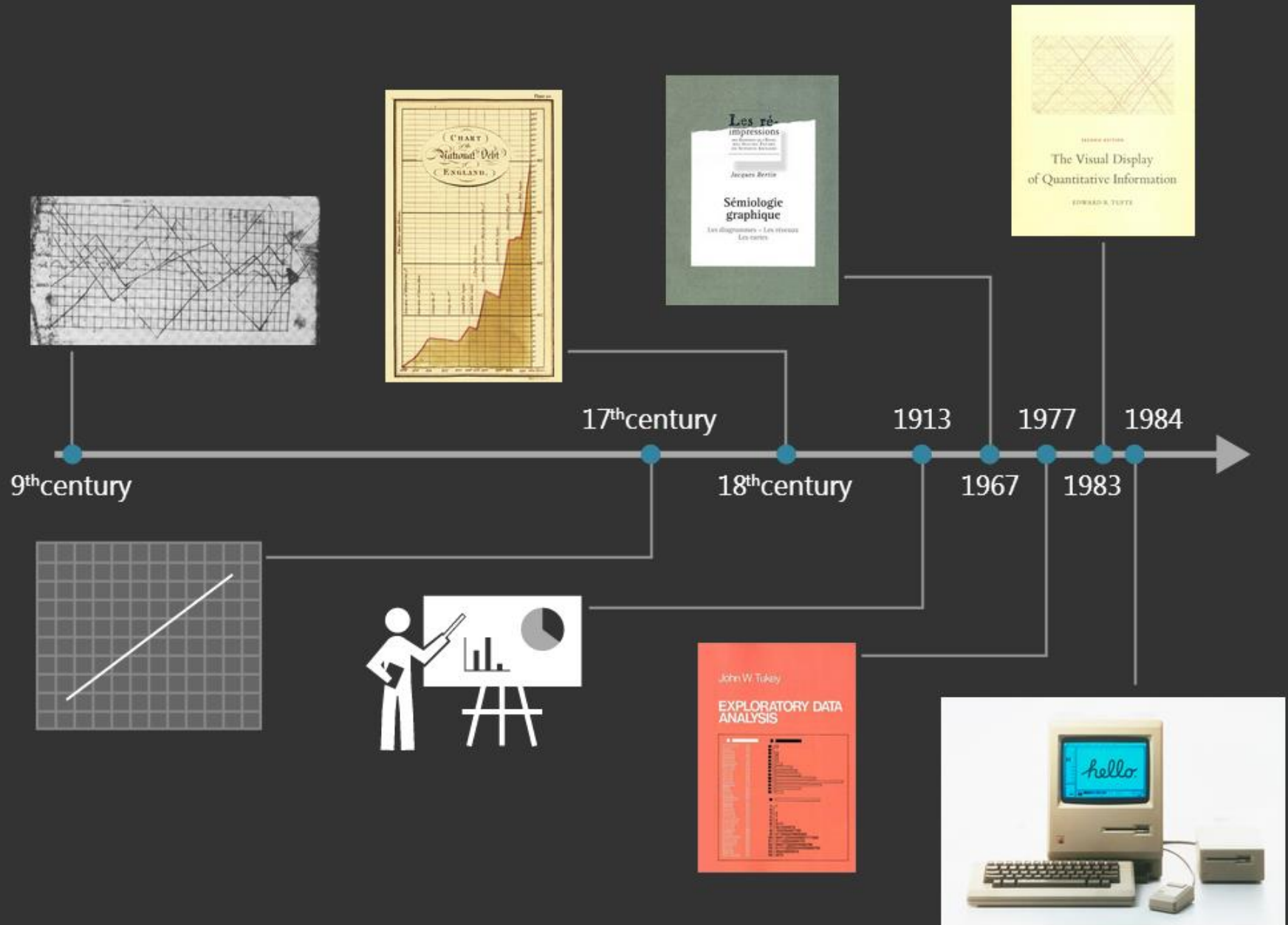


The Mind's Eye

the science behind data visualisation

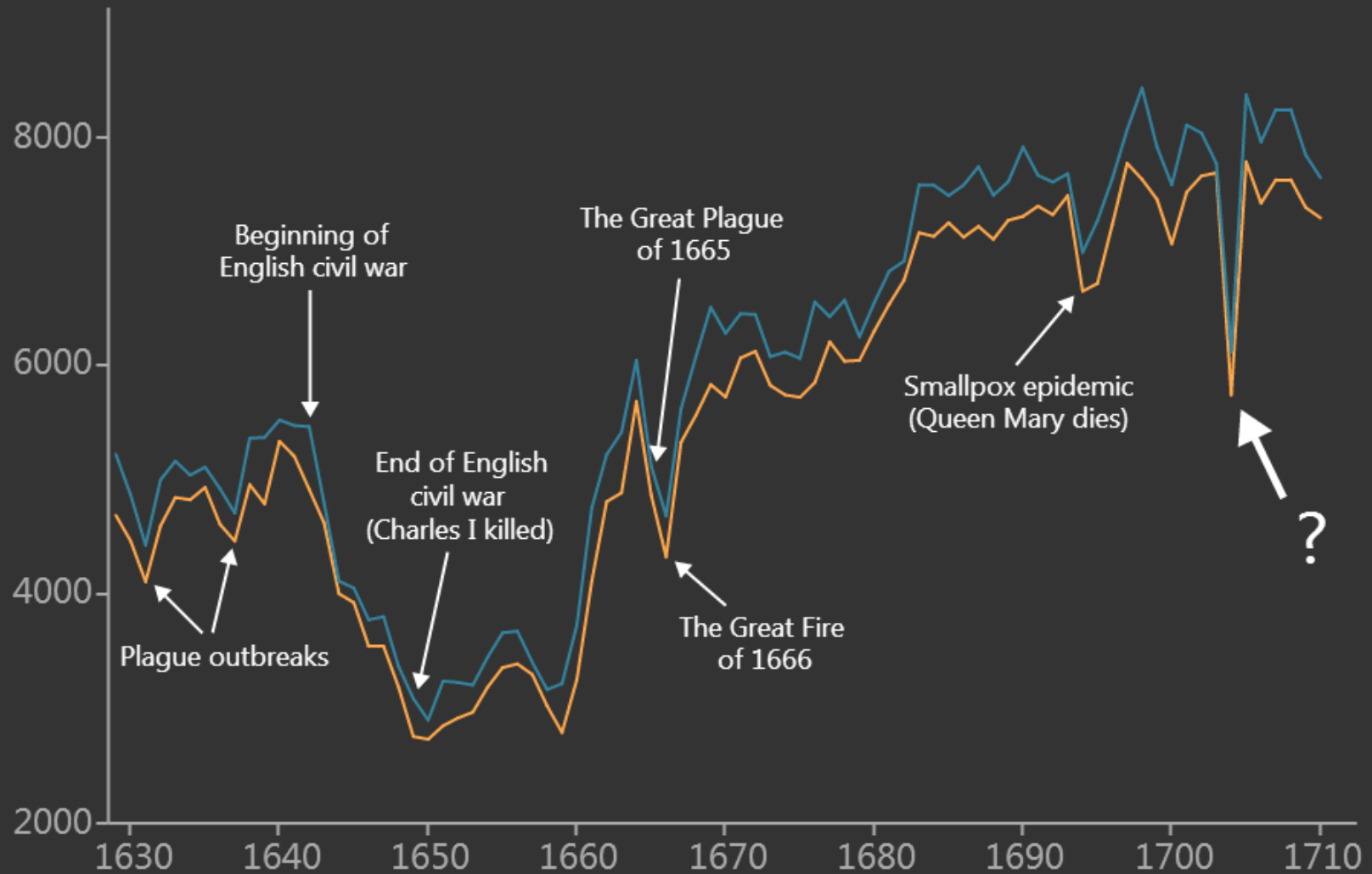
Graham Odds
@g_odds

www.scottlogic.co.uk/blog/graham



- 9th Century – Manuscript found in Auxerre presents Pliny's awkward circular astronomical charts on rectangular grid
- 17th Century – René Descartes (him of "I think therefore I am" fame) invents two-dimensional, coordinates-based graph system for solving certain types of mathematical problems
- 18th Century – William Playfair invents or dramatically improves many of the chart types we use today in his "Commercial and Political Atlas", and starts to create acceptance of data visualisation as a useful tool.
- 1913 – First college course in graphical statistics, at Iowa State
- 1967 – Semiology Graphique by Jacques Bertin introduces the notion of visual language, namely that visual perception operates according to rules that can be followed to express information visually in ways that represents it intuitively, clearly, accurately and efficiently.
- 1977 – John Tukey introduces new approach to analysing data using data visualisation, called *exploratory data analysis*.
- 1983 – Data visualisation guru Edward Tufte published his ground-breaking book *The Visual Display of Quantitative Information*.
- 1984 – During the Super Bowl, Apple Computer introduces us to the first popular and affordable computer that focuses on graphics as a mode of interaction and display.

