The Design of Interactive Computational Media

Class 6: 11 Feb. 2003

Information Design

Hour 1:
Graphic Design and Typography Fundamentals

Hour 2:
Data Display and Information Visualization

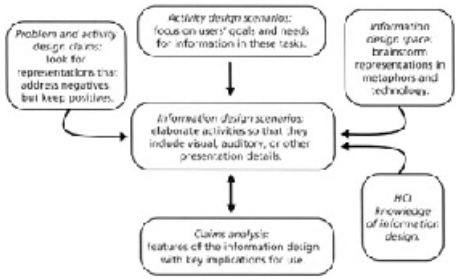
Graphic Design & Typography Fundamentals

- Information design
- Norman's stages of action in HCI
- Perceiving, interpreting, and comprehending information
- Elements of graphic design and typography
- Graphic design principles
- Example: source code typesetting

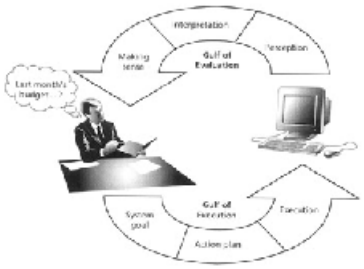
Information Design

- Interactive computational media are systems that allow users to carry out *activities*
- Functionality is determined in *activity design* phase
- Systems typically display *objects* on one or more screens, and display representations of possible user *actions* (e.g., menus)
- *Information design* represents and arranges these objects and possible user actions so they are perceptible and comprehensible

Information Design (Rosson & Carroll)



Norman's Stages of Action in HCI

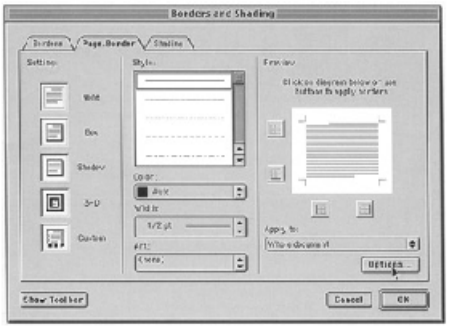


- Perceiving, interpreting, comprehending information

Perceiving Information

- Gestalt principles of perceptual organization (*psychology*)
  - Proximity
    - Elements near each other tend to be seen as a group
  - Similarity
    - Elements that share visual characteristics (shape, color, etc.) tend to be seen as a group
  - Closure
    - Tendency to organize elements into complete, closed figures
  - Area
  - Symmetry
  - Continuity
  - More on this later in the term
- Typography & *graphic design* vocabulary & principles (most of the remainder of first hour of this lecture)

Example:
Microsoft Word Page Border Dialog Box



Interpreting Information

- Familiarity and appropriateness, e.g., in choice of interface vocabulary
  - Examples from Johnson's *GUI Bloopers* (C&R, pp. 120-1)
  - Inconsistent terminology, unclear terminology, geekspeak, careless writing, clueless error messages, etc.
- Choice of imagery
  - Example: Microsoft Word text alignment controls
- Visual affordances
  - Example: Microsoft Word scrollbars

Comprehending Information

- Visual consistency
  - Example: Menu organization consistent across screens
- Visual metaphors
  - Example of virtual science fair exhibits:
    Lab journal, documentary (film), multimedia notebook, electronic whiteboard, Web site
- Data display and information visualization
  - Example of information models:
    Hierarchies for data display and visualization
  - Second hour of this lecture
- Dynamic displays
  - Example: Algorithm animation (to be shown later)

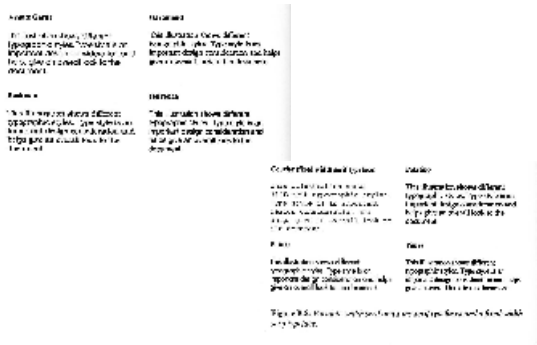
The Graphic Design of "Visible Langauge"

- Typography
  - Typographic vocabulary
  - Typesetting
- Symbolism
  - Icons
  - Graphics, illustrations
- Colour, texture, and value
- Page composition and spatial layout
  - Grids, rules, space
  - Form and structure
- Sequencing, timing, animation
- Design principles
  - Emphasis
  - Guiding the eye
  - Consistency and clarity
- Figures from Baecker and Marcus, *Human Factors and Typography for More Readable Programs*, 1990, ACM Press

