Dad, how come old photographs are always black and white? Didn’t they have color film back then?

Sure. They did. In fact, those old photographs are in color. It’s just the world was black and white then.

Really? Yep. The world didn’t turn color until sometime in the 1930s, and it was pretty grainy color for a while, too.

But then why are old paintings in color? If the world was black and white wouldn’t artists have painted it that way?

Not necessarily. A lot of great artists were insane.

But... but how could they have painted in color anyway? Would their paints have been shades of gray back then?

Of course, but they turned colors like everything else did in the ’30s.

So why didn’t old black and white photos turn color too?

Because they were color pictures of black and white, remember?

The world is a complicated place, Hobbes.

Whenever it seems that way, I take a nap in a tree and wait for dinner.
administrivia...
- assignment 12 is due tonight
- TA office hours
last time...
visualization uses perception to point out interesting things.
visualization uses pictures to enhance working memory.
O-ring damage index, each launch

26°-29° range of forecasted temperatures (as of January 27, 1986) for the launch of space shuttle Challenger on January 28

Temperature (°F) of field joints at time of launch
DIAGRAM OF THE CAUSES OF MORTALITY
IN THE ARMY IN THE EAST.

The areas of the blue, red, & black wedges are each measured from the centre as the common vertex.
The blue wedges measured from the centre of the circle represent area for the deaths from Preventible or Mitigable Zymotic diseases, the red wedges measured from the centre the deaths from wounds, & the black wedges measured from the centre the deaths from all other causes.
The black line across the red triangle in Nov. 1854 marks the boundary of the deaths from all other causes during the month.
In October 1854, & April 1855, the black area coincides with the red; in January & February 1856, the blue coincides with the black.
The entire areas may be compared by following the blue, the red & the black lines enclosing them.

F. Nightingale 1856
Visualizing Algorithms

The power of the unaided mind is highly overrated... The real powers come from devising external aids that enhance cognitive abilities. —Donald Norman

Algorithms are a fascinating use case for visualization. To visualize an algorithm, we don’t merely fit data to a chart; there is no primary dataset. Instead there are logical rules that describe behavior. This may be why algorithm visualizations are so unusual, as designers experiment with novel forms to better communicate. This is reason enough to study them.

But algorithms are also a reminder that visualization is more than a tool for finding patterns in data. Visualization leverages the human visual system to augment human intellect: we can use it to better understand these important abstract processes, and perhaps other things, too.

# Sampling

Before I can explain the first algorithm, I first need to explain the problem it addresses.

![Image of The Starry Night by Vincent van Gogh](https://via.placeholder.com/150)

Light — electromagnetic radiation — the light emanating from this screen, traveling through the air, focused by your lens and projected onto the retina — is a continuous signal. To be perceived, we must reduce light to discrete impulses by measuring its intensity and frequency distribution at different points in space.
design excellence

“Well-designed presentations of interesting data are a matter of substance, of statistics, and of design.”

Edward Tufte
maximize the \textbf{Data-ink Ratio} = \frac{\text{data-ink}}{\text{total ink used in graphic}}
AVOID CHART JUNK
AVOID CHART JUNK
multifunctioning elements
Data Density = \frac{\text{number of entries in data array}}{\text{area of data graphic}}
SHRINK THE GRAPHICS

SMALL MULTIPLES
SHRINK THE GRAPHICS

GRAPHIC PROBLEMSPOSED BY TIME SERIES

Scale in years
With a scale in years, a two-year total (figure 1) should be divided by 2 (figure 2). A total for six months should be multiplied by 2.

Pointed curves
For overly pointed curves (figure 3), the scale of the Q should be reduced; optimum angular perceptibility occurs at around 70 degrees (figure 4).

If the curve is not reducible (large and small variations), filled columns can be used (figure 5).

Flat curves
For overly flat curves (figure 6), the scale of the Q should be increased (figure 7).

