

Designing a graphic

Week 21, 15.02.2016

Dr. Elena Simperl

Data Visualisation (COMP6234)

Session aims

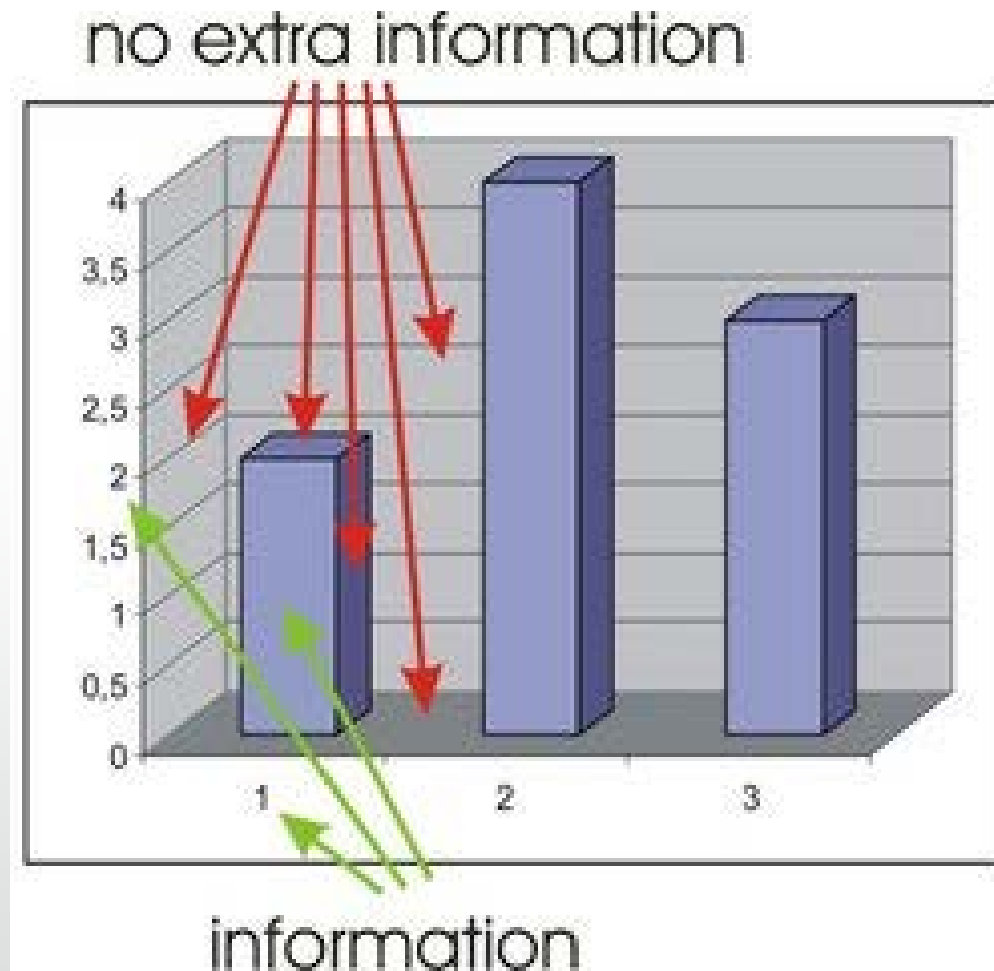
- **Chart junk**
 - The beauty paradox
 - 3D graphs
 - Tufte's theory and alternative views
- **Drawing attention to data**
 - Colour, weight, position, shape, animation
 - Pre-attentive processing
 - Use with Gestalt Theory

CHART JUNK

‘Junk’

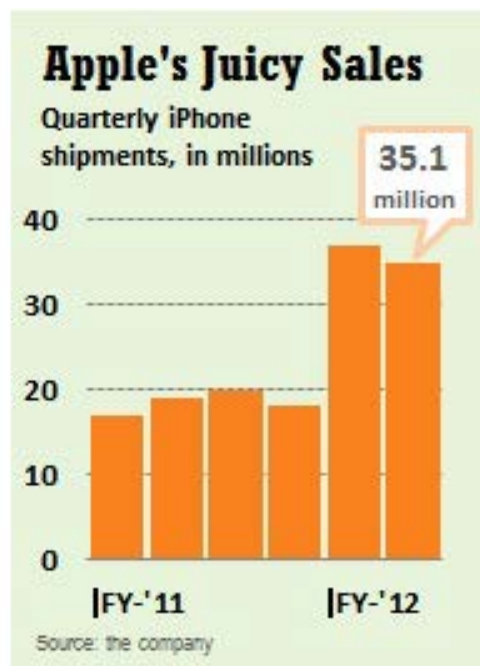
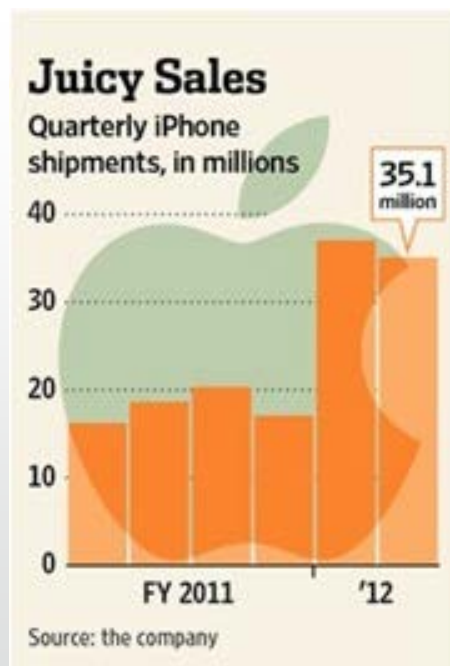
- If something can be removed from a chart without changing its meaning, it’s ‘chartjunk’.
- Why would one want to combat chartjunk?
 - Obscures true meaning and story.
 - Imagery is not information.
 - Imagery draws attention away from the data
- **Short-term memory resources are used to identify the images rather than understand the chart.**

Example



Superfluous information

- Every extra bit of pointless information
 - adds **visual clutter**; and
 - reduces the chart's ability to communicate a message.



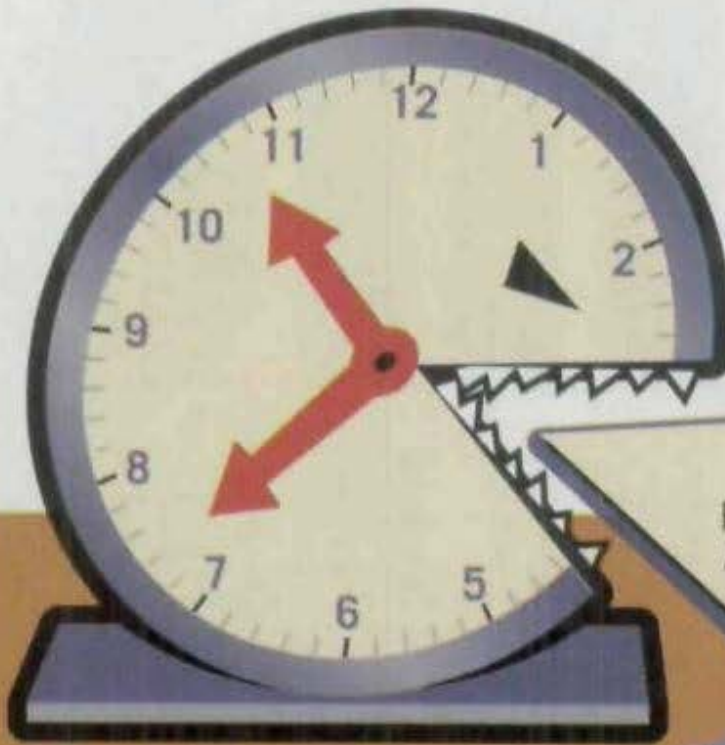
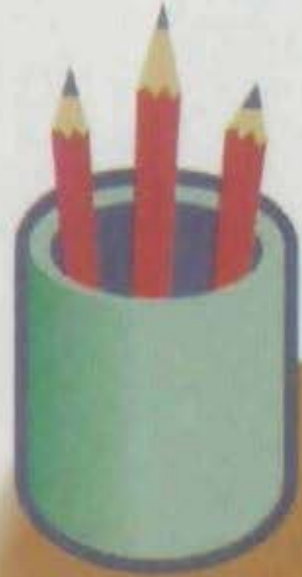
Chartjunk

- Term coined by Edward Tufte in the 1980s
- *“Lurking behind chartjunk is contempt both for information and for the audience. Chartjunk promoters imagine that numbers and details are boring, dull, and tedious, requiring ornament to enliven. (...) **If the numbers are boring, then you’ve got the wrong numbers (...)**”**

** From Cairo, The Functional Art, p. 62*

GIVING UP...

WHAT ENTREPRENEURS
SACRIFICED TO START
THEIR OWN BUSINESSES



70%
FREE TIME
AND REST

5%
NOTHING
AT ALL

50%
COMMUNITY &
VOLUNTEER WORK

67%
SPORTS
AND/OR A
HOBBY

58%
TIME WITH
FAMILY

62%
TIME WITH
FRIENDS

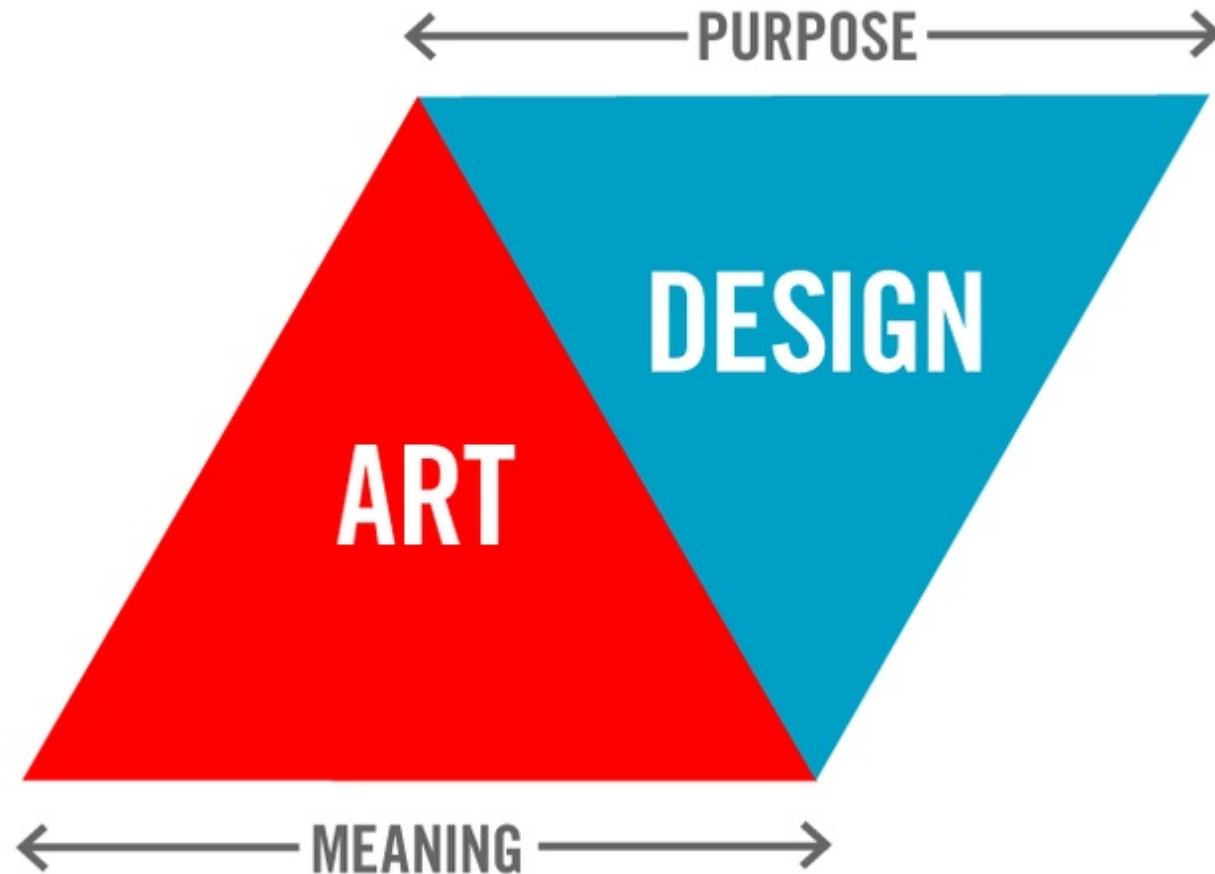
40%
FURTHER
EDUCATION & KEEPING
UP WITH CURRENT EVENTS

DATA: KEY CORP./WIRTHLIN
WORLDWIDE

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bility
jority o
they man
rules and sch
more rigid.