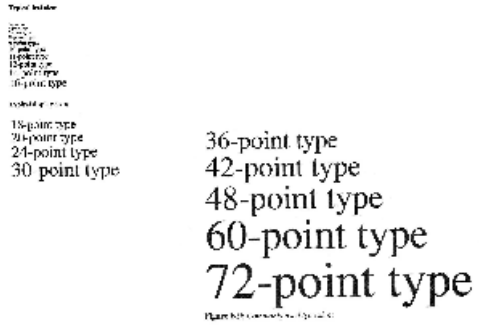
Typographic Vocabulary

- Typeface or style of lettering
- Fixed width or variable width
  - Serif or sans serif
  - Goal of typeface design: enhancing legibility and readability
- Type parameters
  - Size, measured in points, 1 point = 1/72"
  - Weight
  - Proportion
  - Slant
- Character set — Usually ASCII, but ...
  - Mathematical and special symbols
  - Special conditions
  - Resolution

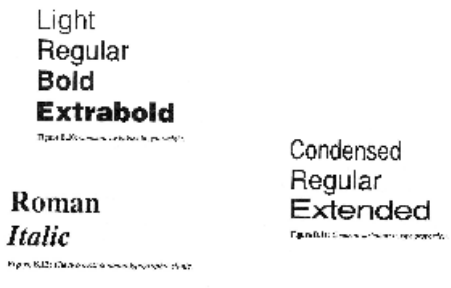
Common type faces (Baecker and Marcus, 1990, p. 298)



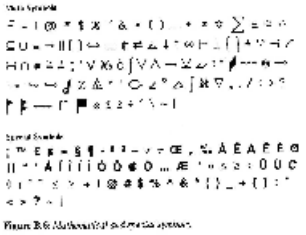
Common type sizes (Baecker and Marcus, 1990, p. 299)



Common type weights, proportions, slants
(Baecker and Marcus, 1990, p. 300)



Math and special symbols (Baecker and Marcus, 1990, p. 297)



Special display conditions (Baecker & Marcus, 1990, p. 301)

Low, medium, and high resolution characters
(Baecker and Marcus, 1990, p. 297)

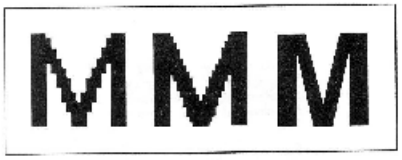


Figure B.7: *Low, medium, and high resolution characters.*

Typesetting

- Letterspacing
  - Kerning
  - Superscripts and subscripts
- Wordspacing
  - Hyphenation and justification
- Linespacing
- Methods of emphasis, with varying effectiveness
- Lists, forms, tables

Common letterspacing in 100th-of-em units
(Baecker and Marcus, 1990, p. 303)

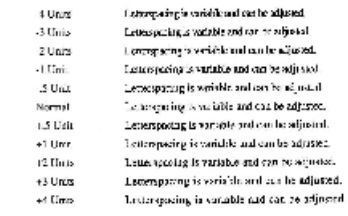


Figure B.16: Common letterspacing in 100th-of-em units.

Kerning in 100th-of-em units (Baecker & Marcus, 1990, p. 303)

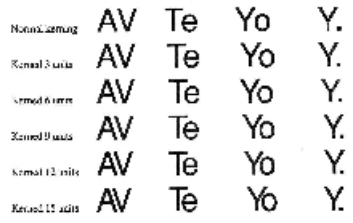


Figure B.17: Kerning in 100th-of-em units.

Common wordspacing in 100th-of-em-units
(Baecker and Marcus, 1990, p. 305)

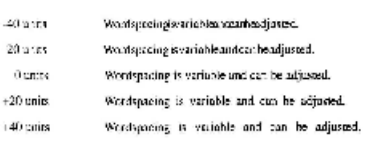
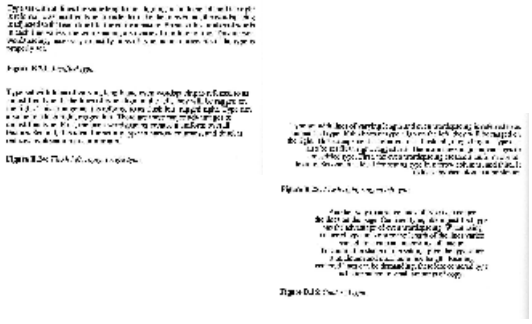


Figure B.22: Common wordspacing in 100th-of-em units.

