An Update from the FDA / Industry / Academia Safety Graphics Working Group: General Principles Sub Team

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Is Your Brain Frozen?

- An article in Newsweek confirms what we all experience
- From brain scans - parts of the brain best at decision-making can get overloaded
- Too much information results in poorer decisions

The Science of Making Decisions Newsweek 27 Feb 2011

Graphical Perception

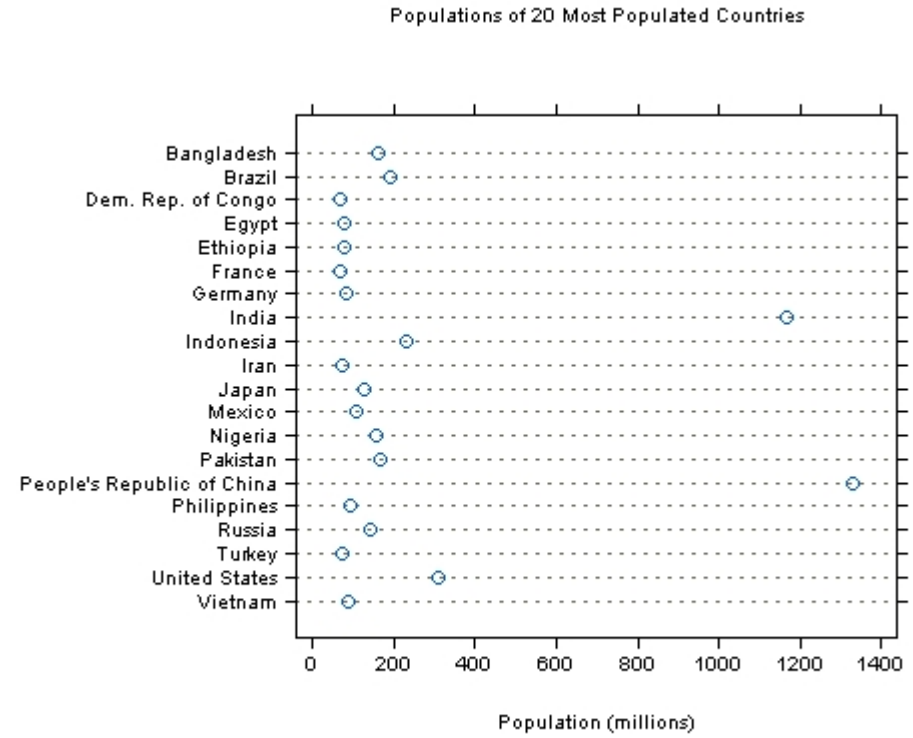
"When a graph is constructed, information is *encoded*. The *visual decoding* of this encoded information is *graphical perception*.

The decoding is the vital link …

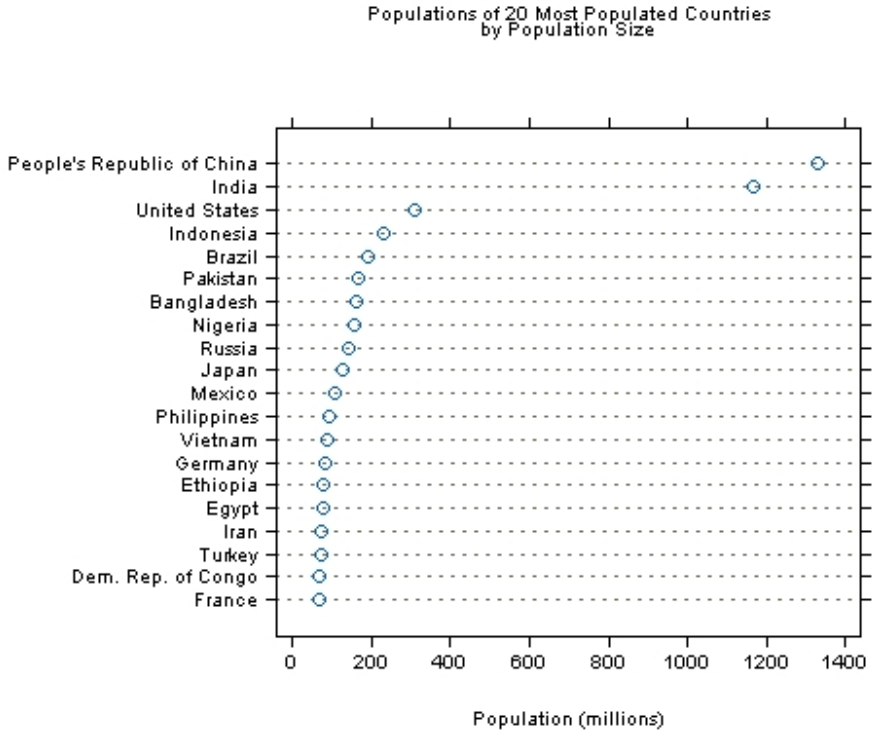
No matter how ingenious the encoding … and no matter how technologically impressive the production, a graph is a failure if the visual decoding fails."

