Written Language Perception

LIGN 170, Lecture 3

Written language systems

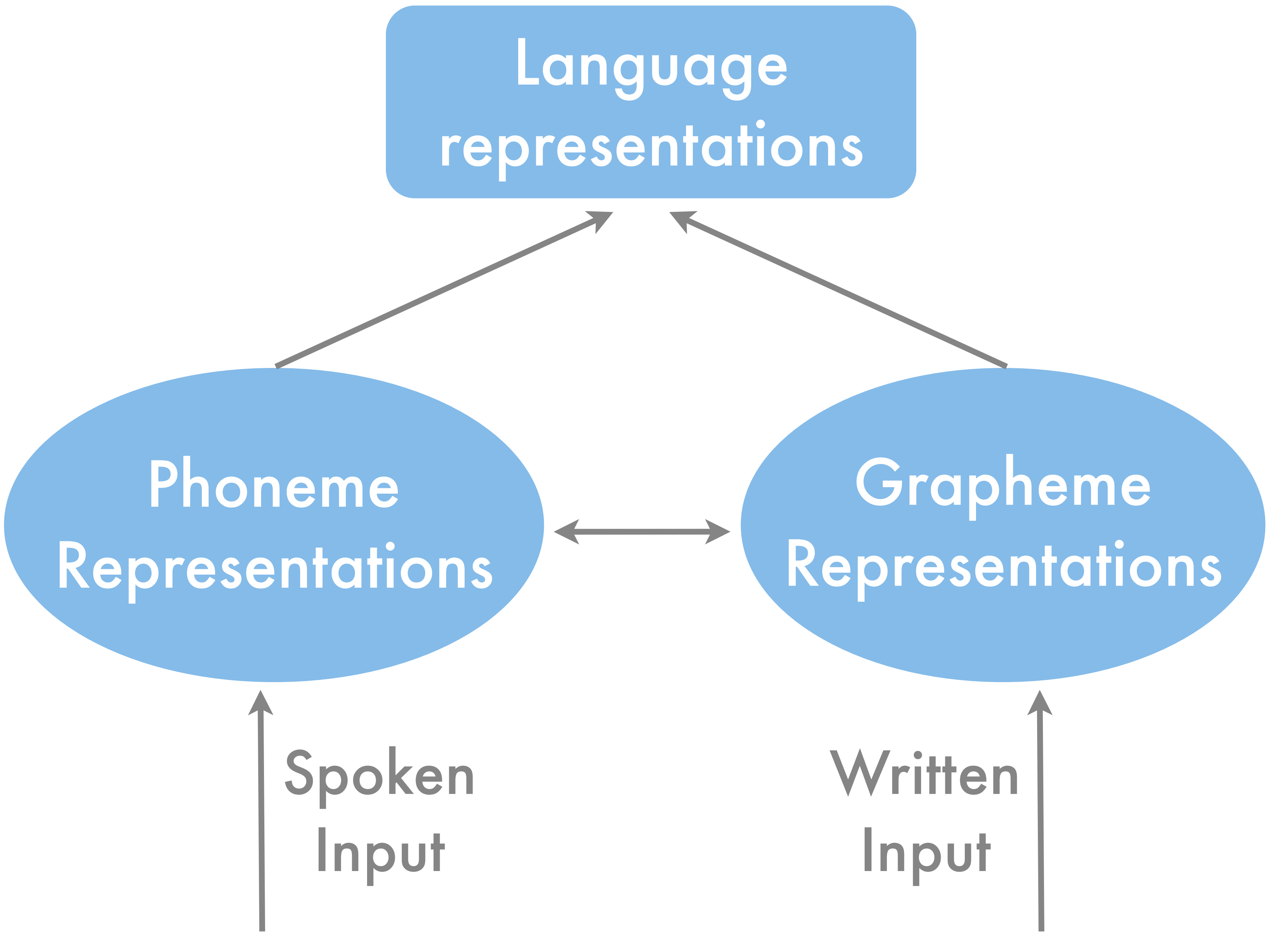
- Logograph systems (e.g. Chinese)
  - Characters represent entire words
- Syllabaries (e.g. Kana in Japanese)
  - Characters represent syllables
- Alphabets (e.g. English)
  - Characters represent phonemes

