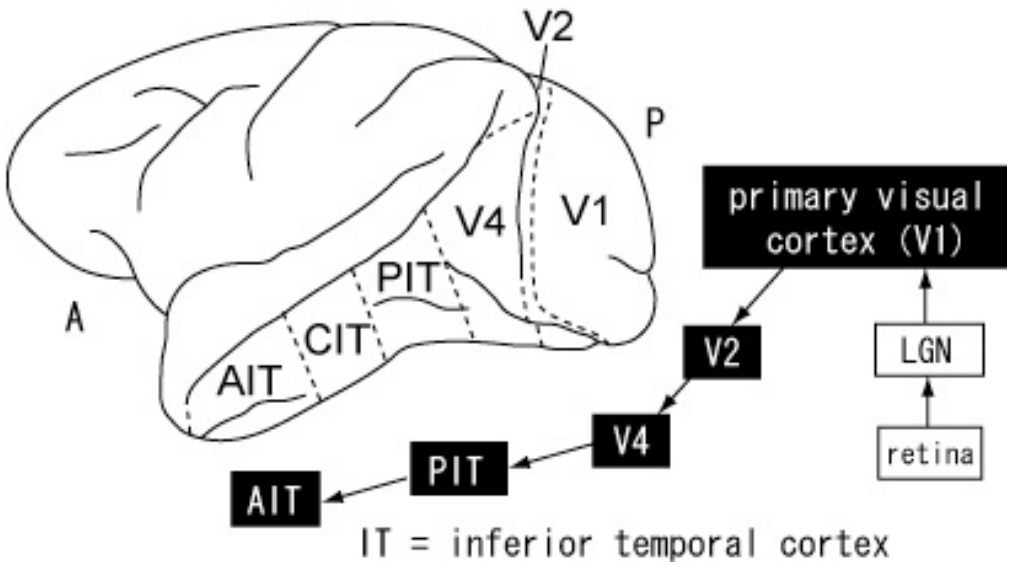
Visual Thinking

Visual objects, words and meaning

Meaning from objects

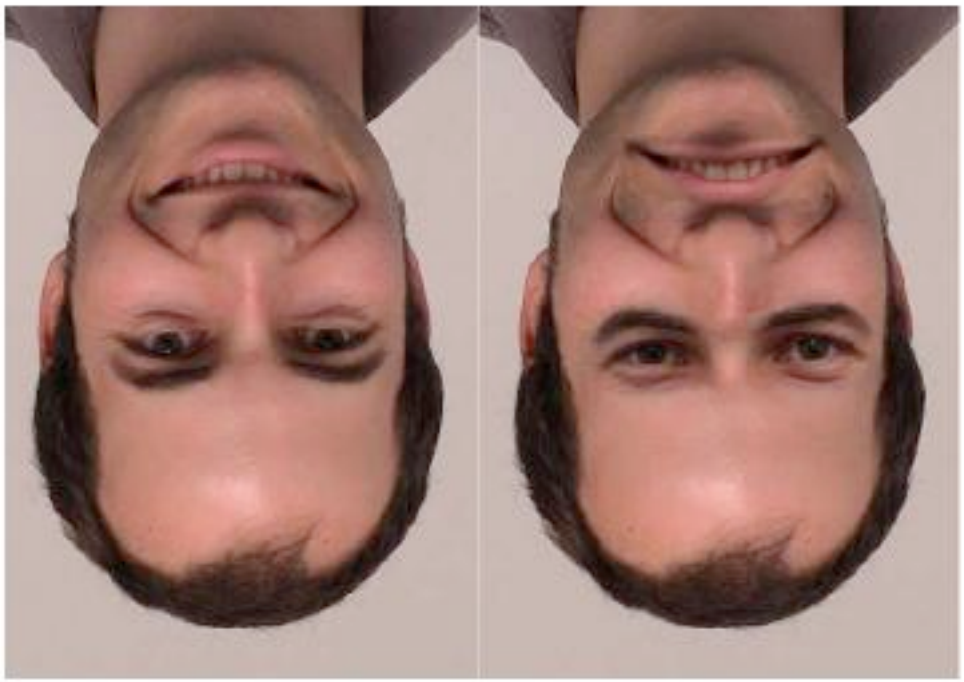
- activation of meaning from an image generally occurs in a fraction of a second
  - much less time than it takes to read a paragraph of text
  - a picture is worth a thousand words

- The *what* channel consists of a series of brain areas that respond to increasingly complex patterns
- end in the inferotemporal cortex – recognizes visual objects and scenes



Meaning from objects

- object recognition is a very difficult problem
- e.g for face recognition, the brain is much better at solving the problem from a familiar viewpoint…



The Thatcher Illusion

Meaning from objects

- recognizing an upside-down face is difficult!

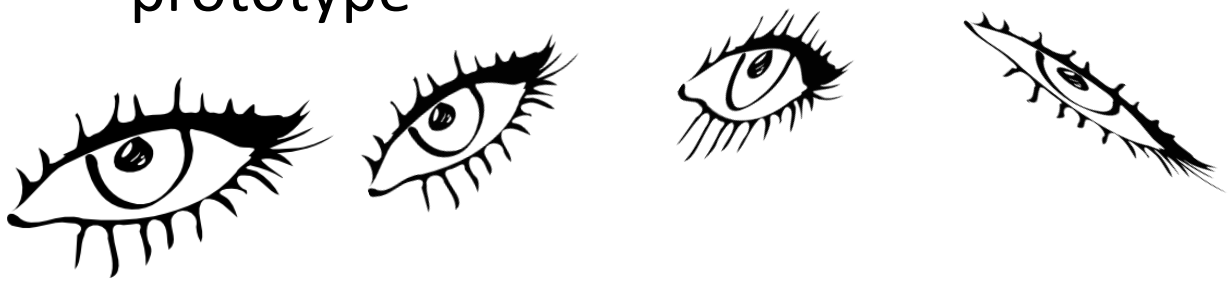
- Spatial memory for scenes is also viewpoint specific
- however, we can generally rotate an object by 20 degrees, of scale it by a factor of 3 and still identify it rapidly

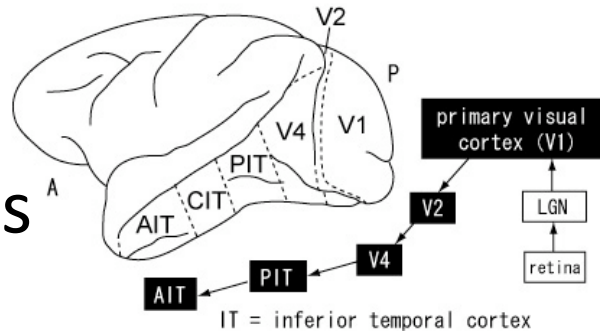
The Thatcher Illusion

Generalized views from patterns

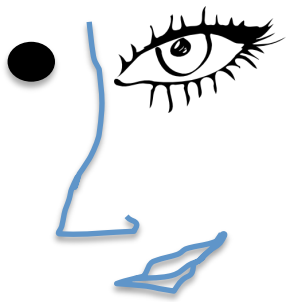
- V4 is the pattern processing region
- V4 neurons can respond to patterns

  that are rotated or distorted from a prototype





- **complex objects**, like faces, can be thought of as **patterns of patterns**

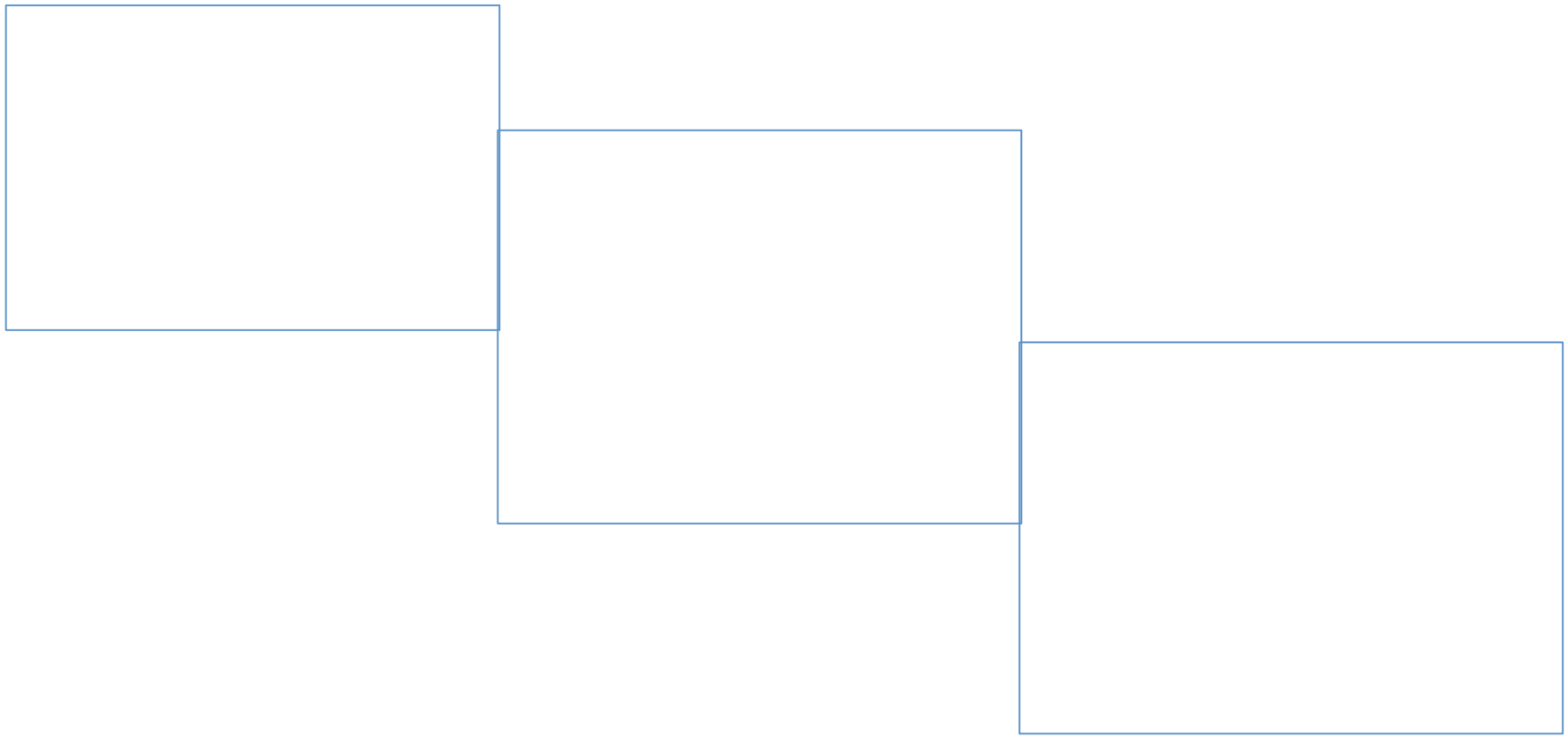


Structured objects

- most evidence suggests that most people do not have 3D models in our mind
  - some people do develop special skills for manipulating 3D structures
  - there are VERY large individual differences in this skill
- clear evidence that we all have some limited ability to perceive the 3D structure of objects

Gist and Scene Perception

- people are able to rapidly characterize scenes:



Gist and Scene Perception

- people are able to rapidly characterize scenes:

Gist and Scene Perception

- people are able to rapidly characterize scenes:

"tropical beach"

"busy street"

"forest"

Gist and Scene Perception

- people are able to rapidly characterize scenes:

"tropical beach"

•we can get the **gist** of a novel scene in **less than a tenth** of a second, independent of its complexity

"busy street"

•this is as fast as we can identify **objects**, so it's can't be the individual objects that we are identifying

•rapid characterization of a scene is called **gist**

"forest"

Gist and Scene Perception

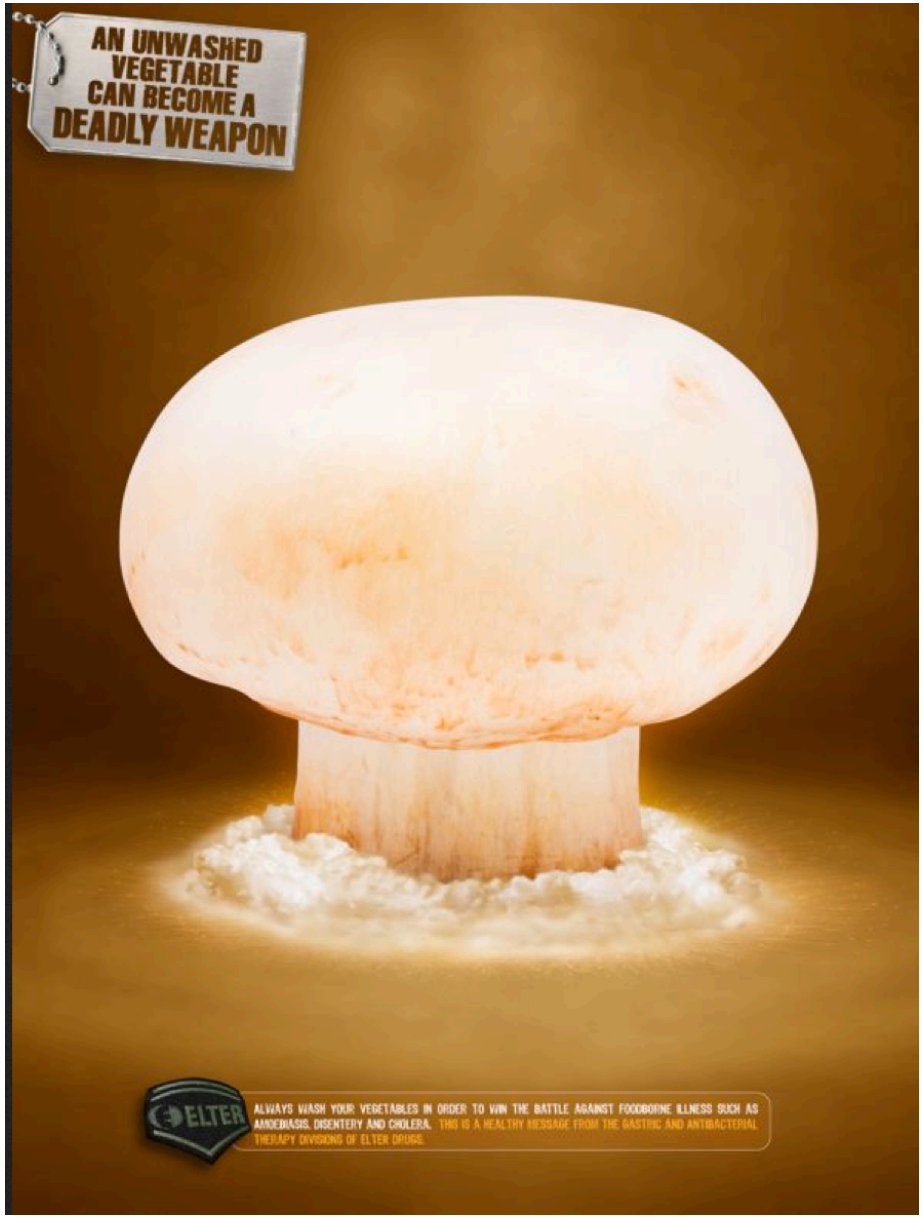
- Patterns are key in gist perception:
  - common scenes have typical spatial feature components, distributed in characteristic ways
  - e.g. large scale pattern arrangements of textures and colours
    - beach scenes usually have large blue area at top (sky), with striated white and blue-grey patches either to the right or left of the image (sea) and a large beige area (sand)

Building the gist of a scene: the role of global image features in recognition. A. Oliva and A. Torralba. Progress in Brain Research. 155:527-532, 2006

- (A) The two original images used to build the hybrid scenes shown above. (B) A hybrid image combining the high spatial frequency (HSF, 24 cycles/ image) of the beach and the low spatial frequency (LSF, 8 cycles/image) of the street scene.
- If you squint, blink, or defocus, the street scene should replace the beach
- (C) The complementary hybrid image, with the street scene in HSF and the beach scene in LSF (cf. Schyns and Oliva, 1994; Oliva and Schyns, 1997).