Styles of justified type (Baecker and Marcus, 1990, p. 306)



Common variations in linespacing
(Baecker and Marcus, 1990, p. 307)

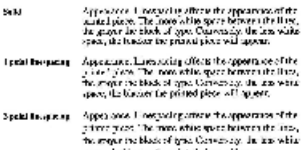
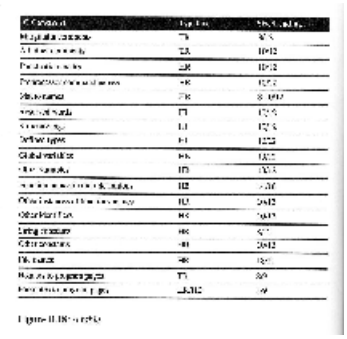


Figure B.25: Common variations in linespacing.

Common means of emphasis in paragraphs
(Baecker and Marcus, 1990, p. 308)

Figure B.26: Common means of emphasis in paragraphs.

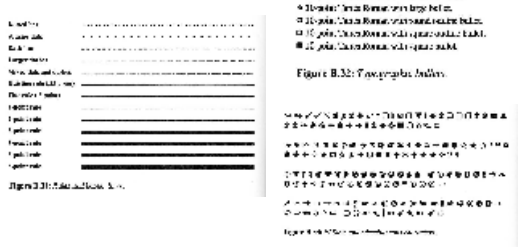
A table (Baecker and Marcus, 1990, p. 304)



Symbolism

- Rules and leader lines
- Pictograms and ideograms
  - Bullets, pi fonts, boxes
  - Icons
- Charts, maps, diagrams, illustrations, photographs

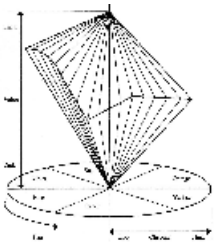
Rules, leader lines, bullets, and pi fonts
(Baecker and Marcus, 1990, p. 310)



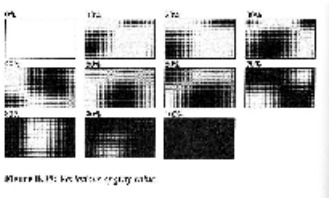
Coulor, Texture, and Value

- Colour
  - Hue
  - Saturation (Chroma)
  - Value
- Value
- Texture

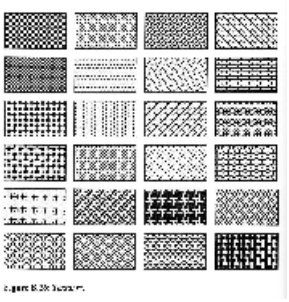
Colour Relationships (Baecker and Marcus, 1990, p. 311)



Variations of grey value (Baecker and Marcus, 1990, p. 312)



Textures (Baecker and Marcus, 1990, p. 312)

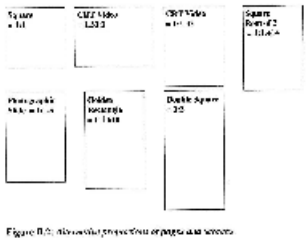


Page Composition

- Page and screen size and proportion
- Layout grids
- Spatial layout

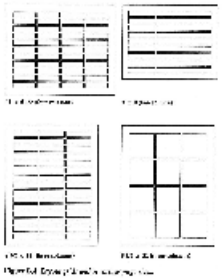
Alternative proportions of pages and screens

(Baecker and Marcus, 1990, p. 293)



Layout grids within various page sizes

(Baecker and Marcus, 1990, p. 294)



Typical page layout with primary and secondary features (Baecker and Marcus, 1990, p. 295)

Sequencing, Timing, Animation

- Sequencing
  - Order of images
  - Use of repetition, cycles
- Timing
  - Rhythm and pacing
  - Anticipation
- Animation
  - Display of series of images in rapid succession
  - Possibilities for smooth motion

Principles of Communication

- Principle 1— Legibility
  - Design the individual characters of the textual vocabulary for a screen so that they are rapidly and reliably identifiable and recognizable.
  - *Application:* Done by designers of type faces
- Principle 2 — Readability
  - Design the textual components of a screen so that they are as easy to interpret and understand as possible.
  - *Application:* Choose type face

Principles of Communication (cont.)

- Principle 3 — Clarity
  - Design all non-textual components of a screen so that their semantics are as unambiguous as possible.
  - *Application:* Choose or design icons
- Principle 4 — Emphasis
  - Use visible language elements to emphasize the most salient features of a screen.
  - *Application:* Use boldface, italics, colour

Principles of Economy

- Principle 5 — Simplicity
  - Include on a screen only those elements that communicate something important. Be as unobtrusive as possible. Maximize the effectiveness of a minimal set of techniques or cues.
  - *Application:* Simplify, simplify, simplify!

