Information Visualization Crash Course

(AKA Information Visualization 101)

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Southwestern University
(graduated from Georgia Tech CS PhD)
What is Infovis?
Why is it Important?
Human Perception
Chart Basics
(If Time, Some Color Theory)
The Shneiderman Mantra
Where to Learn More
Questions Encouraged!
What is Information Visualization?
Information Visualization

“The use of computer-supported, interactive, visual representations of abstract data to amplify cognition.”

Card, Mackinlay, and Shneiderman 1999
Communication

Exploratory Data Analysis
Communication
Communication Gone Wrong
EDWARD R. TUFTE

VISUAL EXPLANATIONS

IMAGES AND QUANTITIES, EVIDENCE AND NARRATIVE
Space Shuttle Challenger

January 28, 1986
Morning Temperature: 31°F
What happened?
Less than 1 second after ignition, a puff of smoke appeared at the aft joint of the right booster, indicating that the O-rings burned through and failed to seal. At this point, all was lost.

On the launch pad, the leak lasted only about 2 seconds and then apparently was plugged by pressure and insulation as the shuttle rose, flying through rather strong cross-winds. Then 58.7 seconds after ignition, when the Challenger was 6 miles up, a flicker of flame emerged from the leaky joint. After 73 seconds, the flame grew and engulfed the fuel tank (containing liquid hydrogen and liquid oxygen). That tank ruptured and exploded, destroying the shuttle.

As the shuttle exploded and broke up at approximately 73 seconds after launch, the two booster rockets crisscrossed and continued flying wildly. The right booster, identifiable by its failure plume, is now to the left of its non-defective counterpart.

The flight crew of Challenger 51-L. Front row, left to right: William M. Shatley, pilot; Francis R. (Dick) Scobee, commander; Ronald E. McNair, payload specialist. Back row: Ellison S. Onizuka, S. Christa McAuliffe, Gregory Jarvis, Judith A. Resnik.
A major malfunction

Challenger's brief flight

.678 seconds
Following Challenger's liftoff, a puff of black smoke — seen only by automatic launch cameras — indicates a problem with one of the O-ring seals at the joint between segments of the shuttle's right-hand solid rocket booster.

No human eyes see the smoke, and there would have been no way to abort the flight if they had.

58 seconds
A small jet of smoke and flame bursts through the side of the booster and quickly grows.

73 seconds
The flame burns through the strut attaching the solid rocket booster to the external fuel tank, causing the booster to swivel into the side of the tank. The resulting massive explosion destroys the space shuttle.

3 minutes, 58 seconds
Challenger's crew compartment, which appeared to come away from the exploding shuttle more or less intact, smashes into the Atlantic Ocean at 200 mph.

Officials never determined whether the shuttle's explosion or the impact with the ocean killed the crew.

External fuel tank
Holds about 143,000 gallons of liquid oxygen and 385,000 gallons of liquid hydrogen.

Solid rocket booster
Manufactured in segments, which are then stacked.

Liquid hydrogen

Liquid compartment

Crew compartment

Main shuttle engines

Full thrust
Once the boosters ignite, there is no way to shut them off.
there would have been no way to abort the flight if they had.

58 seconds
A small jet of smoke and flame bursts through the side of the booster and quickly grows.

73 seconds
The flame burns through the strut attaching the solid rocket booster to the external fuel tank, causing the booster to swivel into the side of the tank. The resulting massive explosion destroys the space
How did this happen?
Morton Thiokol’s Presentation
Temperature Concern on SRM Joints