Implications for design: making objects easy to identify

- Objects are patterns of patterns
  - so some will be easier to identify than others
- Typical representatives of a class are easier to identify than outliers
  - typical viewpoints are easier than non-typical
- Showing joints clearly in a structured object will make it easier to identify
  - connections between components of the object should be clear



Is this graphic effective?

Your analysis should consider **the goal** of the graphic and should apply all the relevant theory that you learnt in the course about what makes graphics effective.

Implications for design: Novelty

- Humans seek visual novelty
  - novelty seeking in babies is so strong that it has become one of the basic tools to understand how babies' minds work
  - we use free cognitive cycles scanning our environment, seeking mental stimulation
    - we are not usually aware that we do this

Novelty

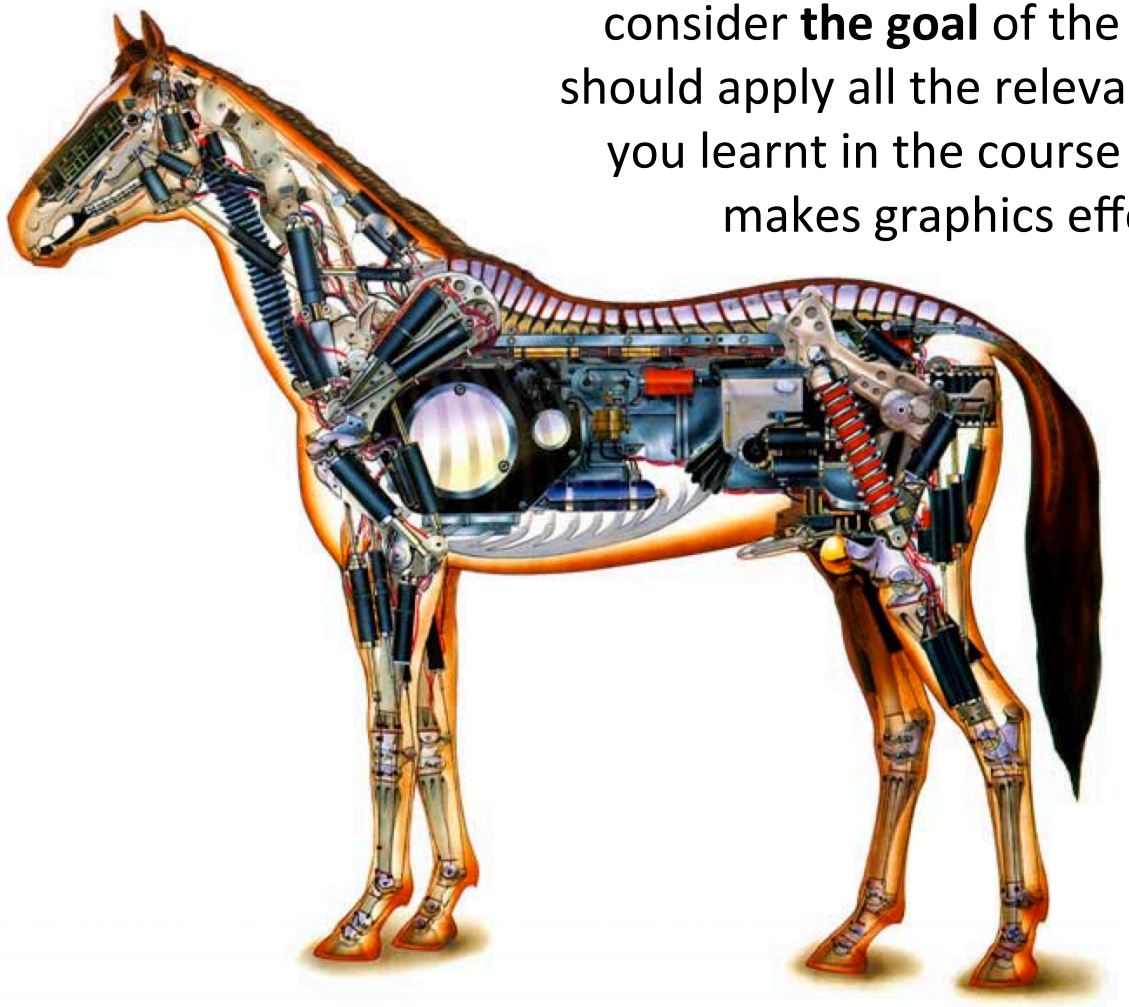
- Opportunity for advertiser
  - create gist-object conflicts to attract attention
  - very easy to do
    - trick is to add a witty twist

Novelty

- Opportunity for advertiser
  - create gist-object conflicts to attract attention
  - very easy to do
    - trick is to add a witty twist

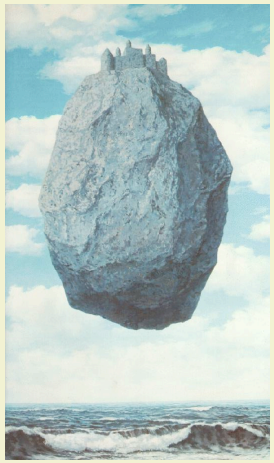
Is this graphic effective?

Your analysis of each image should consider **the goal** of the graphic and should apply all the relevant theory that you learnt in the course about what makes graphics effective.



Gist-object conflict is not new:

Rene Magritte
1898 -1967



Salvador
Dali
1904-1989

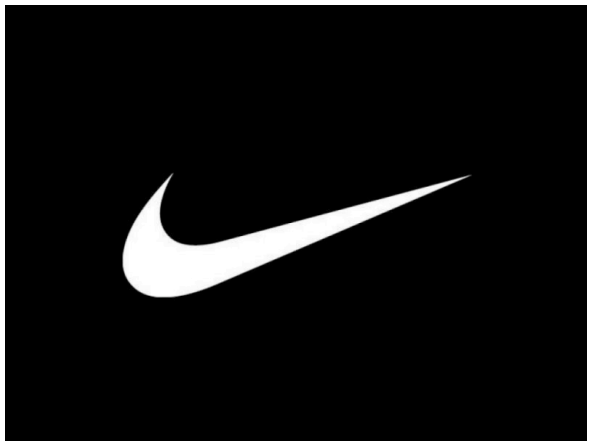
Visual puzzles

- Another way to hold interest is to create a visual puzzle, often with unfamiliar viewpoints to capture a second glance

e.g. those by photographer Tim Flach

Images as symbols

Some graphic symbols function in the same way as words – bound to a particular non-visual cluster of concepts



Meaning and emotion

- perhaps 95% of what we “see” in the outside world is already in our heads

Visual thinking

Visualizations

February 2016

Assoc. Prof. Michelle Kuttel
Department of Computer Science
University of Cape Town

"Science and art have in common *intense seeing,* the wide-eyed observing that generates empirical information."

Edward Tufte in *Beautiful Evidence*

A picture is worth a thousand words…?

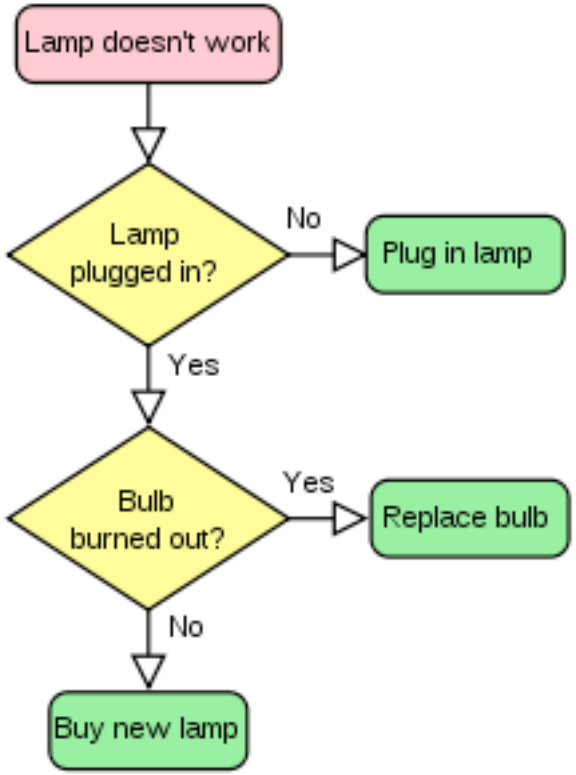
- try to express the following in pictures:

  “If apples are too expensive, buy oranges.”

A picture is worth a thousand words…?

- Good design is not about pictures versus words. Rather:
  - When are images most effective?
  - When are words and other symbols most effective?
  - How should we combine words and images?

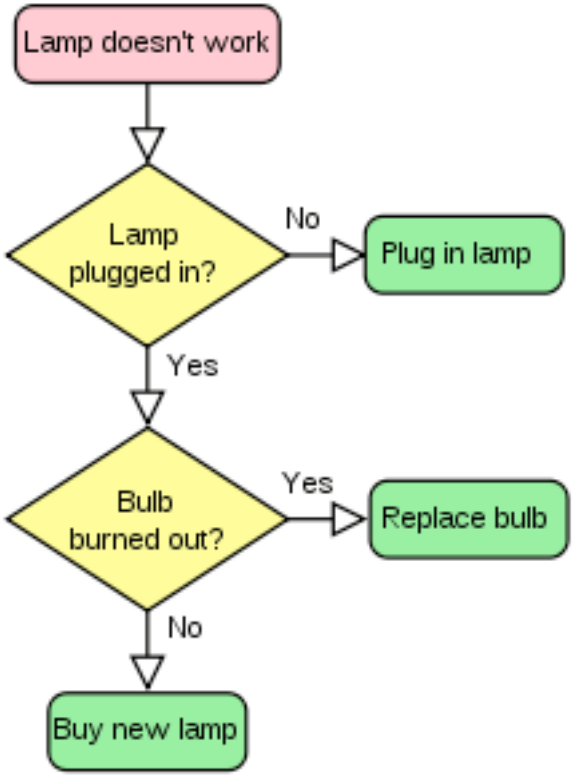
Flowcharts


Lamp doesn't work
Lamp plugged in?
No
Plug in lamp
Yes
Bulb burned out?
Yes
Replace bulb
No
Buy new lamp

Pseudocode

```
if not lamp_working:
    if not lamp_plugged_in:
        plug_in_lamp()
    else if lamp_burned_out:
        replace_bulb()
    else:
        buy_new_lamp()
```

Flowcharts versus pseudocode




```
if not lamp_working:
    if not lamp_plugged_in:
        plug_in_lamp()
    else if lamp_burned_out:
        replace_bulb()
    else:
        buy_new_lamp()
```

Which is easier to understand?

