Lecture 6

10/13/20

Rules of Thumb

- No Unjustified 3D
  - The Power of the Plane
  - The Disparity of Depth
  - Occlusion Hides Information
  - Perspective Distortion Dangers
  - Tilted Text Isn’t Legible
- No Unjustified 2D
- Eyes Beat Memory
- Resolution over Immersion
- Overview First, Zoom and Filter, Detail on Demand
- Responsiveness is Required
- Get it Right in Black and White
- Function First, Form Next

No Unjustified 3D

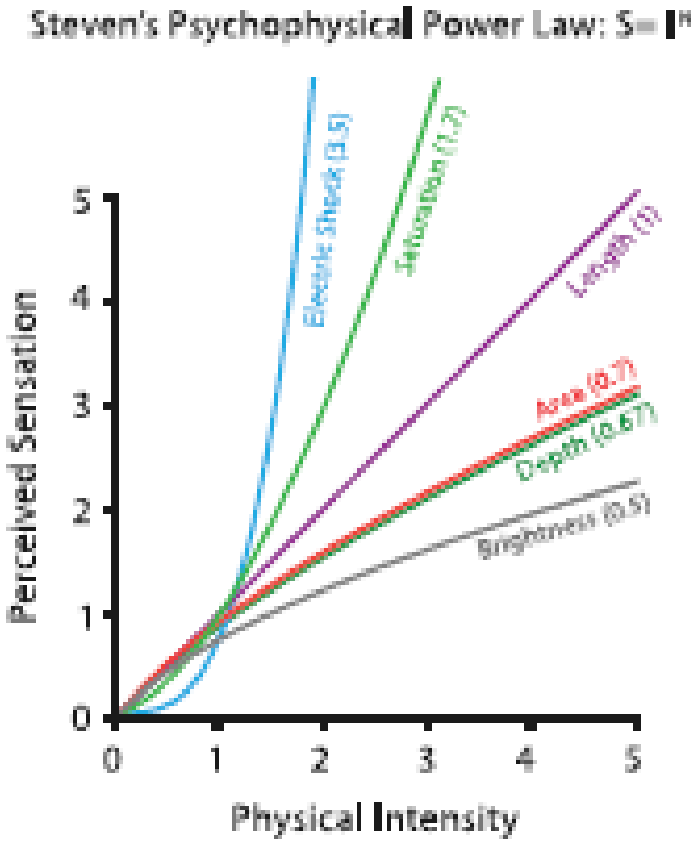
- Justified for:
  - Shape understanding of 3D structures
  - Spatial data
- Most cases:
  - 2D is a better option
  - Often involves a different choice of data abstraction that may entail transforming the dataset by computing derived data
- Depth cues – cues that convey depth information to our visual system
  - Occlusion
  - Perspective distortion
  - Shadows and lighting
  - Familiar size

No Unjustified 3D: The Power of the Plane

- Spatial position channels in chapter 5
  - Apply to planar spatial position, not arbitrary 3D position
  - Vertical and horizontal position are combined into the shared category of planar because:
    - Differences between up-down and side-to-side axes are relatively subtle
    - We do perceive height differences as more important than horizontal position differences, most probably because of the physical effects of gravity in real life

No Unjustified 3D: The Disparity of Depth

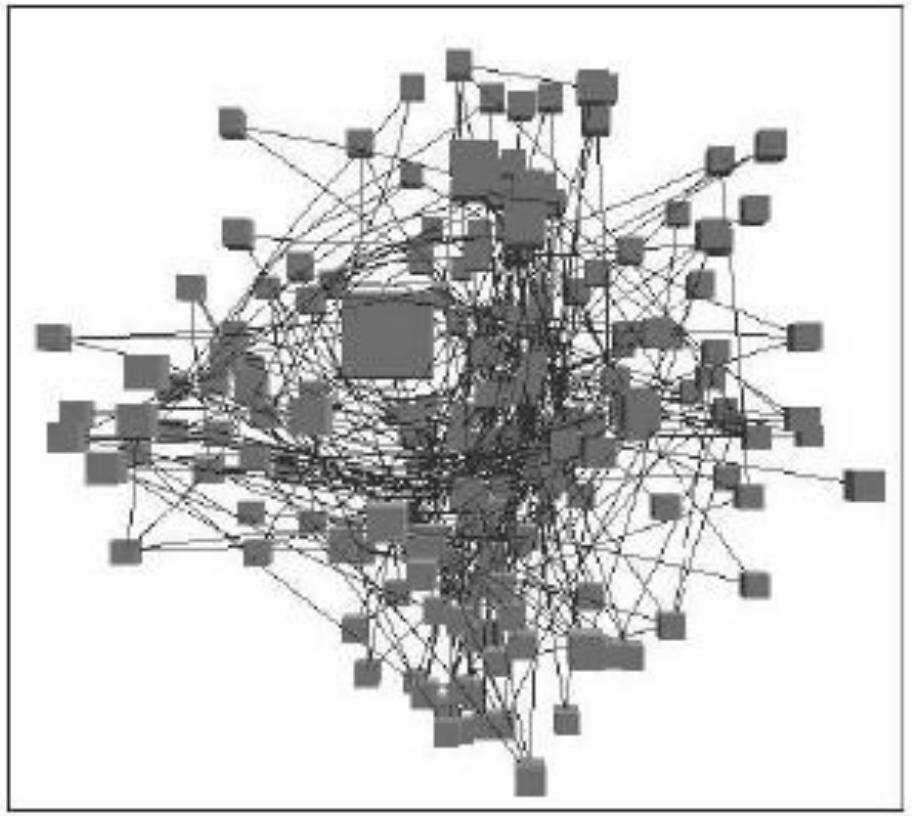
- Chapter 5 Psychophysical Power Law exponents for accuracy
  - Planar spatial position judgements in 2D: highly accurate length perception capability of 1.0
  - For depth judgements of visual distance value was 0.67
  - Area judgements was 0.7
- XY – axis object (2D picture aka image plane)
- Z- axis object
  - Line of sight ambiguity
  - In order to get more information about what is hidden behind the closest objects show in an image plane:
    - Move viewpoint by moving head or shifting body to another position
    - Move the object (rotate the visual)


Steven's Psychophysical Power Law: S= I^n
Perceived Sensation
Physical Intensity
0
1
2
3
4
5
Electric Shock (3.5)
Length (1)
Area (0.7)
Depth (0.67)
Brightness (0.5)

