

Visualization of Information -

- This lecture is based off of a 400 level course on data visualization and statistics within the Climate and Space Department –
- We build up on the statistics side from:
 - Basic and advanced statistics
 - (from t-test to bootstrap analysis)
 - Basic and advanced programming
 - (from reading in data to object oriented data analysis)

The complete labs (not lectures) can be freely accessed including(!) these slides at:

**[github.com/astro-abby/
data_vis_statistics_geosciences](https://github.com/astro-abby/data_vis_statistics_geosciences)**

Visualization of Information -

How can we:

*1) convey our data most informatively
(accuracy)?*

and...use the tools we have (In Python!), to

*2) create interesting and approachable
graphics (aesthetics)?*

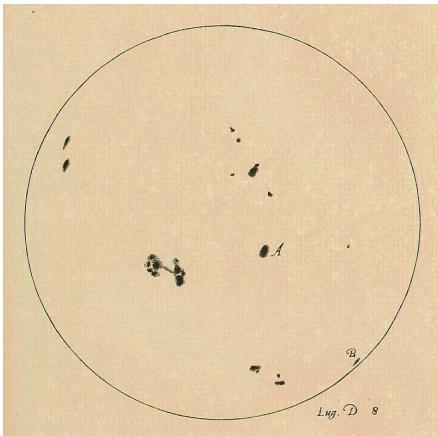
Brief History -

Exploring information about the natural world isn't a new idea -



From ~ 16,500 years ago –
interpretation of Pleides

<http://news.bbc.co.uk/2/hi/science/nature/871930.stm>



1612 AD

Galileo's
observation of
sunspots

http://galileo.rice.edu/sci/observations/sunspot_drawings.html



~10th century AD

"Şūrat al-Ard" (Picture of the World) from
al-İştakhrī's Kitāb al-masālik wa-al-
mamālik (Book of Routes and Realms).

Medieval Islamic Maps : An Exploration – Pinto 2016

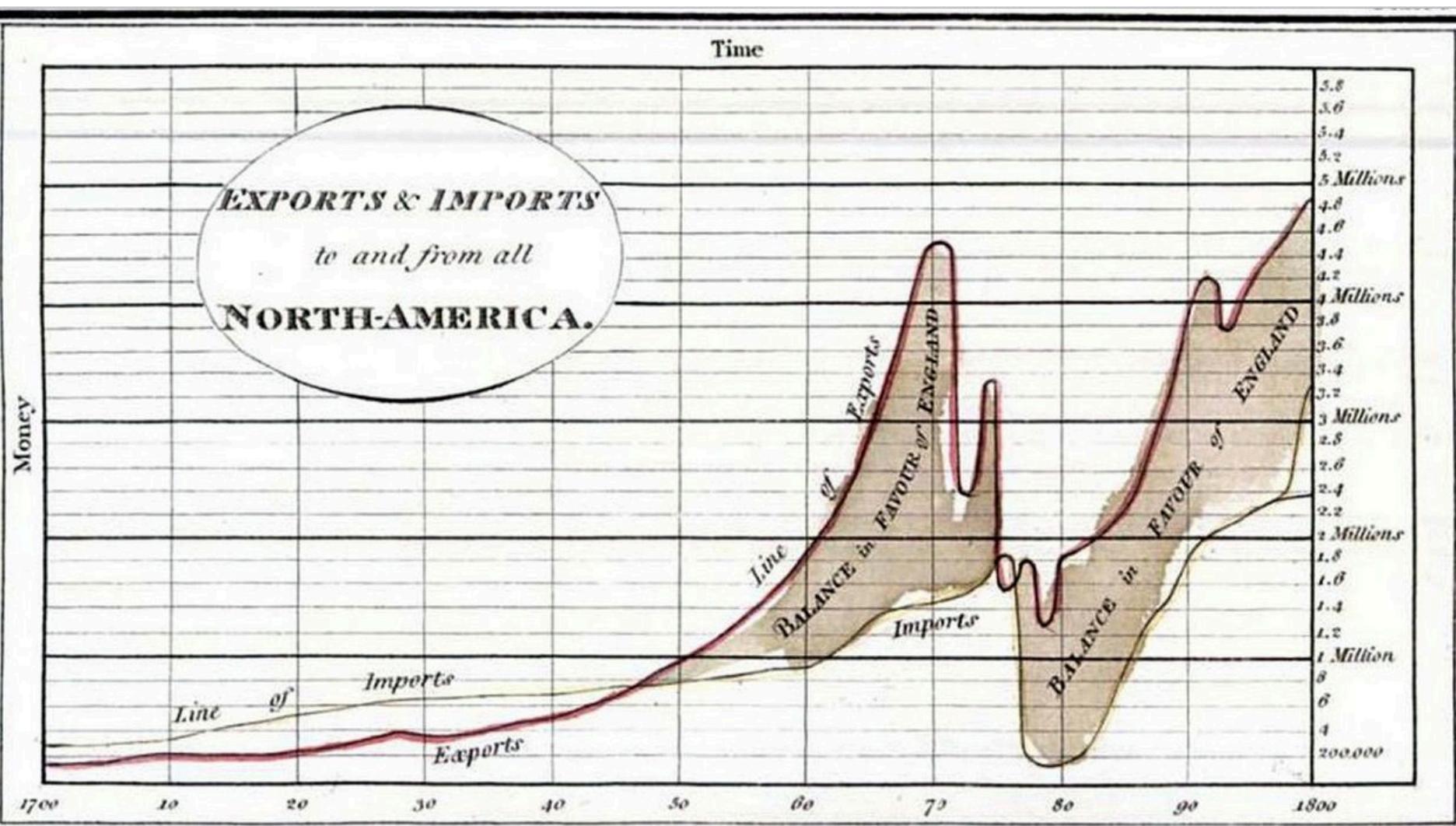
The beginning of a more familiar statistical data visualization

With the beginning of modern statistics & probability theory in (late 1700s – 1900s) came a surge of info-graphics and visualizations

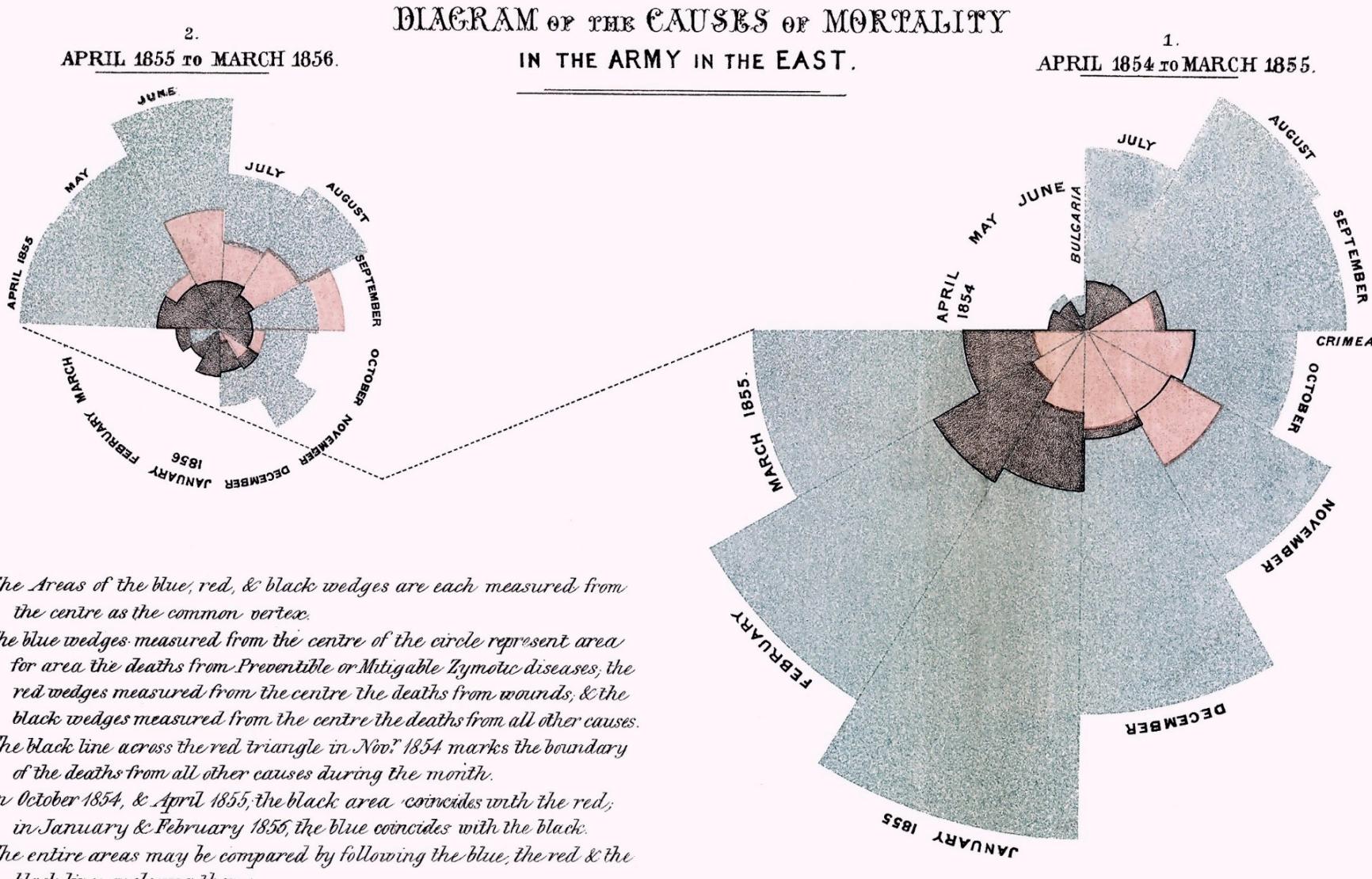
Let's take a look at some of these early charts together – split into small groups around the papers handed out -

- 1) What these graphics are conveying (best guess)?
- 2) What you find familiar about them / unfamiliar?
- 3) What do you find confusing, what do you find interesting?