The beauty paradox: How much should you show?

HOW COMPLEX SHOULD A GRAPHIC BE?



**Good art
is a talent**

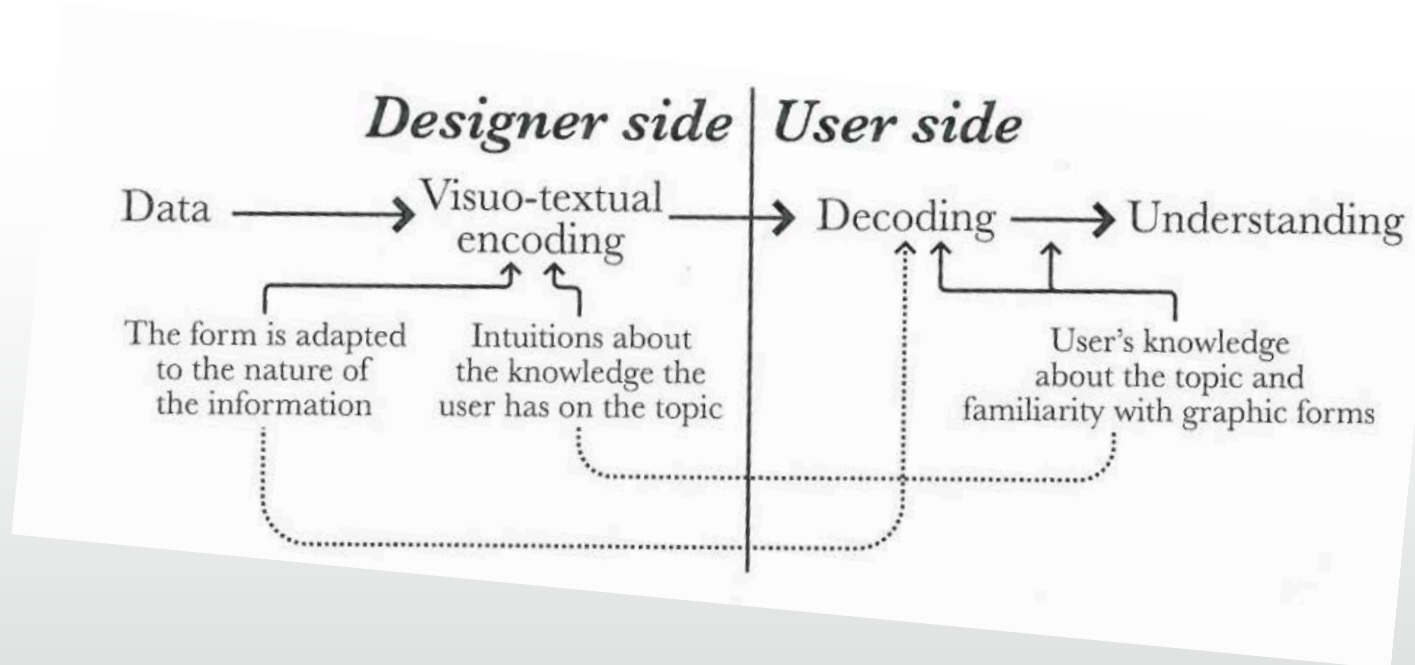
the difference between art & design

**Good design
is a skill**



Identify your audience

- A. Cairo says
 - *‘The complexity of a graphic should be adapted to the nature of your average reader.’*



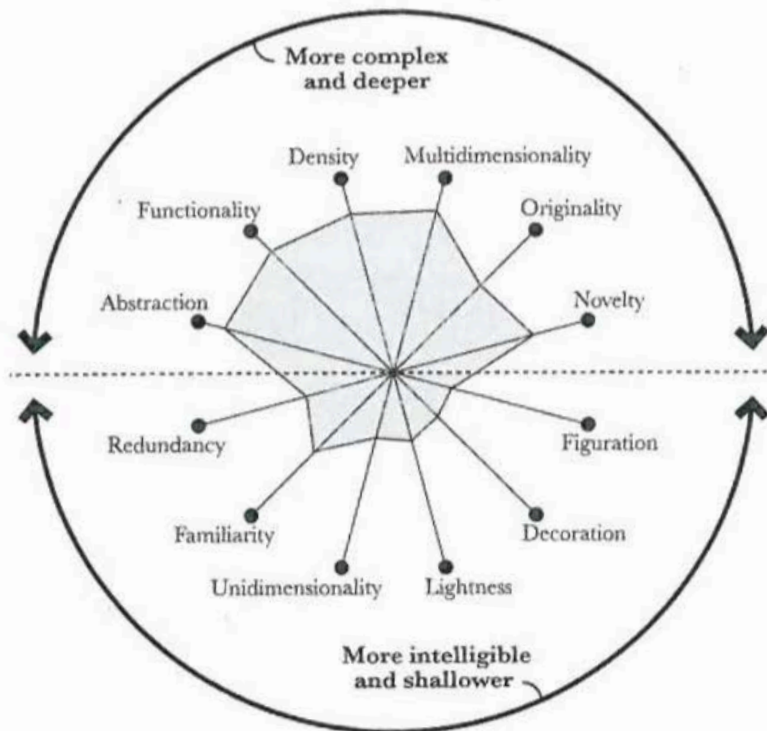
Factors that influence communication

- Effectiveness of visual forms to encode the information you need to tell the graphic's story.
 - See also Cleveland and McGill from last week.
- Previous knowledge the user has about
 - the topic; and
 - how the visual forms work.
- *Not all readers will need things dumbed down completely.*

Some audience stereotyping

the functional art

**The wheel preferred by
scientists and engineers**



**The wheel favored by artists,
graphic designers, and journalists**

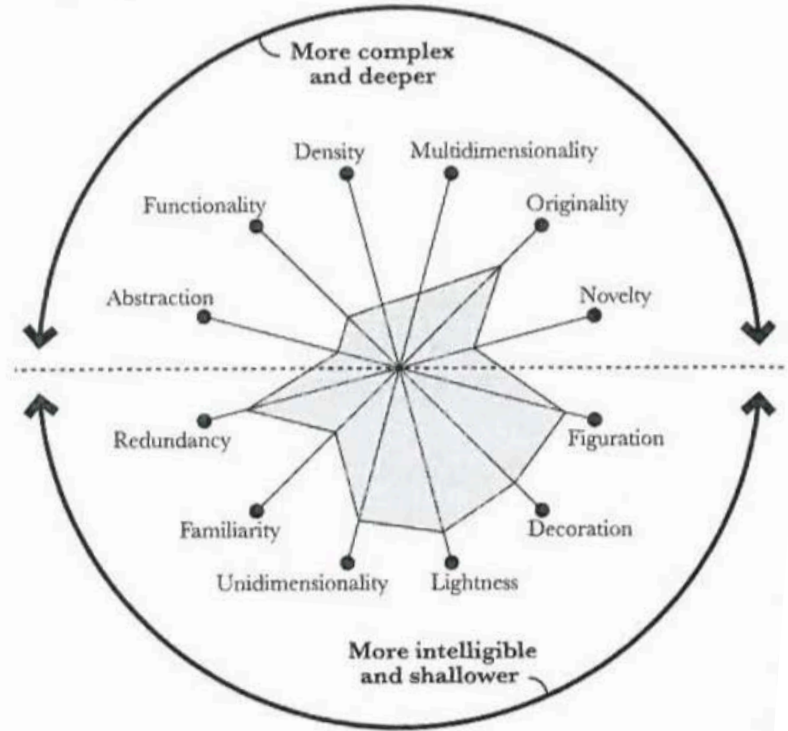


Figure 3.11 Different professional backgrounds, different ways of facing projects.

Minimalism

- For **efficiency**, Tufte prefers **minimalism**.
- Visual design is ‘good’ if it communicates a lot from little.
- “*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.*”*

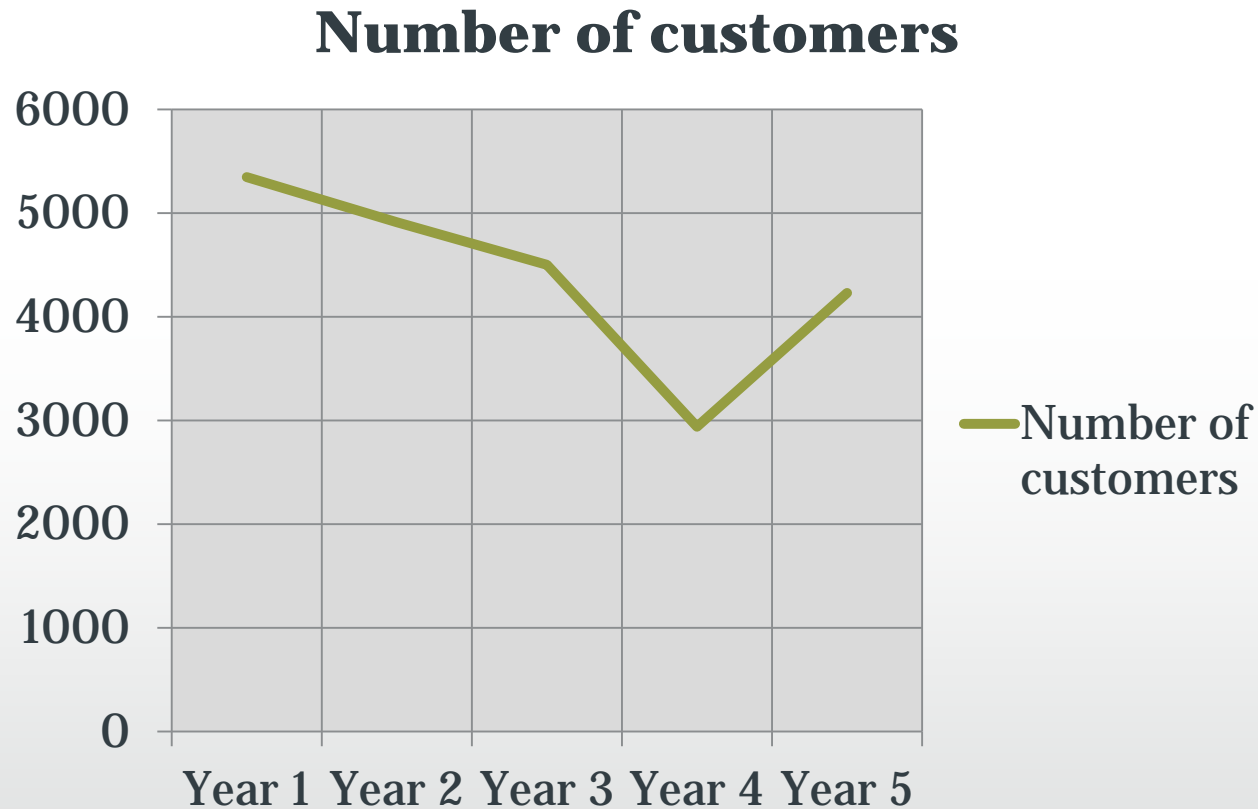
*Tufte, The Visual Display of Quantitative Information, p. 51

Data-to-pixel ratio

- Information needs room to breathe – don't clutter it!
- Every pixel should be helping to tell the story, not cloud it.
 - Based on Tufte's theory.
 - Minimise the amount of ink (**pixels**) used on things that don't add value.