No Unjustified 3D: Occlusion Hides Information

- Occlusion – most powerful depth cue
  - Some objects cannot be seen because they are hidden behind others
  - Visible objects are interpreted as being closer than the occluded ones
  - Motion parallax
    - Occlusion relationships between objects change as we move around
    - Allows to build up an understanding of the relative distances between objects in the world
    - Navigation controls allow the user to change the 3D viewpoint interactively invoke the same perceptual mechanisms to provide motion parallax.
- Main Problem:
  - Presumably important information is hidden and discovering it via navigation has a time cost
  - Occluded detail might be critical; especially likely when using spatial position as a visual channel for abstract non-spatial data

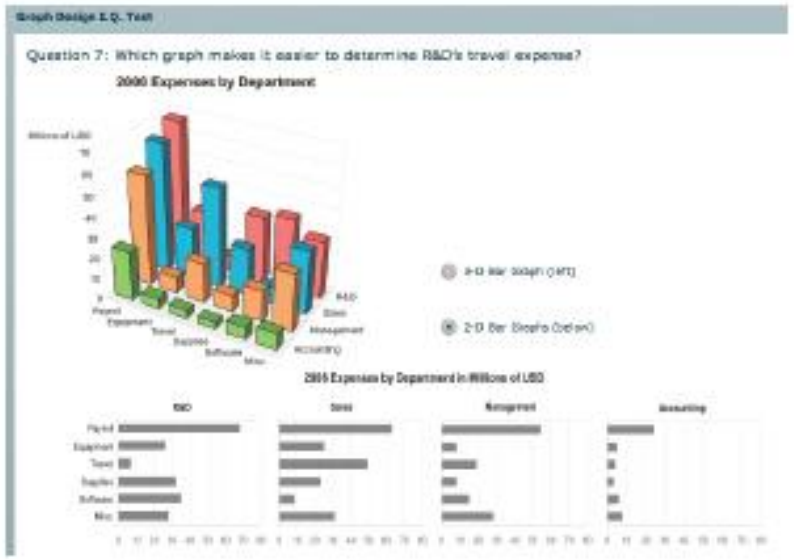
No Unjustified 3D: Occlusion Hides Information



No Unjustified 3D: Perspective Distortion Dangers

- Definition: distant objects appear smaller and change their planar position on the image plane.
- Perspective is a bad thing in the context of visually encoding abstract data
- One of the main dangers of depth
  - Power of the plane is lost
  - Completely interferes with visual encodings that use the planar spatial position channels and the size channel

No Unjustified 3D: Perspective Distortion Dangers



What channels are lost here with perspective distortion?

No Unjustified 3D: Other Depth Cues

- Shadows – communicate depth
- Surface shading – communicates 3D structural information
- These are lighting based cues
  - What channel is this??
- Can create visual clutter
- Distract attention from meaningful parts of the visual
- Can be mistaken for true marks or obstruct true marks

No Unjustified 3D: Tilted Text Isn't Legible

- Text positioning at arbitrary orientations in 3D space can be done quickly, but the text is usually not rendered well
- Text label is usually blocky and jaggy when it is tilted in any way off the image plane
- Legibility is a major problem today

No Unjustified 3D: Benefits of 3D – Shape Perception

- Useful when viewers task requires understanding of 3D geometric structure of objects/scenes
- 3D view with interactive navigations controls
  - Build a mental model of 3D geometry and dataset structure more quickly than several 2D views
- Evidence that 3D outperforms 2D for shape understanding
  - Examples: fluid flow over an airplane wing, airflow/temps in a datacenter

No Unjustified 2D

- Laying out data in 2D should be explicitly justified
  - Alternative: simply showing the data with a 1D list
- Strengths of lists:
  - Show maximal information in minimal space
    - Contrast: 2D layouts such as node-link representation of network data require more space to show the same number of labels, they have much lower information density.
  - Excellent for lookup tasks when ordered appropriately (e.g. alphabetical order)
    - Contrast: 2D node-link layout would require user to hunt around the entire layout unless a search capability is built into the vis tool (time…is it worth it?)
- When requiring understanding of topological structure of network
  - Benefits of showing those relationships outweigh the cost of space required
  - Some task are handled well by linear lists, even if the original data has network structure.

Eye Beat Memory: Memory and Attention

- Lower cognitive load when using our eyes to switch between different views that are shown simultaneously than using our memory to compare a current view with one seen before
- Two different categories of memory:
  - Long-term : last a lifetime, no strict upper limit
  - Short-term aka working memory: lasts several seconds, very limited resource
    - Cognitive load: limits are reached resulting in failure to absorb all the information presented
- Human attention is limited:
  - When consciously searching items, difficulty increases as the number of items to be searched increases
- Vigilance is also limited:
  - Visual search task results are best in the first few minutes than after several hours

Eye Beat Memory: Animation versus Side-by-Side Views

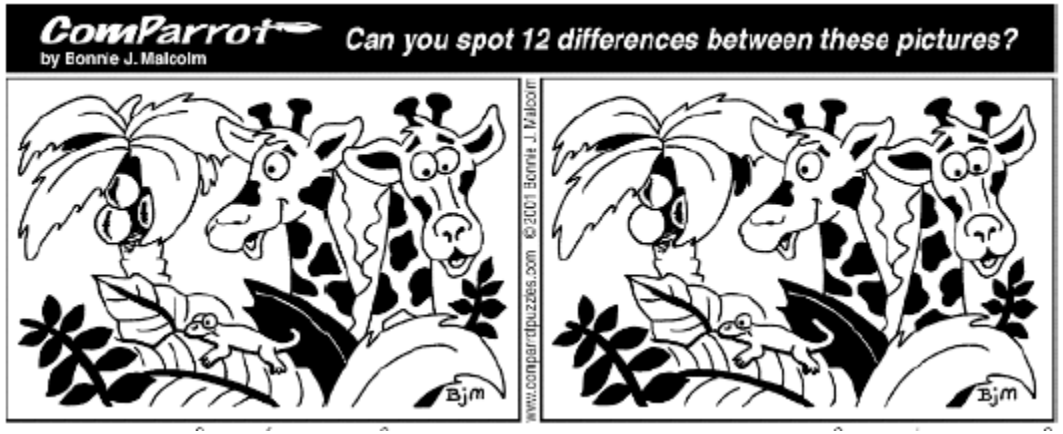
- Animation based idioms: significant cognitive load b/c of implicit memory demands
- Animation definitions:
  - Narrative storytelling, eg popular movies
  - Transitions from one state to another
  - Multiframe sequence with video-style playback: play, pause, stop, rewind, and step forward/back
- Successful storytelling guides the user to look in the right place
- Dataset animation may have simultaneous changes in many parts of the view
- Animation powerful to help maintain context when transitioning between two dataset configurations
  - It helps track changes, therefore can be more effective at times than jump cuts
  - Useful transitions involve only a few things changing at a time
  - Video-style playback allows speed control
- Sometimes, side by side setup of multiple frames is more effective than animation
  - Dozen, not hundreds
  - Meaningful chunks instead of random