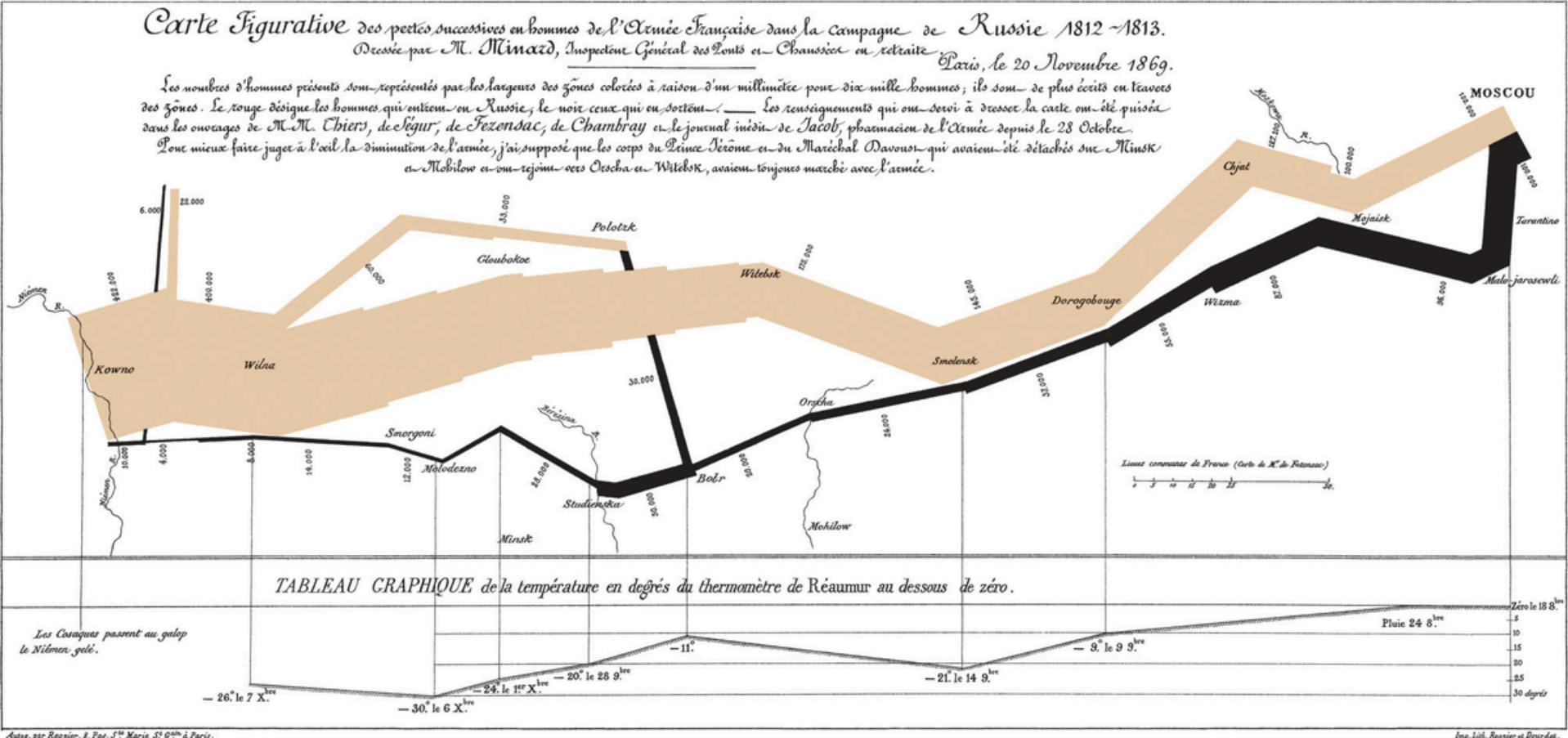
William Playfair's Charts - 1786



Florence Nightingale's Report - ~1858



The “Minard Map” - 1869



What did these all have in common?

- Why do you think they were made?

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- Their choice of presentation of the data is therefore made to create conversation around a certain topic or point -

What did these all have in common?

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How can we implement “good design” as we make our own visualizations and infographics?

What constitutes a “good visualization”?

- What do YOU think?

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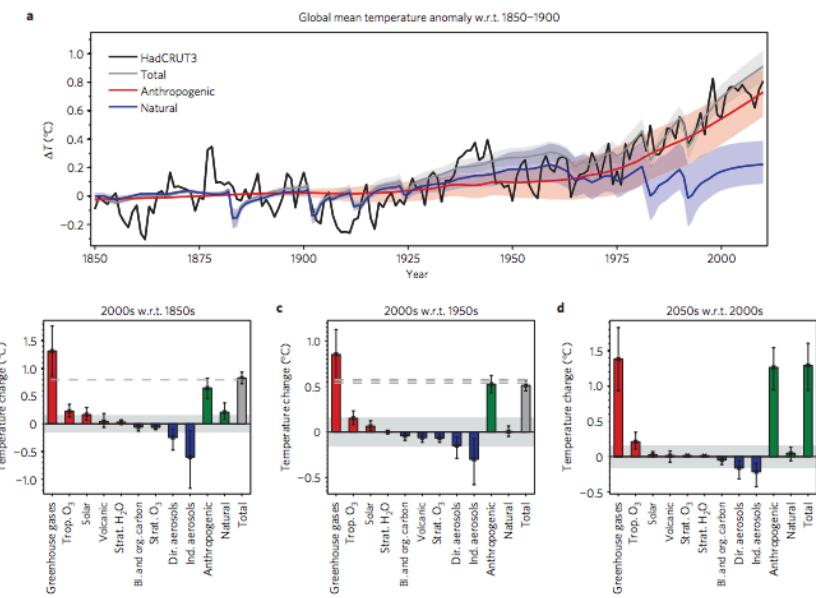
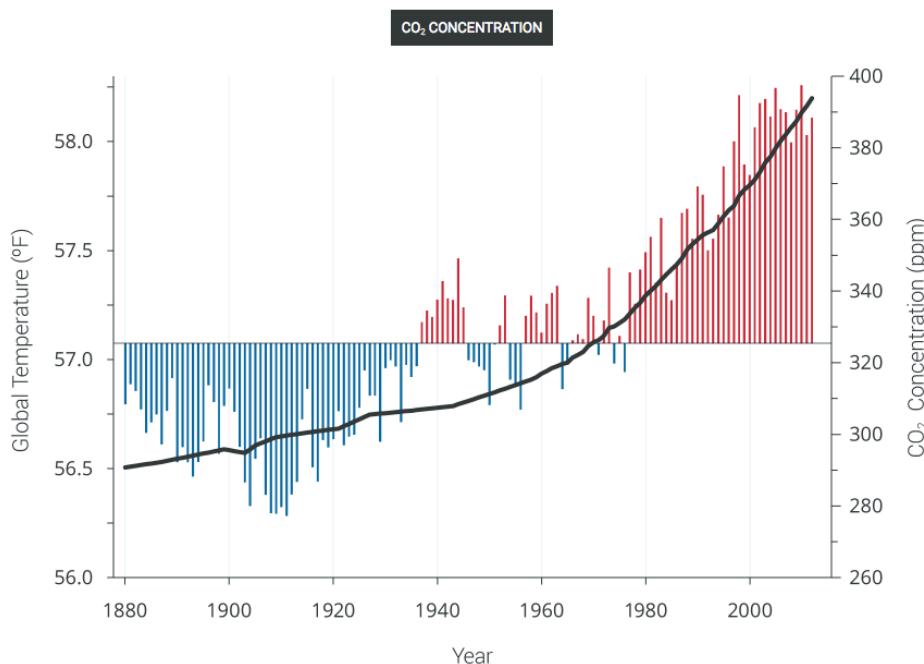
- What do YOU think?
 - Does color matter?
 - What colors are best?
 - Is 3D better than 2D?
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What it all comes down to is: – who is your audience, and what point are you trying to make.

Recall our Audience Examples from Before?

- Same Dataset

INTERACT WITH THE GRAPHIC BELOW



First Step Making a Visualization – Ask Yourself:

- **1) Is the graphic explanatory or exploratory?**
 - **Explanatory** – you are trying to make a point, what is the point you are trying to make?
 - **Exploratory** – you are inviting the viewer to explore the dataset, make their own inferences

Often the very first graphics you make in your work are exploratory and then you finalize into an explanatory graphic.

First Step Making a Visualization – Ask Yourself:

- **2) How will the graphic be used?**
 - In an oral presentation you want something understood without much staring at the data – simplicity is best in this case
 - In a paper or a written document – perhaps more detail that invites the viewer to explore is better.

Above all – know your audience – what can you take for granted they know, what might they need as explanation

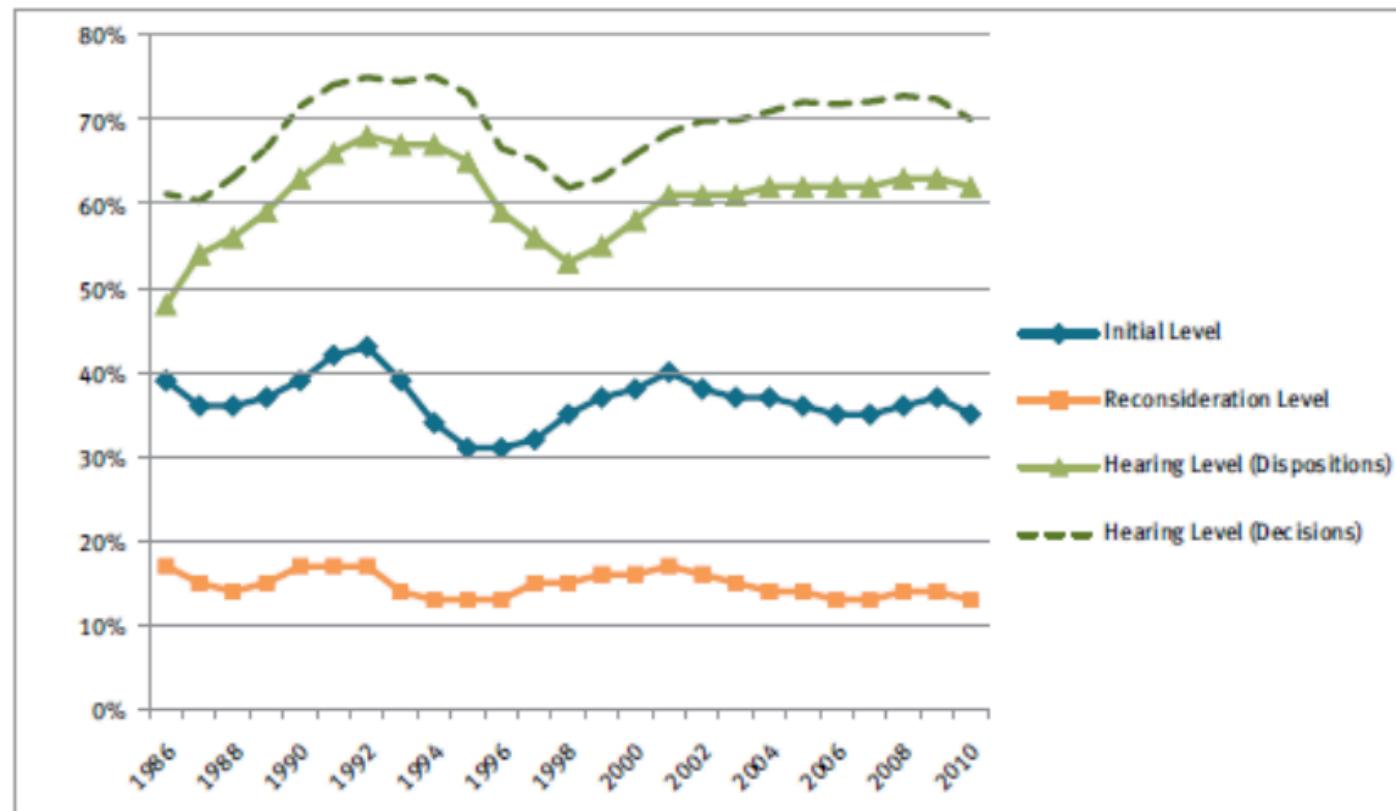
First Step Making a Visualization – Ask Yourself:

- **3) What is the first thing you want the audience to see?**
- All graphics have a “flow” to them. Most audiences are familiar with bar charts, line plots etc – if you want to get creative try to make the viewer know where to look and what the message should be
 - You can use annotation, lines etc.
 - Just try to keep it simple.
- For example...

