PERCEPTION

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slide acknowledgements:
Hanspeter Pfister, Harvard University
Bang Wong, Broad Institute
administrivia . . .
- design critiques start this week
  - please include the visualization in the post

- first assignment goes out Thursday
last time . . .
Tufte’s integrity principles

Clear, detailed, and thorough labeling should be used to defeat graphical distortion and ambiguity.

The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the numerical quantities represented.

Show data variation, not design variation.
Tufte’s design principles

- maximize the data-ink ratio
- avoid chart junk (*sometimes*)
- use multifunctioning elements
- layer information
- maximize the data density
  - shrink the graphics
  - maximize the amount of data shown (*sometimes*)
today . . .
- the eye
- edge detection
- relativity of perception
- things that pop
- gestalt principles
- the eye
- edge detection
- relativity of perception
- things that pop
- gestalt principles
120 million rods

5-6 million cones
Cone Response
Brain pixels vary enormously in size over the visual field. This reflects differing amounts of neural processing power devoted to different regions of visual space.

At the edge of the visual field we can only barely see something the size of a fist at arm's length.

We can resolve about 100 points on the head of a pin held at arm's length in the very center of the visual field called the fovea.

Over half of our visual processing power is concentrated in a slightly larger area called the parafovea.
Adapted from Lindsay & Norman, 1977

The diagram illustrates the distribution of receptors in the retina, with a focus on the fovea and blind spot. The graph shows the number of receptors per square millimeter as a function of angle.

- **Blind spot (no receptors)**
- **Fovea**
- **Optic nerve**
- **Cones**
- **Rods**
Saccadas

- rapid involuntary eye movements
  - moving: 20-100 ms
  - fixations: 200-600 ms
Saccadas

- rapid involuntary eye movements
  - moving: 20-100 ms
  - fixations: 200-600 ms

http://vision.arc.nasa.gov/personnel/jbm/home/projects/osa98/osa98.html
- the eye
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center surround
receptive field

100M rods and cones

1M ganglion cells
Retinal ganglion cells

luminance $L$

\[ \frac{dL}{dx} \]
low activity
center and surrounds cancel

activity increased
or decreased at edges

luminance \( L \)

\[ \frac{dL}{dx} \]
Hermann grid effect
Takeaway

Our visual system sees differences, not absolute values, and is attracted to edges.

Maximize the contrast with the background if the outlines of shapes are important.
consequences of edge extraction
Cornsweet Illusion
Cornsweet Illusion
Cornsweet Illusion

Actual luminance distribution

Perceived luminance distribution
Cornsweet Illusion
Contrast Sensitivity
Contrast Sensitivity

C. Ware, "Visual Thinking for Design"
Takeaway

The brain constructs surface color based largely on edge contrast information.

We have higher contrast sensitivity in the luminance than in the chrominance channel.
- the eye
- edge detection
- relativity of perception
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WEBER’S LAW
we judge based on relative, not absolute, differences
RELATIVE DIFFERENCES
AXIS OF ALIGNMENT

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AXIS OF ALIGNMENT
SIMULTANEOUS CONTRAST

Edward H. Adelson

http://persci.mit.edu/_media/gallery/checkershadow_double_full.jpg
SIMULTANEOUS CONTRAST

http://persci.mit.edu/_media/gallery/checkershadow_double_full.jpg
SIMULTANEOUS CONTRAST
SIMULTANEOUS CONTRAST
SIMULTANEOUS CONTRAST
INTERACTION OF COLOR
INTERACTION OF COLOR
INTERACTION OF COLOR
INTERACTION OF COLOR
INTERACTION OF COLOR
INTERACTION OF COLOR
- the eye
- edge detection
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POPOUT
POPOUT
Based on slide from Mazur
PRE-ATTENTIVE PROCESSING

- requires attention, despite name

- very fast: <200 ms

- what matters most is contrast between features
BASIC POPOUT CHANNELS

- Color
  - hue
  - lightness
- Elementary shape
  - size
  - elongation
- Orientation
- Motion
- Spatial grouping

Ware 2008
which side has the outlier?
CONJUNCTION
or, why to use a single channel at a time

Healey 2007
CONJUNCTION

[Diagrams showing sets of objects with different colors and sizes, illustrating the concept of conjunction.]
Takeaway

We can easily see objects that are different in color and shape, or that are in motion.

Use color and shape sparingly to make the important information pop out.
- the eye
- edge detection
- relativity of perception
- things that pop
- gestalt principles
Gestalt principles

- **German**: “Gestalt” = form

- patterns transcend the visual stimuli that produced them
similarity
similarity
proximity

Andy Rutledge, “Gestalt Principles of Perception”
proximity
connectedness

Ware, “Information Visualization”
grouping

Similarity

Connection

Enclosure

Bang Wong, "Gestalt Principles, I", Nature Methods
grouping
grouping

proximity

similarity

closure
continuity
continuity

closure
closure
figure / ground

M.C. Escher: *Sky and Water I* 1938 woodcut
alignment
common fate
Gestalt principles

- **similarity**: things that look like each other (size, color, shape) are related

- **proximity**: things that are visually close to each other are related

- **connection**: things that are visually connected are related

- **continuity**: we complete hidden objects into simple, familiar shapes

- **closure**: we see incomplete shapes as complete

- **figure / ground**: elements are perceived as either figures or background

- **common fate**: elements with the same moving direction are perceived as a unit
L4. Data abstraction

REQUIRED READING
Chapter 2

What: Data Abstraction

2.1 The Big Picture

Figure 2.1 shows the abstract types of what can be visualized. The four basic dataset types are tables, networks, fields, and geometry; other possible collections of items include clusters, sets, and lists. These datasets are made up of different combinations of the five data types: attributes, items, links, grid cells, and positions. For any of these dataset types, the full dataset could be available immediately in the form of a static file, or it might be dynamic data processed gradually in the form of a stream. The type of an attribute can be categorical or ordered, with a further split into ordinal and quantitative. The ordering direction of attributes can be sequential, diverging, or cyclic.

2.2 Why Do Data Semantics and Types Matter?

Many aspects of vis design are driven by the kind of data that you have at your disposal. What kind of data are you given? What information can you figure out from the data, versus the meanings that you must be told explicitly? What high-level concepts will allow you to split datasets apart into general and useful pieces? Suppose that you see the following data: