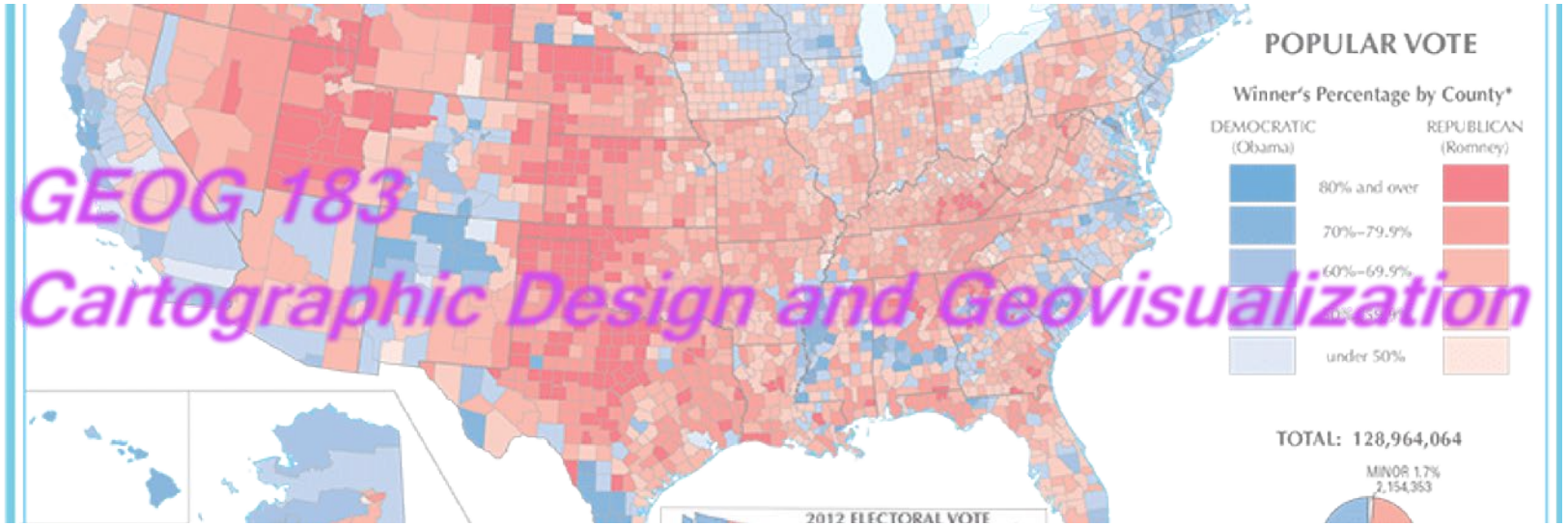


Geog183: Cartographic Design and Geovisualization Spring Quarter 2020

Lecture 2: The human vision system

Bottom line

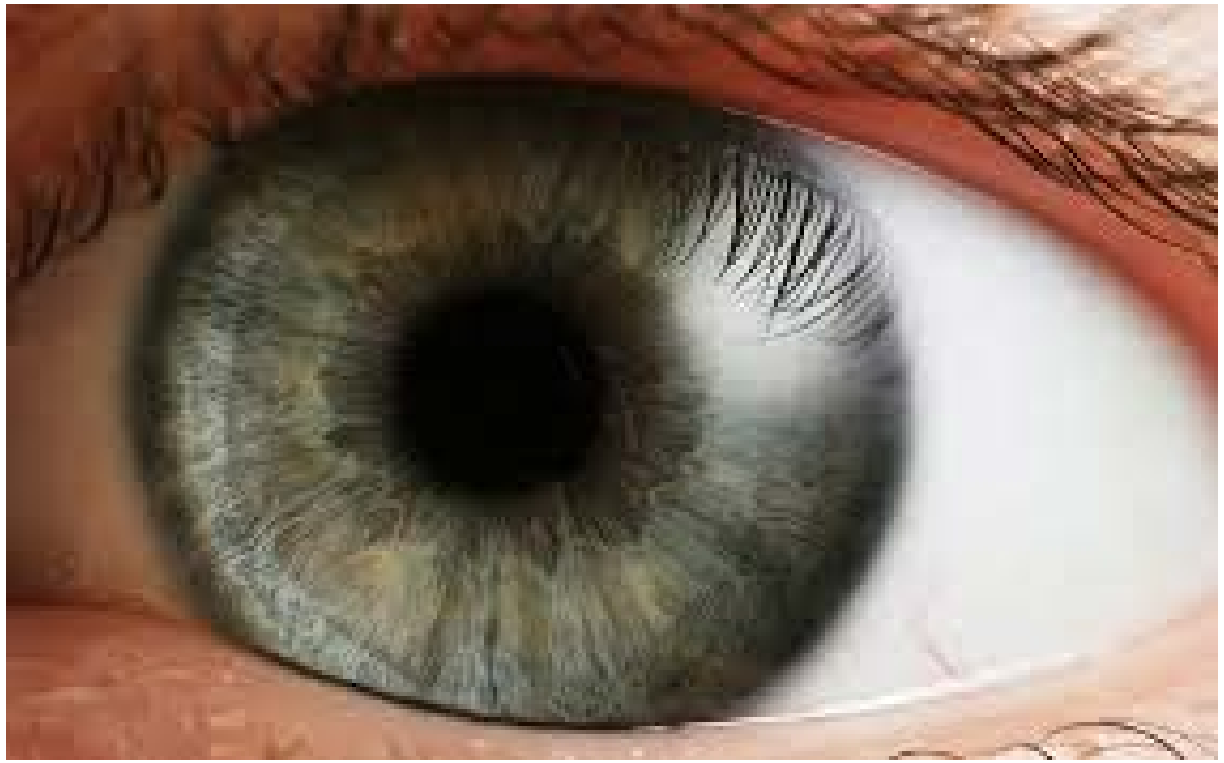
- Use GIS or other mapping software to create map form, layout and to handle data
- Pass result to editing tools to use the design loop
- Better maps through:
  - knowledge
  - skill
  - experience
  - creativity
  - esthetics
  - understanding human vision

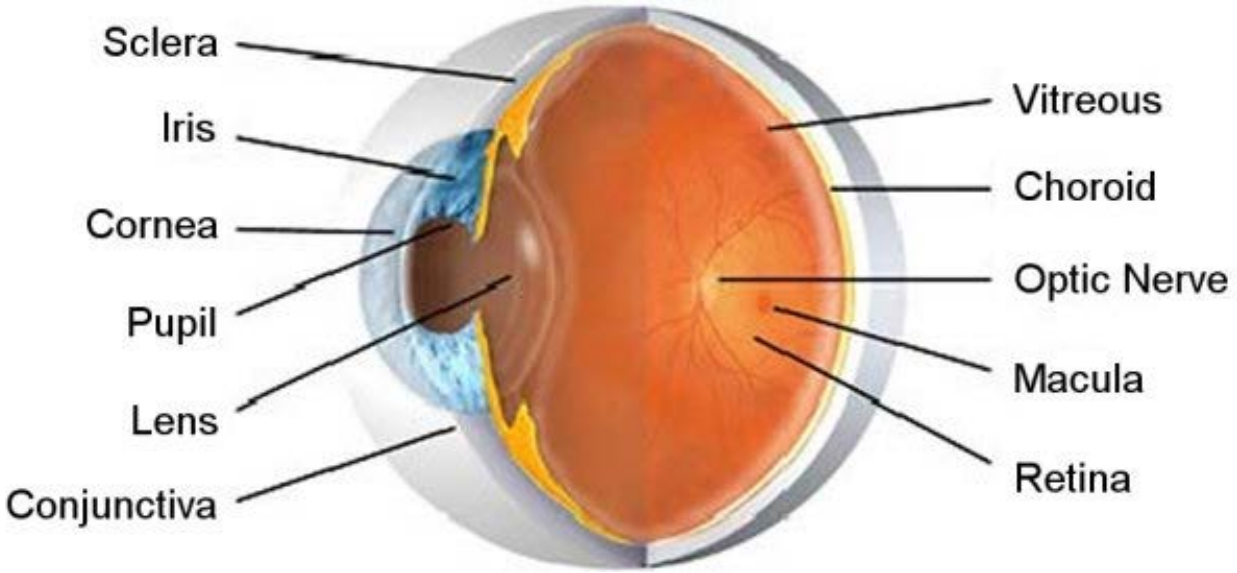
We'll start here!

Human vision elements

- Physical
  - Stereo vision
  - Color/texture/shape
  - Granularity and resolution
  - Field of view
- Perceptual
- Cognitive/behavioral

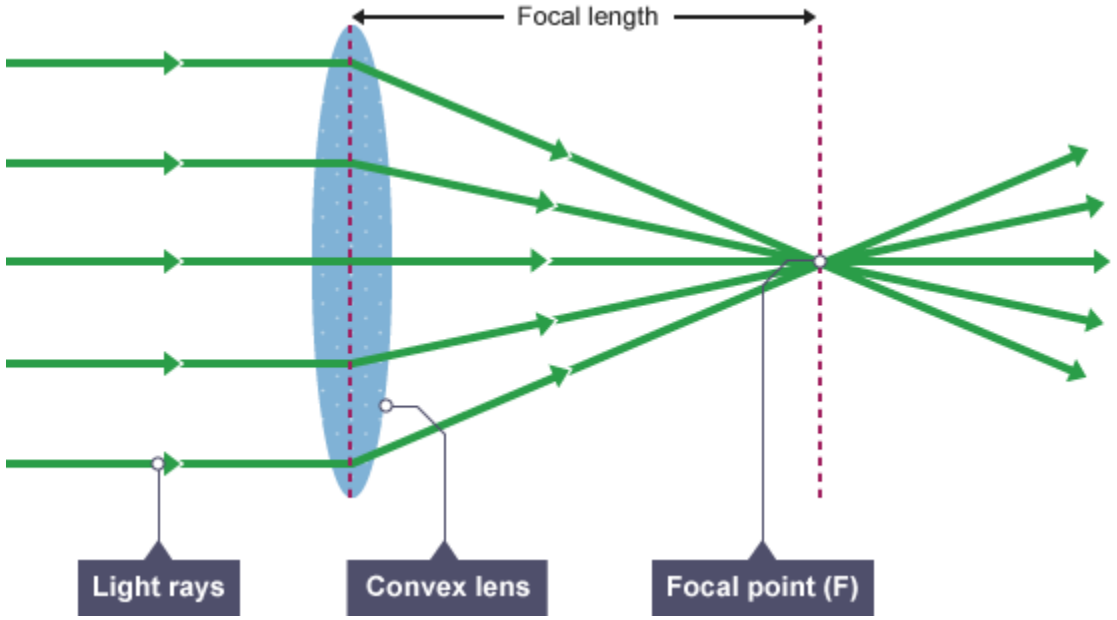
The human eye

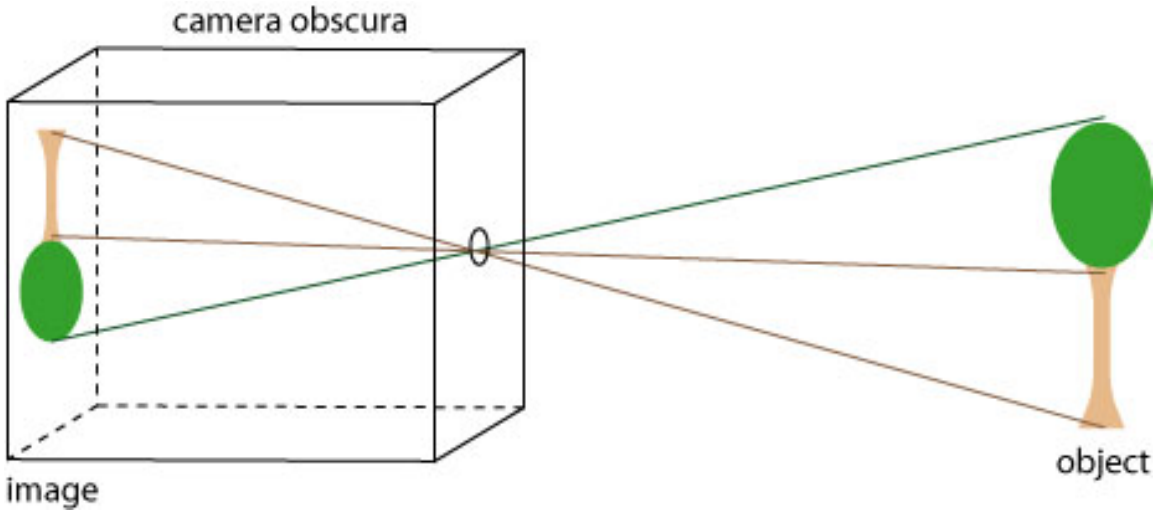




Optic nerve is at fovea
Eye can open/close and move
Eye lens is adjustable
Eyeball shape can adjust
Aperture also adjustable (dilates)