27 Jan 1986
HISTORY OF O-RING DAMAGE ON SRM FIELD JOINTS

<table>
<thead>
<tr>
<th>SRM No.</th>
<th>Cross Sectional View</th>
<th>Top View</th>
<th>Clocking Location (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Erosion Depth (in.)</td>
<td>Perimeter Affected (deg)</td>
<td>Nominal Dia. (in.)</td>
</tr>
<tr>
<td>22A</td>
<td>None</td>
<td>None</td>
<td>0.280</td>
</tr>
<tr>
<td>51C</td>
<td>0.010</td>
<td>154.0</td>
<td>0.280</td>
</tr>
<tr>
<td>51C</td>
<td>0.038</td>
<td>130.0</td>
<td>0.280</td>
</tr>
<tr>
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<td>None</td>
<td>45.0</td>
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<tr>
<td>15B</td>
<td>0.028</td>
<td>110.0</td>
<td>0.280</td>
</tr>
<tr>
<td>13B</td>
<td>0.040</td>
<td>217.0</td>
<td>0.280</td>
</tr>
<tr>
<td>28</td>
<td>0.053</td>
<td>116.0</td>
<td>0.280</td>
</tr>
</tbody>
</table>

*Hot gas path detected in putty. Indication of heat on O-ring, but no damage.
**Soot behind primary O-ring.
***Soot behind primary O-ring, heat affected secondary O-ring.

Clocking location of leak check port - 0 deg.

OTHER SRM-15 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY AND NO SOOT NEAR OR BEYOND THE PRIMARY O-RING.

SRM-22 FORWARD FIELD JOINT HAD PUTTY PATH TO PRIMARY O-RING, BUT NO O-RING EROSION AND NO SOOT BLOWBY. OTHER SRM-22 FIELD JOINTS HAD NO BLOWHOLES IN PUTTY.
PRIMARY CONCERNS -

FIELD JOINT - HIGHEST CONCERN

- EROSION PENETRATION OF PRIMARY SEAL REQUIRES RELIABLE SECONDARY SEAL FOR PRESSURE INTEGRITY
  - IGNITION TRANSIENT - (0-600 MS)
    - (0-170 MS) HIGH PROBABILITY OF RELIABLE SECONDARY SEAL
    - (170-350 MS) REDUCED PROBABILITY OF RELIABLE SECONDARY SEAL
    - (350-600 MS) HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY

- STEADY STATE - (600 MS - 2 MINUTES)
  - IF EROSION PENETRATES PRIMARY O-RING SEAL - HIGH PROBABILITY OF NO SECONDARY SEAL CAPABILITY
    - BENCH TESTING SHOWED O-RING NOT CAPABLE OF MAINTAINING CONTACT WITH METAL PARTS GAP OPENING RATE TO MEOP
    - BENCH TESTING SHOWED CAPABILITY TO MAINTAIN O-RING CONTACT DURING INITIAL PHASE (0-170 MS) OF TRANSIENT
**Blow By History**

**SRM-15 Worst Blow-By**
- 2 Case Joints (50°), (110°) Arc
- Much worse visually than SRM-22

**SRM-22 Blow-By**
- 2 Case Joints (30-40°)

**SRM-13 A, 15, 16A, 18, 23A, 24A**
- Nozzle Blow-By

---

<table>
<thead>
<tr>
<th></th>
<th>MOTOR</th>
<th>M&amp;B</th>
<th>AMB</th>
<th>O-RING</th>
<th>WIND</th>
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<td>47</td>
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<td>10 MPH</td>
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*Degrees F*
Conclusions:

- Temperature of O-ring is not only parameter controlling blow-by.
  - SRM 15 with blow-by had an O-ring temp at 53°F.
  - SRM 22 with blow-by had an O-ring temp at 75°F.
  - Four development motors with no blow-by were tested at O-ring temp of 47° to 52°F.
  - Development motors had putty packing which resulted in better performance.

- At about 50°F blow-by could be experienced in case joints.

- Temp for SRM 25 on 1-28-84 launch will be 29°F at 9 am.
  - 38°F at 2 pm.

- Have no data that would indicate SRM 25 is different than SRM 15 other than temp.

Recommendations:

- O-ring temp must be ≥ 53°F at launch.
  - Development motors at 47° to 52°F with putty packing had no blow-by.
  - SRM 15 (the best simulation) worked at 53°F.