Linguistic expressions

Have

- A rich set of socially invented arbitrary symbols
- A form of logic:
  - “if” , “ands”, “buts”
- processed in language area of the brain
- culturally dependent

Linguistic expressions

Supports complex logical relationships between abstract ideas

Visual representations

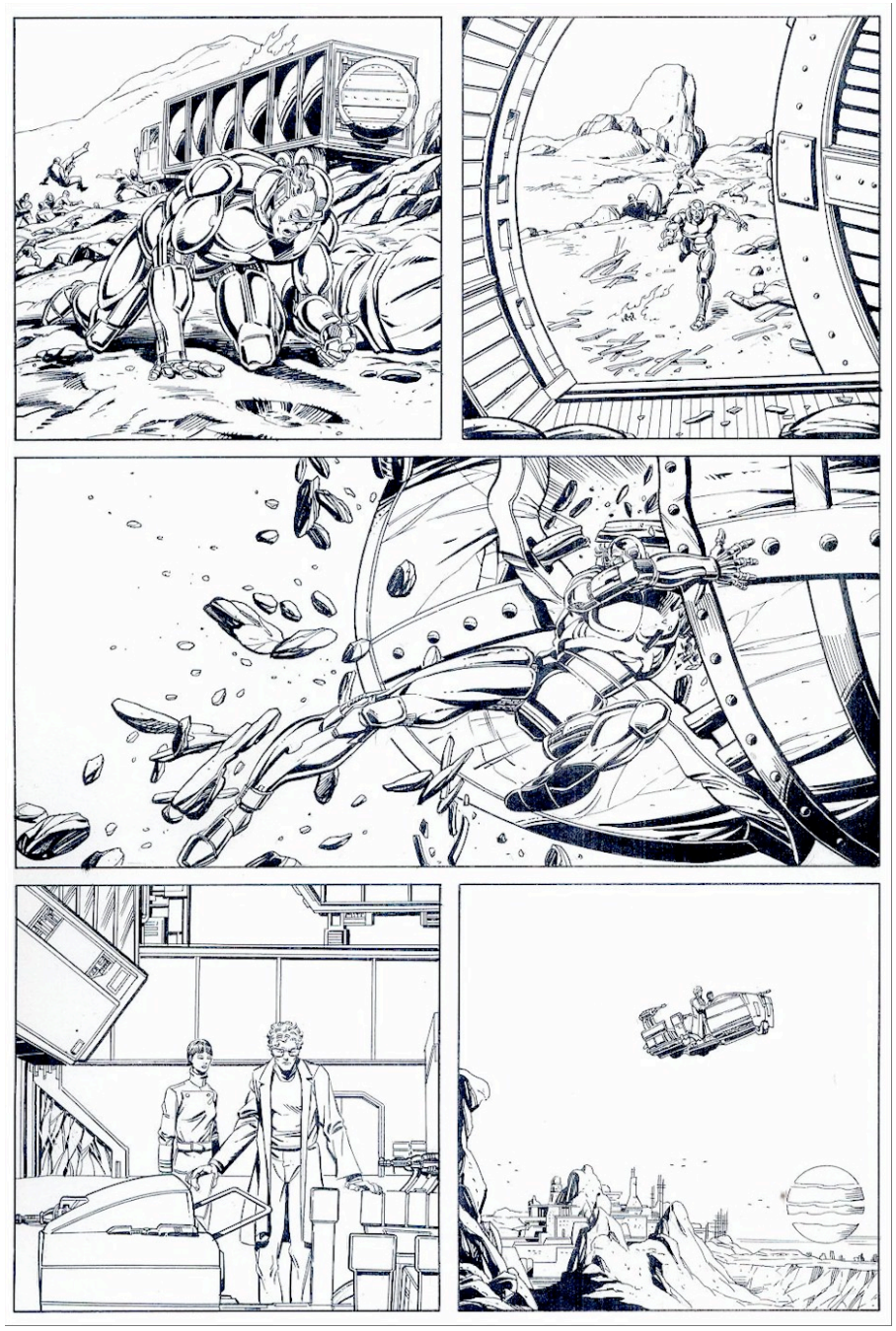
- Visual representations can incorporate a kind of logic, but it is very different from the more abstract logic of natural language
  - logic of pattern, object and space
    - connected to, inside, outside, part-of
    - structural relationships
  - processed in the visual, not language, area of the brain
  - not (or less) culturally dependent

Visual representations

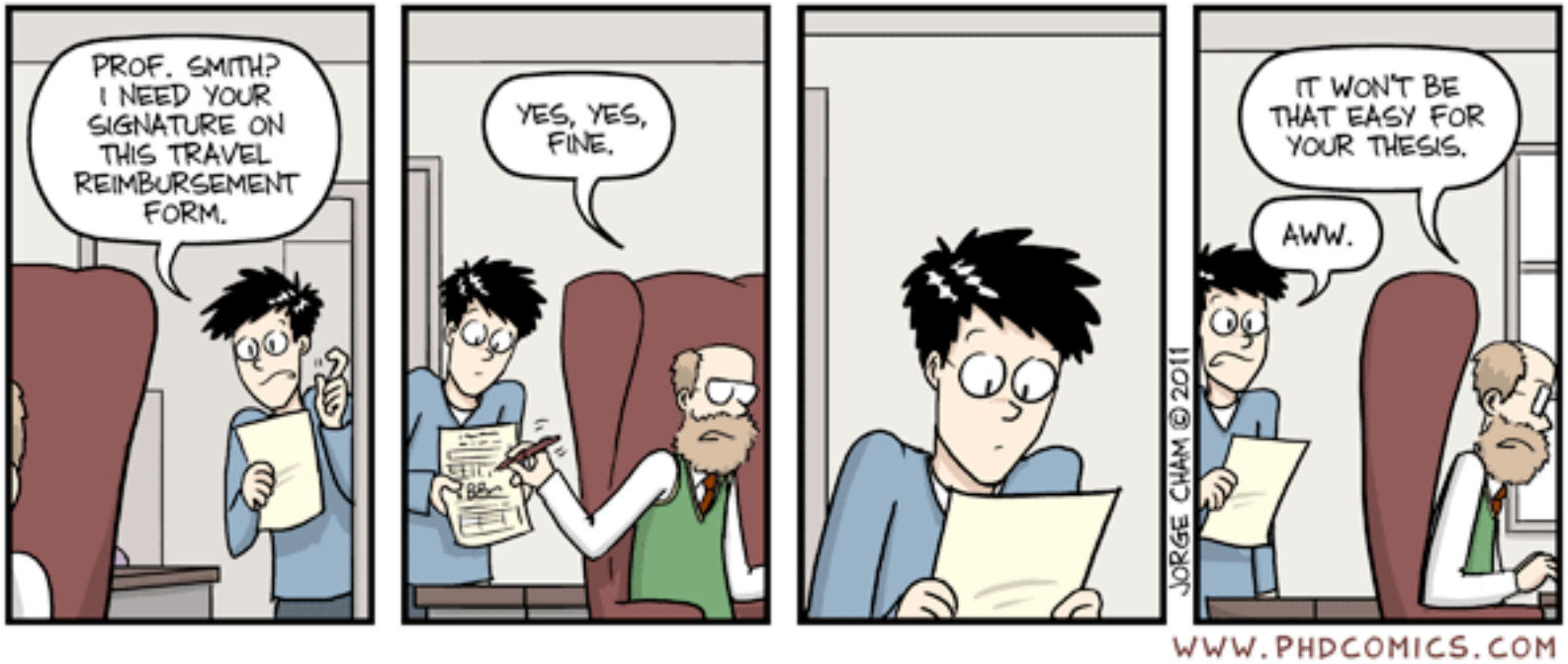
- instantaneous scene gist
- rapid exploration of spatial structure, relationships, emotions and motivations

Narrative

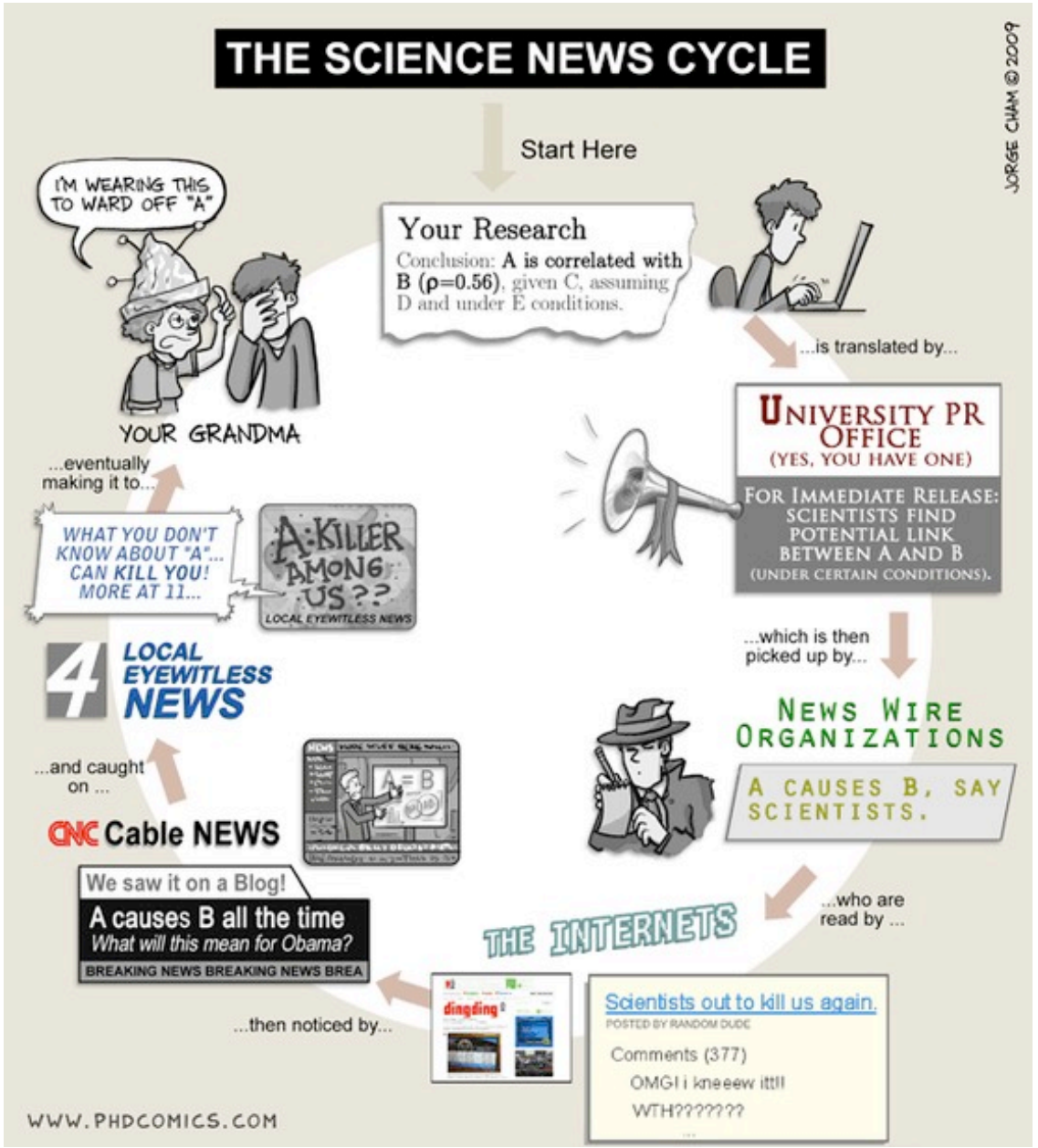
- can be carried through language or visual or both



