IAT 814
Knowledge Visualization

Visual Attention

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Why we care

…in an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it.

--Herbert A. Simon

Designing Organizations for an Information-Rich World", in Martin Greenberger, Computers, Communication, and the Public Interest, Baltimore, MD: The Johns Hopkins Press. 19171

Attention

- Attention is the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things
  - Comprises a range of cognitive and perceptual processes
- top-down or bottom-up
  - Top down :“cognitive”,voluntary
  - Bottom-up :“perceptual”, involuntary

These processes interact, but there are distinct models for each that are relevant to visualization design

Recall: pre-attentive and pop-out

- Attention is both a high-level and a low-level property of vision
  - Most of the time we are not “paying attention”

- The eye as information-gathering searchlight, sweeping the visual world
  - We can “parse” between 4-12 items in each fixation
  - Low-level mechanisms help us understand what is readily available to attention
  - How to make information visually distinct - to stand out

Recap : bottom-up attention (pre-attentive)

- Some features are processed efficiently, possibly in parallel, across the visual field
  - color, orientation, shapes, motion.
- Search for items based on single features leads to efficient search
  - "pop out" from surrounding distractors.
  - Search for conjunction of features is inefficient.
- searching for a red square among blue squares and red triangles
  - We must examine each item individually to find the target.

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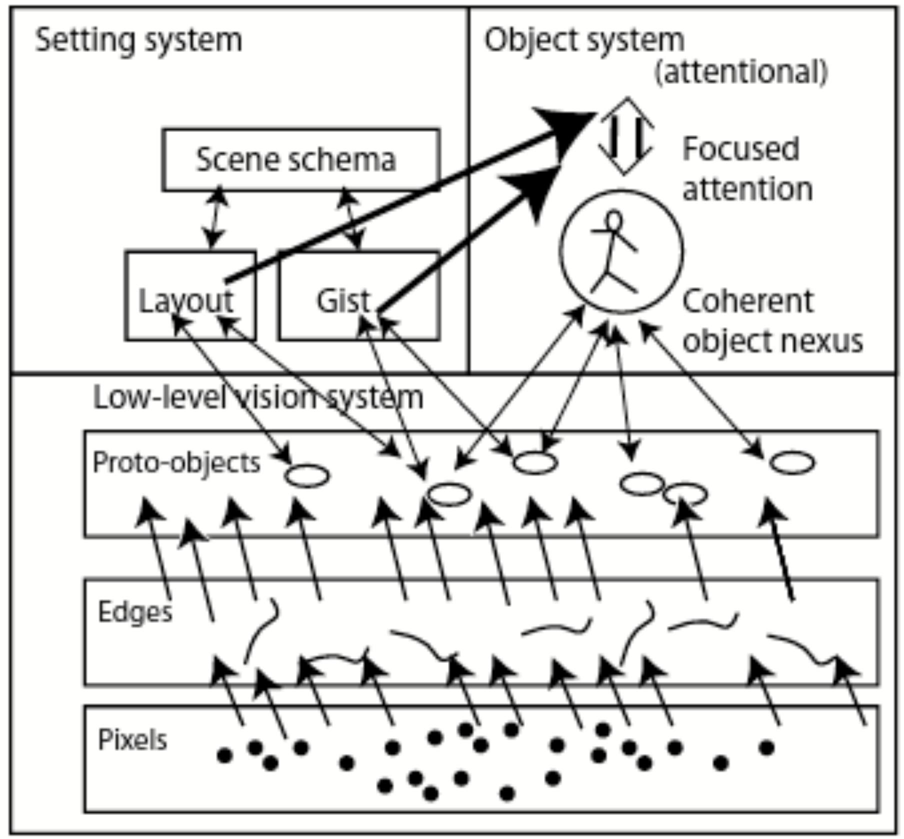
What this tells us

- Inefficient searches show that we are not aware of everything in the entire scene at the same time.
- We constantly shift our gaze and our attention to look at different parts of the scene and examine them in detail.
- We think we see the scene in detail, but we don't.

Implications?

- Rensink's model



Managing attention

"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...It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state."

