Lecture 2: The human vision system
Bottom line

• Use GIS or other mapping software to create map form, layout and to handle data
• Pass result to editing tools to use the design loop
• Better maps through:
  • knowledge
  • skill
  • experience
  • creativity
  • esthetics
  • understanding human vision

We’ll start here!
Human vision elements

• Physical
  • Stereo vision
  • Color/texture/shape
  • Granularity and resolution
  • Field of view

• Perceptual

• Cognitive/behavioral
The human eye
Eye/Brain combination
Homo sapiens vision evolution

• Visible light = 400-800 nm wavelengths
• Search—food, shelter
• Face recognition
• Identification in vegetation--green
• Threat recognition-fight or flight—1000 yard stare
• Motion detection-reaction
• Sense integration (sight, taste, touch, hearing, smell)
• Visual memory is particularly intense, and mostly unconscious
Field of View: Total about 120°
Top to bottom

Figure 11.17  Vertical Field of View
Overall
But, unequal qualities

At center
Max focus
2 retina holes
Stereo

Center to edge
Color
Contrast
Focus
Monocular
Motion sense
Depth perception

- depth cues
  - occlusion (strongest cue)
  - shadowing (light occlusion)
  - lighting (illumination)
  - perspective
  - texturing
  - stereopsis
  - depth of field/focus
  - motion and movement

- perceptual factors can be exploited for a 3D viewing experience or an ‘illusion’ of depth

Photo: A. Cotekin
In computer graphics

- Remove details not needed/cannot be rendered (e.g. culling), cannot be perceived
- Distance
- Size
- Priority
- Hysteresis
- Environments Conditions
- Perceptual factors, e.g. Eccentricity, Velocity, DoF
Depth perception

“virtual street reality”

Julian Beever
Depth perception

Julian Beever
Depth perception
Size depth cues

Depth perception
Stereo vision

- Input from 2 eyes only in part of vision
- Overlap processed in visual cortex
- Processing is perceptual, unconscious
- High speed (30 ms)
- Uses depth cues
- About 2° separation (low)
Stereoscopic depth perception

Differs from camera model
Image is rectangular, suffers from barrel distortion
Sensitive to separation
Stereoscopic viewing

This is a stereogram, hiding the text Florida 2010 created using www.flash-gear.com/stereo/
Stereoscopic viewing

Examples of stereoscopic visualization for terrain and topography

T. Sato and M. Nagaoka,
Geographical Survey Institute, Japan

For the 3D effect, you need to use red/blue glasses and view it in color
(i.e. black and white print will not work)
Texture

Pattern
Color
Contrast
Shadow
Depth
Material
Repetition
Orientation
Granularity
Regularity
Abstraction
Contrast
Granularity

• Human eye can resolve objects that are at least 0.1mm in size
• The size of a fine pencil dot
• 10 dots per millimeter equals 25.4 dots per inch
• At any given representative fraction, a scaled object transforms to a particular size
• Unless a decision is made on how to symbolize a feature, at some scale it will literally disappear from view! (Drop out)
• Relation between granularity and extent
Simplicity, Virginia at 150, 75, 37 and 18 dots per inch
Resolution

River Seine

Louvre

Notre Dame
Human vision elements

• Physical

• Perceptual
  • Focus
  • Gaze
  • Head and shoulder motion
  • Body motion
  • Image motion
  • Depth perception
  • Foveation

• Cognitive/behavioral
Vision and perception

• Physical vision to human
  • Eye strain
  • Lighting
  • Color blindness
  • Vision correction
  • Attention

• Eye to brain
  • Training and experience
  • Differs by FOV, stereo, contrast, etc

• Brain to memory
  • Familiarity
Saliency

Things that *pop out*

• Color
• Orientation
• Size
• Motion

• Visual variables

Ware 2008
Bertin’s six principal visual variables, as presented in “How to lie with maps” (Monmonier, 1991)

<table>
<thead>
<tr>
<th>Visual Variable</th>
<th>Point Symbols</th>
<th>Line Symbols</th>
<th>Area Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
<td><img src="image3" alt="Diagram" /></td>
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<tr>
<td>Shape</td>
<td><img src="image4" alt="Diagram" /></td>
<td><img src="image5" alt="Diagram" /></td>
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<td><img src="image11" alt="Diagram" /></td>
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<tr>
<td>Orientation</td>
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<td><img src="image14" alt="Diagram" /></td>
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<tr>
<td>Hue</td>
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<td><img src="image17" alt="Diagram" /></td>
<td><img src="image18" alt="Diagram" /></td>
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</tbody>
</table>

**FIGURE 2.11.** The six principal visual variables.
Ishihara Test For Color Blindness

<table>
<thead>
<tr>
<th>What People With Regular Vision See</th>
<th>What Red-Green Color Blind People See</th>
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</thead>
<tbody>
<tr>
<td><img src="image.png" alt="Image of Ishihara Test" /></td>
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<td>8</td>
<td></td>
</tr>
</tbody>
</table>
Context matters: The “white” letters are actually darker than the “black” letters (above), as is clear when surroundings are removed (inset).
Watercolor effect, in which the lighter of two colors seems to spread, shows how important color can be in delineating the extent and shape of a figure. The map of the Mediterranean Sea emerges at once when the tint that at first seems to cover the sea (top) spreads to the land area.
Fastest participant: 
~11 seconds, 25 fixations
Slowest participant: 
~521 seconds, 1181 fixations
Virtual and Augmented Reality

Foveation

Visual acuity directly related to human fovea

Around the fixation point only four to five letters are seen with 100% acuity.

Human Visual System’s level of detail management
Human vision elements

- Physical
- Perceptual

- Cognitive/behavioral
  - Detection, extraction and identification
  - Learning and recognition
  - Anticipation
  - Attention

selective attention: https://www.youtube.com/watch?v=vJG698U2Mvo
Cognitive load

- Learning and intellectual performance
  - Visual analytics, spatial thinking
- Types
  - Intrinsic e.g. simultaneous tasks
  - Extraneous e.g. distraction
  - Device/medium
- Biological and experimental measures
  - Task completion, performance, heart rate, blood pressure, pupil size ..
Visual Complexity

“The system that holds about three objects in attention at one time is called visual working memory.” Ware, 2008
Maps play two cognitive functions: Show and store
Usability Engineering

First Principles

(Johnson 2008)

Introduction

Basic Principle 1: Focus on the users and their tasks, not on the technology

Basic Principle 2: Consider function first, presentation later

Basic Principle 3: Conform to the users’ view of the task

Basic Principle 4: Design for the common case

Basic Principle 5: Don’t complicate the users’ task

Basic Principle 6: Facilitate learning

Basic Principle 7: Deliver information, not just data

Basic Principle 8: Design for responsiveness

Basic Principle 9: Try it out on users, then fix it!

“Users are not designers, designers are not users”

Nielsen, 1993
Summary

• Vision Factors
  • Physical
  • Perceptual
  • Cognitive/behavioral

• Cognitive engineering studies how cognition impacts design

• Maps must be readable (simple) but also store information

• Use these ideas in working on your GEOG 183 assignments and project