Example of accentuating communication

Integrate Text and Graphics

7. Combined DI and SSI Allowance Rates at Each Level of Adjudication—Fiscal Years 1986-2010



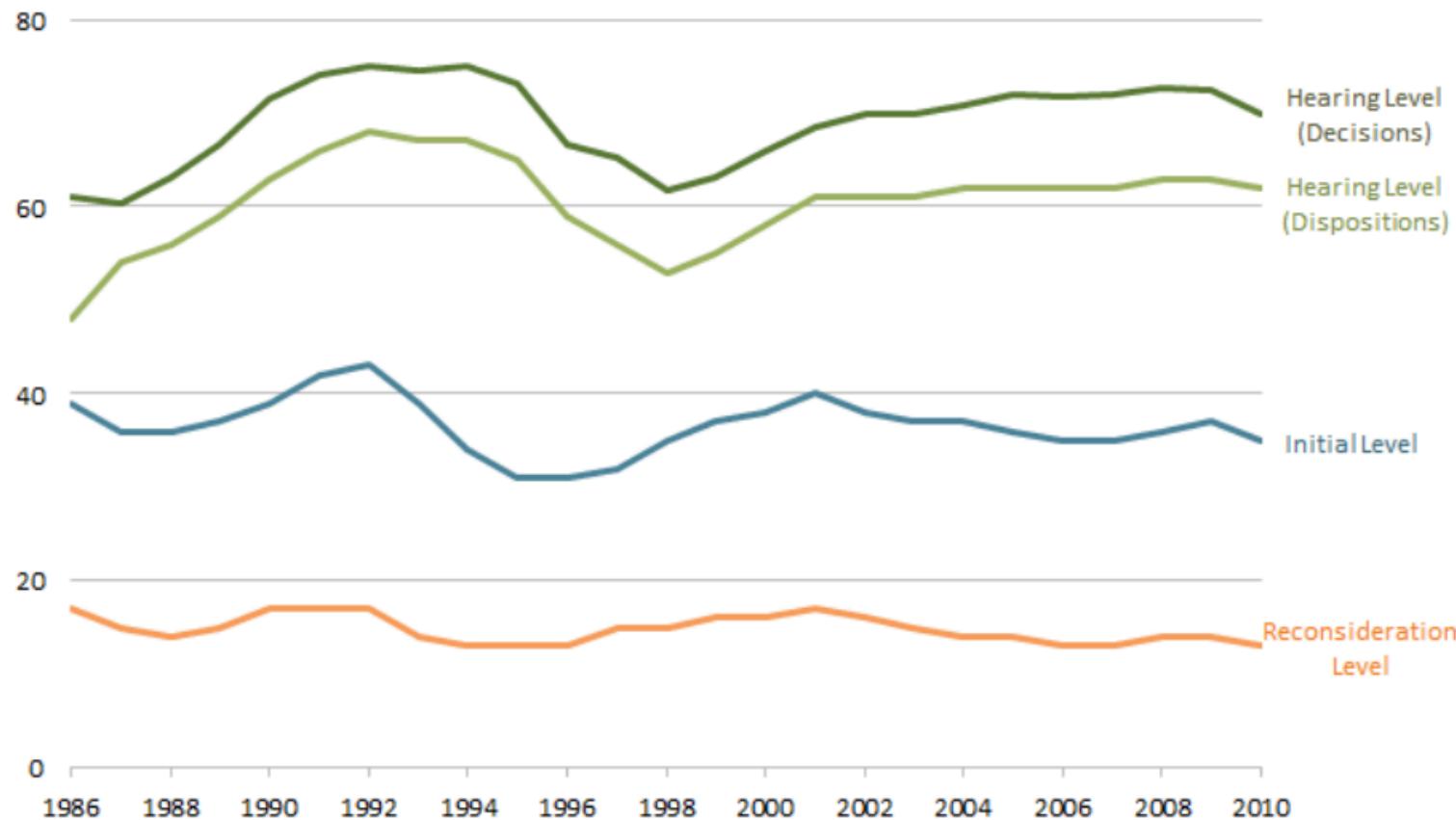
Social Security Advisory Board, *Aspects of Disability Decision Making: Data and Materials*, February 2012

Adapted from Telling Visual Stories About Data, Congressional Budget Office, Fontaine, 2014.

Example of accentuating communication

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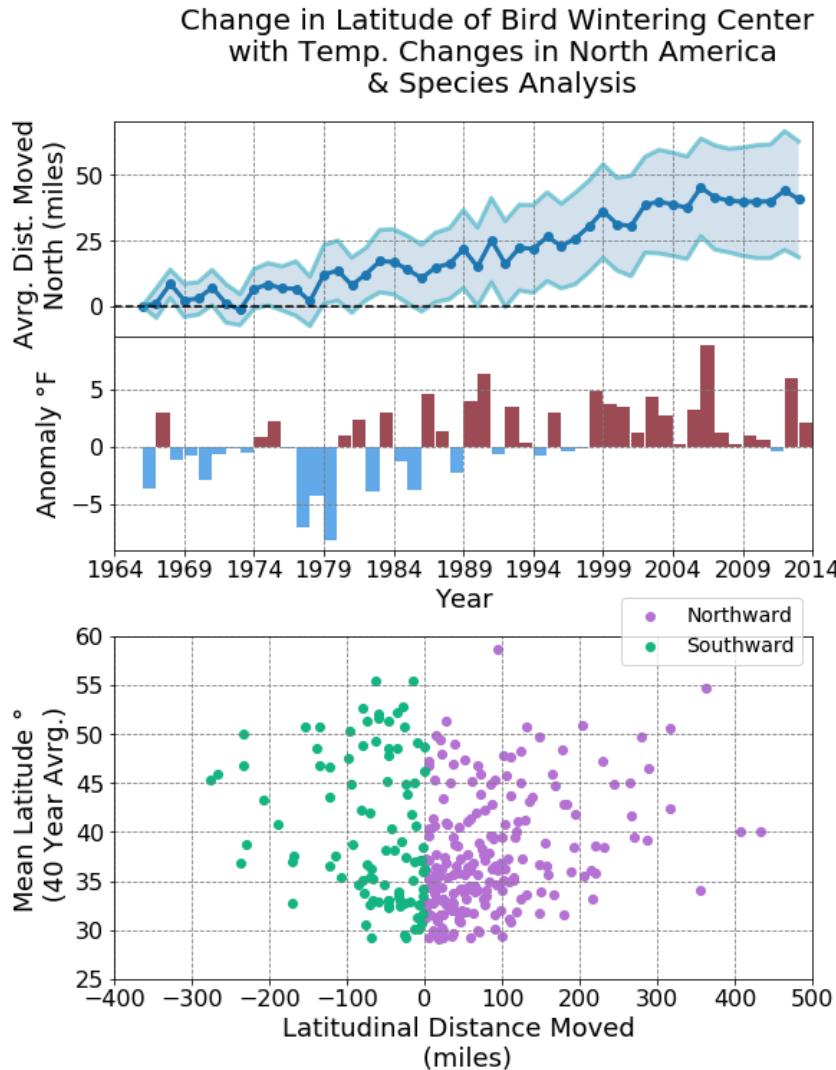
Once you have an idea of what you want to present and to whom...

Consider the following steps and design elements

- Compose
 - Organizing elements, defining relationships
- Abstract
 - Define and represent the meaning
- Color (our favorite)
 - Chose your colors to highlight relationships, label, attract or downplay interest
- Layer
 - Overlap multiple objects to create relationships
- Refine
 - Edit and simplify to the most direct communication possible

Element 1 – Composition – how your figure “flows”

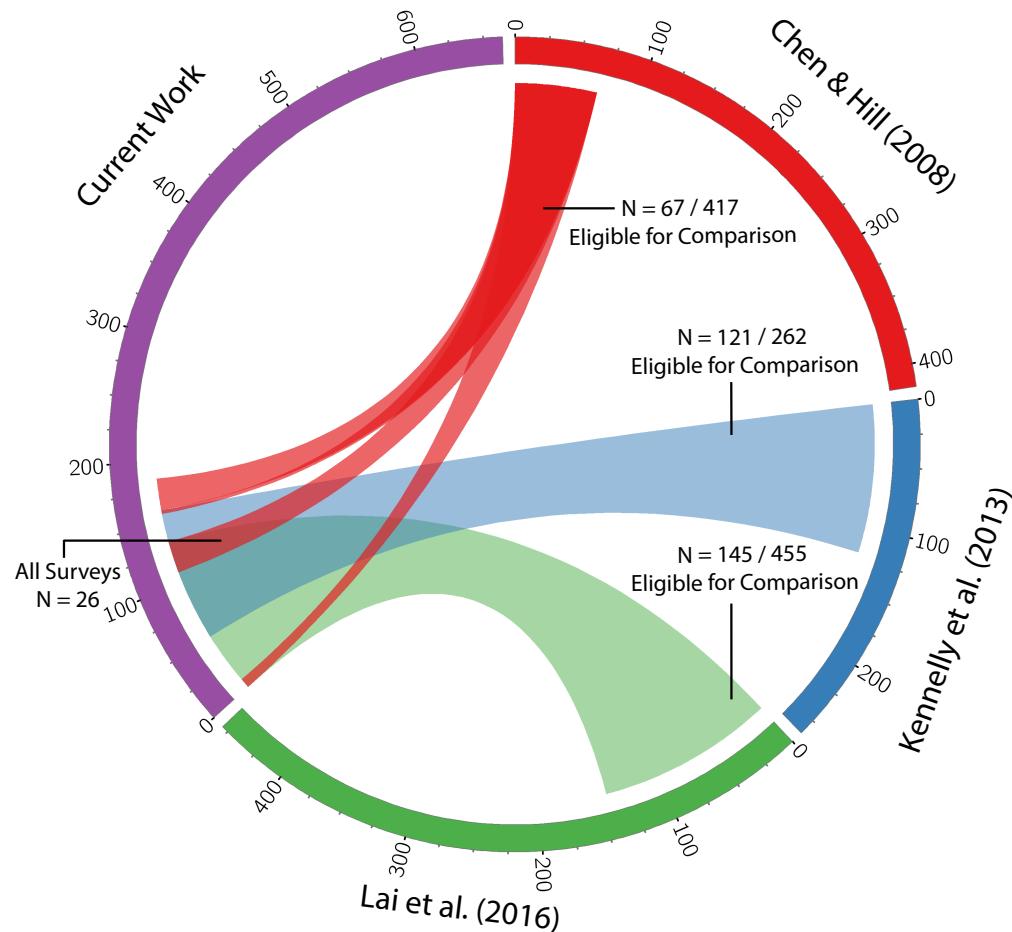
What relationships are you highlighting?