Principles of Organization

- Principle 6 — Consistency
  - Observe the same conventions and rules for all elements. Be consistent from screen to screen. Deviate from current conventions only when there is clear benefit to be gained.
  - *Application:* Simplify, simplify, simplify!
- Principle 7 — Relationships
  - Use visible language elements to show relationships among those elements of a screen that need to be linked, and to show lack of relationship among those that should not be linked.
  - *Application:* Use Gestalt principles — similarity, proximity, closure

Principles of Organization (cont.)

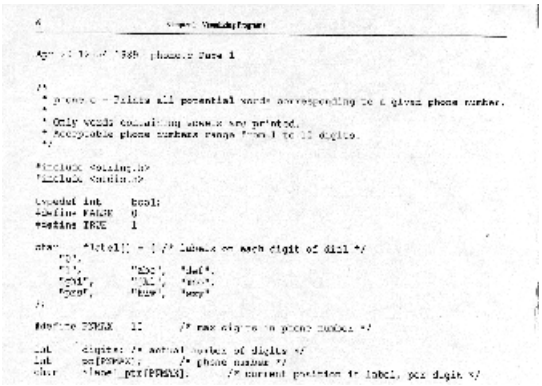
- Principle 8 — Distinctiveness
  - Use visible language elements to distinguish important properties of essential parts of a screen.
  - *Application:* Use bold face, italics, colour
- Principle 9 — Focus and navigability
  - Use visible language elements to position the initial attention of a user or viewer to the screen or one of its components, to direct attention, and to assist in navigating around the screen.
  - *Application:* Use colour, icons, motion

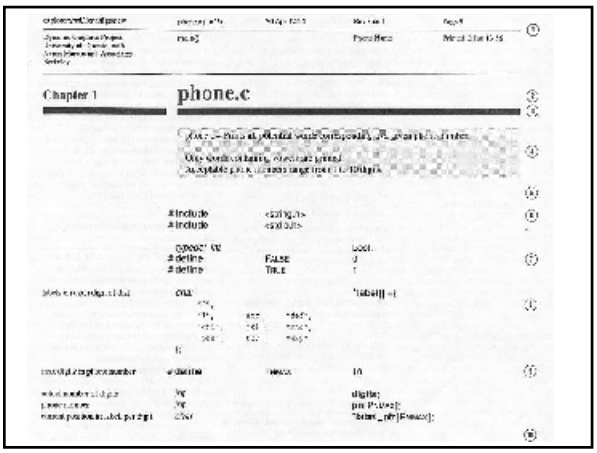
Typical Flaws in Screen Design and Layout

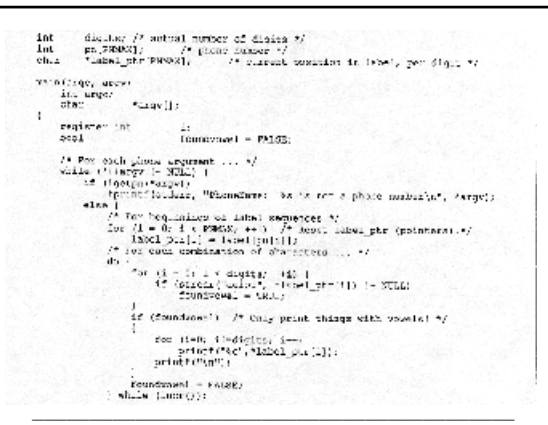
- Fancy, but illegible or unreadable text (violates #s 1, 2)
- Poor choice of terminology (2)
- Intriguing but mysterious icons (3)
- Inappropriate elements emphasized, or nothing emphasized (4)
- Too many typefaces, styles, and sizes are used (5)
- Screen too busy, too cluttered (5)
- Not enough white space (5)
- Inconsistencies from screen to screen, or from system to system (6)
- No apparent logic to the application of typographic style (7, 8)
- No organizing principle for the layout (4, 7, 9)
- Viewer doesn't know where to focus among a sea of undifferentiated text or image (9)

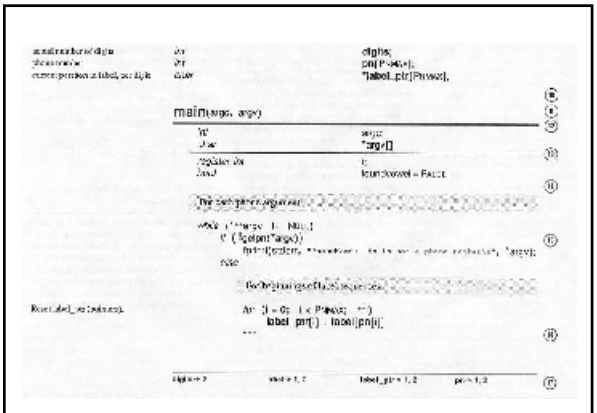
Example: Source Code Design & Typesetting