Ratio	Meaning
1:1	All ink is data
0:1	No ink conveys data

Spot the wasted pixels



Number of customers



Number of customers



Number of customers

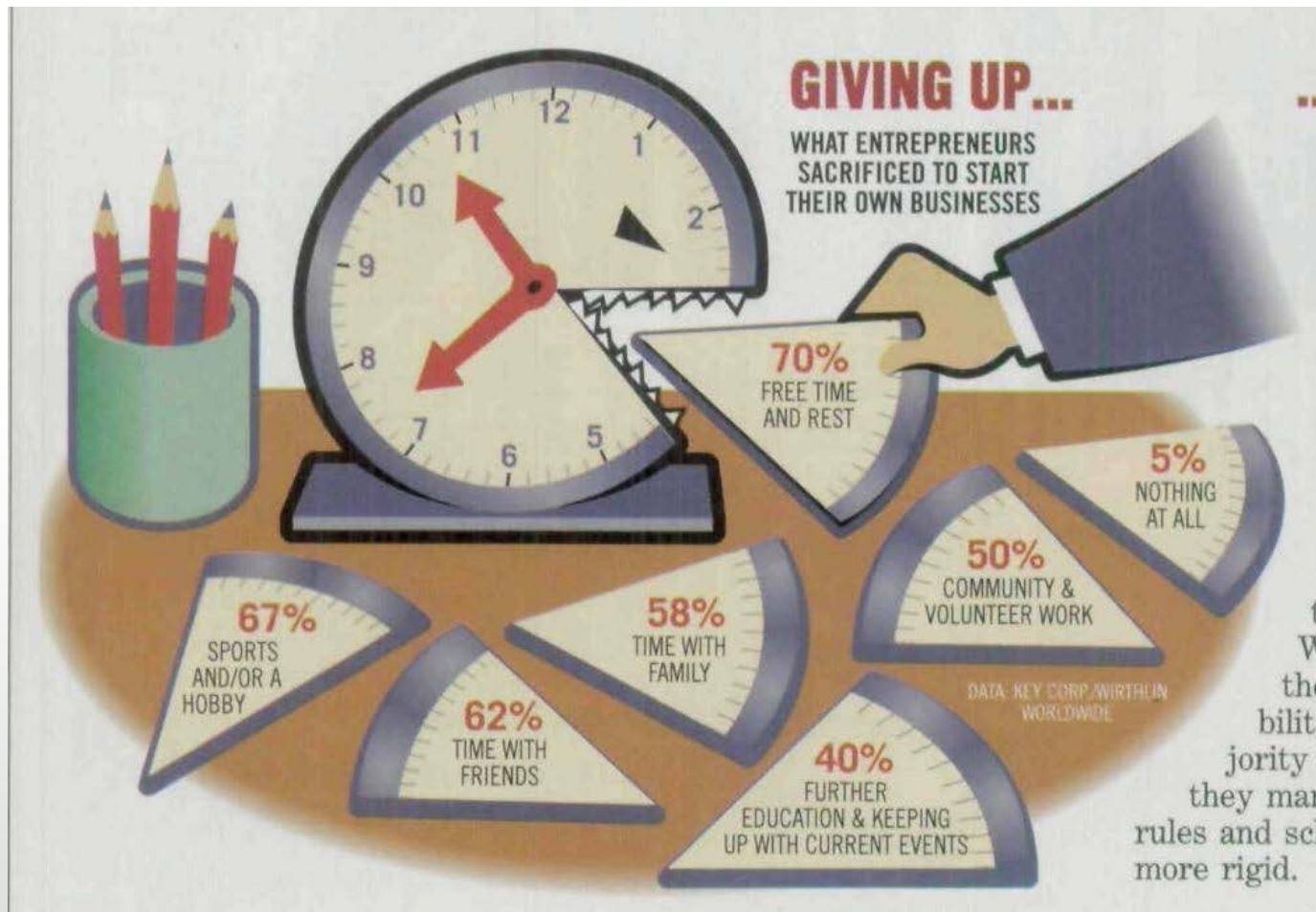


Necessary?

In MS Office,
yes. Not easy
to break the
axis.

Axes can be
manipulated
, badly!
(More on
this next
week)

Let's fix this horrible example

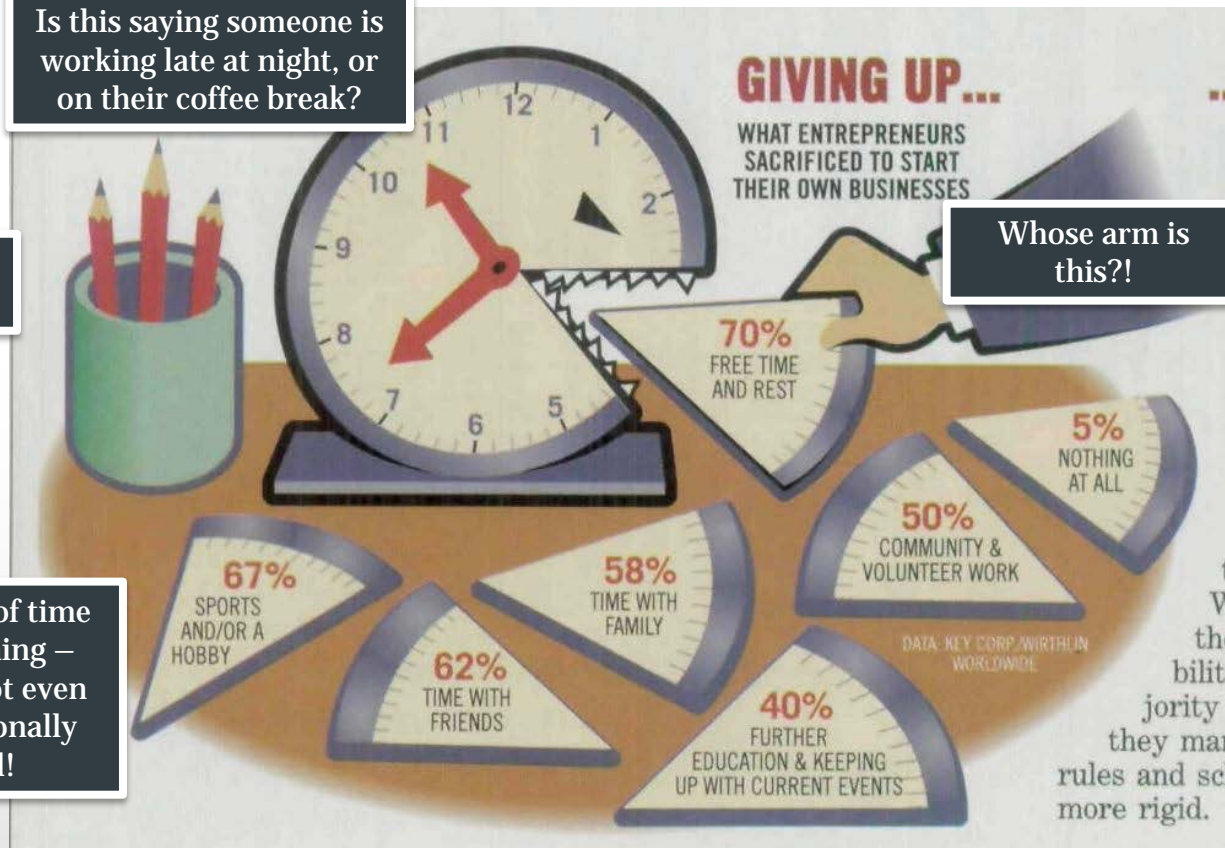


Let's fix this horrible example (2)

Is this saying someone is working late at night, or on their coffee break?

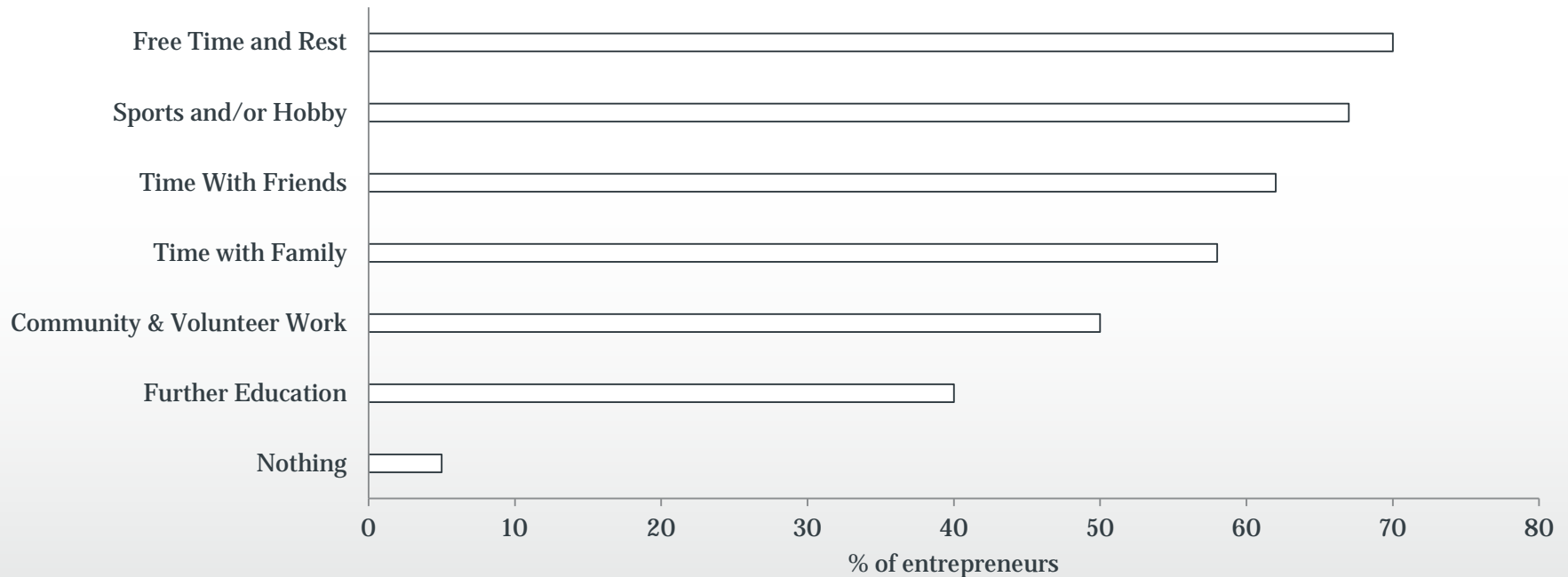
Pencils... they're not data

'Wedges' of time add nothing – they're not even proportionally sized!