- William James (1890, p. 403)

A Game Challenge

- Two teams: white and black shirts
- Each team passes a ball
- Count how many times the white-shirt team passes
- You need to be very focused to get it right.

Inattentional blindness

- Discussion: what are the practical implications of this for everyday life?

Inattentional blindness [Simons,1997-]

- Phenomena of inability to perceive features in a visual scene if they are not being attended to.
  - www.simonslab.com
- Are there only some kinds of things we see when we are not attending?
- What is the relationship between attention and perception?
- How much, if anything, of our (visual) world do we perceive when we are not attending to it?

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And just in case you are not convinced ..

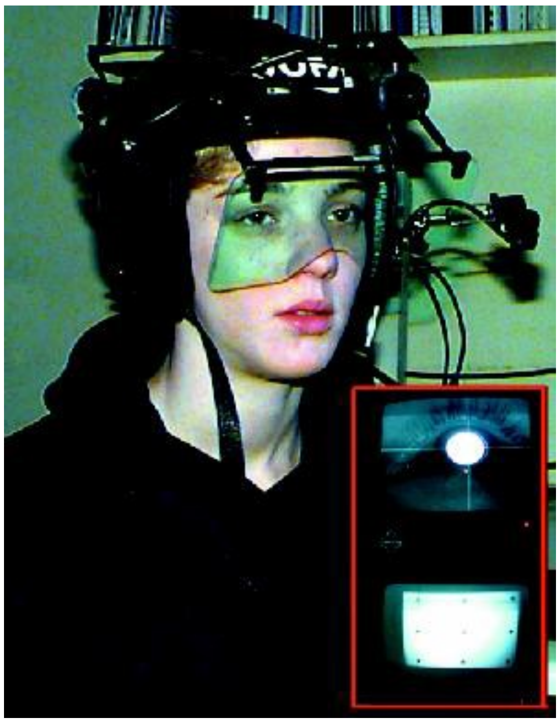
Main models in attention research

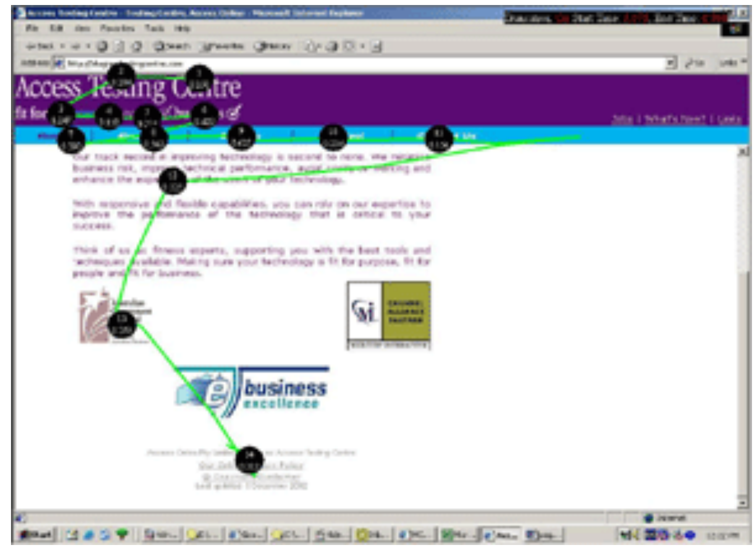
- Selective attention (focused):
  - Whether we become aware of sensory information
  - Non-random selection
  - Stream/bottleneck model

- Divided Attention (multitasking)
  - Attention can be split between multiple tasks
  - Allocation approach
  - Is what some of you are doing right now

