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Lesson 2
Designing Graphics to Enlighten:
# Principles and Best Practices

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What will you learn from this lesson?

- Human perception and information processing
- Perceptual and design principles for effective visual analytics
  - Principles of Graphic Design
  - Rules for Encoding Values in Graph
  - JunkCharts
  - Practical Guides for Using Colour in Charts
  - Data-ink

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Human Perception and Information Processing
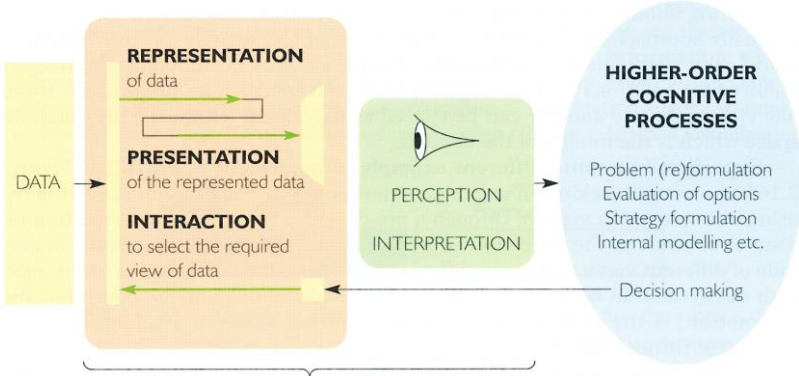
Fact 1: We do not attend to everything we see
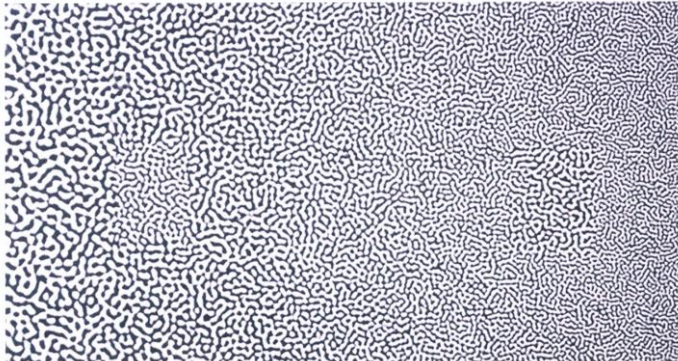
Fact 2: We see what we know and expect

Fact 3: We don't remember everything we see

How Many 3's?

12817687561389765469845069856049828267629809858458224509856458945098450980943585909103020990595959577256467505067890456788457898098216776548763649085609129496866

How Many 3's?

12817687561389765469845069856049828267629809858458224509856458945098450980943585909103020990595959577256467505067890456788457898098216776548763649085609129496866

Preattentive Processing

- A limited set of visual properties are processed preattentively (without need for focusing attention).

- This is important for design of visualizations
  - What can be perceived immediately?
  - Which properties are good discriminators?
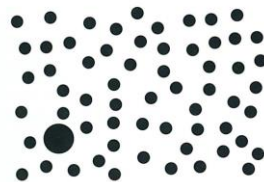 - What can mislead viewers?

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Preattentive attributes
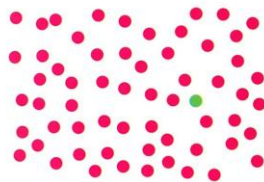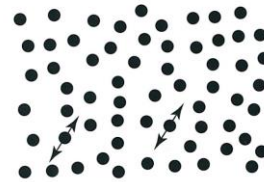

The green dot pops out
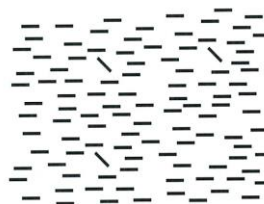
The oblique lines pop out

The large circle pops out

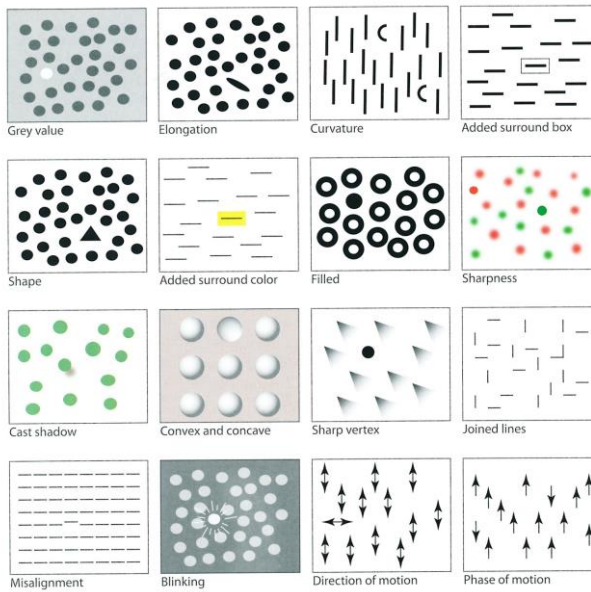If two dots were to oscillate as shown they would pop out

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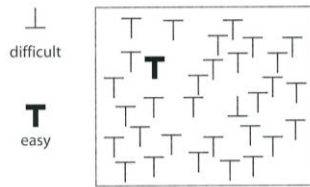SINGAPORE MANAGEMENT UNIVERSITY

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Bertin's Semiology of graphics
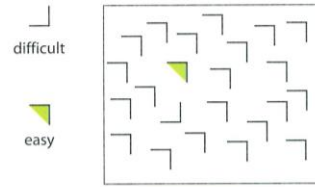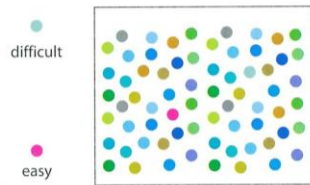

Jacques Bertin

Pop-up effects

Visual conjunctive search

The inverted T has the same feature set as the right-side-up T and is difficult to see. But the bold T does support pop-out and is easy to find.

Similarly the backwards L has the same feature set as the other items, making it difficult to find. But the green triangle addition does pop out.

