Tufte’s Design Principles

CS 4460/7450 - Information Visualization
February 18, 2010
John Stasko

Today’s Agenda

Edward Tufte has written seven books, including Visual Explanations, Envisioning Information, The Visual Display of Quantitative Information, and Data Analysis for Politics and Policy. He writes, designs, and self-publishes his books on analytical design, which have received more than 40 awards for content and design. He is a Professor Emeritus at Yale University, where he taught courses in statistical evidence, information design, and interface design. His current work includes landscape sculpture, printmaking, video and a new book. This website describes Edward Tufte’s books, one-day course, and artwork. For further information, call Graphic Press at 203-272-9187, or fax 203-272-9690, or email. For a moderated forum on analytical design, go to Ask ED.
Graphical Excellence

Principles

- Graphical excellence is the well-designed presentation of interesting data—-a matter of substance, of statistics, and of design
- Graphical excellence consists of complex ideas communicated with clarity, precision and efficiency

According to Tufte

Graphical Excellence

Principles

- Graphical excellence is that which gives to the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space
- Graphical excellence is nearly always multivariate
- And graphical excellence requires telling the truth about the data
Leveraging Human Capabilities

• Data graphics should complement what humans do well

“We thrive in information-thick worlds because of our marvelous and everyday capacities to select, edit, single out, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, list, abstract, scan, look over, sort, integrate, blend, inspect, filter, lump, skip, smooth, chunk, average, approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flop through, browse, glance into, leaf through, skim, refine, enumerate, glean, synopsize, winnow the wheat from the chaff, and separate the sheep from the goats.”  Vol.2, page 50

Summary

• 1. Tell the truth
  – Graphical integrity
• 2. Do it effectively with clarity, precision...
  – Design aesthetics

Let’s look at each of these
1. Graphical Integrity

- Your graphic should tell the truth about your data

Example

Stock market crash?
### Example

#### Show entire scale

- **Values**: 0, 250, 500

#### Show in context

- **Values**: 0, 250, 500

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Chart Integrity

- Where’s baseline?
- What’s scale?
- What’s context?

Vol 1, p. 54 (1)  
Where's 0?  
Note middle '70
Vol 1, p 54 (2)

What’s being compared?

Vol 1, 57

Scale?
Vol 1, p. 61

Scale?

Vol 1, p. 74

Great work!
Local Example

A huge rise?

Atlanta Journal Constitution
Summer ’08
More of the data

Atlanta Journal Constitution Dec. '08

Watch Size Coding

- Height/width vs. area vs. volume
Vol 1, p. 69

area = value?

Vol 1, p. 62

volume = value?
Measuring Misrepresentation

• Visual attribute value should be directly proportional to data attribute value

\[
\text{Lie factor} = \frac{\text{Size of effect shown in graphic}}{\text{Size of effect in data}}
\]

\[
p.62 \quad 9.4 = \frac{4280}{454}
\]

2. Design Aesthetics

• Set of principles to help guide designers
Design Principles

• Maximize data-ink ratio

\[
\text{Data ink ratio} = \frac{\text{Data ink}}{\text{Total ink used in graphic}}
\]

= proportion of graphic's ink devoted to the non-redundant display of data-information

Vol 1, p. 94

Good

Bad
More...

- Above all else, show the data
- Maximize the data-ink ratio
- Erase non-data-ink
- Erase redundant data-ink
- Revise and edit
More...

• Maximize data density

\[
data \text{ density of graphic} = \frac{\text{number of entries in data matrix}}{\text{area of data graphic}}
\]

Quote ...

Maximize Data Density

“Data-rich designs give a context and credibility to statistical evidence. Low-information designs are suspect: what is left out, what is hidden, why are we shown so little? High-density graphics help us to compare parts of the data by displaying much information within the view of the eye: we look at one page at a time and the more on the page, the more effective and comparative our eye can be. The principle, then, is:

Maximize data density and the size of the data matrix, within reason.”

Vol 1, p 168
Redesign charts

• Bar chart, scatter plot, box plot
  (See drawings)

Design Principles

• Avoid chartjunk
  – Extraneous visual elements that detract from message
A classic

Diamonds Were A Girl’s Best Friend
USA Today


Junk Charts Blog

http://junkcharts.typepad.com/
More Thoughts

Great narrative: Vol.2, bottom page 33-34

Design Principles

• Utilize multifunctioning graphical elements (macro/micro readings)
  – Graphical elements that convey data information and a design function
US Army Divisions going to France in WW I

Leonard P. Ayres
*The War with Germany*
1919
Vol 2, p. 36

Michel E. Turgot
Louis Bretz

*Plan de Paris*
1739

Vol 2, p. 37

Manhattan 1989
Manhattan Map Company
Vietnam Memorial in Washington D.C.

