Introduction

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

  [http://www.personal.psu.edu/faculty/c/a/cab38/ColorSch/ASApaper.html](http://www.personal.psu.edu/faculty/c/a/cab38/ColorSch/ASApaper.html)

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](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

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

\[ I = S^p \]

Field of View

Affected by motion

- appearance
- motion

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

- some times changes are not perceived
  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

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 works 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

2358945739756860796752453512346534624356245762457245
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7346987461435895321456865437
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

- **Orientation**: curved/straight
- **Shape**: convex/concave
- **Enclosure**: addition
- **Parallelism**: Juncture
- **Value**: convex/concave
- **Number**: Parallelism

**Examples**:
- Orientation: curved/straight
- Shape: convex/concave
- Enclosure: addition
- Parallelism: Juncture
- Value: convex/concave
- Number: 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

- Colour
- Shape
- Velocity
- Direction
- Flicker
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

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

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Frames can increase accuracy

Similar to Ware’s adaptation of Nakayama et al.
Gestalt Principles: perception

- Based on visual gestalt (perception of ‘wholeness’)
- Descriptive rather than explanatory

Proximity
Similarity
Continuity (connectedness)
Closure
Figure/ground
Symmetry
Common fate (things moving together)

Information Visualization: Perception for Design.
Ware, Morgan Kaufmann, 2000
Gestalt Principles: perception

- Based on visual gestalt (perception of ‘wholeness’)

Gestalt Principles

Proximity  Similarity

Information Visualization: Perception for Design.
Ware, Morgan Kaufmann, 2000
Gestalt Principles

- connectedness

Information Visualization: Perception for Design.
Ware, Morgan Kaufmann, 2000

Gestalt Principles

- Closure

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Ware, Morgan Kaufmann, 2000
Gestalt Principles

- Closure
- Overrules proximity, similarity

Information Visualization: Perception for Design.
Ware, Morgan Kaufmann, 2000

Gestalt Principles

- Symmetry
- Emphasizes relationships

Information Visualization: Perception for Design.
Ware, Morgan Kaufmann, 2000
Gestalt Principles

- Common fate
- [http://tepserver.ucsd.edu/~jlevin/gp/time-example-common-fate/](http://tepserver.ucsd.edu/~jlevin/gp/time-example-common-fate/)

Information Visualization: Perception for Design.
Ware, Morgan Kaufmann, 2000
Gestalt Principles

figure/ground

M. C. Escher print:
Study of the Regular Division of the Plane with Horsemen

http://www.illusionworks.com/
http://www.psychology.psych.ndsu.nodak.edu/mccourt/website/htdocs/HomePage/Projects/Brightness/Brightness%20Perception.htm

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