Christenings in London, 1629 - 1710



The data using in John Arbuthnot's seminal paper "An argument for Divine Providence, taken from the constant regularity observed in the births of both sexes" has a wonderful copy-and-paste error that was never spotted until centuries later when it was visualised.

Story presented in more detail in *Graphic Discovery – A Trout in the Milk and Other Visual Adventures* by Howard Wainer (<http://www.amazon.co.uk/Graphic-Discovery-Trout-Visual-Adventures/dp/0691134057>).

System 1



VS

System 2



System 1 and System 2 are terms in cognitive psychology that were coined by the Nobel-prize winning Daniel Kahneman. There is no better place to learn all about cognitive psychology and decision making theory than his book *Thinking, Fast and Slow* (<http://www.amazon.co.uk/Thinking-Fast-Slow-Daniel-Kahneman/dp/0141033576>).

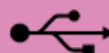


1250 MB/s



same bandwidth as a: computer network

125 MB/s



USB key

12.5 MB/s



hard-disk

Data from Tor Norretranders' *The User Illusion: Cutting Consciousness Down to Size* (<http://www.amazon.co.uk/User-Illusion-Cutting-Consciousness-Penguin/dp/0140230122>).

Visualisation based on *Low Resolution* by David McCandless, from his book *Information Is Beautiful* (<http://www.amazon.co.uk/Information-Beautiful-New-David-McCandless/dp/0007492898>).

Total Bandwidth

(millions of bits per second)