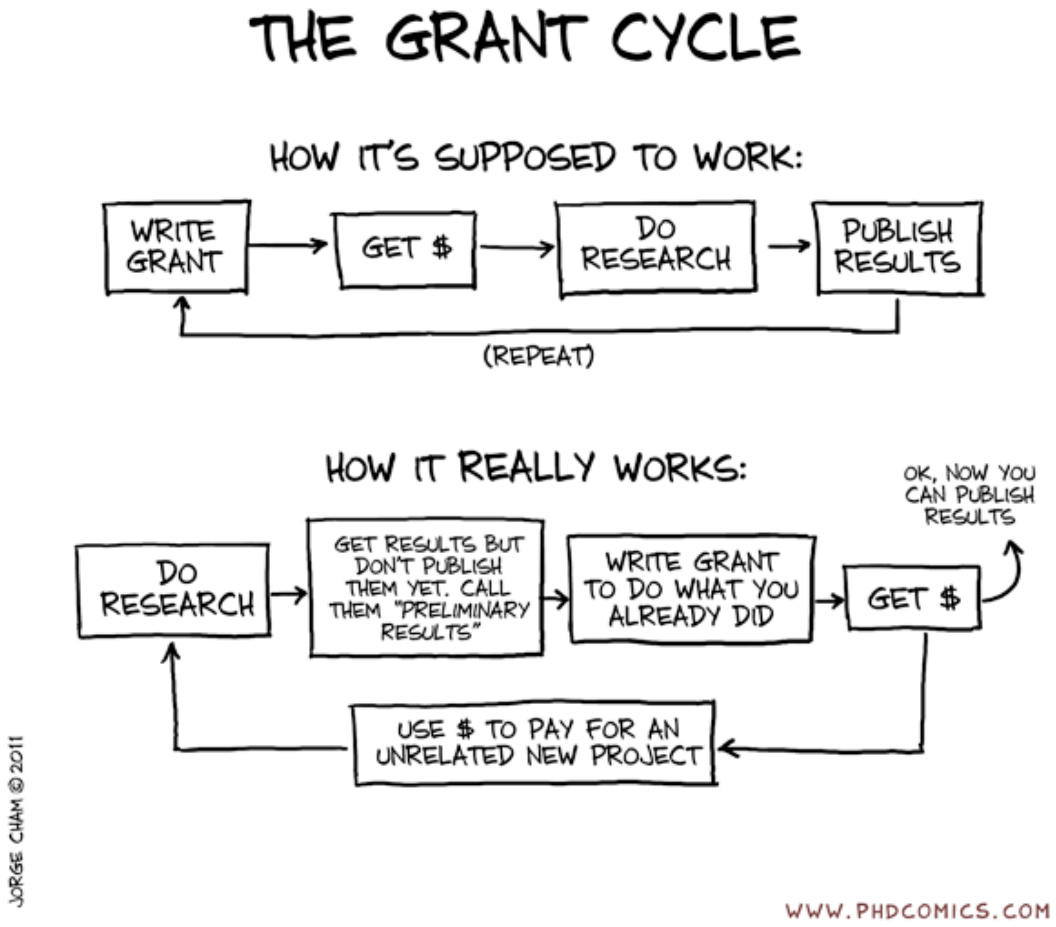
Both

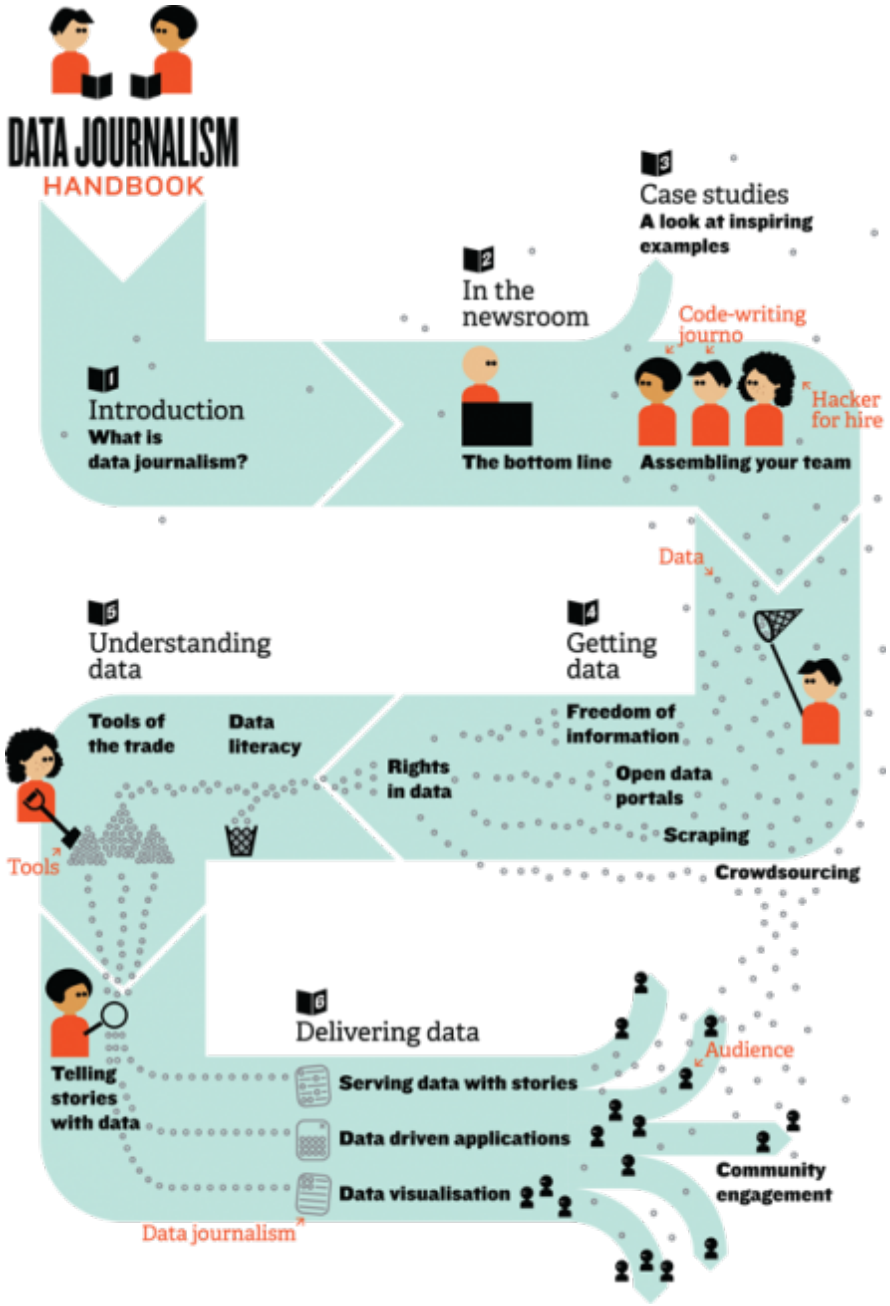

PROF. SMITH? I NEED YOUR SIGNATURE ON THIS TRAVEL REIMBURSEMENT FORM.
YES, YES, FINE.
IT WON'T BE THAT EASY FOR YOUR THESIS.
AWW.
JORGE CHAM © 2011
WWW.PHDCOMICS.COM

One page narrative



One page narrative





Is this graphic effective?

Your analysis should consider **the goal** of the graphic and should apply all the relevant theory that you learnt in the course about what makes graphics effective.

Visualization

- visualization: graphical representation of some data or concepts
  - tools for visual thinking

"Evidence presentations should be created in accord with the **common analytical tasks** at hand, which usually involve **understanding causality**, making **multivariate comparisons**, examining **relevant evidence**, and assessing the **credibility of evidence and conclusions**."

Edward Tufte in *Beautiful Evidence* [own emphasis]

Information visualization

depicts quantified data by systematically mapping it into visual images

Uses graphic language of points, lines, curves, simple shapes and other graphic primitives

We seek to represent, and hence understand, all kinds of data sets

visualization is a tool for discovering patterns, connections and structure in data

Mapped pictures*

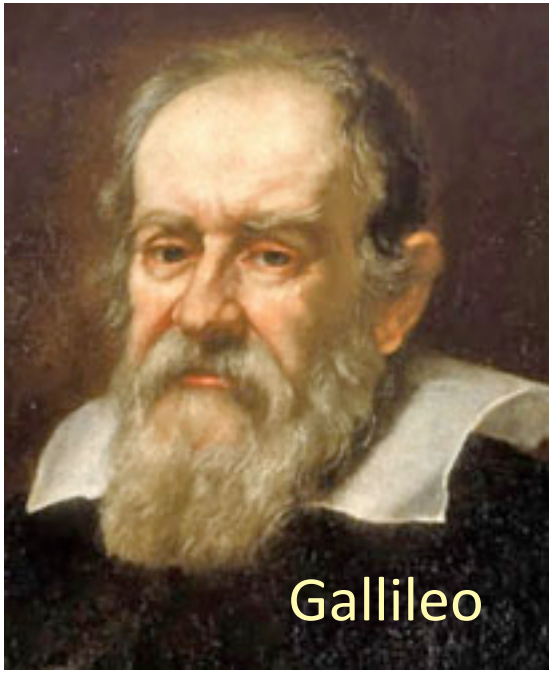
Images as evidence and explanation: mapped pictures combine representational images with scales, diagrams, overlays, numbers, words, images

Detailed annotations can make a figure **credible quantitative evidence**

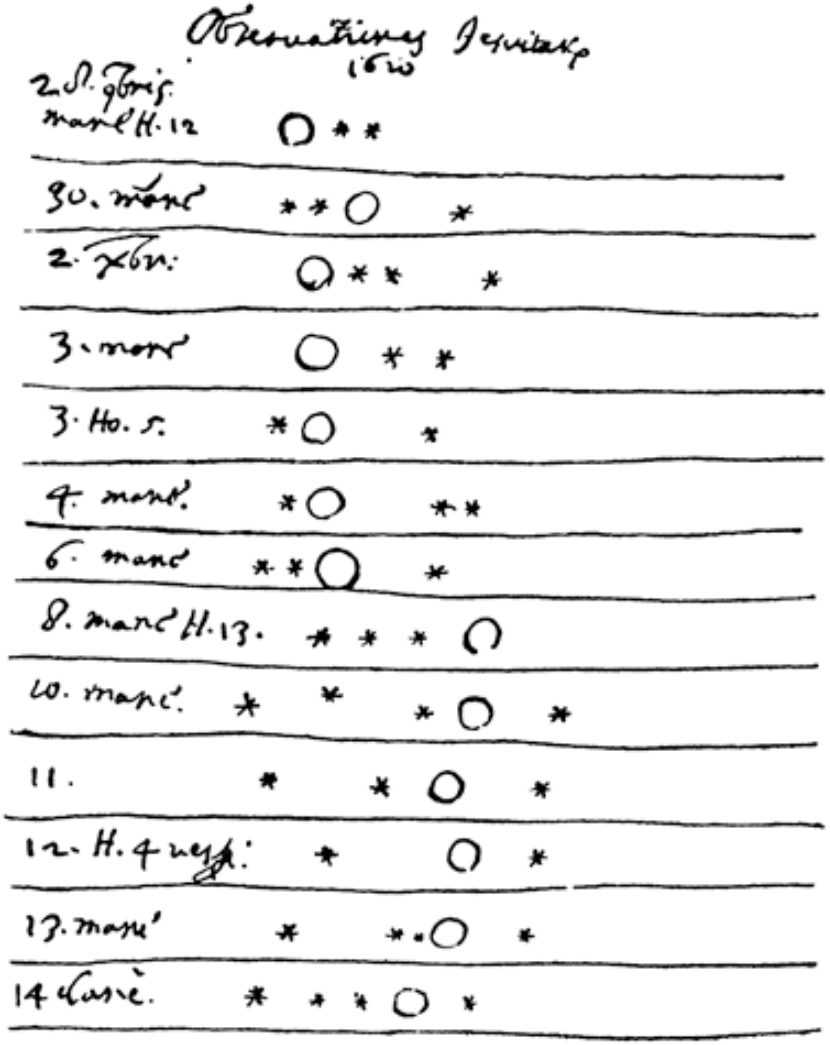
- has **explanatory power**

"Beautiful Evidence" by Edward Tufte, Graphics Press LLC

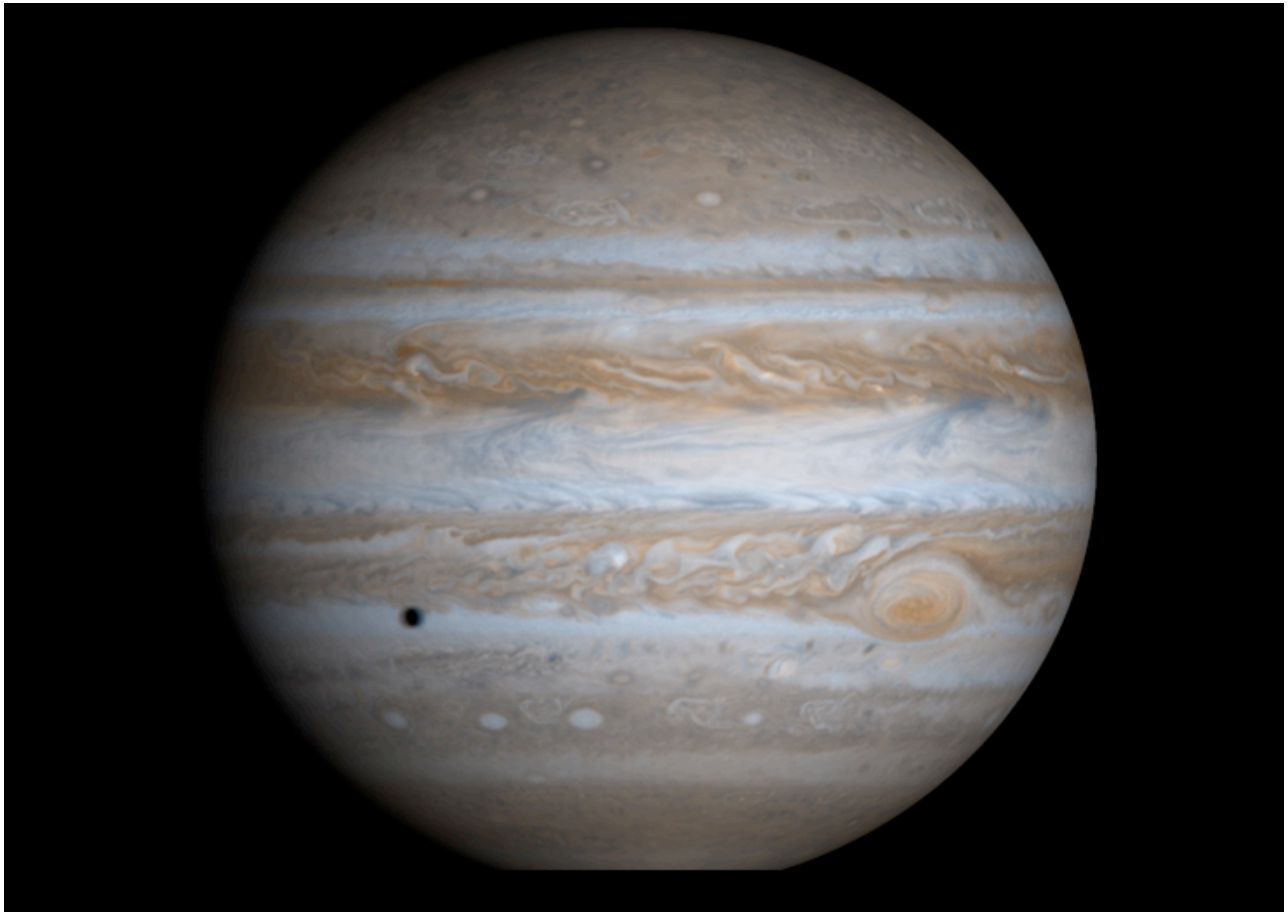
Mapped pictures have a long history…



Galileo's notebook on Jupiter



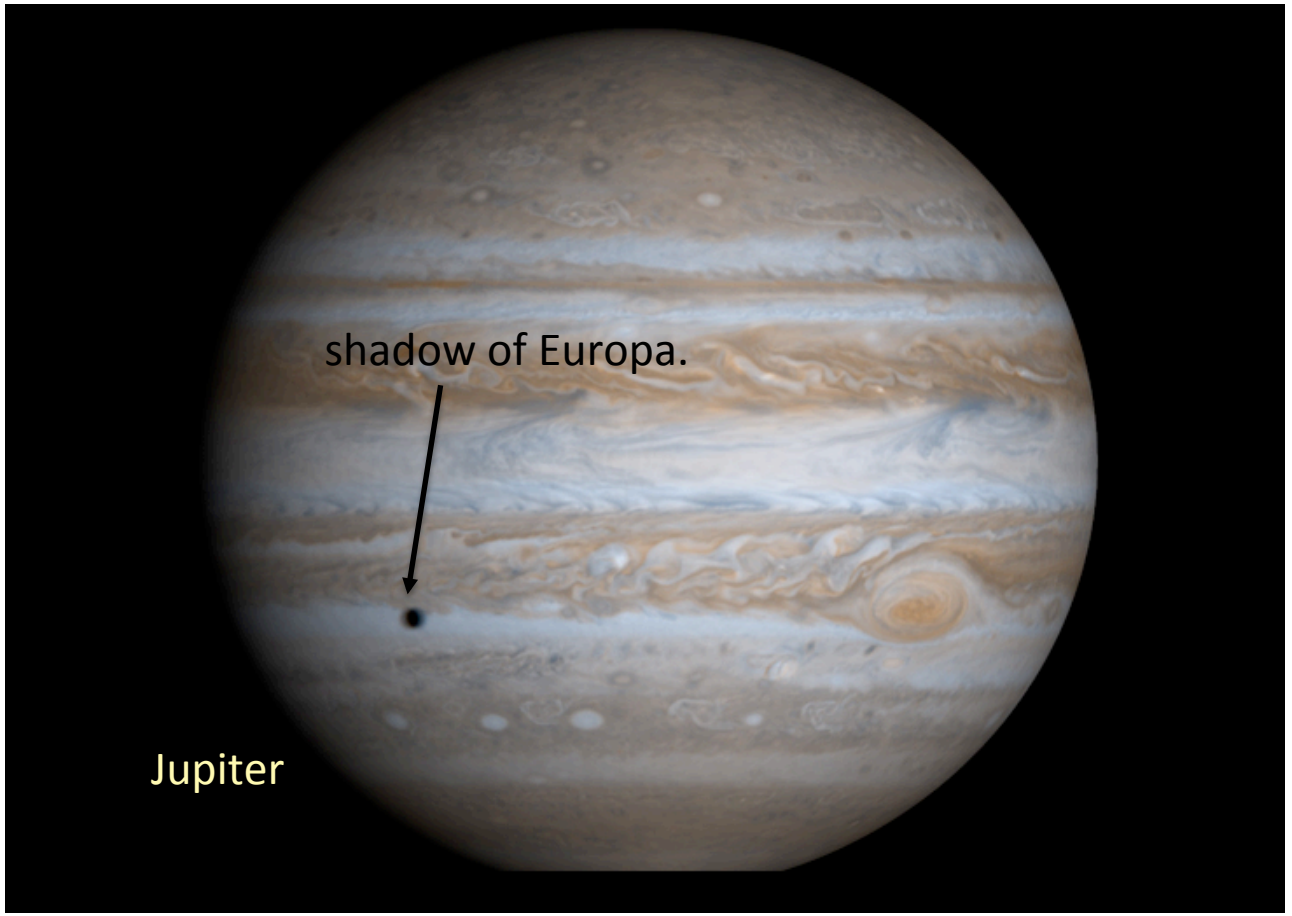
But are not used enough today…



Too many scientific images today are just celebratory photographs: **no scale** of measurement or relevant **comparison**

Jupiter again… from http://solarsystem.nasa.gov

How about some scale?



