(Advanced) Human-Computer Interaction

Module 22133 and 25020

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Week 4 (2016/17)

Heads up display on new Mini (2016).

Does this improve or hinder safety? Why?
Justify your argument to a customer.

https://www.youtube.com/watch?v=XJNtyXT6JdU

https://www.youtube.com/watch?v=xfvLpyHDAx4

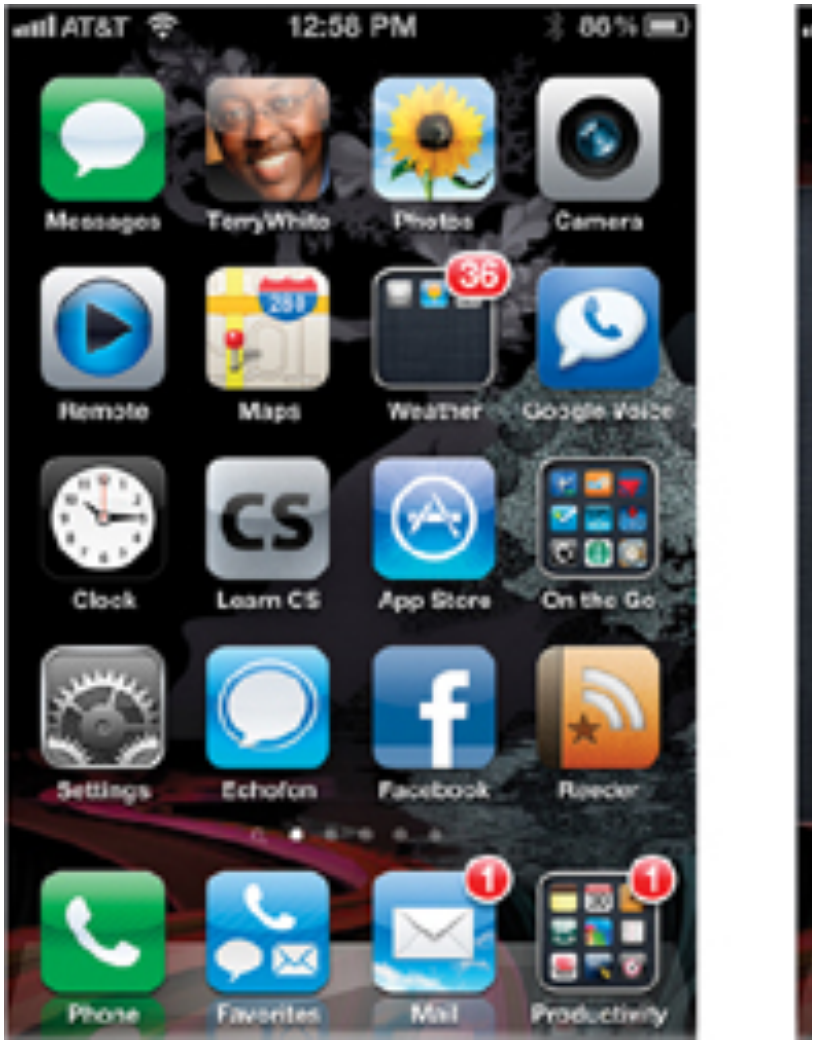
Psychology and design

- New car guidance systems cost tens of millions of Euros to design and must meet very high safety standards.
- The cost of failure is very high.
- Hacking is not the answer!
- Can we help guide the design of technologies by understanding human psychology?

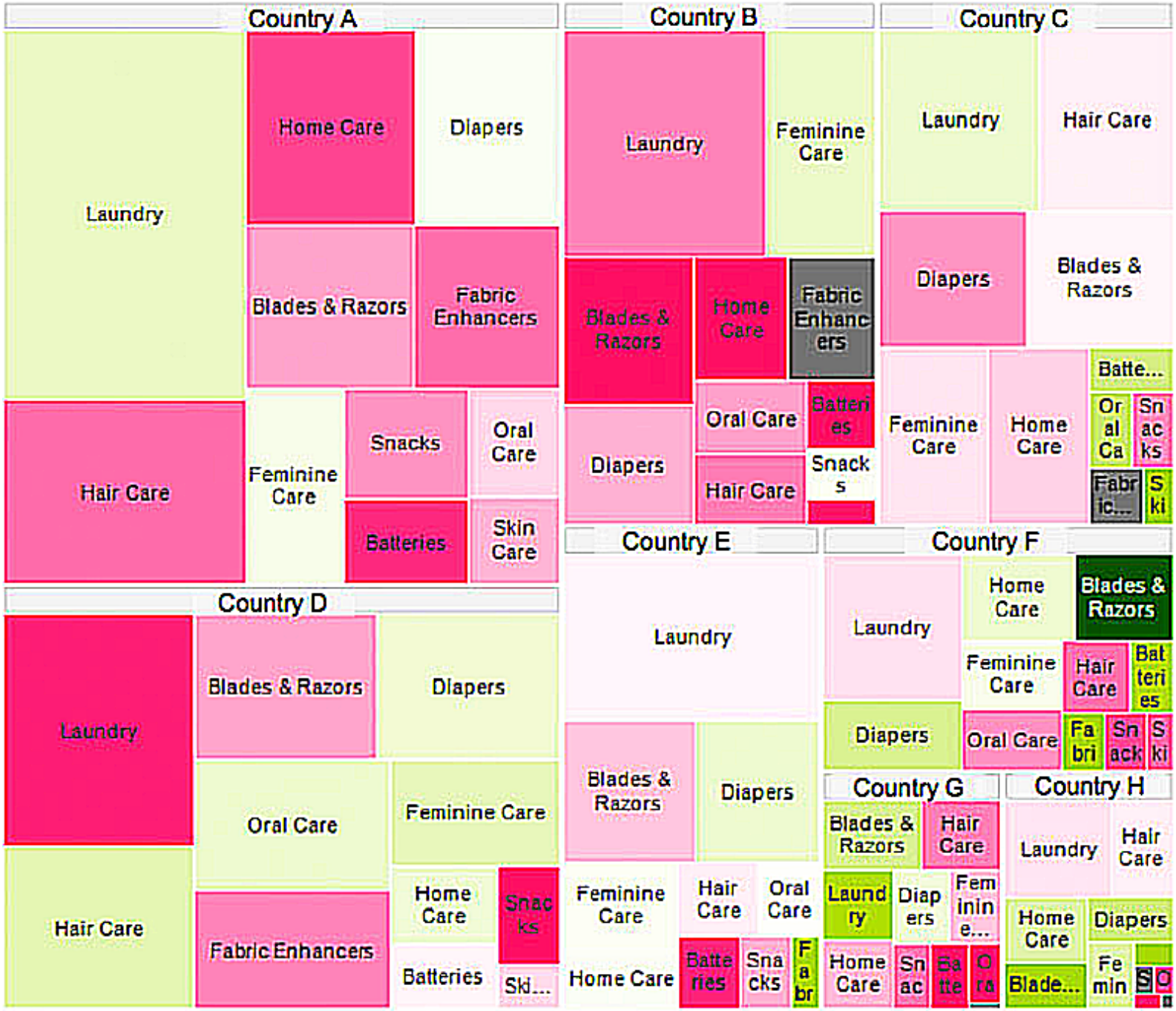
Visual Search

Visual search in human-computer interaction

- A common interactive task is to find an object using vision.
- Find the Facebook icon?
- Find a face?

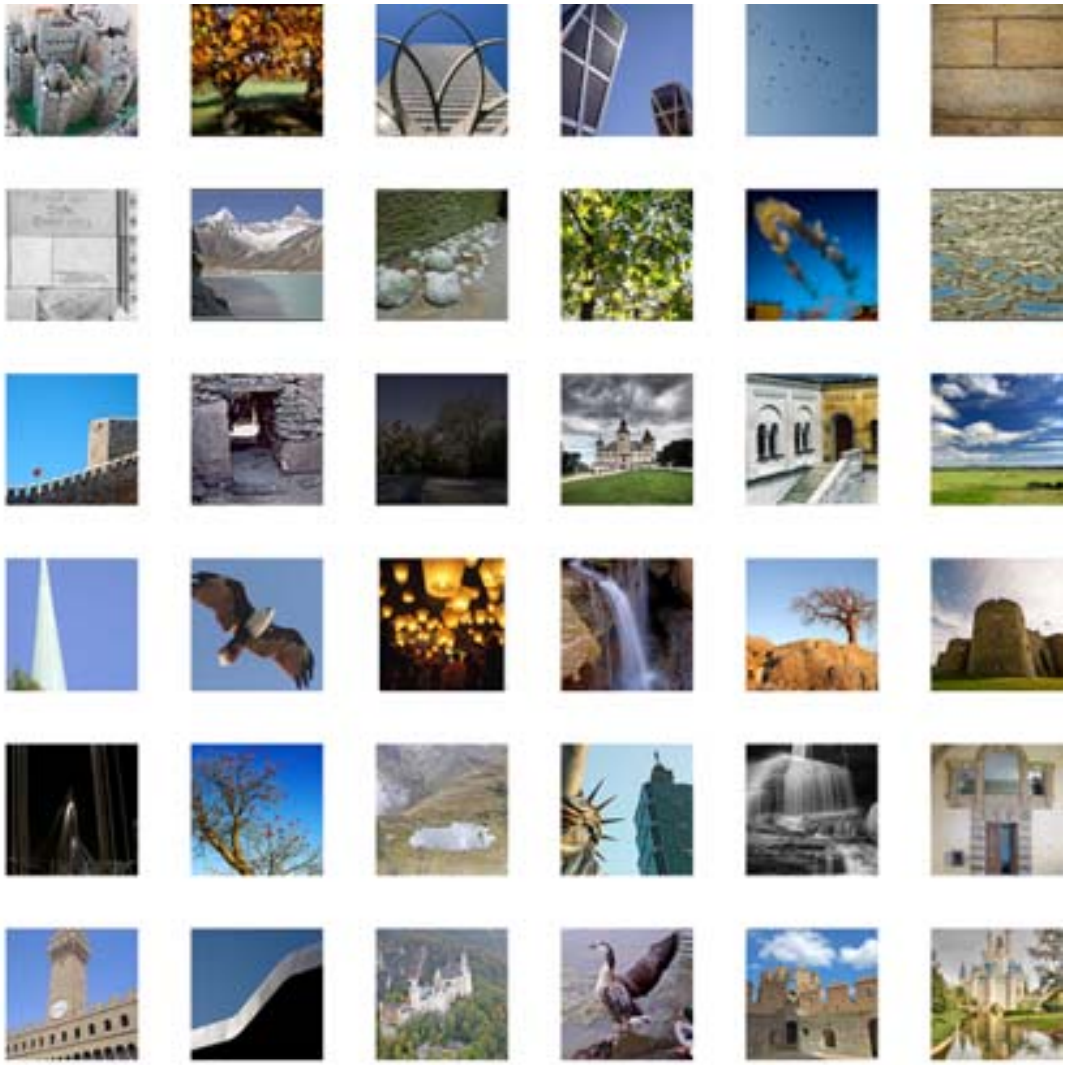


Visual Search with Information Visualisation.



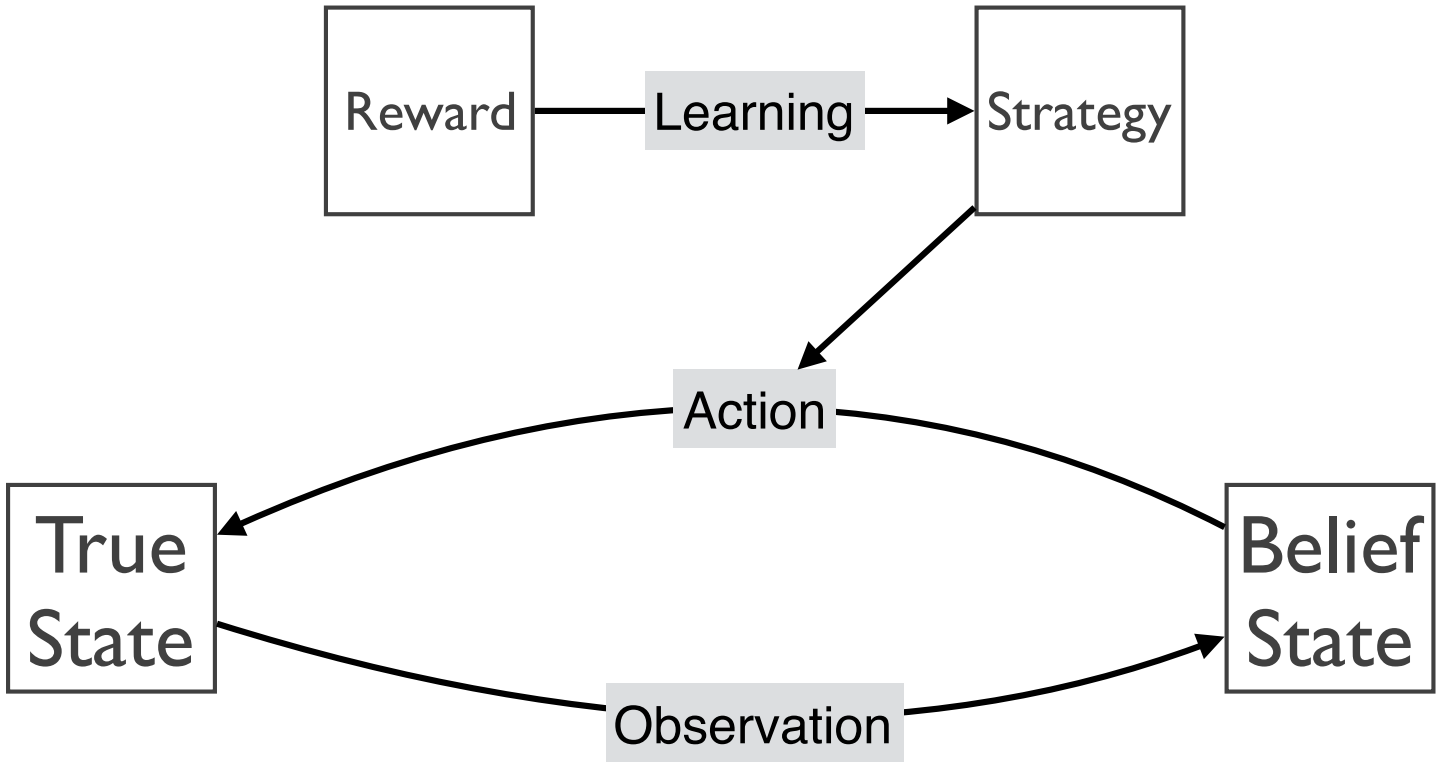
change blindness

- a more complex visual search task:
- find an image with the following features:
- sky, building, water, trees, reflection.