A color that is close to many other similarly colored dots cannot be tuned for and is difficult to find.
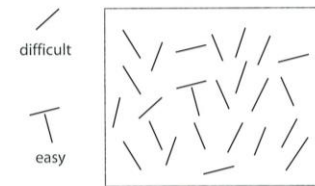
Similarly, if a line is surrounded by other lines of various similar orientations it will not stand out.

Designing Charts to Enlighten

- Principles of Graphic Design
- Rules for Encoding Values in Graph
- JunkCharts
- Practical Guides for Using Colour in Charts
- Data-ink

The Devil is in the Data

Numbers Worth Knowing

- Categorical data: numbers that summarise (i.e. sex, property type, planning region)
  - nominal, ordinal, interval, hierarchical
  - time series
- Continuous data: numbers that measure (i.e. unit price, age, monthly salary)
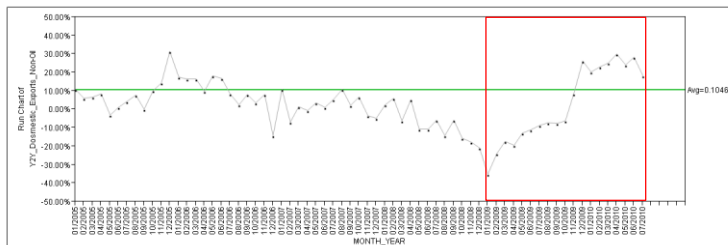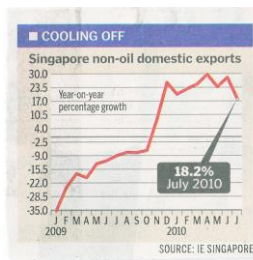 - ranking, ratio

Data Understanding

- Avoid garbage in, garbage out (**GIGO**) problem. For example, display size should be classified as categorical instead of continuous.
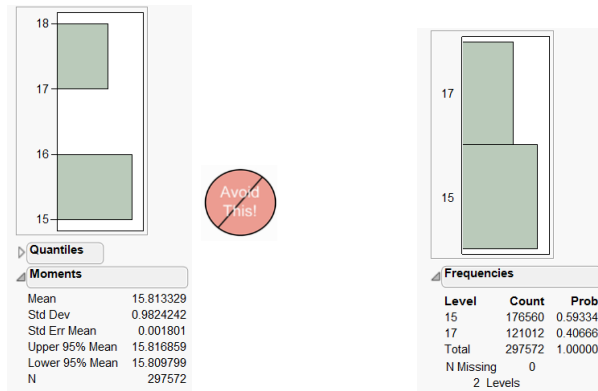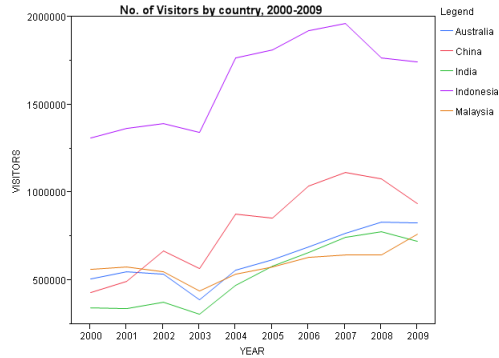

Graphical Integrity: Show Me the Truth

- Snapshoot data can be misleading
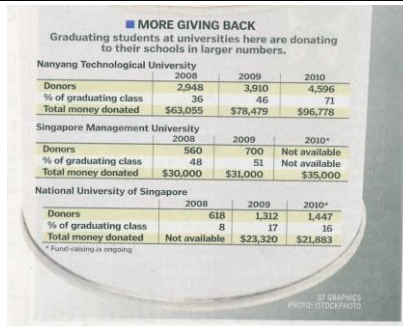
Graphical Integrity: Show Me the Truth

- Do not miss-out what had happened in between


Graphical Integrity: Show me the truth

The Straits Times 26/08/2010
70% of NTU grads are donors

|	NTU			SMU		
Year	2008	2009	2010	2008	2009	2010
Donors	2948	3910	4596	560	700	NA
% of graduateing class	36%	46%	71%	48%	51%	NA
Total money donated	$63,055	$78,479	$96,778	$30,000	$31,000	$35,000
Donation/don	21.39	20.07	21.06	53.57	44.29	

Graphical Integrity: Show Me the Truth

- Sometimes, data need to be transformed
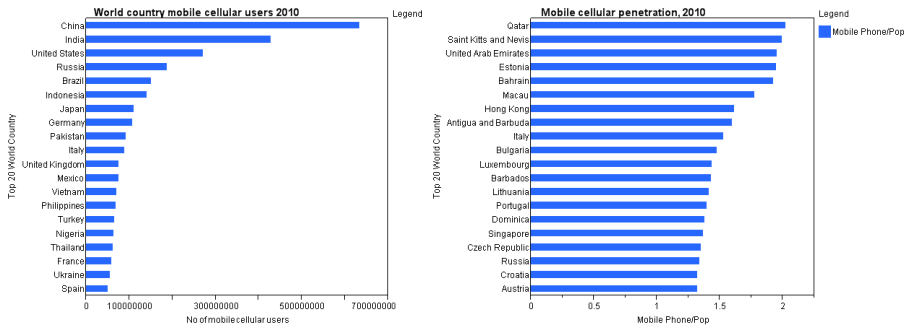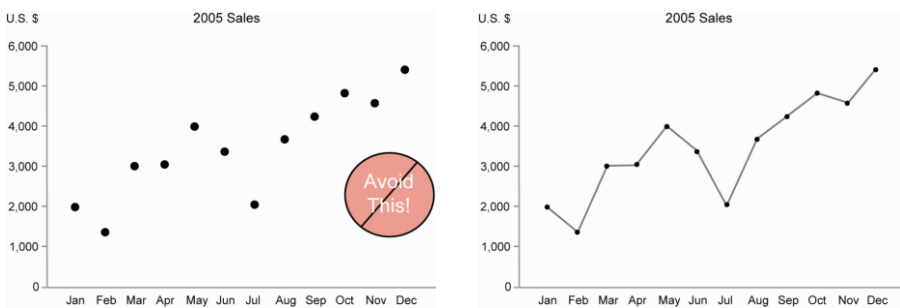

