

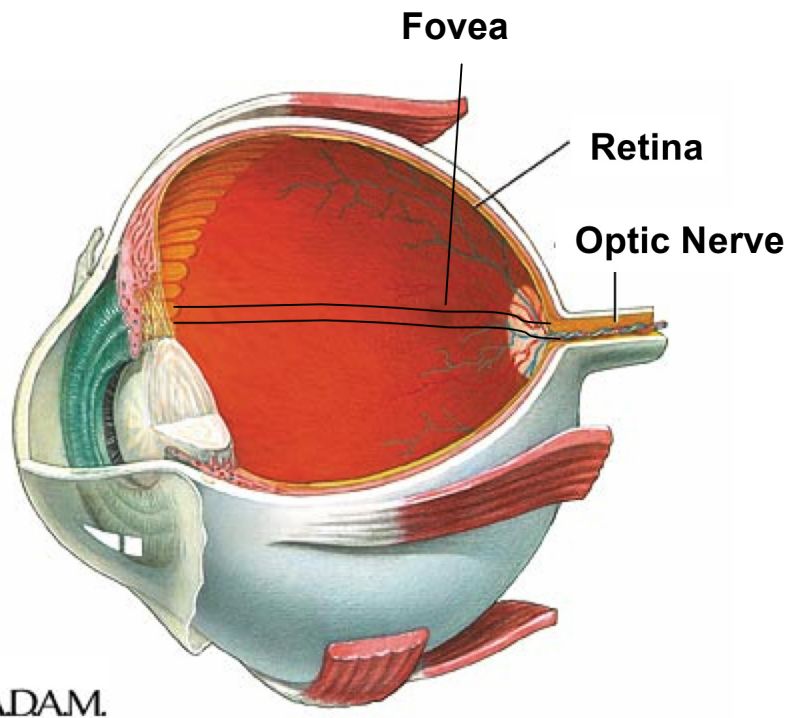
*What are eye movements and how
have they been used in psychology?*

John Trueswell

Some useful books

- Eye Tracking methodology: Theory and Practice, by Andrew T. Duchowski, Springer-Verlog, 2003.
- The Moving Tablet of the Eye: The Origins of Modern Eye Movement Research, by N.J. Wade and B.W. Tatler, Oxford University Press, 2005.
- Eye Movements: A Window on Mind and Brain, Edited by R.P.G van Gompel, M.H. Fischer & W.S. Murray, & R.L. Hill, Elsevier, 2007.

Why are there eye movements?



ADAM.

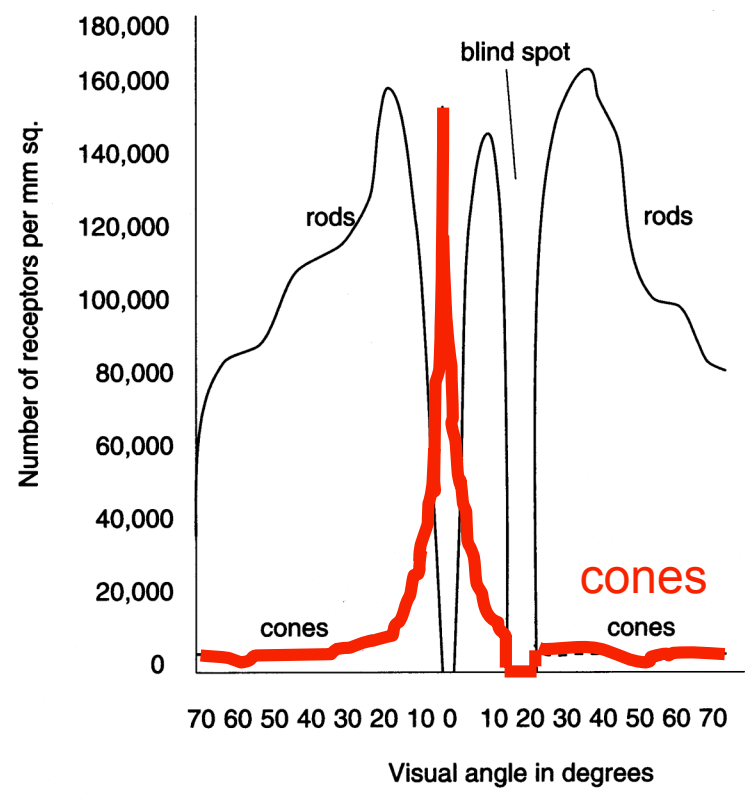


Fig. 3.3. Density distributions of rod and cone receptors across the retinal surface: rod/cone density. Adapted from Pirenne (1967) (as cited in Haber and Hershenson (1973)).

Why study eye movements?