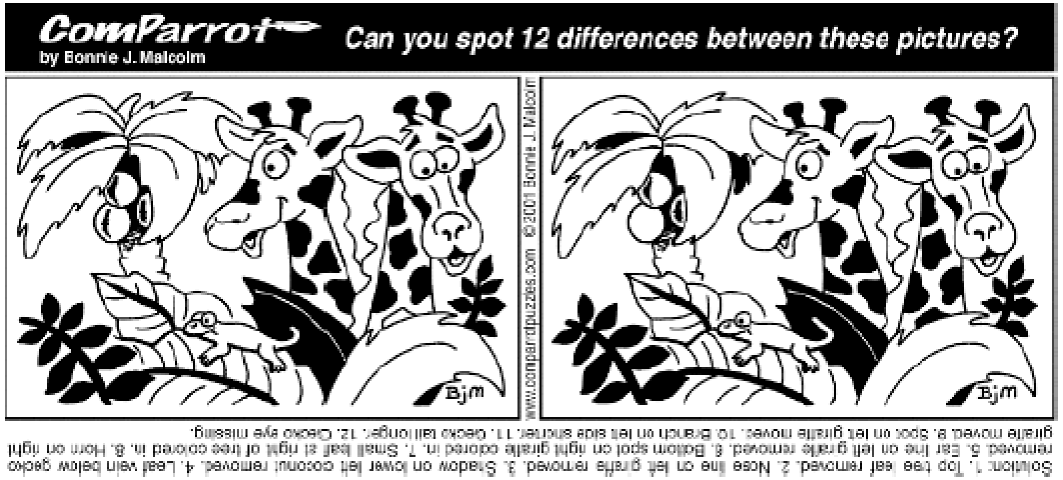
ComParrot
by Bonnie J. Malcolm

Can you spot 12 differences between these pictures?

ComParrot
by Bonnie J. Malcolm

Can you spot 12 differences between these pictures?


ComParrot
by Bonnie J. Malcolm
Can you spot 12 differences between these pictures?
www.comparrotpuzzles.com ©2001 Bonnie J. Malcolm
Bjm
Bjm



ComParrot
by Bonnie J. Malcolm
Can you spot 12 differences between these pictures?
Bjm
Bjm
www.comparrotpuzzles.com ©2001 Bonnie J. Malcolm
Solution: 1. Top tree leaf removed. 2. Nose line on left giraffe removed. 3. Shadow on lower left coconut removed. 4. Leaf vein below gecko removed. 5. Ear line on left giraffe removed. 6. Bottom spot on right giraffe colored in. 7. Small leaf at right of tree colored in. 8. Horn on right giraffe moved. 9. Spot on left giraffe moves. 10. Branch on left side shorter. 11. Gecko tail longer. 12. Gecko eye missing.

Eye Beat Memory: Change Blindness

- Fail to notice drastic changes IF our attention is directed elsewhere
- Do not disregard that there is sensitivity to changes at the focus of our attention, but not so much when our attention is disengaged
- Therefore, this contributes towards the difficulty in tracking complex/widespread changes across multiframe animations

Resolution over Immersion

- Immersion
  - Virtual reality
  - Sense of presence
  - Cost is resolution
  - Perhaps for 3D spatial data, but weigh the costs (ex resolution and workflow)
- Tradeoff between resolution and immersion
  - Resolution – number of available pixels divided by the display area

Overview First, Zoom and Filter, Detail on Demand

- Overview
  - broad awareness of entire information space
  - goal of summarize
  - show all items in the dataset simultaneously
- Reduce
  - Filter, aggregate, zoom
  - Larger datasets
- Overview vs detail
  - Overview: summarize a lot of data with minimal detail
  - Detail view: smaller number of data items with more information about each one

Responsiveness is Required: Visual Feedback

- Latency of interaction
  - Time for the system to respond to user actions
  - Very important for interaction design
  - Why is it so important?

Time Constant	Value (in seconds)
perceptual processing	0.1
immediate response	1
brief tasks	10

- Perceptual processing – screen updates
- Immediate response – visual feedback showing what item user has selected with a mouse click or length of time for animated transition from one layout to another
- Brief task time – breaking down complex tasks into simpler pieces

Responsiveness is Required: Visual Feedback

- Within 1 second
- Use a progress indicator if timespan is longer than expected (rule of thumb: if jumping from one latency class into another)
- Highlight a selected item to confirm desired operation has completely successfully, instead of mistakenly clicking on background and waiting

Responsiveness is Required: Latency and Interaction Design

- For visual feedback consider three mechanisms:
  - Showing information on fixed detail pane at side of screen
    - high latency b/c eyes need to move from cursor to detail pane on side of screen
    - but detail can be shown without occluding anything from main display
  - Popup window at current cursor location
    - Faster to use, eyes don't have to move, but occlusion cost
  - Visual highlight change directly in the view
    - Highlighting all neighbors through a color change

Responsiveness is Required: Interactivity Costs

- Interactivity has both power and cost
- Power
  - Explore a larger information space than can be understood in a single static image
- Cost
  - Requires human time and attention
- Trade-off between finding automatable aspects and relying on the human in the loop to detect patterns
- Goal of vis designer: automatically detect features of interest to explicitly bring to the user's attention via the visual encoding
- Fine balance between user having to exhaustively search every possibility and task at hand to be completely solved by automatic means

Get It Right in Black and White

- Ensure most important aspects of visual are legible even if image is transformed from full color to black and white
  - Literally check your work in black and white
- Encoding the most important attribute in the _____ channel, to ensure adequate _____ contrast.