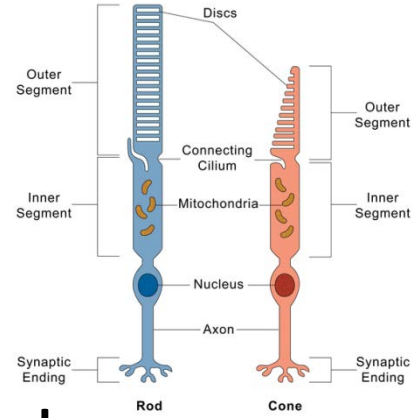
Camera model





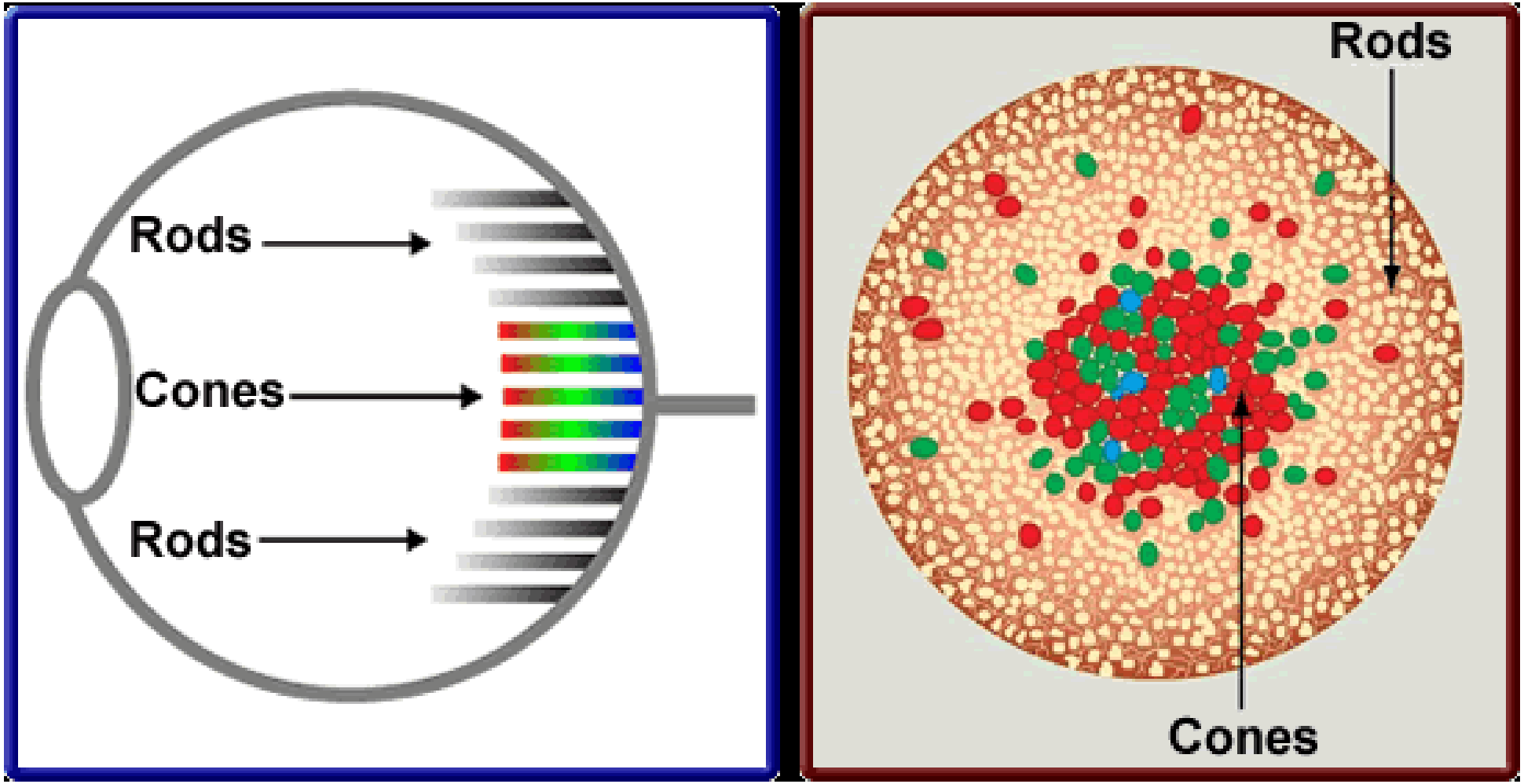
Aperture
Brightness
Depth of field

2 Types of photoreceptors in the human retina, rods and cones.

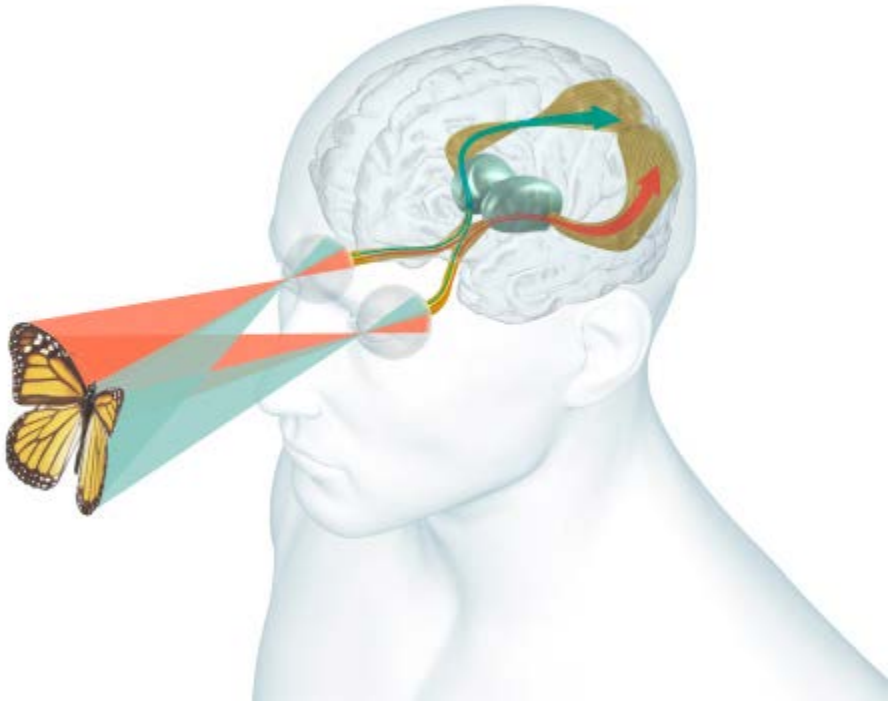


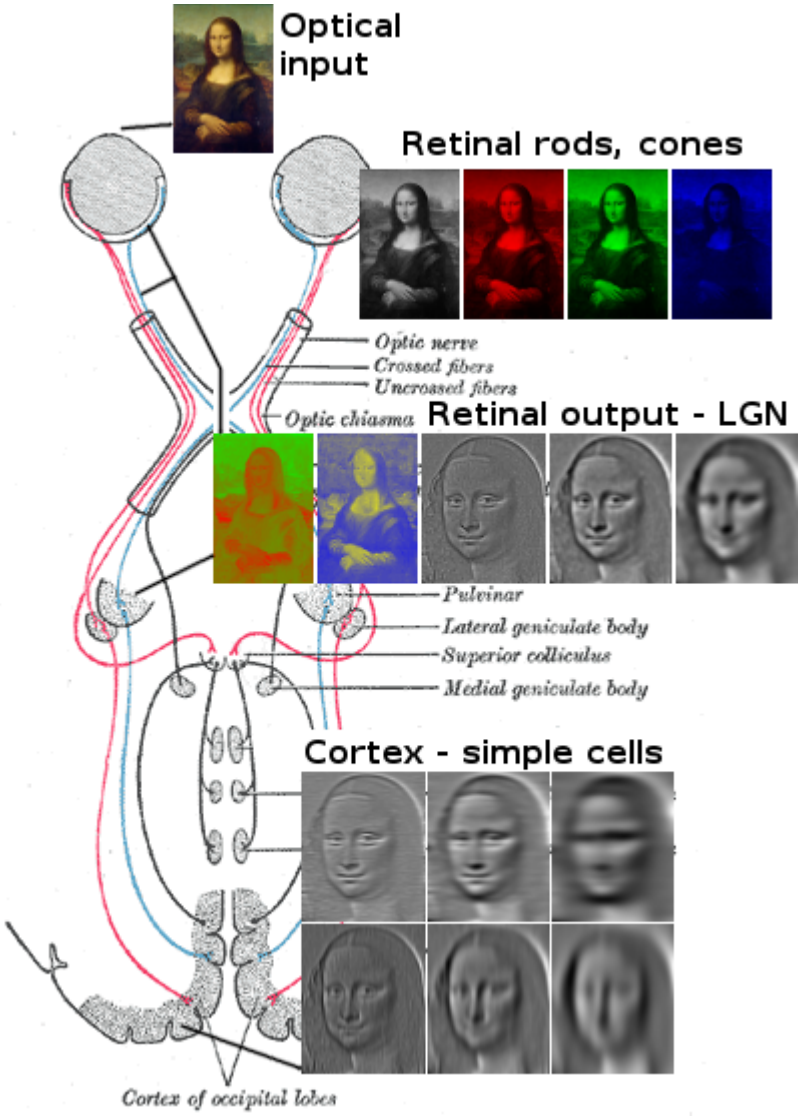
- Rods are responsible for vision at low light levels. Do not mediate color vision, and have a low spatial acuity.
- Cones are active at higher light levels, are capable of color vision and are responsible for high spatial acuity.
- The central fovea is populated exclusively by cones. There are 3 types of cones: short-wavelength sensitive cones, the middle-wavelength sensitive cones and the long-wavelength sensitive cones or S-cone, M-cones, and L-cones for short.
- Broadly corresponds to Red, Green and Blue