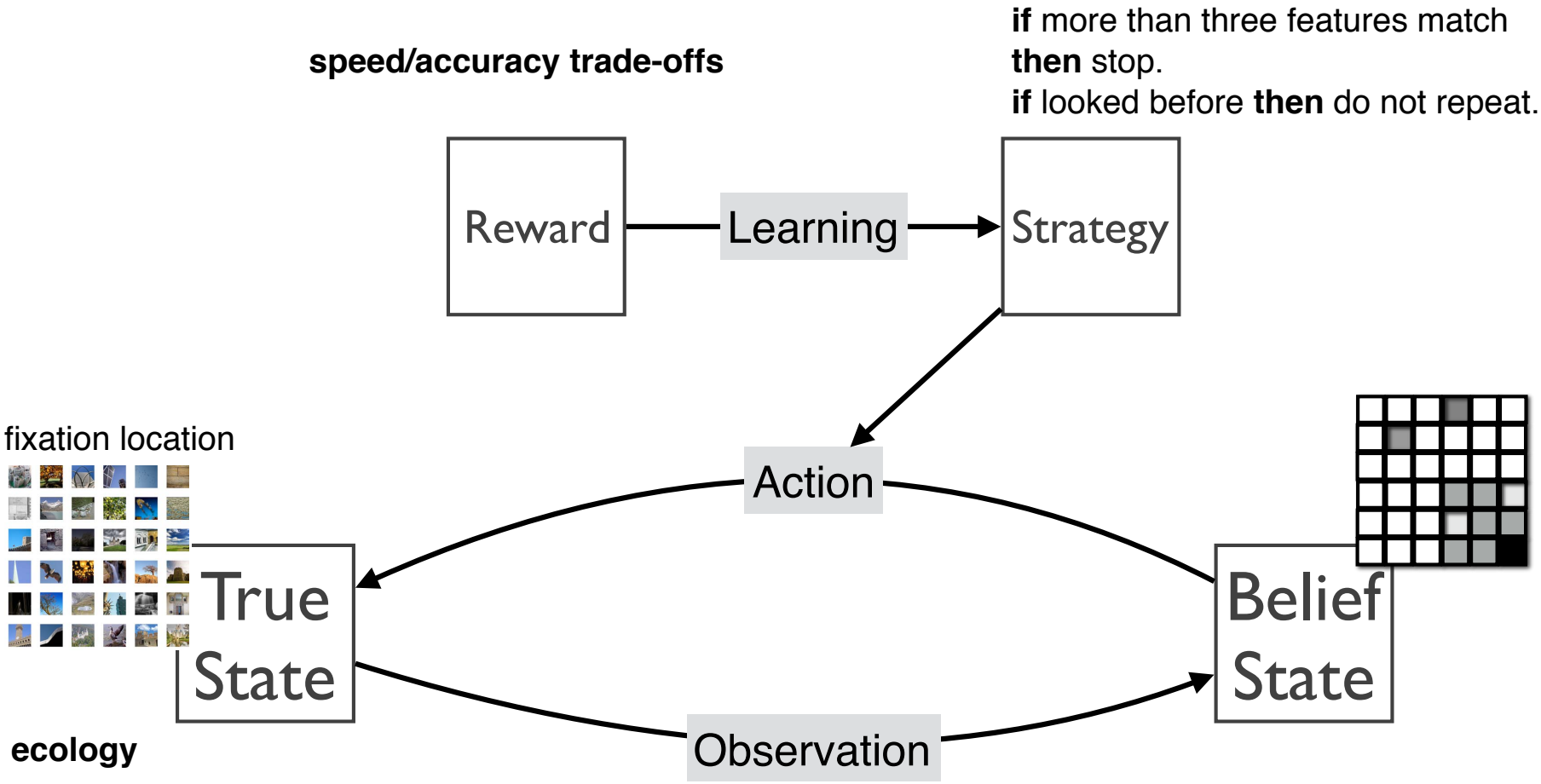


Tseng, Y.C., Howes, A. & Lewis, R.L. (2015) Bounded optimal information gathering in a visual image search task.

The visual search problem can be characterised as a Partially Observable Markov Decision Problem (POMDP)



Butko, N. J., & Movellan, J. R. (2009, June). Optimal scanning for faster object detection. In *Computer vision and pattern recognition, 2009. cvpr 2009. ieee conference on* (pp. 2751-2758). IEEE.


speed/accuracy trade-offs
if more than three features match
then stop.
if looked before then do not repeat.
Reward
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ecology

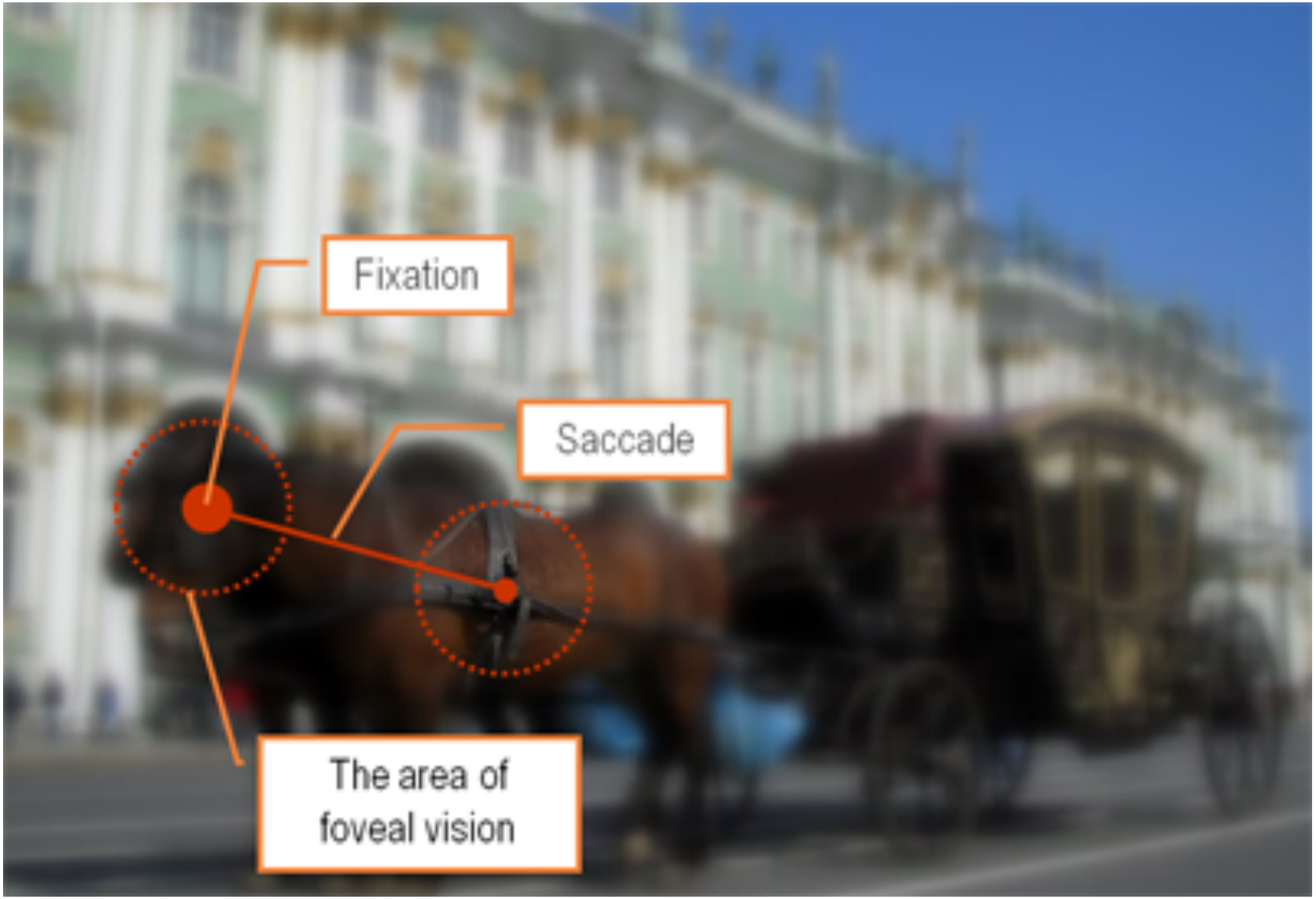
Exercise

- in groups of 2 or 3 write a think aloud protocol for the visual search strategy that you use for finding icons on someone else's smartphone.
- write a description of the task.
- swap phones!
- how might the interaction design be improved?

The observation function

- The observation function is used to make a sequence of observations of the state.
- Observations are not of the whole state.
- Observations are not guaranteed to be correct.
- Observations result in a belief about the world that makes a commitment to one interpretation. The belief is a model.
- Varies across individuals.

fixations and saccades



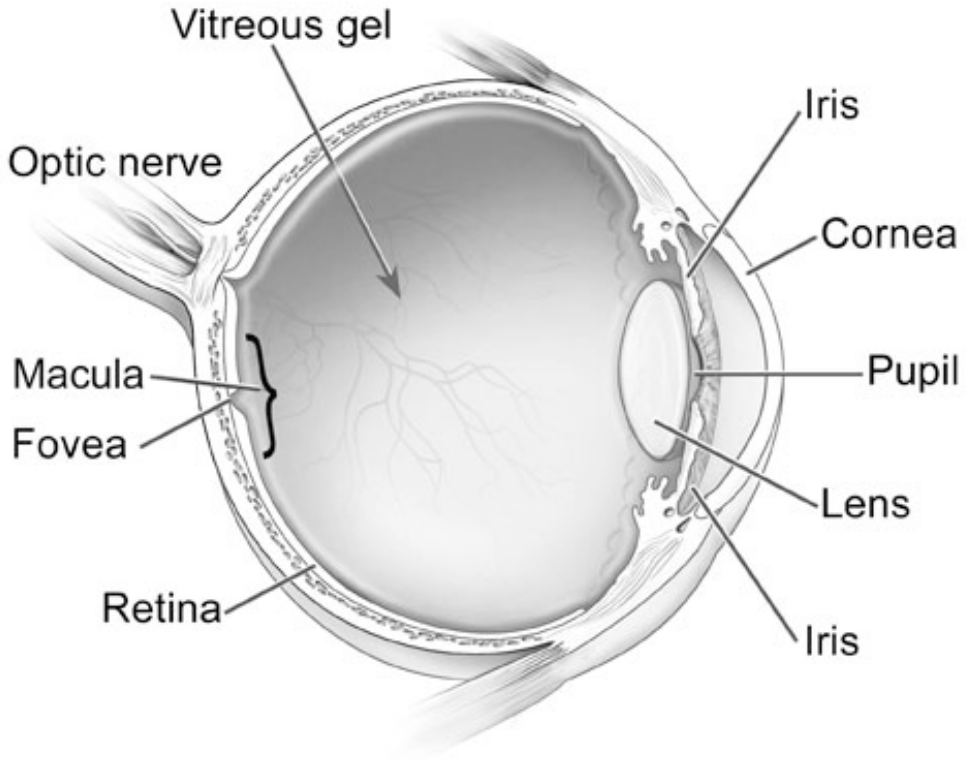
http://eyetracking.me/?page_id=9

Parafoveal vision

- focus on the red "C" of the word "Cognitive" on the right. Can you read the words on the left most white book?
- Move your eyes one book to the left? etc.
- Notice how acuity for books to the left increases as your eyes move to the left.
- Also notice that you can attend to somewhere other than where you are fixated.

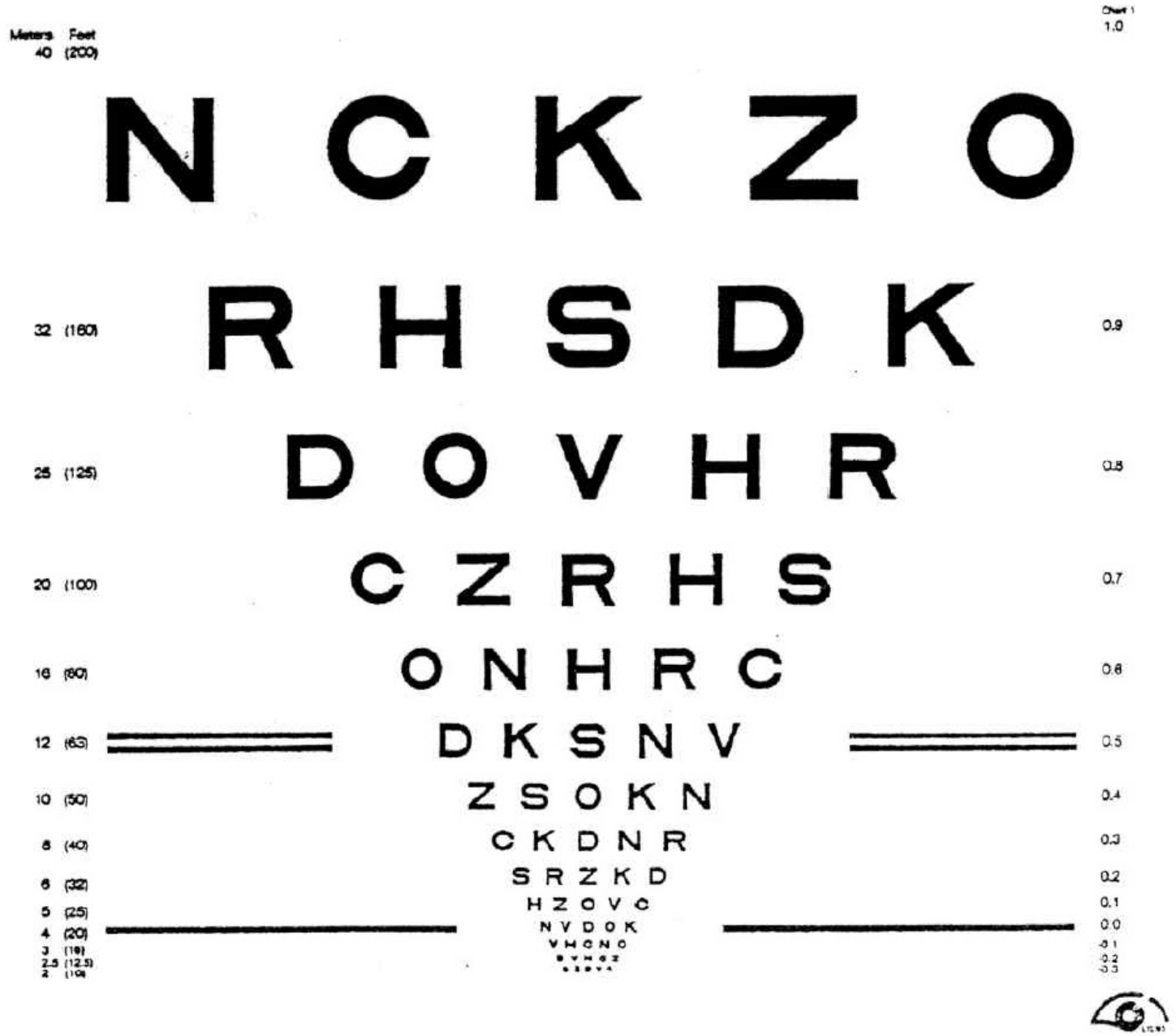
the fovea and parafovea

- The acuity with which we see an object is partly determined by whether the image of the object is on the fovea (high resolution) or the parafovea (relatively low resolution).



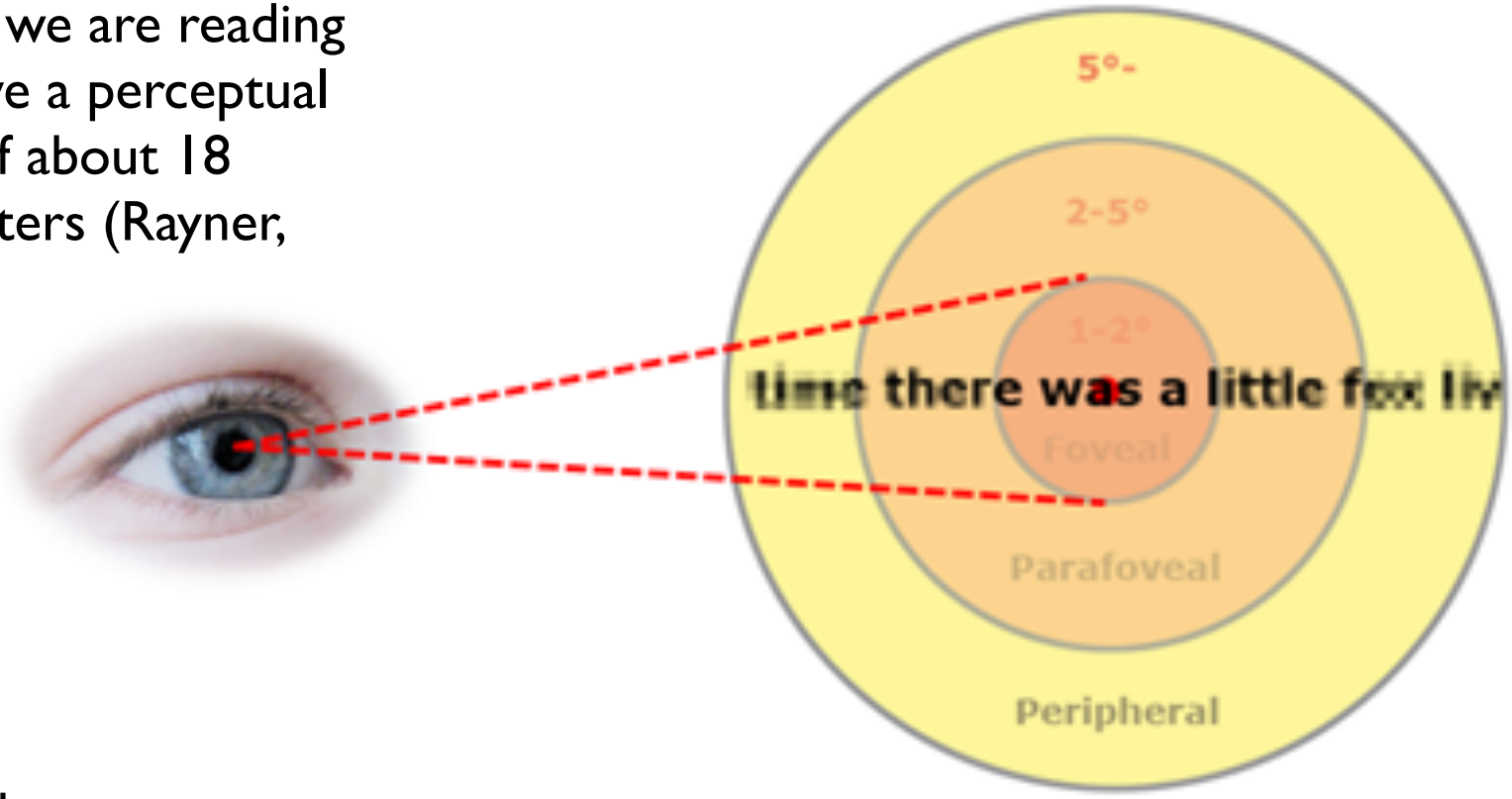
- http://www.ncbi.ie/information-for/eye-health-and-eye-care/your-eye

ETDRS VISUAL ACUITY CHART 1



letter perception

- When we are reading we have a perceptual span of about 18 characters (Rayner, 1998).

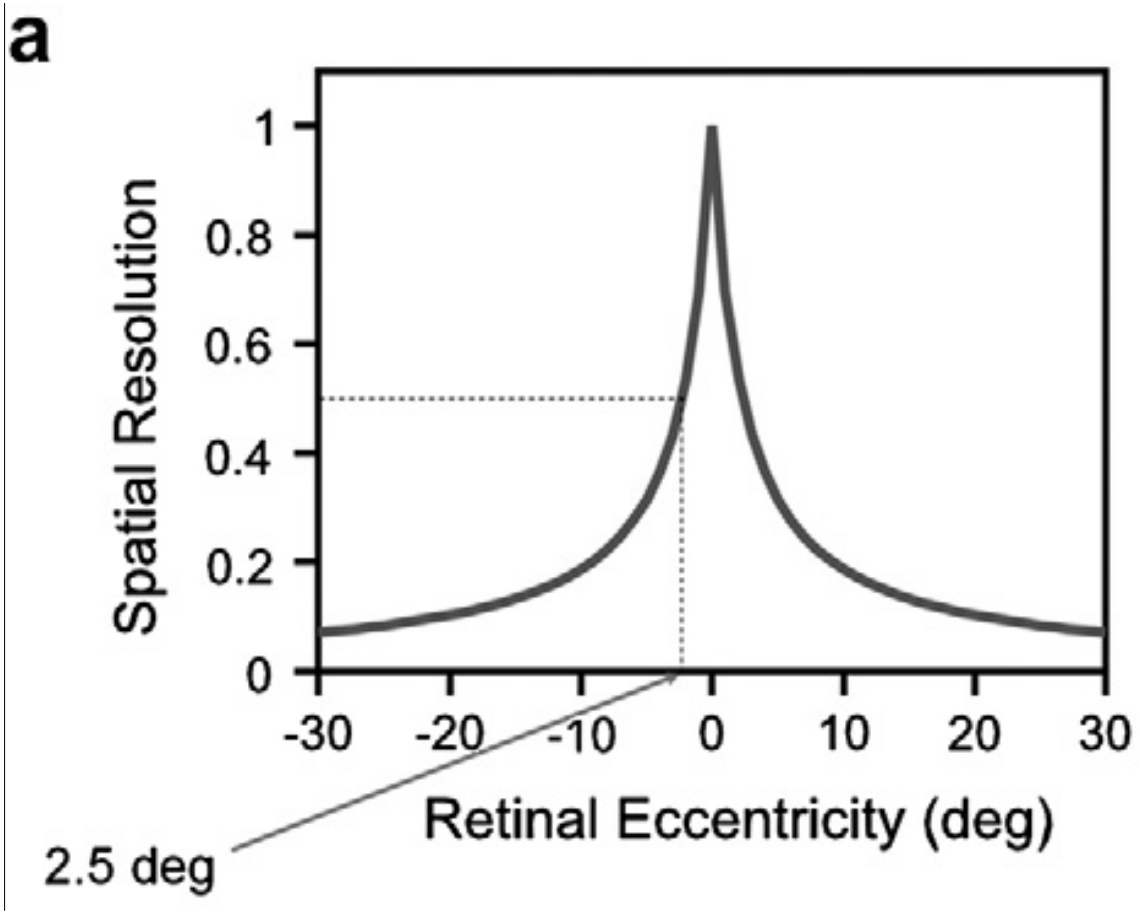


http://eyetracking.me/?page_id=9

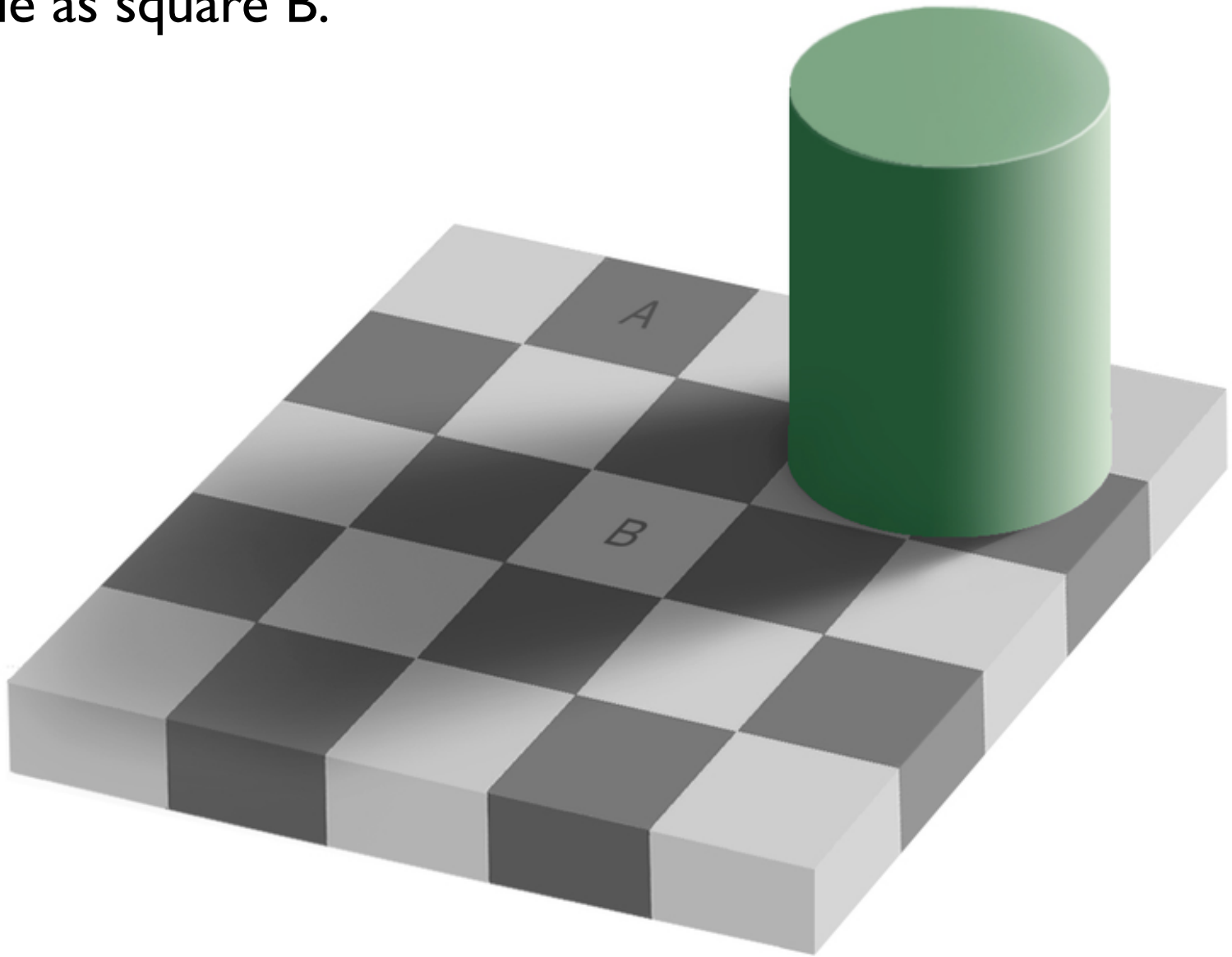
- we make a sequence of fixations and saccades in order to read a sentence.