William Cleveland, The Elements of Graphing Data

Table Look-Up and Pattern Perception



Source: Wikipedia



Concept from William Cleveland, *The Elements of Graphing Data*

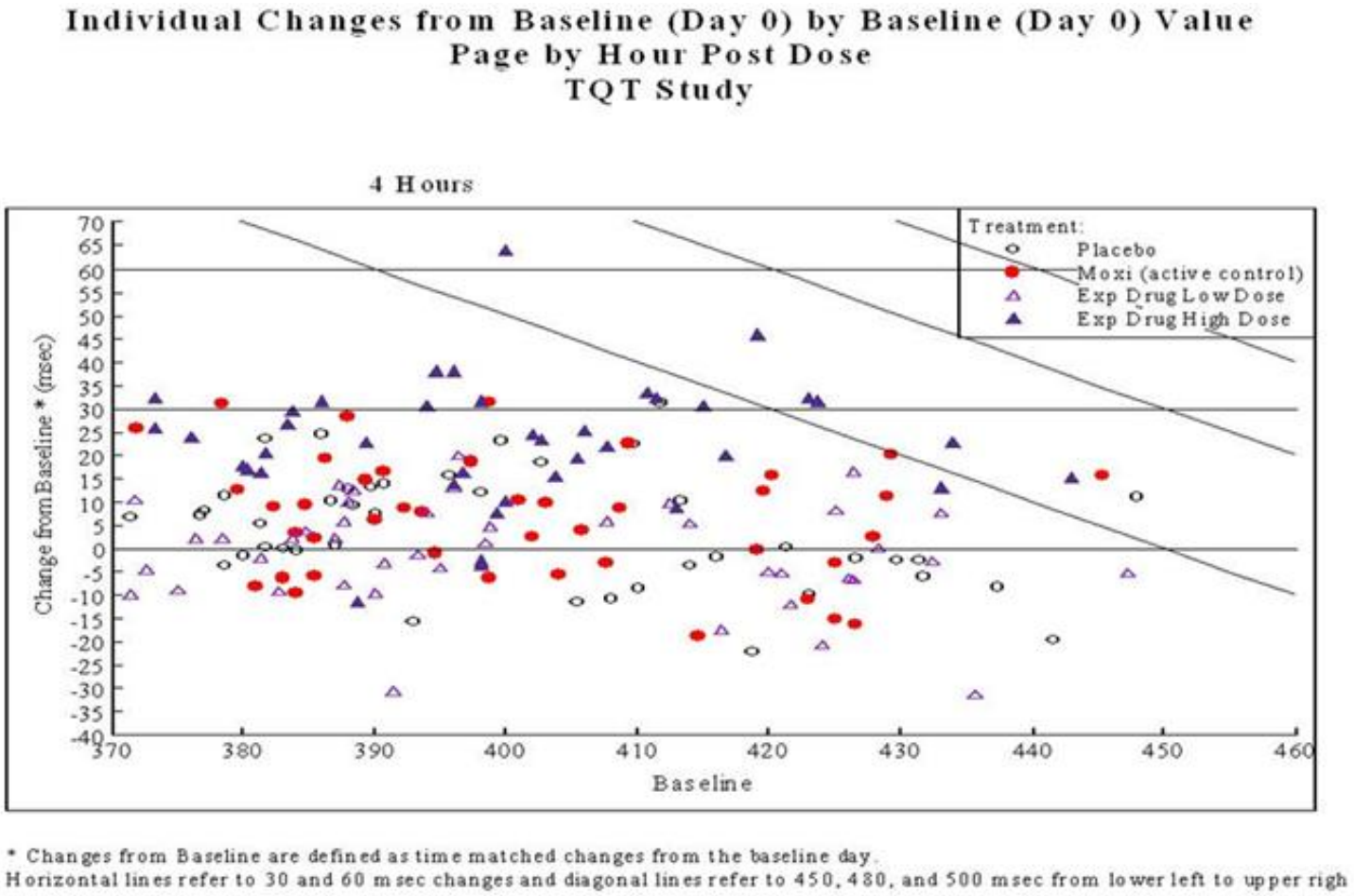
How to Make Quality Graphs More Quickly?
Use Standard Graphs for Common Safety Questions