Small variations
For small variations in relation to the total (figure 8), the total loses its importance, and the zero point can be eliminated, provided the reader is made aware of this elimination (figure 9). The graphic can be interpreted as an acceleration if a precise study of the variations is necessary; here, we use a logarithmic scale (figure 10). (See also page 240.)

Large range
For a very large range between the extreme numbers (figure 11), we must either:
(1) Leave out the smallest variations;
(2) Be concerned only with relative differences (logarithmic scale), without knowing the absolute quantities;
(3) Select different parts (periods) within the ordered component and treat them on different scales above the common scale (figure 12).

Obvious periodicity
If there is obvious periodicity (figure 13), and the study involves a comparison of the phases of each cycle, it is preferable to break up the cycles in order to superimpose them (figure 14). A polar construction can be used, preferably in a spiral shape (figure 15), but we should not begin with too small a circle. As striking as it seems, it is less efficient than an orthogonal construction.

Annual curves
For annual curves of rainfall or temperature, if a cycle has two phases (figure 17), why depict only one (figure 16)?

A contrast
Unlike what we see in figure 18, the pertinent or "new" information must be separated from the background or "reference" information. The background involves: (a) the invariant, highlighted by a heading (Port St. Michell), (b) the highly visible identification of each component (tonnage and dates). The new information (the curve) must stand out from the background (figure 19).

Reference points
It is impossible to utilize a graphic such as figure 20, except in a general manner. There is confusion concerning the position of the points, and no potential comparison is possible, as it is in figure 21.

Precision reading
A precision reading (utilization on the elementary level, as in figure 24) is difficult in figure 22, which results in a poor reading of the order of the points, and in figure 23, where there is ambiguity concerning the position of the points. On the other hand, figure 22 does favor overall vision (correlation).

Null boxes
Curves accommodate null boxes poorly (figure 25). Columns (figure 26) are preferable.

Unknown boxes
The drawing must indicate the unknowns of the information in an unambiguous way (figures 28 and 30). The reader might interpret figure 27 as a change in the structure of the curve and figure 29 as involving null values.

Very small quantities
Except in seeking a correlation (quite improbable here) the number of ships entering into a port is represented better by figure 33 than by figures 31 or 32. The reader can perceive the numerical values at first glance.

Positive-negative variation
This is in fact a problem involving three components O, Q, and it must be visually treated as such. Figure 34 can be improved by utilizing a retinal variable (in figure 35 a value difference: black-white) to differentiate the x component and thus highlight positive-negative variation.
critiques...
U.S. SmartPhone Marketshare

- RIM: 39.0%
- Apple: 21.2%
- Palm: 9.8%
- Motorola: 7.4%
- Nokia: 3.1%
- Other: 19.5%
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- Apple: 19.5%
- Palm: 9.8%
- Motorola: 7.4%
- Nokia: 3.1%
Los Angeles Population By Race

- **Asian**: 438K (11.5%)
- **White**: 2.01 million (52.6%)
- **Black**: 358K (9.4%)
- **American Indian & Alaska Native**: 17K (0.4%)
- **Native Hawaiian & other Pacific Islander**: 6K (0.2%)
- **Two or more races**: 131K (3.4%)
- **Some other race**: 861K (22.5%)

Source: United States Census Bureau, 2012 estimates. Note: The concept of race is separate from the concept of origin; 48 percent of respondents identified themselves as “Hispanic or Latino” but fall into one of the above groups.
today...
-perception basics
  -the eye
  -Weber’s law
  -pre-attentive processing

-encoding channels
  -what’s so special about the plane?
  -animation
  -color
the eye
120 million rods

5-6 million cones
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.
Weber’s law
WEBER’S LAW
we judge based on relative, not absolute, differences

Unframed Unaligned

Framed Unaligned

Unframed Aligned
pre-attentive processing
POPOOUT
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
encoding channels
<table>
<thead>
<tr>
<th>HOW MUCH?</th>
<th>magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHAT?</td>
<td>category</td>
</tr>
</tbody>
</table>
name that channel . . .
Best in Show
The ultimate data-dog

Inexplicably overrated

Bulldog
Great Dane
Bullmastiff
Bernese Mountain Dog
Bull Terrier
Chow Chow
Irish Terrier
Afghan Hound
Saluki
Kerry Blue Terrier
Dandie Dinmont Terrier

Hot dog!