Spatial resolution with eccentricity from the fovea

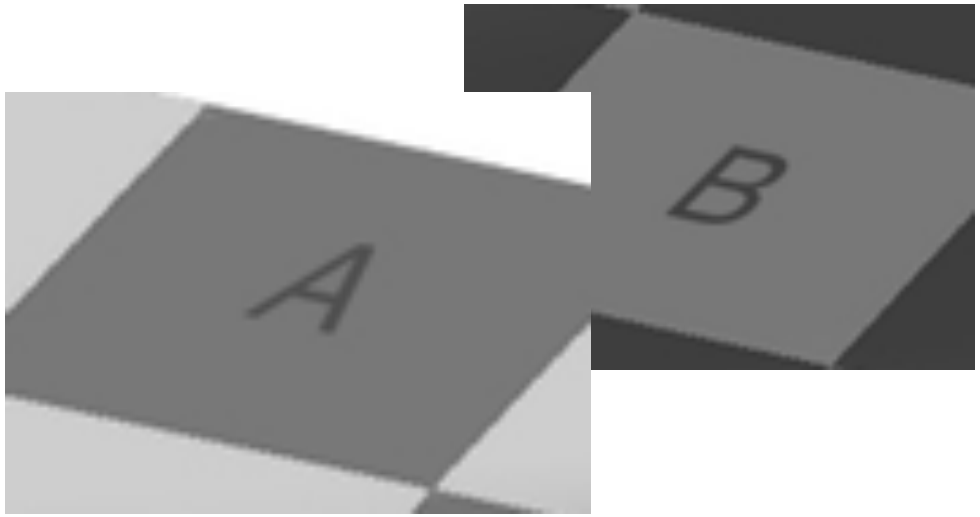
- Geisler (2011) Figure 3.
- At 2.5 degrees of visual angle the spatial resolution has dropped to 50%.



- Square A is exactly the same shade as square B.



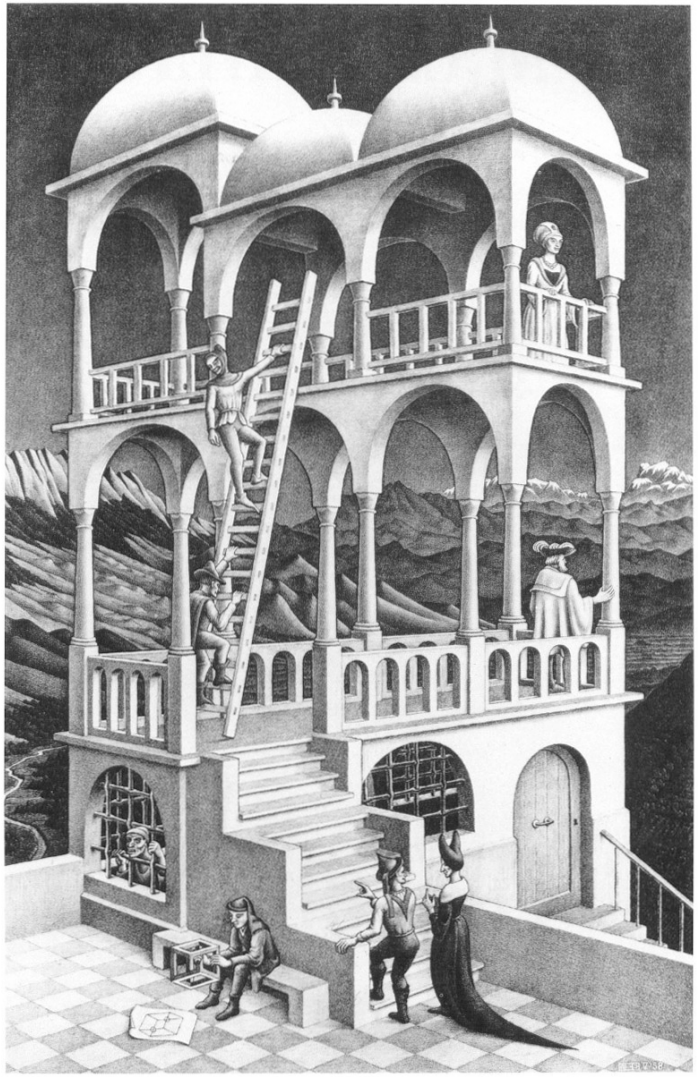
wikipedia.org



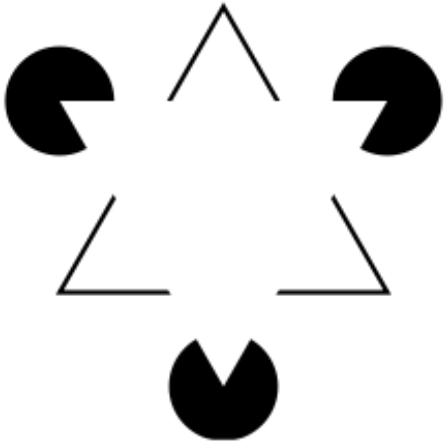
if you do not believe me then do this test yourself on my overheads tonight.

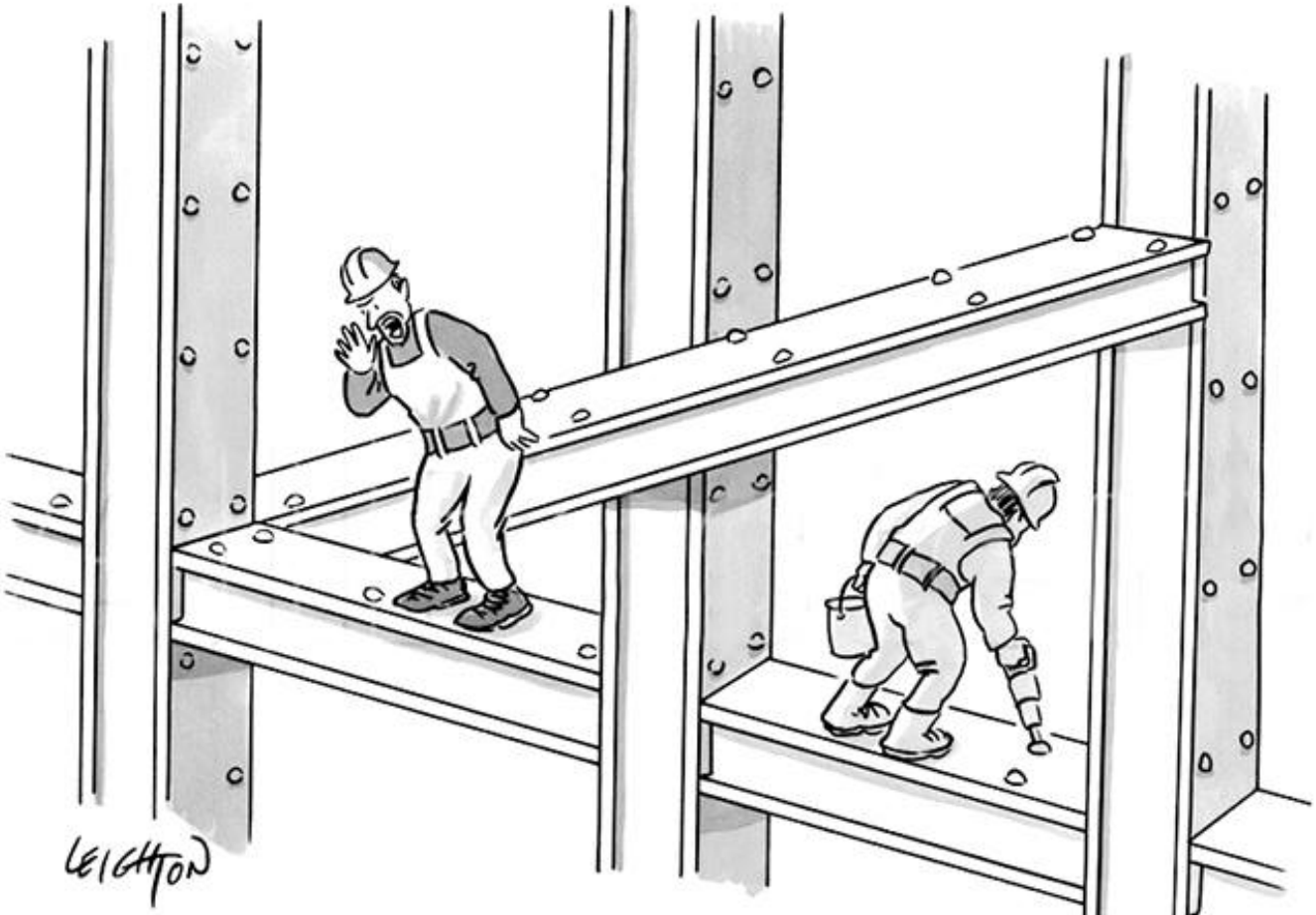
- What happens here is that the brain uses the various elements of the image -- including the green cylinder, its shadow, and the checkerboard -- to infer the probable grayness of each image element.
- What you see, in your mind (your Belief State) is NOT a raw unprocessed image. It is not like a photograph in the head. Rather, your brain computes a representation of the world that is influenced both by information from the eye and by prior expectations about what is likely to be out there.