This is an example from the CLaSP course (Lab 2). We merged these first axis, to make them more comparable for the reader

While these data are of different TYPE (not time dependent) so we keep them separate

Element 1 – Composition – how your figure “flows” *What relationships are you highlighting?*

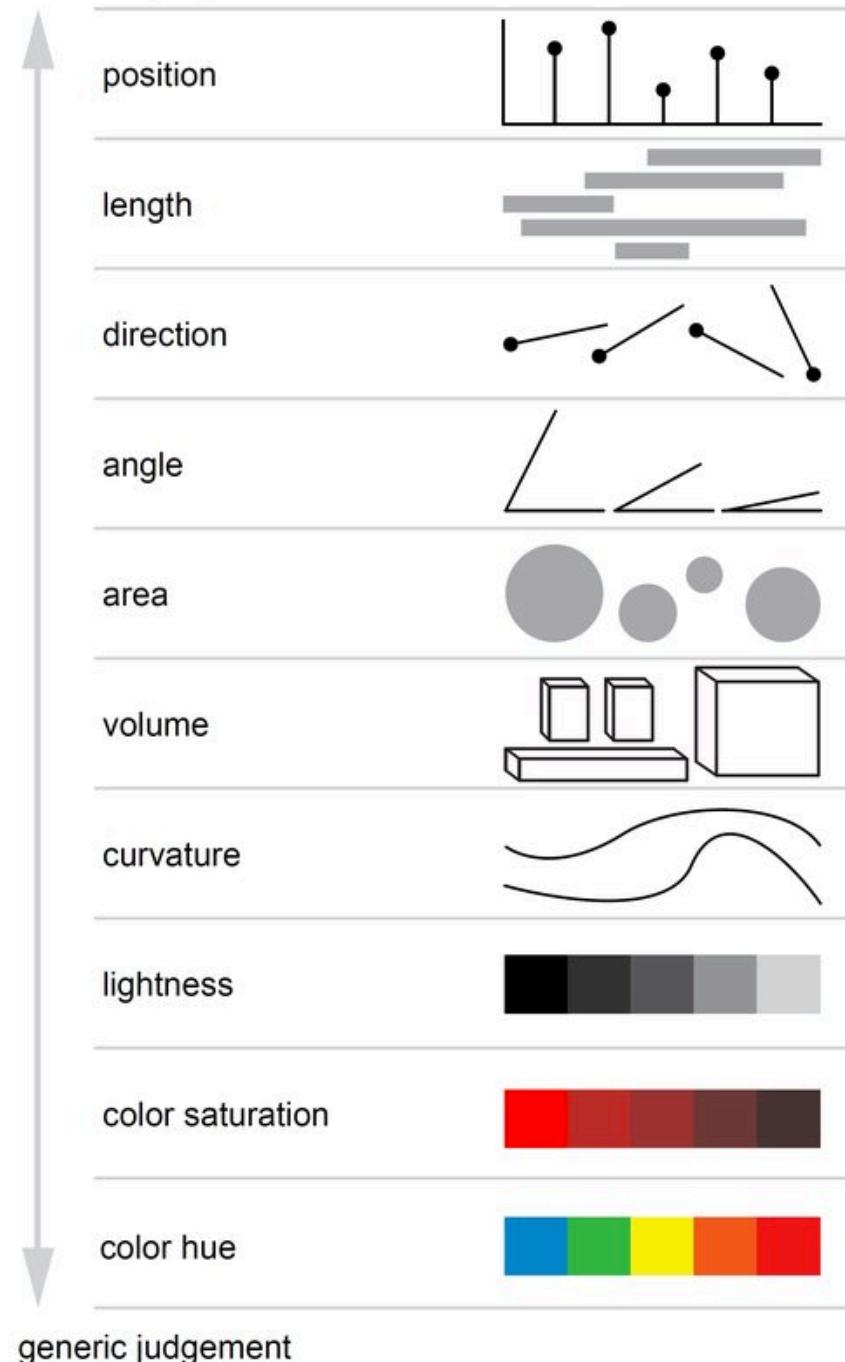


You can also have a single figure display a flow

This is a relational diagram, made with a program called Circos. Here the flow is first circular then across as designated by the connection lines.

Don't be afraid to try new things!

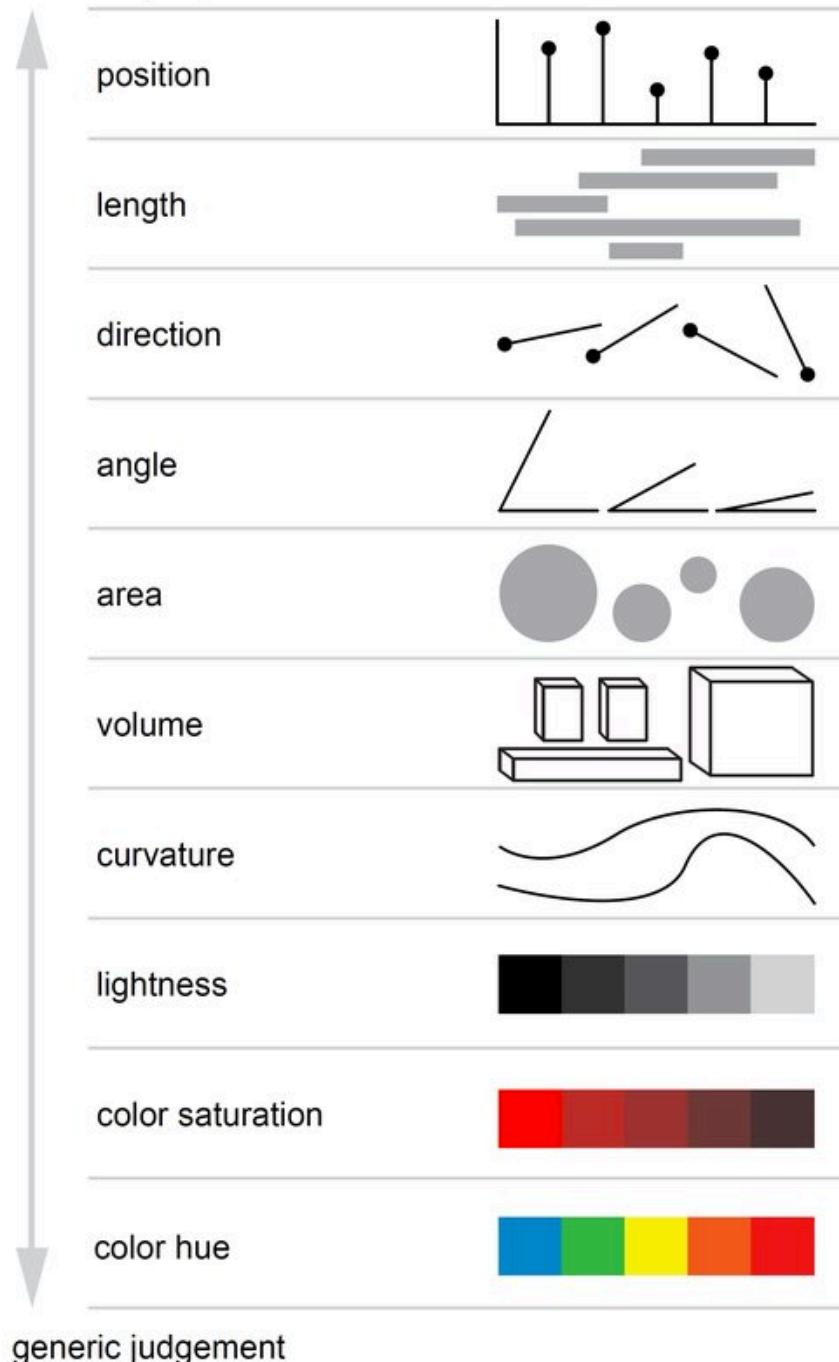
Source: [Azari et al., 2018.](#)



Element 2 – Abstract

What type of abstraction is supposed to represent your data? Define and representation.

Some general guidelines from hallmark graphics study on accuracy perception by Cleveland & McGill



Element 2 – Abstract

This is where some of the quotable “rules” come from –

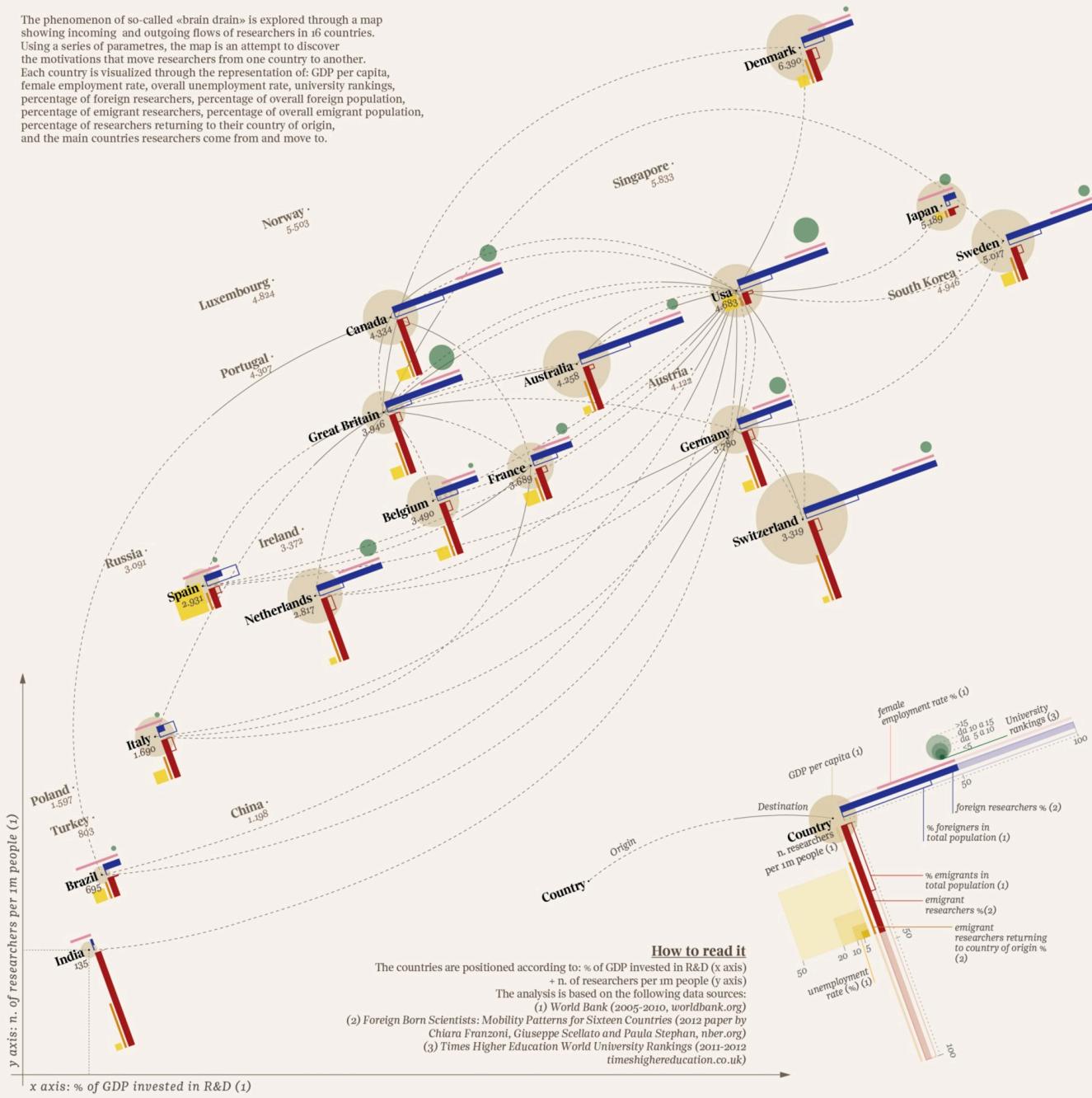
if you can create a figure that avoids relying on color hue or area for direction or position it is usually recommended

Element 2 – Abstract

You can get rather creative here – for example –

This chart is creating a new style of abstraction to communicate “brain drain” between 16 countries

The phenomenon of so-called «brain drain» is explored through a map showing incoming and outgoing flows of researchers in 16 countries. Using a series of parameters, the map is an attempt to discover the motivations that move researchers from one country to another. Each country is visualized through the representation of: GDP per capita, female employment rate, overall unemployment rate, university rankings, percentage of foreign researchers, percentage of overall foreign population, percentage of emigrant researchers, percentage of overall emigrant population, percentage of researchers returning to their country of origin, and the main countries researchers come from and move to.