After removing all the 'junk' and keeping only the 'data', we get:

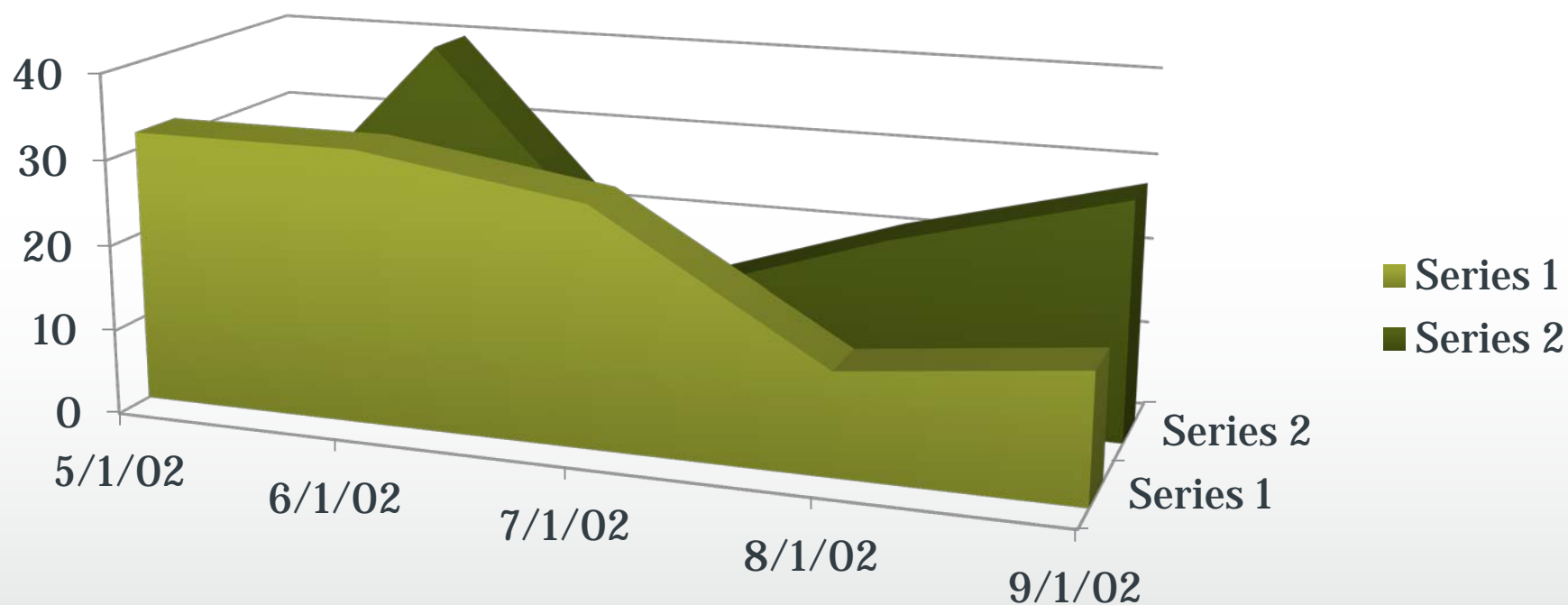
What entrepreneurs sacrificed to start their business



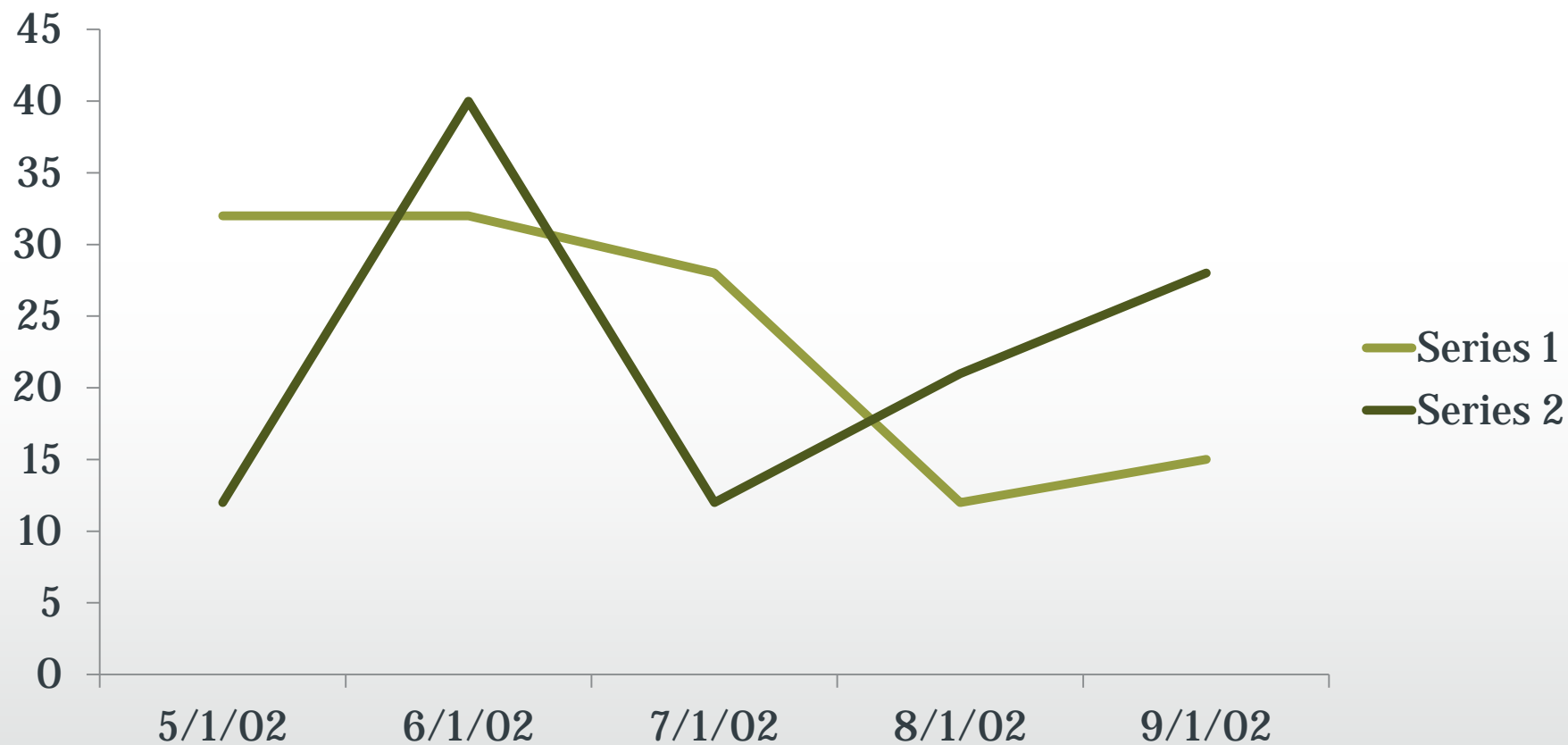
Adding pixels, not value

3D GRAPHS

So many wasted pixels!

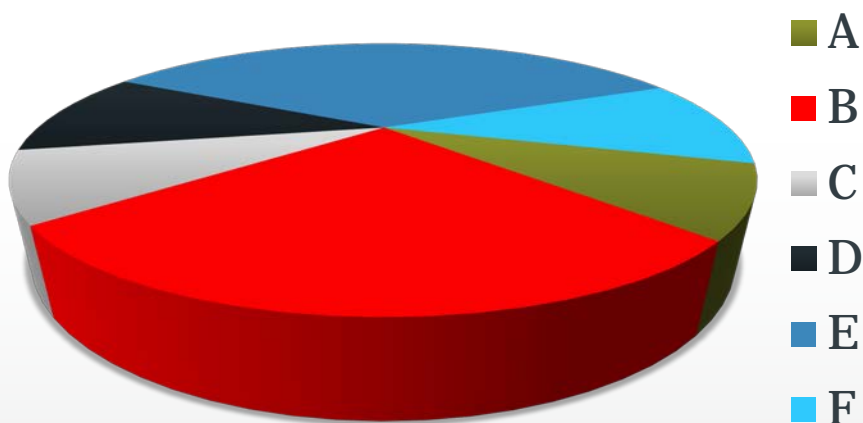


The same data with fewer pixels



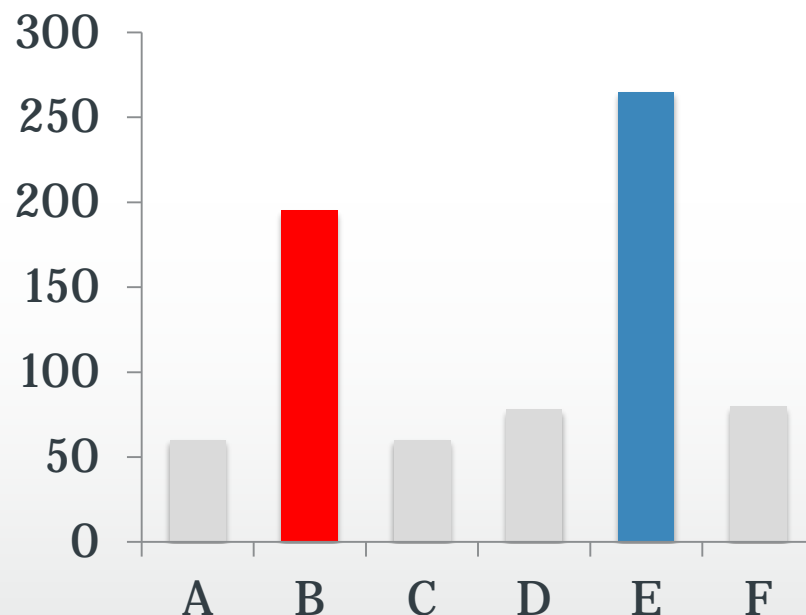
How do parties B and E compare?

Votes



Red area appears larger
because of the 3D
perspective

Votes



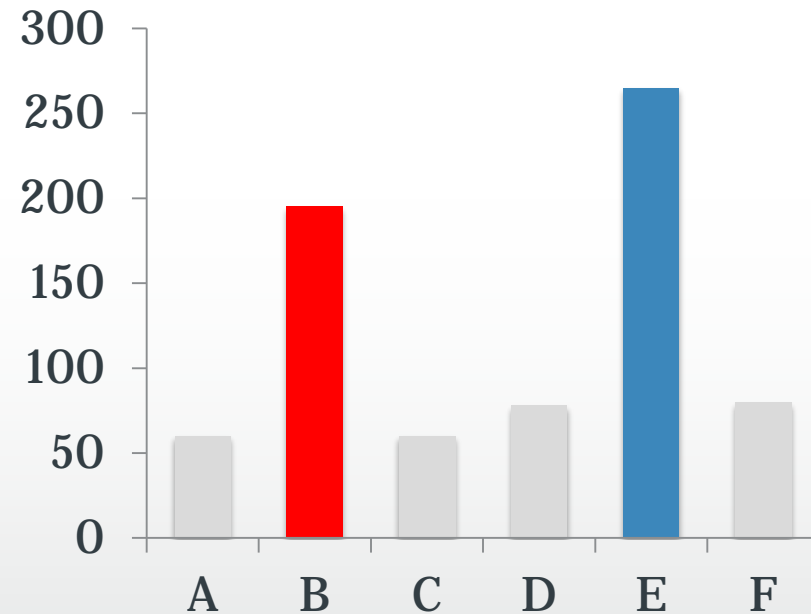
The gap is larger when
the two are compared in
2D

How do parties B and E compare?

Votes



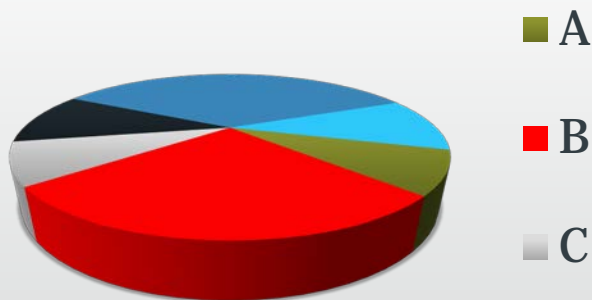
Votes



Recall the point of data visualisation

- To communicate a message clearly and effectively.
- A graph or chart should clarify what numbers in a table are saying.
- 3D does NOT help with this.