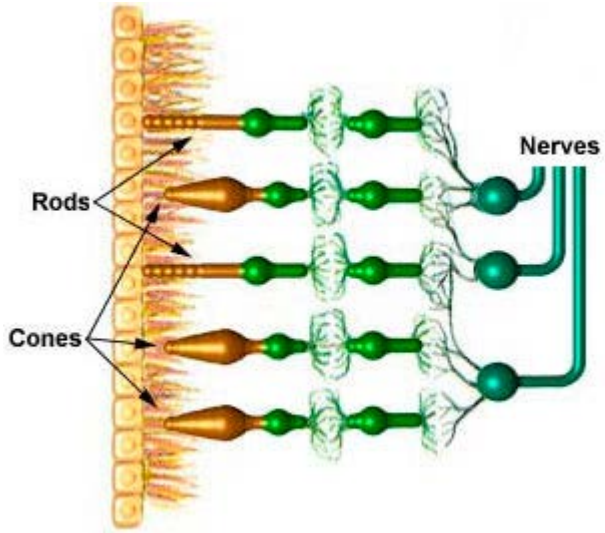
Distribution of rods and cones

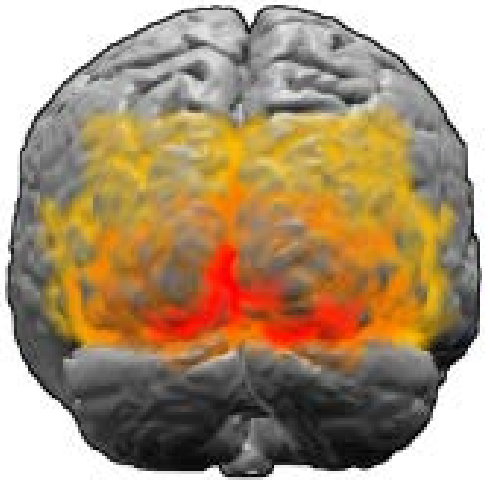


Eye/Brain combination: Visual cortex

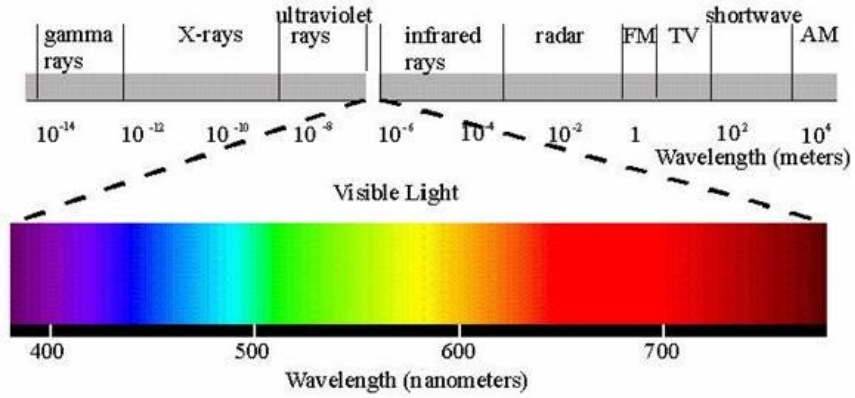






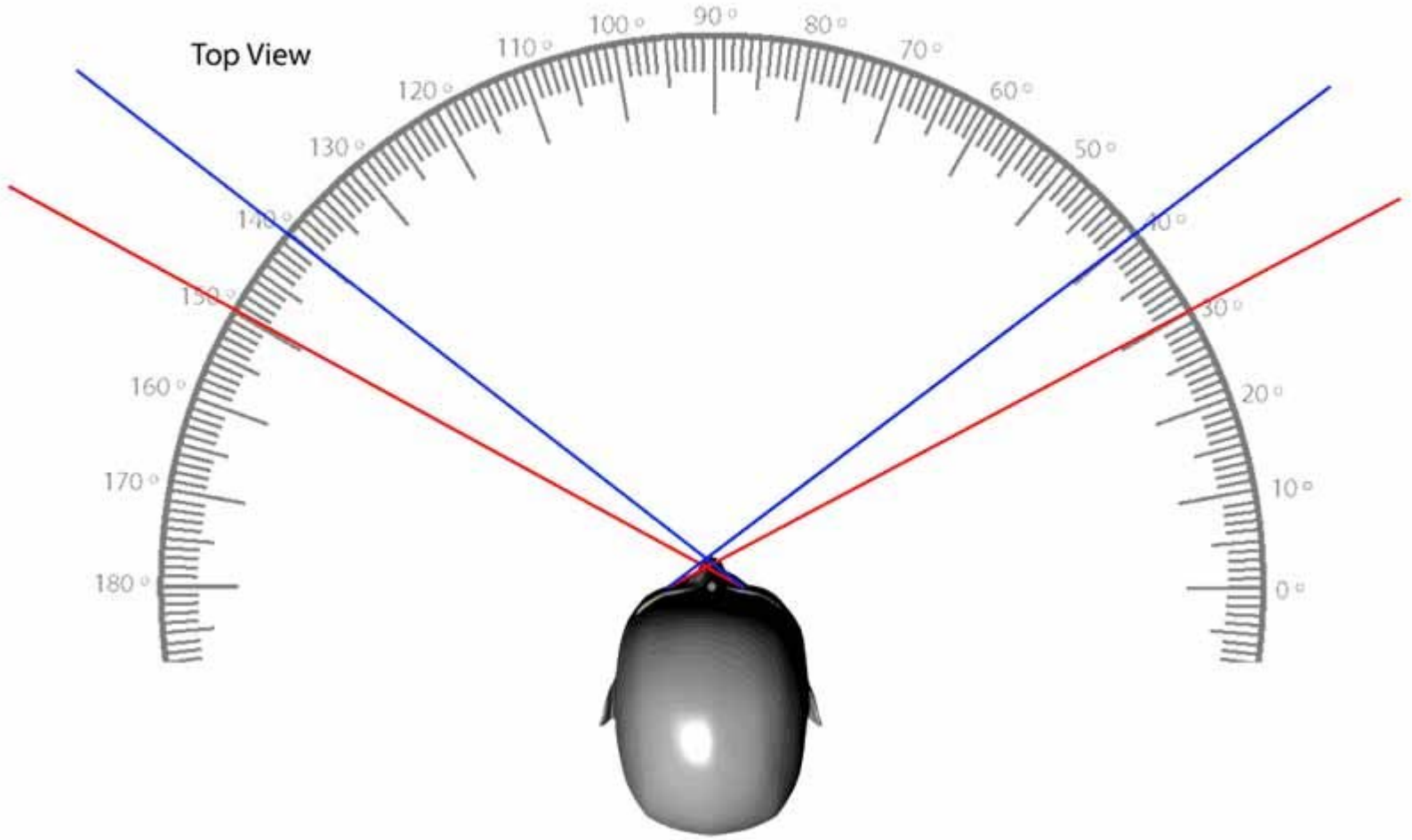


Homo sapiens vision evolution



- 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

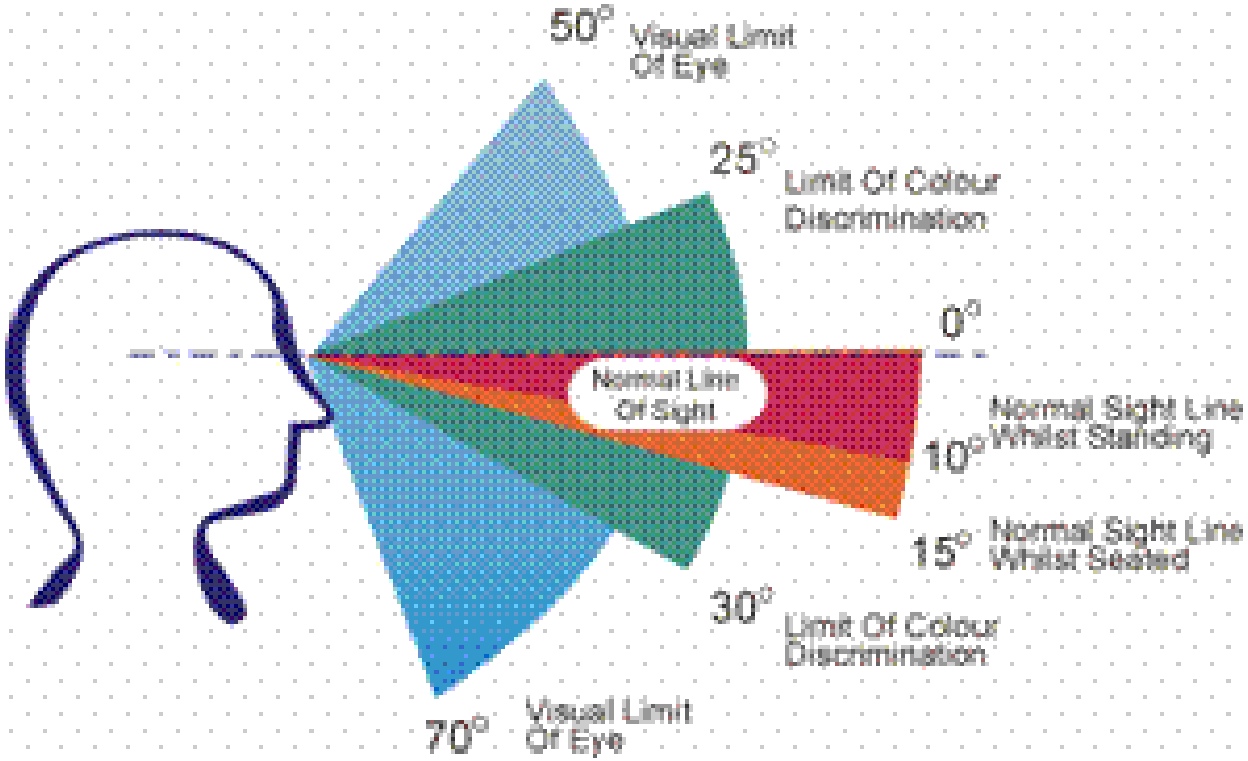
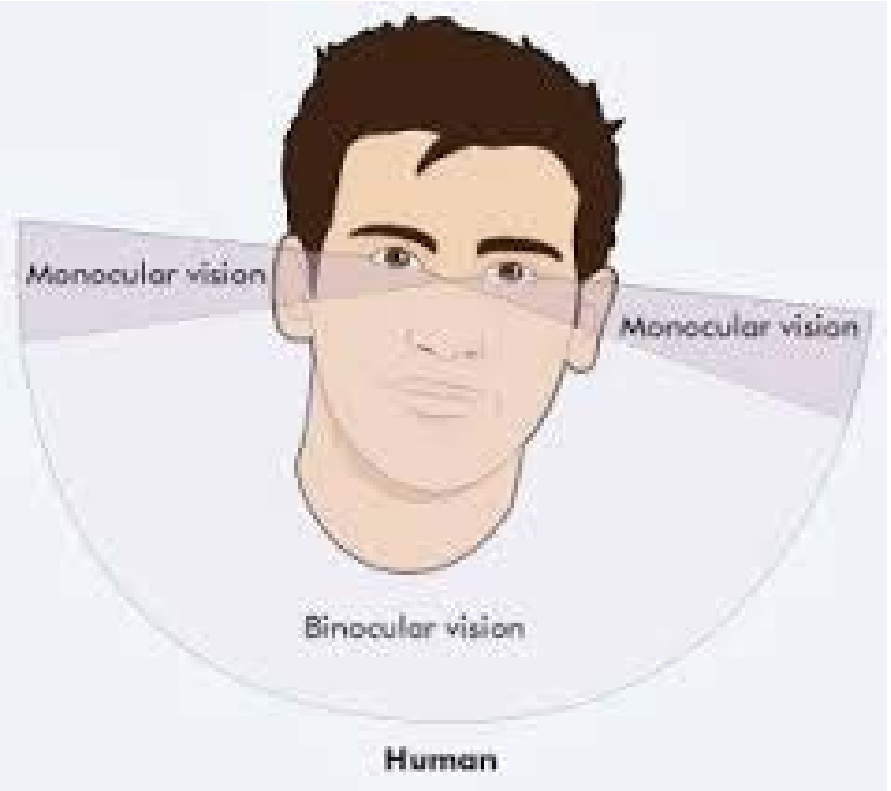
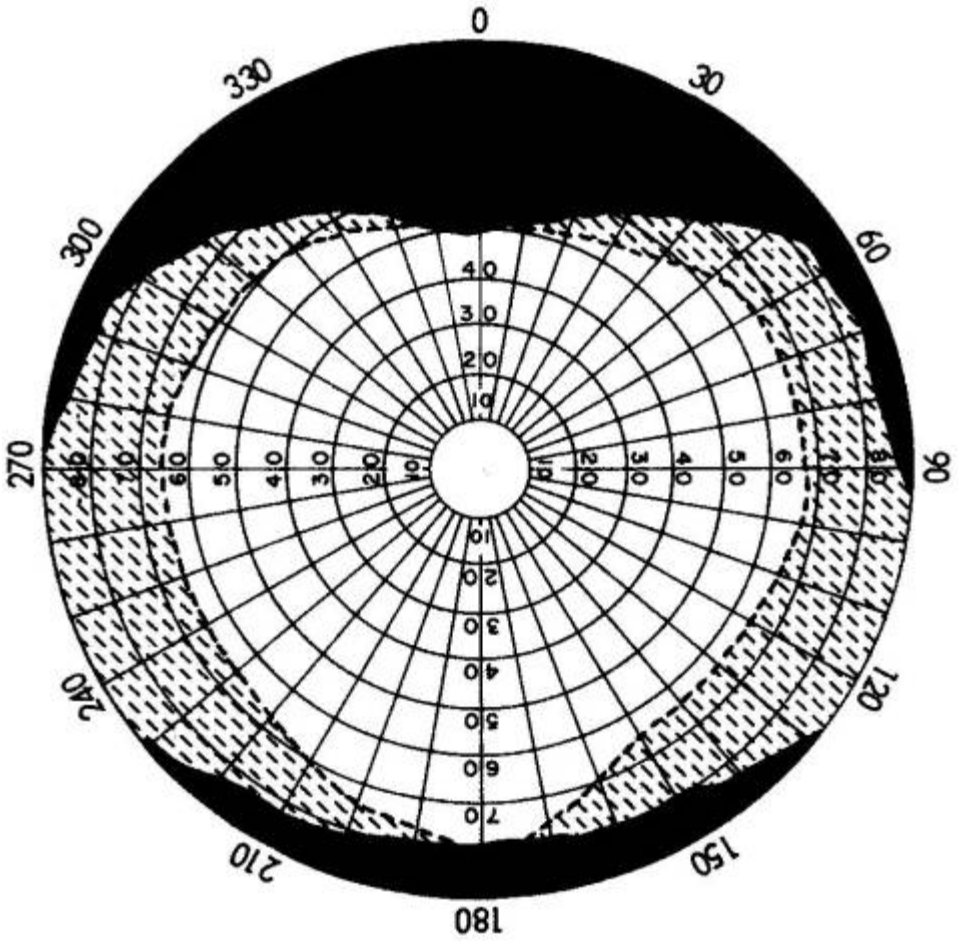


Figure 11.17 Vertical Field of View



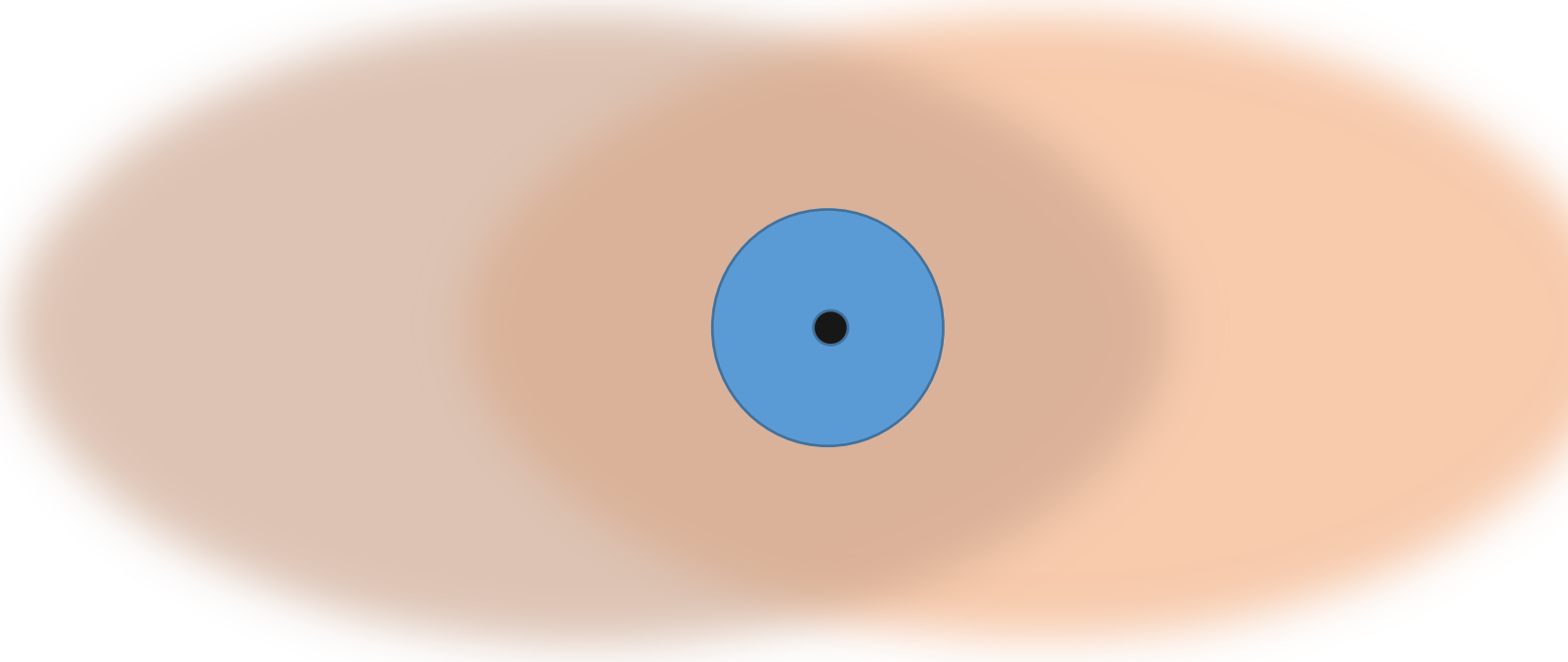
Overall



But, unequal qualities

At center

- Max focus
- 2 retina holes
- Stereo



Center to edge

- Color
- Contrast
- Focus
- Monocular
- Motion sense

Depth perception

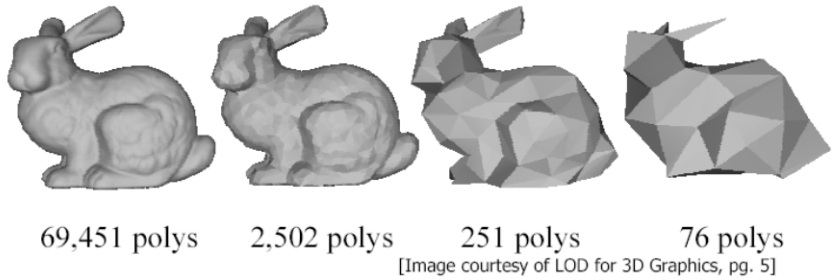
- depth cues
  - occlusion (strongest cue)
  - shadowing (light occlusion)
  - lighting (illumination)
  - perspective
  - texturing
  - **stereopsis**
  - depth of field/focus
  - motion and movement