Earth

Most explanatory and evidential images should be mapped, placed in an appropriate context for comparison and located on a universal grid of measurement

Data graphics

- Visually display measured quantities by means of points, lines, a coordinate system, numbers, symbols, words, shading and colour.

- At their best, instruments for reasoning about quantitative information

The Theory of Data Graphics

- Data graphics should draw the viewer's attention to the **sense** and **substance** of the **data**,
  - not to methodology, graphic design, something else

  The main purpose of a visualization isn't entertainment — it's effective communication.

  A visualization should represent data in a way that makes information assimilation and comprehension simple.

There are right ways and wrong ways to show data; there are displays that reveal the truth and displays that do not. [E. R. Tufte]

Graphical Ducks

"It is all right to decorate construction, but never to construct decoration"

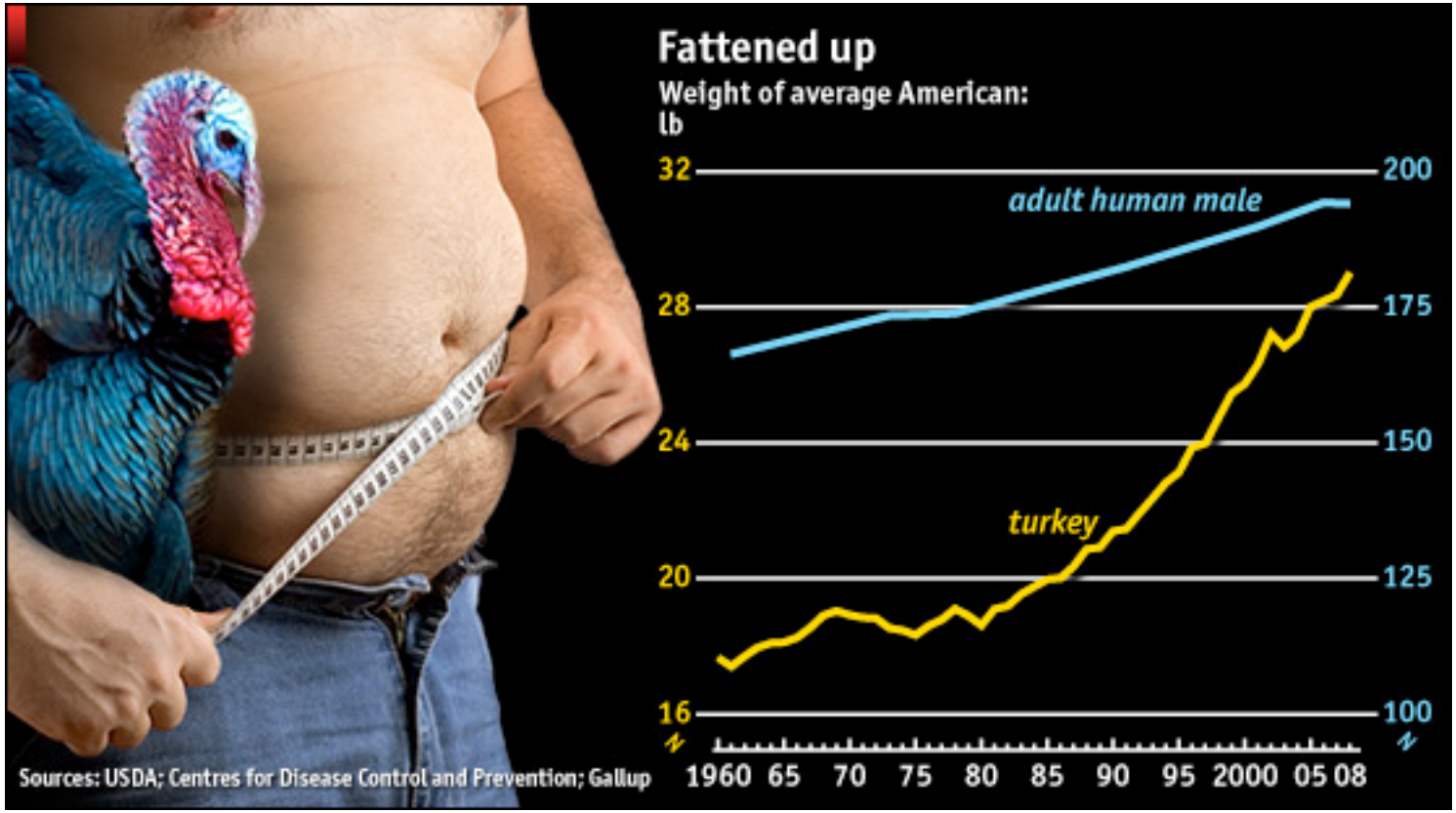
Brown, and Steven Izenour write about the ducks of modern architecture—and their thoughts are relevant to the design of data graphics as well:

> When Modern architects righteously abandoned ornament on buildings, they unconsciously designed buildings that *were* ornament. In promoting Space and Articulation over symbolism and ornament, they distorted the whole building into a duck. They substituted for the innocent and inexpensive practice of applied decoration on a conventional shed the rather cynical and expensive distortion of program and structure to promote a duck. . . . It is now time to reevaluate the once-horrifying statement of John Ruskin that architecture is the decoration of construction, but we should append the warning of Pugin: It is all right to decorate construction but never construct decoration.[2]

[2] Robert Venturi, Denise Scott Brown, and Steven Izenour, *Learning from Las Vegas* (Cambridge, revised edition, 1977), 163. The initial statement of the duck concept is found on 87–103.

Big Duck, Flanders, New York; photograph by Edward Tufte, July 2000.

Data graphics: Examples



From *The Economist*, Nov 26th 2009 *Web only*

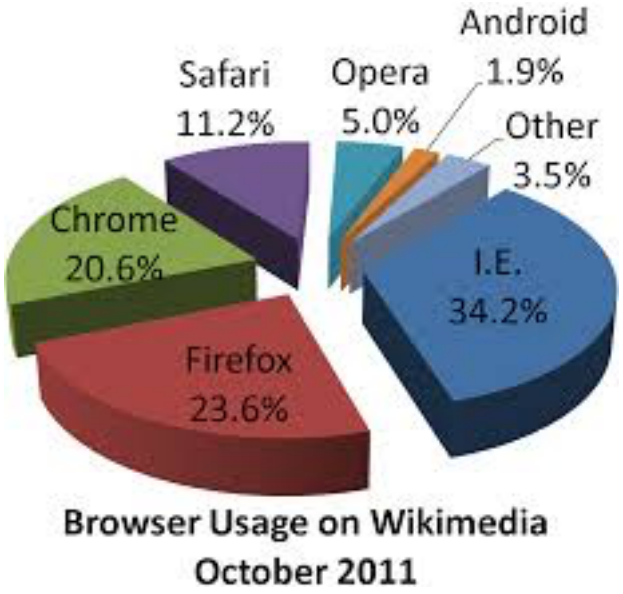
Graphical displays should reveal the data

- show the data
- induce the viewer to think about substance rather than 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 broad overview to fine structure
- serve a reasonably clear purpose
- be closely integrated with the statistical and verbal descriptions of the data set

Bad chart examples: pie charts

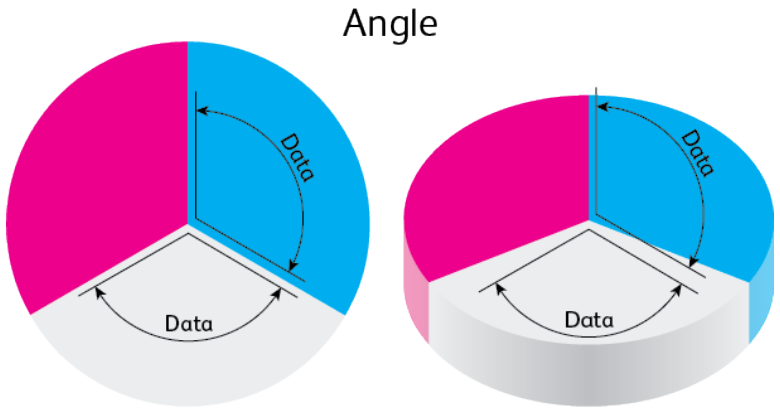
Edward Tufte gives the pie chart a succinct and decisive treatment in "The Visual Display of Quantitative Information":

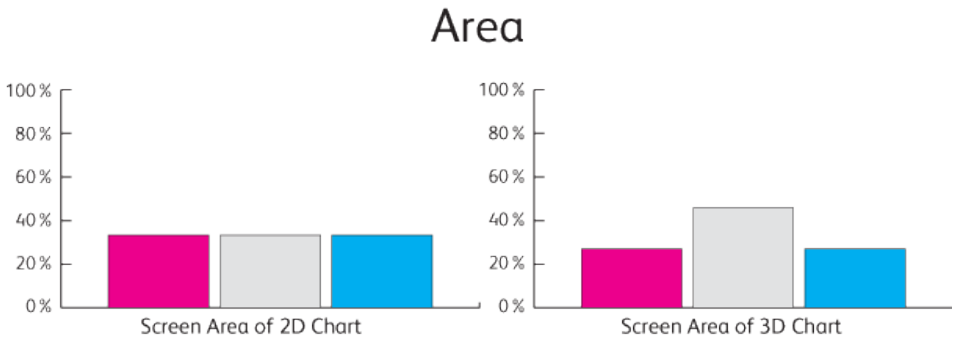
- *A table is nearly always better than a dumb pie chart; the only worse design than a pie chart is several of them, for then the viewer is asked to compare quantities located in spatial disarray both within and between charts [...] Given their low density and failure to order numbers along a visual dimension, pie charts should never be used*.



And worse – 3D pie charts

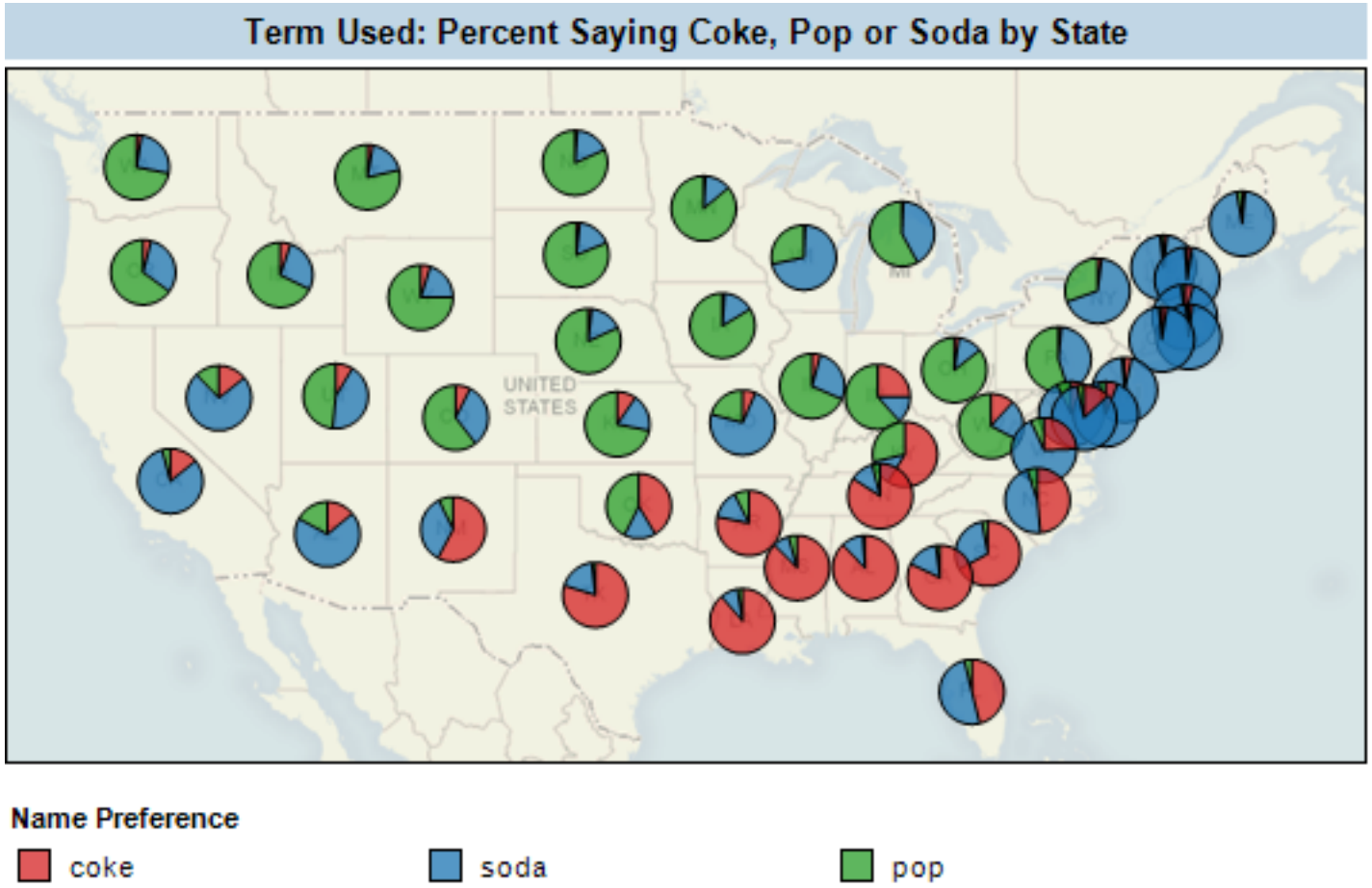
- 3D pie charts are even worse – distort angles and areas.