- Project ambient conditions (temp & wind) to determine launch time.
History of O-Ring Damage in Field Joints (Cont)

O-Ring Temp (°F)

<table>
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<th>SRM No.</th>
<th>O-Ring Temp (°F)</th>
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<td>1</td>
<td>166</td>
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<tr>
<td>1</td>
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<td>73</td>
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<td>12</td>
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O-Ring Temp (°F)

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<td>24</td>
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</tr>
<tr>
<td>24</td>
<td>76</td>
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</tbody>
</table>

*MORTON THERMAL, INC.*
*WEATHER OPERATIONS*

*No Erosion*

*Information on this page was prepared to support an oral presentation and cannot be considered complete without the oral discussion.*
<table>
<thead>
<tr>
<th>Flight</th>
<th>Date</th>
<th>Temperature °F</th>
<th>Erosion incidents</th>
<th>Blow-by incidents</th>
<th>Damage index</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>51-C</td>
<td>01.24.85</td>
<td>53°</td>
<td>3</td>
<td>2</td>
<td>11</td>
<td>Most erosion any flight; blow-by; back-up rings heated. Deep, extensive erosion.</td>
</tr>
<tr>
<td>41-B</td>
<td>02.03.84</td>
<td>57°</td>
<td>1</td>
<td></td>
<td>4</td>
<td>O-ring erosion on launch two weeks before Challenger.</td>
</tr>
<tr>
<td>61-C</td>
<td>01.12.86</td>
<td>58°</td>
<td>1</td>
<td></td>
<td>4</td>
<td>O-rings showed signs of heating, but no damage.</td>
</tr>
<tr>
<td>41-C</td>
<td>04.06.84</td>
<td>63°</td>
<td>1</td>
<td></td>
<td>2</td>
<td>Coolest (66°) launch without O-ring problems.</td>
</tr>
<tr>
<td>1</td>
<td>04.12.81</td>
<td>66°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>04.04.83</td>
<td>62°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>51-A</td>
<td>11.08.84</td>
<td>62°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
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<tr>
<td>51-D</td>
<td>04.12.85</td>
<td>67°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>11.11.82</td>
<td>68°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>03.22.82</td>
<td>69°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>11.12.81</td>
<td>70°</td>
<td>1</td>
<td></td>
<td>4</td>
<td>Extent of erosion not fully known.</td>
</tr>
<tr>
<td>9</td>
<td>11.28.83</td>
<td>70°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>41-D</td>
<td>08.30.84</td>
<td>70°</td>
<td>1</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>51-G</td>
<td>06.17.85</td>
<td>70°</td>
<td></td>
<td></td>
<td>0</td>
<td>No erosion. Soot found behind two primary O-rings.</td>
</tr>
<tr>
<td>7</td>
<td>06.18.83</td>
<td>72°</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8</td>
<td>08.30.83</td>
<td>73°</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>51-B</td>
<td>04.29.85</td>
<td>75°</td>
<td></td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>61-A</td>
<td>10.30.85</td>
<td>75°</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>51-I</td>
<td>08.27.85</td>
<td>76°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>61-B</td>
<td>11.26.85</td>
<td>76°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
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<td>41-G</td>
<td>10.05.84</td>
<td>78°</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>51-J</td>
<td>10.03.85</td>
<td>79°</td>
<td></td>
<td></td>
<td>0</td>
<td>O-ring condition unknown; rocket casing lost at sea.</td>
</tr>
<tr>
<td>4</td>
<td>06.27.82</td>
<td>80°</td>
<td></td>
<td></td>
<td>?</td>
<td></td>
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<tr>
<td>51-F</td>
<td>07.29.85</td>
<td>81°</td>
<td></td>
<td></td>
<td>0</td>
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</tr>
</tbody>
</table>
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
So, communication is extremely important.