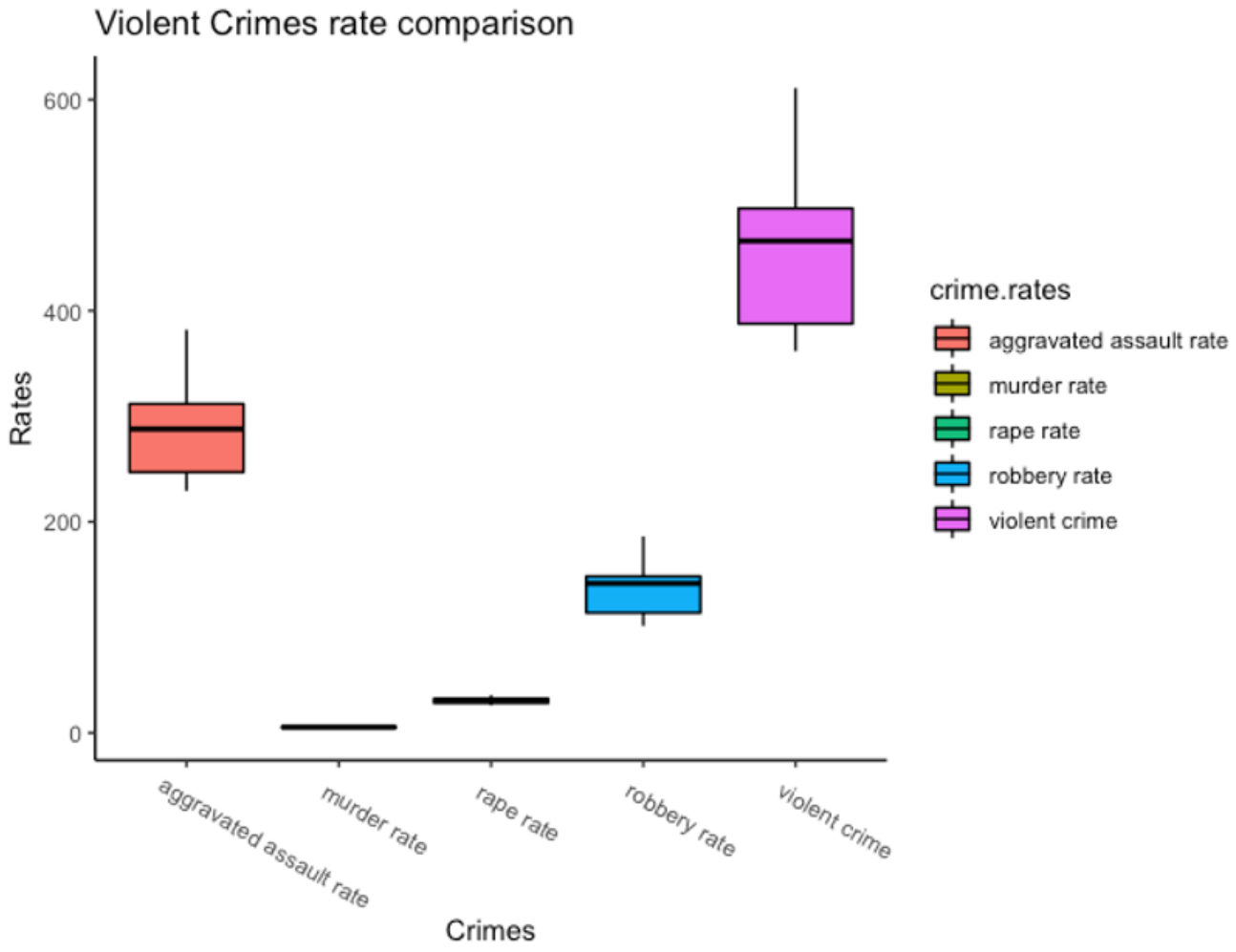
Function First, Form Next

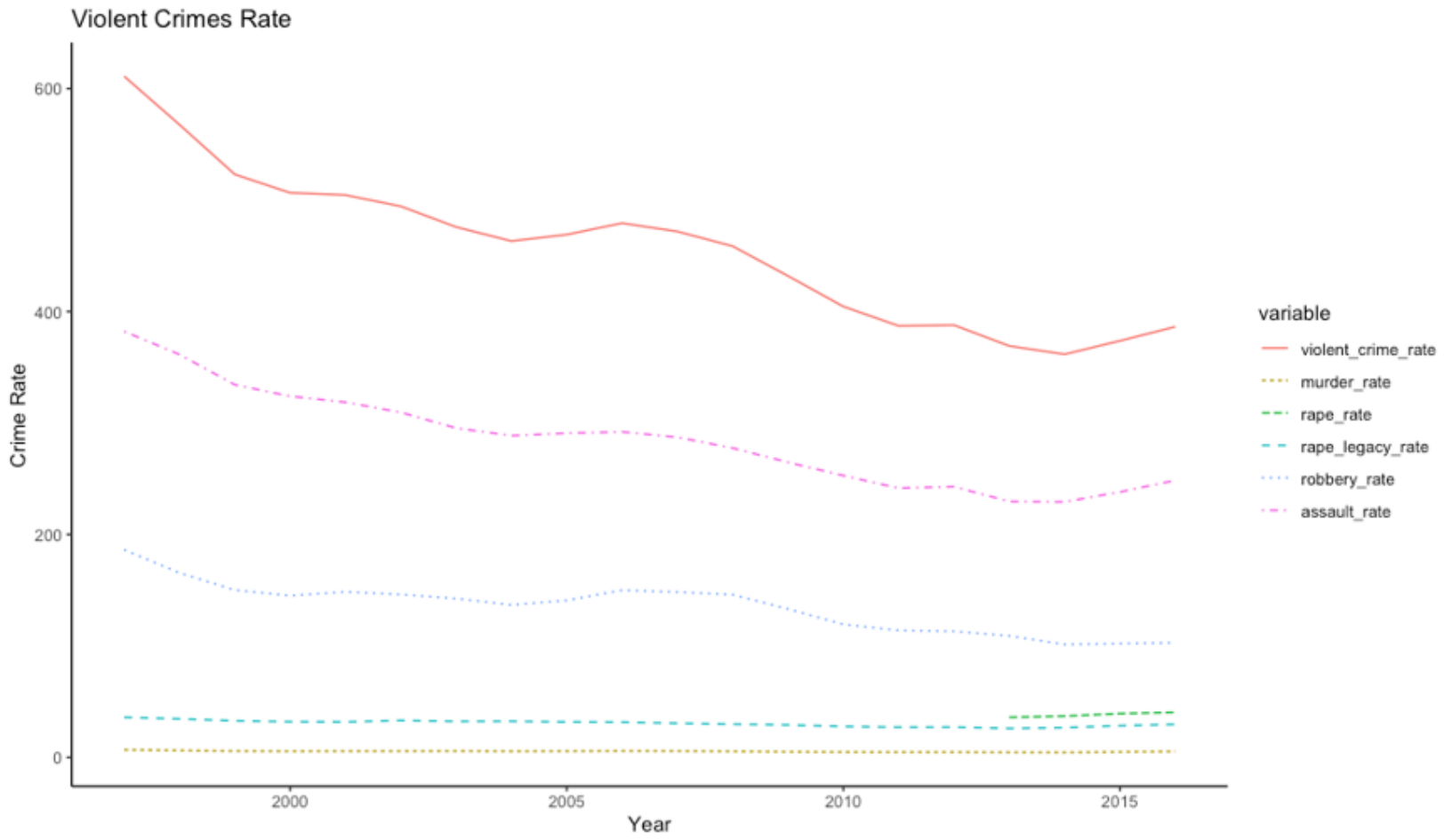
- Best vis design should have both form and functions, ie both beautiful and effective
- An effective but ugly design has potential
  - Form can be refined for a more beautiful visual, while maintaining effectiveness
    - Can be accomplished via collaboration with people who have the background if the designer himself/herself is not experienced
- A beautiful but ineffective design
  - Probably need to toss it out and start from scratch
  - Progressive refinement usually not possible
  - Therefore, don’t focus on form first
- Given two effective designs, one beautiful one ugly
  - Good visual form enhances the effectiveness of visual representation

