



# Seeing Is Believing! Good Graphic Design Principles for Medical Research

*Track 15: Statistical Science and Quantitative Thinking*

**Susan Duke, GSK**

**Brenda Crowe, Lilly**

**Richard Forshee, FDA - CBER**



# Today's Session

- **Motivators for Use of Graphs in Medical Research**

Susan Duke, MS

Director, Benefit Risk Evaluation, Global Clinical Safety and Pharmacovigilance, GlaxoSmithKline

- **Not every graph is a good one: Examples of improvements to commonly used graphs**

Brenda Crowe, PhD

Sr. Research Advisor, Global Statistical Sciences, Eli Lilly and Company

- **Spaghetti, Lasagna, and Cooking Up Graphs from Scratch**

Richard Forshee, PhD

Associate Director, Office of Biostatistics and Epidemiology, CBER, FDA



# What you can learn from this session

- Discuss motivations for use of good statistical graphics principles, with examples
- Illustrate ways to improve the quality and transparency of statistical graphics in medical research
- Describe a new framework for selecting the appropriate graph type for the situation at hand





# Motivators for Use of Graphs in Medical Research

**Susan Duke, MS**

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# Disclaimer

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# Motivators for Well-Designed Graphics in Medical Research

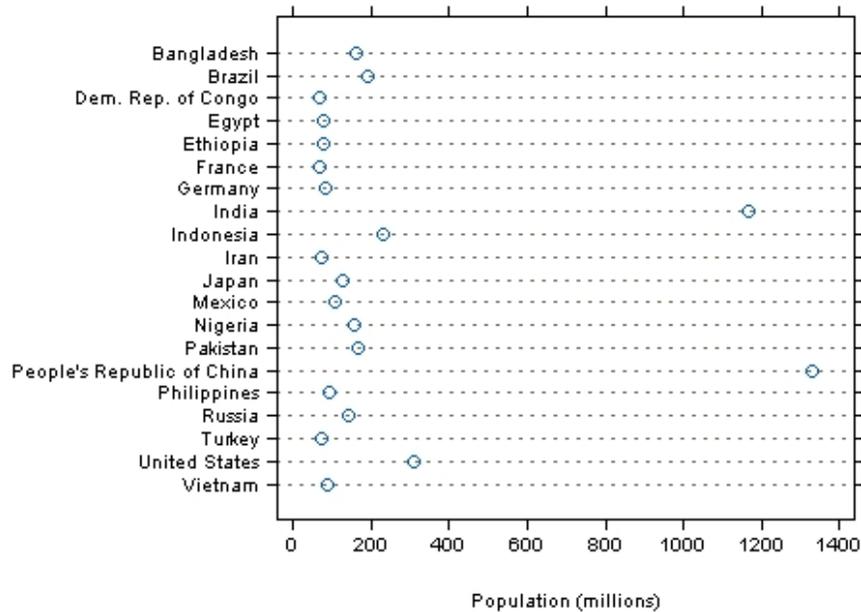
1. Visual decoding
2. It's what the masters did (Tukey, Cleveland, Tufte)
3. Human's keen visual perception often best choice for signal detection
4. Why not?