Design principles for effective visual presentation

- Principles of Graphic Design
- Rules for Encoding Values in Graph
- JunkCharts
- Practical Guides for Using Colour in Charts
- Data-ink

Components of a graph
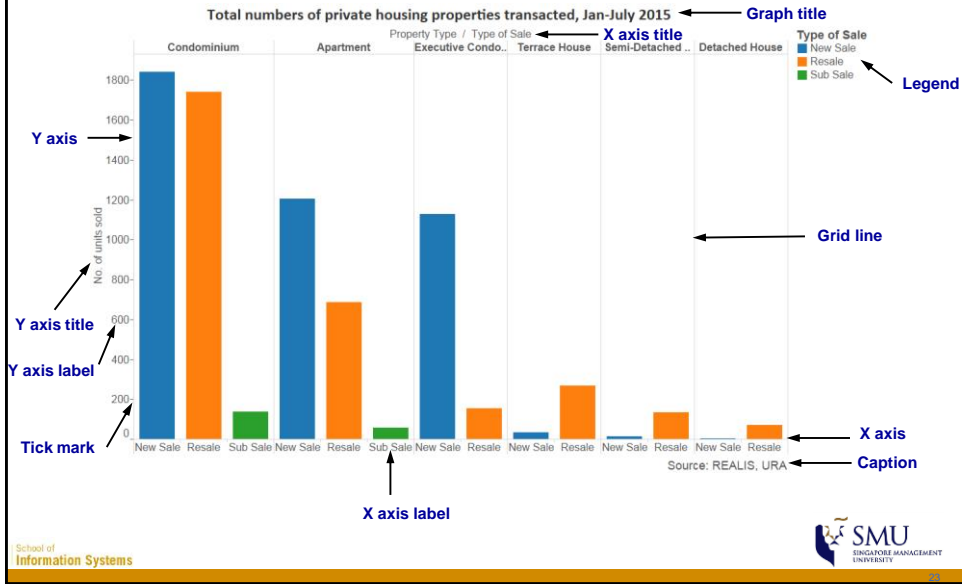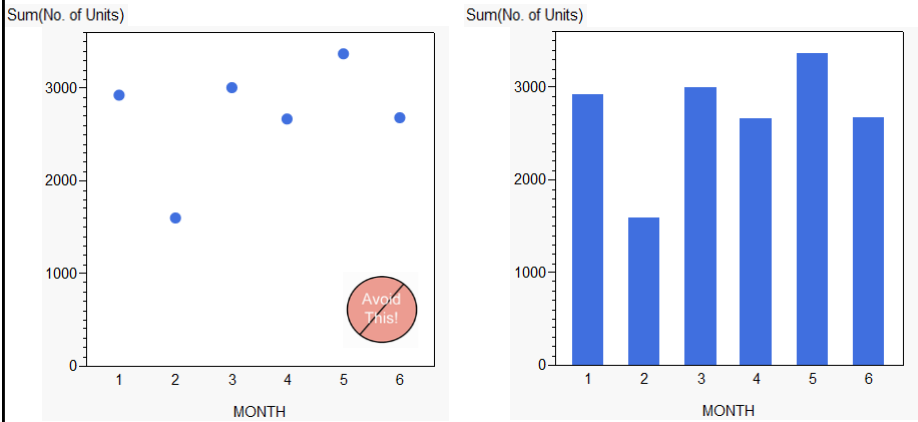

Rules for Encoding Values in Graph

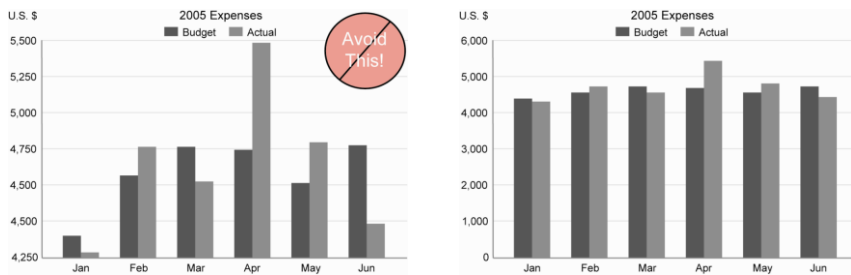- Rule 1: Avoid using point alone to display time-series data

Rules for Encoding Values in Graph

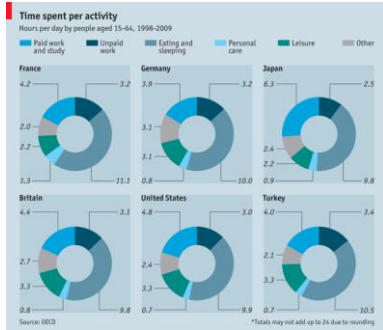- Rule 2: Avoid using points to represent discrete values

Rules for Encoding Values in Graph

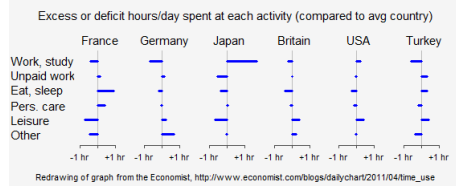- Rule 3: Bars don't work unless the quantative scale begins at zero

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Rule for Encoding Values in Graph

- Rule 4: Avoid pie chart if possible because our eyes are not good in reading areas

Source: Time use: A day in the life,
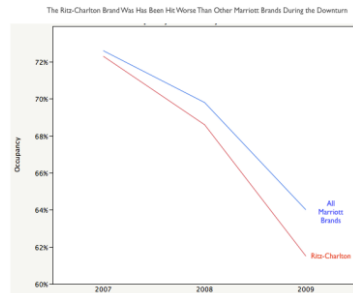Apr 19th 2011, 15:00 by The Economist online

Additional reference: http://junkcharts.typepad.com/junk_charts/2015/09/a-not-so-satisfying-rose.html