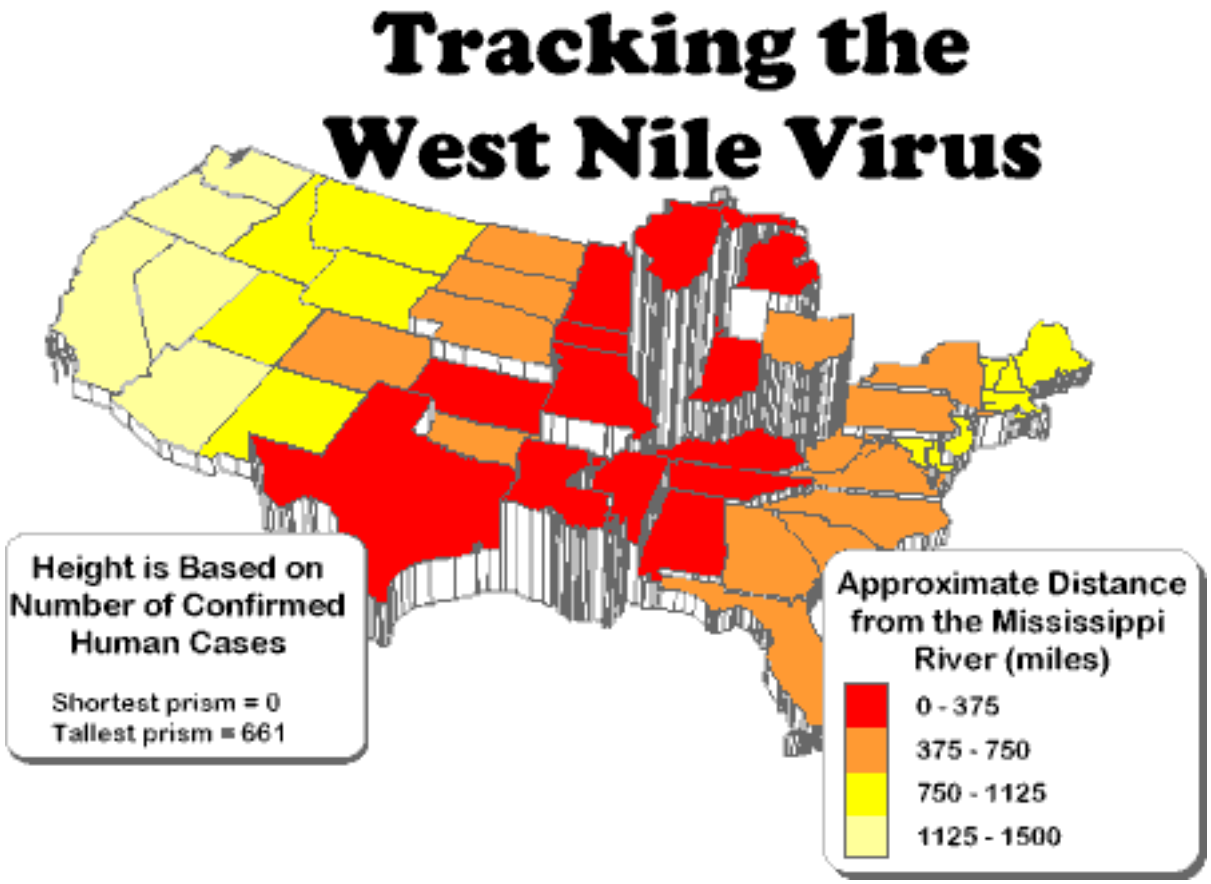
http://peltiertech.com/extra-distortion-in-a-pie-chart/

Do You Say Coke, Soda or Pop?

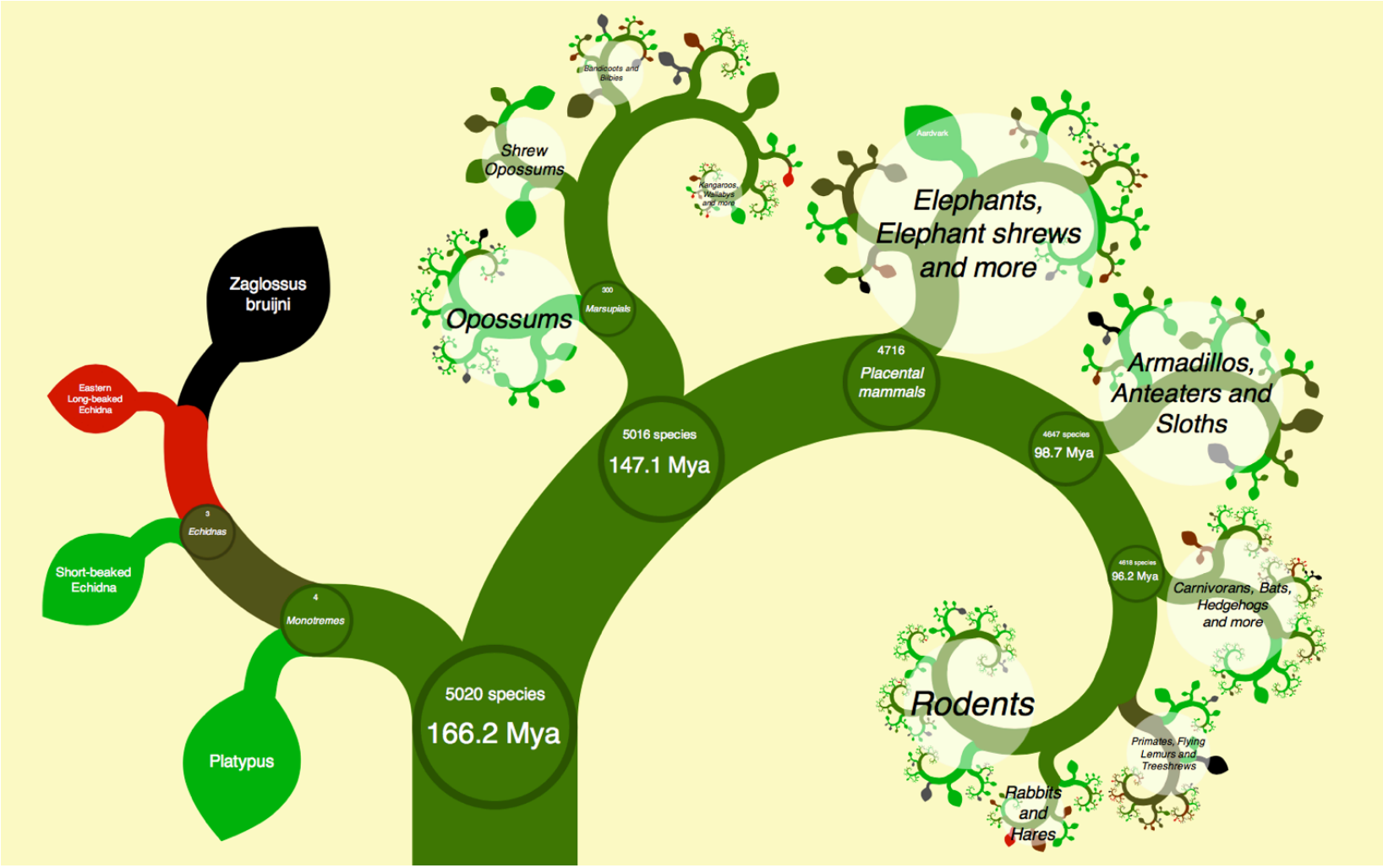


http://www.tableau.com/blog/do-you-say-coke-soda-or-pop-map-visualization-shows-your-likely-answer