0 1 2 3 4 5 6 7 8 9 10



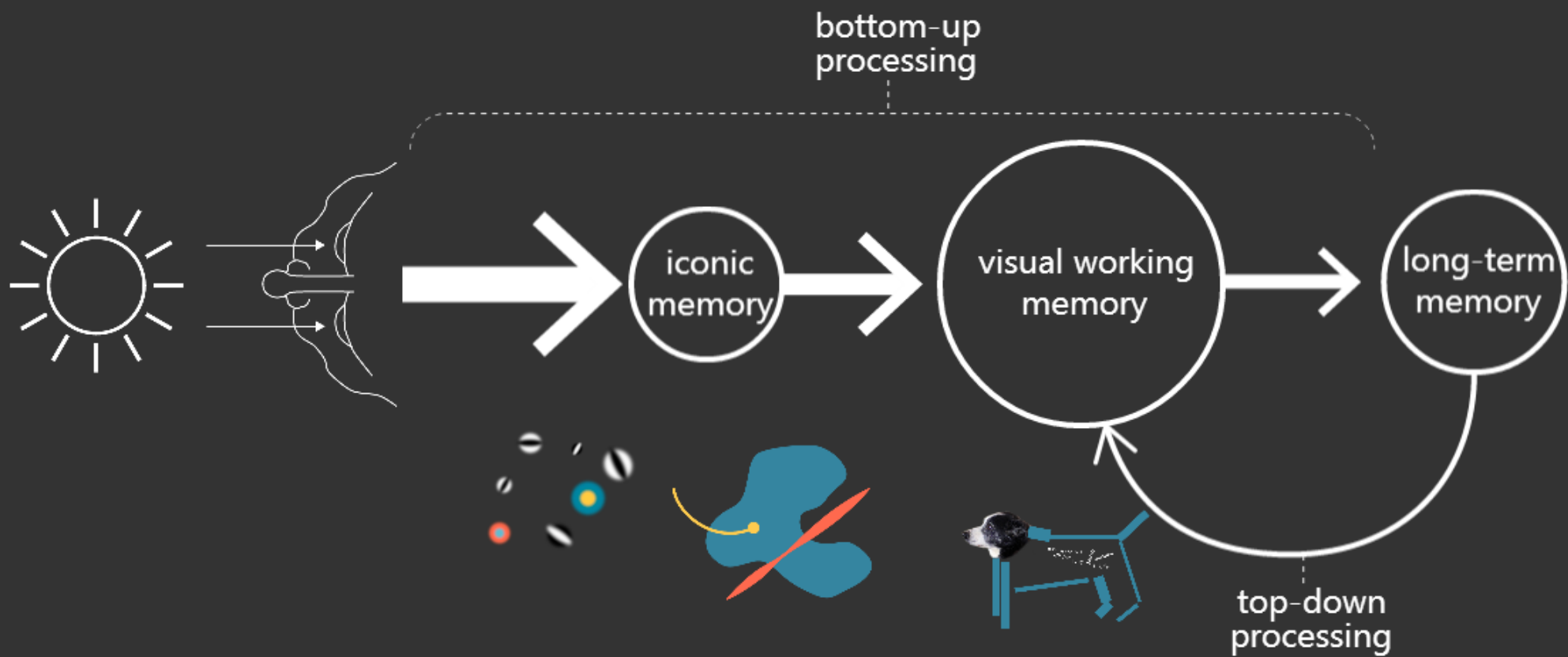
Conscious Bandwidth

(bits per second)

0 5 10 15 20 25 30 35 40



Data from Tor Norretranders' *The User Illusion: Cutting Consciousness Down to Size* (<http://www.amazon.co.uk/User-Illusion-Cutting-Consciousness-Penguin/dp/0140230122>).



Based on a combination of sources:

Information Visualisation: Perception for Design by Colin Ware

(<http://www.amazon.co.uk/Information-Visualization-Perception-Interactive-Technologies/dp/0123814642>)

Visual Thinking for Design by Colin Ware

(<http://www.amazon.co.uk/Visual-Thinking-Kaufmann-Interactive-Technologies/dp/0123708966>)

The Functional Art: An Introduction to Information Graphics and Visualisation by Alberto Cairo

(<http://www.amazon.co.uk/Functional-Art-Introduction-Information-Visualization/dp/0321834739>)

12

A B C

14

Form

Orientation



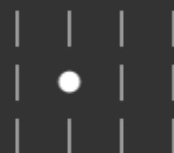
Line length



Line width



Shape



Added marks



Curvature



Enclosure



Size



Colour

Hue



Intensity



Position

2D location



A selection of visual features that are processed pre-attentively, i.e. before reaching conscious thought.

Based on a combination of sources:

Information Visualisation: Perception for Design by Colin Ware
(<http://www.amazon.co.uk/Information-Visualization-Perception-Interactive-Technologies/dp/0123814642>)

Show Me The Numbers: Designing Tables and Graphs to Enlighten by Stephen Few
(<http://www.amazon.co.uk/Show-Me-Numbers-Designing-Enlighten/dp/0970601972>)

Now You See It by Stephen Few
(<http://www.amazon.co.uk/Now-You-See-Stephen-Few/dp/0970601980>)

Form

Orientation



Shape



Enclosure



Line length



Added marks



Size



Line width



Curvature



Colour

Hue



Intensity



Position

2D location



The visual features onto which quantitative values can be naturally mapped and interpreted (the others can be good for categorical differentiation).

Based on a combination of sources:

Information Visualisation: Perception for Design by Colin Ware

(<http://www.amazon.co.uk/Information-Visualization-Perception-Interactive-Technologies/dp/0123814642>)

Show Me The Numbers: Designing Tables and Graphs to Enlighten by Stephen Few

(<http://www.amazon.co.uk/Show-Me-Numbers-Designing-Enlighten/dp/0970601972>)

Now You See It by Stephen Few

(<http://www.amazon.co.uk/Now-You-See-Stephen-Few/dp/0970601980>)

Form

Orientation



Shape



Enclosure



Line length



Added marks



Size



Line width



Curvature



Colour

Hue



Intensity



Position

2D location



Quantitative values can be very precisely mapped and interpreted using these visual features.