- The ECG example (one of six graphs for ECG)
- Each graph entry in the wiki has a description of use, sample program code & data
- The wiki is searchable, has a glossary and many other features

Safety Graphics Wiki ECG Subteam's Answer for a Standard Graph

- Typically Tabular summaries of Categorical QTc
  - Changes from Baseline: N's and % changes exceeding 30 and 60 msec
  - Raw/Absolute QTc values: N's and % exceeding 450, 470, and 500
- Problem: interpreting the changes without knowing the Baseline or absolute QTc value
- Plot shows relationship of change to the absolute

Safety Graphics Wiki ECG Subteam's Answer for a Standard Graph

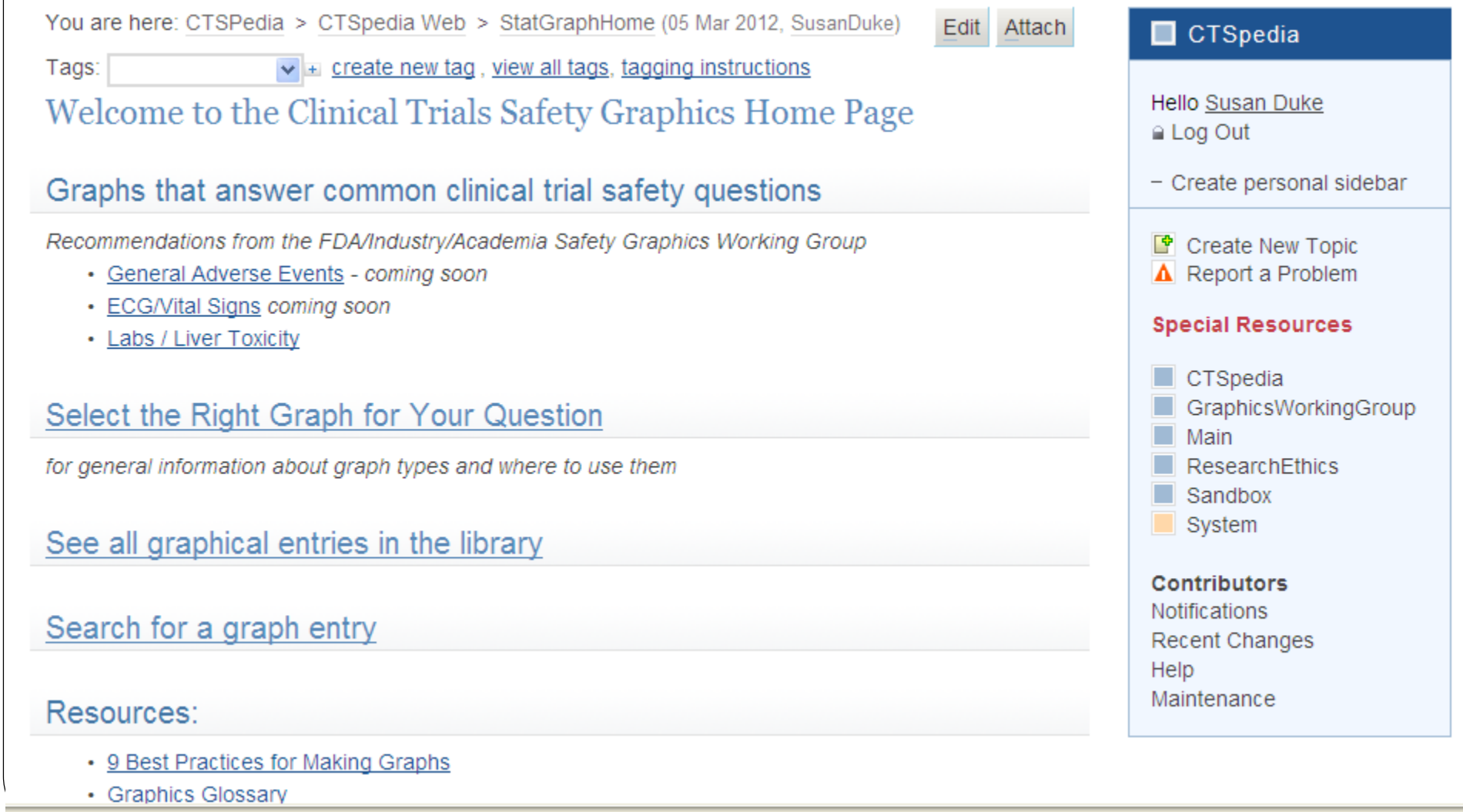


Interpretation of Categorical QTc plot

- Design shortcoming of this graph type: regression to the mean
  - The majority of large changes occur in subjects with low baseline
  - The majority of large absolute values started with a high baseline