- Typesetting source code to enhance readability
- Sophisticated prettyprinting
- Experimental evidence of effectiveness
- Programs as publications
- See Baecker & Marcus, *Human Factors & Typography for More Readable Programs*, 1990, ACM Press

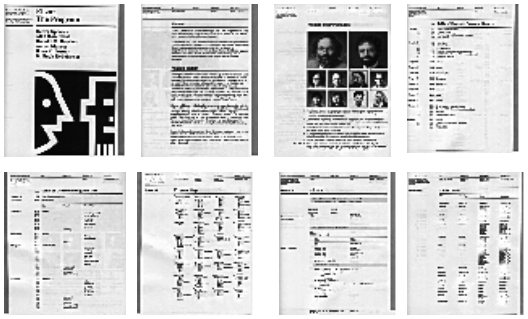








Eliza Program Book



The Principles Applied to This Example

Legibility	Confusion of "." versus ","
Readability	">=" not very readable; confusing variables and reserved words
Clarity	Two uses of "*"
Emphasis	Function names, global variables in bold
Simplicity	*Our approach overdesigned*
Consistency	Use of boldface, italics
Relationships	Display of comments, nesting context
Distinctiveness	Parts of function definition, preprocessor definition
Focus and navigability	File names, function names, footnotes

Summary

- Information design
- Norman's stages of action in HCI
- Perceiving, interpreting, & comprehending information
- Elements of graphic design and typography
- Graphic design principles
- Example: source code typesetting

Questions and Discussion

Break

Data Display and Information Visualization

- Purpose
- Excellence in data display
- Techniques for data display
- Graphical integrity
- Pitfalls and flaws in data display
- Opportunities in data display
- Applications of information visualization
- Example: Animation of sorting algorithms

Why Data Display & Information Visualization

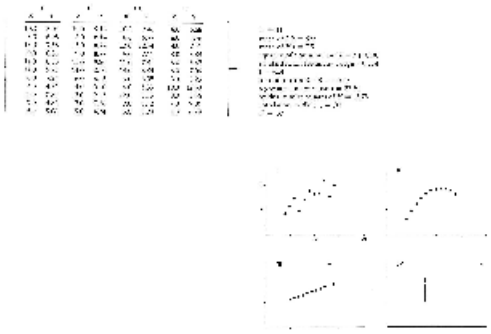
- What is computer science?
  - The study of algorithms
  - The study of systems design and software engineering
  - The study of data management and data processing
- We manage and process data by computers because:
  - Data sets are large
  - Data sets change over time
  - Data sets embody complex interrelationships
- But how do we comprehend the data?
  - How do we know what is there and what is not?
  - How do we know if there are errors in the data?
  - How do we know what relationships exist in the data?
  - How do we know what "the data means"?

Why Data Display & Information Visualization

- Usually, we don't, because we can't see it and we can't visualize/perceive/understand it
- The purpose of data display and visualization techniques is to help us see the data and understand the data
- "We thrive in information-thick worlds because of our marvelous and everyday capacities to select, edit, single out, structure, highlight, group, pair, merge, harmonize, synthesize, focus, organize, condense, reduce, boil down, choose, categorize, catalog, classify, refine, abstract, scan, look into, idealize, isolate, discriminate, distinguish, screen, sort, pick over, group, pigeonhole, integrate, blend, average, filter, lump, skip, smooth, chunk, inspect, approximate, cluster, aggregate, outline, summarize, itemize, review, dip into, flip through, browse, glance into, leaf through, skim, list, glean, synopsize, winnow wheat from chaff, and separate the sheep from the goats." (Tufte, 1990, p. 50)
- Computer graphics has introduced a revolution in data display, but it is easier to produce visual garbage than it is to produce elegant visual representations that convey meaning

Data sets displayed as numbers & as graphs

(Tufte, 1983, pp. 13,14)



Graphical Displays Should (Tufte, 1983, p. 13)

- "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 the statistical and verbal descriptions of a data set."

Excellence in data display

- Tufte goes on (1983, p. 51):
  - "Graphical excellence is the well-designed presentation of interesting data — a matter of *substance*, of *statistics*, and of *design*.
  - ... consists of complex idea communication with clarity, precision, and efficiency.
  - ... is that which gives the viewer the greatest number of ideas in the shortest time with the least ink in the smallest space.
  - ... is nearly always multivariate.
  - ... requires telling the truth about the data."
- And finally (1983, p. 191):
  - "What is to be sought in designs for the display of information is the clear portrayal of complexity. Not the complication of the simple, rather the task of the designer is to give visual access to the subtle and the difficult — that is,*the revelation of the complex*."