- To follow the observer's path of attention.
 - What draws attention.
 - What was of interest to the observer.
 - How the observer perceived scene.



Yarbus (1967)



But, a person is often more than
just a passive 'observer'.

To which of the following does this scene most likely belong?
Repin's Unexpected Visitor





Yarbus (1967)



1

Examine picture
at will.

Estimate
economic status.

Estimate ages.

Guess what
people were
doing before
arrival of visitor.

Remember
people's clothing.

Remember
position of people
and objects.

Estimate time
since guest's last
visit.

Important implication for what draws our attention:

- Exogenous (stimulus) factors.
 - Parallel saliency maps?
- Endogenous (goal/memory) factors.
 - Parallel relevancy maps?

William James basically had it right.

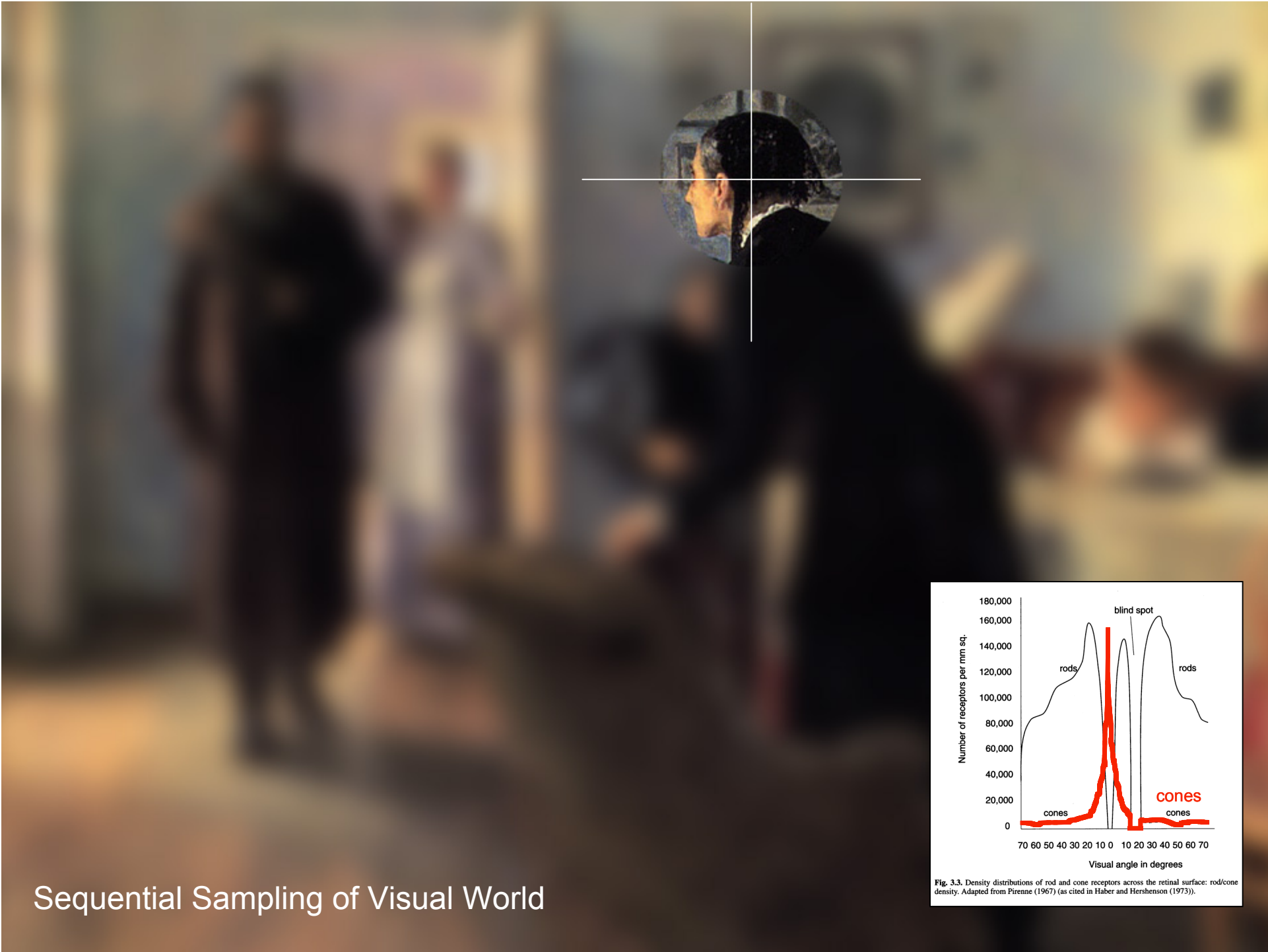
- *Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others.*
 - *William James, Principles of Psychology, 1890*

Under this view, a person is never
a passive viewer...