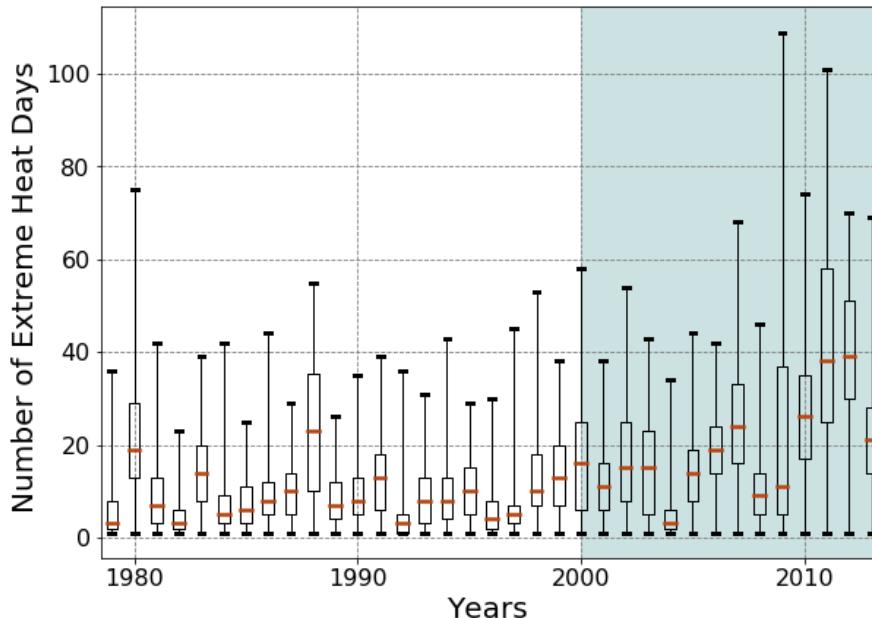
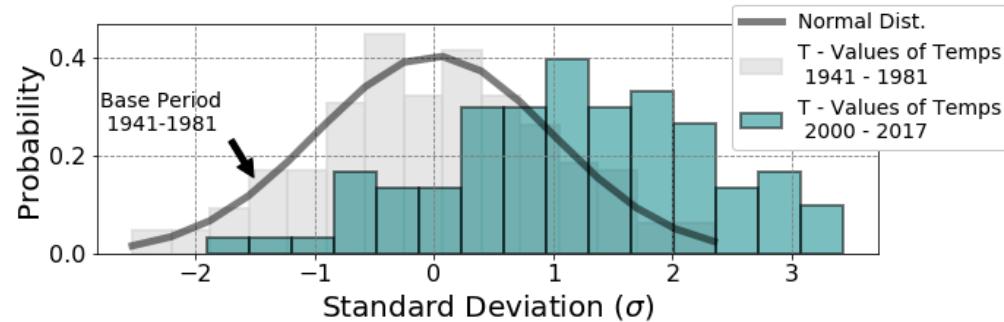


Source: The global Brain Drain—Accurat for La Lettura, Corriere della Sera

Element 3 – Color

Use color to highlight, to show relationships, to indicate values

“colors are the mother tongue of the subconscious” – Carl Jung



We spend a lot of our time in this class with colors –

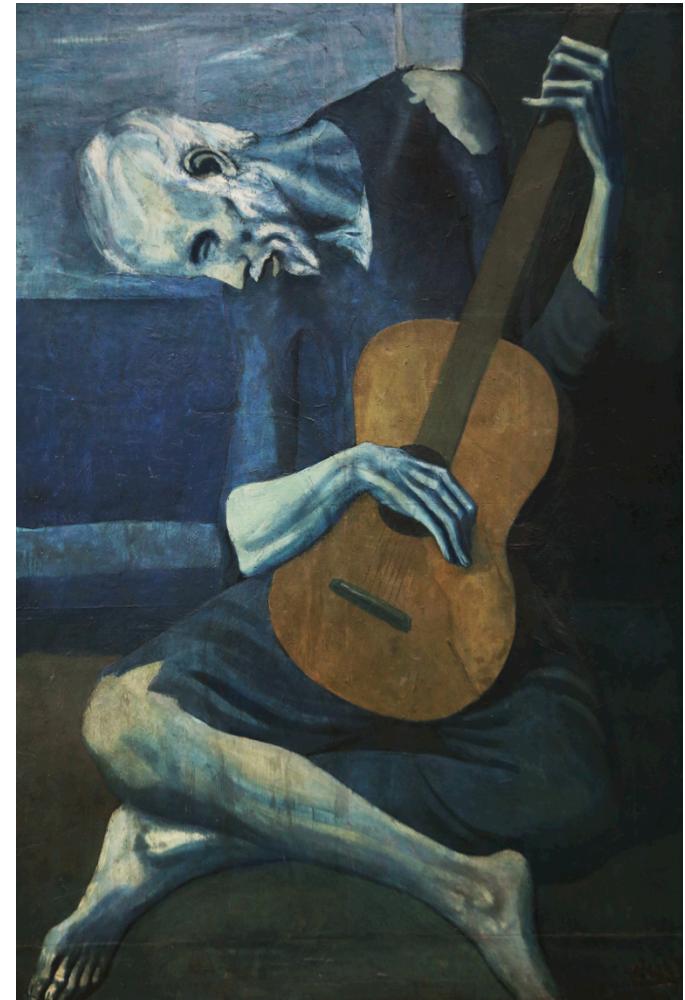
Here we tied together two times periods by signifying color

Element 3 – Color

Some guidelines of color in design

Consider Conveying
Information Or Meaning By
Color Choice –

- Red usually will highlight something extreme or something “hot”, blue is more “sedate”
- In general if you are graphing a location - green is good for land, blue for ocean etc



Old Guitarist – Pablo Picasso

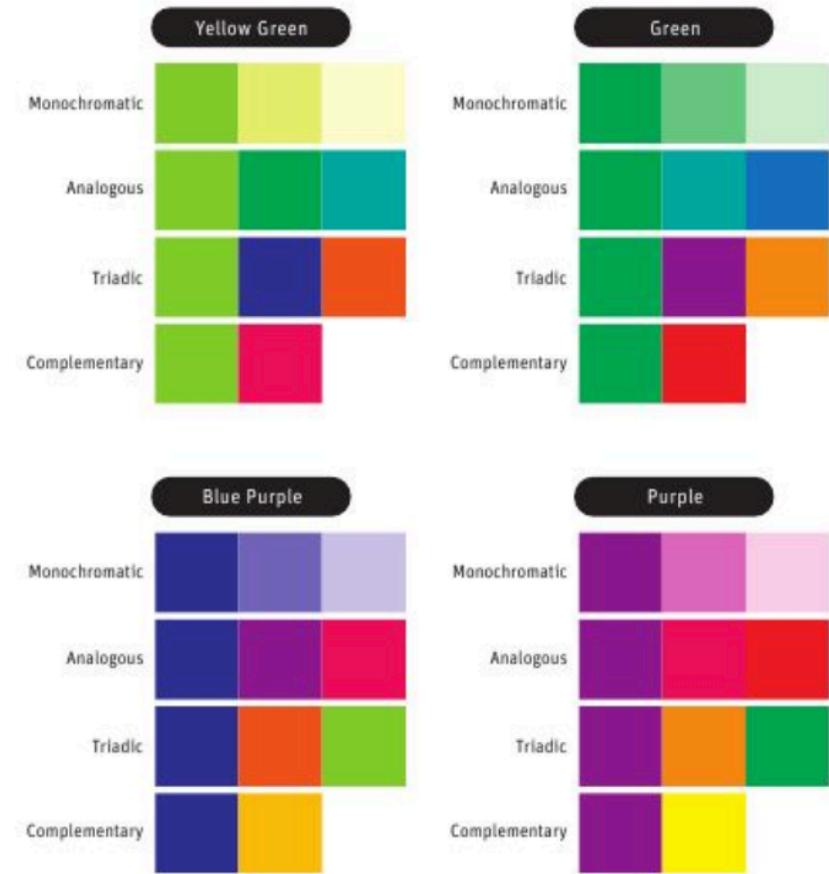
Element 3 – Color

Some guidelines of color in design

Once you choose a color –
create color harmony

Suggestions for building a
color palette –

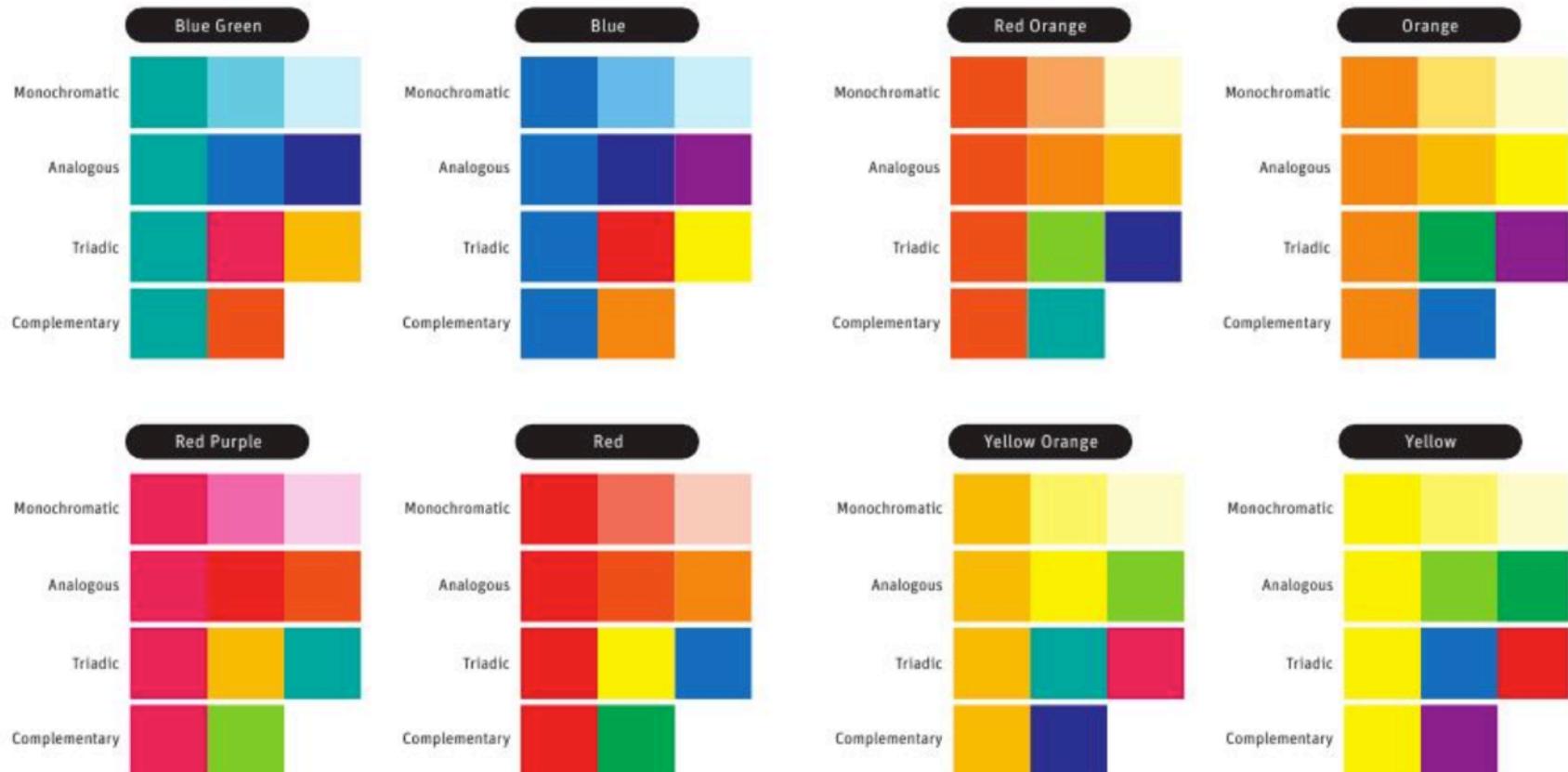
- Choose a **primary color – and then accent** around it
- Do not overload on colors, usually **5 or less is good** enough
- Play around – **what looks good?** What accentuates difference?



