return sweep**

1. Basics of vision and eye movement

Eye movement patterns during reading:

- **Fixation** — 150-500 ms
  - eyes are close to immobile
  - **all** visual information extracted during fixations
- **Saccade** [səkɑd] — 20-35 ms
  - rapid movement (ballistic — “launched”)
  - eyes move about **7-9** character spaces (regardless of text size, if non-extreme)
  - 4-5 saccades per second

1. Basics of vision and eye movement

Eye movement patterns during reading:

- **Regression** (regressive saccade; moves backward)
  - about 10-15% of saccades
  - about 1 regression every 2 sec
  - reader unaware of most regressions
- **Return sweep** — eyes move to start of new line
  - starts 5-7 characters before end of line
  - lands 3-7 characters after beginning of line
  - may be followed by short regression (correction?)

1. Basics of vision and eye movement

- Real-time eye-tracking video (YouTube)
- Eye-tracking data: Fig 4.1, p 94
  - Fixations and fixation duration are marked
  - Saccades between fixations
  - Can you find a regression?
  - Most words have one fixation — can you find exceptions?
    - Skipped words
    - Words with multiple fixations

1. Basics of vision and eye movement

- **Oral reading** is a little different
  - Fixations last about 50 ms longer
  - Saccades are shorter
  - There are more regressions
  - Why?

1. Basics of vision and eye movement

- **Oral reading** is a little different
  - Fixations last about 50 ms longer
  - Saccades are shorter
  - There are more regressions

  - Why?
    Differences seem to be related to preventing eyes from getting too far ahead of voice
    - Eyes typically about 2 words ahead of voice (skilled adult readers)

1. Basics of vision and eye movement

- **Fovea**
  - Where is this visual region?
  - What kind of processing happens here?
- **Parafovea**
  - Where is this visual region?
  - What kind of processing happens here?
- **Periphery**
  - Where is this visual region?

1. Basics of vision and eye movement

(p 108; see also Ch 1, p 9 in same book)

- **Fovea**
  - 2 degrees around fixation point (central 7 letters)
  - Best for processing **detail**
- **Parafovea**
  - 5 degrees (~15 letters) each side of foveal region
  - Reading with only parafoveal vision very slow
    - 12 words/min, vs. about 330 words/min (foveal)
- **Periphery**
  - The rest of the visual field

2. Measuring processing time

- Why are reading researchers interested in measuring **fixation duration** and **saccades**?

2. Measuring processing time

- Why are reading researchers interested in measuring **fixation duration** and **saccades**?
  - "Since virtually all the information is extracted during the fixations, the interest in fixations is on how their **duration** reflects the **processing of information** during the fixation."
  - "Since saccades exist to move the eyes to another fixation, the interest in saccades is the extent to which the **direction** and **size** of the saccade reflect what is being processed."

(Rayner et al. 2011: 100)

2. Measuring processing time

- Fixation duration reflects **processing** duration
  - Measuring fixation duration provides information about **information processing** during reading
    → What is information processing?

2. Measuring processing time

- Supplementary discussion: What is meant by (language/reading) **processing**?
  - Basically: The route from receiving a **stimulus** (spoken or written) to comprehending the **message**
  - Some important steps in this process:
    - **Identifying** the **categories** (sound and/or letter) that the stimulus is composed of
    - **Word recognition**: **Activating** the appropriate **entry** in the mental lexicon
    - **Syntax** and **meaning** processing
  - These steps may overlap/interact

2. Measuring processing time

- What does it mean to **activate** a **lexical entry**? Quick overview:
  - When an incoming stimulus matches a lexical entry, that entry gets **activated** (metaphor: it "lights up") to some degree
  - This matching can involve sound category (phoneme), letter category, meaning, etc.
  - Lexical entries can also activate and suppress each other
  - When a lexical entry reaches a certain activation **threshold**, it is "recognized"

2. Measuring processing time

- So, fixation duration in reading might be affected by any of these factors:
  - How long it takes to visually **identify** the letter categories in the stimulus
  - How long it takes to **activate** a lexical entry (“recognize a word”)
  - How long it takes to **incorporate** new information into the structure and/or meaning that has already been processed

2. Measuring processing time

- How to **measure** **fixation duration** on a word?
  - What are some of the ways considered in the reading?
  - See Fig 4.1 and the measurement examples discussed there

2. Measuring processing time

- How to **measure fixation duration** on a word?
  - Duration of **first fixation**
  - **Gaze duration** (time on word before eyes move ahead)
    - May include multiple fixations
    - Does not include regressions to earlier words
  - **Total viewing time**
    - May include multiple fixations
    - Includes later regressions back to same word
  - **Go-past time** (also called **regression path duration**)
    - Total time after fixating on word until eyes move past
    - Includes duration of regressions to earlier words

3. Perceptual span

- How much text information can be taken in during one fixation?
  - The chapter talks a lot about how this has been determined experimentally
  - Our discussion will focus on how it works / how it matters in reading

3. Perceptual span

- “Mutilated text” methodology
  - How does this work? (Relevance of “window”?)