Rule for Encoding Values in Graph

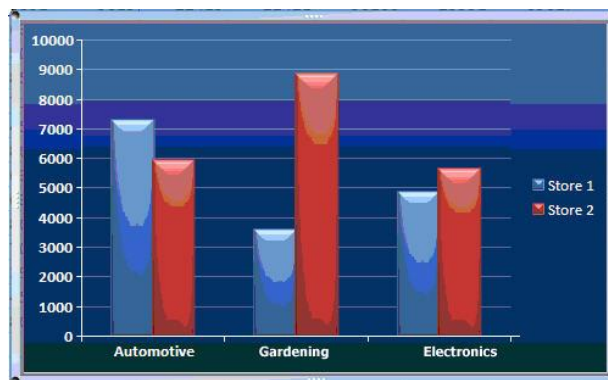Reference: Pies fail to deliver (http://junkcharts.typepad.com/junk_charts/2010/09/pies-fail-to-deliver.html)

What is ChartJunk

- Chartjunk refers to all visual elements in charts and graphs that are not necessary to comprehend the information represented on the graph, or that distract the viewer from this information.
- It was first introduced by Edward Tufte in his 1983 book The Visual Display of Quantitative Information.
- There is an interesting blog called Junk Charts (http://junkcharts.typepad.com/junk_charts/) by Kaiser Fung, examines chartjunk

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ChartJunk I

- Avoid using unnecessary colour shading for the bar

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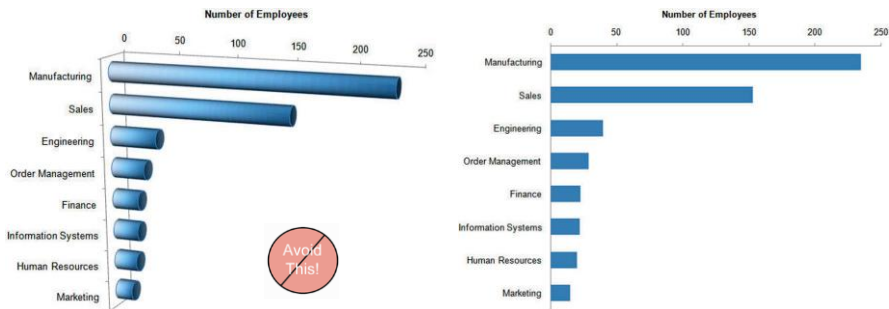Information Systems

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ChartJunk II

- Avoid colourful or wallpaper background
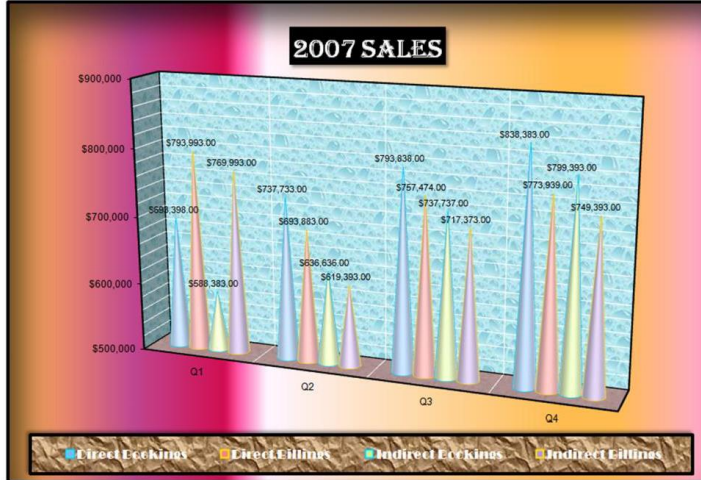
ChartJunk III
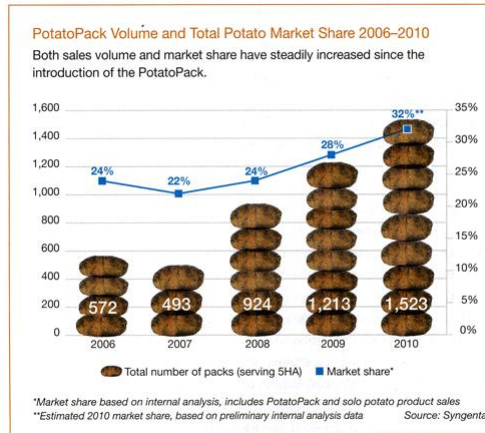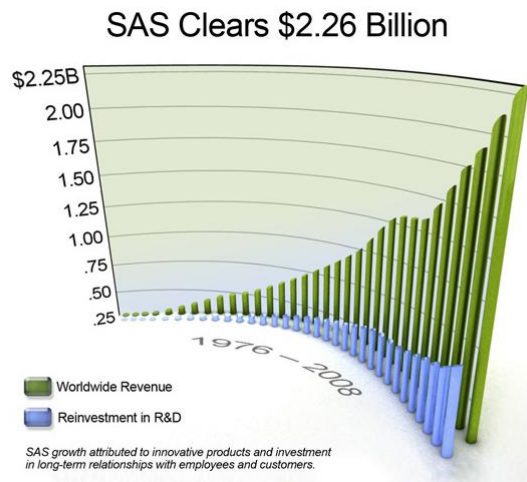
- Avoid using 3D effects in graphics.

ChartJunk IV

- Avoid using misleading graphical representation
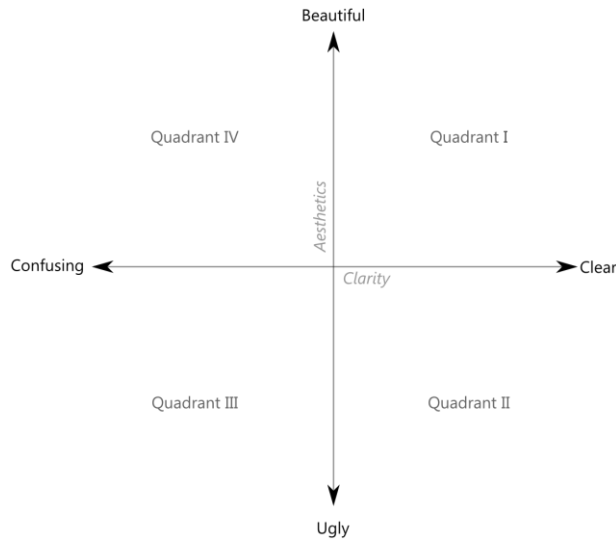