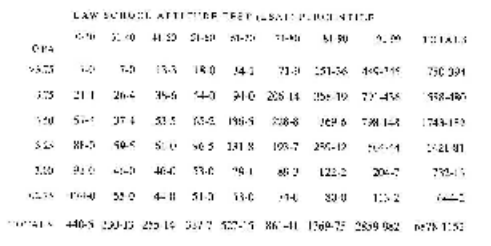
Data Display Techniques : Tables

- Used for organizing and displaying
  - Lists
  - Series of related numbers, categories, concepts, etc.
- Example: Comparing techniques for data display

Technique	Major use
Tables	Organized description of relationship among discrete elements
Charts and graphs	Pictures of relationships among quantitative data
Maps	Displays of geographical or spatially-distributed data
Diagrams	Portrayals of interrelationships among abstractions, e.g., block diagram, tree chart, pert chart

Table of law school #s applying & admitted

(Tufte, 1990, p. 29)

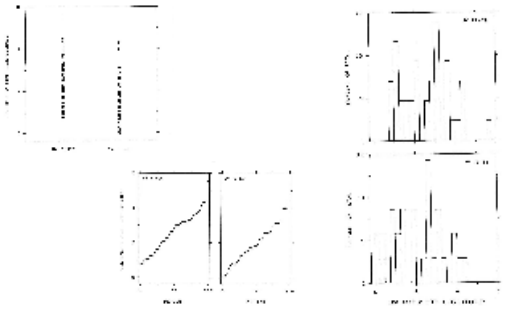


Data Display Techniques: Charts & Graphs

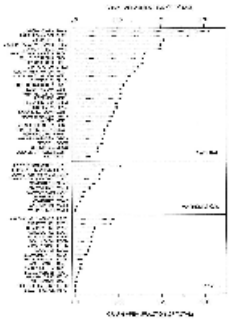
- Distributions of one quantitative variable
- One quantitative variable with labels
- Two quantitative variables
- Time series
- Multiple integrated time series
- Two quantitative variables with categories & colour

Distributions of one quantitative variable: point graph, histograms, percentile graphs

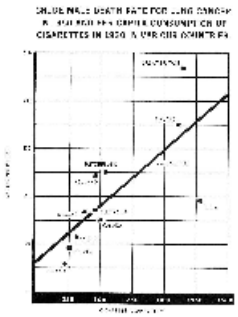
(Cleveland, 1985, pp. 124, 126, 128)



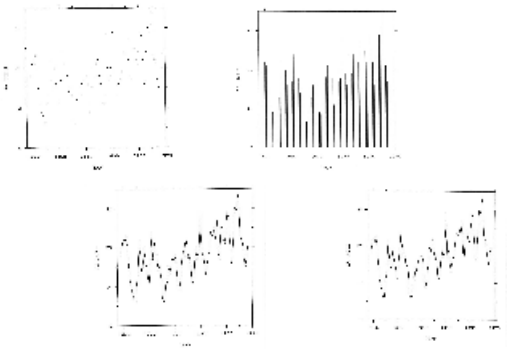
Distributions of one quantitative variable with labels: Dot chart (Cleveland, 1985, p. 145)



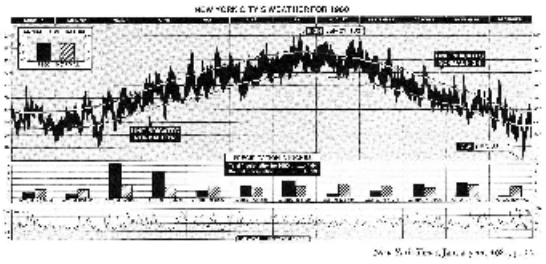
Two quantitative variables (Tufte, 1983, p. 47)



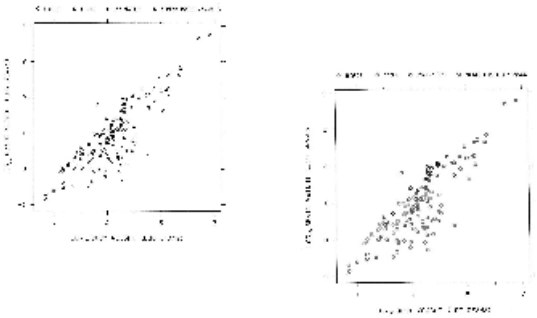
Time series (Cleveland, 1985, pp. 181, 180, 182, 183)



Multiple integrated time series (Tufte, 1983, pp. 30)