ecology

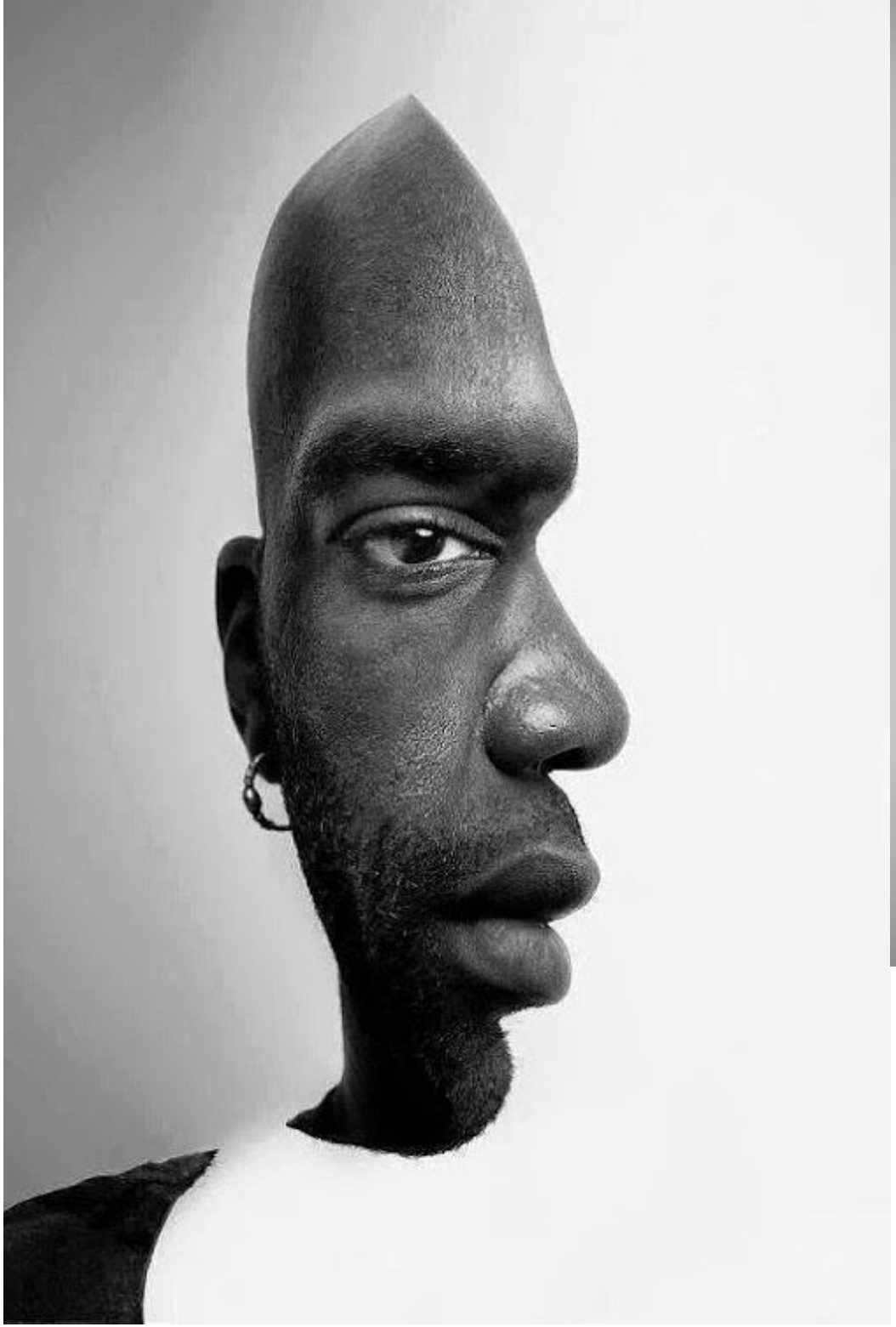


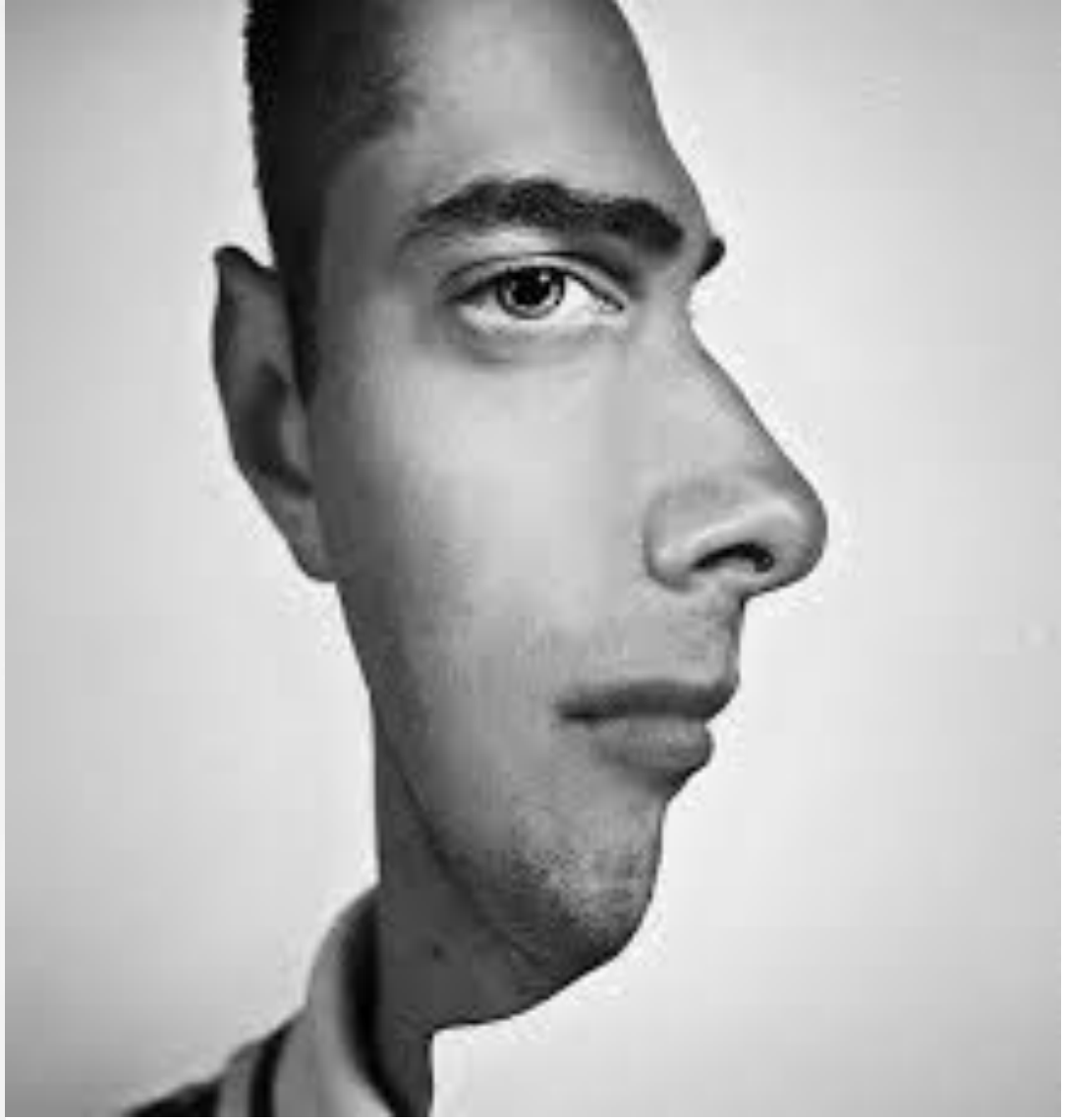
cognitive
illusions
show us that
the brain
infers
structure in
the world
given
expectations.





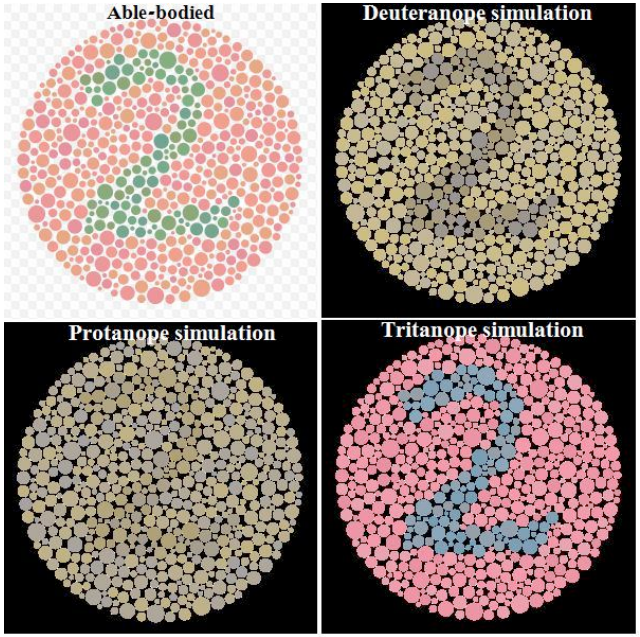
"Escher! Get your ass up here."





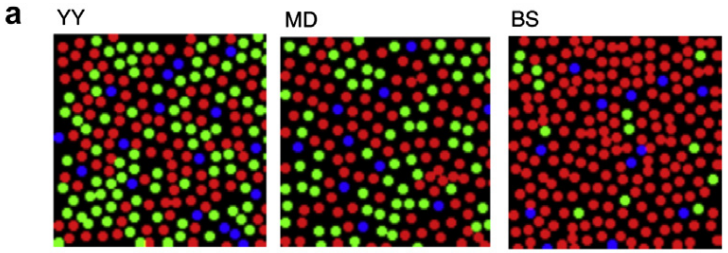
"Aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoatnt tihng is taht the frist and lsat ltteers be at the rghit pclae. The rset can be a toatl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe."

the observation function varies across individuals… and species.

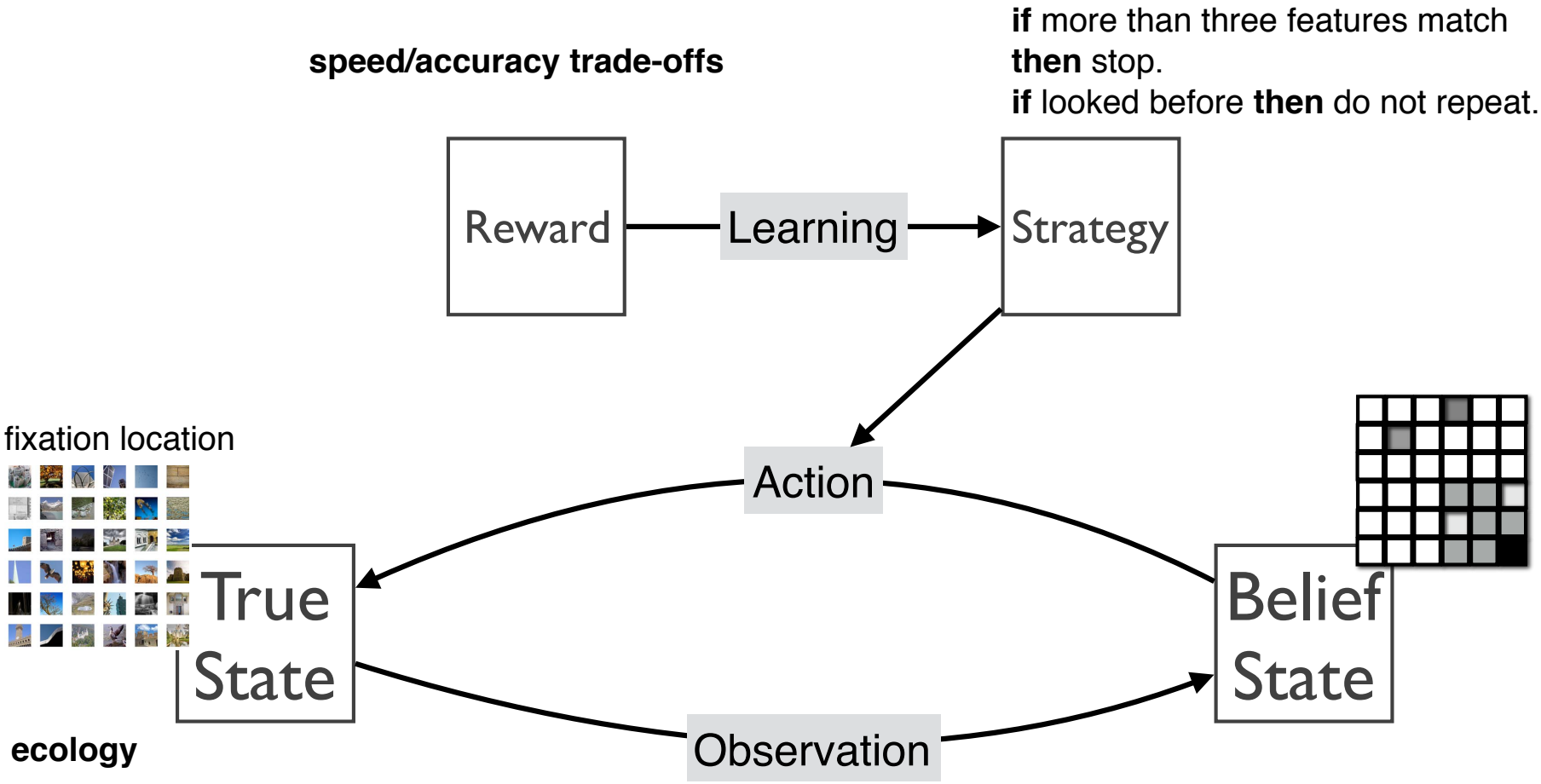


wikipedia

dog.vision.com



variation in cone arrangement across three individuals (as cited in Geisler,2011)


speed/accuracy trade-offs
if more than three features match
then stop.
if looked before then do not repeat.
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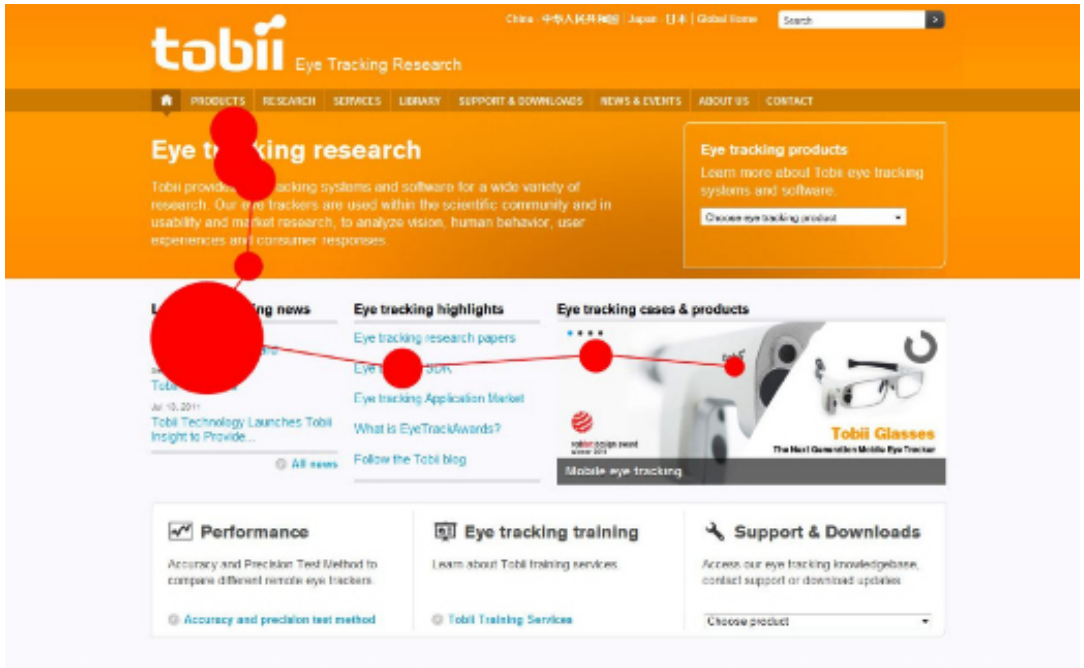
ecology

