Information Visualization Crash Course

(AKA Information Visualization 101)

Chad Stolper
Google
(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
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 (EDA)
Communication
(gone wrong)
Edward Tufte

An American statistician and professor emeritus of political science, statistics, and computer science at Yale University.

He is noted for his writings on information design and as a pioneer in the field of data visualization.

-Wikipedia
Space Shuttle Challenger

January 28, 1986

Morning Temperature: 31°F
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 fuel 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. In 5 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: Robert C.McMillan, mission specialist; Michael J. Smith, pilot; Francis R. (Dick) Scobee, commander; Ronald E. McNair, mission specialist. Back row: Ellison S. Onizuka, S. Christa McAuliffe, Gregory B. Jarvis, Judith A. Resnik.
Rubber O-rings, nearly 38 feet (11.6 meters) in circumference; 1/4 inch (6.4 mm) thick.

The field joint that leaked.

Most Watched Science Experiment

Richard Feynman, Physics Nobel laureate explained how rubber became rigid in cold temperate

YouTube video: https://youtu.be/6Rwcbsn19c0

Video originally from: http://www.FeynmanPhysicsLectures.com
How did this happen?
Engineers at Morton Thiokol, the rocket maker, presented on the day before and recommended **not to launch**.
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 21 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°F 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 1-28-86 launch will be 29°F 9 AM
  38°F 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°F 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)**

| 1       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 3       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 4       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 5       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 6       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 7       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 8       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 9       |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 10      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 11      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 12      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

**O-Ring Temp (°F)**

| 13      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 14      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 15      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 16      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 17      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 18      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 19      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 20      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 21      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 22      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 23      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 24      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

*MORTON THIOKOL, INC.
Wasatch Operations

INFORMATION ON THIS PAGE WAS PREPARED TO SUPPORT AN ORAL PRESENTATION AND CANNOT BE CONSIDERED COMPLETE WITHOUT THE ORAL DISCUSSION

* No Erosion
<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>
</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>
</tr>
<tr>
<td>41-B</td>
<td>02.03.84</td>
<td>57</td>
<td>1</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>61-C</td>
<td>01.12.86</td>
<td>58</td>
<td>1</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>41-C</td>
<td>04.06.84</td>
<td>63</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>04.12.81</td>
<td>66</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>04.04.83</td>
<td>67</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>51-A</td>
<td>11.08.84</td>
<td>67</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>51-D</td>
<td>04.12.85</td>
<td>67</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>11.11.82</td>
<td>68</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>03.22.82</td>
<td>69</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>11.12.81</td>
<td>70</td>
<td>1</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>11.28.83</td>
<td>70</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>41-D</td>
<td>08.30.84</td>
<td>70</td>
<td>1</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>51-G</td>
<td>06.17.85</td>
<td>70</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>06.18.83</td>
<td>72</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>08.30.83</td>
<td>73</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>51-B</td>
<td>04.29.85</td>
<td>75</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>61-A</td>
<td>10.30.85</td>
<td>75</td>
<td>2</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>
</tr>
<tr>
<td>61-B</td>
<td>11.26.85</td>
<td>76</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>41-G</td>
<td>10.05.84</td>
<td>78</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>51-J</td>
<td>10.03.85</td>
<td>79</td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>06.27.82</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51-F</td>
<td>07.29.85</td>
<td>81</td>
<td></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**Comments**

- Most erosion any flight; blow-by; back-up rings heated.
- Deep, extensive erosion.
- O-ring erosion on launch two weeks before Challenger.
- O-rings showed signs of heating, but no damage.
- Coolest (66°) launch without O-ring problems.

Extent of erosion not fully known.

- No erosion. Soot found behind two primary O-rings.
- O-ring condition unknown; rocket casing lost at sea.
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 – communicate ideas and insights.
Hans Rosling:

The best stats you've ever seen

TED2006 · 19:50 · Filmed Feb 2006
Subtitles available in 48 languages

http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve EVER_seen.html
Visualization can also help with Exploratory Data Analysis (EDA)

But why do you need to explore data at all???
“There are three kinds of lies: lies, damned lies, and statistics.”
Mystery Data Set
Mystery Data Set

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</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>
</tr>
</tbody>
</table>
Anscombe’s Quartet

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

Sanity Checking Models

Outlier Detection
Data visualization leverages human perception
Name the five senses.
<table>
<thead>
<tr>
<th>Sense</th>
<th>Bandwidth (bits/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight</td>
<td>10,000,000</td>
</tr>
<tr>
<td>Touch</td>
<td>1,000,000</td>
</tr>
<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>
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 = lasting for a short time)*
Stage 2: Serial Processing

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

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

1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
Example

1281768756138976546984506985604982826762
98098584582224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
A few more examples from Prof. Chris Healy at NC State
Raise your hand if a RED DOT is present...