- Values of real concern are large changes with large absolute values – upper right is area of concern
- This couldn't be assessed with a table where absolute and changes are presented separately – the dependence of one on the other is lost with tabular displays

How to Make Quality Graphs More Quickly?

Use Standard Graphs for Common Safety Questions

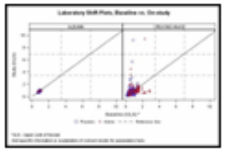
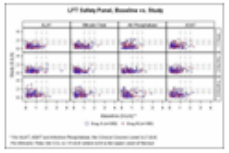


Graphs that answer common lab questions

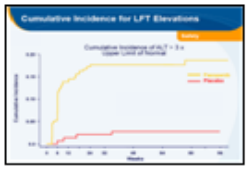
Recommended graphs designed to answer common clinical trial safety questions for: Labs and Liver Toxicity

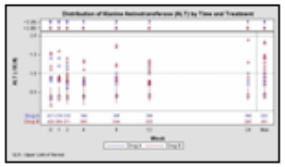
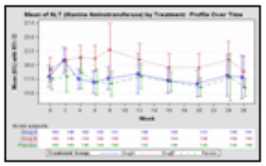
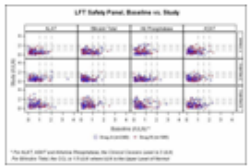
Baseline and Trending over Time

1. What are the changes and percent changes from baseline over time?
   ie, are abnormal lab values a result of an abnormal baseline or have values changed on study?

