“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

Poster child for ICS

Turing Award in Computer Science in 1975

Nobel Prize in Economics in 1978

National Medal of Science in 1986

Lifetime Achievement Award in Psychology in 1993
Overview – Attention

- What is perceived and how it is interpreted depends heavily on the perceptual processes
- Substantial processing of perceptual input is built in (and thus automatic)
- Today: How to deal with all the potential information
  - can only handle limited information at a time
  - but can enlarge effective rate via switching & automaticity
Design Implications

- Visualizations should be designed knowing how visual attention works
- Take advantage of what the visual system does for “free”
- Ensure that what is central to the visualization is attended to

Attention & Effort

- Cognitive tasks take effort
- Have only a limited amount of effort to expend
- Often have to do multiple tasks
  - Switching
  - Automaticity

Attention Problem

- A tremendous amount of parallelism in perception systems
- But bottleneck exists in essentially all of them: can only attend to one thing at a time
- To interpret and recognize information, need to select
- **Attention**: what is perceived of what is sensed
  - Used to be viewed as mind/brain issue (what is made conscious)
  - But many things are unconsciously attended; seems to be a continuum

Fundamental Law of Attention

- Able to do only one thing at a time
- Limited parallelism at the level of selective attention
- But it seems like we can multi-task?
  - Rapid attention switching
  - Automaticity
Attention: Themes

- **Involuntary attention**
  - Our attention is drawn
  - Vision
    - Movement (especially in periphery)
    - Size
    - Color
    - Etc.
  - Audition
    - Loudness
    - Sudden onset
    - Etc.

Attention: Themes

- **Selective attention**
  - Orienting of sensors
    - Eye movements
    - Turning head to hear better
    - Etc.
  - Central selection
    - "Cocktail party" effect
    - Selecting from among what's presented to the senses

Visual “pop out”
Figure 11.2.21: An example of parallel search. The tilted line segments can be detected as quickly among 20 distractors as among 2, indicating a parallel search process.

Pop-out (texture)

Pop-out (more texture)
Pop-out (harder texture)

Pop-out (color)

Pop-out (color + texture)

Pop-out Performance vs. Distractors
Eye Movements

- Able to move eyes quickly, and hit targets effectively
- Used to be very expensive to measure
- Now – inexpensive, accurate eye trackers
Reading Example:
This person is reading the text for understanding. So even though not every word is fixated, the amount of time spent on each word is indicative of the processing of the word.

Skimming Example:
This person is skimming the text. This is most obvious from the pattern of fixations that are more dispersed and shorter fixation durations that is typical for this type of reading. The main gist maybe understood, but poorer memory for the text usually results.
Eye Movements

- Rapid ballistic movements – saccades
  - 30-120 msec.
  - Saccadic suppression
- Fixations – 200-600 msec.

- Jerry Lohse – eye movements over advertising material (yellow pages)

What influences people’s gaze?

- Size
- Color
- Graphics
- Position on page
- Font – bold better

Orienting the Sensors

- Eye movements
- Head movements
- Etc.
Central Selection

- Choosing among things at the level of the brain (not the peripheral sensors)
- So-called “cocktail party” phenomenon

Dichotic Listening Task

What’s Heard in the Unattended Channel

- Yes – gross physical characteristics
  - That it’s there
  - Male vs. female
- No – content
  - Language
  - Content
- Maybe – but on order of 25% of time
  - Own name
- Interesting – evidence for some level of processing
  - If message switches, can follow
Visual attention

- Neisser experiments

- Superimposed images
  - Track one
  - Cannot notice much in the other

Video

“inattentional blindness”
Adapting to bottleneck

- Basic principle: Can only attend to (approximately) one thing at a time
- How do we adapt to this constraint?
  - rapid attention switching
  - focusing perceptors
  - automating tasks so they do not require (much) attention
    - an important element of skill (e.g., piano)
    - pattern recognition (a learning problem)

Automaticity

- Automatic processing
  - Occurs without intention
  - Not subject to introspection
  - Uses few attentional resources
  - Happens very rapidly
- Controlled processes
  - Occurs with intention
  - Subject to introspection
  - Uses attentional resources
  - Happens relatively slowly

Automaticity: Stroop effect

Say the ink color:

- blue
- red
- green
- orange
- black
- yellow

blue
red
green
orange
black
yellow

Automaticity

- Results from extended practice
- Effortless processing
- Frees attentional resources for other levels of analysis
Implications of Attention

- How to use time
  - e-mail overload
  - attentional economics
- Interruptions
  - Function
  - How to manage
- Design
  - Use attention to achieve goals

Management of Interruptions

- Studies of frequency, characteristics
  - Outside interruptions
  - Self interruptions
  - Work is bursty – 10-15 minutes between interruptions
- Instrument the user
  - Can we automatically predict when interruptions will be OK
  - Economic models used to predict
    - Cost-benefit analysis

Distractions While Driving

- Kinds of distraction
  - Visual – looking elsewhere
  - Motor – hands off wheel
  - Central – mental focus shifts
- Sources
  - Cell phones
  - Eating & drinking
  - Talking to passenger
  - Grooming
  - Reading, including maps
  - PDA or GPS system
  - Watching video
  - Changing radio, CD, MP3
Cell Phones While Driving

- Cell phones distract attention
  - Slower reaction times to events
  - "makes a 20-year-old behave like an 80-year-old"
  - Equivalent to a blood alcohol level of .08
- Estimates of effects
  - Distraction
    - 5500 deaths in 2009
    - 448,000 injuries
  - Estimate – 20% of these were cell phones
  - Also traffic jams
- What is the problem?
  - Not motor behavior – hands-free no better
  - Cognitive distraction
    - Listening to radio, talking to passengers have smaller but similar effects

Summary

- Attention is a scarce resource
- Can do only one thing at a time
- Manage this limit via
  - Switching
  - Automaticity
- Design for characteristics of attention
- Emerging work – economic models of attention

Howard Rheingold, Virtual Community

- Rule Number One: Pay attention
- Rule Number Two: Pay attention to where you pay attention.