- Control and Automaticity

Selective Attention





- Spotlight model
- Eye movements/fixation

Divided attention

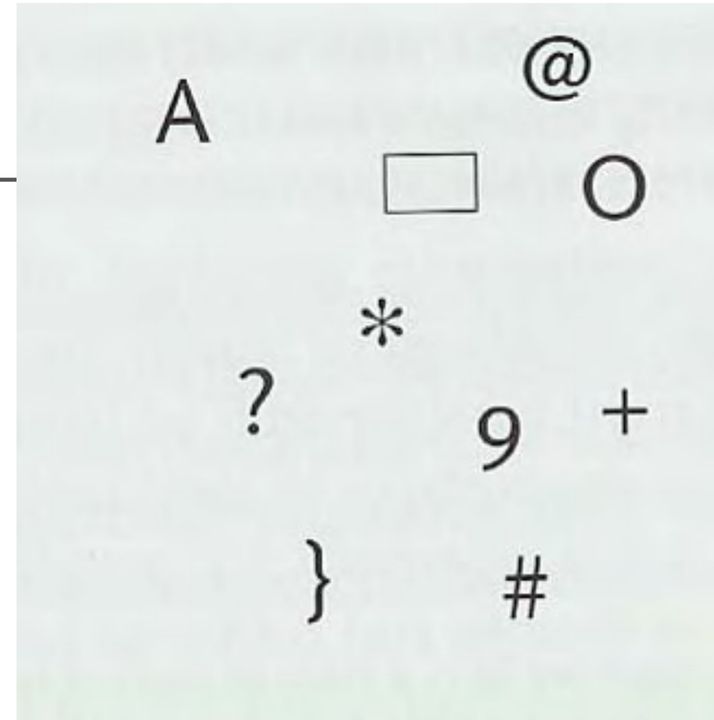
- More recent models of attention as a resource that is allocated between processes
- Top-down, consciously driven “spotlight” set: focus of attention
  - How many foci can we maintain?
  - What kinds of tasks demand more resources than others?
- Bottom-up, stimulus driven “demand” events
  - Involuntary response to perceptual cue
  - Flashing light or alarm bell
- How much can we attend to? No established capacity

Conscious attention and restricted awareness

- Can we be conscious of things without attending to them?
- Are there only some kinds of things we see when we are not attending?
- If we don't have a highly salient cue of some kind, we will miss changes in the world
  - Motion
  - Sound
  - sensation

buffer

- How many of these symbols can you remember after a glimpse 1/10 second long?

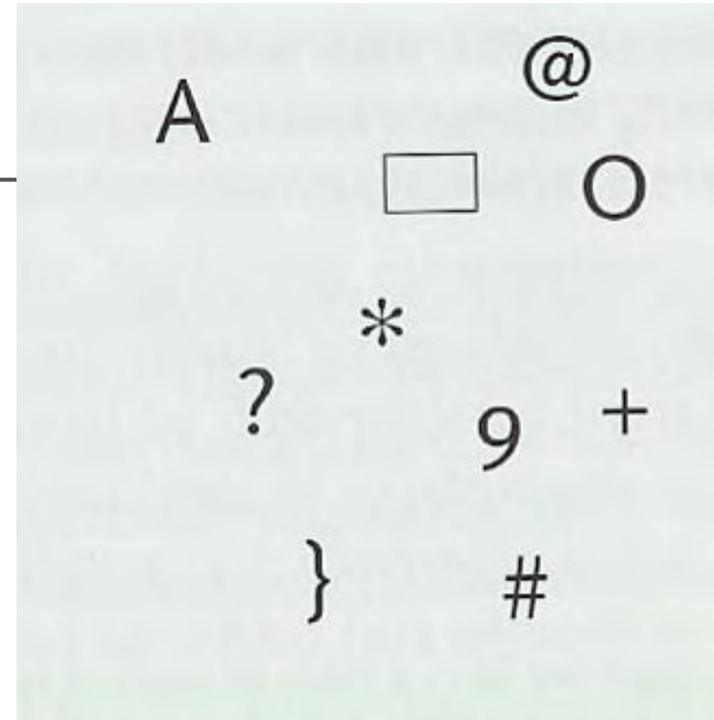


Ware, C. Information Visualization: Perception for Design. Elsevier, 2004. P 149.