Photo: A. Cotekin

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

Depth perception

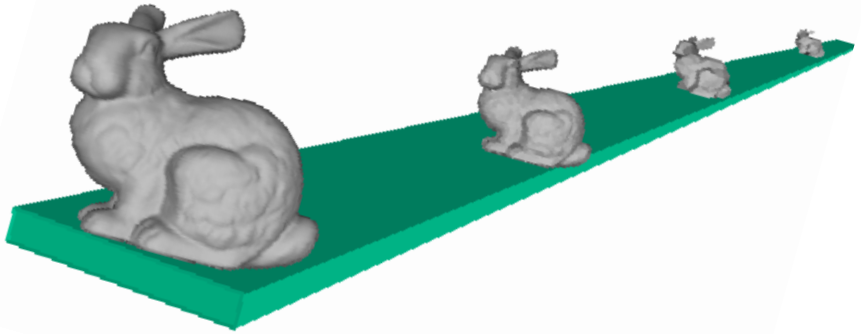
LOD Management



[Image courtesy of LOD for 3D Graphics, pg. 5]

In computer graphics

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



Depth perception

"virtual street reality"

Julian Beever

Depth perception

Julian Beever

Depth perception

wlu.ca

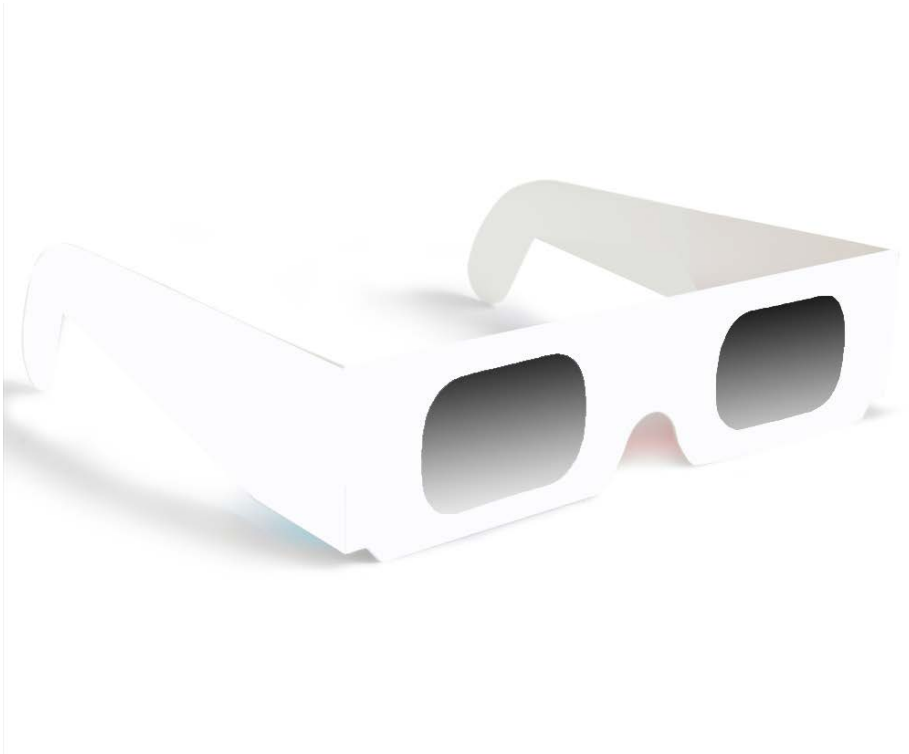
Size depth cues

Depth perception

wlu.ca

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 2º separation (low)

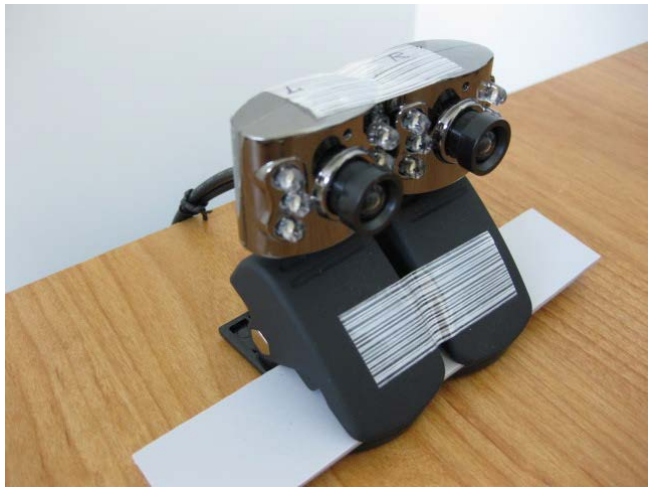


Stereoscopic depth perception

Differs from camera model

Image is rectangular, suffers from barrel distortion

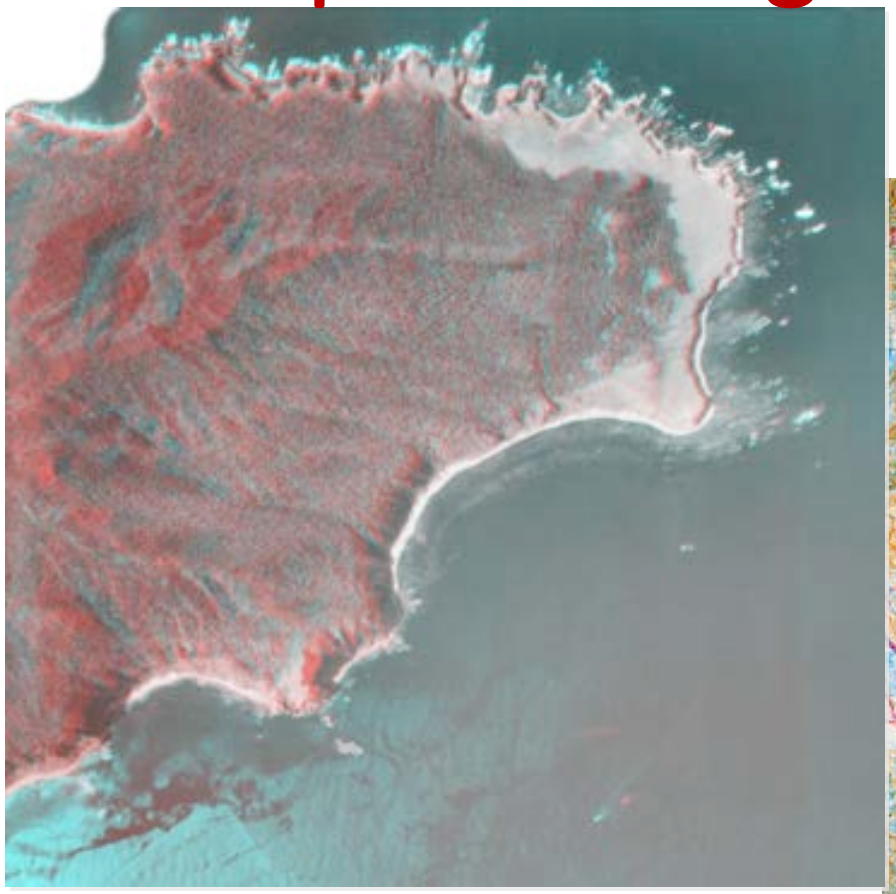
Sensitive to separation



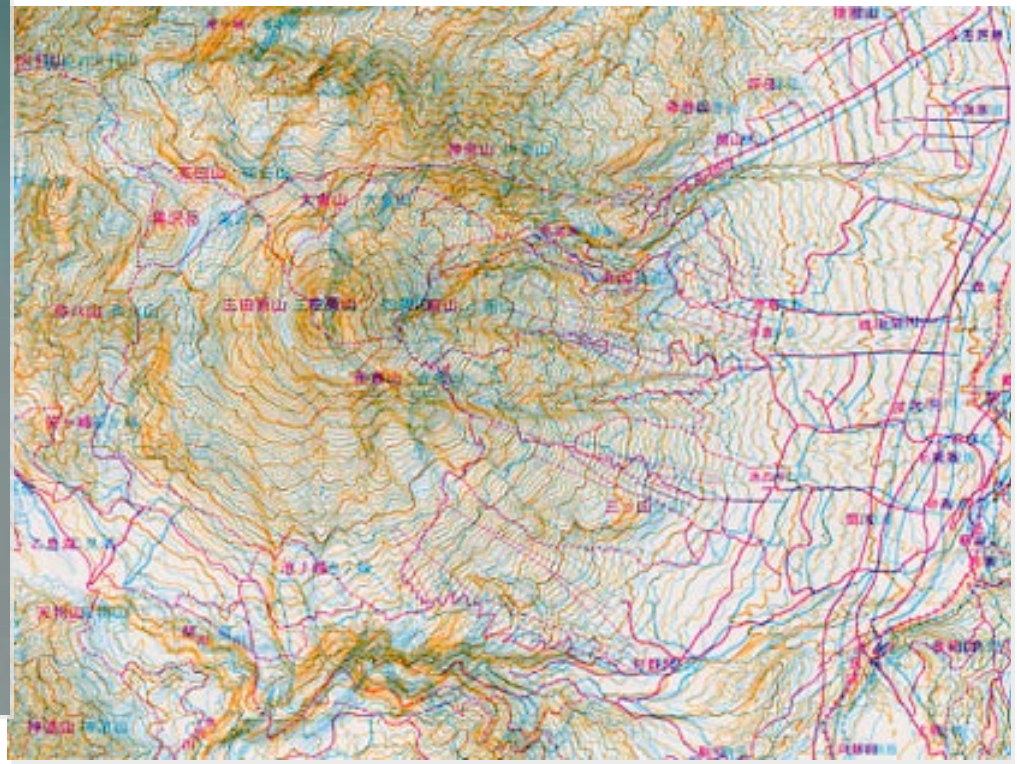
Stereoscopic viewing

This is a **stereogram**, hiding the text GEOG183
created using www.flash-gear.com/stereo/

Stereoscopic viewing



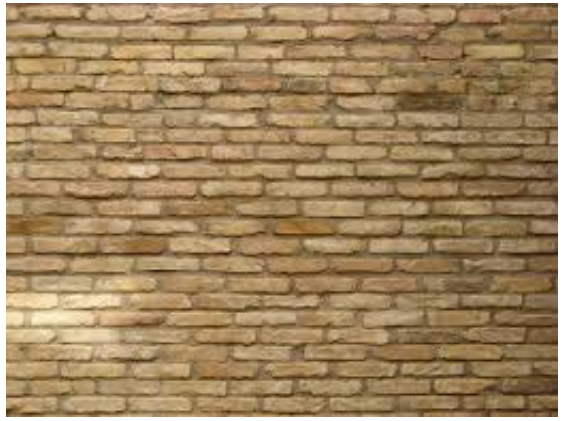
Examples of stereoscopic visualization for terrain and topography



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



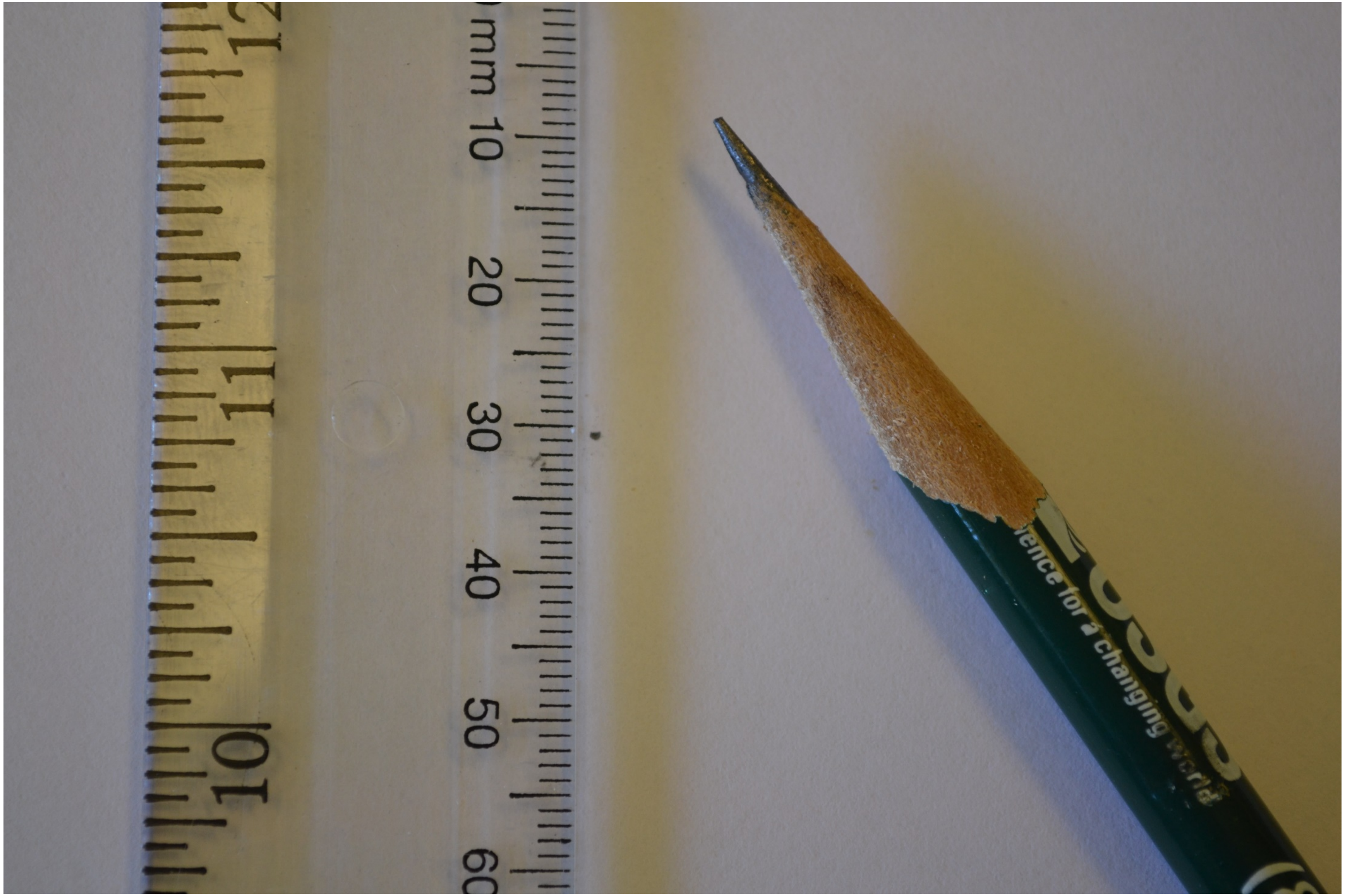
Pattern
Color
Contrast
Shadow
Depth
Material
Repetition
Orientation
Granularity
Regularity
Abstraction