- So let's ask the question again:
- Why study eye movements?
 - To understand:
 - How people interact with the world.
 - How people *manipulate, interrogate*, visual world to meet their goals.

Isn't the primary goal of a perceiver to get a detailed representation of the scene as a whole?

- Classic passive-viewer answer: *Yes.*
- *Attention allows us to sample the world to build up a detailed internal visual representation of our surroundings.*
 - *Serial sampling of world leads to incremental construction of a detailed image.*



Sequential Sampling of Visual World

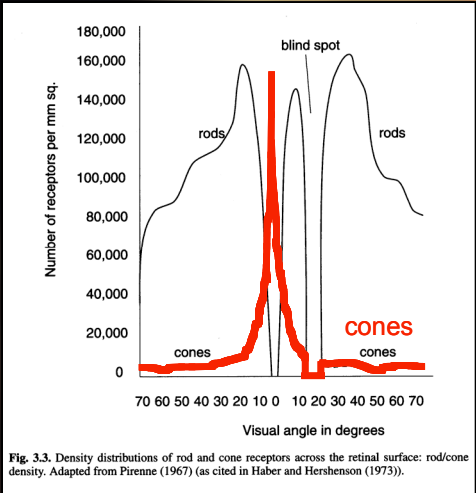
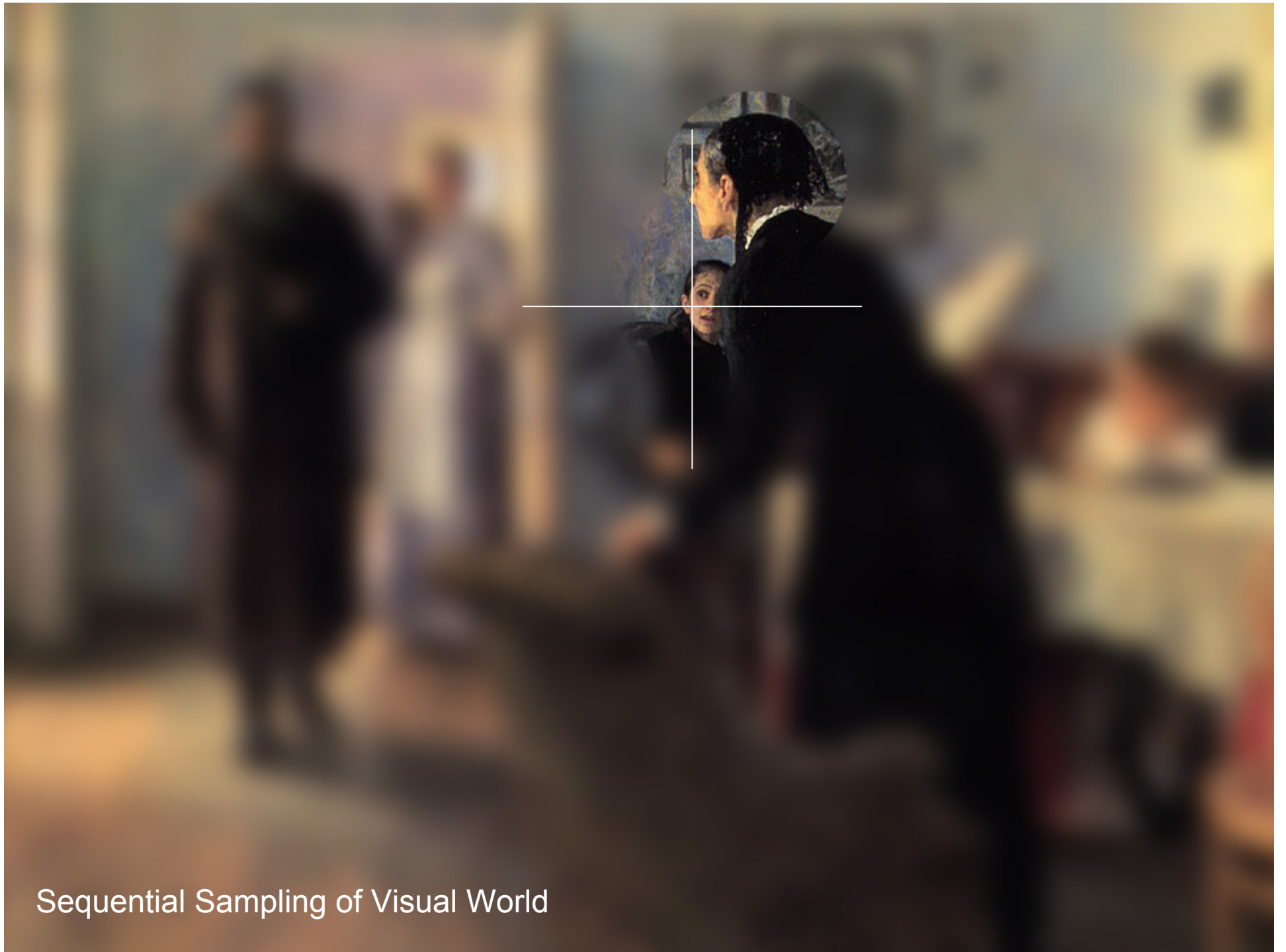


Fig. 3.3. Density distributions of rod and cone receptors across the retinal surface: rod/cone density. Adapted from Pirenne (1967) (as cited in Haber and Hershenson (1973)).