Iconic buffer

- How many of these symbols can you remember after a glimpse 1/10 second long?
- Typically 3 -7 only

- Short-term (*iconic*) memory
  - Highly transient
- Visual working memory for symbolic analysis



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What this tells us

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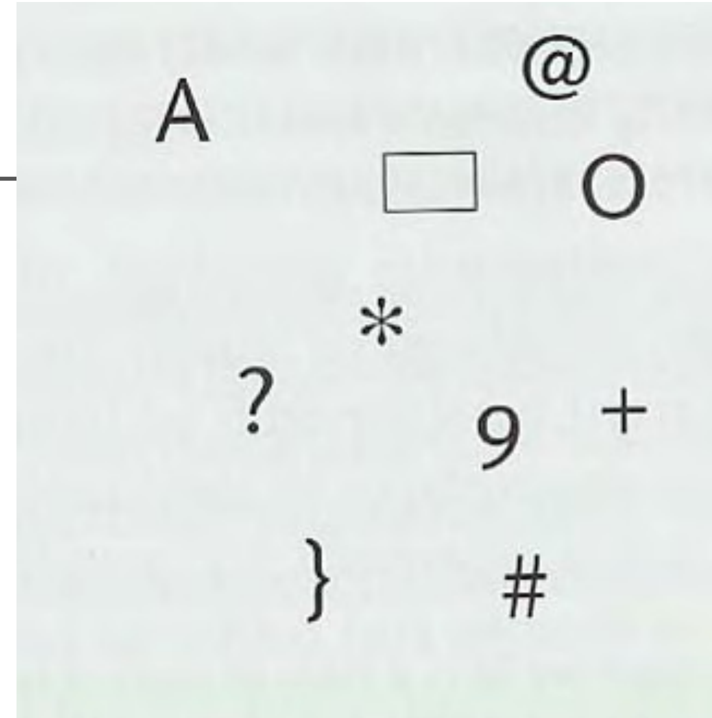

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- We are constantly making rapid eye movements, known as saccades, as we scan a scene.
- Vision is suppressed during saccades.
- People fail to notice large changes in the scene if the change occurs during a saccade. (McConkie, Grimes, Ballard and others).
- People also fail to notice large changes in the scene if they occur during a brief disruption (e.g. short blank period).
- This is known as ***change blindness***. (Rensink et al., 1996)

Change blindness

- Different from inattentional blindness
  - you don’t notice when things around you are altered to be drastically different than they were a moment ago.
- Because we remember so little, we miss changes to the display
  - Saccades
- To see an object change, it is necessary to **attend** to it
  - Examples: http://www2.psych.ubc.ca/~rensink/flicker/download/

- A cut between scenes, with a change in camera angle, can also induce change blindness.
  - http://www.simonslab.com/videos.html
  - Only 1 in 10 people detected a change.
- Change blindness occurs even for objects that are the center of attention:
  - http://www.simonslab.com/videos.html
  - Only 33% of 40 people noticed the main change.
- Disruptions in real life
  - http://www.simonslab.com/videos.html

What causes change blindness?

- don't see the entire scene in detail - only the region attended to
- We constantly shift our eyes to see other parts of the scene in detail.
  - Only attended regions get into short term memory.
- We must serially scan the picture, item by item, to find the one that is changing.
- Attention is not enough
  - We must intentionally process the details in order to detect the changes.

- A cut between scenes, with a change in camera angle, can also induce change blindness. Simons and Levin showed this in a series of experiments.
  - Movie task www.simonslab.com

- Change blindness occurs even for objects that are the center of attention
  - http://viscog.beckman.illinois.edu/grafs/demos/23.html
  - Only 33% of 40 people noticed the main change.
- Disruptions in real life can also lead to change blindness:
- http://viscog.beckman.uiuc.edu/grafs/demos/12.html

Automatic and controlled processing

Automatic processing (automaticity):

- Highly familiar and learned tasks
- Does not require conscious attention
- Occur without intention
- Not available for conscious inspection
- Well practiced responses
- Unaffected by capacity
- Fast
- Difficult to modify

- Driving a car and listening to the radio
- Reading and (not) listening to your partner

Controlled attention:

- Requires conscious attention
- Takes resources
- Limited capacity
- Not well practiced
- Slow

- Driving on the other side of the road
- Reading unfamiliar/rare words
- Listening to lyn lecture