ChartJunk V

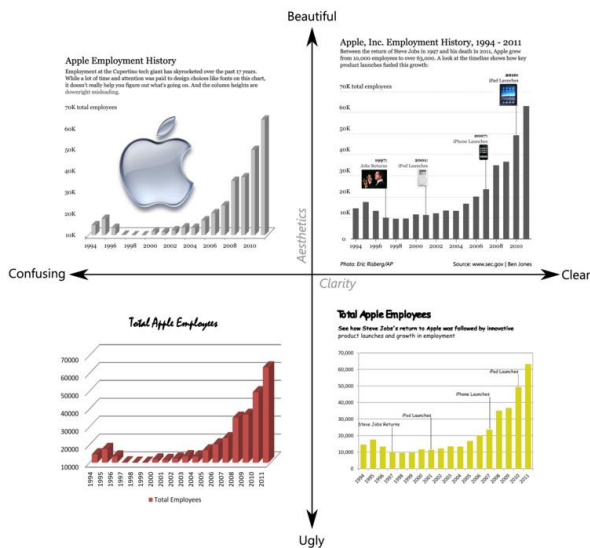- Avoid using artistic design which is difficult to visualise

Clarity or Aesthetics?

Source: http://dataremixed.com/2012/05/data-visualization-clarity-or-aesthetics/

A Tale of Four Quadrants

Quadrant IV – Confusing yet Beautiful
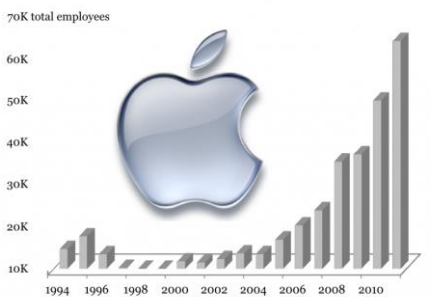
Why is it "beautiful"?
- Well placed & aligned title & lead-in
- Attention to detail with font selection
- Inclusion of image

Why is it "confusing"?
- Y-axis starts at 10K (column height misleading)
- 3D effect makes it difficult to gage heights
- Title & lead-in aren't helpful

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Quadrant III – Confusing and Ugly

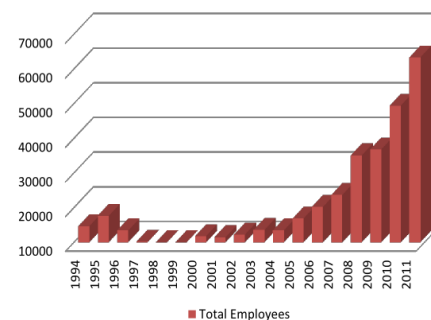Why is it "ugly"?
- Horrible font & color choice
- Grid lines are too dark & distracting
- Format of axes (vertical x-axis labels, number format of y-axis)

Why is it "confusing"?
- Y-axis starts at 10K (column height misleading)
- 3D effect makes it difficult to gage heights
- No lead-in or call-outs to provid context

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Quadrant II – Clear but Ugly

Why is it "ugly"?
- Poor color (puke yellow?) and font (Comic Sans?) choices
- Slightly pixelated – poor attention to image quality detail
- Chart details – axis orientation, grid lines, outline

Why is it "clear"?
- The y-axis starts at 0 and the 2D columns are easy to gage
- For the first time, we see call-outs of relevant events on the timeline
- This time the lead-in paragraph is actually informative

Total Apple Employees
See how Steve Jobs's return to Apple was followed by innovative product launches and growth in employment

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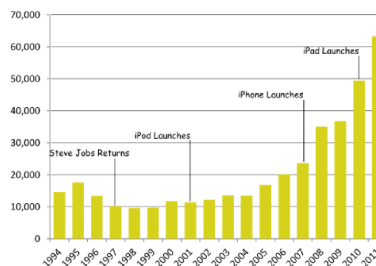
Quadrant I – Clear and Beautiful

Why is it "beautiful"?
- Good font & color choices throughout
- Soft gridlines don't distract
- All elements well aligned and spaced
- High res images are "useful" chartjunk

Why is it "clear"?
- The y-axis starts at 0 and the 2D columns are easy to gage
- Call-outs with images aid cognition
- Improved title & lead-in verbiage provide further elucidation
- For the first time, a photo credit and data source are included

Apple, Inc. Employment History, 1994 - 2011
Between the return of Steve Jobs in 1997 and his death in 2011, Apple grew from 10,000 employees to over 63,000. A look at the timeline shows how key product launches fueled this growth:
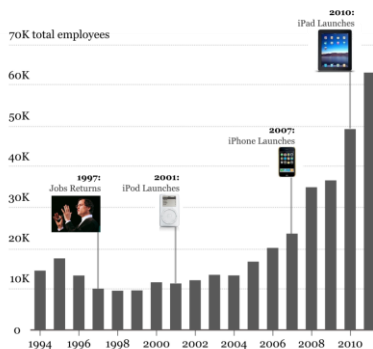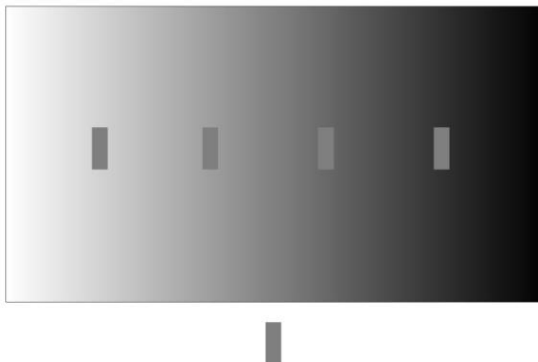
Photo: Eric Risberg/AP   Source: www.sec.gov | Ben Jones

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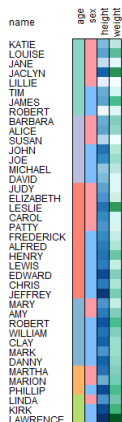SINGAPORE MANAGEMENT UNIVERSITY

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Practical Guides for Using Colour in Charts

- Rule 1: If you want different objects of the same colour in a graph to look the same, make sure that the background- the colour that surrounds them – is consistent.