Votes



Votes



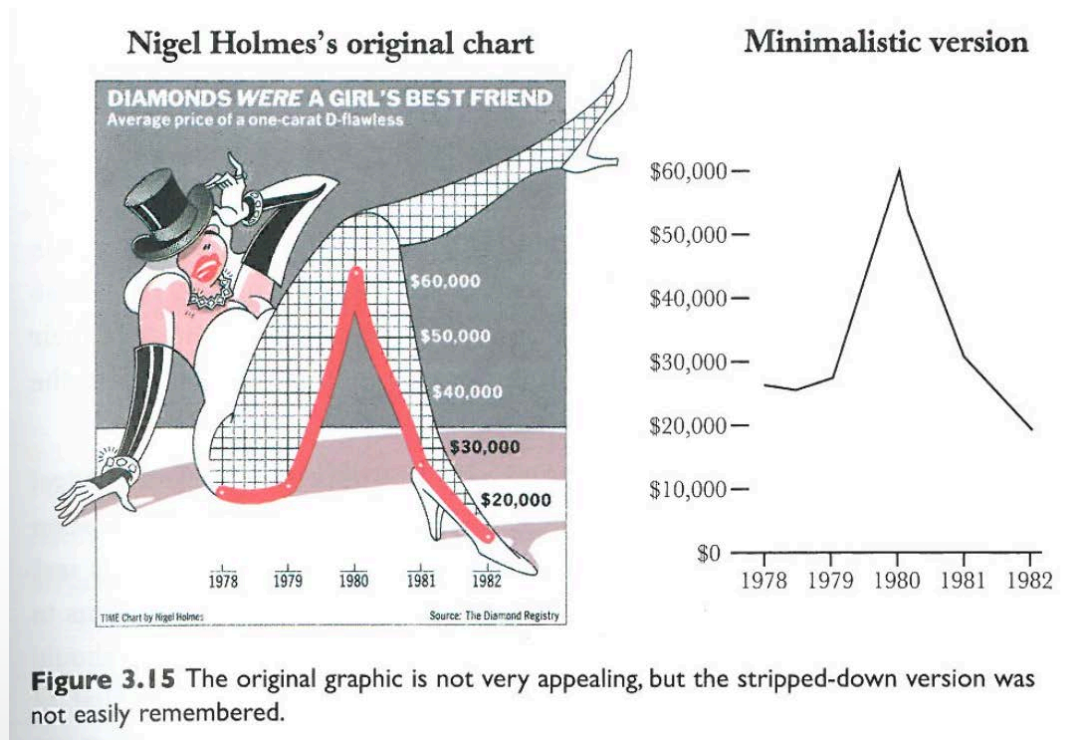
Party	Votes
A	60
B	195
C	60
D	78
E	265
F	80

CRITIQUING TUFTE

Criticisms of Tufte

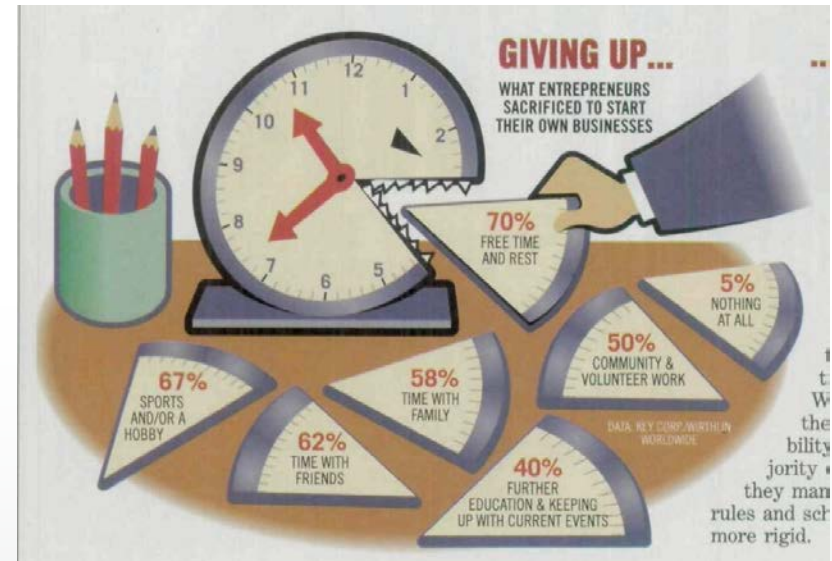
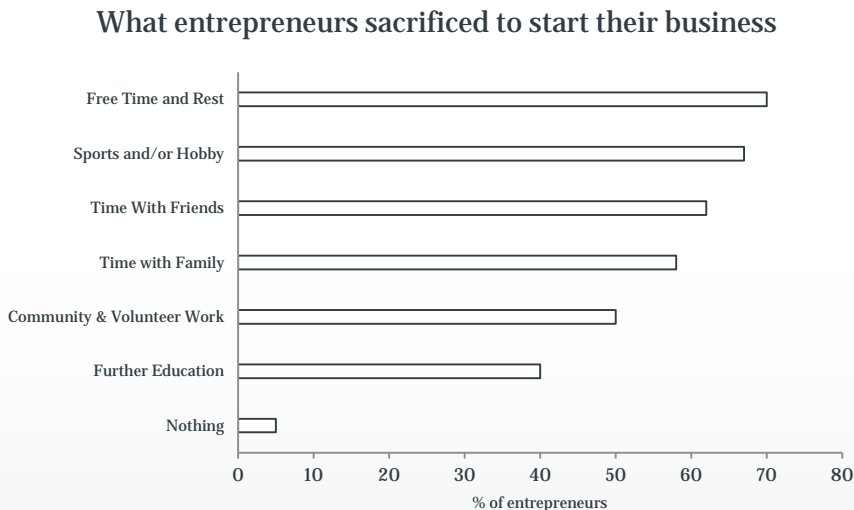
- Difficult to determine what is opinion and what is based on research.
- His works aren't really guides, but a series of thoughts about visualisation.
- Claim that higher efficiency (minimalism) **always** helps understanding is unsubstantiated.
 - Some things e.g., gridlines may help understanding, even if they don't directly tell the story.
 - Minimalism does not guarantee excellent design.

Criticisms of Tufte (2)



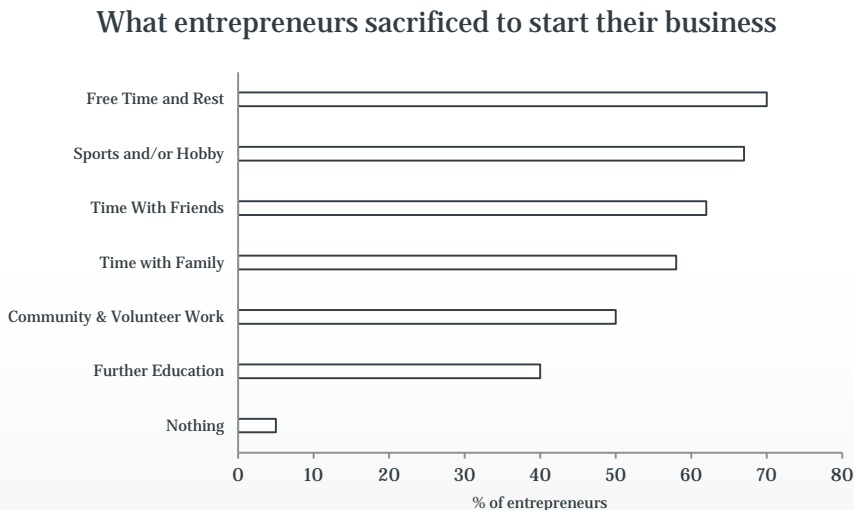
- 20 participant study (Note: this is small and means these insights are not rigorous themselves).
- No significant differences in effectiveness of the two graphics.
- Participants able to recall the 'arty' graphic better – both after 5 minutes, and 3 weeks later.

Are Tufte's graphics too 'boring'?



- Does this philosophy go too far?
- The graphic we made is simple, but will it really interest people? Will they remember it?

Are Tufte's graphics too 'boring'?



- Does this philosophy go too far?
- The graphic we made is simple, but will it really interest people? Will they remember it?
- Remember that design is about function.

Alternative thoughts

- Otto Neurath: Visuals should be serious, but combined with charm and direct appeal to everybody.
- Nigel Holmes: Humour is a powerful weapon to use, aids memory, can encourage the reader to look further.
- Both: Convey a small number of ideas with **clarity and power**.
 - *Humour, friendly-looking, easily digestible.*

A Neurath example

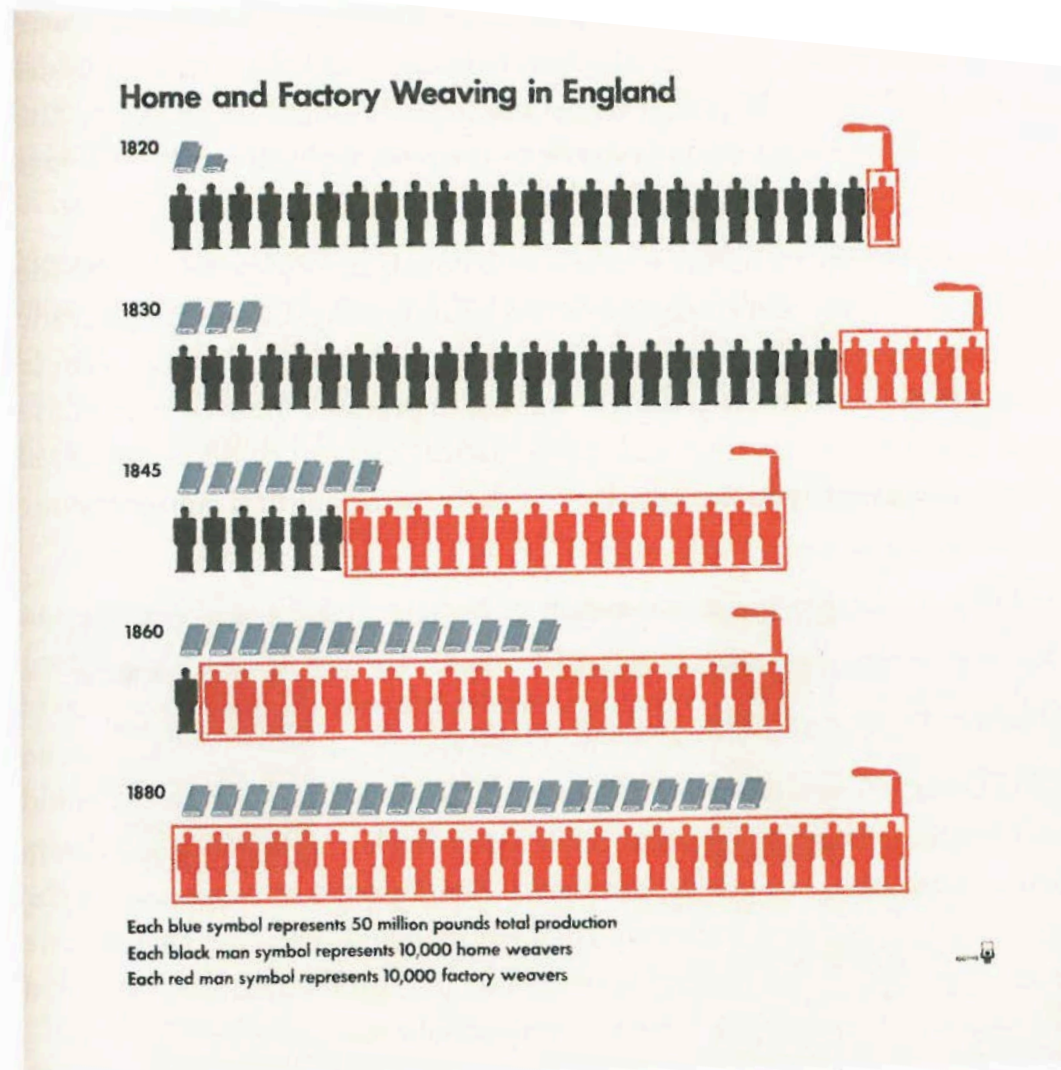


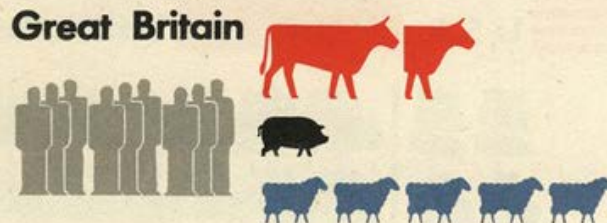
Figure 3.18 Otto & Marie Neurath Isotype Collection, University of Reading.