Alphabets

- Havelock (1976)
  - Each phoneme must be represented in the writing system
  - Unambiguous one-to-one grapheme-phoneme correspondence (ideally)
  - Total number of graphemes should be relatively limited (20-30 is ideal)

English

- One to one correspondence?
  - Many graphemes for one phoneme:
    - /k/: cat, kettle
  - Many phonemes for one grapheme:
    - daughter, laughter
    - cough, through, bough, tough
  - Many to many correspondence!


Language representations
Phoneme Representations
Grapheme Representations
Spoken Input
Written Input

Early stages of visual processing

- Much like auditory processing:
- Feature level – physical features of the letter
- Letter level – identity separate from its physical manifestation
  - F f F f F f F f F f F f
- Word level – putting features/letters together into a word

Letters in isolation

- Present letters for 50 ms, ask for identity
  - Some features perceived, but not all
  - E confused for F, R for P
  - So, features are useful and very quickly used

- Find “Z” in a chunk of letters like “ODGQR” vs. “IVMXEW”
- Faster when Z is embedded with letters with unlike features

Word-superiority effect

- Word vs. Non-word: *word* vs. *owrd*
  - Shown for 50 ms
  - Subjects asked for specific letter (say, last letter was *d* or *k*?)
    - Accuracy best with word
    - We process letters best when in context of words – top-down effect

Basics of eye movements

- During reading
  - Saccades: rapid eye movements
    - Saccadic suppression: No visual input processed during saccades
    - Typical saccades during reading last around 30msec (2° movements)
    - Each saccade takes 150-175 msec of program

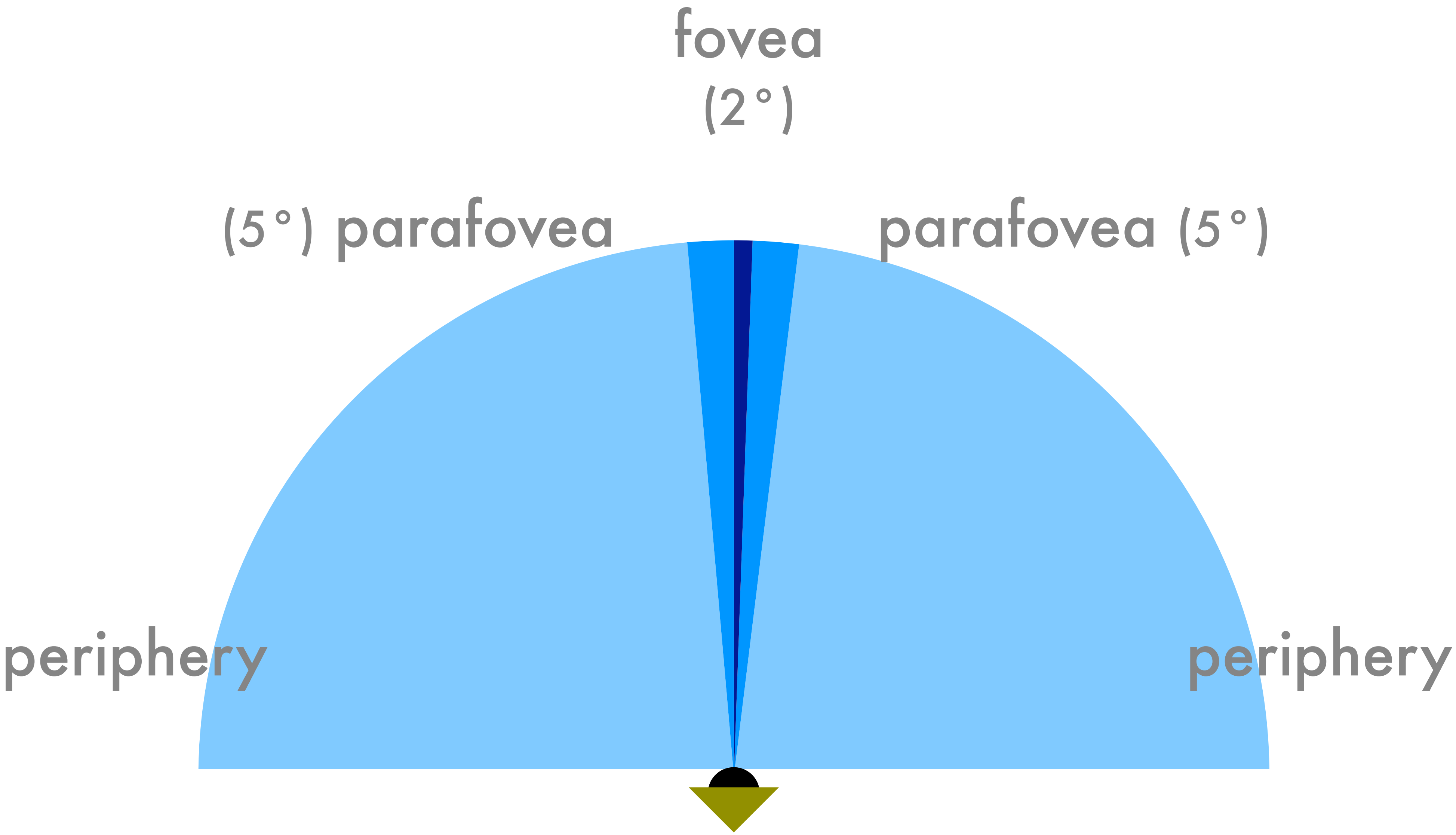
Other eye movements

- Saccades are different from other eye movements
  - Smooth pursuit (tracking a moving object)
  - Vergence (moving inward to fixate on a close object)
  - Vestibular (rotation to maintain same direction of visual during head/body movement)