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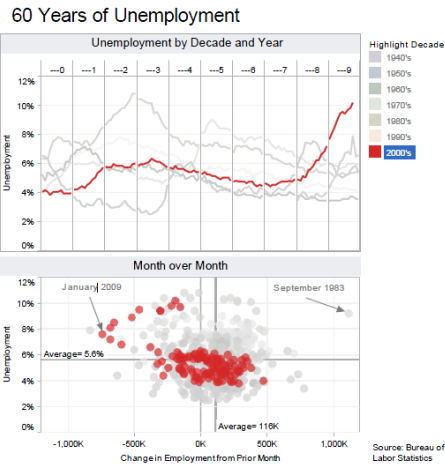**Information Systems**

Practical Guides for Using Colour in Charts

- Rule 2: If you want objects in a graph to be easily seen, use a background colour that constracts sufficiently with the object

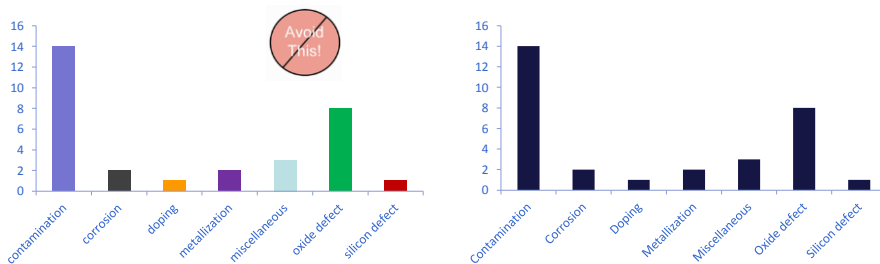

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Practical Guides for Using Colour in Charts

- Rule 3: Use color only when needed to serve a particular communication goal

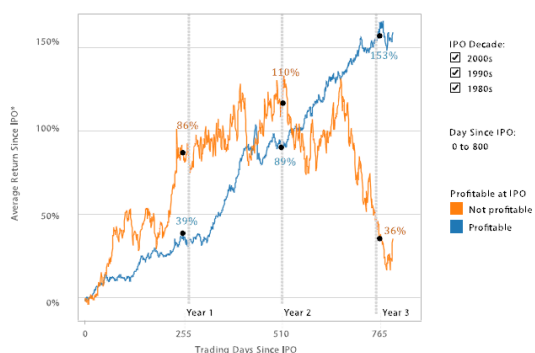## Practical Guides for Using Colour in Charts

- Rule 4: Use different colours when they corresponding to differences of meaning in the data

Practical Guides for Using Colour in Charts

- Rule 5: Use soft, natural colours to display most information and bright and/or dark colours to highlight information that requires greater attention
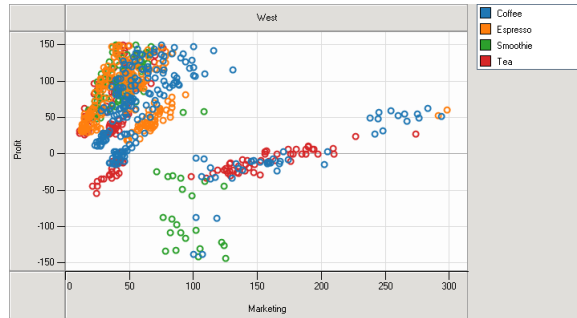

Practical Guides for Using Colour in Charts

- Rule 6: When using colour to encode a sequential range of quantitative values, stick with a single hue (or a small set of closely related hues) and vary intensity from pale colours for low values to increasingly darker and brighter colours for high values
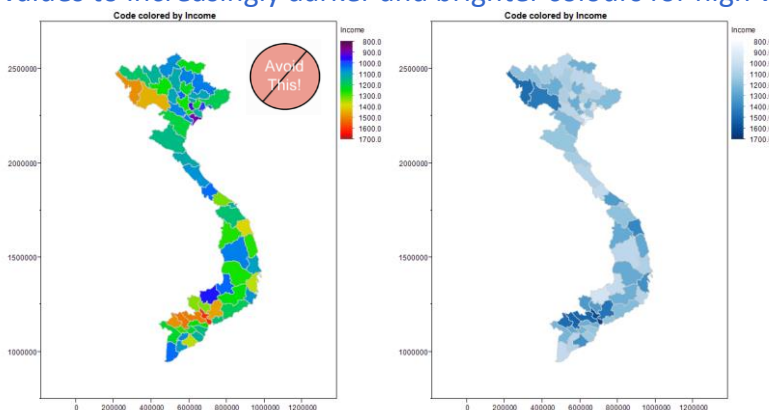
Practical Guides for Using Colour in Charts

- Rule 7: Non-data components of a graphs should be displayed just visibly enough to perform their role, but not more so, for excessive salience could cause them to distract attention from the data

Practical Guides for Using Colour in Charts

- Rule 8: To guarantee that most people who are colourblind can distinguish groups of data that are colour codeded, avoid using a combination of red and green in the same display
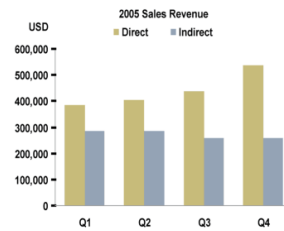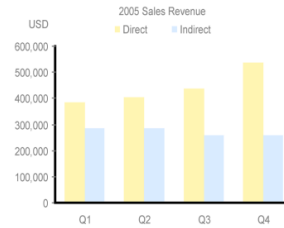
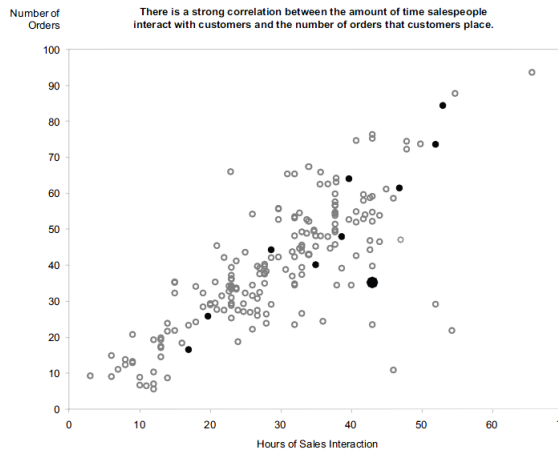Tree Map of Planning Area, Property Type Sized by No. of Units Colored by Unit Price ($ psm)
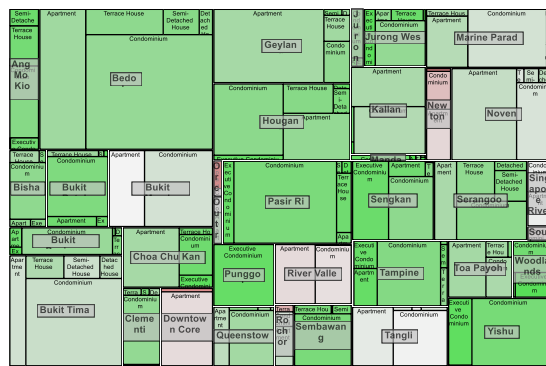
Data-ink