Sequential Sampling of Visual World



Sequential Sampling of Visual World



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Sequential Sampling of Visual World



Sequential Sampling of Visual World

Final Internal Representation



But if a high-quality internal representation is built up, it should be trivial to detect a subsequent change in that image.







Now we'll make it easy to see the change.





One interpretation of 'change blindness'

- People use the visual world as their 'memory for details'.
 - For the most part they only hold the spatial layout of their immediate environment in 'internal' memory.
 - People assume that the properties of most objects do not change suddenly.
- Result is that eye movements serve as dynamic access to this 'external memory'.

Can we find evidence for this
by using eyetracking?

Measuring Eye Movements

- “Barlow photographed a droplet of mercury placed on the limbus.
Translations of the head were minimized by having subjects lie on a stone slab with their heads wedged tightly inside a rigid iron frame”

– Kowler, 1990

Scleral Eyetrackers

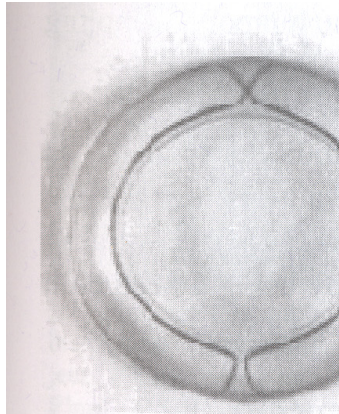
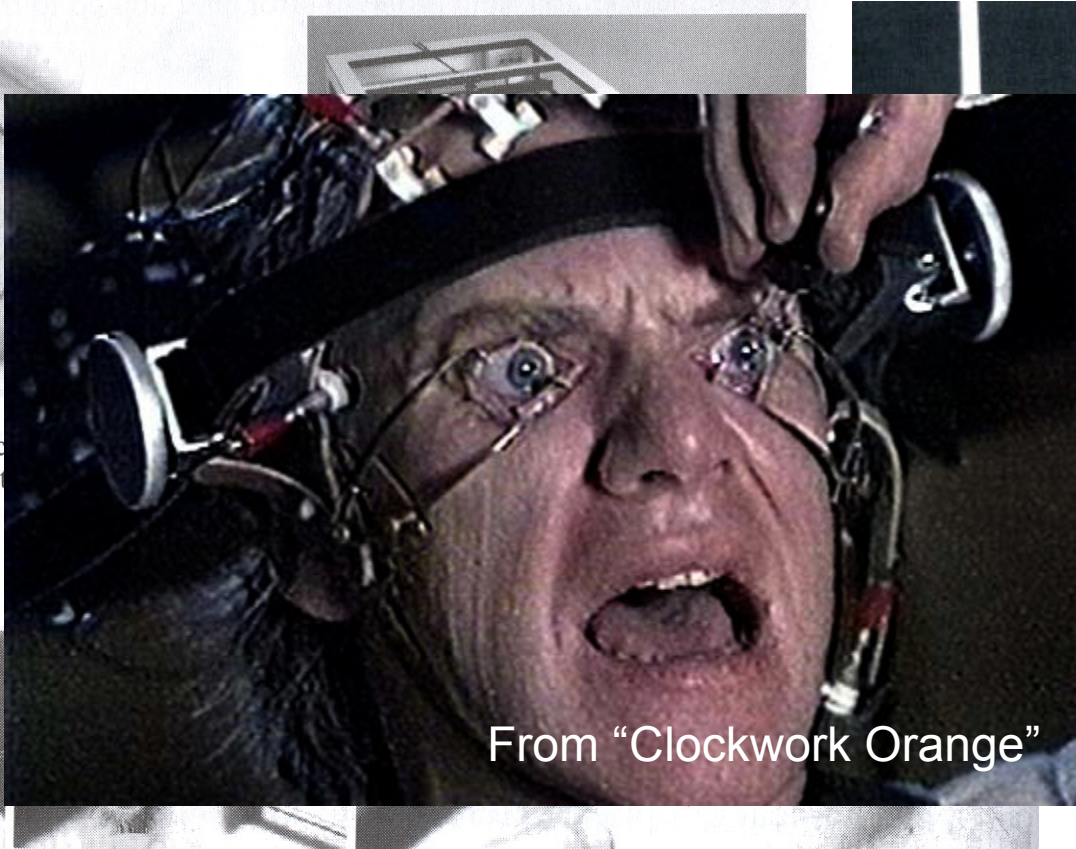