Visualization can help with that.
Visualization can also help with Exploration Data Analysis (EDA)
“There are three kinds of lies: lies, damned lies, and statistics.”
Mystery Data Set
## Mystery Data Set

<table>
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<tr>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>mean( x )</td>
<td>9</td>
</tr>
<tr>
<td>variance ( x )</td>
<td>11</td>
</tr>
<tr>
<td>mean( y )</td>
<td>7.5</td>
</tr>
<tr>
<td>variance ( y )</td>
<td>4.122</td>
</tr>
<tr>
<td>correlation ( x,y )</td>
<td>0.816</td>
</tr>
<tr>
<td>Linear Regression Line</td>
<td>$y = 3 + 0.5x$</td>
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</table>
Anscombe’s Quartet

https://en.wikipedia.org/wiki/Anscombe%27s_quartet
Anscombe’s Quartet

Sanity Checking Models

Outlier Detection
Anscombe’s Quartet

Sanity Checking Models

Outlier Detection
Anscombe’s Quartet

Sanity Checking Models

Outlier Detection
Anscombe’s Quartet

Sanity Checking Models

Outlier Detection
Human Perception
Name the five senses.
<table>
<thead>
<tr>
<th>Sense</th>
<th>Bandwidth (bits/sec)</th>
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<tbody>
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<tr>
<td>Touch</td>
<td>1,000,000</td>
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<tr>
<td>Hearing</td>
<td>100,000</td>
</tr>
<tr>
<td>Smell</td>
<td>100,000</td>
</tr>
<tr>
<td>Taste</td>
<td>1,000</td>
</tr>
</tbody>
</table>

http://www.britannica.com/EBchecked/topic/287907/information-theory/214958/Physiology
A (Simple) Model of Human Visual Perception
A (Simple) Model of Human Perception

Stage 1: Parallel detection of basic features into an iconic store

Stage 2: Serial processing of object identification and spatial layout
Stage 1: Pre-Attentive Processing

Rapid Parallel Automatic (Fleeting)
Stage 2: Serial Processing

Relatively Slow
(Incorporates Memory)
Manual
Stage 1: Pre-Attentive Processing

The eye moves every 200ms
Stage 1: Pre-Attentive Processing

The eye moves every 200ms
(so this processing occurs every 200ms-250ms)
Example

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
Example

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
A few more examples from Prof. Chris Healy at NC State
Raise your hand if a RED DOT is present...
Color (hue) is pre-attentively processed.
Raise your hand if a RED DOT is present...
Shape is pre-attentively processed.
Determine if a RED DOT is present...
Hue and shape together are NOT pre-attentively processed.
Pre-Attentive Processing

- length
- width
- size
- curvature
- number
- terminators
- intersection
- closure

- hue
- lightness
- flicker
- direction of motion
- binocular lustre
- stereoscopic depth
- 3-D depth cues
- lighting direction
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<th>Group</th>
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<td>Spatial Grouping</td>
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<td>Motion</td>
<td>Direction</td>
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</table>
Pre-Attentive $\rightarrow$ Cognitive
Gestalt Psychology

Berlin, Early 1900s
Gestalt Psychology

Goal was to understand pattern perception

Gestalt (German) = “seeing the whole picture all at once”

Identified 8 “Laws of Grouping”

Gestalt Psychology

1. Proximity
2. Similarity
3. Closure
4. Symmetry
5. Common Fate
6. Continuity
7. Good Gestalt
8. Past Experience
How many groups are there?
Proximity
How many groups are there?
Similarity
How many shapes are there?
Closure
How many items are there?
Symmetry
How many sets are there?
Common Fate
How many objects are there?
Continuity
How many objects are there?
Good Gestalt
What is this word?
(Please Shout)
FLICK
Past Experience

FLICK
Past Experience

flick
Pre-Attentive Processing

Gestalt Laws
Detect Quickly
Detect Quickly

Detect Accurately
EXPERIMENT 1B: RECTANGULAR AREA JUDGMENTS

We sought to compare our circular area judgment (T7) to rectangular area judgments arising in visualization studies. After successfully replicating Cleveland & McGill's results, we further extended the experiment to more judgment types. Prior to this, extreme variability in the results for the position-angle experiment led us to attempt a factorial design with 6 replications for a total of 108 unique trials (HITs). In the first display condition (T8) we varied the circular case, but that performance would be impacted by additional distracting elements, which might bias estimation. We used a 2 (display) ⇥ 2 (shape) factorial design with 6 replications for a total of 108 judgments. We used a 2 (display) ⇥ 2 (shape) factorial design with 6 replications for a total of 108 judgments.
Automating the Design of Graphical Presentations

Fig. 14. Accuracy ranking of quantitative perceptual tasks. Higher tasks are accomplished more accurately than lower tasks.