Beagle
Golden Retriever
Pug
Italian Greyhound
Basset Hound
Basset Hound

Rottweiler
Rhodesian Ridgeback
Bulldog
Bloodhound
Alaskan Malamute
Pekingese
Staffordshire Bull Terrier

Saint Bernard
Bloodhound
Alaskan Malamute
Pekingese

Our data score
intelligence longevity ailments costs grooming appetite data score

Rightly ignored

Greyhound
Pug
Italian Greyhound
Saluki
Kerry Blue Terrier
Dandie Dinmont Terrier

Overlooked treasures

Clumber Spaniel
English Toy Spaniel
Briard
Welsh Springer Spaniel
Affenpinscher
Bedlington Terrier
Affenpinscher

INTELLIGENCE
dumb clever
SIZE
smal med lrg
Hunting Hound Non-sporting Sporting Terrier Toy Working
what’s so special about the plane?
we see the world as a 2.5D space
- power does not extend to 3D
  - perspective cues
    - interfere with color and size channels
  - occlusion of data
  - text legibility
exception...
animation
RSM-09-11-03 Canine In Situ Model

Progression of ST Elevated Regions (ST 40)

Axial Plane A

Demand

Supply

Flow Rate: 35ml

Pacing Rate: 400ms

Occlusion Cycle: 15
Can you spot 12 differences between these pictures?
Can you spot 12 differences between these pictures?
Can you spot 12 differences between these pictures?

1. Giraffe moved. 2. Spot on left giraffe moved. 3. Branch on left side shorter. 4. Coconuts left longer. 5. Coconuts eye missing.

Solution:
1. Top tree seat removed. 2. Nose line on left giraffe removed. 3. Shadow on lower left coconut removed. 4. Left tail vein below giraffe.
visualization uses pictures to enhance working memory.
WHEN TO USE ANIMATION?
GOOD: STORYTELLING
GOOD: TRANSITIONS

Animated Transitions in Statistical Data Graphics

Jeffrey Heer
George G. Robertson

Microsoft Research
BAD: COMPARING COMPLEX STATE CHANGES OVER TIME
BAD: MULTIPLE STATES WITH MULTIPLE CHANGES
**BAD:** MULTIPLE STATES WITH MULTIPLE CHANGES

alternative: small multiples

Barsky 2008
color
Get it right in black and white.

Maureen Stone
next time...

Hello Processing
by Daniel Shiffman et al.
Short video lessons introduce coding exercises that lead to designing an interactive drawing program.
Level: Beginner

Getting Started
by Casey Reas and Ben Fry
Welcome to Processing! This introduction covers the basics of writing Processing code.
Level: Beginner

Processing Overview
by Ben Fry and Casey Reas
A little more detailed introduction to the different features of Processing than the Getting Started tutorial.
Level: Beginner

Coordinate System and Shapes
by Daniel Shiffman
Drawing simple shapes and using the coordinate system.
Level: Beginner

Color
by Daniel Shiffman
An introduction to digital color.
Level: Beginner

Objects
by Daniel Shiffman
The basics of object-oriented programming.
Level: Beginner

Interactivity
by Casey Reas and Ben Fry
Introduction to interactivity with the mouse and keyboard.
Level: Beginner

Typography
by Casey Reas and Ben Fry
Working with typefaces and text.
Level: Beginner

Strings and Drawing Text
by Daniel Shiffman
Learn how use the String class and display text onscreen.
Level: Intermediate
-homework
-assignment 12 due tonight