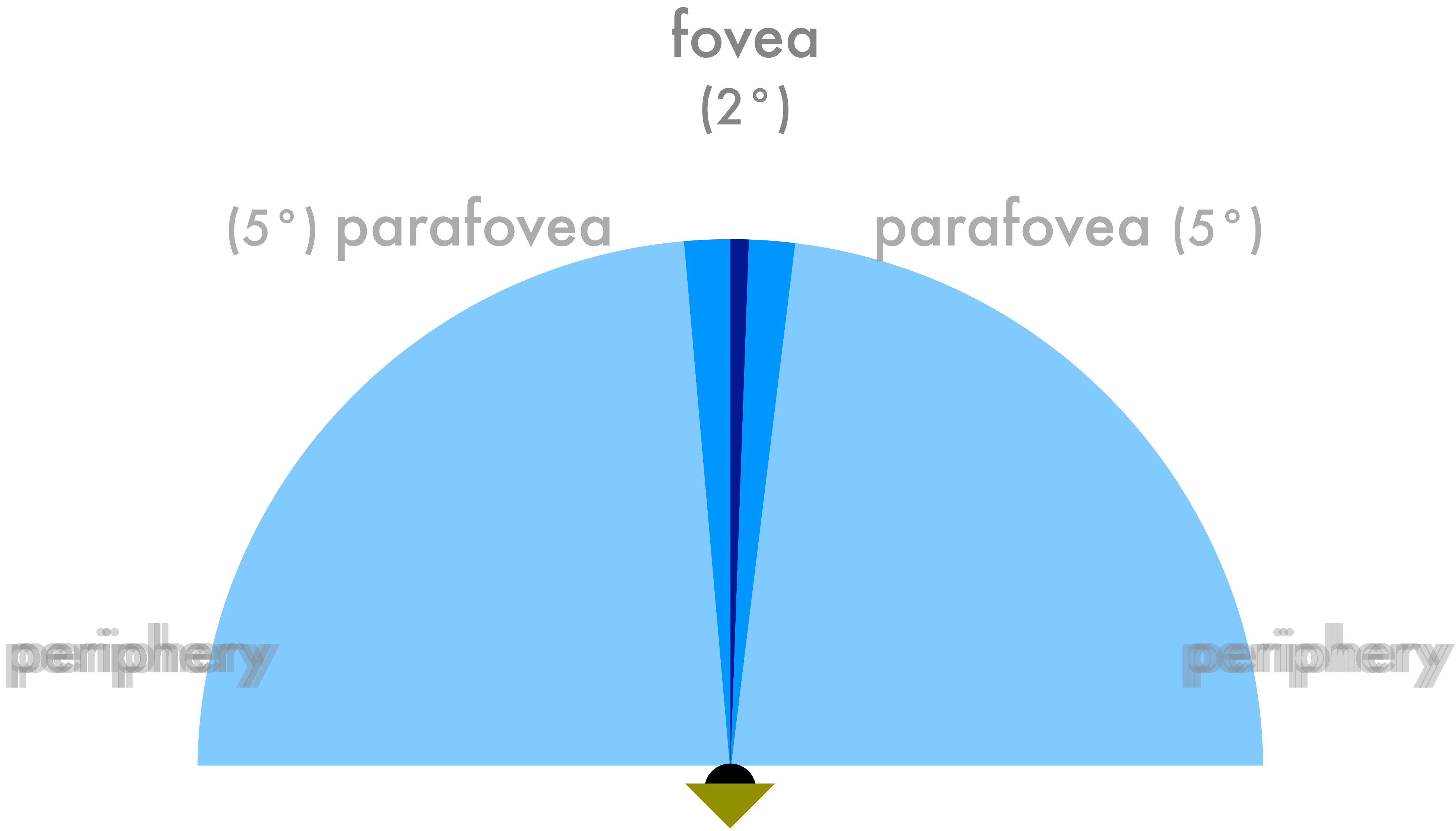
Fixations

- Fixations
  - When the eyes remain (relatively) still
    - Relatively?
      - Nystagmus
      - Drifts & Microsaccades
  - Visual information is taken in during fixations

What can we see?

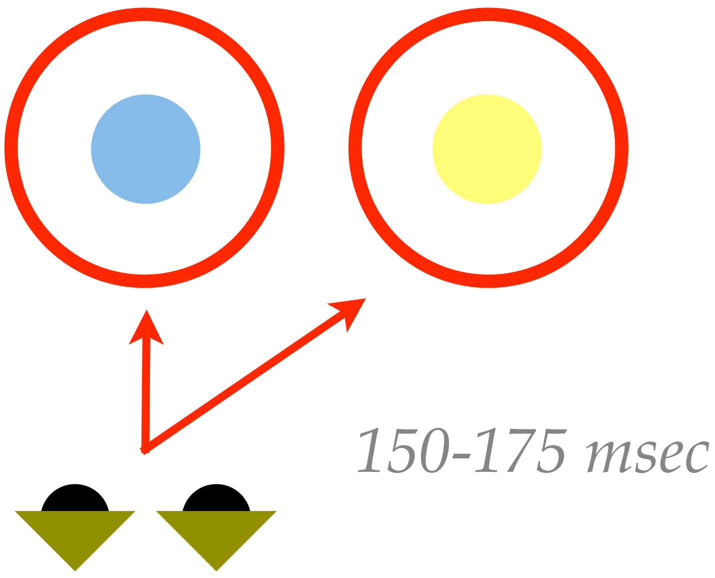


What can we see?