Cleveland and McGill empirically verified the basic properties of this ranking.

Fig. 15. Ranking of perceptual tasks. The tasks shown in the gray boxes are not relevant to these types of data.

An example analysis for area perception is shown in Figure 16. The top line shows that a series of decreasing areas can be used to encode a tenfold quantitative range. Of course, in a real diagram such as Figure 13, the areas would be laid out randomly, making it more difficult to judge the relative sizes of different areas accurately (hence, area is ranked fifth in Figure 14). Nevertheless, small misjudgments about the size of an area only leads to small misperceptions about the corresponding quantitative value that is encoded.

Mackinlay, 1986
<table>
<thead>
<tr>
<th>Precision of Quantitative Perception</th>
<th>Attribute</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very precise</td>
<td>Length</td>
<td>[ ]</td>
<td>Longer = greater</td>
</tr>
<tr>
<td>2-D Position</td>
<td></td>
<td>• • • •</td>
<td>Higher or farther to the right = greater</td>
</tr>
<tr>
<td>Not very precise</td>
<td>Width</td>
<td>[ ]</td>
<td>Wider = greater</td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td>• • • •</td>
<td>Bigger = greater</td>
</tr>
<tr>
<td>Intensity</td>
<td></td>
<td>• • • •</td>
<td>Darker = greater</td>
</tr>
<tr>
<td>Blur</td>
<td></td>
<td>• • • •</td>
<td>Clearer = greater</td>
</tr>
</tbody>
</table>
What does this tell us?
Barcharts, scatterplots, and line charts are really effective for quantitative data.
(and for statistical distributions)
Tukey Box Plots
Outliers

Largest < Q3 + 1.5 IQR

Largest < Q3

Median

Smallest > Q1

Smallest > Q1 - 1.5 IQR
The diagram illustrates the relationship between the Interquartile Range (IQR) and the data distribution. The IQR is the range between the first quartile (Q1) and the third quartile (Q3). The values Q1 - 1.5 × IQR and Q3 + 1.5 × IQR are used to identify outliers in the data. The diagram also shows the empirical rule for a normal distribution, where approximately 68.27% of the data falls within 1 standard deviation (σ) of the mean, 95.45% within 2 standard deviations, and 99.73% within 3 standard deviations.
Tufte’s Chart Principles
Edward Tufte
Edward Tufte
Tufte’s Chart Principles

DO NOT LIE!
Tufte’s Chart Principles

DO NOT LIE!
Maximize Data-Ink Ratio
Minimize Chart Junk
Subsea Oil Collection

- Avg circa 2,000 bbl per day
- Total of 13,500 bbis collected

Cumulative Oil Collected, bbls

- Laser Insertion Tube Tool (LITT)
PET PEEVE #208:

GEOGRAPHIC PROFILE MAPS WHICH ARE BASICALLY JUST POPULATION MAPS
Tufte’s Chart Principles

DO NOT LIE!
Maximize Data-Ink Ratio
Minimize Chart Junk
DIAMONDS WERE A GIRL’S BEST FRIEND
Average price of a one-carat D-flawless

$60,000
$50,000
$40,000
$30,000
$20,000


TIME Chart by Nigel Holmes
Source: The Diamond Registry

Please...
No pie charts.
No 2.5D charts.
PLEASE DON’T EVER DO THIS!
Two times to use a pie chart...
50-50
But otherwise…
Barcharts, scatterplots, and line charts are **really effective** for quantitative data.
Anyone else bored by my color choices?
In fact, grayscale can be risky...
In fact, grayscale can be risky...
Color is Powerful
Color

Call attention to information
Increase appeal
Increase memorability
Another dimension to work with
How many of you have heard of RGB?
We see in RGB, but we don’t interpret in RGB...
How many have heard of HSV?
HSV Color Model

Hue/“Color”
Saturation/Chroma
Value/Lightness
Hue

Post & Greene, 1986
Actual color names if you’re a girl ...