Automaticity: the Stroop Effect

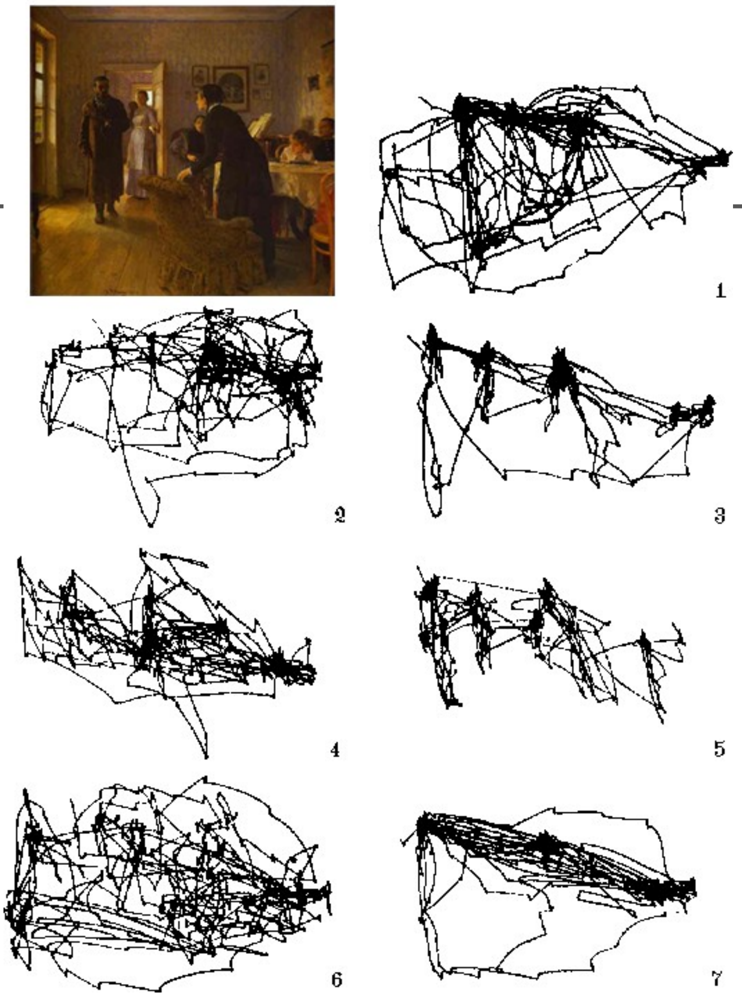
- blue green red yellow

- How to best represent information in a display so that a user finds relevant information?
- How best to avoid distraction?
  - Salience (how perceptually efficient and attractive it is)
  - Expectation (what and where I expect to see it)
  - Value/Pertinence (relates to emphasis)
  - Effort (how much work do I have to put in to find/see/decode it?)

Task-driven

Implication [Ward 07] –

if we don’t perceive parts of the scene what’s the point rendering it to such a high level of fidelity?!



The real-life nature of the issue

- CF-5 cockpit

The cell phone study

- Cell phone use in driving has been linked to 400% increase in accidents

- Assumptions: issue is interference due to handling the cell phone

BUT

- No reduction in accidents for those who used hands' free models.

- Why??

The cell phone study conclusion

- **conversation** is an automatic process

- During normal car conversations there will be lulls when the driver stops responding/talking because the road conditions require more attention
- The passenger is aware of the change in conditions and simply waits for the conversation to continue…

- A cell phone caller will increase the demands on the driver
  - “Hello? Are you still there? Can you hear me now?

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Factors affecting attention

- Stress
  - Environmental stressors
  - Noise, heat, light
- Physical conditions
  - Fatigue, impairment (e.g. blurred vision)
- Psychological factors
  - Fear, anger, boredom, excitement
- Optimal level of arousal
  - Performance deteriorates after it is reached
- Current level of demand
  - It’s not an unlimited resource!

Designing for attention

Two basic goals

1. Provide relevant information without overloading the user

2. Attract and engage the user's attention appropriately
   - Situation awareness

Designing for attention

represent information in a display so that a user finds relevant information

- avoid distraction
- Highlight

- Salience (how perceptually efficient and attractive it is)
- Expectation (what and where I expect to see it)
- Value/Pertinence (relates to emphasis)
- Effort (how much work do I have to put in to find/see/decode it?)