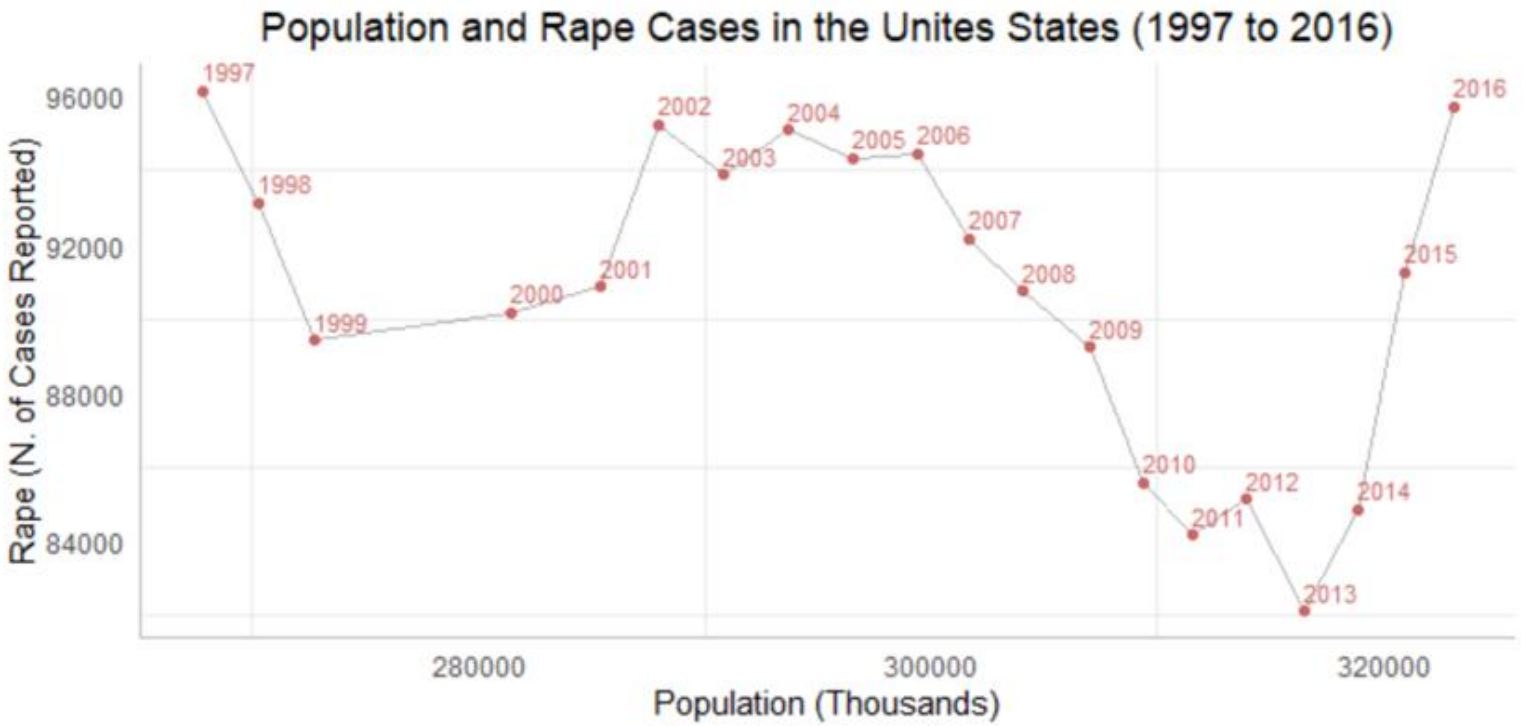
Sources/Credits

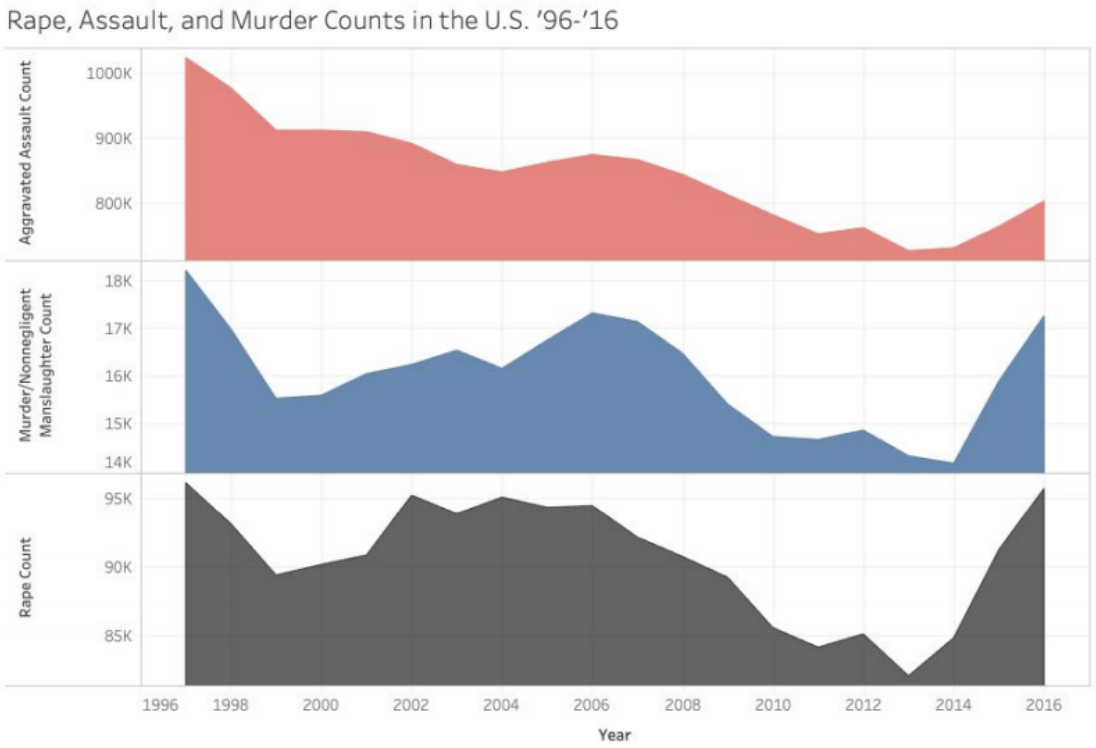
- Tamara Munzner, Visualization Analysis & Design, A K Peters Visualization Series, CRC Press, 2014.
- Utah, Miriah Meyer, Visualization (2014).
- UMass Dartmouth, David Koop, Data Visualization (2015).

Interesting Visuals from Homework 5


Violent Crimes rate comparison
600
400