- Reduce the non data-ink
  - Removed unnecessary non data-ink
  - Deemphasise or regularise the remaining non data-ink

- Enhance the data-ink
  - Remove unnecessary data-ink
  - Emphasise the remaining data-ink

Practical used of data-ink

- Shouting to emphasize what's interesting

What should the relative lengths of the axis be?

- Should not manipulate the aspect ratio to intentionally exaggerate or downplay the rate of change.
- Stick to the convention of making your graphs wider than they are tall.

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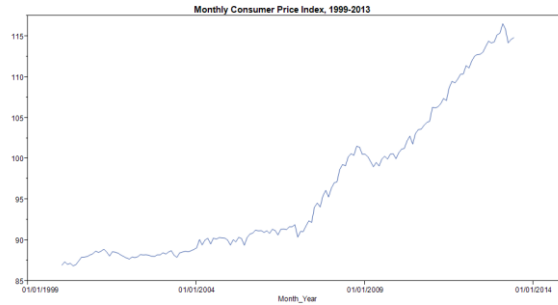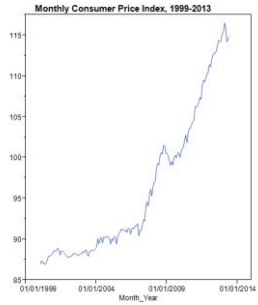
When can you eliminate tick mark?

- Tick marks are superfluous on categorical scale.

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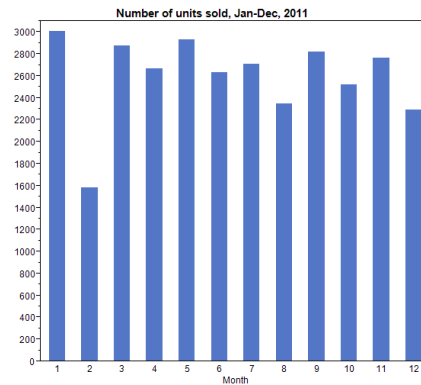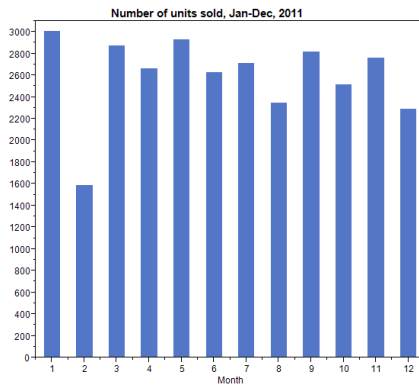
When you shouldn't eliminate tick mark?

- Tick marks are necessary on continuous scale.

Monthly consumer price index, January 2000-June 2013
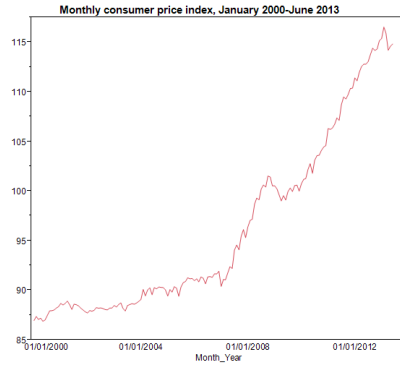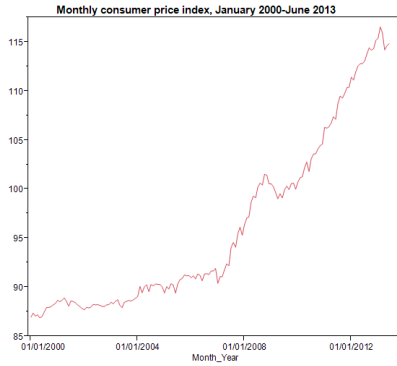
How many tick marks should you use?

- There is no exact number that works best in all circumstances, and the size of the graph is a factor that must considered: the longer the scale line, the more tick marks it should contain.

Monthly consumer price index, January 2000-June 2013
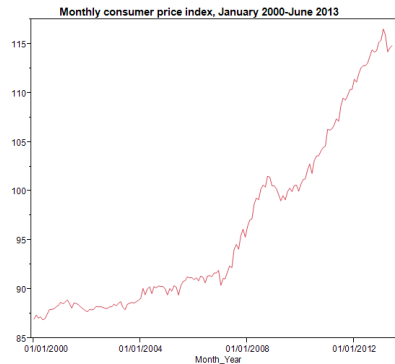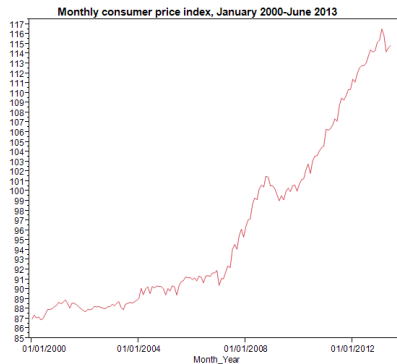
When can you eliminate legends?
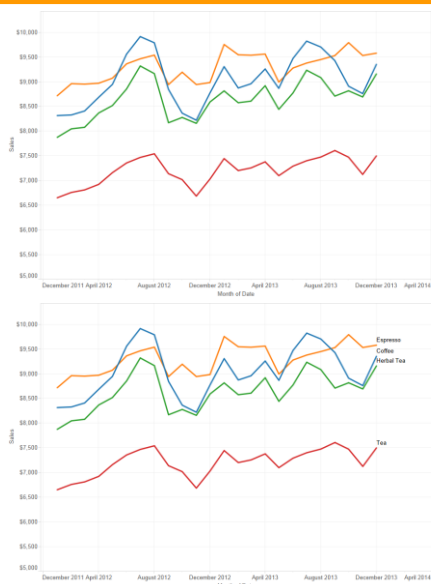
- In this graph, a legend is used to indicate product types.