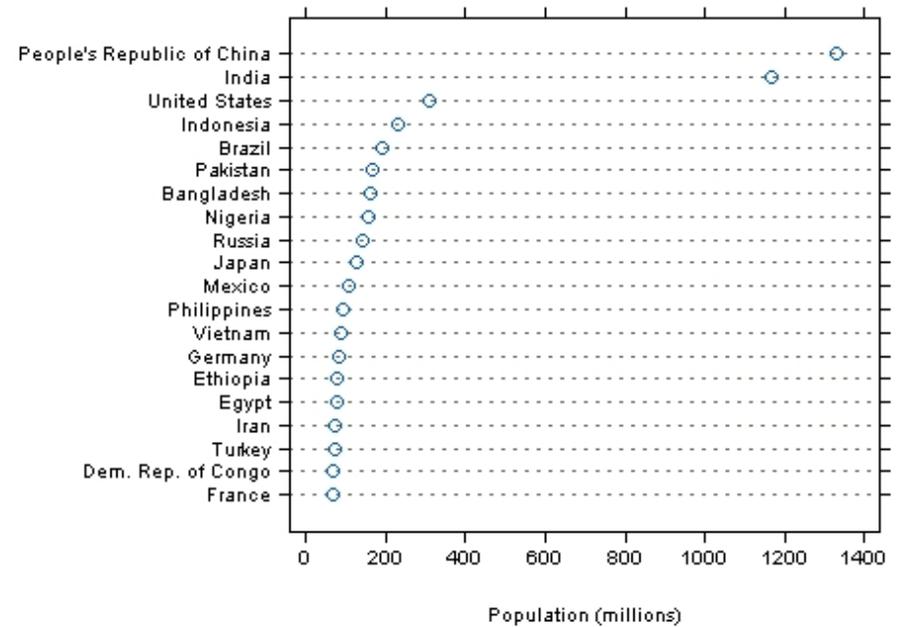
# Visual Decoding

## Table Look-Up vs Pattern Perception

Populations of 20 Most Populated Countries



Populations of 20 Most Populated Countries by Population Size



Source: Wikipedia

Concept from William Cleveland, *The Elements of Graphing Data*  
 Graphs by Susan Duke, GSK



# Visual Decoding

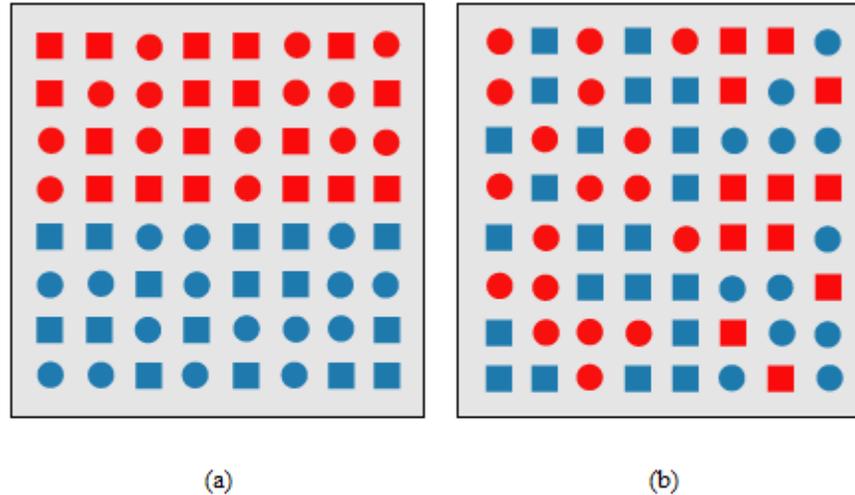


Fig. 4: An example of a boundary detection from Treisman's experiments: (a) a boundary defined by a unique feature hue (red circles and red squares on the top, blue circles and blue squares on the bottom) is preattentively classified as horizontal; (b) a boundary defined by a conjunction of features (red circles and blue squares on the left, blue circles and red squares on the right) cannot be preattentively classified as vertical

See more at <http://www.csc.ncsu.edu/faculty/healey/PP/index.html>



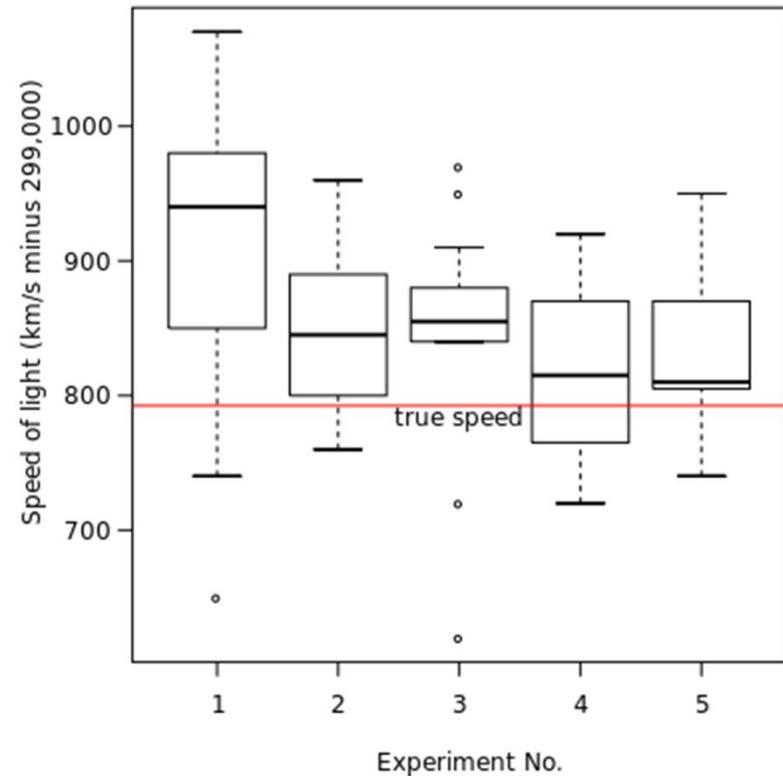
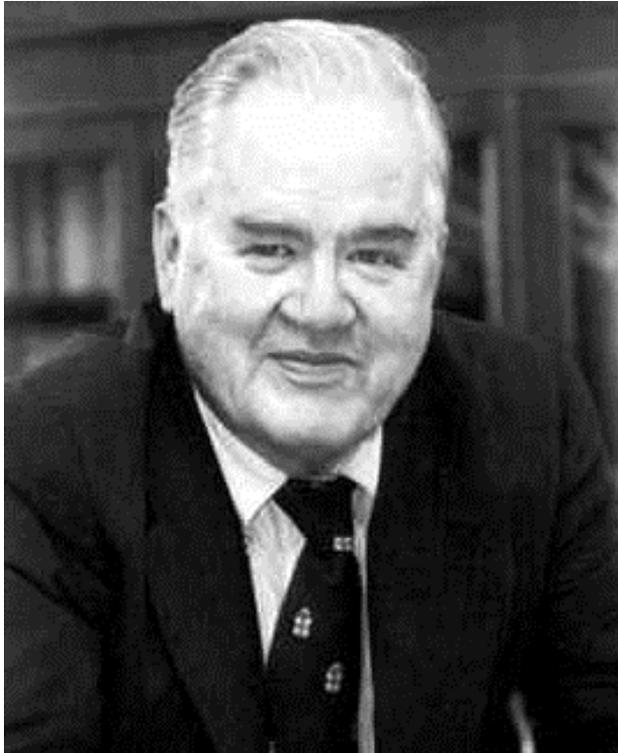
# Good Graphics Practices