200
0
Rates
aggravated assault rate
murder rate
rape rate
robbery rate
violent crime
Crimes
crime.rates
aggravated assault rate
murder rate
rape rate
robbery rate
violent crime

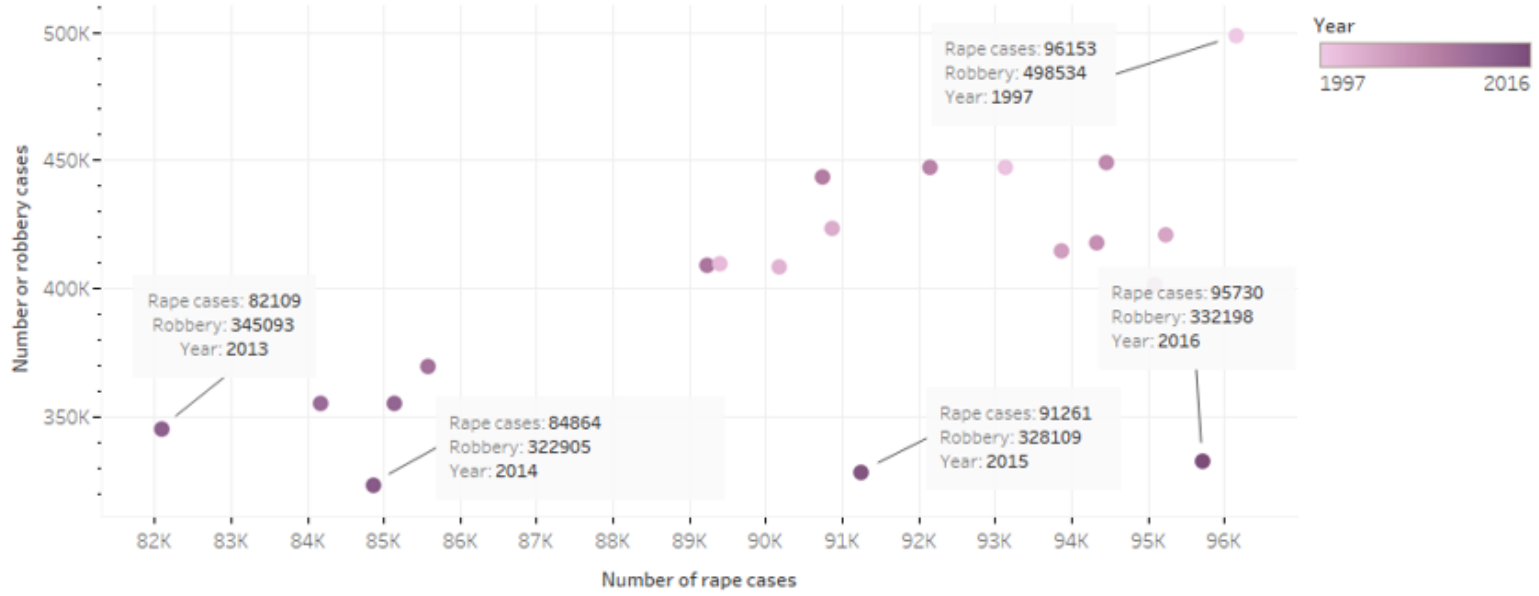

Violent Crimes Rate
600
400
200
0
Crime Rate
2000
2005
2010
2015
Year
variable
violent_crime_rate
murder_rate
rape_rate
rape_legacy_rate
robbery_rate
assault_rate