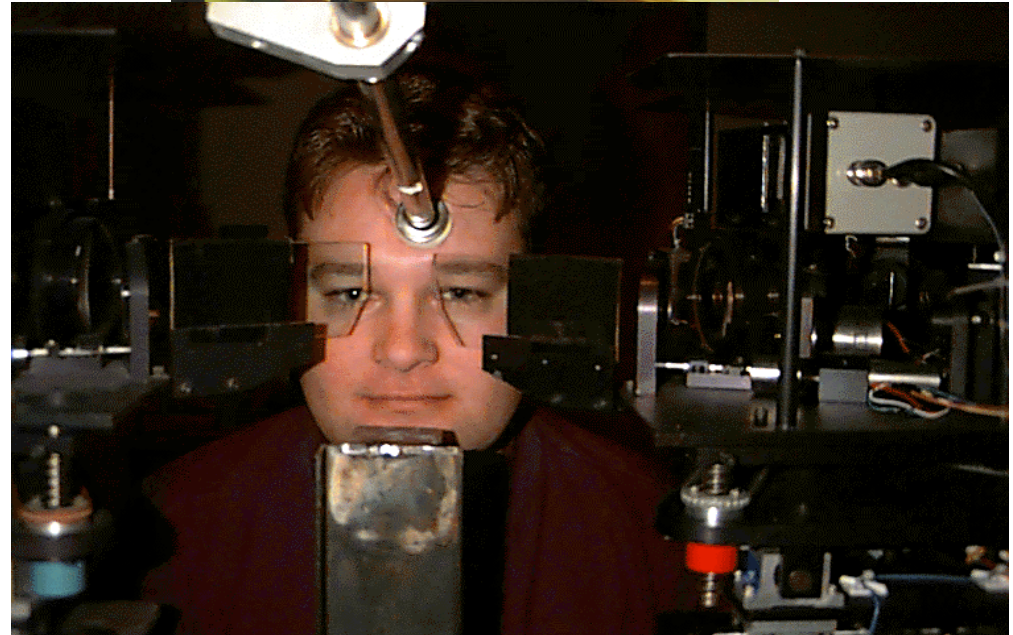
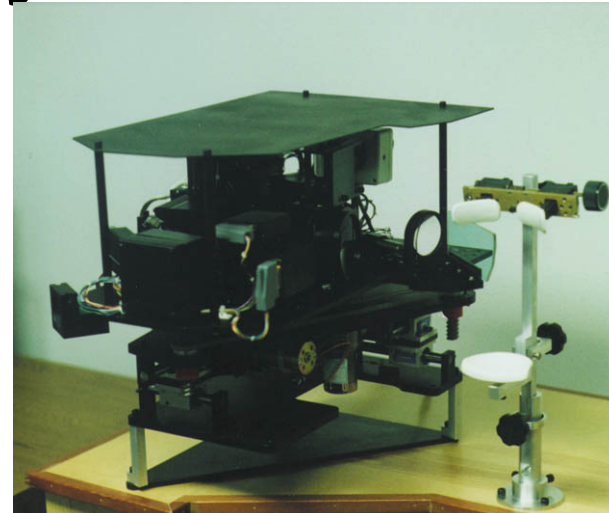
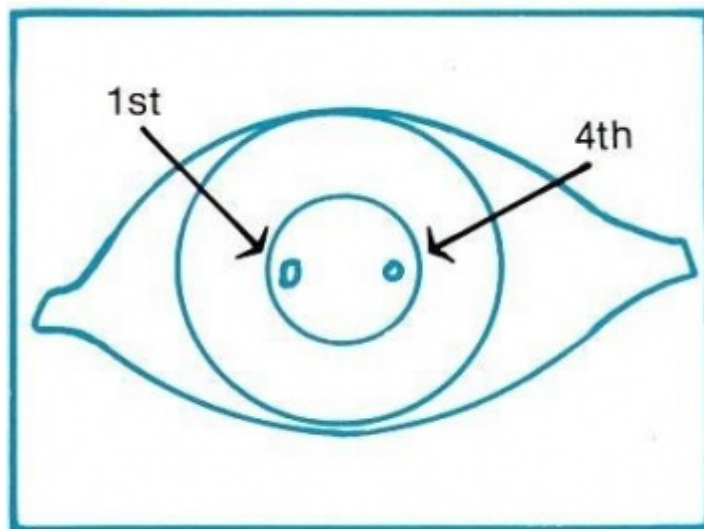
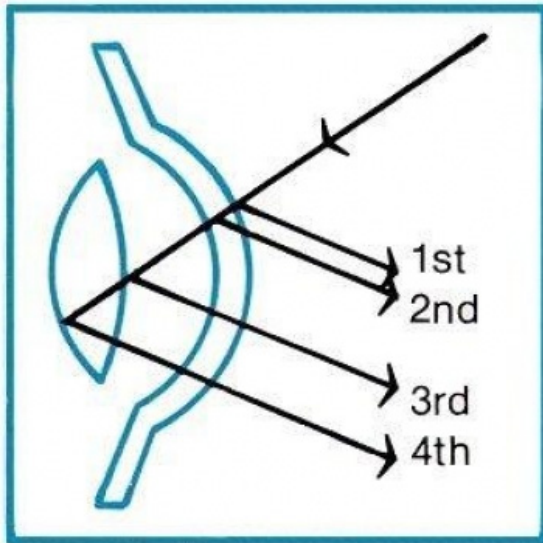
Fig. 5.2. Example of search coil eye movement measurement. Courtesy of Skalar Medical, PO Box 233, 2600 AE DELFT, The Netherlands



