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Seeing and Responding to Signals

Fundamentals

Introduction to Signal Sighting

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- Why is signal sighting important?
- Mental processes involved in reading and responding to a signal
- Physics of the eye
- Human Factors considerations – sources of error.
- Good practice

Why is signal sighting important?

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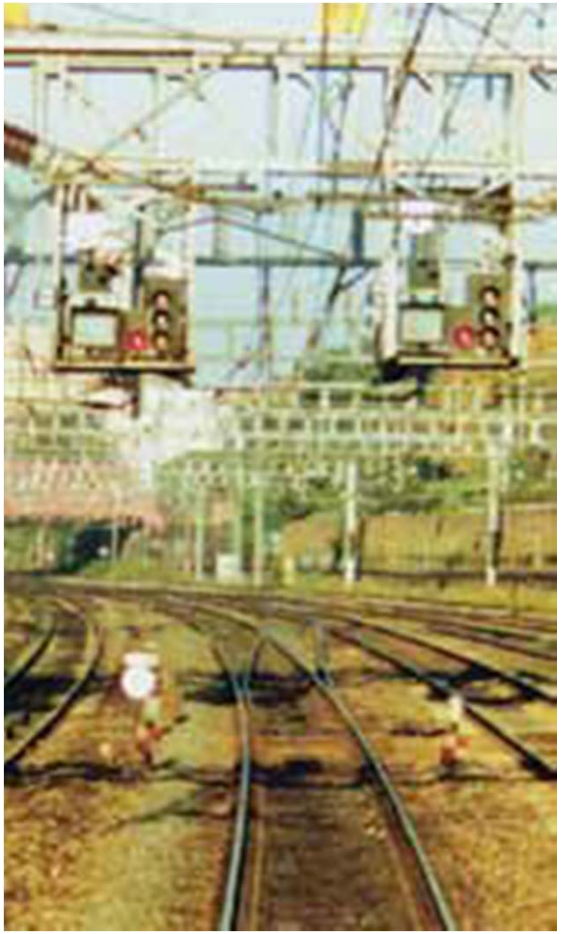
- Drivers reliably see signal in nearly all cases
  - Approximately 1 “stop” signal in 10,000 passed at danger (SPAD)
  - For an individual driver, corresponds to 1 in 17 years
  - **1 – 6% of these involve failure to respond to a signal**.
  - This presentation is about reducing that 1 in 1 million to a smaller number
  - This presentation does not address directly fatigue, drugs, driver health, etc.
- Consequence of getting it wrong
  - Ladbroke Grove (UK - 5 October 1999)
  - Driver passed signal at speed
  - Collision caused 31 deaths



Mental Processes

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Vigilance	**Signal sighting is a vigilance task that requires sustained levels of attention and alertness.**
Detection	**Visible features of a signal are detected in the environment.**
Recognition	**Signal perception – the signal's form is identified and discriminated from surrounding objects** **Association with line – signal is recognised as appropriate for the driver's route.**
Interpretation	**Signal aspect is read and appropriate response is chosen**
Action	**Driver responds to the signal**

Physics of the eye

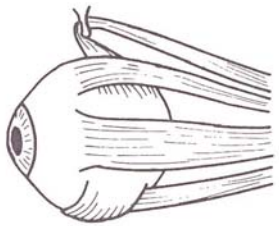


Fig. 2.1(a). The eye and the extra-ocular muscles used to move it.

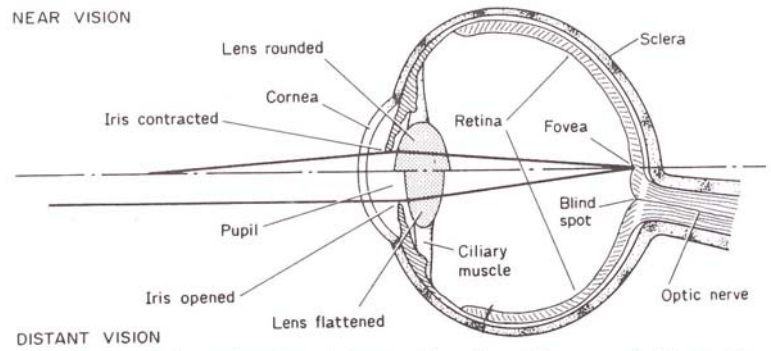


Fig. 2.1(b). A vertical section through the eye when adjusted for near and distant vision.

- **Retina** – detecting part of the eye. Contains "rod" and "cone" cells. Also "blind spot".
- **Fovea** – Within 1° of centre. Only part which can detect colour and detail (cones).
- **Central vision** – within 5-8° of centre. Optimised for detecting change. Highest density of rods.