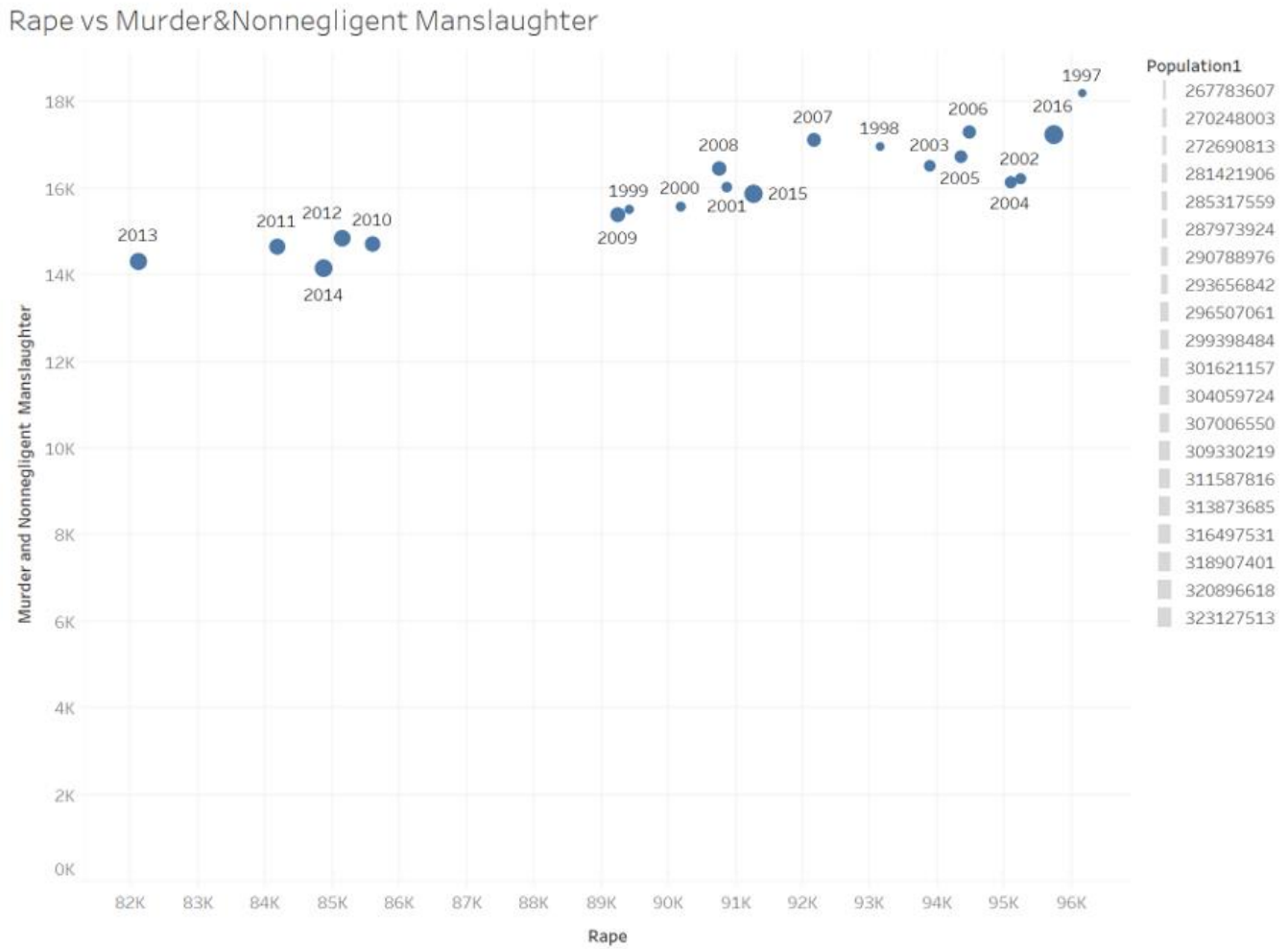

Population and Rape Cases in the Unites States (1997 to 2016)
Rape (N. of Cases Reported)
96000
92000
88000
84000
280000
300000
320000
Population (Thousands)
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016



This new interesting graph, shows relationships between Aggravated Assault, Murder, and Rapes in the timespan of the dataset. I wanted to look at this because they are all violent crimes and I was wondering if they are all connected in any way. It is interesting because all three of these crimes share a similar trend with large declines approaching 2013. Also it is interesting that rapes are higher than aggravated assault for a portion of the decade of the 2000's. It is even more noteworthy since it is well known that a large portion of rapes are also not even reported to the authorities. Murder is lower than the other two crimes but share a similar line with them. There must be some type of relationship and it is fascinating.

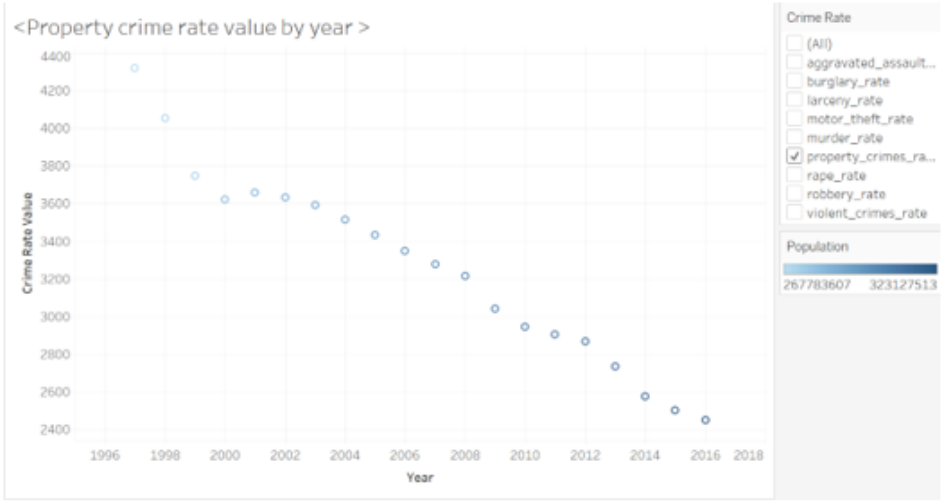
The variation between robbery and rape





The trend of Murder and nonnegligent manslaughter for Rape (legacy definition4). Size shows details about Population1. The marks are labeled by Year.