Actual color names if you’re a guy ...

Hue

This chart shows the dominant color names over the three fully-saturated faces of the RGB cube (colors where one of the RGB values is zero).

http://blog.xkcd.com/2010/05/03/color-survey-results/
Hue and Colorblindness

10% of males and 1% of females are Red-Green Colorblind
NOAA's Latest High Resolution Weather Model is Released

Color and Quantitative Data

Gray scale

Full spectral scale

Single sequence part spectral scale

Single sequence single hue scale

Double-ended multiple hue scale
Can you order these (low→hi)?
• categorical limits: noncontiguous – 6-12 bins hue/color
• far fewer if colorblind – 3-4 bins luminance, saturation
• size heavily affects salience


http://www.personal.psu.edu/faculty/c/a/cab38/ColorSch/Schemes.html via Munzner
Color Scales

Color Brewer

http://colorbrewer2.org/
Overview
Zoom+Filter
Details on Demand

Shneiderman Mantra
(Information-Seeking Mantra)
NameVoyager: Explore baby names and name trends letter by letter

Looking for the perfect baby name? Sign up for free to receive access to our expert tools!

Baby Name > Chal

Names starting with 'CHA' per million babies

Click a name graph to view that name. Double-click to read more about it.
WHAT 3-D PIE CHARTS ARE GOOD FOR.

META 3-D PIE CHARTS

PIE CHARTS MADE OF EDIBLE PIES

ANNOYING BUSINESS ANALYTICS PEOPLE, CAUSING THEM TO DIE A LITTLE BIT INSIDE

MAKING EDWARD TUFTED CRY, OR ROLL OVER IN HIS GRAVE EVEN THOUGH HE'S STILL ALIVE; ALSO POSSIBLY KILL KITTENS

http://flowingdata.com/2012/06/15/what-3-d-pie-charts-are-good-for/
Where to learn more?
CS 7450
Information Visualization
Every Fall
Visualization @GeorgiaTech

vis.gatech.edu
How to Make Good Charts

• Edward Tufte’s One-Day Workshop
  – http://www.edwardtufte.com/tufte/courses

• Edward Tufte, *Visual Display of Quantitative Information*
  – http://www.edwardtufte.com/tufte/books_vdqii

• Stephen Few, *Show Me the Numbers: Designing Tables and Graphs to Enlighten*
Visualization Theory “Books”

• Tamara Munzner VIS Tutorial and Book
  – http://www.cs.ubc.ca/~tmm/vadbook/
• Colin Ware, Information Visualization: Perception for Design
• Stephen Few, Now You See It
  – http://www.amazon.com/Now-You-See-Visualization-Quantitative/dp/0970601980/ref=pd_bxgy_b_img_z
• Edward Tufte, Envisioning Information
  – http://www.edwardtufte.com/tufte/books_ei
• Edward Tufte, Visual Explanations
  – http://www.edwardtufte.com/tufte/books_visex
• Edward Tufte, Beautiful Evidence
  – http://www.edwardtufte.com/tufte/books_be
• Tamara Munzner, Visualization Analysis & Design
Perception and Color Websites

• Chris Healy, NC State
  – http://www.csc.ncsu.edu/faculty/healey/PP/index.html

• Color Brewer
  – http://colorbrewer2.org/

• Maureen C. Stone (Color Links, Blog, Workshops)

• Subtleties of Color by Robert Simmon of NASA
Visualization Blogs

• Flowing Data by Nathan Yau
  – http://flowingdata.com/
• Information Aesthetics by Andrew Vande Moere
  – http://infosthetics.com/
• Information is Beautiful by David McCandless
  – http://www.informationisbeautiful.net/
• Visual.ly Blog
  – http://blog.visual.ly/
• Indexed Comic by Jessica Hagy
  – http://thisisindexed.com/
Infographics

Visual.ly/view

(wtfviz.net)
Thanks!

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Questions?

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