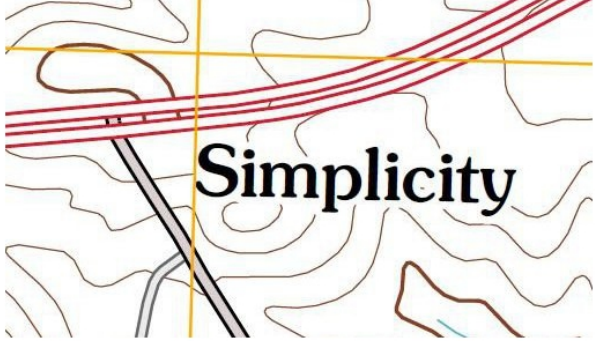
Contrast

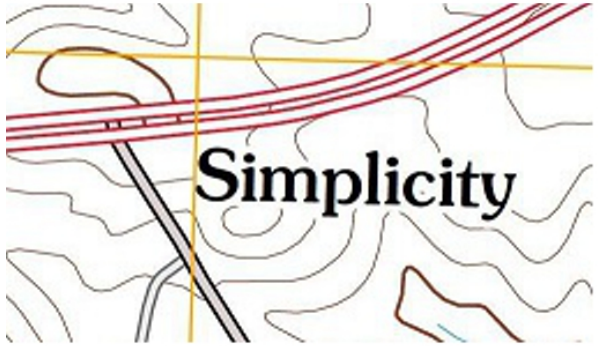
Figure vs. ground
Range
Quantification

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


mm 10
20
30
40
50
60





Simplicity, Virginia at 150,75,37 and 18 dots per inch

Resolution

30 meters per pixel

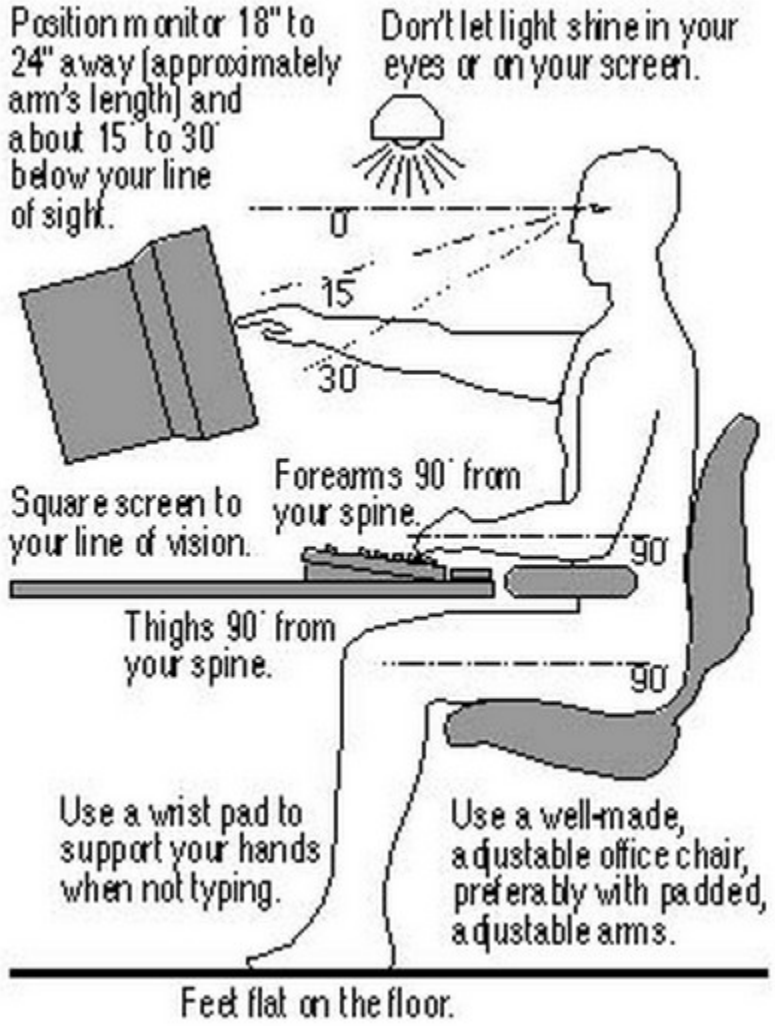
10 meters per pixel

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

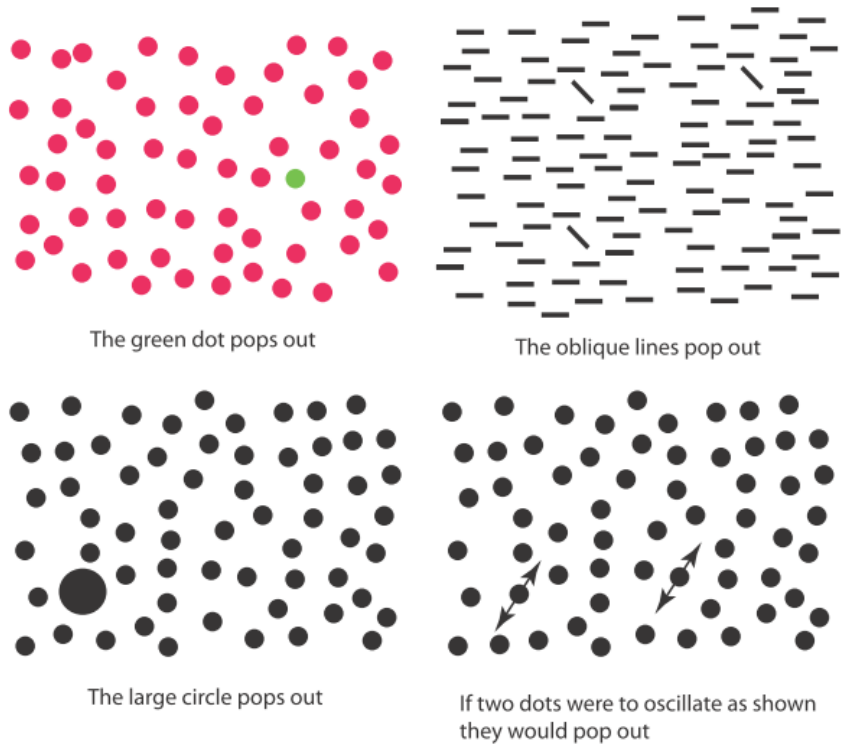


Saliency

Things that *pop out*

- Color
- Orientation
- Size
- Motion

- **Visual variables**



Ware 2008

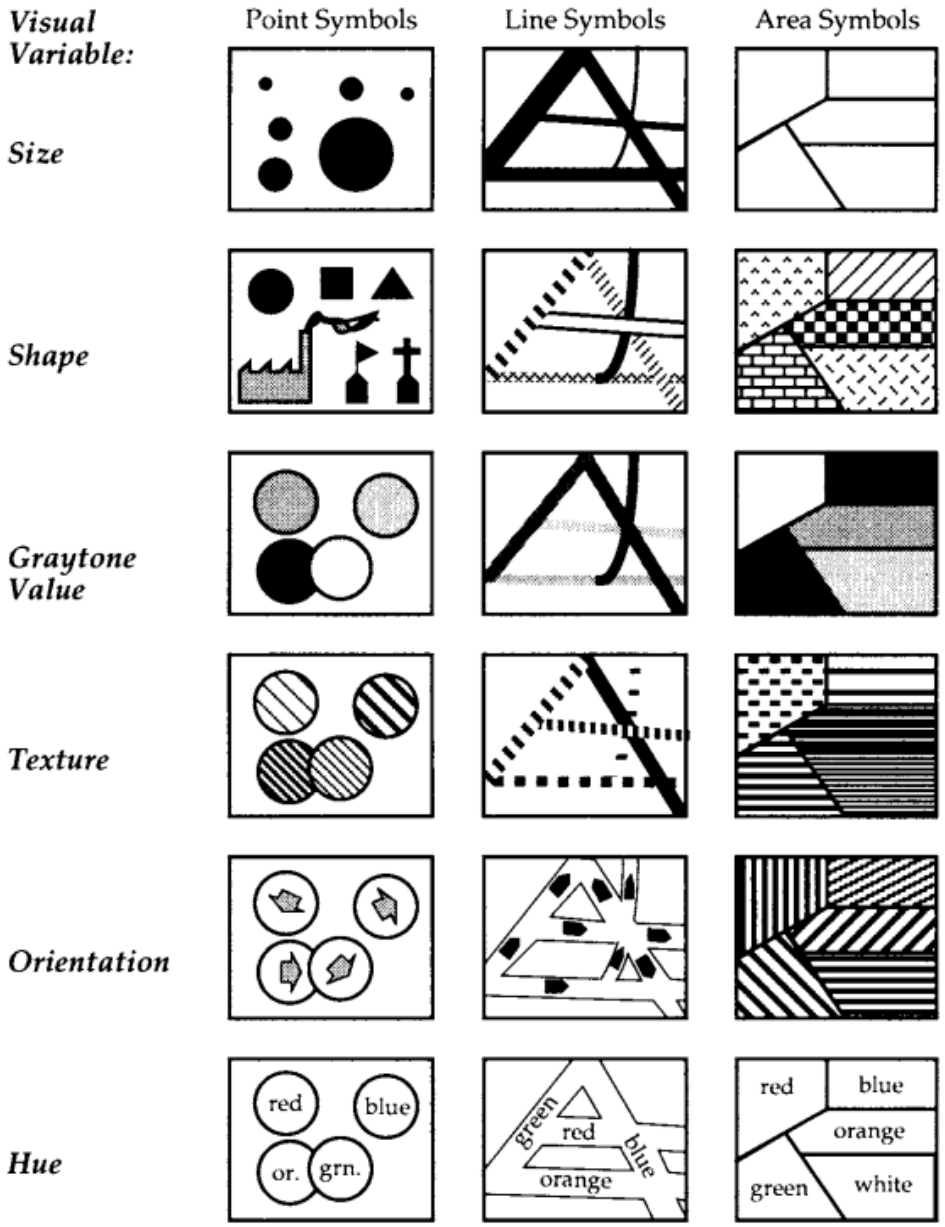
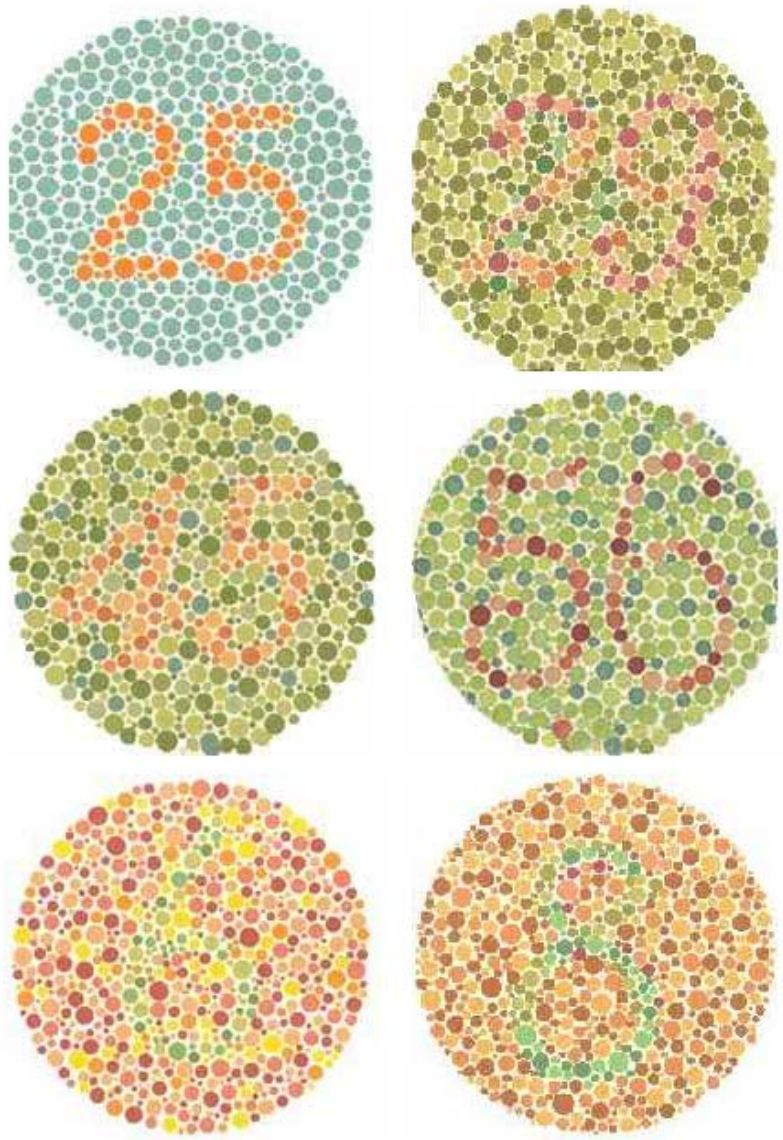


FIGURE 2.11. The six principal visual variables.