- In this graph, categorical product types are labeled directly.

When should you use other text?

Index of real
oil prices
(first year = 1)

Based on oil prices
in 2006 $/barrel

Q1 '73 - Q3 '86

Overlay of Q1 '99 - Q1 '07

Figure 4: Real refinery acquisition cost for imported crude oil to the U.S.
(First year of time series = 1.0)

Graph typography

• Avoid using artistic fonts

Monthly total unit sold by stores, 2009

Graph Labeling

• Orientation of label should be reader friendly
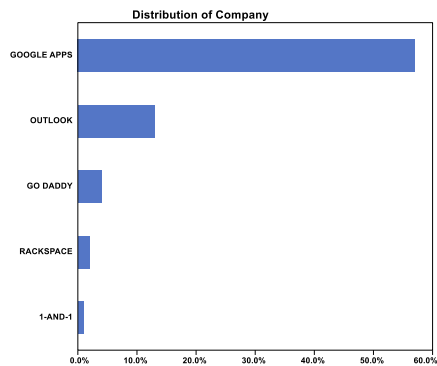
Data Visualisation Design Best Practices

- Focus on a few key stories that will resonate with your audience, and design graphs that help you tell those stories.
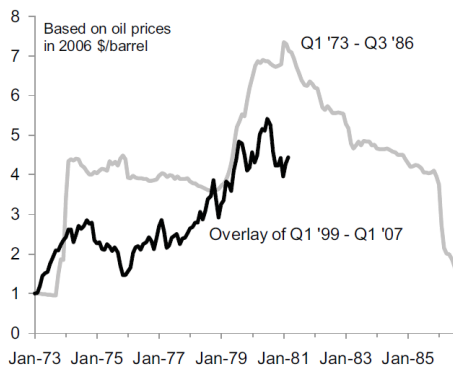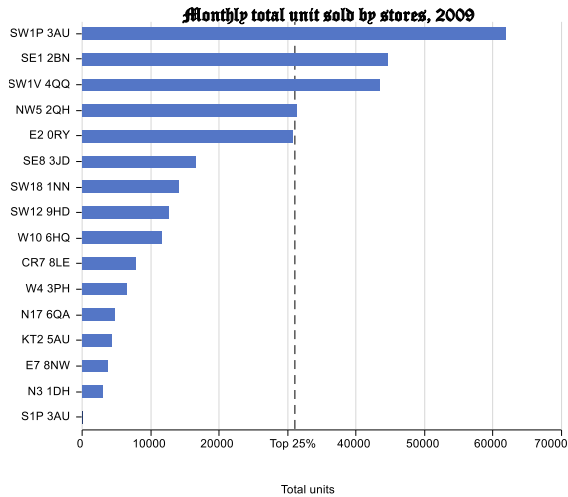   - Organise the information in order to emphasise what you are trying to say to the audience, and don't bury the key messages in a mass of detail.
    - Write out key points on the graphic itself, and label the important data events - the graphic should speak for itself
- Accurately represent the data.
    - Include data source
- Avoid what Tufte calls "chart junk," which is ornamentation that does not show data, such as clip art.

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Data Visualisation Design Best Practices

- Review every bit of ink on your chart and make sure it conveys data -- it if doesn't, modify or delete it.
- Never use 3D graphs unless they actually illuminate (rather than obscure) the data.
- Leave enough time before your presentation or report deadline for comments, editing, and revisions.
- Finally, study the work of the masters to improve your technique and revisit these lessons every few years.

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Data visualisation design process

- Start with a clear message
- Search for appropriate data
- Prepare the data
- Use the right graph type
- Express and explain
- Review and seek feedback from experts and casual readers

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Reference

- Few, Stephen (2012) (2nd edition) **Show Me the Numbers: Designing Tables and Graphs to Enlighten**, Analytics Press, Oakland, USA
- Robbins, Naomi B. (2005) **Creating More Effective Graphs**, John Wiley & Sons, New Jersey, USA
- Wong, Dona M. (2010) **The Wall Street Journal Guide to Information Graphics**, W. W. Norton & Company, Inc. New York

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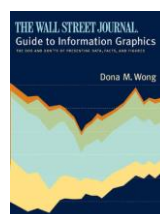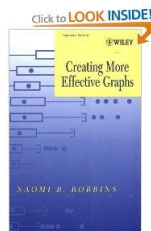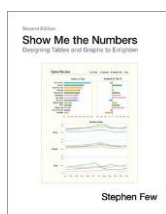
Reference

- Tufte, Edward (2nd Edition) **The Visual Display of Quantitative Information**, Graphics Press LLC, Connecticut, USA
- Yau, Nathan (2013) **Data Points: Visualization that means something**, John Wiley & Sons, Inc.

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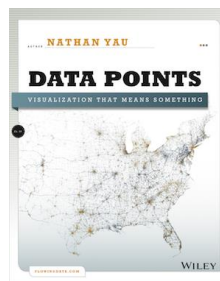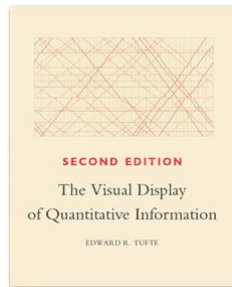
Information Graphics and Data Visualisation blogs

- Junk Charts (http://junkcharts.typepad.com/junk_charts/)
- Perceptual Edge (http://www.perceptualedge.com/blog/)
- Statistical Graphics and more (http://www.theusrus.de/blog/)
- EagerEyes (http://eagereyes.org/)
- Visualizing Economics (http://visualizingeconomics.com/)
- The Global Sociology Blog (http://globalsociology.com/)
- The Cranky Sociologists (http://thecrankysociologists.com/)

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