Another example

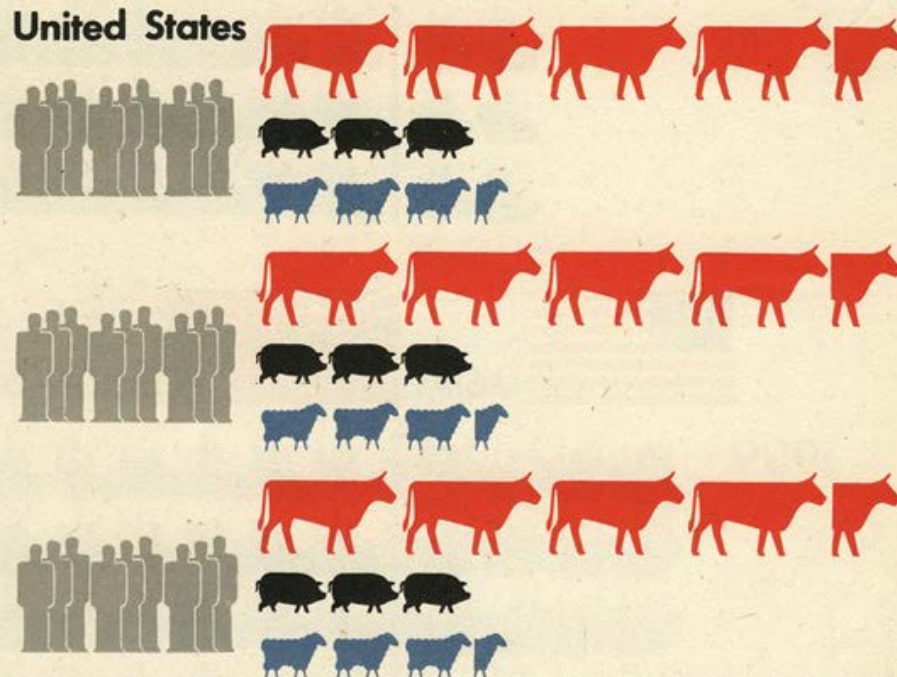
- ISOTYPE visualisation.
 - International System of
Typographic Picture Education.
- Greater quantities represented by a **greater number** of pictograms, and NOT by **larger sized** pictograms.
- Experiment with different styles:
- <http://steveharoz.com/research/isotype/> (bottom of page)
 - See which you prefer
 - Stacked shapes
 - Stretched pictures
 - Stacked pictures

Population and Live Stock

Great Britain



United States



Each grey figure represents 5 million population
Each complete red symbol represents 5 million cattle
Each complete black symbol represents 5 million pigs
Each complete blue symbol represents 5 million sheep

Average for 1935 - 1939

There are more cattle and pigs per head of population in America than Britain, but sheep—only 5 in U.S. for every 9 in Britain—are a different story, and provide the tender home-grown leg of mutton prized by the British.

Cairo's advice

- Regardless of the style (Tufte or Neurath) that you choose, ***'take advantage of the space you have available to see depth within reasonable limits. After that, and only after that, worry about how to make the presentation prettier.'***
- Graphics should not **simplify** messages.
- Instead they should **clarify** them.
- Once you've settled on your style , you then need to draw attention to the key points.

DRAWING ATTENTION TO DATA

Catching the eye

- With multiple datasets, it is likely that certain data points will need to be highlighted.
 - These are the **key points** that make up the story.
- This can be done without causing a large increase in pixels.
- **Colour, weight, position, shape and animation**
 - These make use of ‘pre-attentive processing’.

Attentive vs. pre-attentive processing

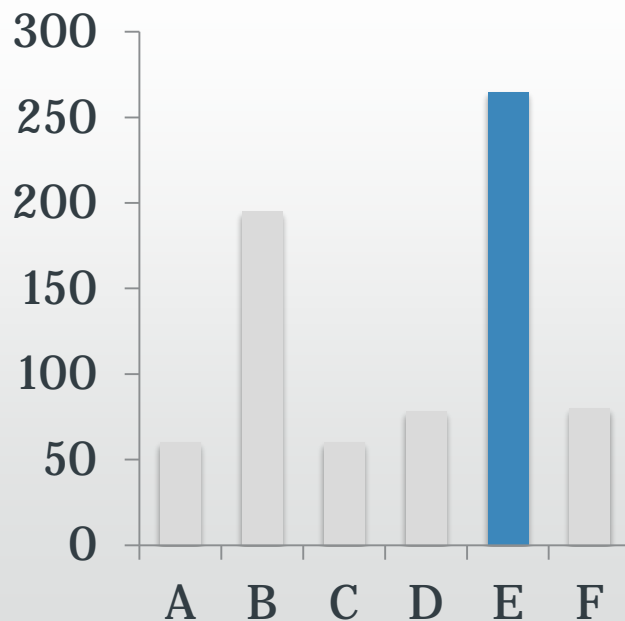
Attentive	Pre-attentive
Slow	Fast
Conscious	Below conscious level
Sequential	Tuned to detect specific attributes

Pre-attentive attributes are those which allow us to quickly distinguish specific graphical elements

- Colour (hue or intensity)
- Width
- Orientation
- Shape
- Size
- Enclosure
- Position

Colour (1)

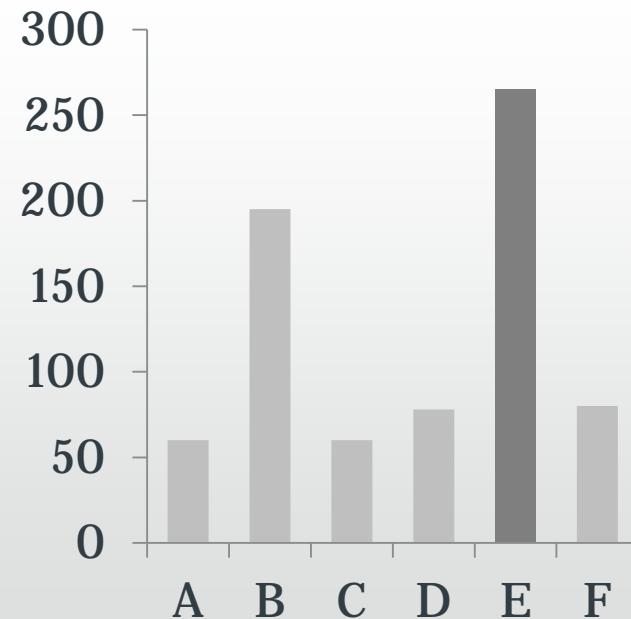
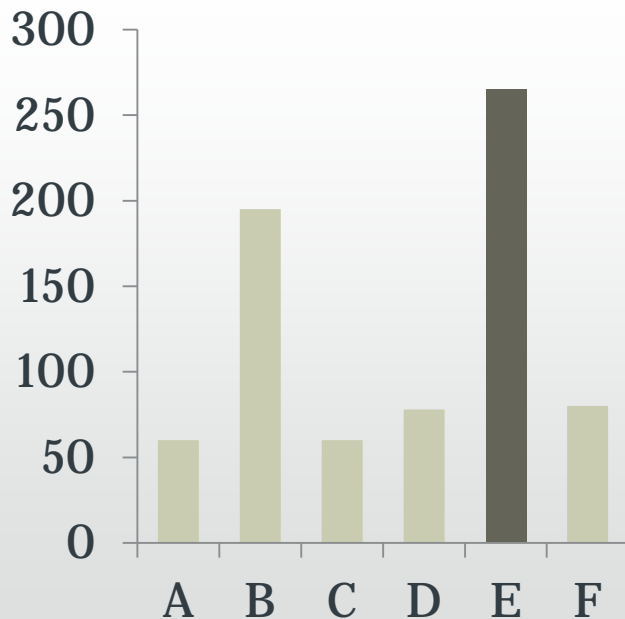
- Use a single colour to highlight key information against a black/white/grey chart.
- All other data remains as context, but fades into background so the message isn't obscured.



3 3 0 3 0 1 8 7 6 8 2 1 4 0 3 8 3 7 7 2 0 5 2 3 2 7 0 2 0
7 1 4 6 0 2 1 3 2 7 6 0 2 5 6 3 2 5 7 6 3 3 0 2 0 3 0 7 2
8 7 5 7 2 8 3 8 7 7 8 2 0 7 7 5 2 3 1 1 5 6 3 8 4 7 8 2 0
0 5 0 5 1 6 1 7 5 6 8 0 4 4 6 7 4 7 1 4 0 0 8 4 4 3 0 3 2
2 4 3 1 3 5 4 9 5 0 7 6 0 7 4 3 1 8 2 7 3 4 6 0 2 4 8 2 3
8 6 2 2 6 5 4 6 7 0 7 6 0 0 3 9 0 2 4 7 1 7 2 3 3 5 8 7 0
0 8 4 5 1 3 1 7 6 4 5 4 1 2 4 5 3 3 5 4 9 6 7 7 6 3 4 2 5
4 7 7 0 2 2 0 1 1 7 7 7 0 2 6 6 4 7 5 8 6 1 4 3 7 8 5 4 6
4 3 6 6 4 6 6 2 8 4 8 5 3 7 8 8 1 3 8 5 4 5 7 4 0 3 2 8 4
5 5 0 3 5 3 5 3 8 3 2 3 8 2 3 1 6 2 7 2 4 6 3 6 4 4 3 2 5
4 4 0 2 1 7 2 4 4 7 4 1 9 2 4 5 2 5 0 4 0 0 5 3 6 3 3 6 7
7 4 6 6 8 7 5 7 9 2 0 2 8 8 8 8 3 2 4 2 6 4 0 4 6 3 7 2 1
0 1 7 1 5 9 1 4 2 8 7 3 7 1 4 5 1 8 7 8 0 5 1 7 0 5 8 8 1
2 8 5 2 1 2 8 7 7 6 2 5 6 2 6 4 1 5 1 6 1 2 1 1 0 5 6 4 0
2 1 1 7 7 2 0 0 1 8 7 0 2 9 0 2 8 5 7 8 4 6 0 6 5 0 7 1 2
0 5 2 4 1 5 3 3 1 5 5 1 4 0 1 6 4 3 3 9 8 8 3 4 6 8 4 8 6
7 3 7 5 2 4 0 2 7 6 3 8 5 5 4 5 8 8 7 5 5 6 5 6 7 9 7 7 4
0 3 2 8 1 4 4 6 0 8 2 3 0 1 3 4 6 2 0 5 7 7 3 6 1 8 7 3 5
4 4 8 3 3 3 5 0 1 0 3 8 6 3 2 0 5 0 6 1 3 3 4 3 6 1 5 8 6
1 0 2 2 7 6 3 3 0 8 8 0 3 1 8 8 1 2 1 7 5 2 9 3 5 8 3 2 5

Colour (2)

- Sometimes your chart is already coloured (branding guidelines), or you can only print in black and white.
- Vary the intensity of the colour on the key information.



Colour to detect differences

- Recall the wolf example from last week
 - It is the difference in colour that catches the eye.
 - The actual difference in shape is hard to spot (3rd image).