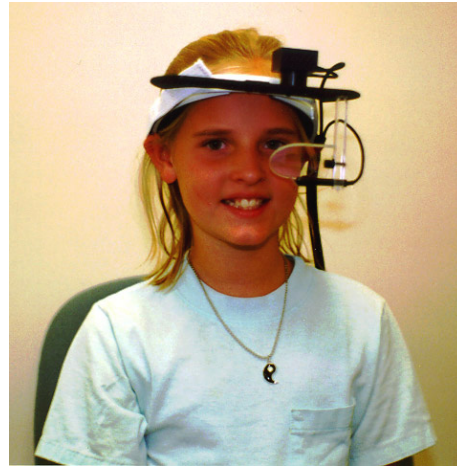
From "Clockwork Orange"

Fig. 5.3. Example of scleral suction ring insertion for search coil eye movement measurement. Courtesy of Skalar Medical, PO Box 233, 2600 AE DELFT, The Netherlands <<http://www.skalar.nl>>. Reproduced with permission.

Dual Purkinje Eyetrackers



Video-based Visor eye trackers

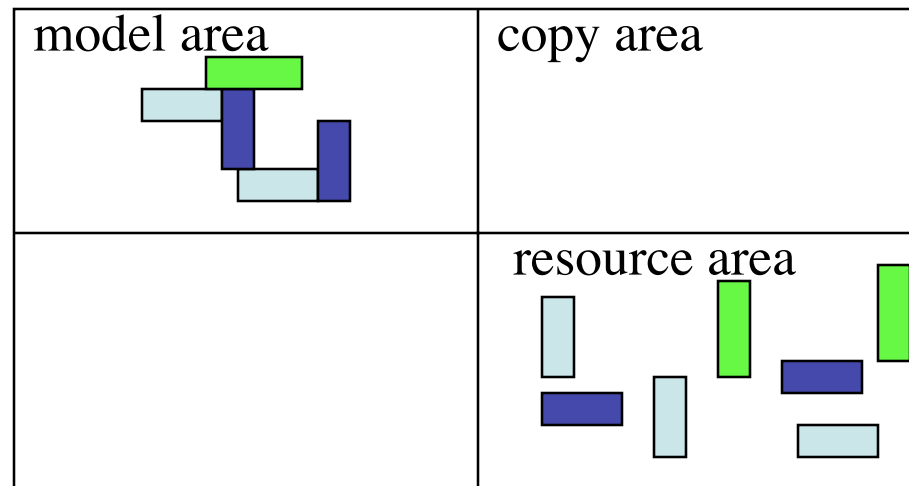


Remote Eyetracker



Visual Attention in the Wild (Ballard, Hayhoe & Pelz, 1995)

- What do eye movements look like in simple copying tasks?



- It looks like we use the visual world as our memory for details...