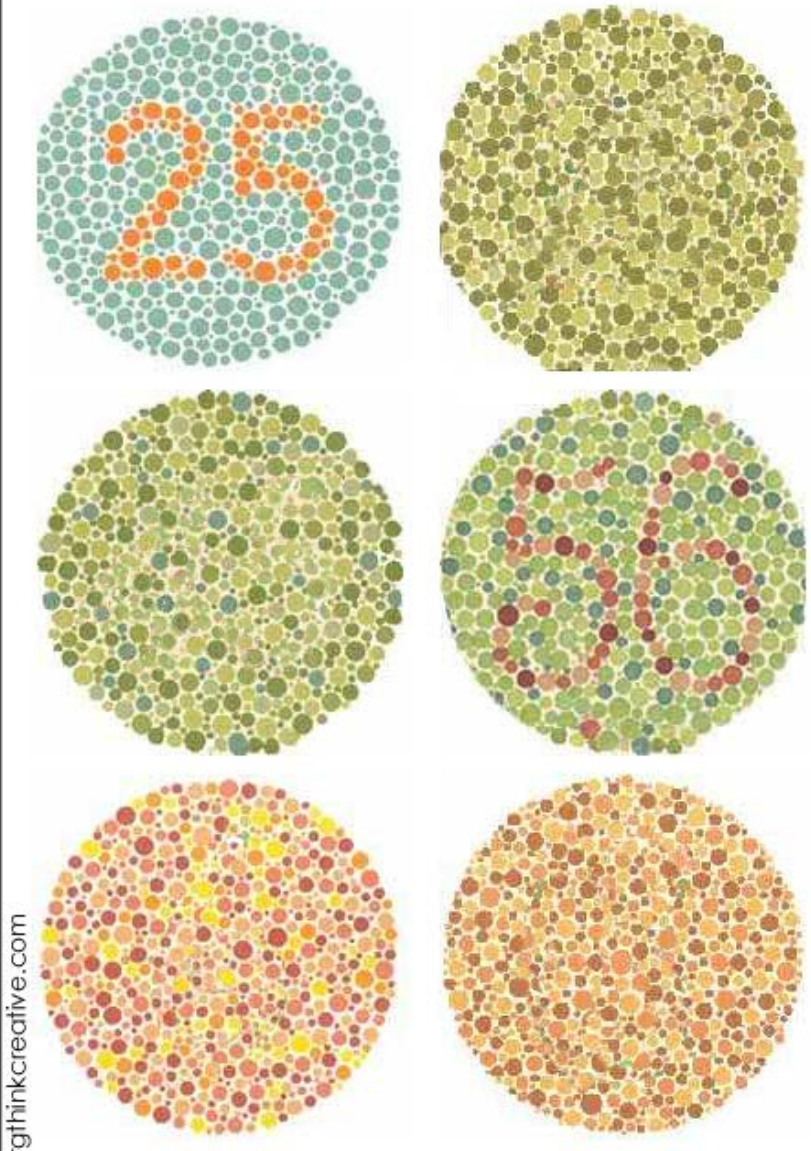
Bertin's six principal visual variables, as presented in "How to lie with maps" (Monmonier, 1991)

Ishihara Test For Color Blindness

What People With Regular Vision See



What Red-Green Color Blind People See

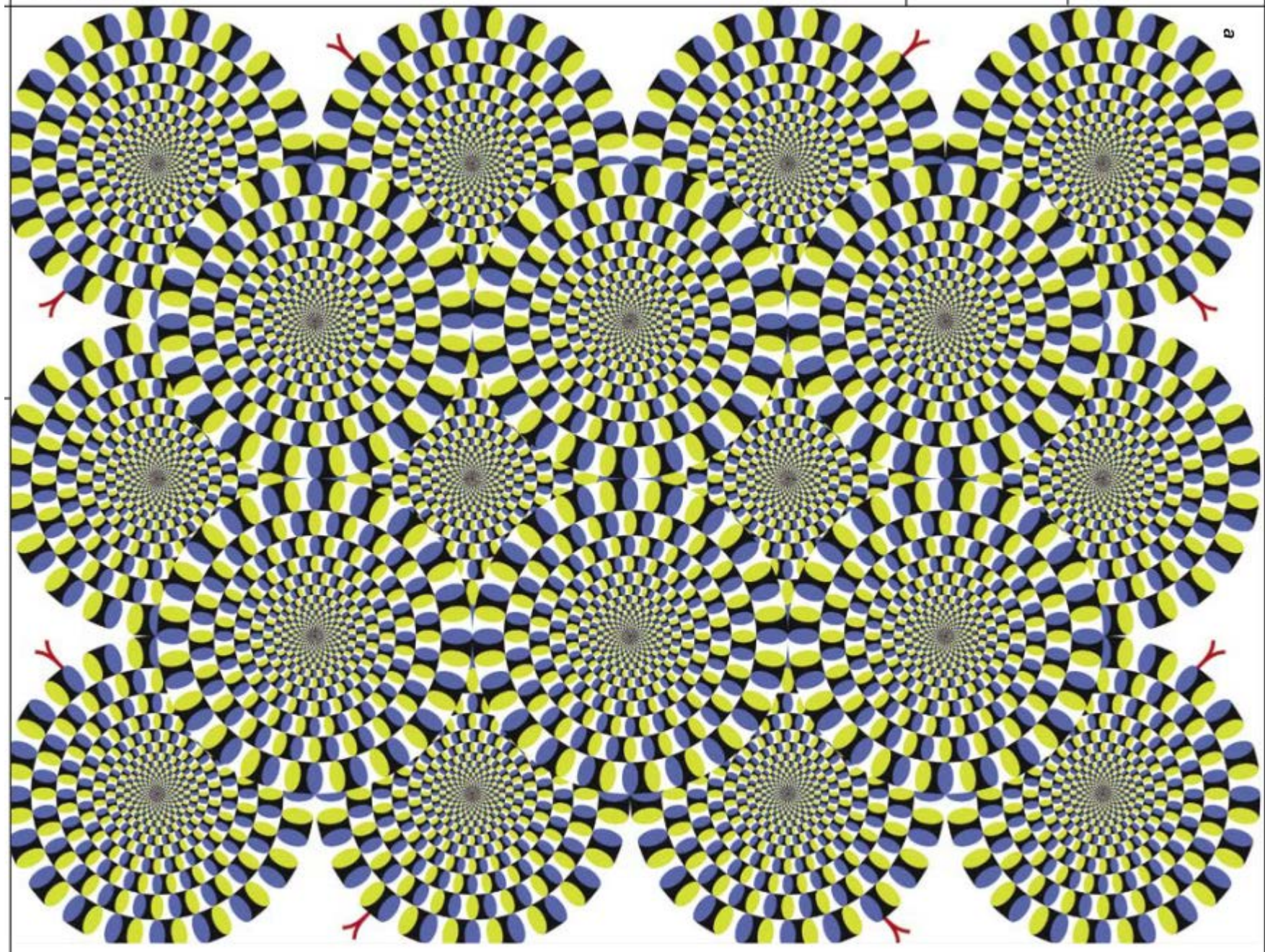


Perception

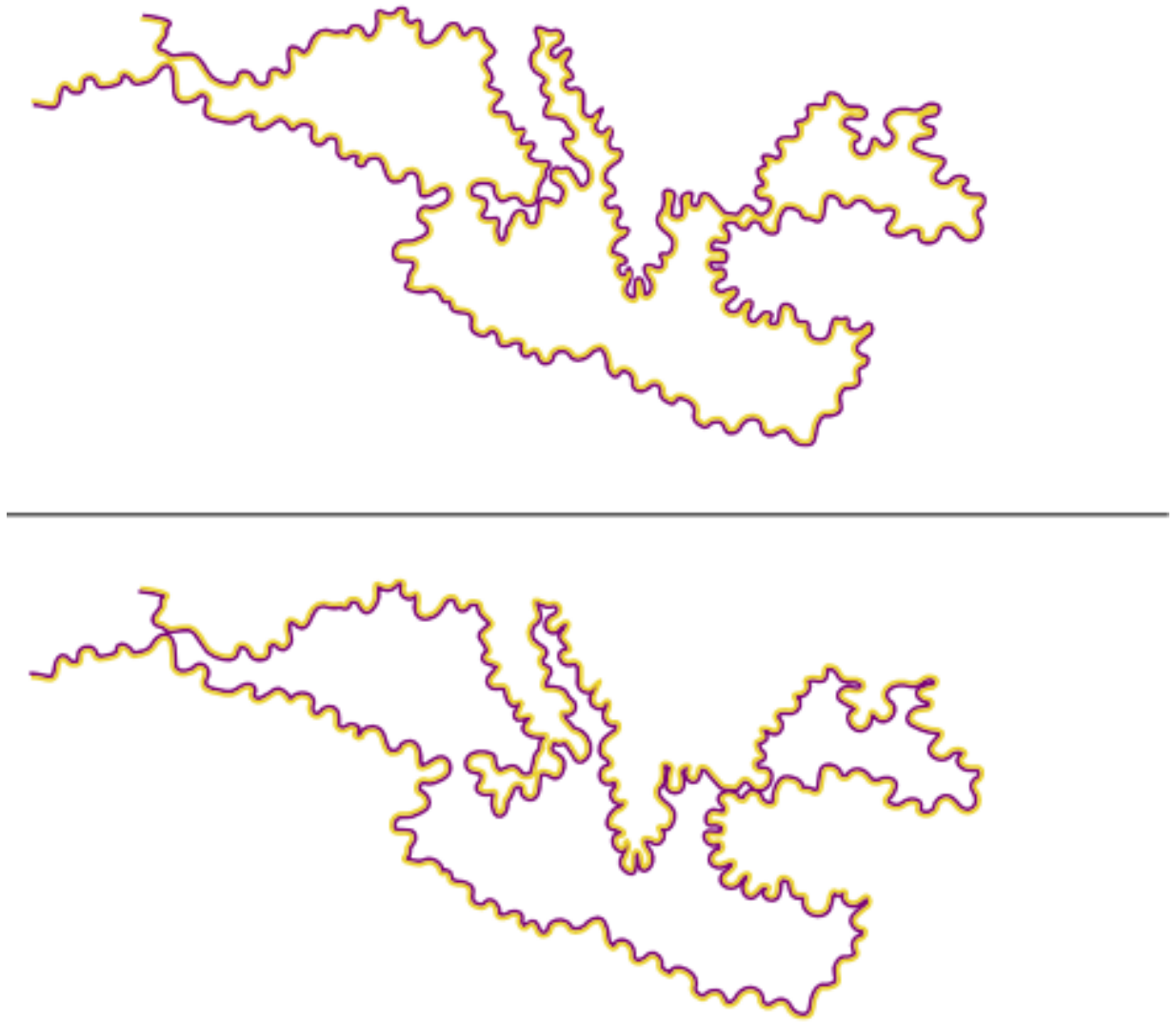
Context matters: The "white" letters are actually darker than the "black" letters (*above*), as is clear when surroundings are removed (*inset*).