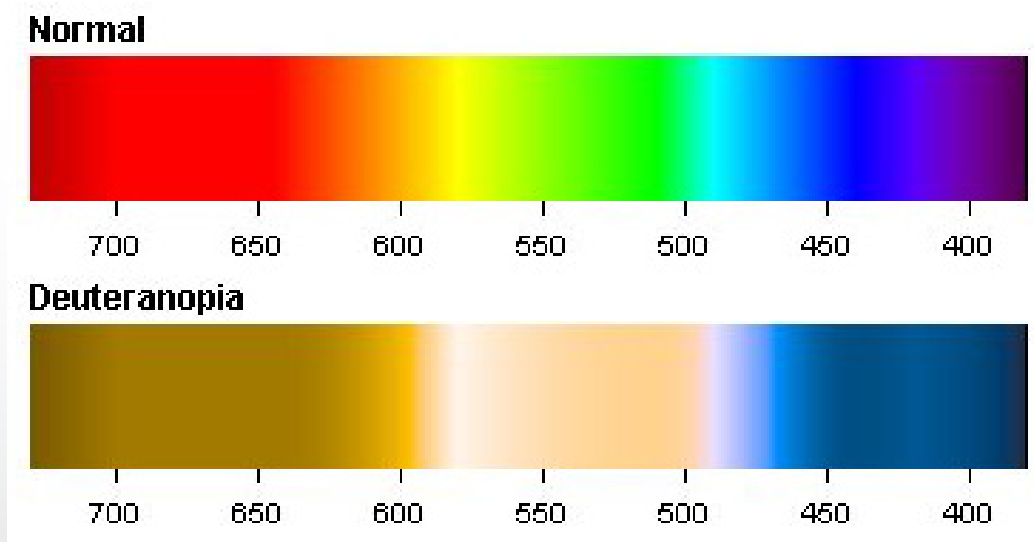
Colour + Gestalt Theory's principle on 'similarity'

- From last week: **Identical or similar objects belong to a group.**
- Eye is drawn to the red bars (use of colour to highlight).
- Gestalt Theory states that we can easily identify that these all belong to the same group (e.g., grades on the first of 3 tests for each student below).

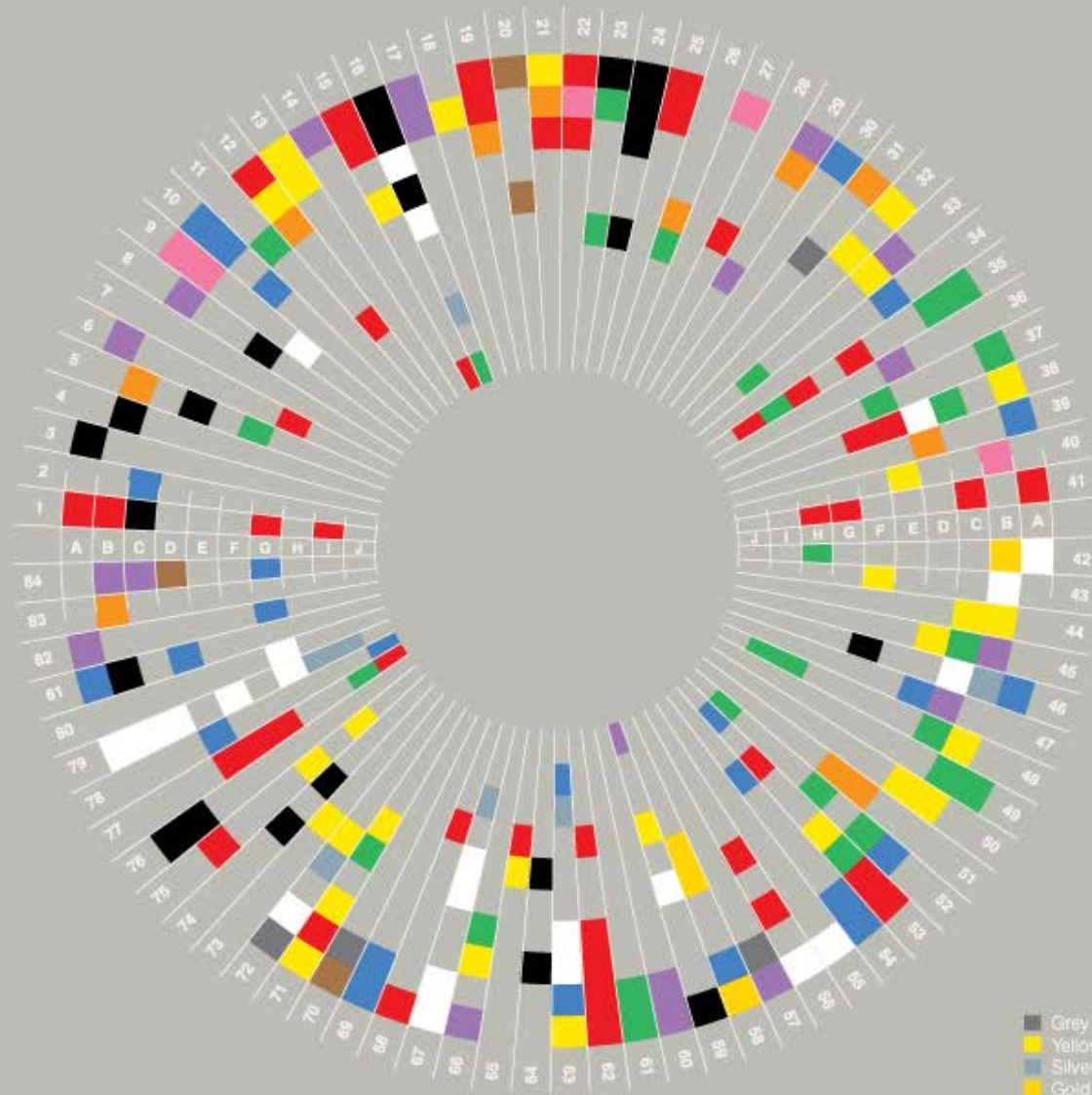


Issues with colour – remember last week

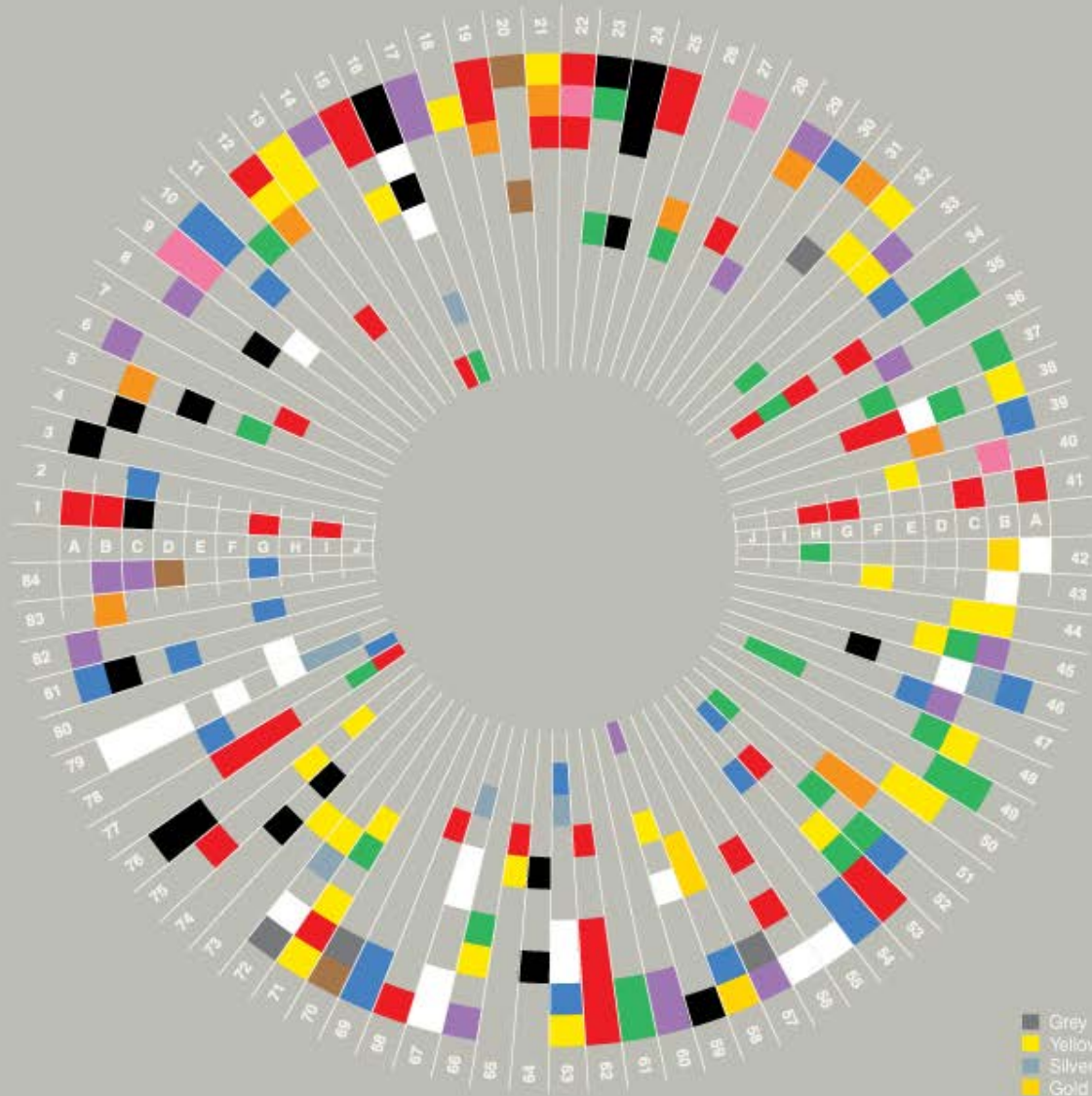
- Colour-blindness can make distinguishing certain colours difficult for some people.



Colours In Cultures



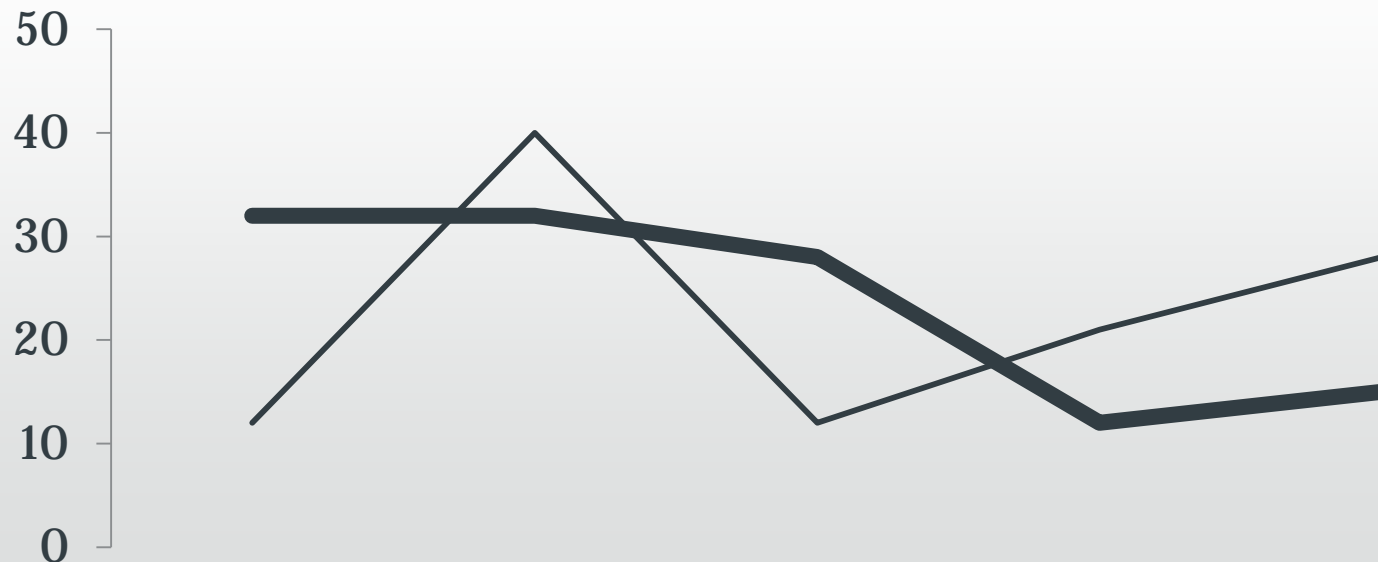
Colours In Cultures



Bonus round:
What isn't very good about this visualisation?