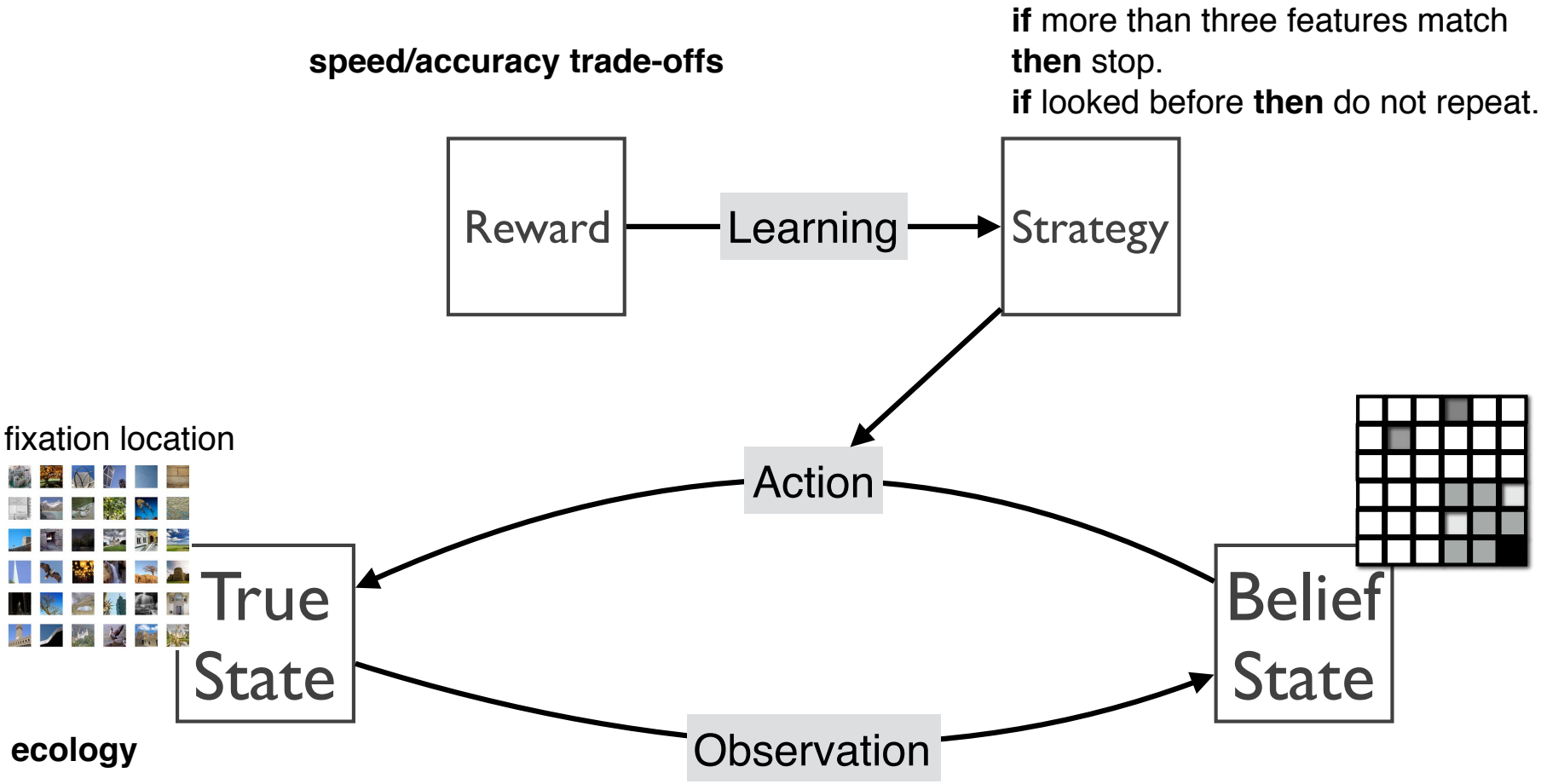
The action function

- Important actions include: saccade and fixation.
- There are minimum time requirements for how long it takes to make eye movements
- For reading,
- Saccade duration is between150 and 175ms (Rayner, 2008).
- Fixation durations vary between 100 and over 500ms.
- where a millisecond (ms) is 1/1000th of a second.

fixations and saccades

- We can measure individual fixation dwell times and patterns of saccadic eye movements with an eye tracker.

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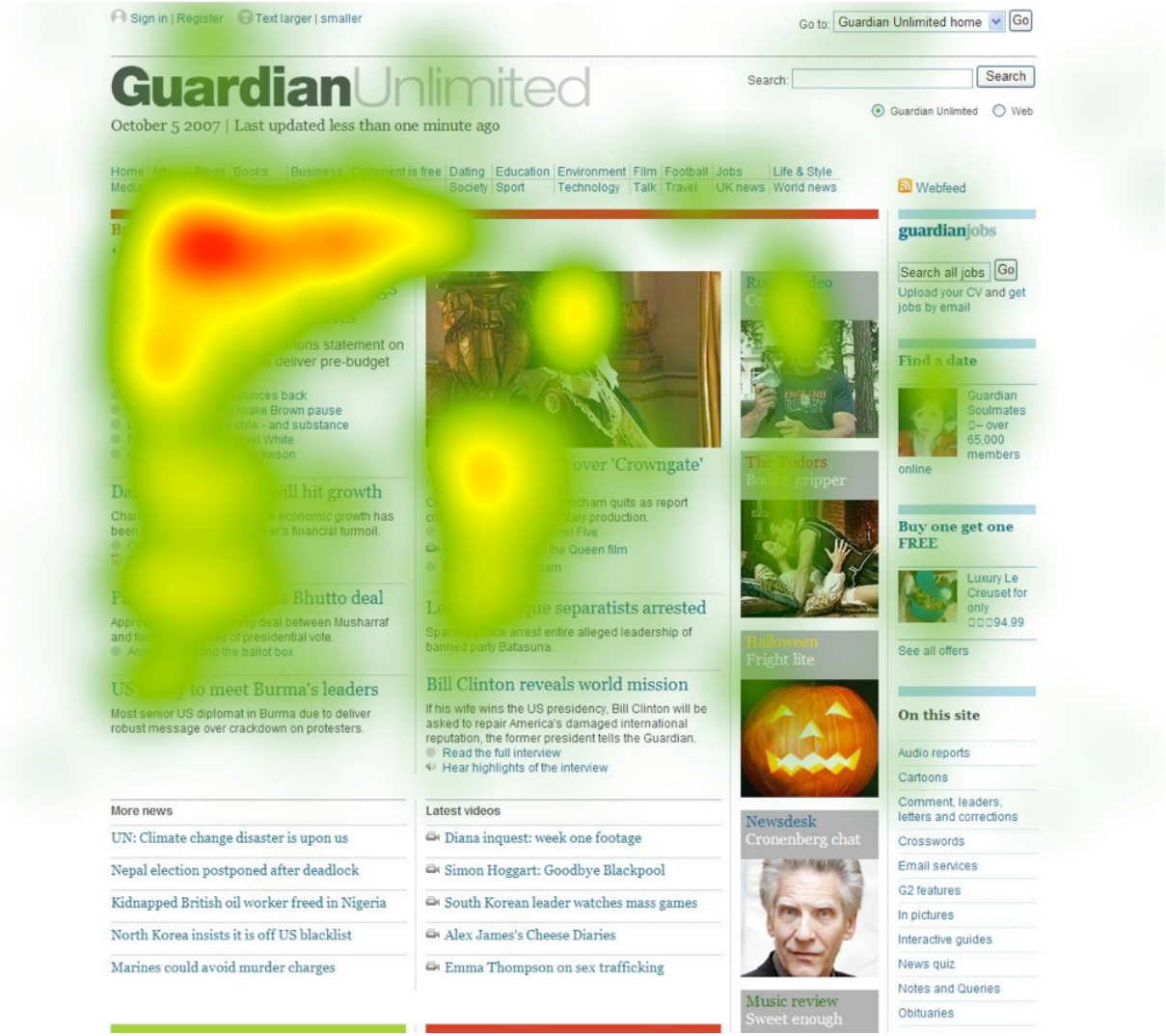


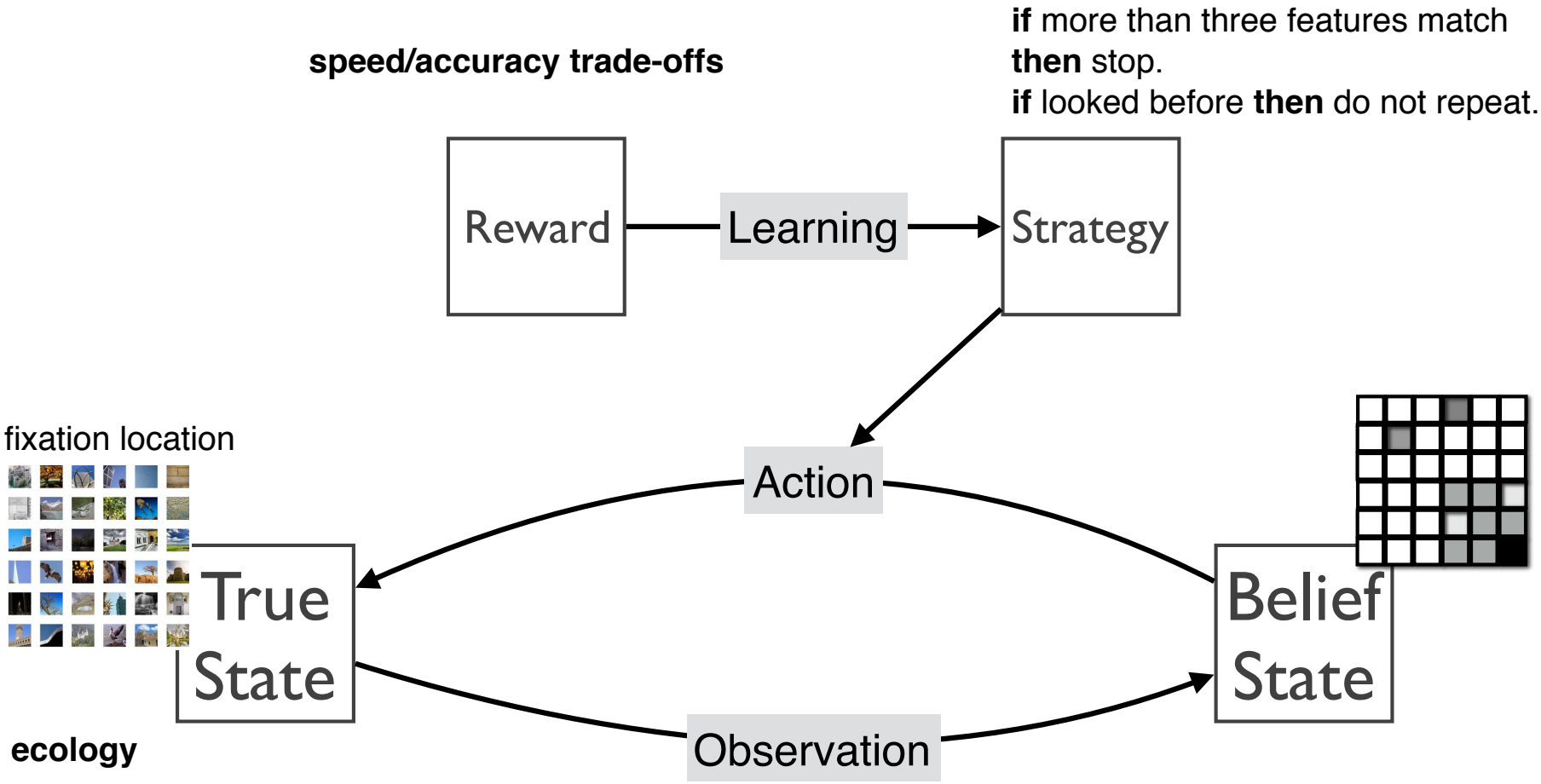
http://wel.cs.manchester.ac.uk/studies/saswat/images/guardian_dynamic.jpg

reward function

- The reward function represents the costs and benefits of action to the person.
- Information gain is one key benefit of fixations.
- All actions have a time cost.
- The benefit of saccades are deferred.
- People gain information from eye movements.