Element 3 – Color

Some guidelines of color in design

Example of color choice in action – these are classic pallets to put together – you can find more of course online



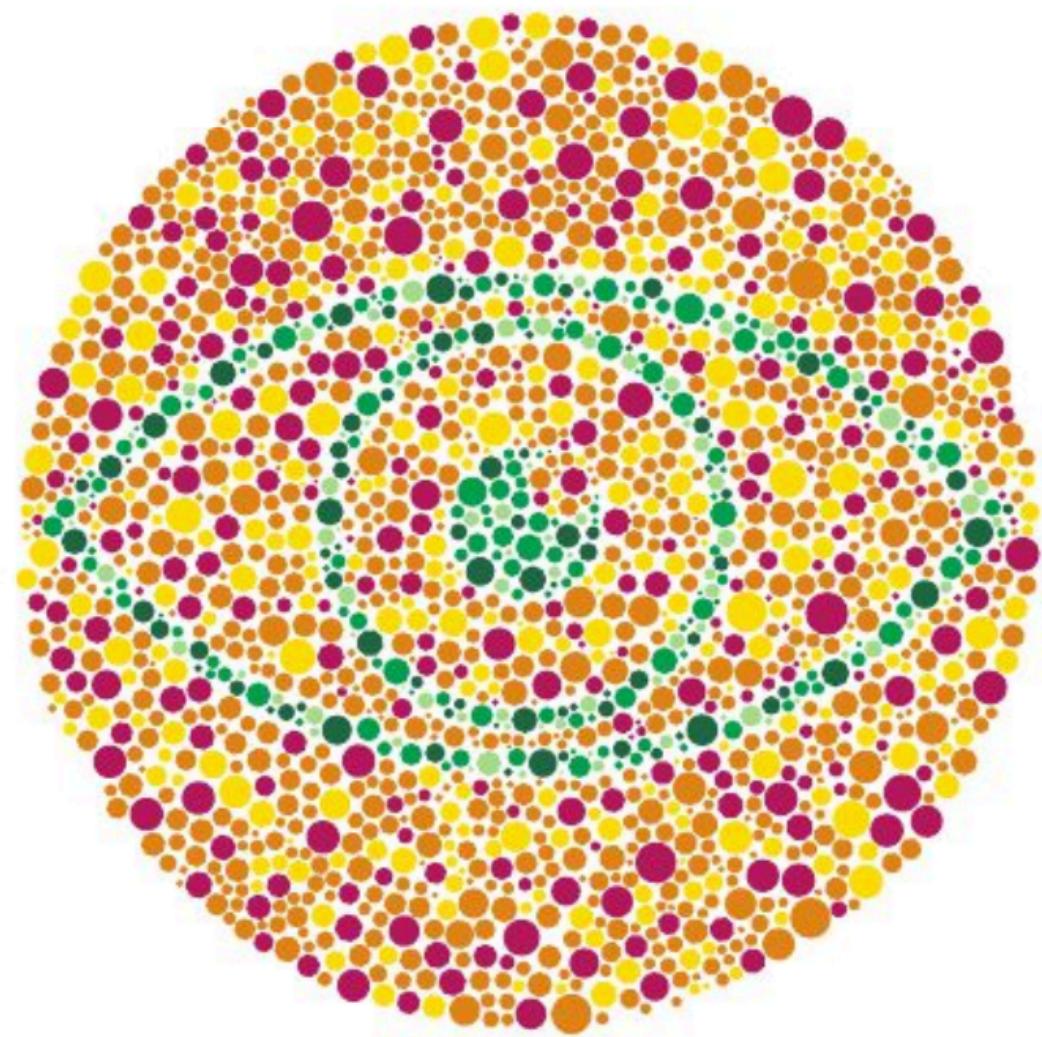
Element 3 – Color

Some guidelines o
color in design

People see colors
differently

Good colors to *avoid*:
Red & Green in combo

Resource: You can get
“hex codes” and palettes
from a variety of websites
– my favorites [\[1\]](#), [\[2\]](#), [\[3\]](#)



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VIZ PALETTE By: Elijah Meeks & Susie Lu

PICK

Use Chroma.js Add Replace

Use Colorgorical

Use ColorBrewer

EDIT

7 Colors

Add hex orgb hsl

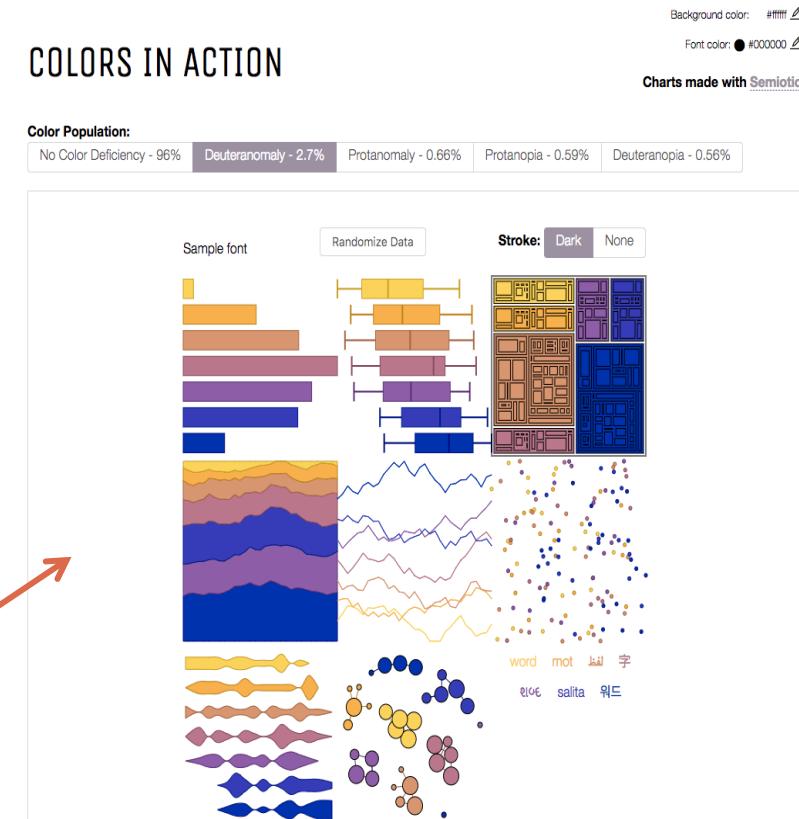
1 #ff6700 2 #ffb14e 3 #a8775 4 #ea5f94 5 #cd34b5 6 #9d02d7 7 #0000ff

GET

String quotes Object with metadata

```
[{"#ff6700", "#ffb14e", "#a8775", "#ea5f94", "#cd34b5", "#9d02d7", "#0000ff"]
```

COLORS IN ACTION



<http://projects.susielu.com/viz-palette>

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Some guidelines on color in design

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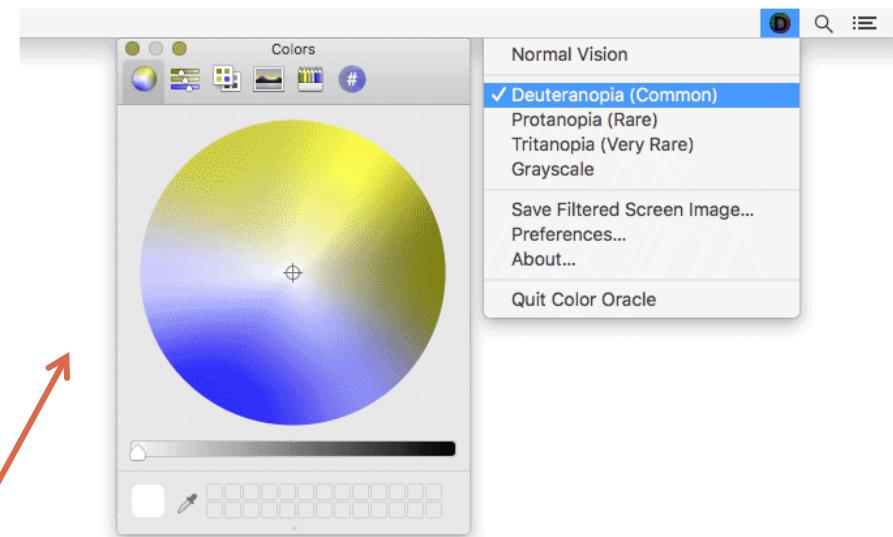
Color Oracle – Usage

Design for the Color Impaired



The system-wide menu quickly converts your art into a palette that simulates what colorblind people see. Color Oracle integrates smoothly in your workflow. Select the type of color-blindness in the menu or press one of the keyboard shortcuts while you are working with your preferred graphics software. Color Oracle immediately filters your screen image and hides itself automatically when you press any key or click the mouse button.

See the [Manual](#) for more details.



<https://colororacle.org/usage.html>

Element Color

Some guidelines of color in design

People see colors differently

Try to vary in hue AND saturation

Feel free to experiment!

Light Colors

Dark Colors

High Contrast

Not as effective

2. Choose dark colors with hues from the bottom half of this hue circle against light colors from the top half of the circle. Avoid contrasting light colors from the bottom half against dark colors from the top half. The orientation of this hue circle was chosen to illustrate this point.

For most people with partial sight and/or congenital color deficiencies, the lightness values of colors in the bottom half of the hue circle tend to be reduced.

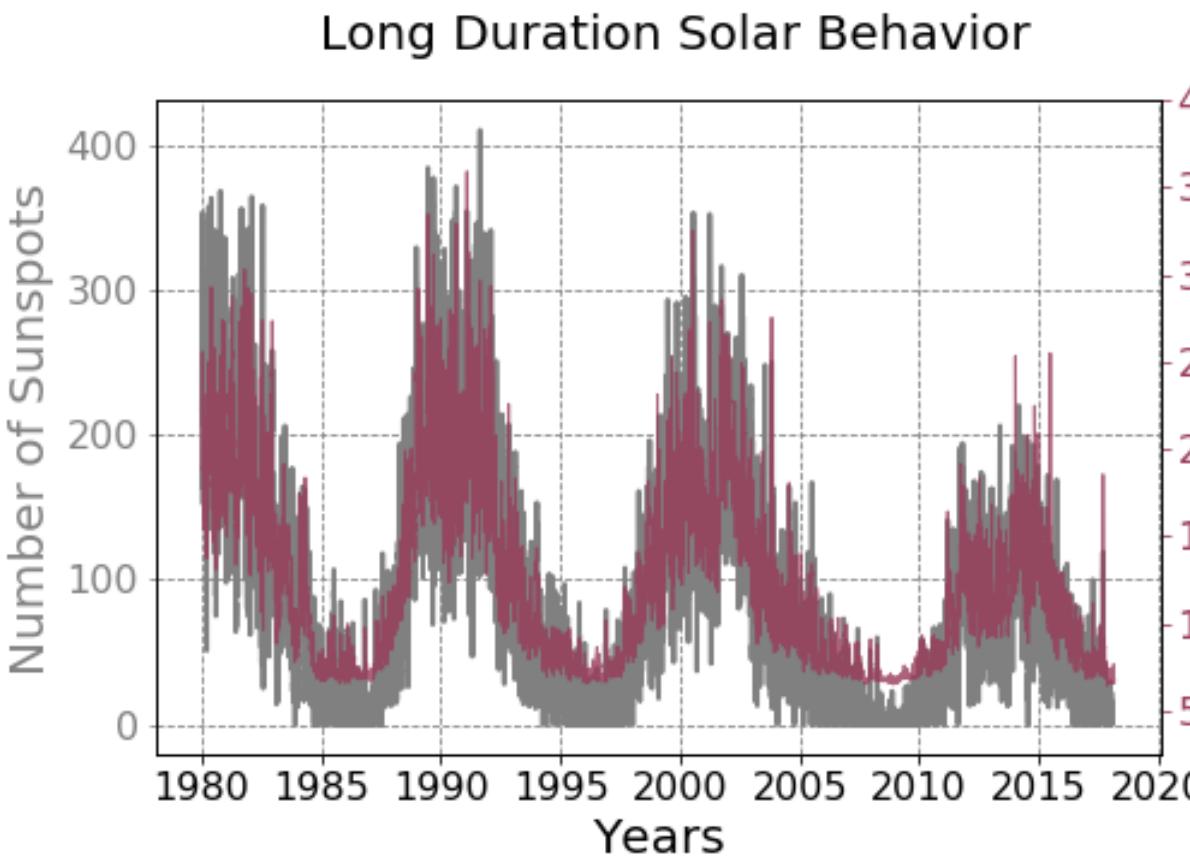
3. Avoid contrasting hues from adjacent parts of the hue circle, especially if the colors do not contrast sharply in lightness.