Other bad 3D visualizations

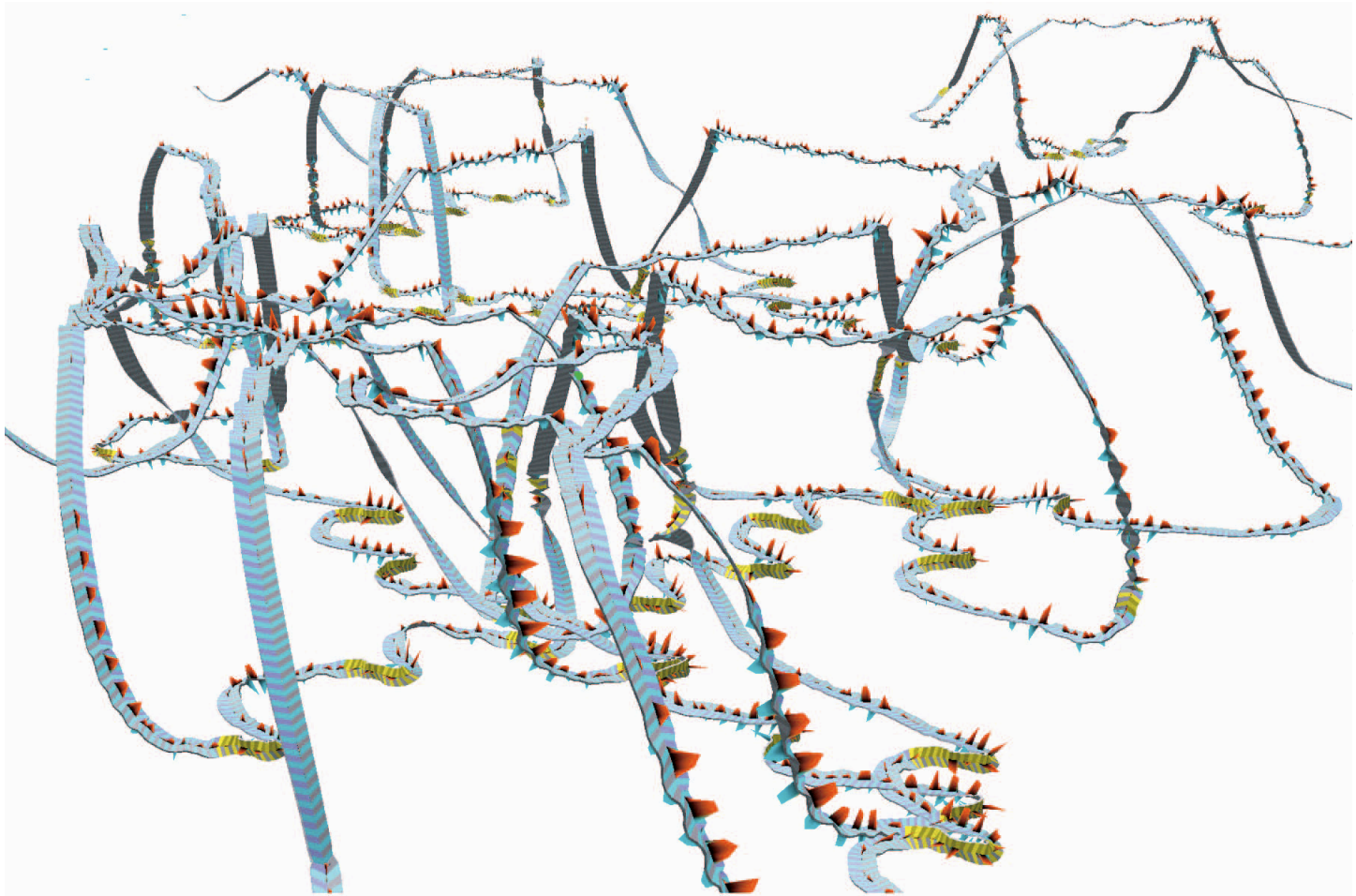


Interactive visualizations



http://www.onezoom.org

Data Graphics: Examples



Visualizing the Underwater Behavior of Humpback Whales,

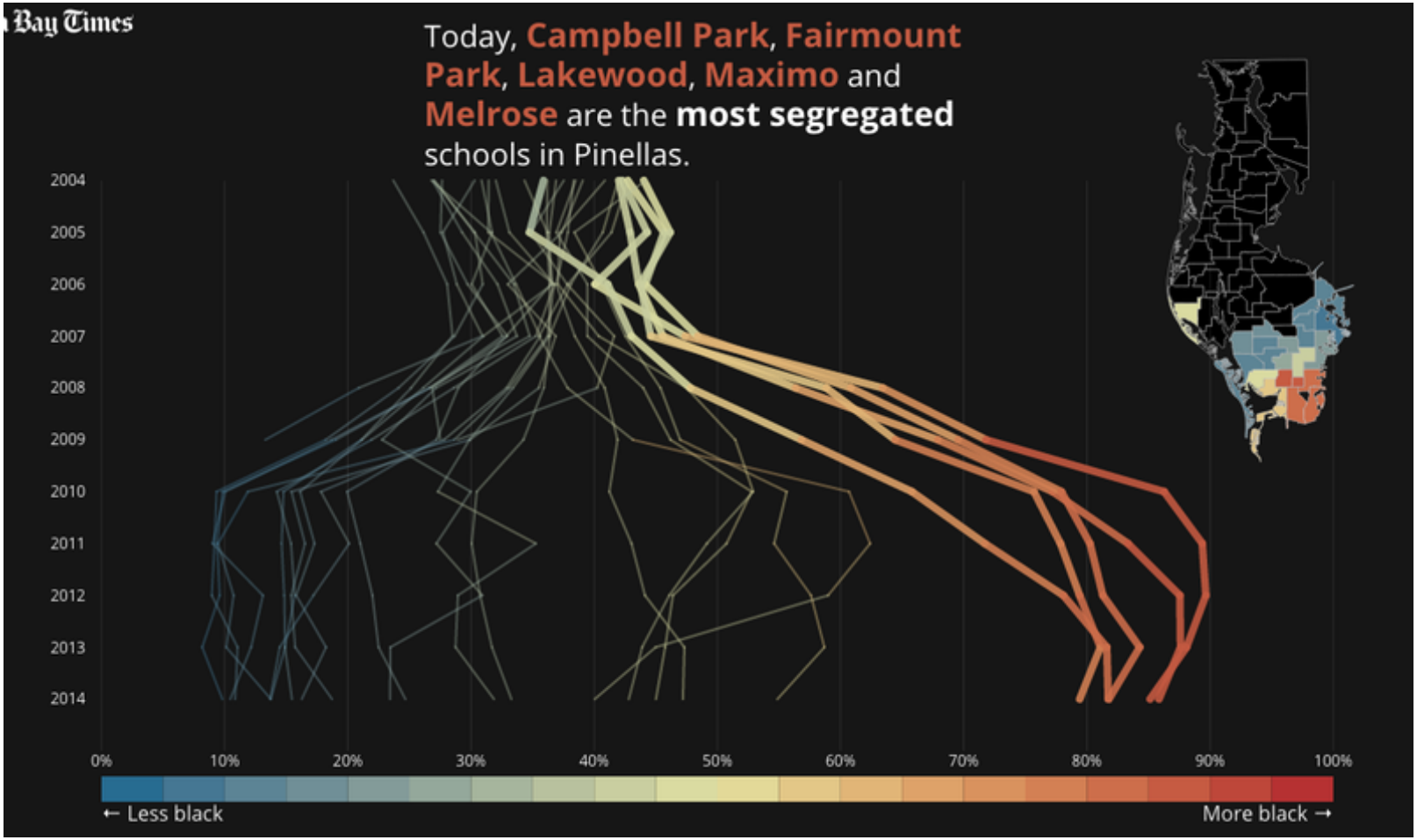
Colin Ware,

Roland Arsenault, Matthew Plumlee,

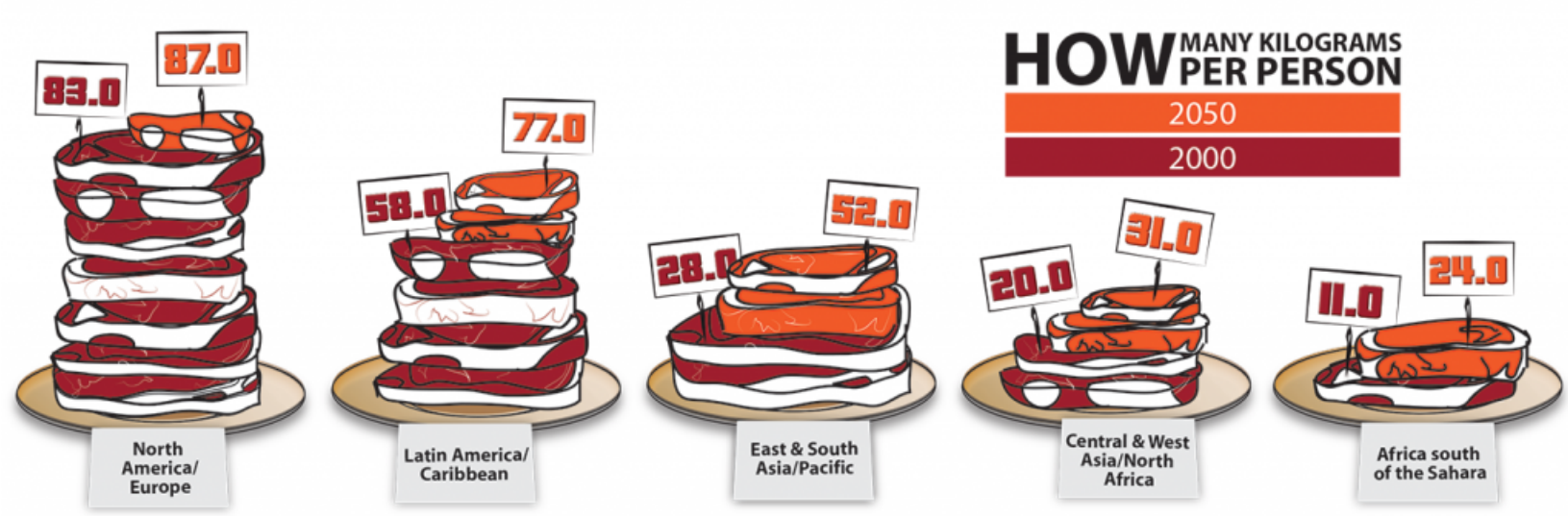
David Wiley

IEEE Computer Graphics and Applicatiions, 2006, July/ August, 14-18

TrackPlot showing several hours of whale foraging behavior. This is an oblique view looking down on the water. The animal is mostly either at the surface or on the bottom, with steep transitions between.


Bay Times
Today, Campbell Park, Fairmount Park, Lakewood, Maximo and Melrose are the most segregated schools in Pinellas.
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
← Less black
More black →

Is this a “data graphic”?



Also, is this graphic effective?

Your analysis should consider **the goal** of the graphic and should apply all the relevant theory that you learnt in the course about what makes graphics effective.

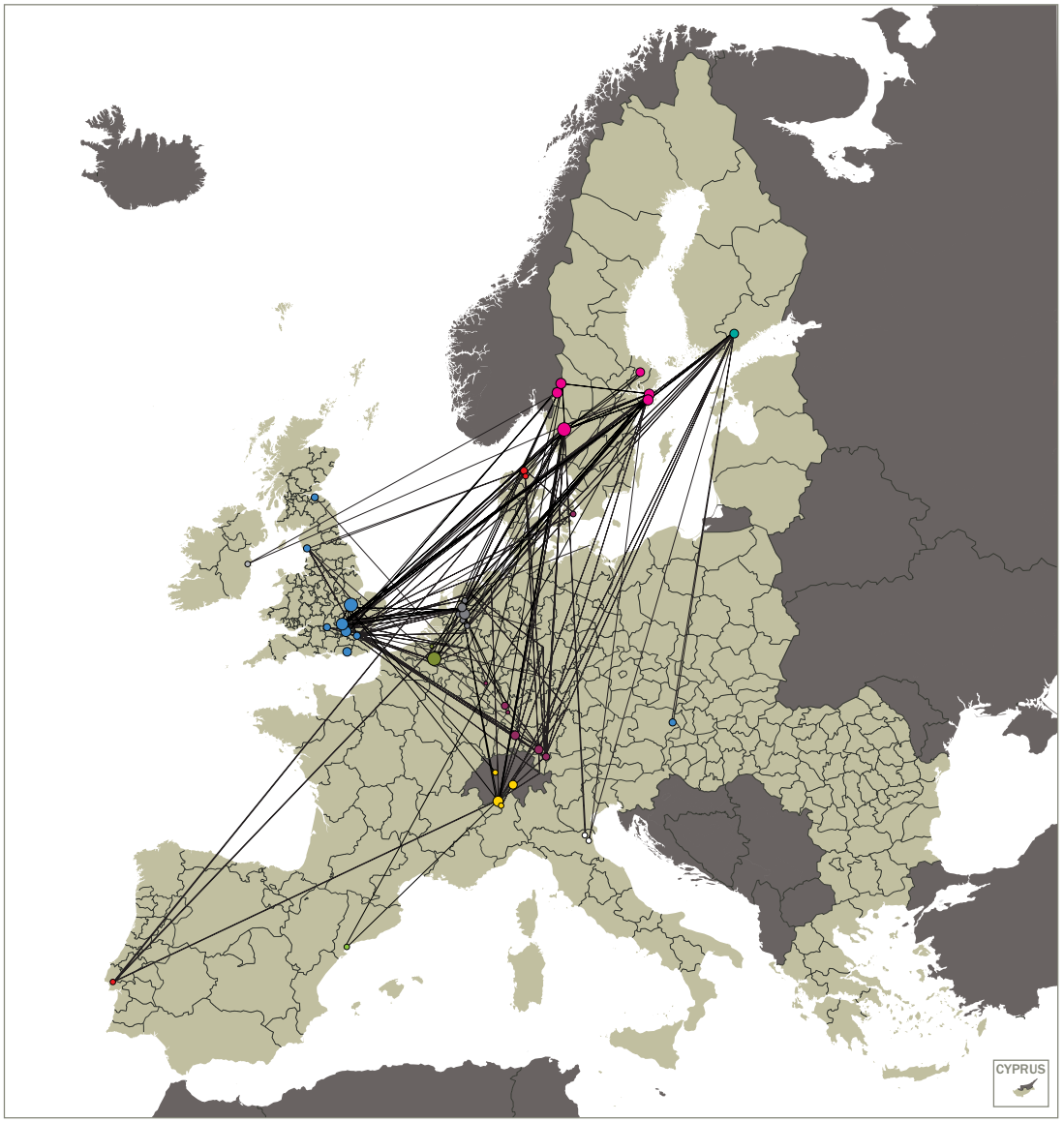
wheel of seasonal food

Is this a “data graphic”?

FIGURE II.1.4 FP6 R&D collaborations between European universities that cooperate in more than ten research projects

Is this a “data graphic”?

Is it effective?

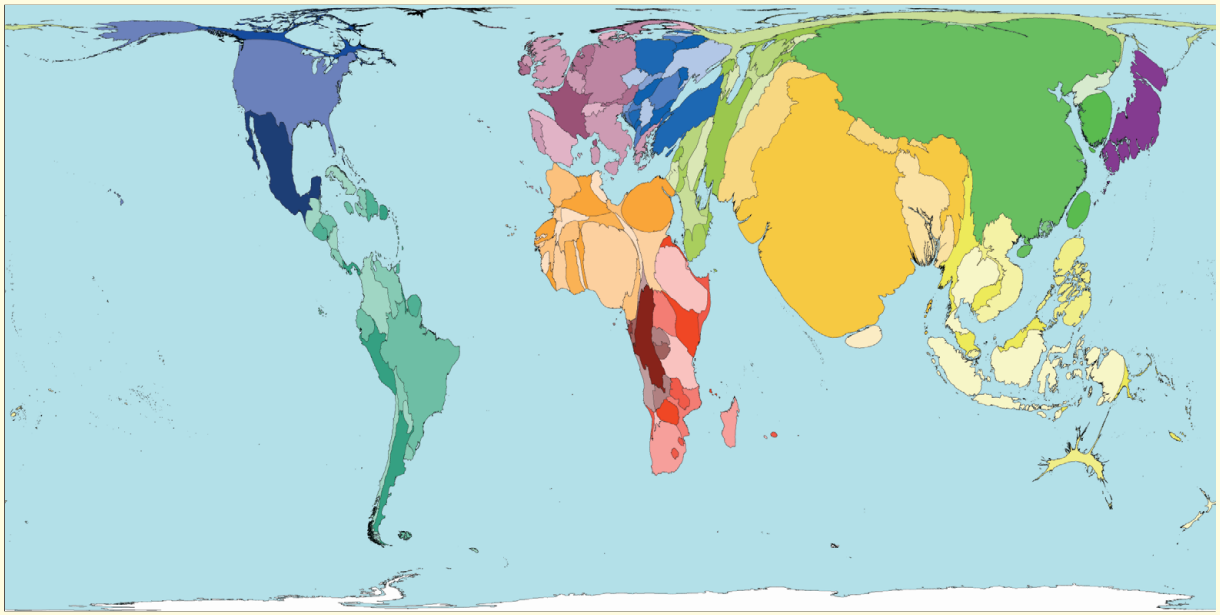


- Universities with 10-500 collaborations
- Universities with 500-1000 collaborations
- Universities with more than 1000 collaborations

Source: DG Research
Data: EUPRO (Austrian Research Centres)

Total Population

The University Of Sheffield. The Leverhulme Trust Geographical Association
Produced by the SASI group (Sheffield) and Mark Newman (Michigan)

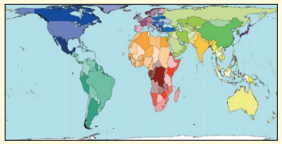


In Spring 2000 world population estimates reached 6 billion; that is 6 thousand million. The distribution of the earth's population is shown in this map.

India, China and Japan appear large on the map because they have large populations. Panama, Namibia and Guinea-Bissau have small populations so are barely visible on the map.

Population is very weakly related to land area. However, Sudan, which is geographically the largest country in Africa, has a smaller population than Nigeria, Egypt, Ethiopia, Democratic Republic of Congo, South Africa or Tanzania.

The size of each territory shows the relative propotion of the world's population living there.



Land area

Technical notes

- Data source: United Nations Development Programme, 2004, Human Development Report.
- Population data is from 2002
- The population not included is estimated as 2 to 3 million (see Appendix map 2).
- See website for further information.