Scientific American
Special Issue on Perception, 2008

AKIYOSHI KITAOKA 2003



2

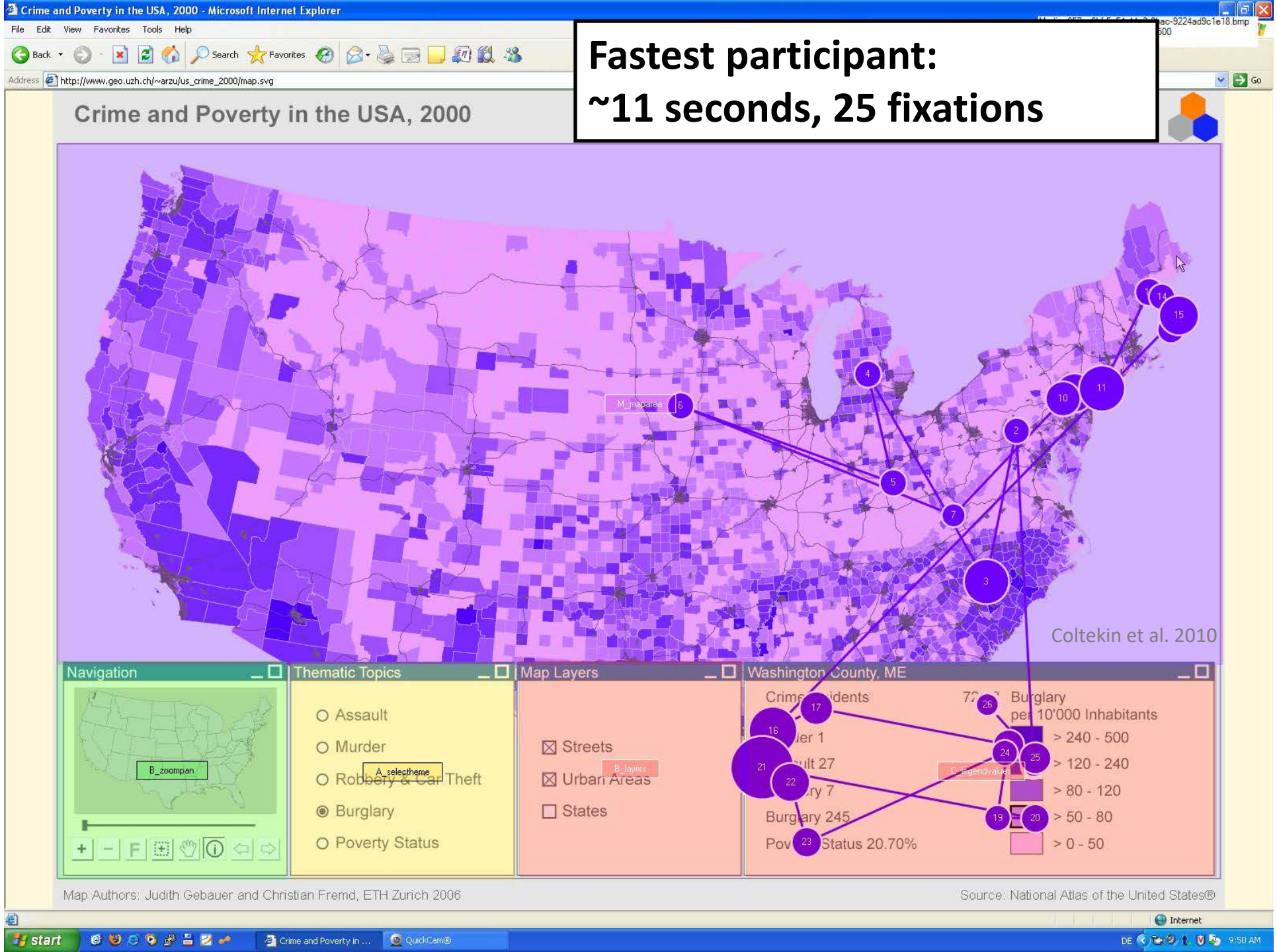


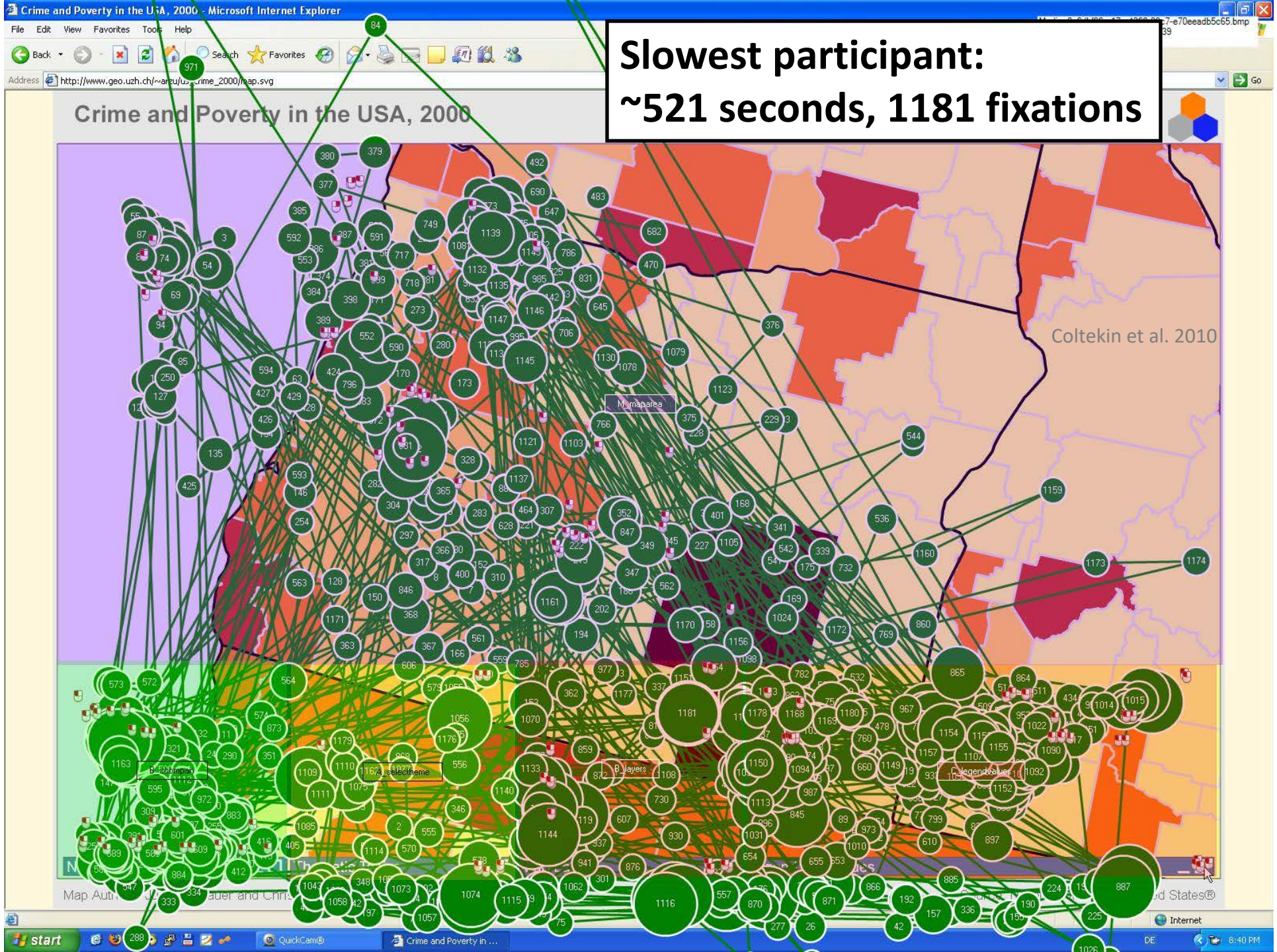
Scientific American
Special Issue on Perception, 2008

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.

Vision by movement

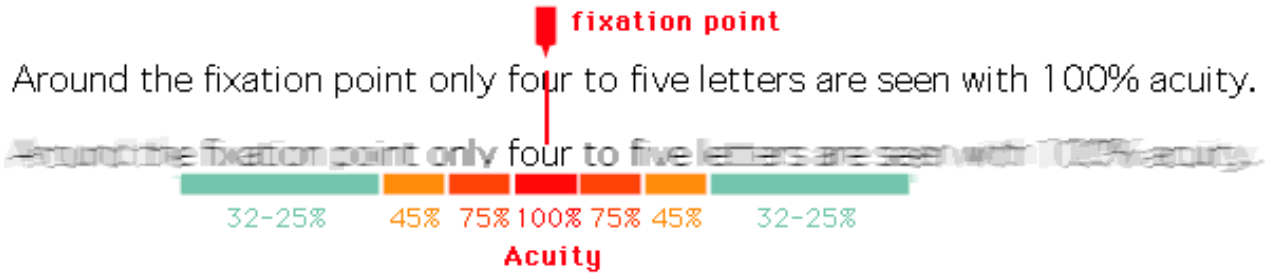
- Eyes in socket and refocus
- Head movement, rotation
- Aids to vision e.g. telescope
- Body movement
- Aids to movement, e.g. google street view
- Movement by vehicle, travel etc.
- Multiple views from one (or more) locations, e.g. panorama (e.g. http://indiain360.in/view/taj-mahal/

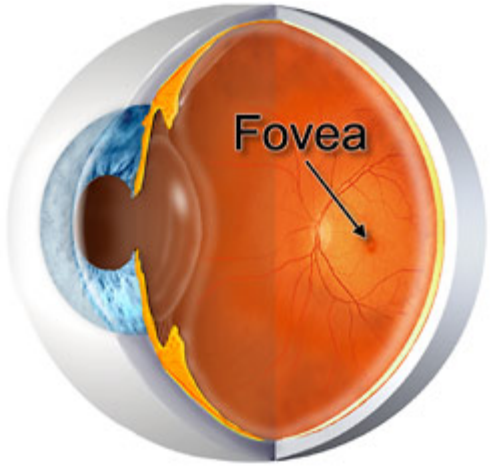

Crime and Poverty in the USA, 2000 - Microsoft Internet Explorer
http://www.geo.uzh.ch/~arzu/us_crime_2000/map.svg
Crime and Poverty in the USA, 2000
Fastest participant:
~11 seconds, 25 fixations
Coltekin et al. 2010
Navigation
Thematic Topics
Assault
Murder
Robbery & Car Theft
Burglary
Poverty Status
Map Layers
Streets
Urban Areas
States
Washington County, ME
Burglary
per 10'000 Inhabitants
> 240 - 500
> 120 - 240
> 80 - 120
> 50 - 80
> 0 - 50
Map Authors: Judith Gebauer and Christian Fremd, ETH Zurich 2006
Source: National Atlas of the United States®

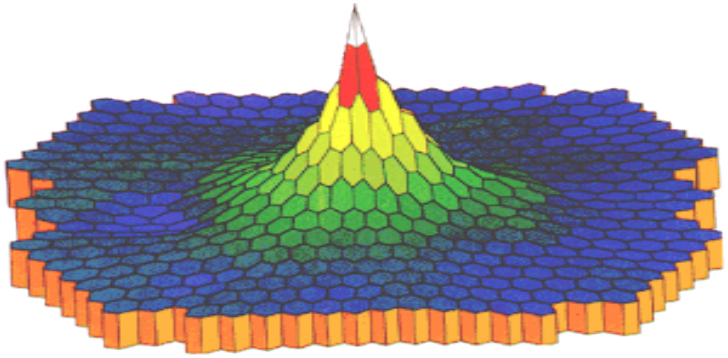

Crime and Poverty in the USA, 2000 - Microsoft Internet Explorer
Slowest participant:
~521 seconds, 1181 fixations
Crime and Poverty in the USA, 2000
Coltekin et al. 2010

Foveation (angling the eyes to focus on an object).

Visual acuity directly related to human fovea







Human Visual System's level of detail management

Structure from Motion: Photogrammetry

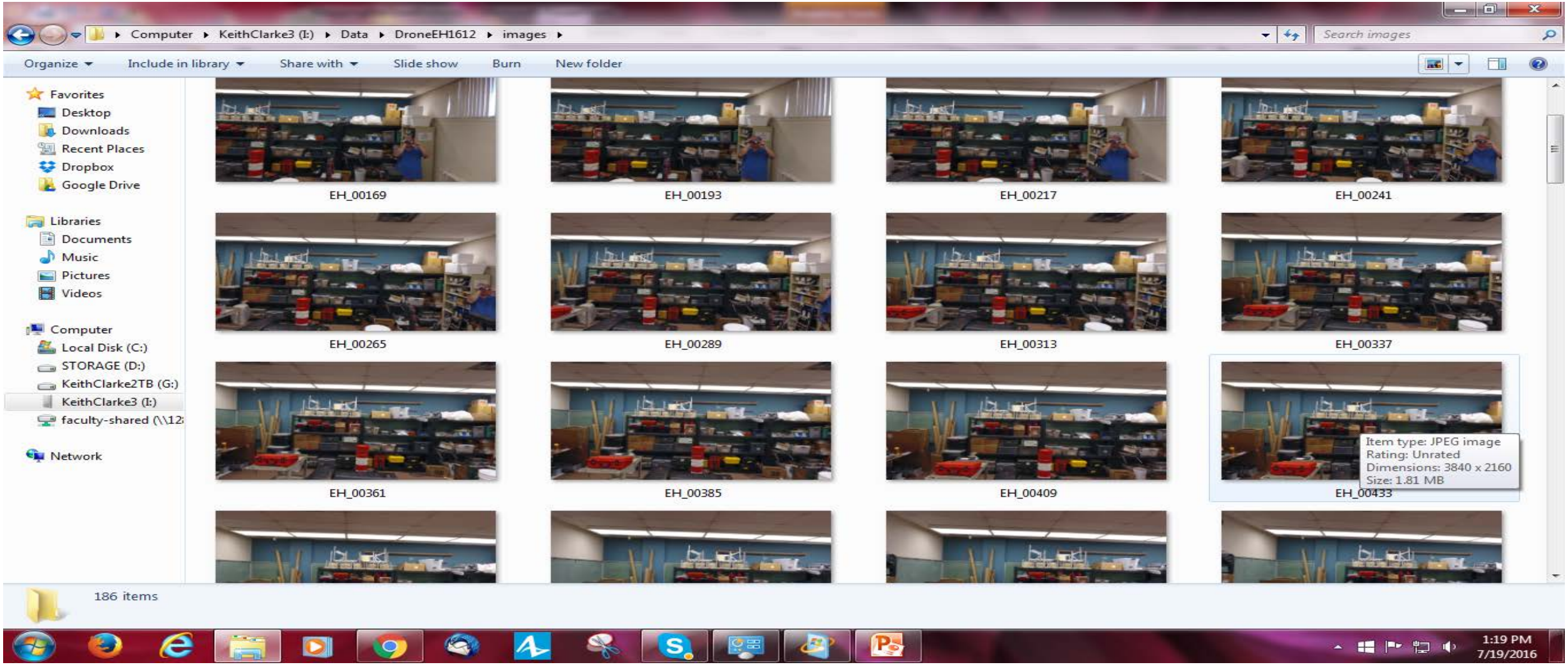
- Need many images from different angles
- Overlap creates stereo model
- Agisoft Photoscan then extracts model and assigns point cloud with color
- Can process with Meshlab, CloudCompare, other software
- Our answer: Drone (Quadcopter)

Phantom 4 with collision avoidance

Scans height by IR sensor
Position using GPS
Fully gimballed camera
Can be programmed to collect
video or interval images
20 minutes of flight with rechargeable batteries
Flight planning software, smartphone or tablet piloting