Color deficiencies associated with partial sight and congenital deficiencies make it difficult to discriminate between colors of similar hue.

Based on Adams, 2008.

Element 4 – Layering

Add layers to express meaning



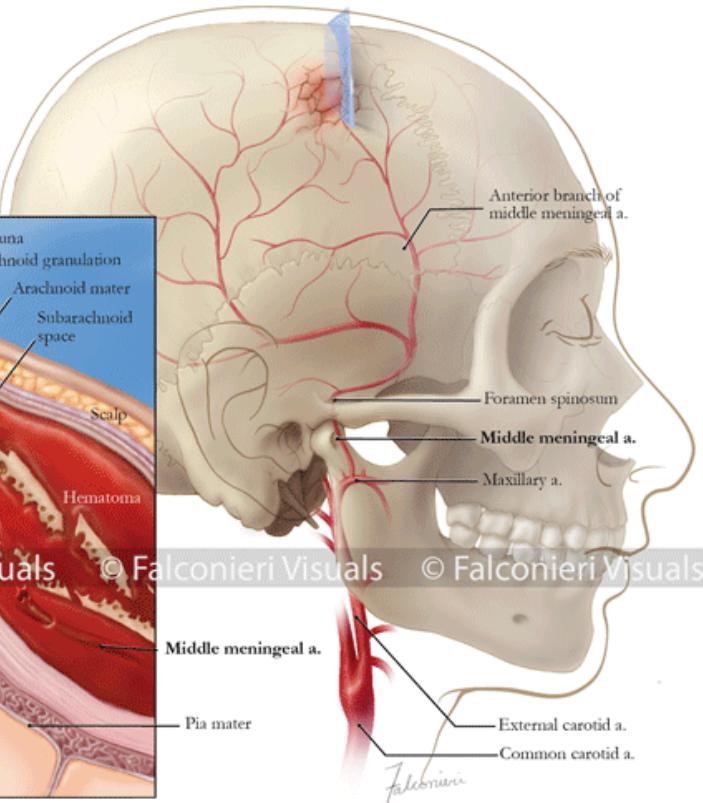
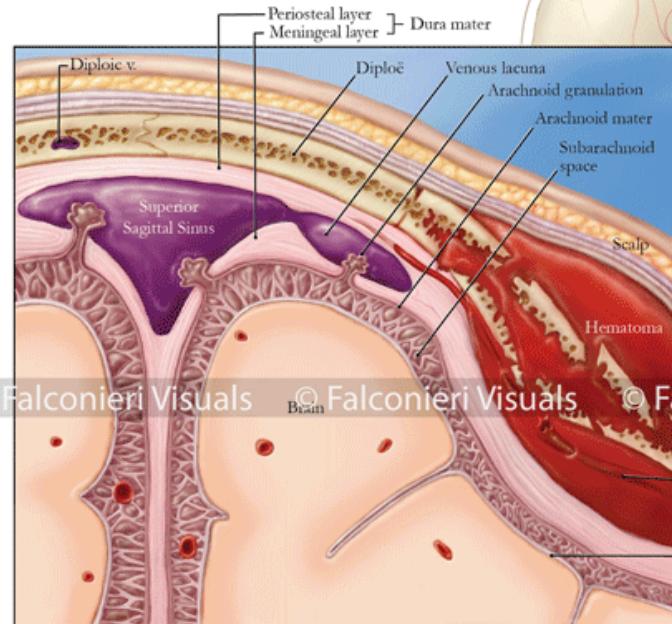
This graphic is produced in Lab 7. We are using layers to express potential relation

Element 4 – Layering

Add layers to express meaning

Role of the Middle Meningeal Artery in Extradural Hematoma

The middle meningeal artery is often the source of blood during extradural hematoma. Due to its location adjacent to the bone in more lateral regions of the skull, the middle meningeal artery is easily damaged by head trauma. Blood accumulation between dura mater and bone creates pressure that may result in brain injury or death.



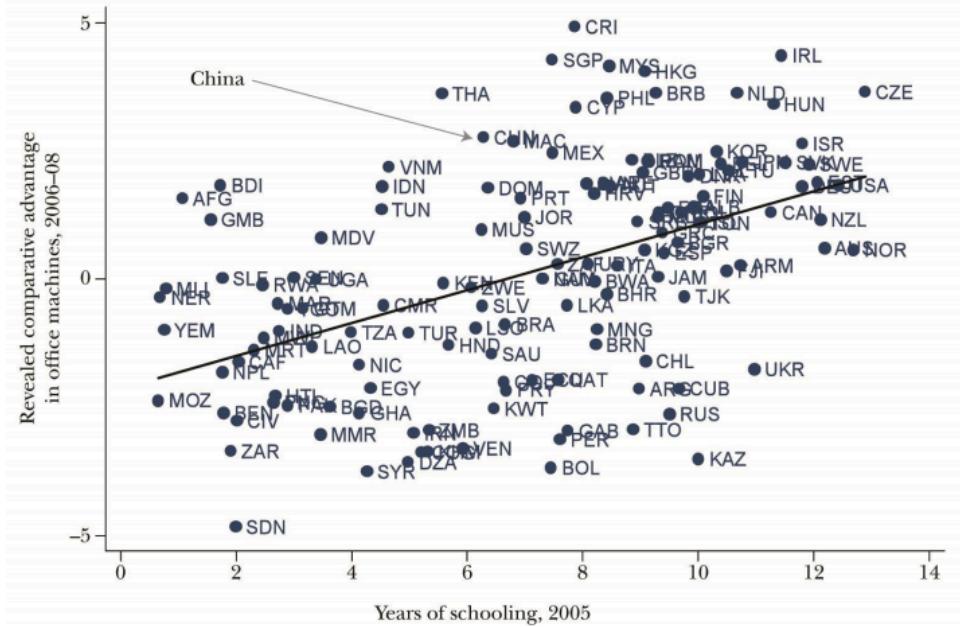
From V.
Falconieri –
[http://
falconierivisuals.
com/](http://falconierivisuals.com/)

Element 5 – Refine

Once you have a good layout – try seeing how you can simplify it to express the most meaning

Reduce Clutter

Figure 4
Education and Exports of Office Machines



Gordon Hanson, *Journal of Economic Perspectives*, Spring 2012

Based on Frankel and DePace, 2012.

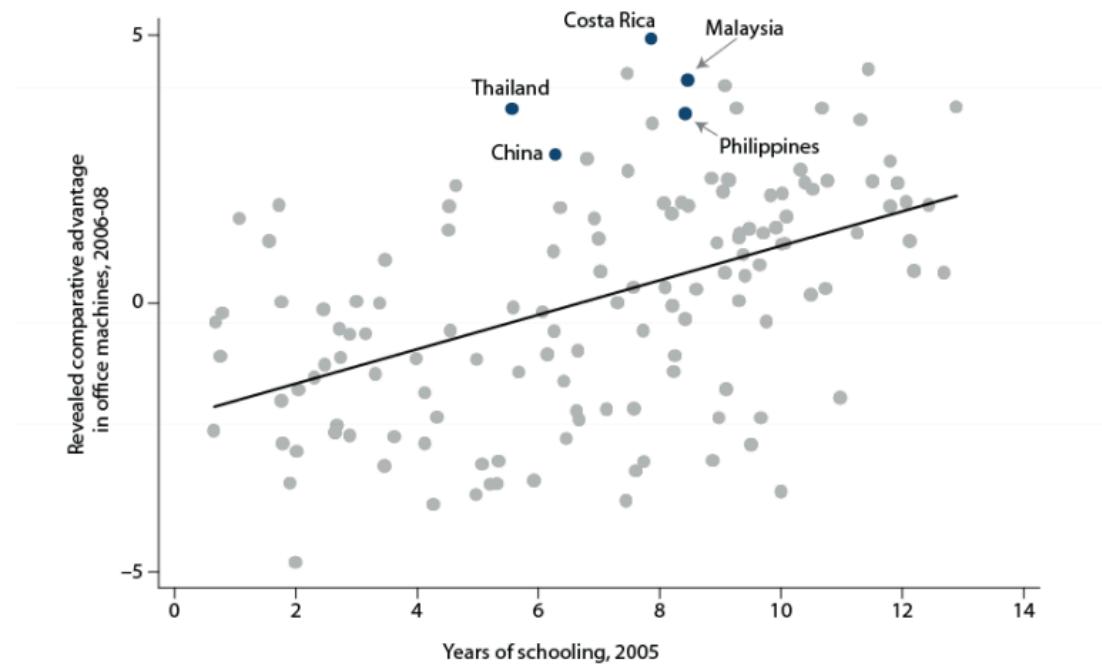
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Based on Frankel and DePace, 2012.
Adapted from Telling Visual Stories About Data, Congressional Budget Office, Fontaine, 2014.

What we've learned

When starting a visualization for data consider what is the main point of my graphic and what is my audience?

- Is my graphic **explanatory** or **exploratory**?
- How will it be **used**?
- What is the first thing you want your audience to see?