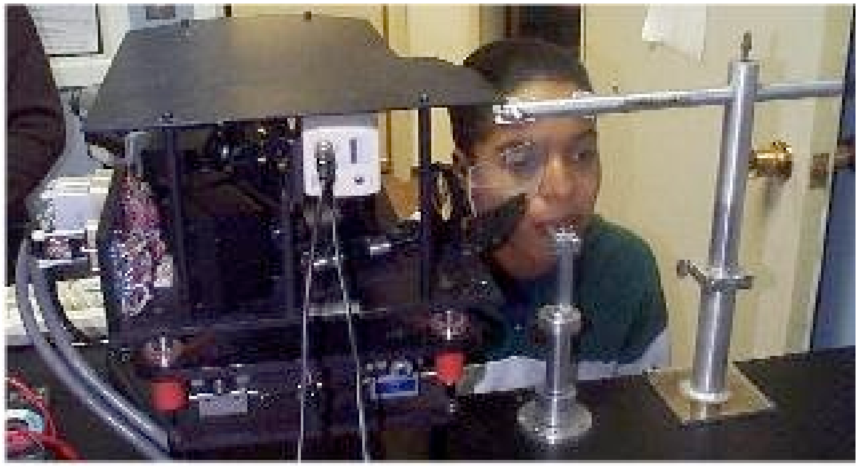


Fixation & attention

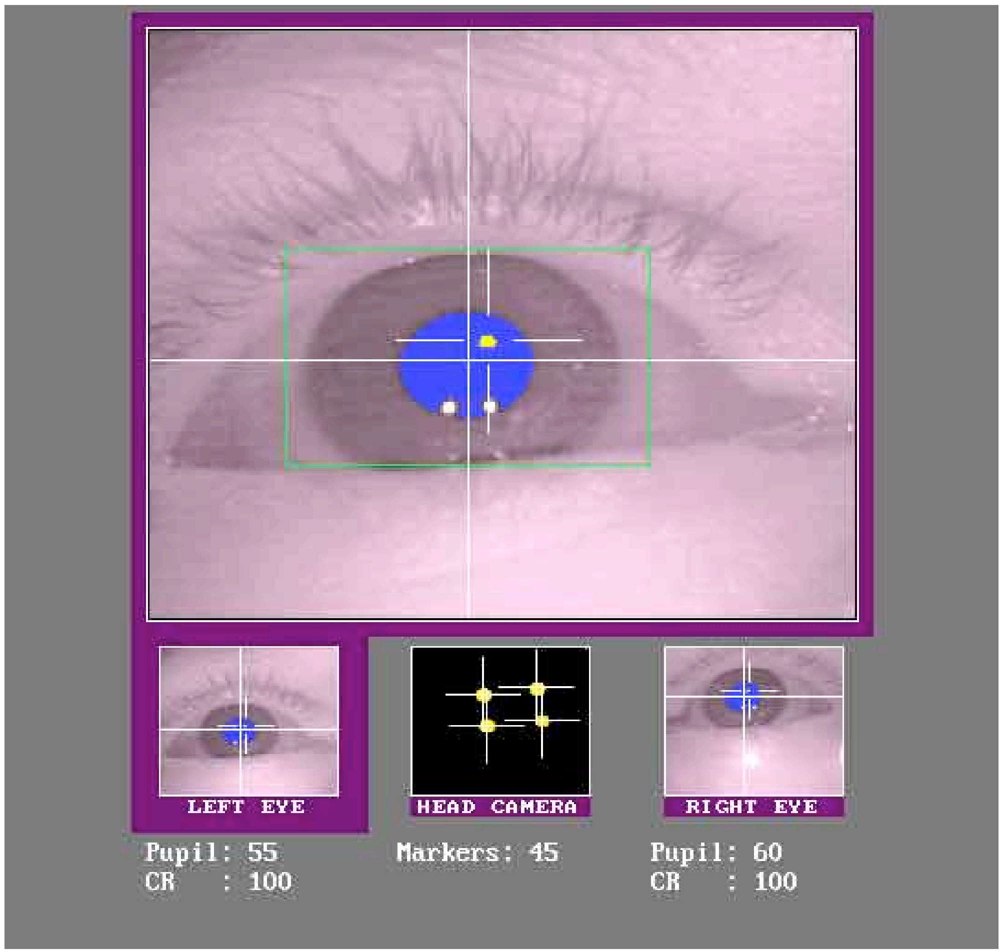
- Under normal circumstances:
  - We look at what we are paying attention to
  - We shift attention ahead of eye gaze