Digital view of the eye

- Only cone cells detect colour
- 120 cone cells across 1 degree of arc – 1 cone cell per ½ minute of arc
- 5 minutes arc needed to resolve 2 objects reliably
  - 1.2m at 800m

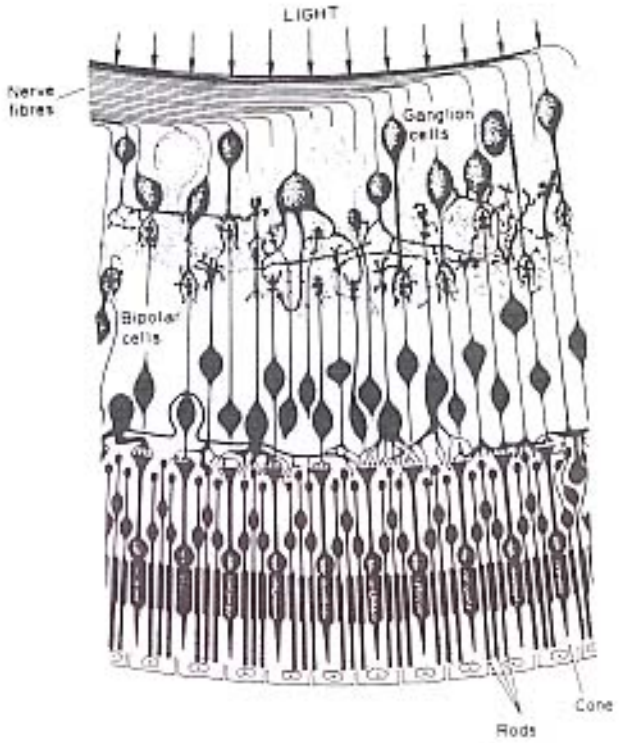
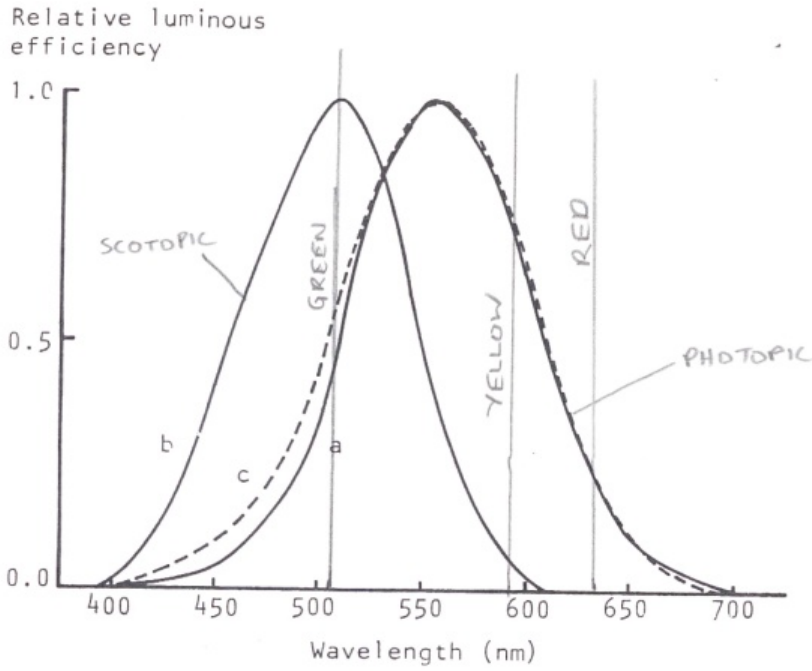