- John Tukey
- Edward Tufte
- William Cleveland
- Safety Graphics Wiki



# John Tukey

## Best known for the Boxplot



[http://en.wikipedia.org/wiki/John\\_Tukey](http://en.wikipedia.org/wiki/John_Tukey)



# Tukey's Recommendations from 1990

*“Data-Based Graphics: Visual Display in the Decades to Come”*

“We need to pay serious and continuing attention to securing:

- a) Immediate and strong impact
- b) Easy flow of attention across parallel elements
- c) Planning to show phenomena, not numbers
- d) Attention to both prospecting for what the data might show and transfer (to others)
- e) Partnership with computation
- f) Put disproportionate response to work”

Statistical Science 1990 5(3): 327-339



# Tufte on Analytical Reasoning

"Be approximately right rather than exactly wrong." John W. Tukey



"The first principle is that you must not fool yourself--and you are the easiest person to fool." Richard Feynman

Ask questions.

Develop and fine-tune *a sense of the relevant*, both for identifying the key leverage points in any problem and also for examining large amounts of information to find the rare diamonds in the sand.

Nearly all serious analysis requires multivariate-thinking, comparison-thinking, and causal-thinking. Develop such thinking.

[http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg\\_id=0002bA](http://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=0002bA)





# William Cleveland

“Visualization is critical to data analysis. It provides a front line of attack, revealing intricate structure in data that cannot be absorbed in any other way. We discover unimagined effects, and we challenge imagined ones.”

- “Tools matter... There are exceptionally powerful visualization tools, and there are others, some well known, that rarely outperform the best ones.”
- “Our tendency is to be misled into thinking we are absorbing relevant information when we see a lot. But the success of a visualization tool should be based solely on the amount we learn about the phenomenon under study. ”

<http://www.stat.purdue.edu/~wsc/visualizing.html>



# Safety Graphics Wiki

## General Principles

1. **Content** Every graph should stand on its own
2. **Communication** Tailor each graph to its primary communication purpose
3. **Information** Maximize the data-to-ink ratio **Annotation** Provide legible text and information
4. **Annotation** Provide legible text and information
5. **Axes** Design axes to aid interpretation of a graph
6. **Styles** Make symbols and plot lines distinct and readable
7. **Colors** Make use of color if appropriate for the medium of communication
8. **Techniques** Use established techniques to clarify the message
9. **Types of plots** Use the simplest plot that is appropriate for the information to be displayed