MOST AND FEWEST PEOPLE

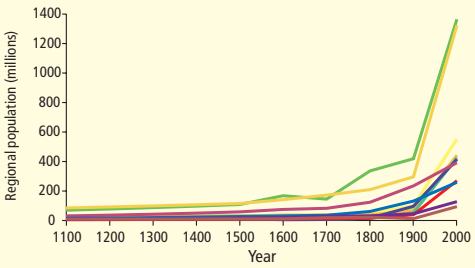
Rank	Territory	Value
1	China	1295
2	India	1050
3	United States	291
4	Indonesia	217
5	Brazil	176
6	Pakistan	150
7	Russian Federation	144
8	Bangladesh	144
9	Japan	128
10	Nigeria	121

millions

Rank	Territory	Value
191	Saint Kitts & Nevis	42
192	Monaco	34
193	Liechtenstein	33
194	San Marino	27
195	Palau	20
196	Cook Islands	18
197	Nauru	13
198	Tuvalu	10
199	Niue	2
200	Holy See	1

thousands

WORLD POPULATION BY REGION



"Out of every 100 persons added to the population in the coming decade, 97 will live in developing countries."
Hania Zlotnik, 2005

Contextualized Monitoring and Root Cause Discovery in IPTV Systems Using Data Visualization

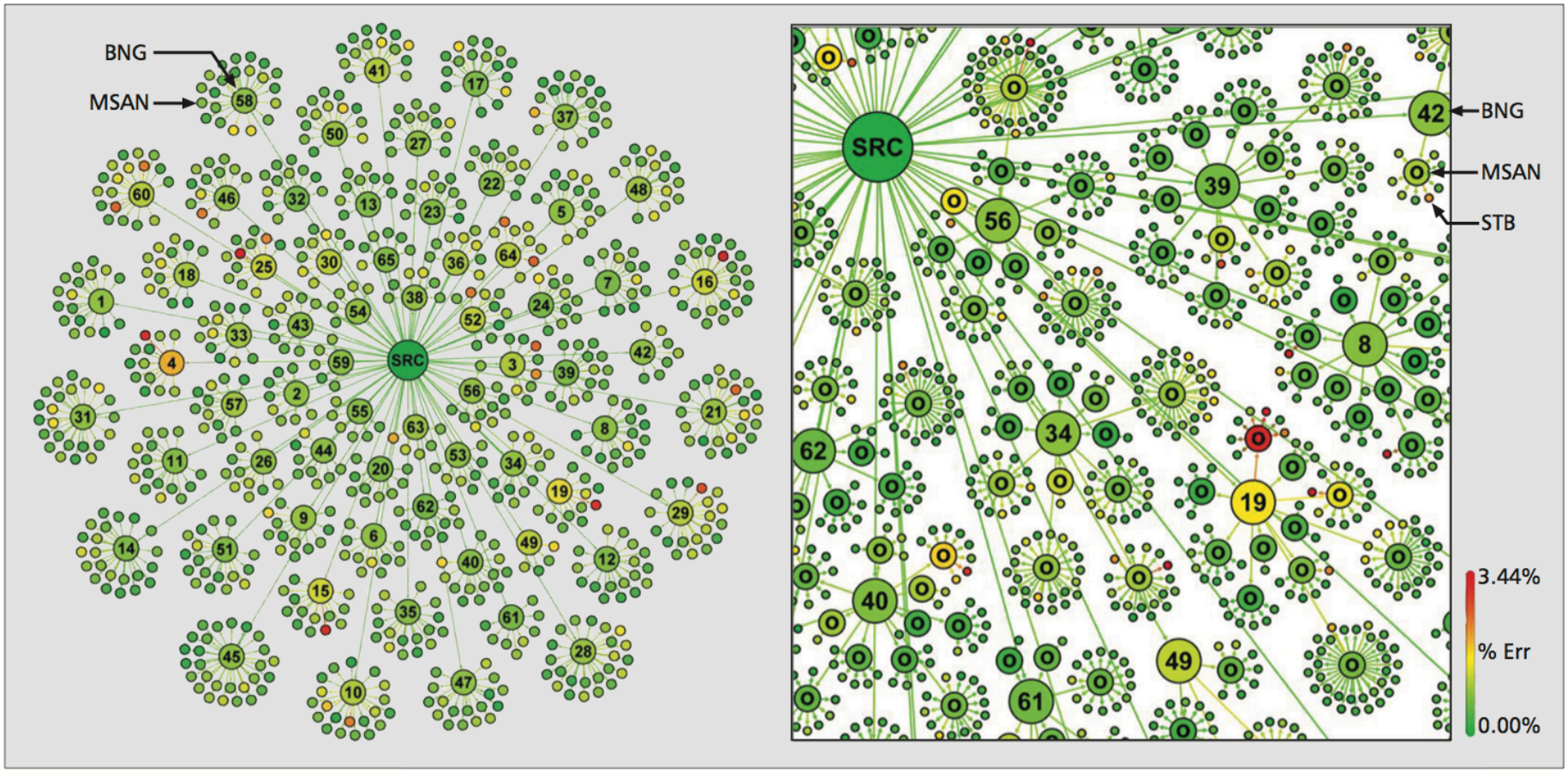
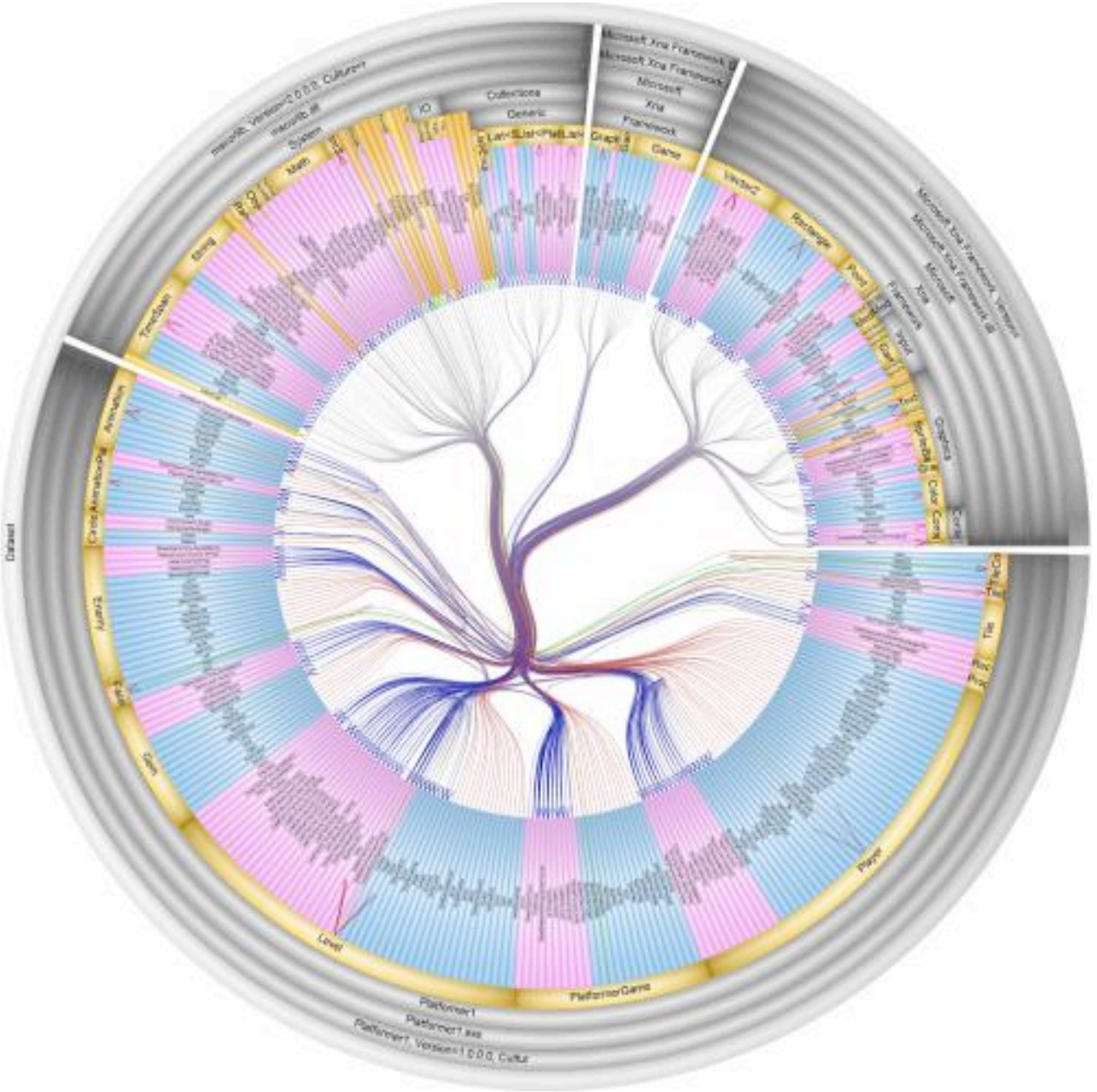


Figure 3. *IPTV network topology map obtained by working back from the end nodes (tree leaves) and matching them to common ancestors. The first graph shows the entire network from the source (SRC) to MSANs with the BNGs numbered from 1 to 65; the second picture shows a zoomed-in section of a larger graph with an additional hierarchical level: the end users. Node size in both graphs is a function of logical distance from the source. Node color indicates percentage of transport stream errors (green is low, red is high). BNGs are marked with numbers, while MSANs in the second graph are marked with a circle. End-node labels in both graphs were omitted for clarity. Created using the open source GePhi software.*

The Radial view of SolidSX shows source code elements as neste rectangles in the outer rings. The relations between these elements, such as call and inheritance relations, are shown as curved arrows. The colors on both elements and relations are used to encode attributes or metrics.



http://bit.ly/7qCHo2

Information visualization

Visualcomplexity.com

- Online gallery with best projects in information visualization
- focused on visualization of networks

- Find an example of a good visualization and one with clear flaws – give reasons for your classification.

The process of Design

A few thoughts on how to approach design of a visualization.

Implications of this course for design

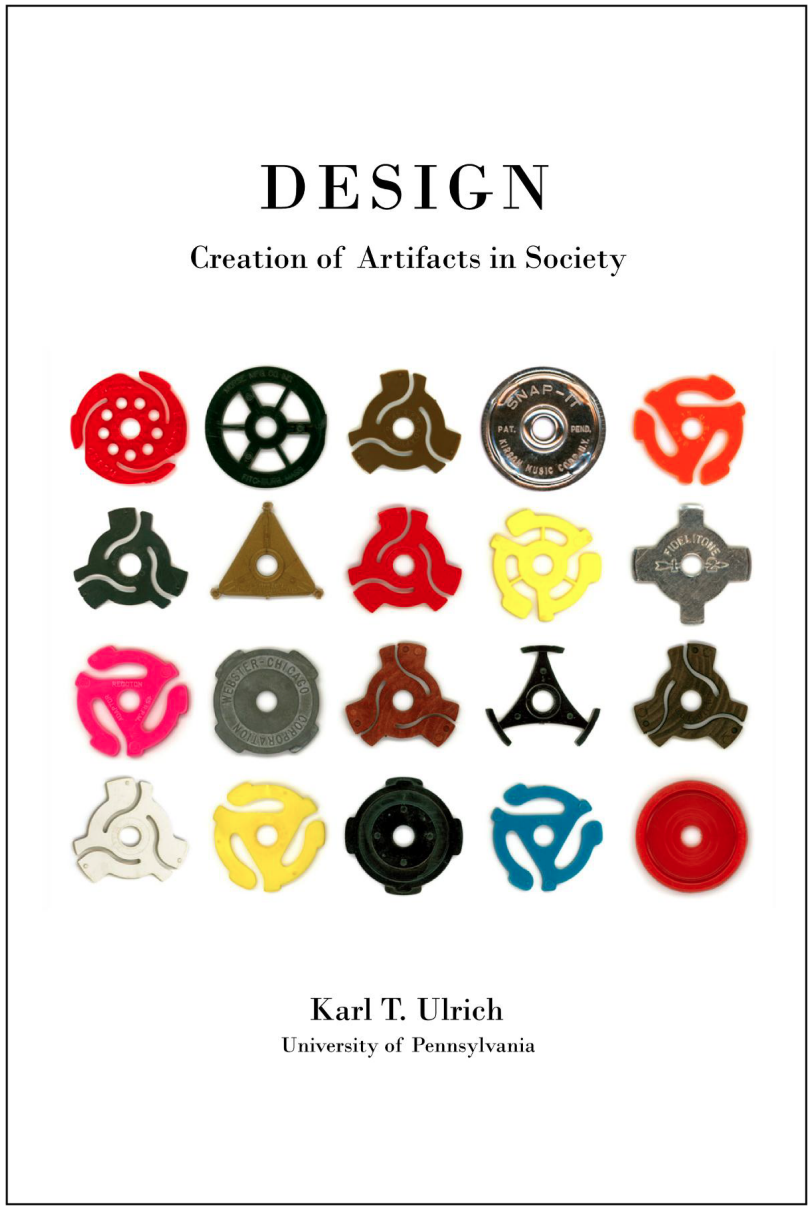
Effective design should start with a visual task analysis,

determine set of visual queries to be supported by a design

then use colour, form and space to efficiently serve those queries

NOTE: There is never a single optimal solution to a design problem, but rather a huge variety of alternative clear and effective designs.

- A good guide, in more depth that we have time for here
- book/ coursera course



A definition

- Design is conceiving and giving form to artifacts that solve problems
  - Karl. T. Ulrich, Penn State.
- Edgar Kaufmann Jr., curator of the industrial design department at MOMA 1946–1948, wrote that "**design is conceiving and giving form to objects used in everyday life**"
- Klaus Krippendorf and Reinhart Butter (1984) wrote, "**Design is the conscious creation of forms to serve human needs.**"

The process of design

- divergence versus convergence
- design is fundamentally **iterative**
  - a lot of back and forth between:
    - clarifying the task
    - searching for concepts
    - fixing the concepts

Identifying your project

- Find the gap.
- Design begins with a perception of a gap in the user experience.
- Without a gap, there is no motive for design.
- The gap may be perceived by users themselves or by observers.

Find the gap

- Have to detect the problem your self.
  - Main criteria:
    - you personally have to **feel the pain**
    - problem likely to be addressed with skills that you have.

Define the problem

Problem definition is the creation by the designer of an explanation of why the user experiences a gap.

- an identification of user needs that are not being met in the current state and/or the
- recognition of criteria for a high-quality solution.
- Problem definition is implicit in many design efforts
  - but generally an explicit part of professional design efforts, expressed in the form of a design brief, customer needs list, or other document

Explore alternatives

- Go through a number of candidate solutions/ approaches (This step is sometimes called search.)
- Select one, with justification.
  - Exploration typically exposes more than one solution, so design requires some sort of evaluation and selection from among alternatives.
  - Some designers consider many alternatives simultaneously when selecting a plan. Others articulate, evaluate, and refine plans iteratively and select the first plan that is good enough

Creative meta-seeing

Studies of how artists and designers work suggest that, although the germ of an idea may often come purely through thought, the major work of creative design is done through interaction with some rapid production medium:

sketch, clay, power point, scripting language etc.

Pencils (coloured pens) and paper are very useful for the first stages of design.

Stages in the creative process

- visual concept
- externalization
- constructive critique
- consolidation and extension

- mkuttel@cs.uct.ac.za