Multi-attribute reward functions

- Multi-attribute utility function for speed and accuracy
  - utility = speed x W1 + accuracy x W2
- Time and money.
  - utility = money x W1 - time x W2
- How people combine multiple attributes is an open research question (Vlaev, Seymor, Dolan, Chater, 2009; Talmi, 2009).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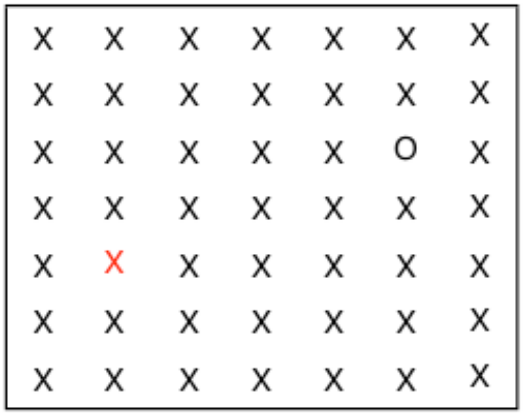
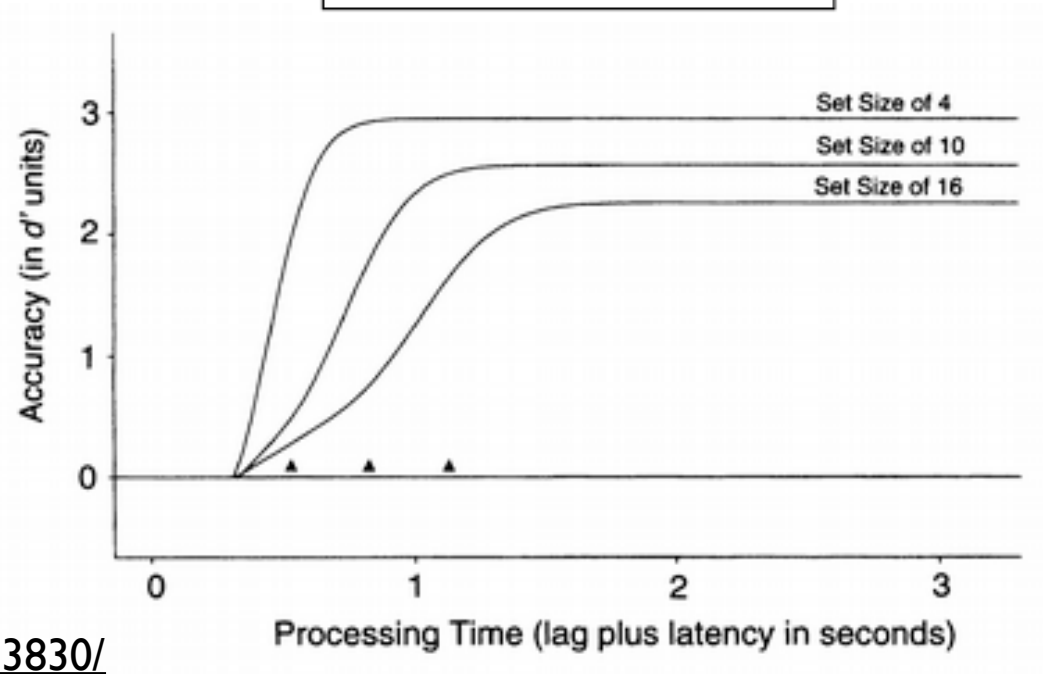
speed versus accuracy in a feature search task

- Is there an O present?
- The figure shows accuracy versus versus processing time for a feature search task.
- Accuracy improves with processing time but then reaches a plateaux.
- The rate of improvement varies with set size.
- The reward function weights speed and accuracy.

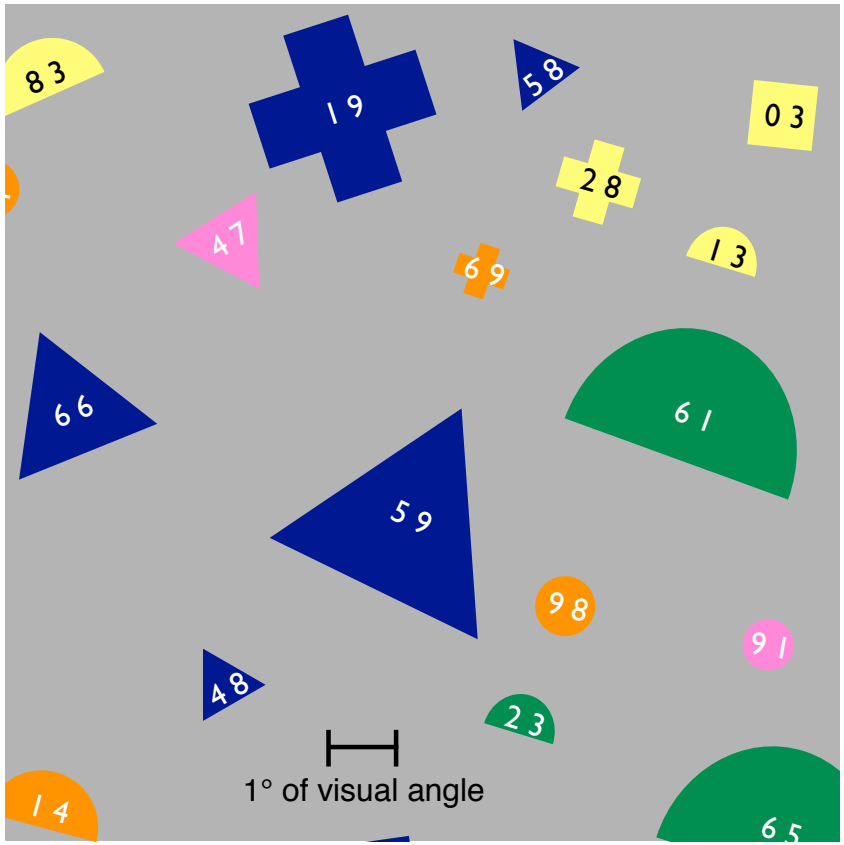




McElree and Carrasco (1999)
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3313830/

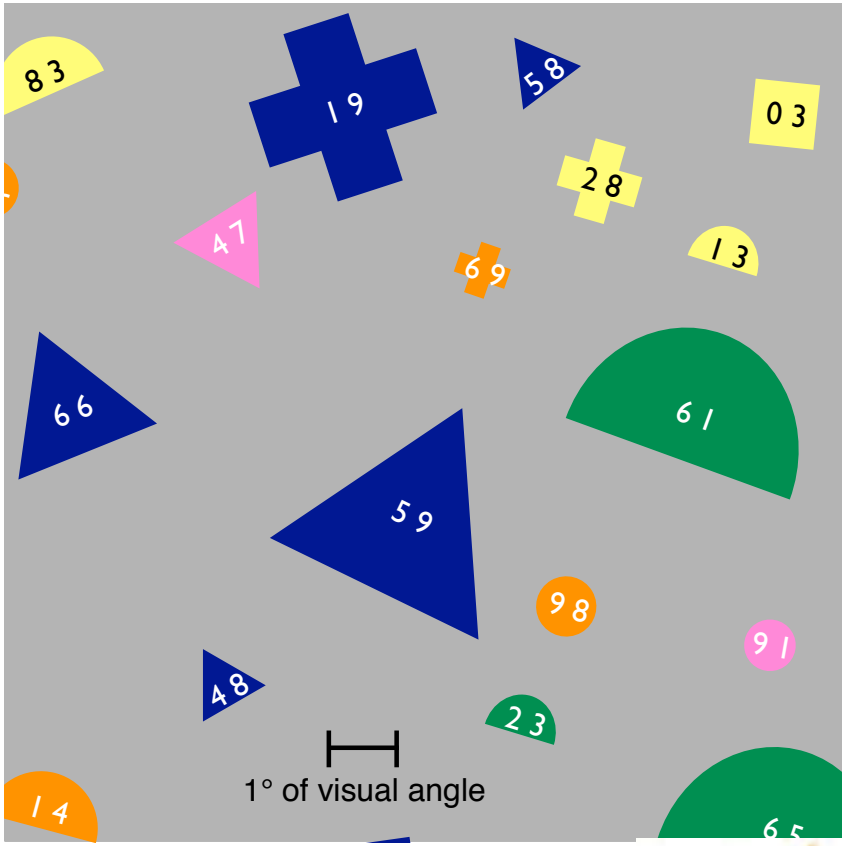
A study of visual search

- primary visual features such as colour, shape and size, are good for guiding visual search.
- detailed visual information is less good.
- Apple's design iterations has increasingly emphasised primary visual features.
- See Kieras and Hornof (2014).


83
19
58
03
28
47
69
13
66
61
59
98
91
48
23
14
65
1° of visual angle

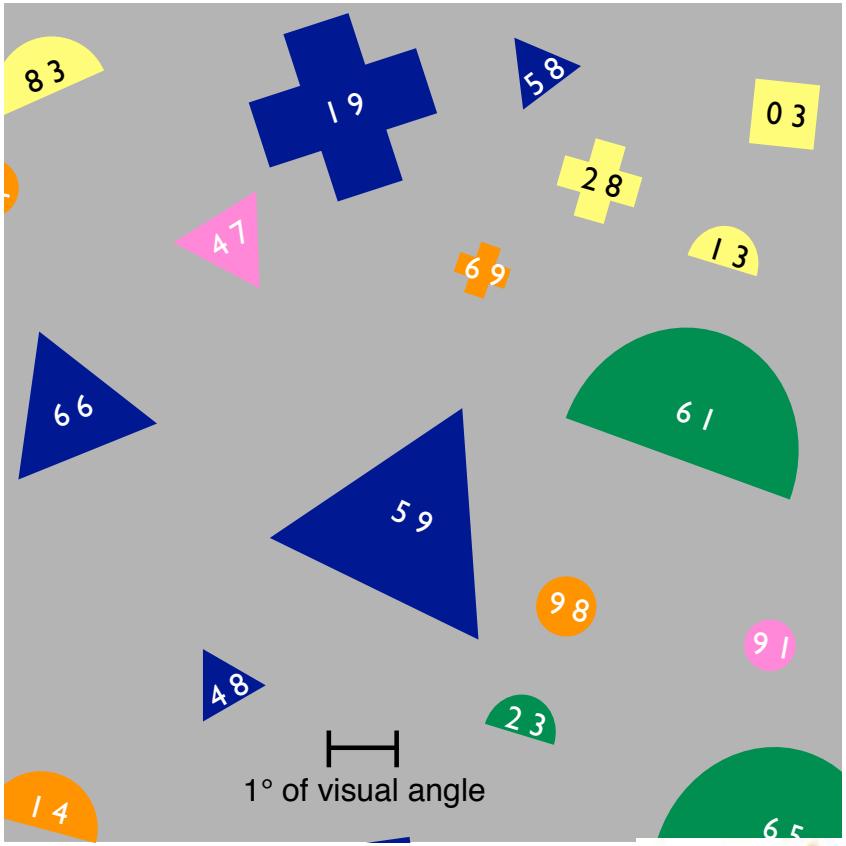
The Williams task

- Search for one of a very large number of objects varying in shape, colour and size.
- E.g. find the yellow 83. Do it now.
- 100 possible objects (4 sizes, 5 colours, 5 shapes).
- Williams (1966).



The Williams task

- The entire display was 39 x 39 degrees of visual angle.
- Search objects ranged from 0.8 to 2.8 degrees.
- Eye movements were recorded by Williams (1966) and the total number of fixations counted.
- Precues were given (e.g. yellow 83)
- The hypothesis was that if a pre-cue was effective then more fixations would fall on that cue.



results

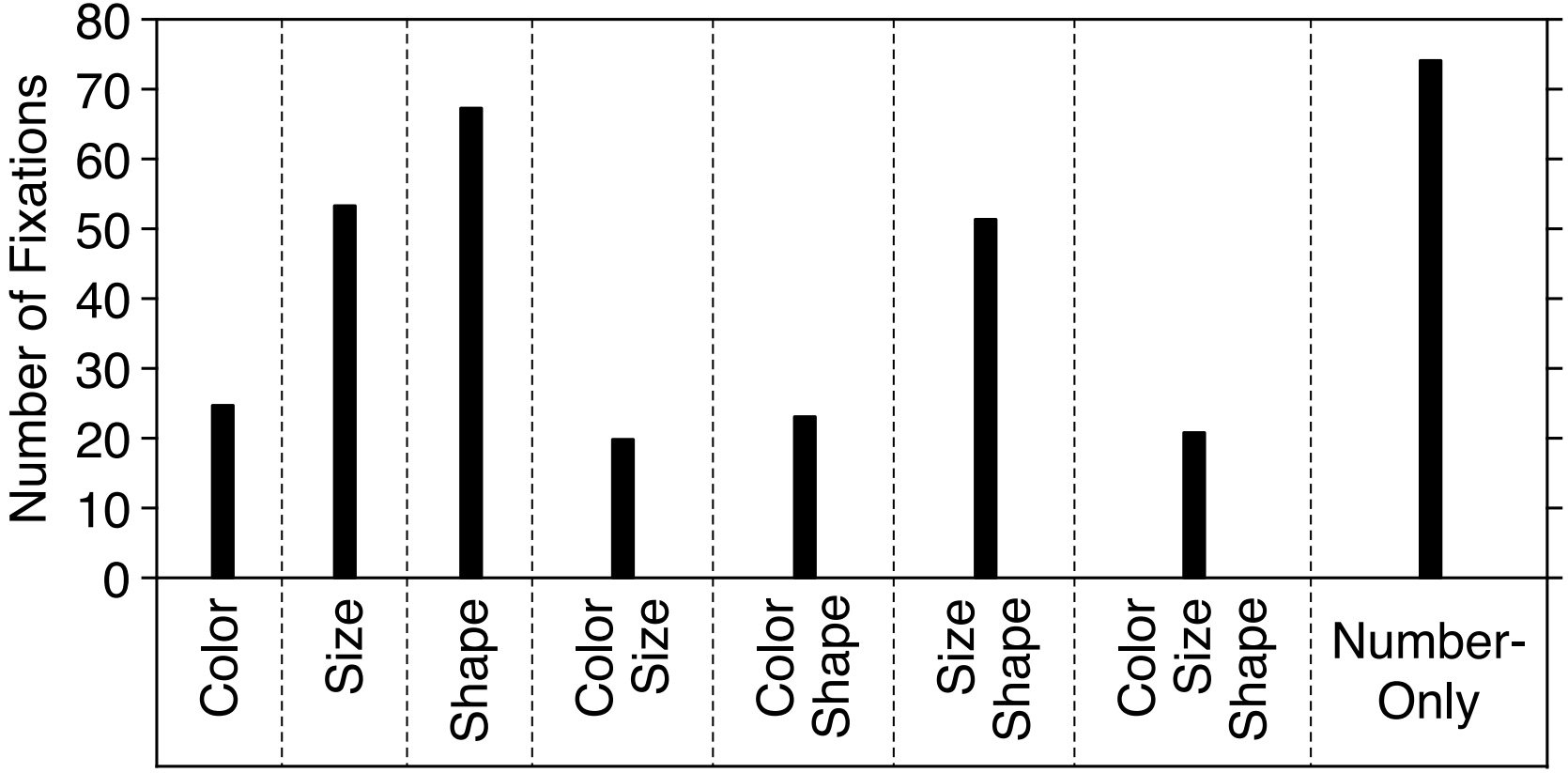


Figure 3. The average number of fixations observed for each precue type from the Williams experiment [29, 30].