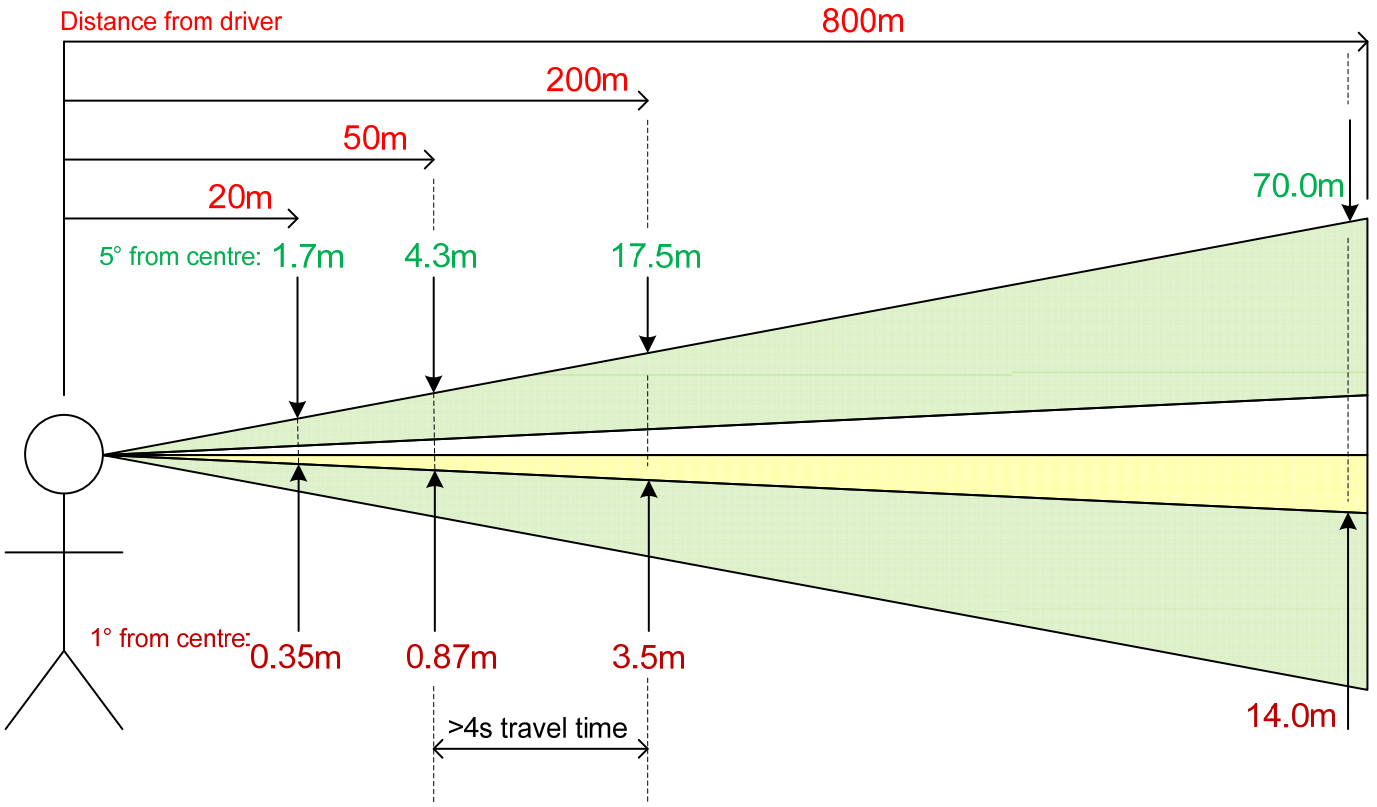
Fig. 2.2. A schematic illustration of the retinal structure.

Detection of colour

- Photopic (colour) vision – cone cells only
  - Reliable detection limit ~1km
- Scotopic (no colour) vision – rod cells
  - Low light conditions
  - Peripheral vision
  - Detects change and movement
  - Sensitive to green
  - Cannot see red