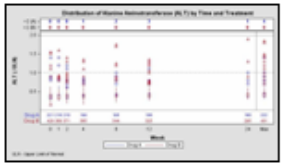



2. Is there a temporal relationship between treatment and lab values?



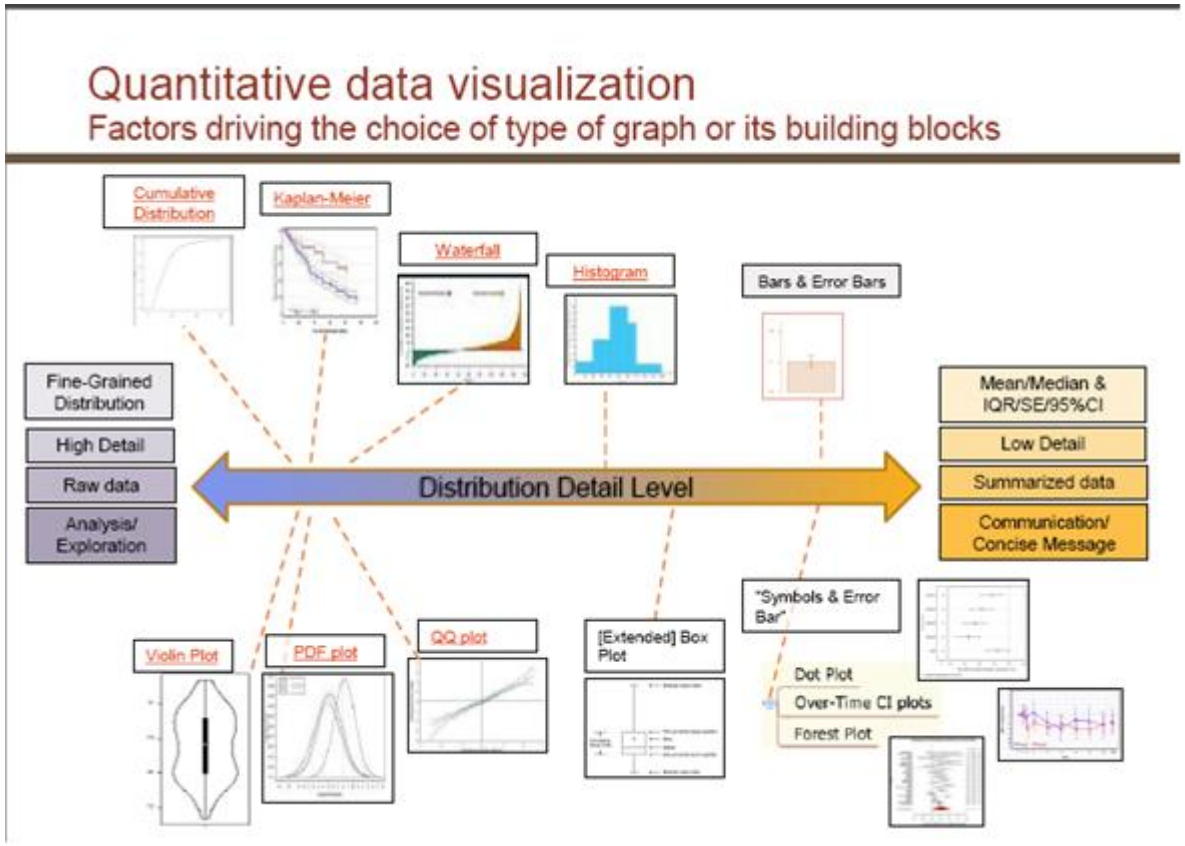
3. What are the toxicity grade trends over time?



How to Make Quality Graphs More Quickly?

Industry-wide: FDA/Industry/Academia Safety Graphics Wiki

- … and if you're not sure what kind of graph you need, Safety Graphics Wiki has guidance to find the best graph type for your needs



9 Best Practices for Making Graphs

Best Practices Recommendations

Contributed by: SusanDuke

1. **Content** Every graph should stand on its own
    1. It should tell its story without a need for detailed explanatory text or supporting documents.
    2. It should be clear, effective and informative for the intended audience.
2. **Communication** Tailor each graph to its primary communication purpose
    1. What is insight the graph is intended to convey? Is it intuitive?
    2. Avoid packing too much information into a single display and distracting from the main message.
3. **Information** Maximize the data-to-ink ratio
    1. Each spot of ink should be necessary for imparting the main message
    2. Do not clutter a graph with what you don't need. Less is more.
4. **Annotation** Provide legible text and information
    1. Position annotation (including legends) so that it aids interpretation and does not distract from the message.
    2. Use legible font that can be read without eye strain or a great deal of effort. Consider the format (presentation or document)

9 Best Practices for Making Graphs

5. **Axes** Design axes to aid interpretation of a graph
    1. Scale axes to show the interesting features of the data; for example, for longitudinal data, use time (on a continuous scale) instead of visit number (on an ordinal scale).
    2. Give careful consideration to inclusion of the zero of each axis; if excluded, ensure its absence is clearly sign-posted.
    3. Avoid crowded axes.
    4. Use the same axis scales on graphs that need to be compared.
    5. Choose the appropriate style of axes. For example, select between a box, X and Y axes, X only, Y only; consider grid lines; ensure intelligent placing of tick marks.
    6. If the nature of the data suggests the shape of the graphics, follow that suggestion; otherwise, use horizontal graphics about 50% wider than tall.
6. **Styles** Make symbols and plot lines distinct and readable
    1. Choose plot symbols with simple, familiar shapes and intuitive interpretation (eg 'A' for active and 'P' for placebo)
    2. If a graph is to be displayed by projection onto a screen, or in a poster, use thick lines, large symbols and large fonts to achieve legible display.
    3. Where possible and appropriate, data representations (such as styles of symbols, lines and bars) should have the same meaning across all similar graphs within a package; for example, if one line graph uses a solid blue line to represent Placebo, all graphs in the package should use a solid blue line for Placebo.