Kieras, D. E., & Hornof, A. J. (2014, April). Towards accurate and practical predictive models of active-vision-based visual search. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 3875-3884). ACM.

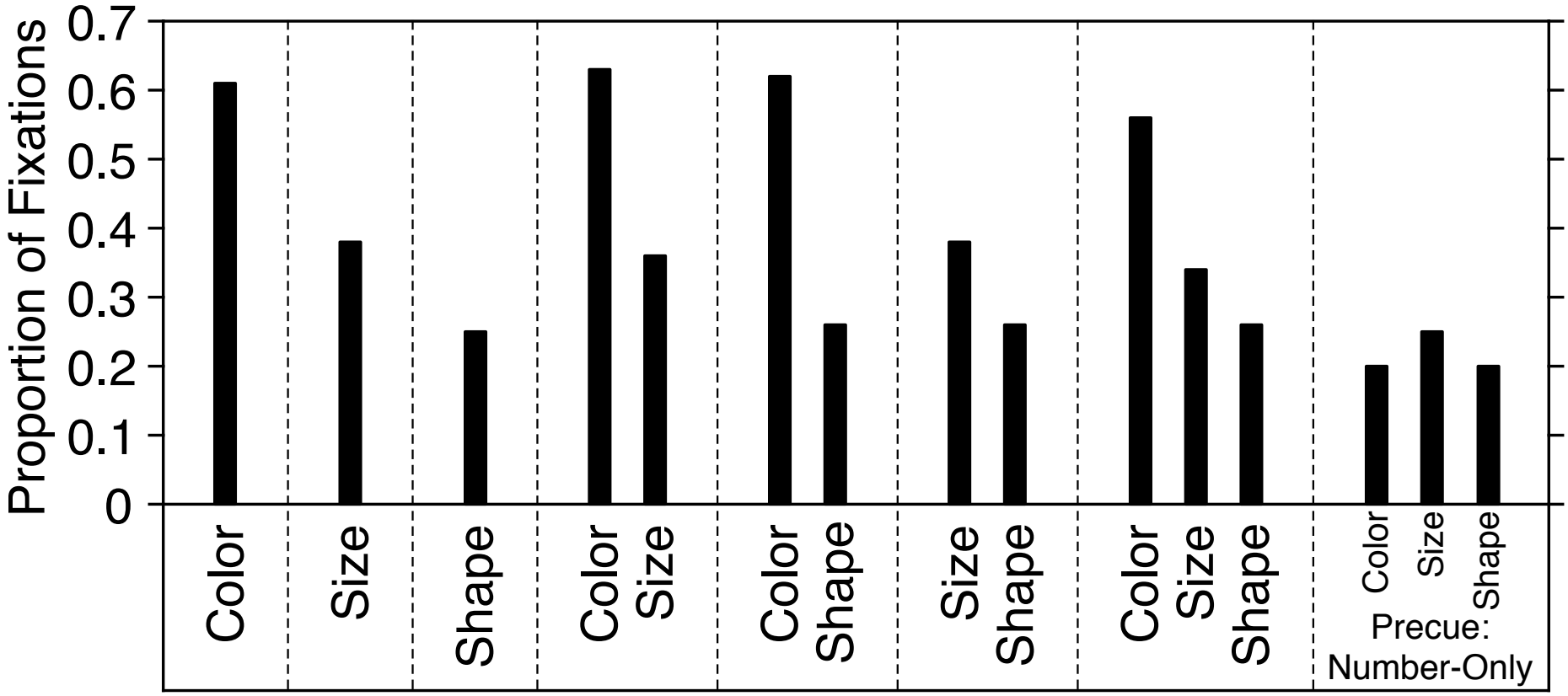
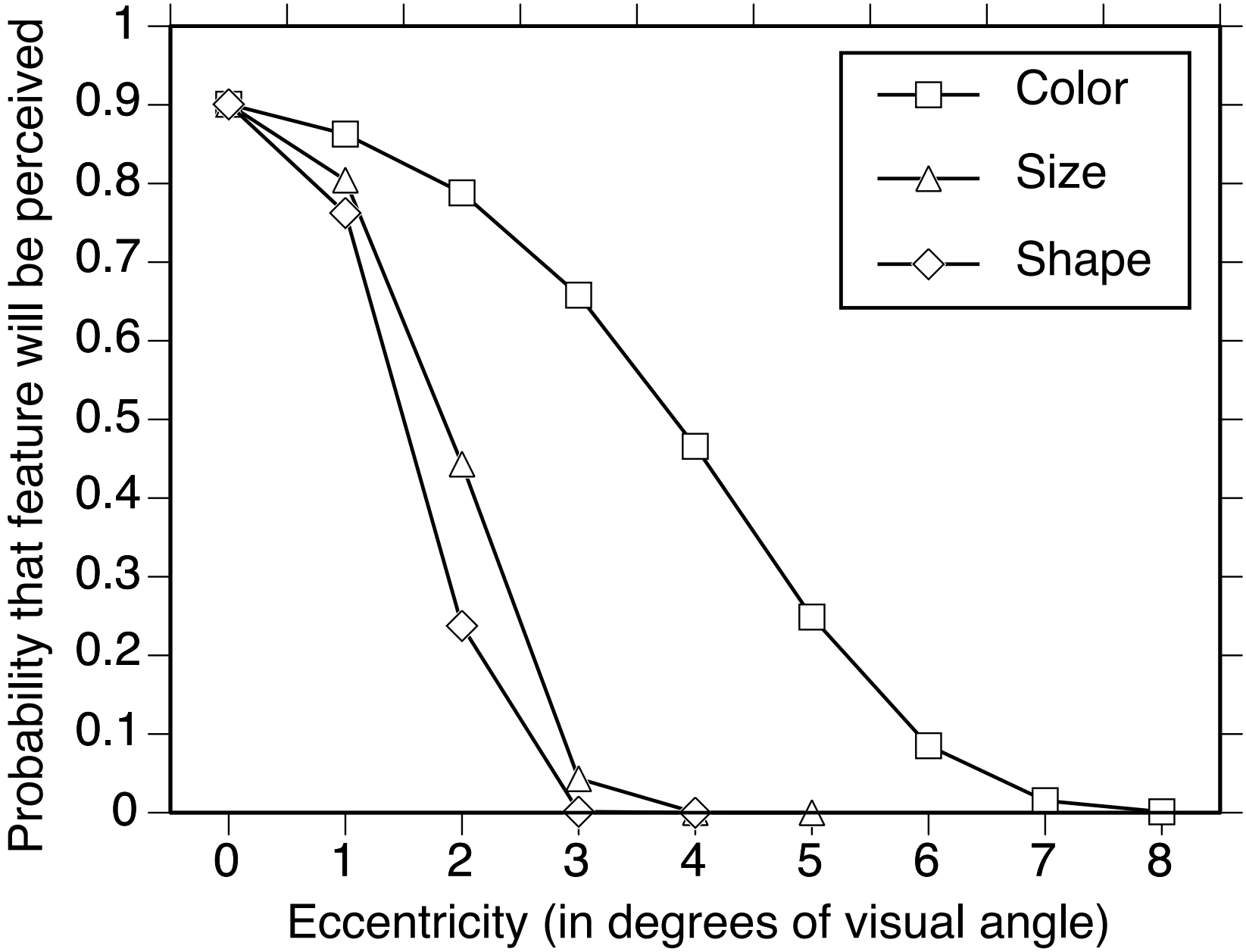


Figure 4. The proportion of fixations landing on objects with the features specified in the precue, for the eight precue types.

Kieras, D. E., & Hornof, A. J. (2014, April). Towards accurate and practical predictive models of active-vision-based visual search. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 3875-3884). ACM.

model

- Kieras and Hornof (2014) modelled these results.
- The model used an observation function that had a human-like acuity function.
- Reward and learning were not modelled.
- The model used a programmed strategy that prioritised targets according to the relative acuity of colour, shape and size.



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strategy

- prioritise colour, then size, then shape.
- in parallel:
  - saccade and fixate objects according to the priority.
  - monitor fixated objects and terminate when target found.

Strategy

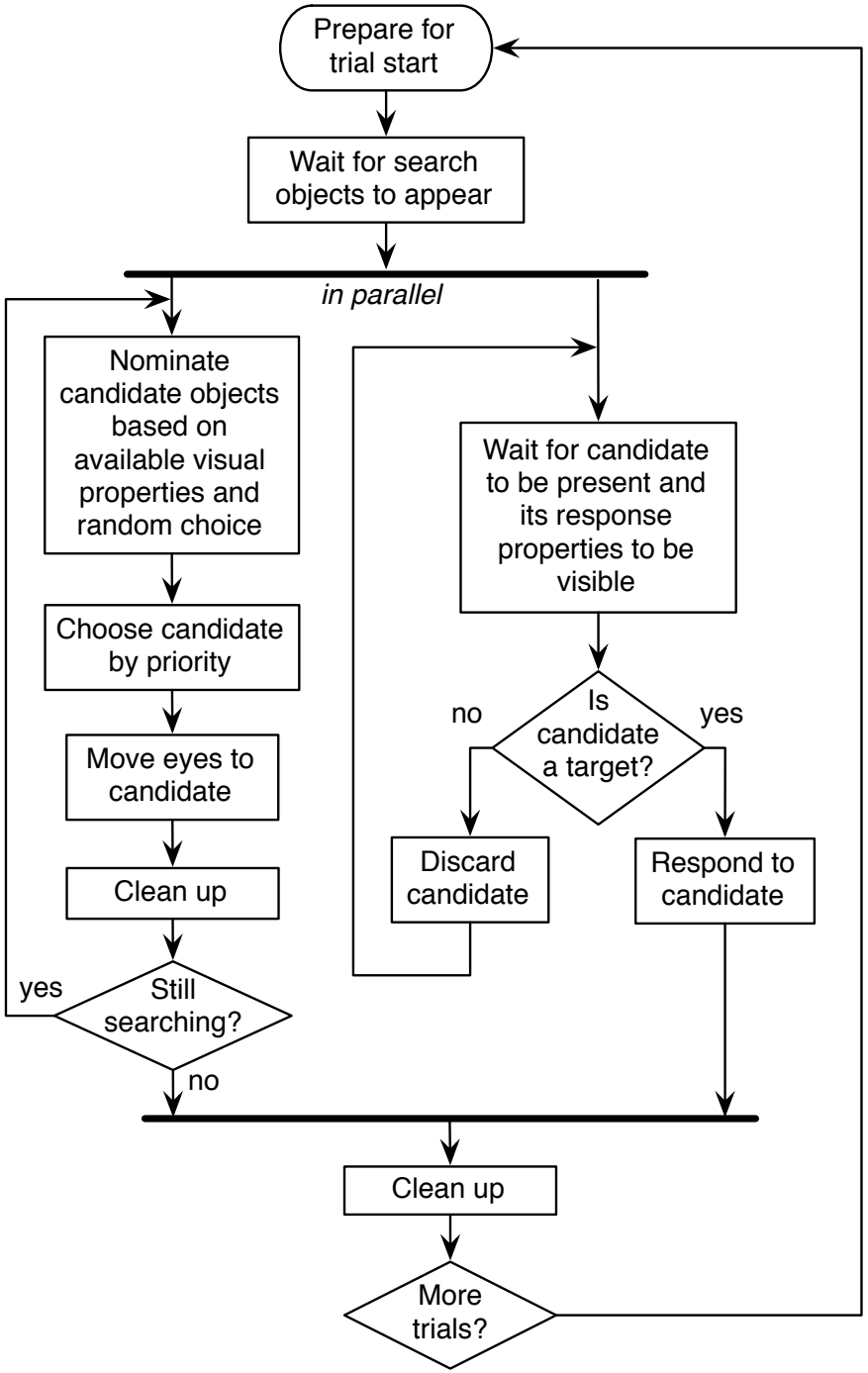

Figure 8. Flowchart for the search task strategy.

Kieras, D. E., & Hornof, A. J. (2014, April). Towards accurate and practical predictive models of active-vision-based visual search. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 3875-3884). ACM.

Exercise

- The implication is NOT that red icons will stand out more.
- What is the implication?

Exercise: Explain how people use visual search to use icons

Exercise

- Given what you have learned about visual search, how would you write a heuristic (a rule) to help designers?
- How might the icons on your smartphone be improved? How would you use colour, shape and size?
- What else would you like to know about human visual search in order to help design?

https://www.youtube.com/watch?v=xfvLpyHDAx4

Further exercise

- How would you design an augmented reality system for driving?

Reading

- Rayner, K (1998). Eye Movements in Reading and Information Processing: 20 Years of Research. *Psychological Bulletin*, vol. 124, pp. 372–422.
- Kieras, D. E., & Hornof, A. J. (2014). Towards accurate and practical predictive models of active-vision-based visual search. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 3875-3884). ACM.
- Advanced:
  - Butko, N. J., & Movellan, J. R. (2009, June). Optimal scanning for faster object detection. In *Computer vision and pattern recognition*, 2009. cvpr 2009. ieee conference on (pp. 2751-2758). IEEE.