CPSC 599.28/601.28
Cognitive Perspective

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Introduction

• Supporting visual thinking
  – developing representations
  – comprehension
• some vision perception basics
• attention
• colour
• depth
References


Foveal vision

- size of a thumbnail at arms length
- Corresponds to a small high resolution area on the retina

http://www.cs.nyu.edu/~yap/visual/home/proj/foveation.html
Foveal vision

- size of a thumbnail at arms length
- Corresponds to a small high resolution area on the retina

http://svi.cps.utexas.edu/mpeg.shtml

Foveal vision

http://psy.ucsd.edu/~sanstis/SABlur.html
Foveal vision

http://psy.ucsd.edu/~sanstis/SABlur.html

Field of View

- Useful field of view varies with task
  - low character density - as wide as 15°
  - high character density - as narrow as 1° to 4°
Foveal vision

http://psy.ucsd.edu/~sanstis/SABlur.html

Saccades

- Fovea gives small high resolution images
- Saccades do rapid scanning
- Brain assembles
- Vision perceived as continuous

http://vision.arc.nasa.gov/personnel/jbm/home/projects/osa98/osa98.html
Eye movements

- Saccadic movements
  - eye moves rapidly from fixation to fixation
  - dwell period 200 to 600 msec
  - saccade takes 20 to 100 msec
  - peak velocity can be 900 deg/sec
  - *ballistic* - cannot be adjusted mid saccade
  - saccadic suppression - less sensitive visually during a saccade

- smooth-pursuit movements
  - ability to ‘lock-on’ to a smoothly moving object
  - enables head and/or body movements while maintaining visual contact

- convergent movements
  - towards - eyes converge
  - away - eyes diverge

- accommodation
  - new target - refocus - 200 msec
  - convergence and accommodation neurologically coupled

Psychophysical Measurement

- Just noticeable difference (JND)

- Increment where human notices change

- Average to create subjective scale
Non-linear perception of magnitudes

Sensory modalities
NOT equally discriminable

Steven’s Power Law
$$I = S^p$$

[Stevens, On the theory of scales of measurement, Science 103:2684, 1946]

Field of View
Affected by motion
- appearance
- motion
Change Blindness

- some times changes are not perceived
http://viscog.beckman.uiuc.edu/djs_lab/demos.html

http://www.psych.ubc.ca/~rensink/

Rensink, Ronald A.; O'Regan, J. Kevin & Clark, James J. (1997), To see or not to see: the need for attention to perceive changes in scenes, Psychological Science 8 (5): 368-373.


Light and Objects

- objects reflect light
- luminance
  - black paper in sunlight vs. white paper in indoor lighting conditions
- eyes and photometers - we see differences not absolutes (this is similar to many sensory systems)
Human Perception and Light

- Difference Signaling
  - Contrast vs. value information
  - Light value information vs. object information.
- cell has normal rate
  - light in centre excites
  - light in surrounds inhibits
Consequences

• Hermann Grid Illusion

Consequences

• Scintillating Grid
Consequences

- Grating Induction Effect

Consequences

- Mach Banding
Consequences

- Chevreul Illusion

Consequences

- Crispening
Consequences

- Craik-Cornsweet Effect

Seurat: The Bathers

- Craik-Cornsweet Effect
CS Applications

- CRTs
  - Loss of texture
  - CRT as its own illumination source
  - \( L = V^\gamma \)
    - Counteract Brightness = Luminance^n
    - Gives linear increase with voltage
  - Other light sources confusing, but necessary.

Lightness/Brightness summary

- Encoding of Information in greyscale
  - Perception may not be as expected
- C. Ware’s advice - often better ways to encode information than to use a greyscale
- The human eye is not a photometer, and should not be treated as such
- Understanding how the eye does work can help us avoid problems that might arise
Overview for Attention

- eye movements
- searching
- neural processing
- information density
- information coding
- applications

Reading and short term memory

- How many symbols can you remember?

- Usually about 7
- 7+ or - 2
- short term memory
**Pre-attentive processing**

![Pre-attentive processing diagram](image-url)

- **Number of distracters**
  - 1000
  - 250
  - 750
  - 500
  - 250

- **Response time (milliseconds)**
  - 3
  - 6
  - 9
  - 12

- **Typical results**
  - **Non-pre-attentive**
  - **Pre-attentive**

![Diagram showing response times and number of distracters](image-url)
Pre-attentive processing

• Features thought to be pre-attentive
  • form
    – line orientation
    – line length
    – line width
    – line collinearity
    – size
    – curvature
    – spatial grouping
    – added marks
    – numerosity
  • colour
    – hue
    – intensity
  • spatial position
    – 2d position
    – stereoscopic depth
    – convex/concave from shading
  • motion
    – flicker
    – direction of motion
Pre-attentive processing

- value
- enclosure
- convex/concave

- addition
- Juncture ??
- Parallelism ??

Pre-attentive processing

- depth
- Length/width
- closure
- lighting direction

- terminators
- density
- intensity
- intersection

http://www.csc.ncsu.edu/faculty/healey/PP/
Pre-attentive processing

3D orientation

Artistic effects

Pre-attentive processing

velocity  direction  flicker
Pre-attentive processing

- Colour

Pre-attentive processing

- Conjunction search
- Colour and shape
Pre-attentive processing

- generalizations
- which dominates seems to vary with degree of ‘separation’
- adding is ‘better’ than taking away
- to be pre-attentive a colour needs to be ‘outside’ the boundary of the region defined by the other colours in the display

Linewidth

Telecommunications traffic flow map

- Mappa.mundi.net/maps/maps_014/telegeography.html
Position: best for all data types

### Quantitative
- Position
- Length
- Angle
- Slope
- Area
- Volume
- Density
- Saturation
- Hue
- Texture
- Connection
- Containment
- Shape

### Ordinal
- Position
- Density
- Saturation
- Hue
- Texture
- Connection
- Containment
- Length
- Angle
- Slope
- Area
- Volume
- Shape

### Nominal
- Position
- Hue
- Texture
- Connection
- Containment
- Density
- Saturation
- Shape
- Length
- Angle
- Slope
- Area
- Volume

Mackinlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986

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For quantitative data

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<th>Mackinlay</th>
<th>Cleveland</th>
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<td>position</td>
<td>position along common scale</td>
</tr>
<tr>
<td>length</td>
<td>position along nonaligned scales</td>
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<tr>
<td>angle</td>
<td>length, direction, angle</td>
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<td>slope</td>
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<tr>
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<td>area</td>
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<tr>
<td>volume</td>
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<td>shading, color saturation</td>
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</tr>
<tr>
<td>shape</td>
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</table>
Weber’s Law

For a noticeable difference the ratio of background to change remains constant

$$\frac{\Delta I}{I} = K$$

Frames can increase accuracy

Similar to Ware’s adaptation of Nakayama et al.