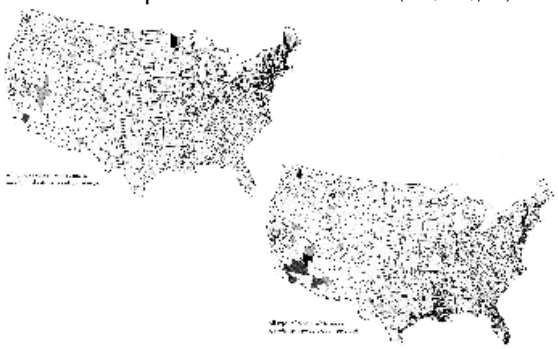
Scatterplot of two quantitative variables with categories and colour (Cleveland, 1985, p. 207, opposite p. 213)



Data Display Techniques: Maps

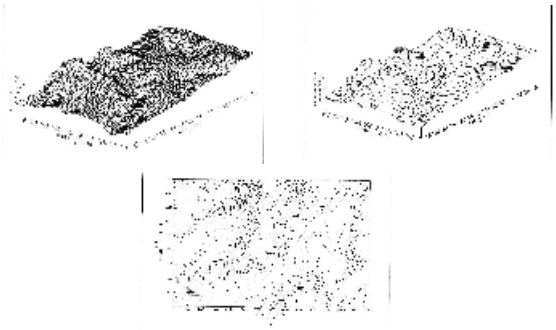
- Data maps of discretized data
- Data maps of topographic, continuous data

Data maps of discretized data (Tufte, 1983, p. 17)



Data maps of topographic, continuous data

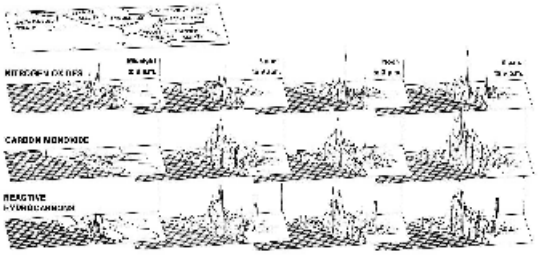
(Kerlow and Rosebush, 1986, pp. 244, 246, 246)



Data Display Techniques: Small Multiples and Table-Graphics

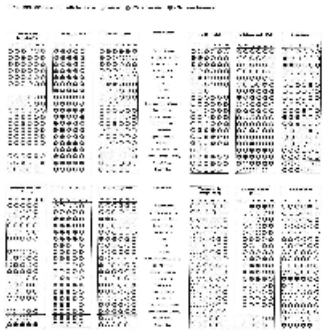
- A small multiple
- A table graphic
- A small multiple of table graphics

A small multiple (Tufte, 1983, p. 42)



A table graphic (Tufte, 1983, p. 158)

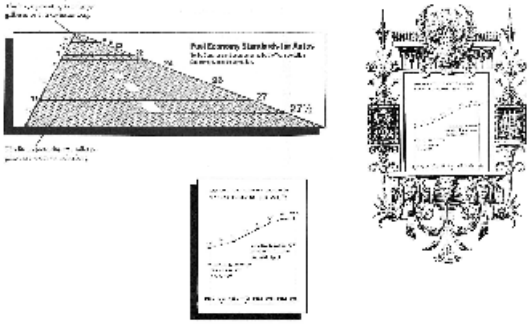
A small multiple of table graphics (Tufte, 1983, p. 174)



Graphical Integrity

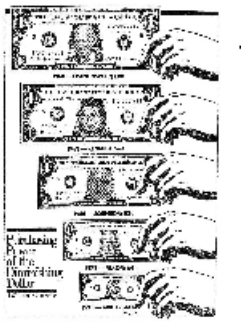
- Lying with data graphics
  - The lie factor
  - Compounding the lie factor: what is being compared? Length or area?
  - The importance of context
- Unintentional lies due to graphical perception

Lie factor of 14.8, truthful graphic, and needlessly decorated version (Tufte, 1983, pp. 57, 58, 59)

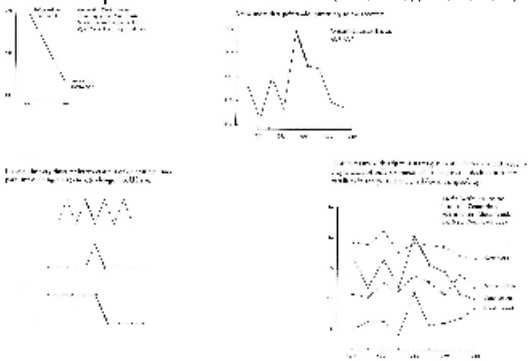


Compounding the lie: length vs. area

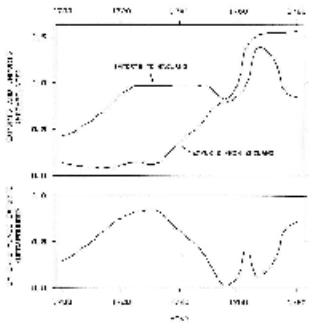
(Tufte, 1983, p. 70)