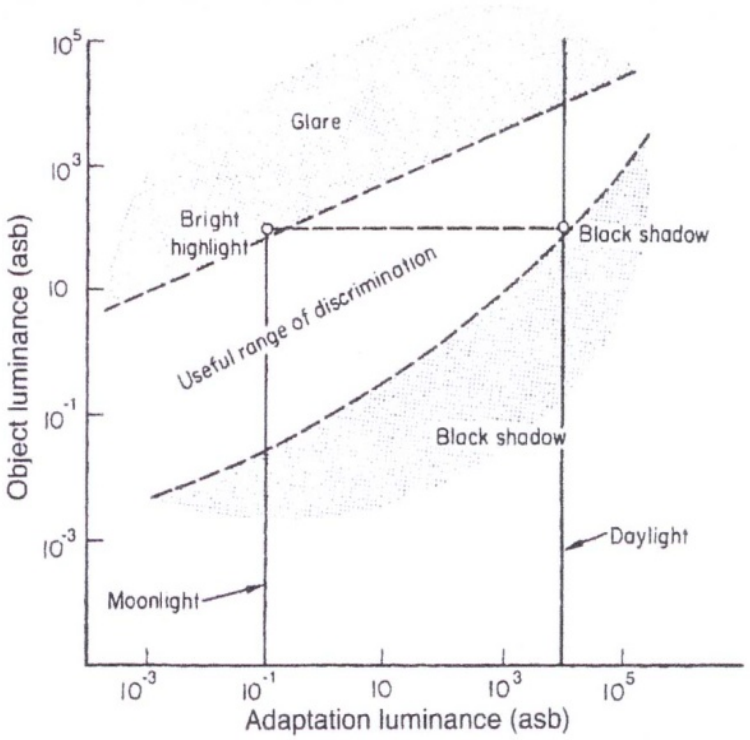
Detection & Recognition



Driver central vision area at various distances

Avoidance of glare

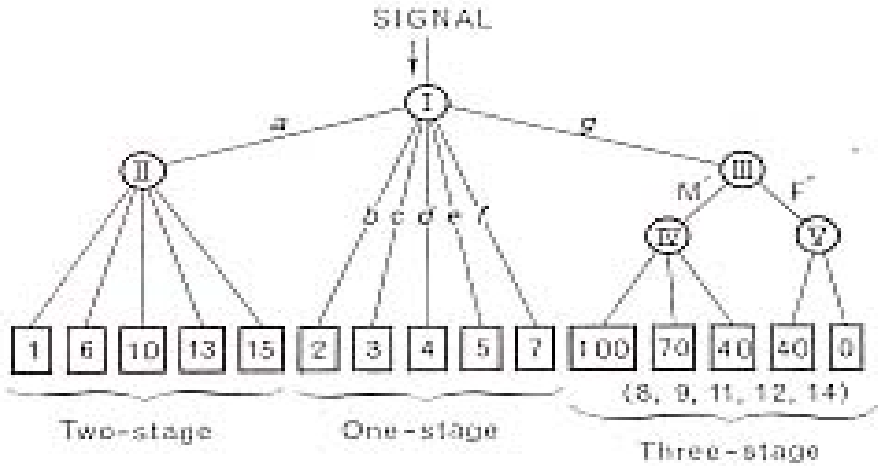
- Eye responds to light levels over 6 orders of magnitude
- 3 orders of magnitude around adaption level
  - Colour not seen (washed out)for bright lights at night
  - Internal contrast ratio between 4:1 and 50:1 for good detection



Detection out of centre

Signal Aspect	Central (0.8°) Detect time (% detected)	Mid side (5.5°) Detect time (% detected)	Outer (18°) Detect time (% detected)
"G"	0.8s (97%)	2.1s (32%)	2.4s (5%)
"R"	0.8s (99%)	2.3s (28%)	3.8s (5%)
"Y"	0.9s (93%)	1.2s (68%)	3.7s (6%)

Interpreting

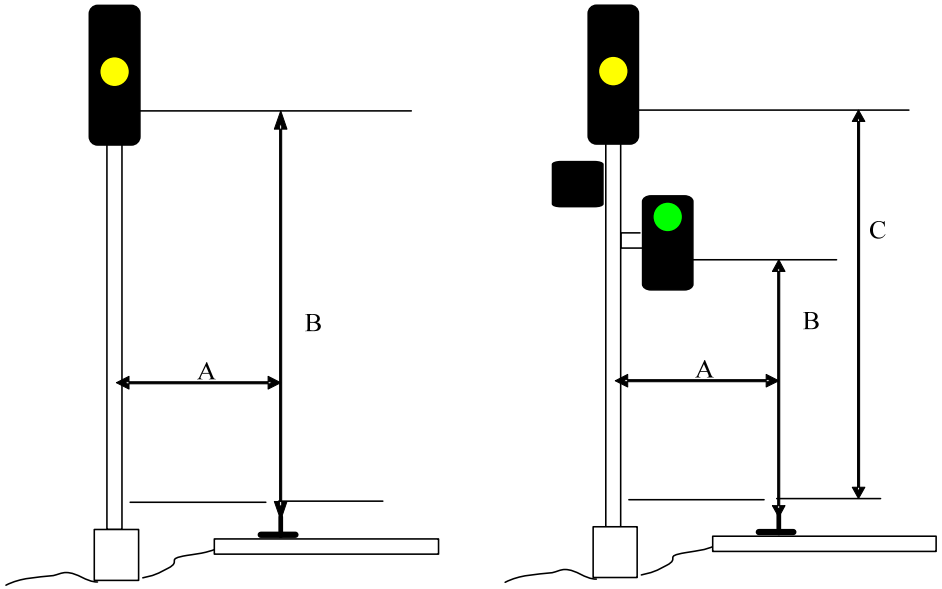


6-11 Information-tree representing system A.

- Time to interpret varies with aspect complexity
- Interpreting “2 stage” signal adds ~1 second
- Accuracy depends on simplicity

Simple and Complex Signals

- Recognition times
  - 1.7 – 2.7s for simple
  - 2.6 – 3.5s for complex
- Error Rate
  - 37% higher for complex
  - Transposition (eg Y/G = G/Y) common



Good Practice

- Signal light at driver's eye level
  - Driver seated = 2.6 – 3.1m for locomotive
  - Signal "in your face" at 50m
  - Red aspect 3 – 5 m above rail
- Signal laterally close to track
- Light intensity
  - Sufficient contrast during day
  - Below "glare" threshold at night
- Good sighting from10s (ideal) approach to signal
  - 20 – 300m at common speeds
  - Limit of viewability ~800m
- Keep aspect sequence simple
  - Avoid complex forms
  - "Less" can be more