Mapping Ellison 1612

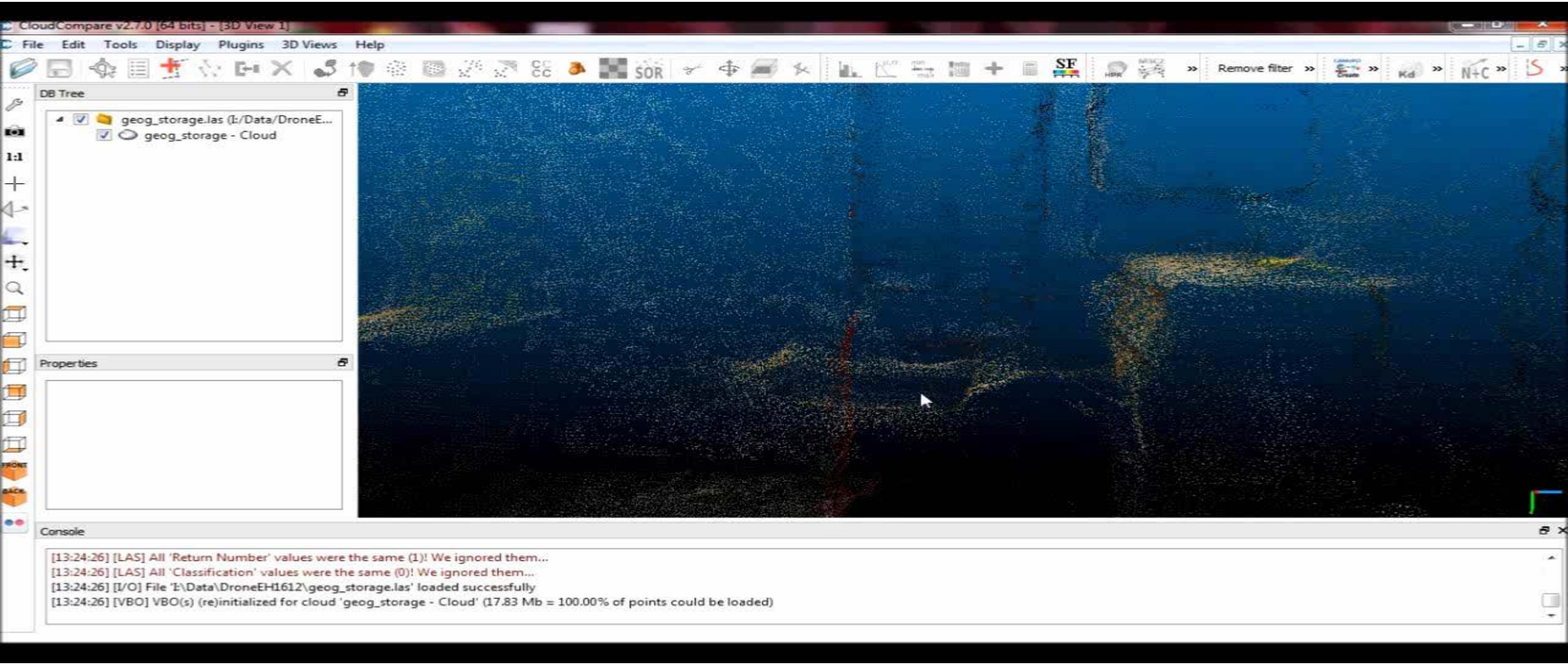
Image capture



Point Cloud

This is not a photograph

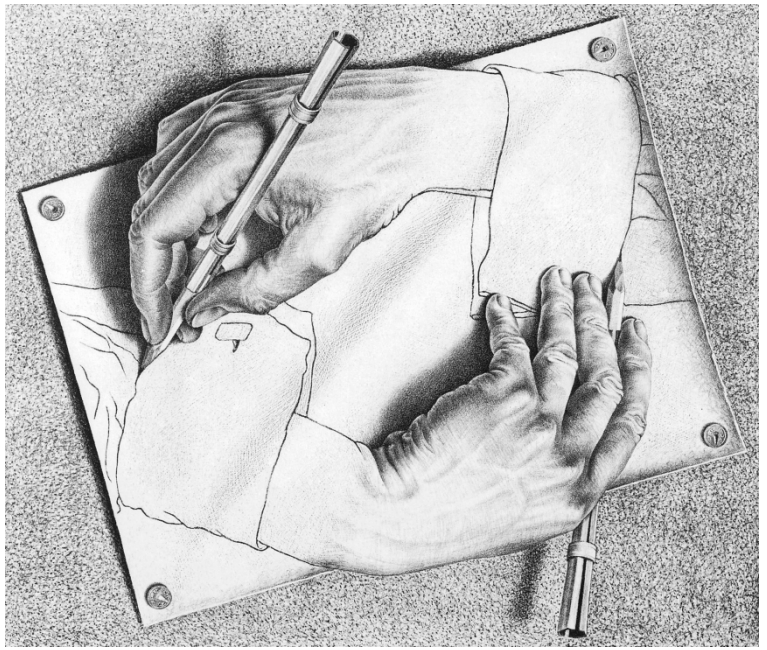
A 3D model from scratch



Human vision elements

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

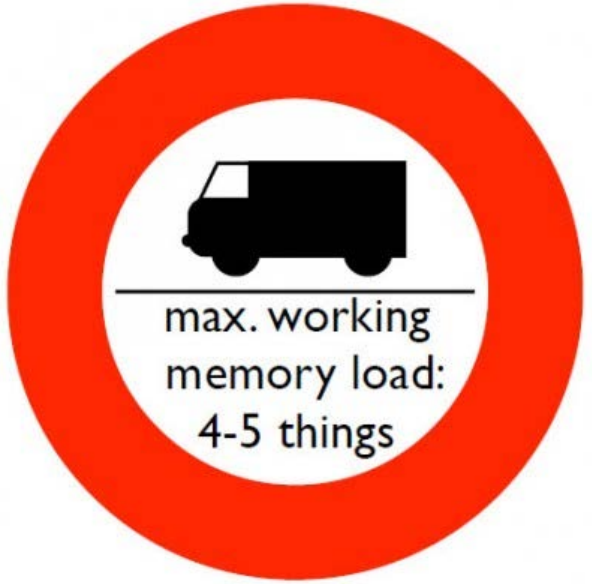
selective attention: https://www.youtube.com/watch?v=qhF_baBVIOs



Blow Up (1966)

Cognitive load

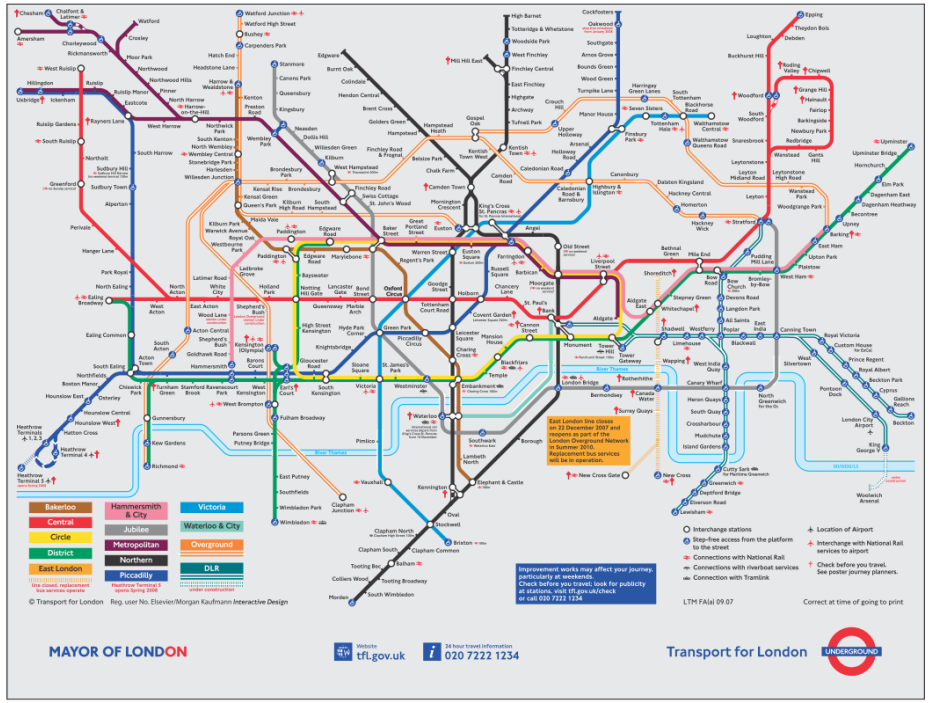
- Learning and intellectual performance
  - Visual analytics, spatial thinking
- Types
  - Intrinsic e.g. simultaneous tasks
  - Extraneous e.g. distraction
  - Device/medium
- Biological and experimental measures
  - Task completion, performance, heart rate, blood pressure, pupil size ..

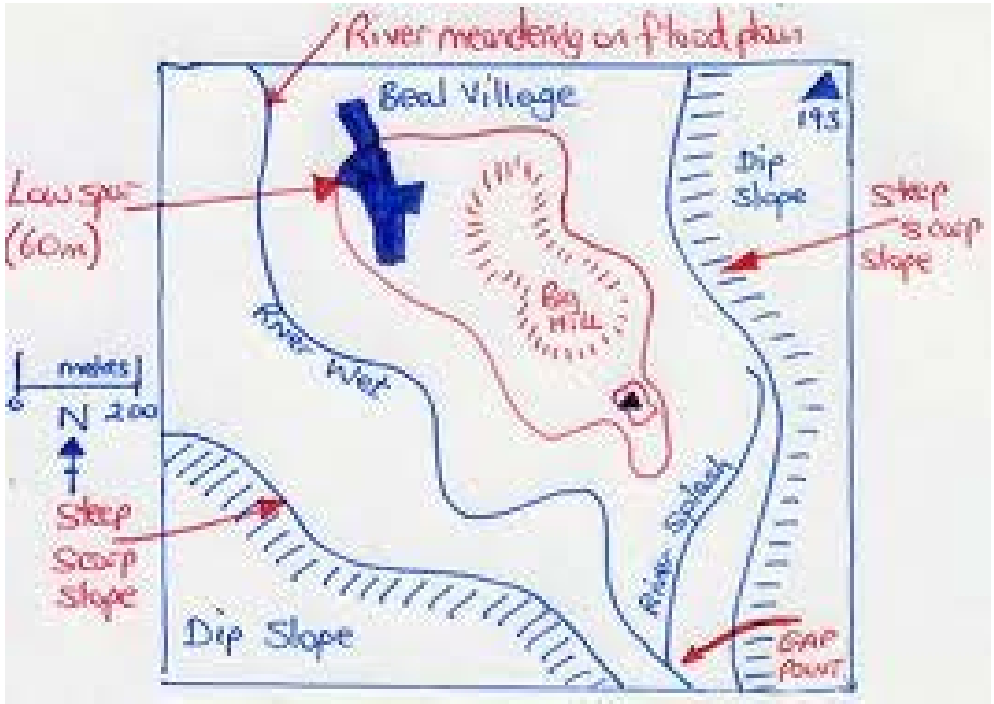


speakingaboutpresenting.com

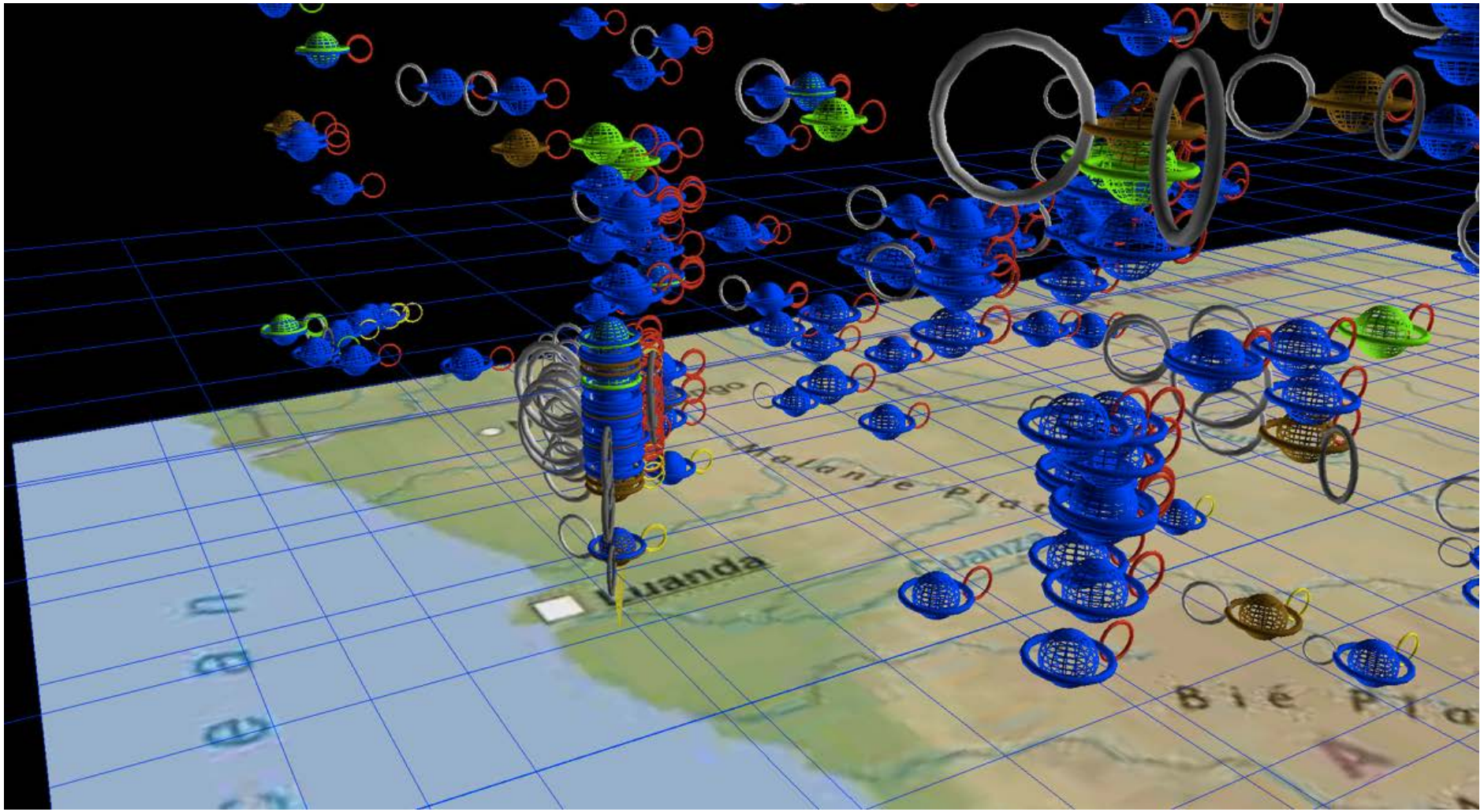
Visual Complexity

"The system that holds about three objects in attention at one time is called **visual working memory.**" Ware, 2008





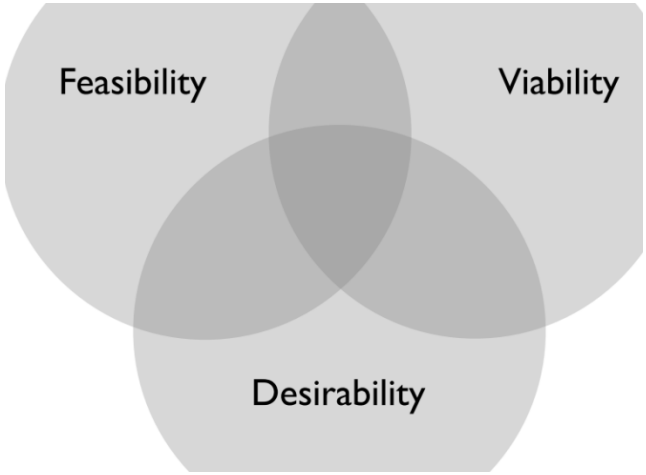
Maps play two cognitive functions: Show and store



Usability Engineering

First Principles

(Johnson 2008)



Jeffrey Veen

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