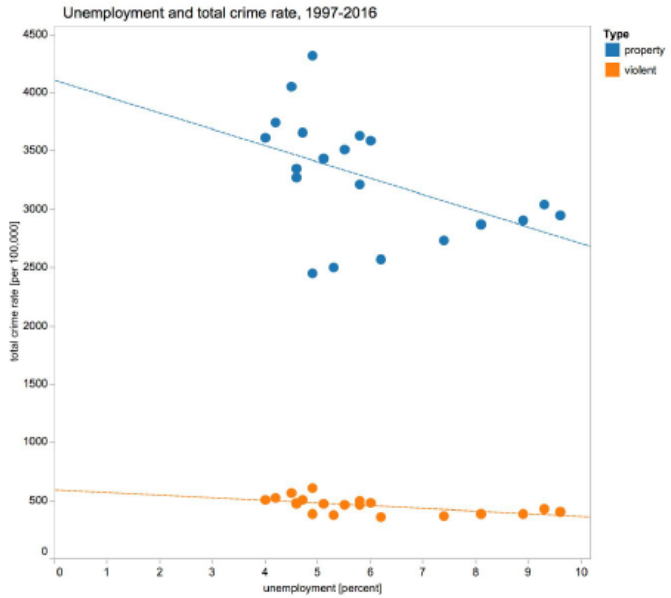
3) New visual



-The graph above shows the property crime rate value by year. The property crime rate has been decreasing since 1997 in general. It also shows that the population has been increasing since the blue dots are getting darker as years go by.

3. Analysis visual

While working on this dataset, I recognized that 2008 occurred pretty centrally in the dataset and became interested in how economic factors might correlate with the total crime rate. So, I found this Statista data of yearly average American unemployment and plotted it against the crime rate for those years. This is the result:



Slightly to my surprise, the correlation between unemployment and crime rate was negative. In excel, I calculated Pearson's rho between unemployment and violent crime as -.58 and r between unemployment and property crime as -.48. This means that there is a moderate negative correlation

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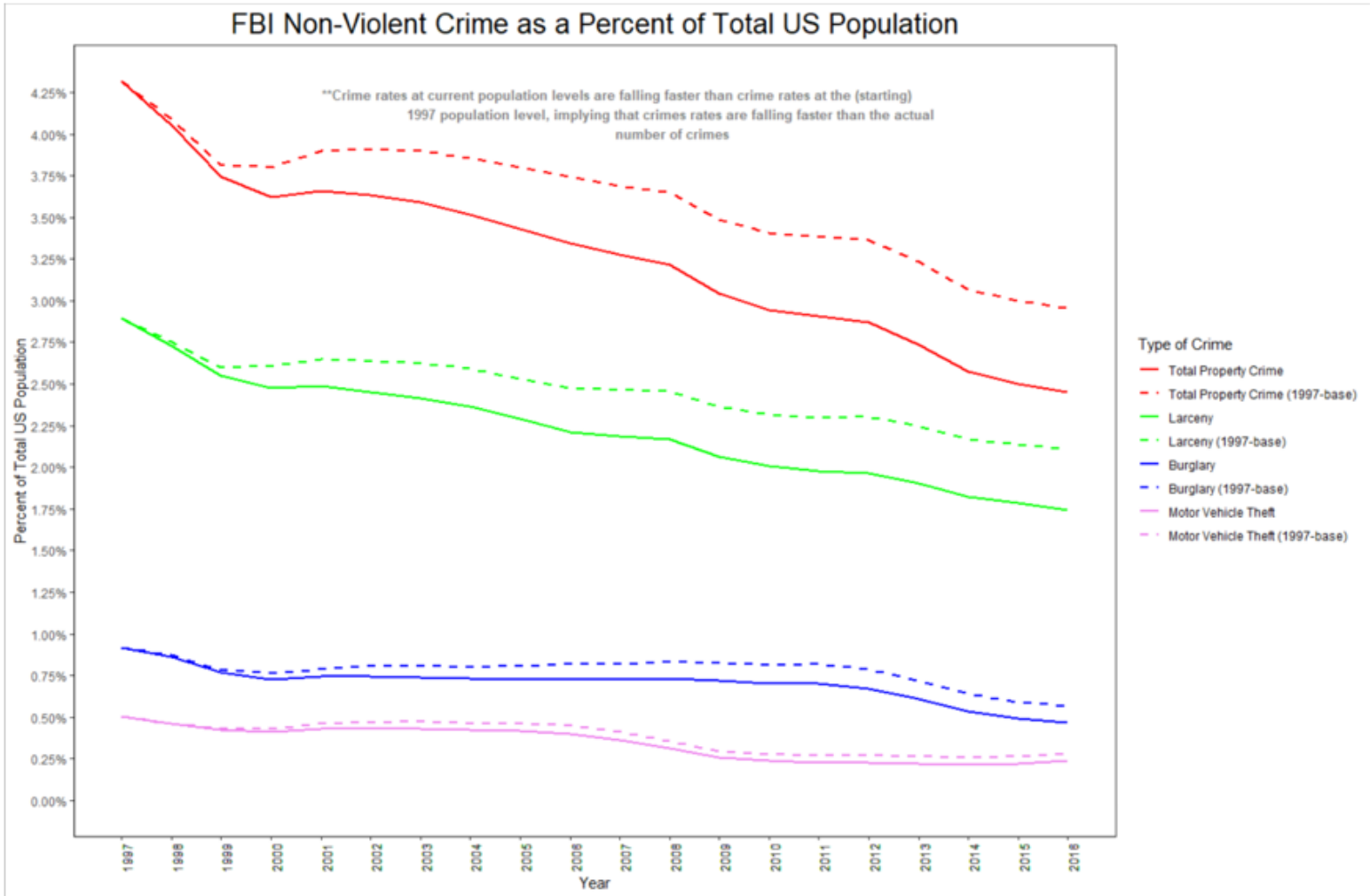
between unemployment and both violent and property crime rates, so years with higher unemployment tended to have lower rates of both property and violent crime, on average. I found this to be an interesting and unexpected conclusion that provided some context for the circumstances surrounding the dataset. In the future, I'd be interested in narrowing the unemployment rate data down to the locality to which the crime rate data refers.


FBI Non-Violent Crime as a Percent of Total US Population
**Crime rates at current population levels are falling faster than crime rates at the (starting) 1997 population level, implying that crimes rates are falling faster than the actual number of crimes
Percent of Total US Population
4.25%
4.00%
3.75%
3.50%
3.25%
3.00%
2.75%
2.50%
2.25%
2.00%
1.75%
1.50%
1.25%
1.00%
0.75%
0.50%
0.25%
0.00%
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year
Type of Crime
Total Property Crime
Total Property Crime (1997-base)
Larceny
Larceny (1997-base)
Burglary
Burglary (1997-base)
Motor Vehicle Theft
Motor Vehicle Theft (1997-base)