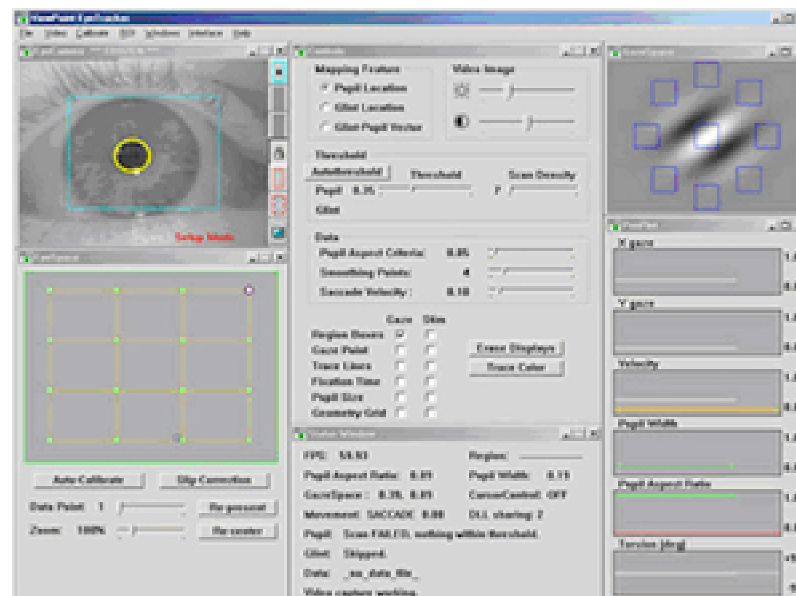


Eye-tracking methods



Eye-tracking methods





Silent reading

- On average in English:
  - Fixations last 200-250 milliseconds
    - But lots of variation (even within person)
      - under 100 to over 500!
  - Saccades are 7-9 character spaces
    - range 1-15 (over 15 rare, but when people go return to where they regressed from)

Silent reading

- Not every word is fixated
  - Content words: fixated 85% of the time
  - Function words: fixated 25% of the time
    - Shorter than content words
    - 5 letters: 25% of time
    - 8+ letters nearly 100%
  - Regressions back to previous text 10-15% of time

Designing experiments

- What kinds of information gets processed, and when?
  - Perceptual span
    - How far away from the fixation do we collect information?
    - What kind of information is relevant?

Perceptual Span

- Moving Window Technique (McConkie & Rayner, 1975)

- Logic: if critical information is missing - and *noticed* as missing - then eye movement should be disrupted (or at least different from when information is present)

- Normal Text:

```
The quick brown fox jumped over
```

- Moving Window:

```
XXXXXXXXXXXXXXwn fox jumpeXXXXXX

XXX XXXXX XXXwn fox jumpeX XXXX

Pko jnarb knuwn fox jumpeh awoc
```

- More fun with moving windows

```
Pko jnarb knuwn fox jumpeh awoc
              4   ↑   7

Pko jnarb knuwn fox jumped ovoc
              4   ↑   11

Pko jnarb brown fox jumped ovoc
              7   ↑   11
```

Perceptual Span

- Moving Window Technique (McConkie & Rayner, 1975)