Three Specific Tasks

- Supervisory Control
- Target Search/Sampling
- Structured Visual Search

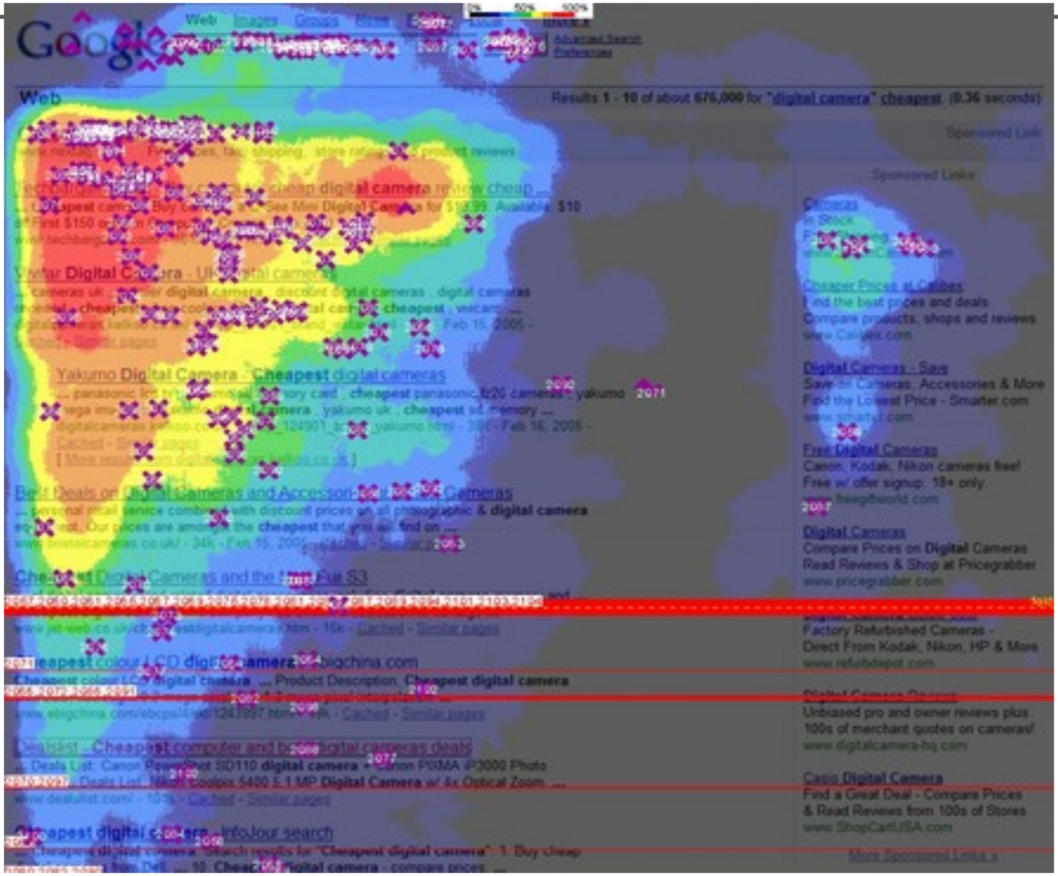
1. Visual supervisory control

Design Principles

- Visual scanning in info displays
  - monitoring (vigilance)
  - Situation awareness

1. Build on mental models
2. Consider direction of scanning and group components
3. Provide sampling reminders
4. Create expectation via preview
5. Reminders during failure
6. Do not use highly salient cues for low-priority events

2. Visual Target Detection



Design Strategies

1. Serial vs parallel search?
2. Order and conflation of dimensions
3. Guidelines for Target properties which will induce faster search

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Target Properties Inducing Parallel Search

- Discriminability from background elements
  - color, size, brightness, and motion
- Simplicity
  - Defined only by one dimension
  - No conjunctive search (look for the red square)
- Automaticity:
  - highly familiar

Design Principles

Visual target search in info displays

1. Leverage or train expectation
2. Use salience
3. Combine display & conceptually driven cues
   - Avoid singletons
   - Avoid edges
4. Consider effects of aging

3. Structured Visual Search

- Design structure of search
- Menus
- Minimize time to frequent targets
  - Top down
  - Linear search
  - Avoid similarity
- Speed is proportional to distance from top

Rapid Serial Visual Presentation