Maya Ying Lin

58,000+ dead soldiers
Names listed chronologically by death

Design Principles

- Use small multiples
  - Repeat visually similar graphical elements nearby rather than spreading far apart
Vol 1, p. 170

23 hours of LA air pollution

Vol 1, p. 173

Chromosomes of man, chimpanzee, gorilla & orangutan
Vol 1, p. 174

Consumer Reports

Vol 2, p. 68

NY Trains
Vol 2, p. 68

How to draw letters

Vol 2, p. 69

Calligraphy
Sparklines: theory and practice
Theory of sparklines (small, intense, simple datavisuals) along with many practical examples of recent sparkline developments. Excerpt from Edward Tufte's book Beautiful Evidence.
-- Edward Tufte, May 27, 2004

Sparklines: Intense, Simple, Word-Sized Graphics

Test most common data display is a mean followed by some standard deviation. For example, a medical patient's current level of glucose is typically reported as a clinical record as a mean and standard deviation.
Design Principles

- Show mechanism, process, dynamics, and causality
  - Cause and effect are key
  - Make graphic exhibit causality

Space shuttle case we discussed first day

Vol 3, p. 144

Washington Post
Design Principles

- Escape flatland
  - Data is multivariate
  - Doesn’t necessarily mean 3D projection

Vol 2, p. 12

Guide for visitors to Ise Shrine, Japan
Timetable for Java railroad line
Spring 2010  CS 4460/7450  59

Music history
Steve Chapple and Reebee Garofalo
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Design Principles

- Utilize layering and separation
  - \(1+1 = 3\) or more
  - Good or bad

Vol 2, p. 54

IBM Series III Copier
Design Principles

• Utilize narratives of space and time
  – Tell a story of position and chronology through visual elements
Life of a beetle
L. Hugh Newman
Spring 2010
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Czech air schedule

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66
Design Principles

- **Content is king**
  - Quality, relevance and integrity of the content is fundamental
  - What’s the analysis task? Make the visual design reflect that
  - Integrate text, chart, graphic, map into a coherent narrative
Graph and Chart Tips

- Avoid separate legends and keys -- Just have that information in the graphic
- Make grids, labeling, etc., very faint so that they recede into background

Vol 2, p. 54  New Jersey Transit

Before

After
Vol 2, p. 63

Before

After

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Vol 3, p. 74

Before

After

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Using Color Effectively

- “The often scant benefits derived from coloring data indicate that even putting a good color in a good place is a complex matter. Indeed, so difficult and subtle that avoiding catastrophe becomes the first principle in bringing color to information: *Above all, do no harm.*”

Proper Color Use

- To label
- To measure
- To represent or imitate reality
- To enliven or decorate
Examples

• The bad...

Vol 1, p. 153
Description

“..despite its clever and multifunctioning data measure, formed by crossing two four-colored grids, this is a puzzle graphic. Deployed here, in a feat of technological virtuousity, are 16 shades of color spread on 3,056 counties, a monument to a sophisticated computer graphics system. But it is surely a graphic experienced verbally not visually. Over and over, the viewers must run little phrases through their minds, trying to maintain the right pattern of words to make sense of the visual montage: “Now let’s see, purple represents counties where there are both high levels of male cardiovascular disease mortality and 11.6 to 56.0 percent of the households have more than 1.01 persons per room...”
“Color’s multidimensionality can also enliven and inform what users must face at computer terminals, although some color applied to display screens has made what should be a straight-forward tool into something that looks like a grim parody of a video game.”
Examples

• The good...

Vol 2, p. 91 & Vol 3, p. 76
Swiss Mountain Map

**Guides for Enhancing Visual Quality**

- Attractive displays of statistical info
  - have a properly chosen format and design
  - use words, numbers and drawing together
  - reflect a balance, a proportion, a sense of relevant scale
  - display an accessible complexity of detail
  - often have a narrative quality, a story to tell about the data
  - are drawn in a professional manner, with the technical details of production done with care
  - avoid content-free decoration, including chartjunk
Information Overload

What about confusing clutter? Information overload? Doesn’t data have to “boiled down” and “simplified”? These common questions miss the point, for the quantity of detail is an issue completely separate from the difficulty of reading. \textit{Clutter and confusion are failures of design, not attributes of information.} Often the less complex and less subtle the line, the more ambiguous and less interesting is the reading. Stripping the detail out of data is a style based on personal preference and fashion, considerations utterly indifferent to substantive content. \textit{Vol. 2, p. 51}

Minard graphic

<table>
<thead>
<tr>
<th>size of army</th>
<th>latitude</th>
<th>temperature</th>
<th>date</th>
</tr>
</thead>
<tbody>
<tr>
<td>direction</td>
<td>longitude</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Graphical Displays Should

- Show the data
- Induce the viewer to think about substance rather than about methodology, graphic design, the technology of graphic production, or something else
- Avoid distorting what the data have to say
- Present many numbers in a small space
- Make large data sets coherent
- Encourage the eye to compare different pieces of data
- Reveal the data at several levels of detail, from a broad overview to the fine structure
- Serve a reasonably clear purpose: description, exploration, tabulation, or decoration
- Be closely integrated with statistical and verbal descriptions of a data set

Website & Seminar
Discussion Forum

At this moderated forum, I will answer questions dealing with information design. Others can then extend the discussion. I will try to answer questions that have general interest or where I have something to say. Not all questions will be answered, usually because I don’t know the answer.

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Drawing a Graph

- Given an adjacency matrix for a graph, draw a “nice-looking” node-link representation of it

Due next Thursday

Spend about 30 minutes on it
Upcoming

- Text and Documents
  - Reading
    Wattenberg & Viegas

- Graphs and Network Data
  - Reading
    Perer & Shneiderman

Sources Used

E. Tufte, *The Visual Display of Quantitative Information*
E. Tufte, *Envisioning Information*
E. Tufte, *Visual Explanations*