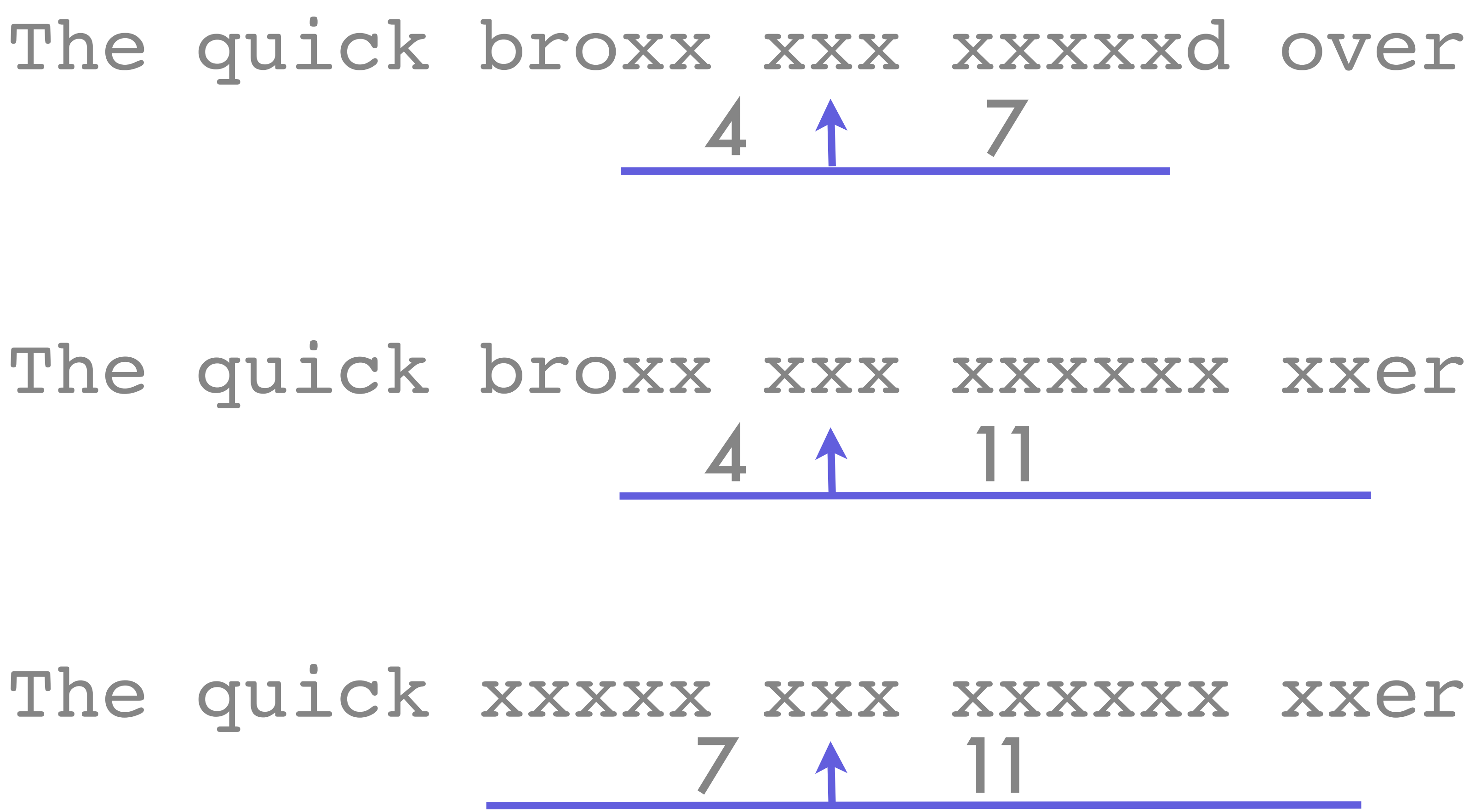
- How big does the window need to be before it doesn't affect eye movements during reading?
- Does it matter what information gets masked?