3. Perceptual span

- “Mutilated text” methodology
  - Eye-tracker senses where reader is fixating
  - Software turns text to Xs or letters outside a “window” around fixation point
  - Researchers manipulate **window size** and **mutilation type**
  - What does this methdology show us?

3. Perceptual span

- "Mutilated text" methodology
  - Eye-tracker senses where reader is fixating
  - Software turns text to Xs or letters outside a "window" around fixation point
  - Researchers manipulate **window size** and **mutilation type**
  - If a certain window size **impairs** reading, then information **outside** the window is normally used during a fixation

3. Perceptual span

- Size and direction of perceptual span
  - What can you remember about this?

3. Perceptual span

- Size and direction of perceptual span
  - Right side matters more than left (for English)
    - But: reading is slower w/o beginning of word
  - Window **14-15 characters** to R of fixation point: Normal reading speed, comprehension
    - What **visual region(s)** are involved?
  - Smaller windows: Normal comprehension but reduced speed
  - Very small window (size = 1, one letter at a time): Comprehension affected

3. Perceptual span

- Size of perceptual span
  - Beginning readers and dyslexic readers have a **smaller** visual span for reading than non-dyslexic, practiced readers

3. Perceptual span

- What kind of info is used at what distance from fixation point? ("mutilated text" methodology)
  - Info about **spaces** between words is useful out to about 15 characters to the right of fixation
    - May help plan saccades
  - **Letter shape** information (similar ascenders/ descenders) is useful out to about 10 characters to the right of fixation
    - Readers are only *consciously* aware of letter shape info *within* the word being fixated

4. Information from preview

- A closer look:

  What information is a reader getting from those ~15 characters to the right of the fixation point?

4. Information from preview

- Newer methodology: the **boundary technique**
  - How does this work?
    (Relevance of the “CWL = critical word location”?)

4. Information from preview

- Newer methodology: the **boundary technique**
  - **CWL** = critical word location
    - Point being tested for info availability when **previewed** on fixation to left
  - CWL has certain content as gaze approaches
  - When a saccade crosses a specified **boundary**, content in the CWL is **changed**
  - Does this switch **affect CWL fixation duration**?
    - If yes, relevant info was available from the CWL at distance of prior fixation

4. Information from preview

- Boundary-technique findings

Distance, **prior fixation → CWL**	**Type of information** **with an effect**
>12 character spaces	
7-12 character spaces	
6 character spaces	

  - Find this information in **Fig 4.6**? (data graphic)
    - ***parse*** *graphic* — Axes? Symbols? Conditions?
    - ***interpret*** *graphic* — What "story" do we see?

4. Information from preview

- Boundary-technique findings

Distance, prior fixation → CWL	**Type of information with an effect**
>12 character spaces	No effect
7-12 character spaces	• Shape of word • Shapes of letters • First or last letter matches
6 character spaces	• CWL is word/nonword

4. Information from preview

- **Preview benefit**: When readers preview a word before fixating on it, they then fixate on the previewed word for a shorter time
  - Mostly affects word *n*+1
  - Partial information about word can be gained, then integrated when that word in turn is fixated
- Sometimes words are even **skipped** = identified during fixation on the previous word (or predicted)
  - Most often short words, function words

4. Information from preview

- What kind of information is **activated** during parafoveal preview, such that it helps facilitate **processing** when the previewed word is fixated?
  - This information seems to be based on **orthographic similarity**
    - word/letter shape
    - matching first/last letters
  - But: what kind of information is it?

5. How does preview help word recognition?

- What word info is (partially) activated in parafoveal preview? Authors consider 5 possibilities:
  1. Purely visual information about letter shapes
  2. Semantic (meaning) information
  3. Sound codes (phonemes, syllables)
  4. Orthographic codes (letter forms, not shapes)
  5. Lexical entry of word partly activated

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       - What do we conclude?

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    → Hypothesis rejected

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- What word info is (partially) activated in parafoveal preview? Authors consider 5 possibilities:

  2 Semantic (meaning) information

  - No evidence for semantic priming

    semantic priming: you see/hear a *semantically related* word (related by meaning) first, and it makes you respond to the target word faster

    - What do we conclude?

5. How does preview help word recognition?

- What word info is (partially) activated in parafoveal preview? Authors consider 5 possibilities:

~~2. Semantic (meaning) information~~

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  5 **Lexical entry** of word partly activated

  - Comments? Do the authors think any of these are likely to be involved?

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  5 **Lexical entry** of word partly activated

  - According to authors, these three are plausible
    - They likely interact
  - We will investigate some of these in other studies

6. For next time

- We will look at some ways of assessing reading and non-reading skills

- We will preview the article presentation assignment, especially the process of choosing articles / forming presentation groups