Based on a combination of sources:

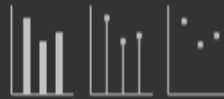
Information Visualisation: Perception for Design by Colin Ware
(<http://www.amazon.co.uk/Information-Visualization-Perception-Interactive-Technologies/dp/0123814642>)

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Now You See It by Stephen Few
(<http://www.amazon.co.uk/Now-You-See-Stephen-Few/dp/0970601980>)

Allows more
accurate judgments

2D position along common, aligned scale



2D position along common, but unaligned scales



Length



Slope



Angle



Area



Colour intensity



Allows more
generic judgements

Volume



Colour hue



William S. Cleveland and Robert McGill have published two papers creating a ranking of visual attributes for quantitative graphs:

Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods (1984)

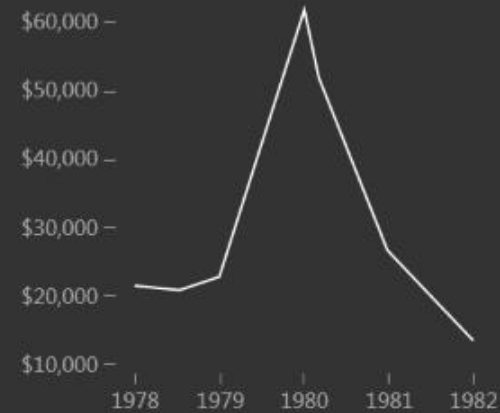
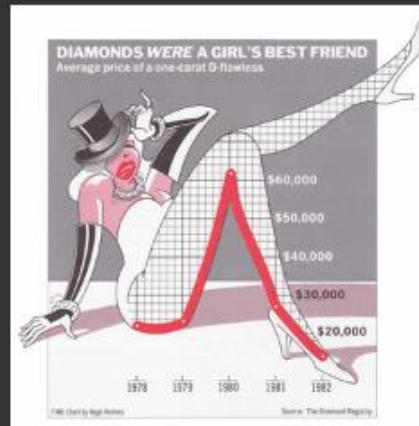
Graphical Perception and Graphical Methods for Analyzing Scientific Data (1985).

These papers are the primary source for the scale. However, the secondary sources that made the information a bit more digestable were:

The Functional Art: An Introduction to Information Graphics and Visualisation by Alberto Cairo

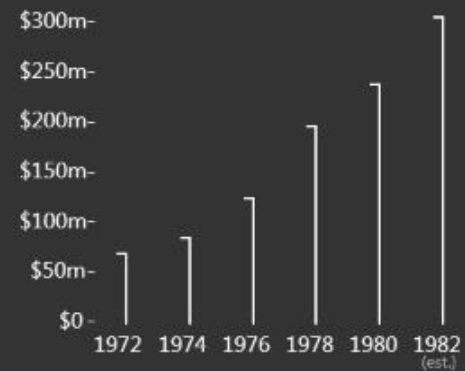
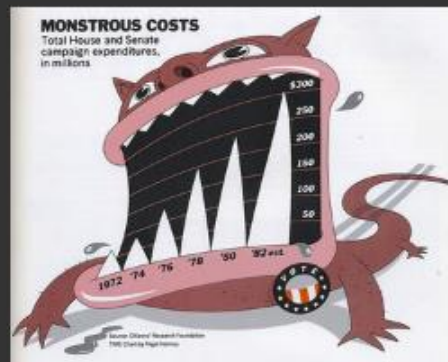
(<http://www.amazon.co.uk/Functional-Art-Introduction-Information-Visualization/dp/0321834739>)

<http://sfew.websitetoolbox.com/post/Clevelands-Graphical-Features-Hierarchy-4696938>



Presentation

Exploration



Edward Tufte's attack on chartjunk is in his book *Envisioning Information* (<http://www.amazon.co.uk/Envisioning-Information-Edward-R-Tufte/dp/0961392118>).

For a detailed discussion of the presentation vs exploration spectrum and how to make decisions around where a particular visualisation should lie on that spectrum read *The Functional Art: An Introduction to Information Graphics and Visualisation* by Alberto Cairo (<http://www.amazon.co.uk/Functional-Art-Introduction-Information-Visualization/dp/0321834739>).

The research comparing Nigel Holmes' *Diamonds Were a Girl's Best Friend* chart to its minimalist equivalent:

S. Bateman, R.L. Mandryk, C. Gutwin, A.M. Genest, D. McDine, C. Brooks. "Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts", *Proceedings of the 28th International Conference on Human Factors in Computing Systems*, (New York: ACM, 2010).



Display countries alphabetically | by rank

Moritz Stefaner's (<http://stefaner.eu/>) OECD Better Life Index visualisation (<http://www.oecdbetterlifeindex.org/>).

He explains some of the design thinking behind it here:
<http://moritz.stefaner.eu/projects/oecd-better-life-index/>

Thank You!

Graham Odds

@g_odds