<http://www.ctspedia.org/do/view/CTSpedia/BestPractices>



# Visual perception for signal detection

Event	Drug A (%)	Drug B (%)	<del>50/50</del>	Lowest%	Highest%
ARTHRALGIA	33	03	70	16	313
NAUSEA	100	46	41	28	60
ANOREXIA	35	00	39	12	181
HEMATURIA	32	09	36	10	122
INSOMNIA	60	18	33	13	79
VOMITING	88	28	31	10	62
DYSPEPSIA	97	37	26	14	49
WEIGHT DECREASE	21	08	23	08	90
PAIN	39	18	21	08	53
DIARRHEA	208	106	20	14	28
FATIGUE	37	10	19	07	51
FLATULENCE	46	28	16	07	37
DIZZINESS	67	42	16	08	31
ABDOMINAL PAIN	142	93	16	10	24
RESPIRATORY DISORDER	26	18	14	05	40
HEADACHE	84	65	10	07	28
INJURY	70	56	12	07	28
GASTROESOPHAGEAL REFLEX	26	23	13	04	33
BACK PAIN	53	46	12	06	28
HYPERKALEMIA	21	19	11	04	34
RASH	21	19	11	04	34
SINUSITIS	65	60	11	08	20
INFECTION VIRAL	60	58	11	08	21
UPPER RESP TRACT INFECTION	158	153	10	07	10
MYALGIA	28	28	10	04	28
URINARY TRACT INFECTION	28	28	10	04	28
COUGHING	60	50	10	05	18
MELENA	28	32	09	03	22
RHINITIS	39	51	08	04	17
BRONCHITIS	26	37	07	03	18
CHEST PAIN	28	42	07	03	16
CHRONIC OBSTRUCTIVE AIRWAY	220	562	06	05	08
DYSPNEA	21	68	03	01	08



Where is the signal?



# Why Not? Part 1

From GSK's experience...

- Regardless of therapy area, we found that **every group has one or a few “graphics gurus.”**
  - This is a key resource!
  - Ensure they understand graphic design too
- ... **making the right graph is key to answering the right question.** ... Both [graphic design and clinical interpretation] are topics [that] improve communication about our medicines.

[http://www.amstat.org/sections/sbiop/BiopharmReport/2012\\_Spring\\_BR.pdf](http://www.amstat.org/sections/sbiop/BiopharmReport/2012_Spring_BR.pdf)



# Why Not? Part 2

From GSK's experience...

- **Software does matter.**
  - **A visual interface makes the graph come alive as it's constructed.**
    - We discovered by accident when we delivered both a graphical user interface (GUI) and some macros in our first deployment that users much preferred the GUI (and barely used the macros).
  - **Software that requires many iterations to create the desired graph is painful.**
    - For example, struggling with software to get appropriate device drivers takes longer and is more painful to use than software that has the right device drivers included by default.
  - **Standard graph templates (and pre-processing macros to shape the data) make it especially easy to answer commonly asked clinical trial questions with graphs.**
- [http://www.amstat.org/sections/sbiop/BiopharmReport/2012\\_Spring\\_BR.pdf](http://www.amstat.org/sections/sbiop/BiopharmReport/2012_Spring_BR.pdf)



# Why Not? Part 3

## How to Make Quality Graphs More Quickly?

- Use Standard Graphs for Common Safety Questions
- This wiki is available to everyone!
- Created by FDA/Industry/Academia Working Group

The screenshot shows the CTSPEDIA website interface. At the top, there is a blue header with the CTSPEDIA logo and a search bar. Below the header, the breadcrumb trail reads: "You are here: CTSPedia > CTSpedia Web > StatGraphHome (02 Dec 2013, MaryBanach)". There are "Edit" and "Attach" buttons next to the breadcrumb. A "Tags" section includes a dropdown menu and links for "create new tag", "view all tags", and "tagging instructions". The main content area is titled "Welcome to the Clinical Trials Safety Graphics Home Page" and features a section "Graphs that answer common clinical trial safety questions". This section includes "Recommendations from the FDA/Industry/Academia Safety Graphics Working Group" with links for "Labs / Liver Toxicity", "General Adverse Events", and "ECG". Below this, there is a link for "for general information about graph types and where to use them". The page also has sections for "Select the Right Graph for Your Data", "See all graphical entries in the library", and "Search for a graph entry". A "Resources" section lists "9 Best Practices for Making Graphs", "Graphics Glossary", and "FDA/Industry/Academia Safety Graphics Presentation Archive" with an "UPDATED" badge. On the right side, there is a sidebar with the CTSpedia logo, a "Log In or Register" link, and a "Webs on CTSpedia" section with links to "CTSpedia", "Main", "ResearchEthics", "Sandbox", and "System". At the bottom of the sidebar are links for "Recent Changes" and "Help".

<http://www.ctspedia.org/do/view/CTSpedia/StatGraphHome>



# Thank you

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