9 Best Practices for Making Graphs

7. **Colors** Make use of color if appropriate for the medium of communication
    1. Use color only when it decodes information. When color is used, choose contrasting and clearly visible colors; avoid yellow, and contrasts with red, green or brown which are difficult for people with color-deficient vision.
    2. If a graph may be viewed in black and white, ensure that all distinctions made by color are also made by other features such as symbols and line-styles.
    3. For black-and-white media, make use of line-styles (dashing and gray levels) that are easy to distinguish.
    4. Design backgrounds to set off the graph, not compete with it.
    5. Choose area fills that are distinct but compatible.
    6. Make secondary plot lines lighter in weight, color or style.
    7. Keep reference lines and grids distinct from other data lines.
    8. Color Brewer is an excellent reference for choice of colors.
8. **Techniques** Use established techniques to clarify the message
    1. Show causality: when a causal relationship exists between variables make sure it is easily discernable from the graph.
    2. Make comparisons from a common baseline.
    3. Sort categories according to relevant features of the data.
    4. Do not introduce spurious dimensions to a graph, as they reduce clarity.
    5. Combine multiple images into a single display when information needs to be presented together.
    6. When a graph summarizes data at an aggregate level, always plot estimates of variability in the data.

9 Best Practices for Making Graphs

9. **Types of plots** Use the simplest plot that is appropriate for the information to be displayed (see Select the Right Graph for My Question)
    1. To show a distribution of values, use whichever form is most appropriate: rugplot, strip plot, dotplot, boxplot, histogram, CDF plot, or more specialized display.
    2. Use scatter and line plots to show association between a pair of variables, thinking carefully about the representation of variability of actual data.
    3. Use trellis displays to show changes in association between a pair of variables with respect to a third variable.

Adapted from: GlaxoSmithKline Graphics Principles (used with permission)

Revised by: General Principles subteam, FDA/Industry/Academia Safety Graphics team (24Mar2011)

Graphics Glossary

Glossary of Graphics Information

The following is a list of terms used in the graphing of data.

A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z

A

- **Aspect ratio**: The aspect ratio of a graph is the height of the data rectangle divided by the width. An aspect ratio of 1 means the data rectangle is square with the height and width being the same length.

B

- **Bar chart**: A bar chart is a chart with rectandular bars with lengths proportional to the values that they represent. The bars can be plotted vertically or horizontally. Bar charts are used for plotting *discrete* data.
- **Boxplot**: A boxplot is a graph of the statistical five number summary. A central box spans the the first (25th percentile) and third (75th percentile) **quantiles**. A line bisects the box at the median (50th percentile). Lines extend from the box to the smallest and largest observations. An alternate version of the box plot, the **modified boxplot**, has lines that extend from the box to 1.5 **IQR** (see below).

C

Special Thanks, Part 1

- **ECG Sub Team Members:**
  - Rich Anziano (lead) – Pfizer
  - Eric Frimpong – CDER
  - Liping Huang – CSL Bering
  - Antonio Paredes - CDER

- **Former Member:**
  - Peter Bridge - Roche

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- **General Principles Sub Team Members:**
  - Susan Duke (lead) - GSK
  - Rich Forshee – CBER
  - Fabrice Bancken - Novartis
  - Mat Soukup – CDER
  - Brenda Crowe - Lilly
  - Mary Banach – UC Davis
  - Frank Harrell – Vanderbilt
  - Qi Jiang - Amgen
  - Larry Gould - Merck
  - Andreas Krause - Actelion

- **Former Member:**
  - Markus Yap – FDA

- **In addition,** Peter Lane, GSK *lead author, GSK's graphics catalogue, principles & glossary*

Inspiring Words from Edward Tufte

- **Principles of Graphical Excellence**
  - 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.
  - 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.