- When window equals region that the reader can get information from -
  - there will be no difference between reading with and without the window

- This will tell us what kinds of information can be extracted from the visual information, and at what point

- Moving Mask Technique (Rayner & Bertera, 1979)
- Normal Text:
- `The quick brown fox jumped over`
- Moving Mask:
- `The quick broXXXXXXXXXXXed over`

- More fun with moving masks



- How small does the mask need to be before people can figure out what the text says?

- Boundary Technique (Rayner, 1975)
- Pre-boundary text:
- `The quick brown fox jumped over`
- Post-boundary text:
- `The quick brown dog jumped over`

invisible boundary

- What these fiendish methods show us:
  - Perceptual span is relatively small
  - Span is also asymmetric
  - Alphabetic languages:
    - The quick brown dog

3-4 ↑ 14-15

- What these fiendish methods show us:
  - Perceptual span is relatively small
  - Span is also asymmetic

  - Asymmetry reverses for right-left languages (e.g. Hebrew)
    - האכלעוו האקסום האמאהיר

14-15 ↑ 3-4

- What about non-alphabetic languages?
- Japanese
  - 13 character spaces (6 to the right)
- Chinese
  - 1 character to the left, 3 to the right

- Perceptual Span
  - Gets smaller with difficulty
  - Children:
    - With age appropriate material, 4th graders have adult-like span
    - With college-level material, span shrinks

- What information is attended to in the span to the right of the fixation?
  - Partial word information
    - The first three letters of the next word appear to be important
  - But shape information is also detected
    - XXXX vs. visually similar words

- Word length information
    - If the word in the right is short,
        - Longer fixations time followed by longer saccade to skip short word
        - ... found the pencil ...
- Suggests lexical processing possible from information in the parafovea

- Big Picture of eye movements during reading
  - Eyes do not move smoothly across text
    - Fixations and saccades
  - Information is taken in from upcoming words (first few characters)
  - Eyes move back to previous text 10-15% of the time

Sentence contexts

- Lima & Inhoff (1985)
  - The boy hoped to see several
- Few similar words: **dwa**rves
- Many similar words: **clo**wns
  - Bigger benefit for *dwarves* because limits possible words?

The boy hoped to see several …

- No preview difference at “several”
- However, fixation time for “clown” faster
  - Frequency of word-initial letters aids processing
- Follow-up study found preview benefit for high-frequency words compared to low
  - The boy wanted a viola / piano.

Predictability

- Balota et al. (1985)
  - Predictable words more likely to be skipped than unpredictable
  - When fixated, times were shorter for predictable words

Processing difficulty

- Henderson & Ferreira (1990)
  - Boundary technique
  - Target: High vs. low frequency
  - Parafovea: Same, similar, dissimilar

High Frequency: Control

Mary bought a chest despite the high price.

Mary bought a chest despite the high price.

High Frequency: Similar

Mary bought a chest desquila the high price.

Mary bought a chest despite the high price.

High Frequency: Dissimilar

Mary bought a chest zqdloyv the high price.

Mary bought a chest despite the high price.

Low Frequency: Control - Similar - Dissimilar

zqdloyv
Mary bought a trunk despite the high price.
desquila

Mary bought a trunk despite the high price.

- Results:
  - Frequency effects at target
    - chest vs. trunk
  - High Frequency - Preview benefit
  - Low Frequency - No Preview benefit

Mary bought a chest desquila the high price.

Mary bought a trunk desquila the high price.

Mary bought a chest despite the high price.

Increased difficulty leads to less attention paid to the right parafovea

Written language

- Skilled readers process some information from upcoming text
  - Letter shape in far parafovea
  - Lexical processing in near parafovea
- Limited attentional resources
  - Processing burden at fovea affects parafoveal processing