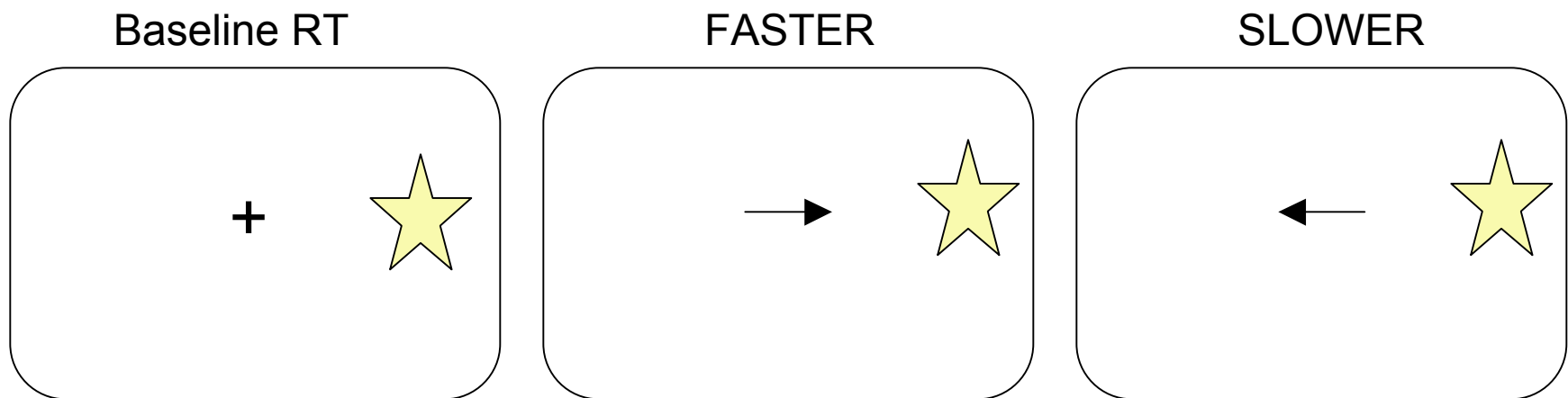
Visual memory and motor planning in a natural task [\(Hayhoe et al, 2003\)](#)



(Linked to video samples from paper.)

Caveat 1: Spatial attention without eye movements

- Covert Spatial Attention (Posner, 1980)
- Hold your gaze in center at all times.
- Press a button every time you see a star out of the corner of your eye.



Caveat 2: Non-spatial Attention

Questions for BLUE people:

Did the GREEN sentence have the word “house” in it? The word “future”? “friend”?

Questions for GREEN people:

Did the BLUE sentence have the word “ball” in it? The word “mouse”? “banana”?

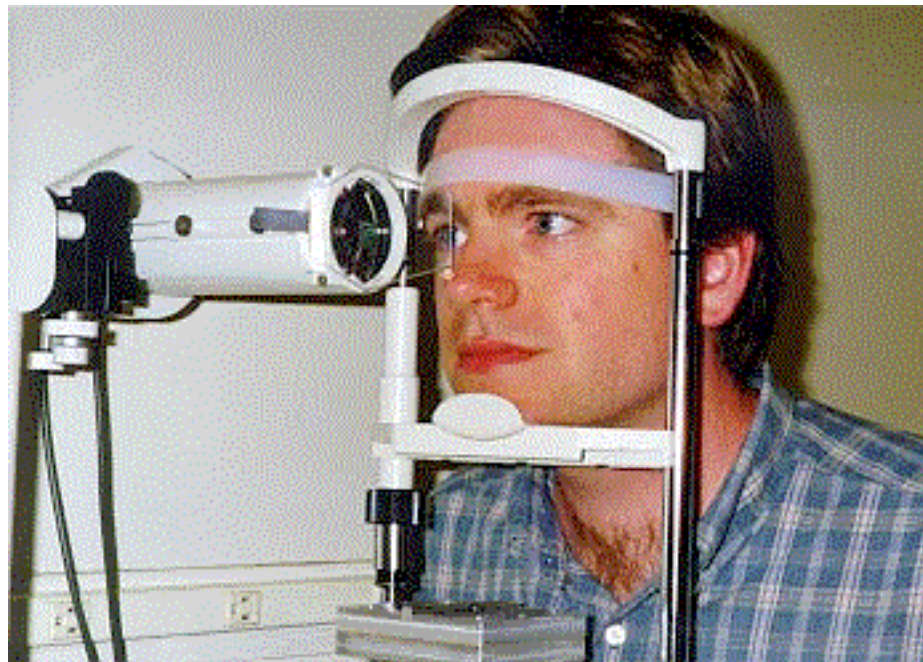
Plastics are the future, my dear friend.
The table had a ball and a banana on it.