The importance of context (Tufte, 1983, pp. 74, 74, 75, 75)



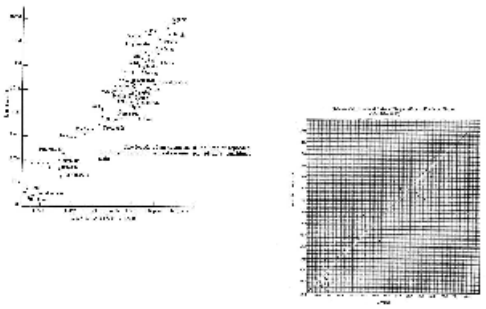
Visual perception problem (Cleveland, 1985, p. 277)



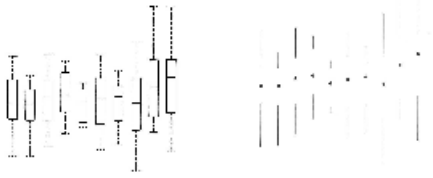
Pitfalls in Data Display

- Data ink and the data ink ratio
- Chartjunk
  - Vibrations
  - Ducks

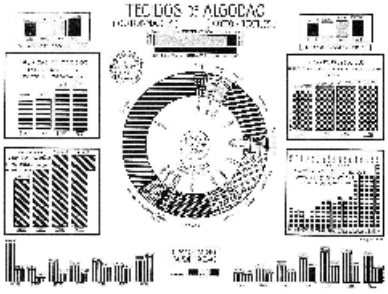
High and low data ink ratios (Tufte, 1983, p. 94)



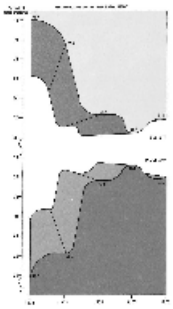
Data ink maximization (Tufte, 1983, p. 125)



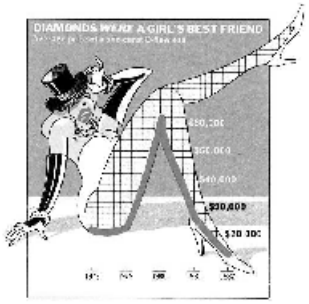
Chartjunk: Vibrations (Tufte, 1983, p. 108)



Ducks: Silly use of colour (Tufte, 1983, p. 118)



Ducks: Preposterous use of colour (Tufte, 1990, p. 34)



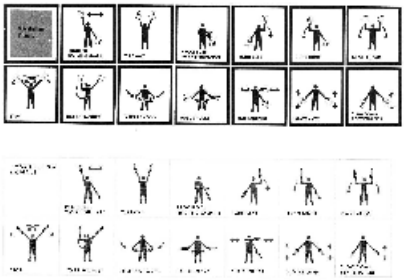
Opportunities in Data Display: Colour

- Data map with colour
- Small multiples diagram with colour
- Geometry proof with colour

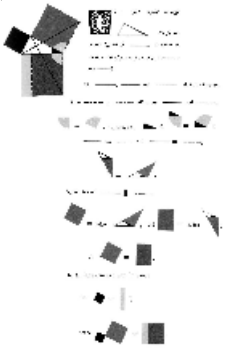
Data map with colour (Tufte, 1990, p. 40)

Small multiples diagram with colour

(Tufte, 1990, p. 63)



Geometry proof with colour (Tufte, 1990, p. 85)



Applications of Information Visualization

- Banking and finance
- Industrial and manufacturing
- Resources and exploration
- Medical
- Educational
- Software development

Example: Visualization of Sorting Algorithms

- Linear insertion and binary insertion

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.

Recap, speeded up 12 times

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.

9-way race

QuickTime™ and a Sorenson Video decompressor are needed to see this picture.

The Principles Applied to This Example

Legibility	———————————————————
Readability	Simple labels on axes of graphs
Clarity	Vertical rectangles, horizontal rectangles, numbers
Emphasis	Highlighting elements being compared
Simplicity	Lines and dots wherever possible
Consistency	Colours for depicting being compared, in correct position
Relationships	Colour, highlighting, and timing to show relationships
Distinctiveness	Element values portrayed by one clear dimension only
Focus and navigability	Simple rectangular grid in 9-way race

Summary

- Purpose
- Excellence in data display
- Techniques for data display
- Graphical integrity
- Pitfalls and flaws in data display
- Opportunities in data display
- Applications of information visualization
- Example: Animation of sorting algorithms

Questions and Discussion