(On the left or on the right?)
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
<table>
<thead>
<tr>
<th>Group</th>
<th>Attribute</th>
<th>Length</th>
<th>Width</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td></td>
<td><img src="image1" alt="Length Image" /></td>
<td><img src="image2" alt="Width Image" /></td>
<td><img src="image3" alt="Orientation Image" /></td>
</tr>
<tr>
<td>Size</td>
<td><img src="image4" alt="Size Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape</td>
<td><img src="image5" alt="Shape Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curvature</td>
<td><img src="image6" alt="Curvature Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enclosure</td>
<td><img src="image7" alt="Enclosure Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blur</td>
<td><img src="image8" alt="Blur Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hue</td>
<td><img src="image9" alt="Hue Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td><img src="image10" alt="Intensity Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Position</td>
<td>2-D Position</td>
<td><img src="image11" alt="2-D Position Image" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial</td>
<td>Spatial Grouping</td>
<td><img src="image12" alt="Spatial Grouping Image" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motion</td>
<td>Direction</td>
<td><img src="image13" alt="Direction Image" /></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stephen Few  
"Now You See It"  
pg. 39
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” instead of a collection of parts

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?
FLIGHT
Past Experience

FLIGHT
Pre-Attentive Processing

Gestalt Laws
Detect Quickly
Detect quickly does NOT mean detect accurately

Ideally you want both.
Positions

<table>
<thead>
<tr>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="chart1.png" alt="Diagram" /></td>
<td><img src="chart2.png" alt="Diagram" /></td>
<td><img src="chart3.png" alt="Diagram" /></td>
<td><img src="chart4.png" alt="Diagram" /></td>
<td><img src="chart5.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Angles

Circular areas

Rectangular areas (aligned or in a treemap)

T6

T7

T8

T9

unique trials (HITs). In the first display condition (T8) we 
tios) factorial design with 6 replications for a total of 108 
centage the smaller was of the larger by making a “quick 
marked task: subjects were asked to identify which of two rectangles 
We again used Cleveland & McGill’s proportional judgment 
Method 
additional distracting elements, might bias estimation. 
wanted to assess if other differences, such as the presence of 
is unclear that this approach is perceptually optimal. We also 
tempting to minimize deviance from a 1:1 aspect ratio, but it 
prized that, on average, subjects would perform similarly to 
tions such as cartograms [9] and treemaps [26]. We hypoth-
sults with rectangular area judgments arising in visualiza-
we further extended the experiment to more judgment types. Based on 
EXPERIMENT 1B: RECTANGULAR AREA JUDGMENTS 
T1 T2 T3 T4 T5 T6 T7 T8 T9 

directly comparable to their position-length results. 
than length, but as stated their position-angle results are not 
perform worse than length, but the results do not support this. 
area to perform worse than angle, and both to be significantly 
should be more apt for comparison. Indeed, the new results 
and 7 to adhere to the same format as the others, the results 
showed two rectangles with horizontally aligned centers; in 
A or B 

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. The middle line shows that area can encode three ordinal values. However, one must be careful to make sure...

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></td>
<td>2-D Position</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></td>
<td>Size</td>
<td>• • • •</td>
<td>Bigger = greater</td>
</tr>
<tr>
<td></td>
<td>Intensity</td>
<td>• • • •</td>
<td>Darker = greater</td>
</tr>
<tr>
<td></td>
<td>Blur</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
Median

Outliers

Largest < Q3 + 1.5 IQR

Largest < Q3

Median

Smallest > Q1

Smallest > Q1 - 1.5 IQR

112
Tufte’s Chart Principles

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 bbls collected

Cumulative Oil Collected, bbls

- 10 May: 5,000
- 17 May: 9,000
- 25 May: 10,000
- 30 May: 12,000
- 28 June: 13,500

Fiber Insertion Tube Tool (FITT)
“Cumulative”
Our site's users

Subscribers to Martha Stewart Living

Consumers of furry pornography

The business implications are clear.

Pet Peeve #208: Geographic profile maps which are basically just population maps.

http://xkcd.com/1138/
DO NOT LIE!
Maximize Data-Ink Ratio
Minimize Chart Junk
Please...
No pie charts.
No 2.5D charts.
PLEASE DON’T EVER DO THIS!
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
Have you heard of RGB?

Additive color model: colors create by mixing **red**, **green**, **blue** light

We see in RGB, but we don’t interpret in RGB...
HSV Color Model

- Hue
- Saturation
- Lightness

Source: color picker in Affinity Designer
Hue

Post & Greene, 1986
148
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

Sep 30, 2014

Color and Quantitative Data

Can you order these (low→hi)?
Colormaps

- Categorical limits: noncontiguous – 6-12 bins hue/color; 3-4 bins luminance, saturation; size heavily affects salience
- Use high saturation for small regions, low saturation for large

Color Brewer for Picking Color Scales

Overview
Zoom+Filter
Details on Demand

Shneiderman Mantra
(Information-Seeking Mantra)

https://www.mat.ucsb.edu/g.legrady/academic/courses/11w259/schneiderman.pdf
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 > Cha | Both Boys Girls
Current rank: boys girls

Names starting with 'CHA' per million babies

Click a name graph to view that name. Double-click to read more about it.

http://www.babynamewizard.com/voyager
Where to learn more?
CS 7450
Information Visualization
Every Fall
Many current and past members of the Vis group attended VIS.
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](http://www.csc.ncsu.edu/faculty/healey/PP/index.html)

- Color Brewer
  - [http://colorbrewer2.org/](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!

Chad Stolper

chadstolper@gatech.edu
Questions?

Chad Stolper
chadstolper@gatech.edu