Important implications for our purposes

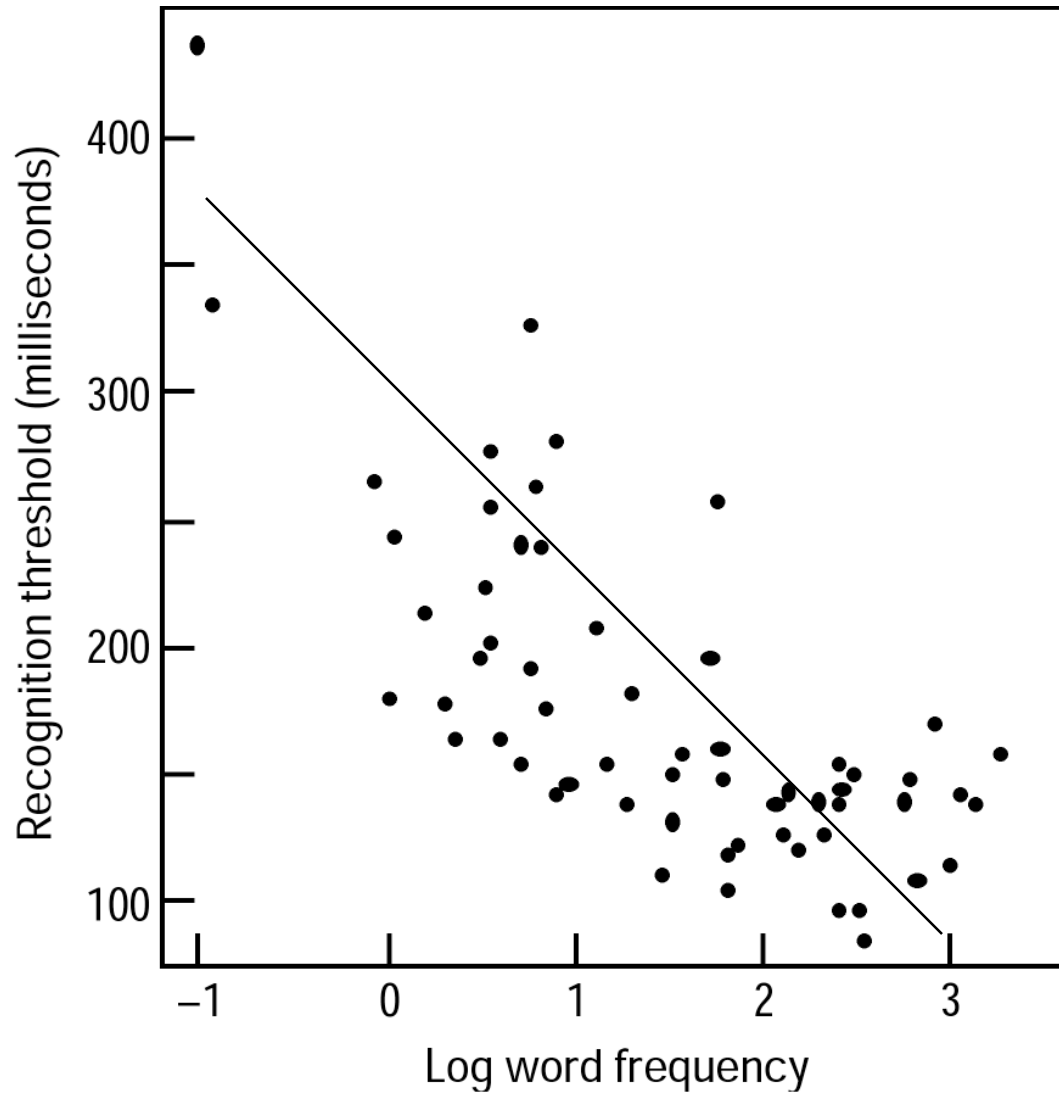
- Caveat 1: Covert Attention
 - People can sometimes attend to what they aren't fixating.
 - But this takes effort and is unlikely to be the norm.
- Caveat 2: Non-Spatial Attention
 - Eye position tells you *where* people are looking but not necessarily *what* they are thinking about.
 - But an understanding of the person's current goals can allow a researcher to use eye position to infer what a person is thinking about.

Using eye movements to study language processing: eye-tracking during reading

- ◆ *The lawyer examined the claims that there...*



More common words are read faster.



What about a word with more than one meaning? (Duffy & Rayner, 1988)

- “Of course the pitcher was often forgotten...”
(280 msec)

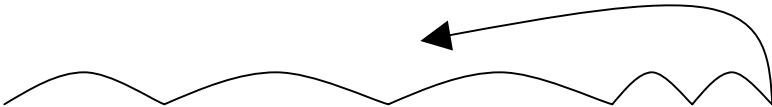
- “Of course the whiskey was often forgotten...”
(250 msec)

Long fixation time may imply:

we compute both meanings of ambiguous words and dynamically resolve the meaning.

What about syntactic ambiguity?

(e.g., Trueswell, Tanenhaus & Garnsey, 1994)



The defendant examined by the lawyer turned out to be unreliable.



The evidence examined by the lawyer turned out to be unreliable.



The defendant who was examined by the lawyer turned out to be unreliable.



The evidence that was examined by the lawyer turned out to be unreliable.

Eyetracking during listening

Take it away, Mike!