Weight

- “Pixel width”
- Do not use with bar charts.
 - Why is one bar wider than the others?

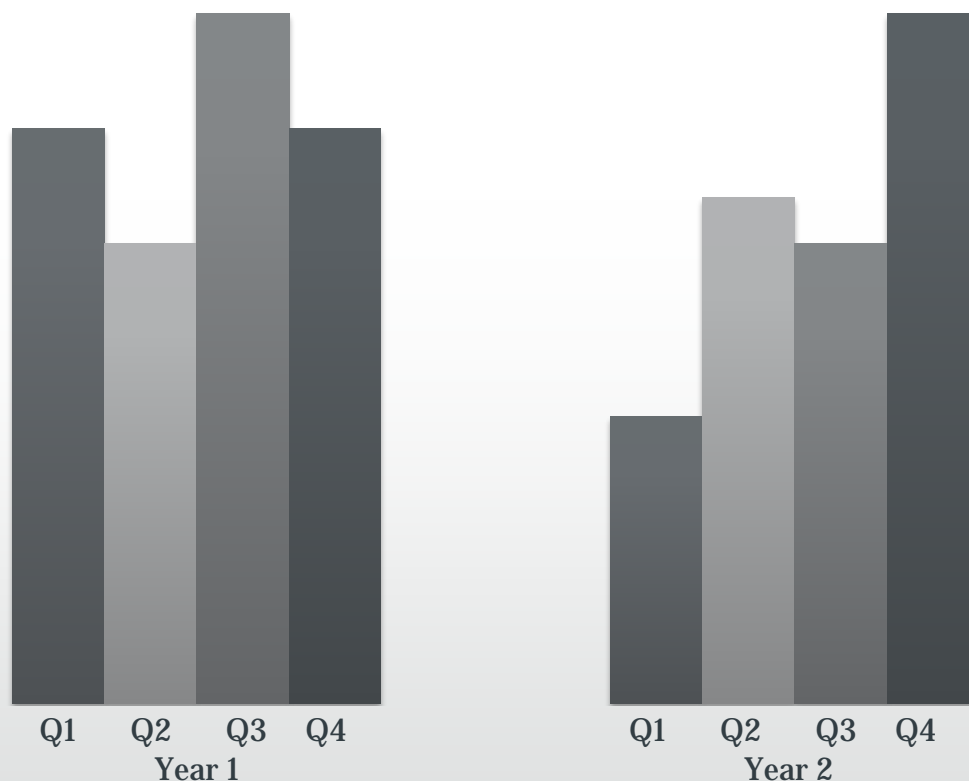


Position

- Recall the Gestalt Theory's pattern recognition from last week
 - The brain follows a number of principles for perceptual organisation (how it groups elements into 'patterns').
 - The mind is very good at grouping things based on position.
- White space can enhance these groupings.

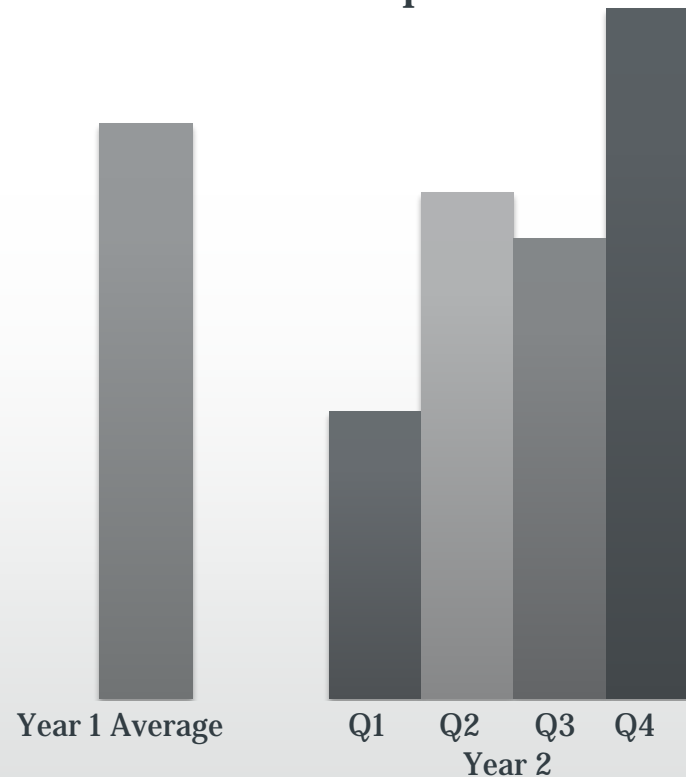
Gestalt Theory's principle on 'proximity'

Proximity – objects that are close are perceived to be natural groups.
Even without the labels, we could easily infer that this chart has two different groups.



Gestalt Theory's principle on 'proximity' + position to draw attention

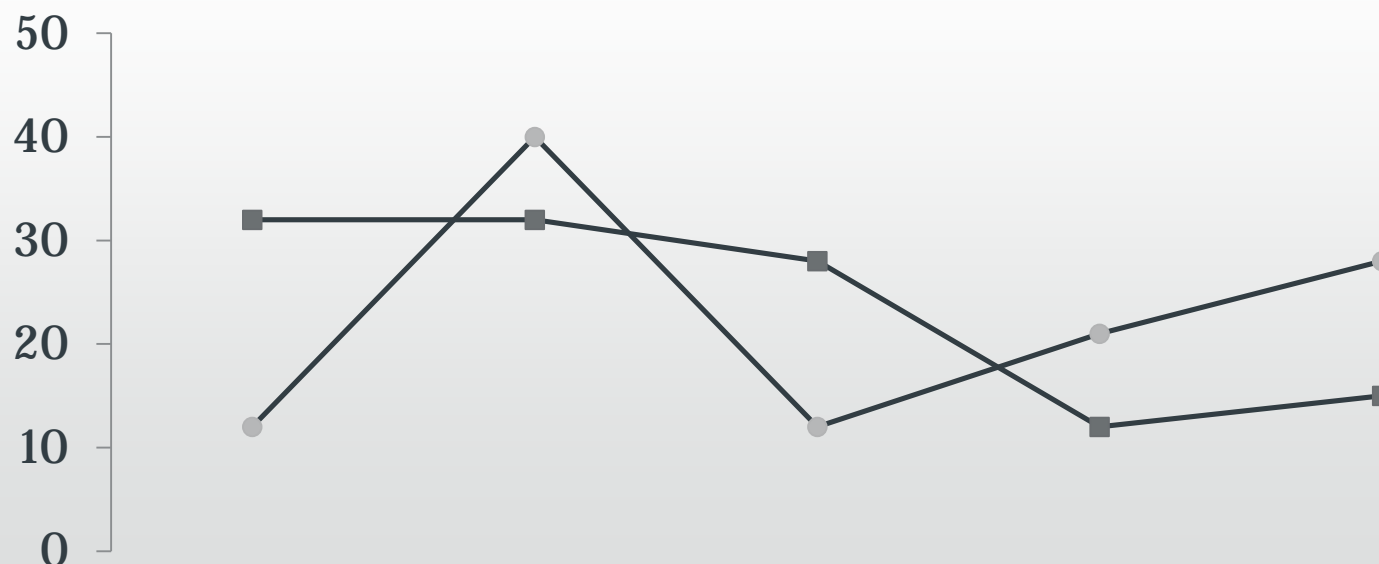
Proximity – objects that are close are perceived to be natural groups



By using 'position' to move and isolate one value, we draw attention to it. 53
Now we know the 4 values for year 2 are a group, and that the year 1 value is 'important'.

Shape

- An alternative to differentiating datasets when colour isn't available
 - Particularly useful for black-and-white graphics.



Animation

- Enhancing the other techniques with dynamic changes.
- Colour
 - Pulsing to grab attention.
 - Subtle highlighting that fades away after change.
- Weight
 - User's actions change which line or bar will be widened.
- Position
 - Move things on the chart to show changes over time, or as a result in other variables changing.
- Shape
 - ... Very quickly becomes pointless junk.

Animation

- Saccadic movement of eyes (remember last week's lecture) builds up an image of everything in your peripheral vision.
- Movement will attract more attention and draw the eye's focus. E.g.,
 - Changing position
 - Pulsing/changing colour
 - Widening lines

Pre-attentive processing in action

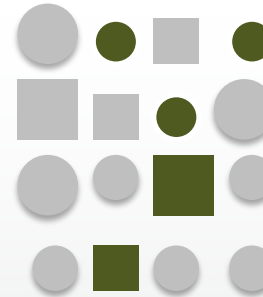
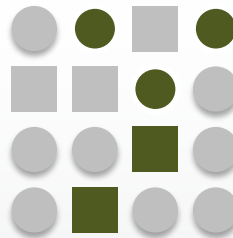
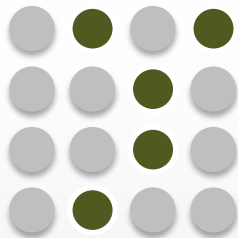
- <https://www.youtube.com/watch?v=UFNzATczkDU>

Limits to pre-attentive processing

- We can only perceive a limited number of attributes at a time.
- About 8 different hues (colours).
- 4 different orientations.
- 4 different sizes.
- All these visual attributes should be limited in use, to emphasise what they are meant to be highlighting.
- Too many, and people switch from distinguishing them pre-attentively, to having to use slower, attentive processing.

Limits to pre-attentive processing (2)

- Generally, the mind can only handle pre-attentive processing for **one attribute at a time**.



More visual attributes, harder
for the brain to process

Takeaway message

- Following these principles to draw attention to particular data will increase the efficiency of a visualisation.
- Combined with Gestalt Theory, this offers a range of techniques for improving the functionality of your visuals.
 - Organisation and layout of all components (using Gestalt Theory).
 - Colour/weight/shape/position to further emphasis key data points.
- You aren't ***simplifying*** the message, you're ***clarifying*** it using visual cues.

Takeaway message (2)

- Conversely, ‘junk’ draws attention away from the key data points, obscuring the story.

- Remember Tufte:

“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.”

- Following the simple techniques outlined in this lecture, in combination with Gestalt theory, allows us to maximise the efficiency of graphics by taking advantage of how the brain works.

Going further (2)

- **Gestalt Theory** guides us on how to organise/layout components.
- **Pre-attentive processing attributes** suggest how to draw attention to specific data points.
- **Cleveland and McGill** give us a hierarchy of graphic properties to use based on humans' ability to detect differences and compare data points
 - Suggest graphic forms to use depending on the importance of comparison in the graphic.

Other considerations

- What format is your visualisation going to be viewed in?
 - Computer monitor? Typically around 72-96 pixels per inch (until Retina displays came along...).
 - Newspapers: 150-220 dots per inch, Books: 300+
- Screenshots from Excel may not look very good when printed out
 - Vector format images will help.

Other considerations (2)

- Colour
 - Costs more when printing – raises design costs
 - On a screen, changing colour is free.
 - Colour can draw attention
 - But evokes feelings and emotions (used a lot in branding).
 - These can differ across cultures.

Further reading

- Key texts for this lecture:
 - Suda, Brian. *A Practical Guide to Designing with Data*. Mark Boulton Design Limited, 2010.
 - Chapter 2
 - Cairo, Alberto. *The Functional Art: An introduction to information graphics and visualization*. New Riders, 2012.
 - Chapter 3
- Bateman, S., Mandryk, R.L., Gutwin, C., Genest, A., McDine, D. and Brooks, C., 2010, April. Useful junk?: the effects of visual embellishment on comprehension and memorability of charts. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2573-2582). ACM. Vancouver
- Tufte, Edward. “The Visual Display of Quantitative Information” 2nd Edition
- Few, Stephen. “Show Me the Numbers: Designing Tables and Graphs to Enlighten”, 2012
 - Chapter 5

Next time

- Sri on
 - Bad design and deception
 - Lying with stats
- Use this knowledge for good!