When making a figure consider:

- Composition
- Abstraction
- Coloring (make sure to consider colorblind palettes!)
- Layering
- Refining

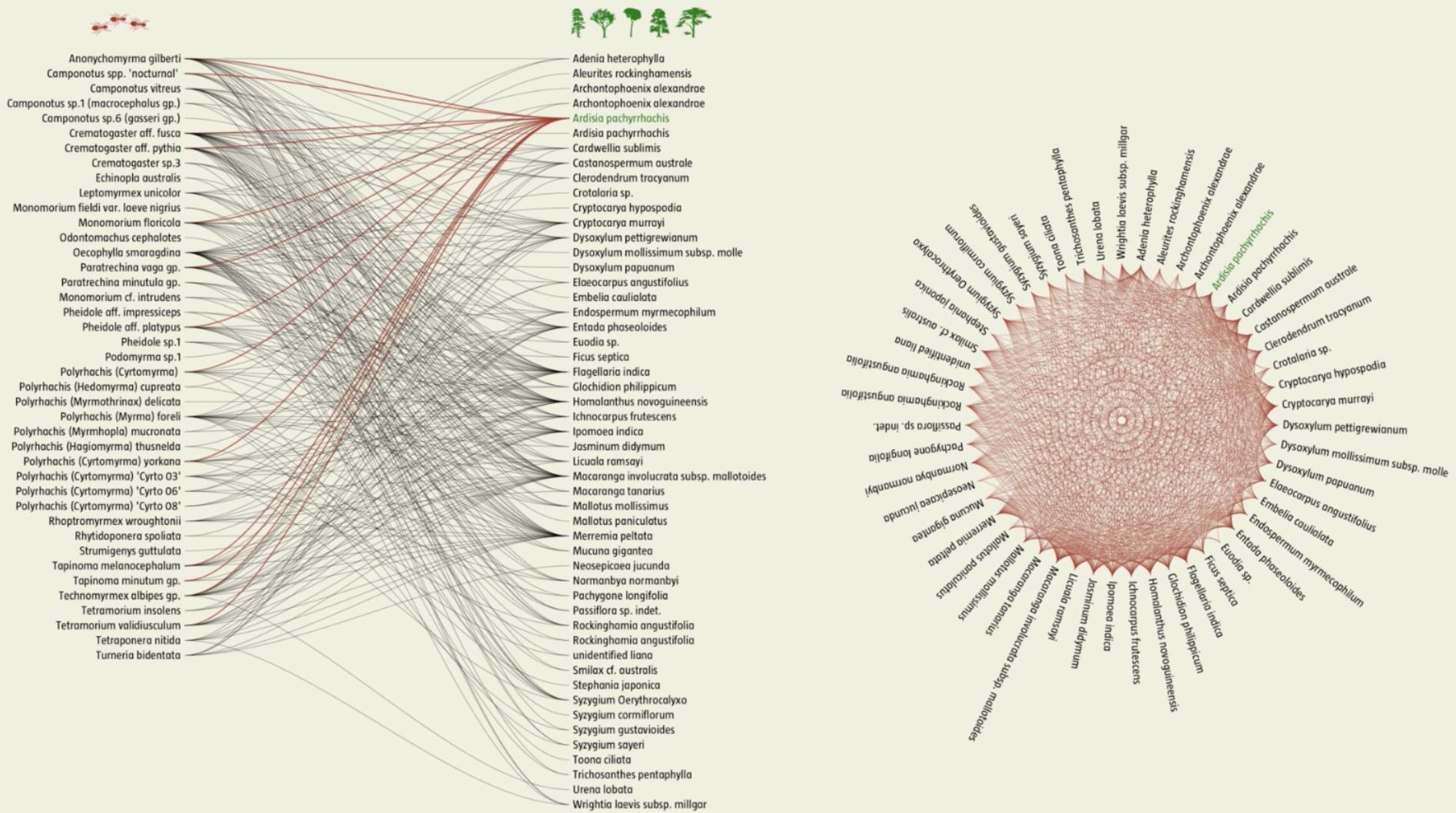
Let's put what we've learned into practice

- Consider these as we watch the following video -
[http://players.brightcove.net/679256133001/NkgrDczuol_default/index.html?
videoid=5373954480001](http://players.brightcove.net/679256133001/NkgrDczuol_default/index.html?videoid=5373954480001)
- This won the NSF Expert's Choice award in 2017 for best video visualization.
- Think as we watch this how these use the elements to address their audience
 - Composition
 - Abstraction
 - Coloring
 - Layering
 - Refining

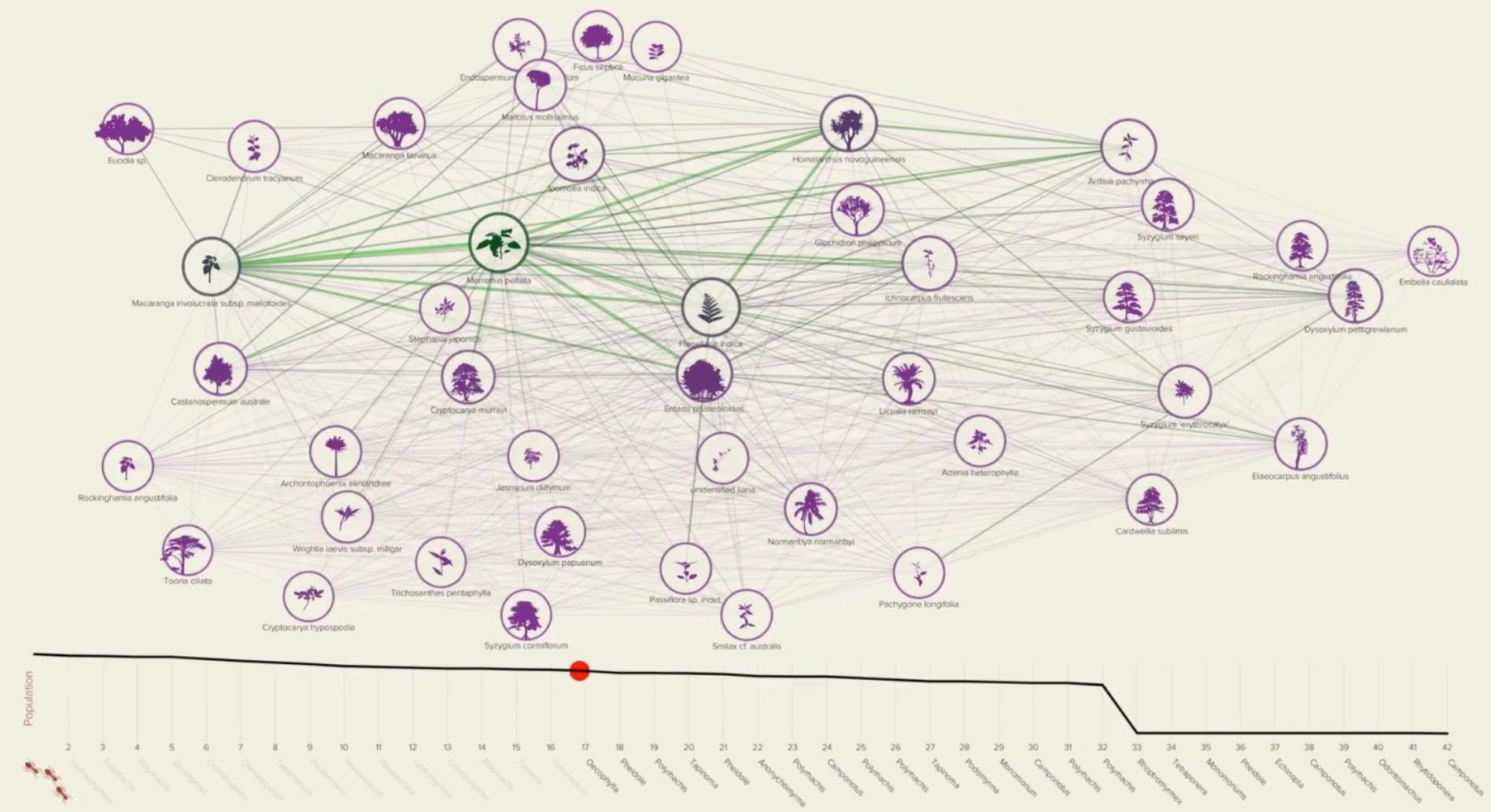
Let's put what we've learned into practice

Now on your desk discuss the screenshots with a friend
...and how these use the elements to address their audience

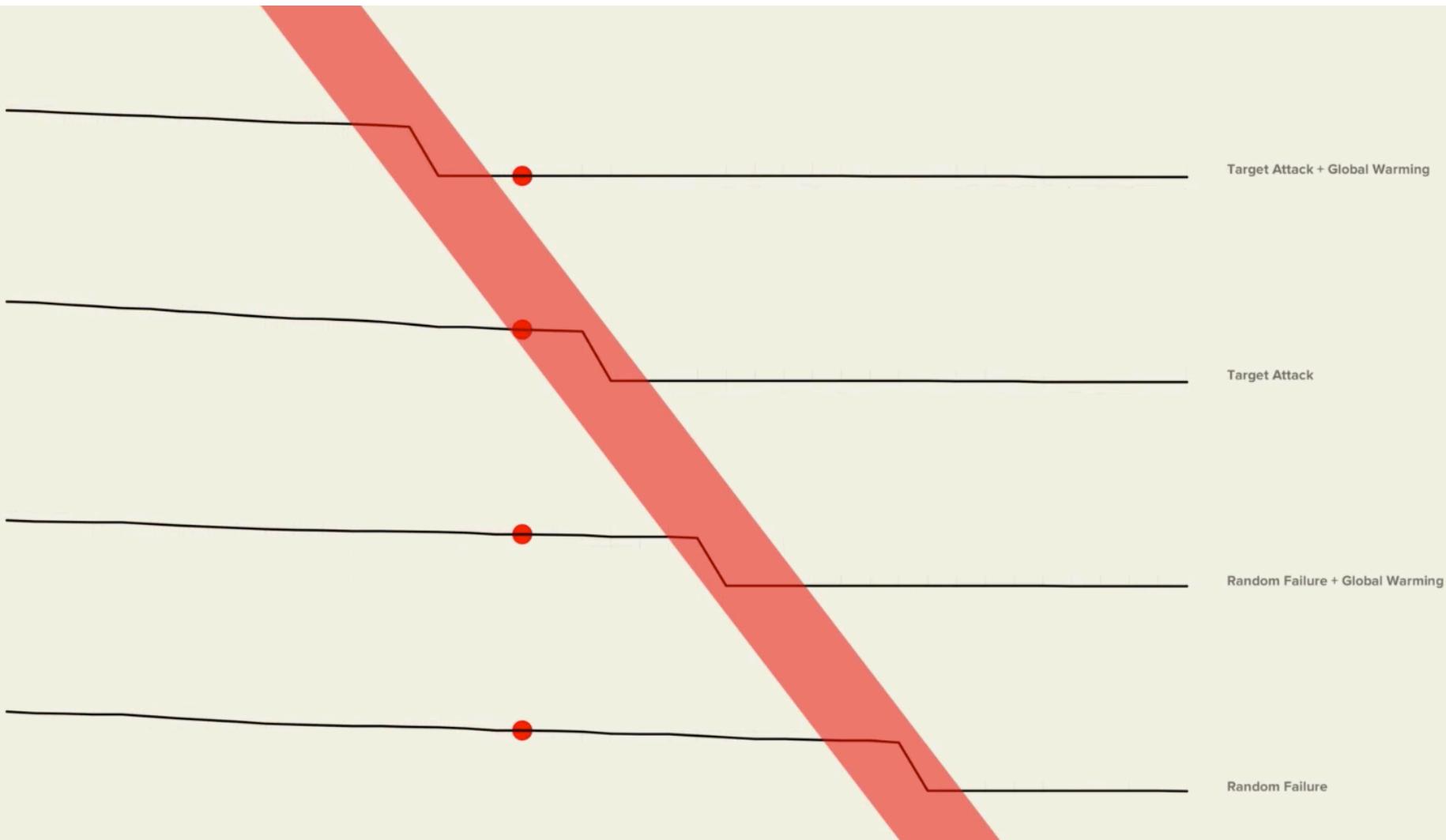
- Composition
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- Coloring
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- Refining



Source: Network Earth, Mauro Martino, Jianxi Gao, Baruch Barzel, Albert-László Barabási. Narration: Shamini Bundell



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