Data Visualization

Overview for the ASSURE REU

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The goal for today is to introduce you to two guiding questions when you pursue data visualization

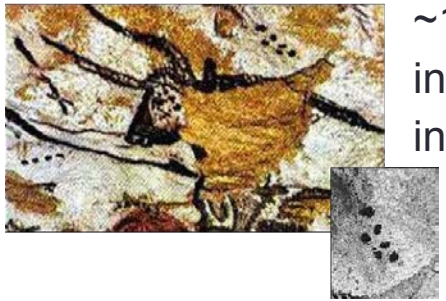
1) How can I convey my findings (data/conclusions) most informatively (**accuracy**)?

2) How can I create *interesting* and *approachable* graphics (**aesthetics**)?

...with the tools we have in computing (next lesson)

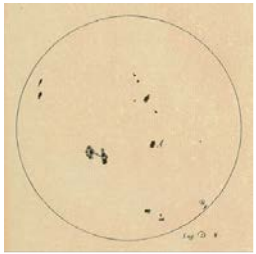
A Brief History of Visualization

Exploring information about our and other worlds in visualization is part of human history



~16,500 years ago – interpretation of Pleiades in the Lascaux Caves

10th century, Surat al-Ard (Picture of the World) from al-Istakhri



1612 AD - Galileo's observation of sunspots

11-12th century - Mayan codex on eclipses and historical records ('Dresden Codex')

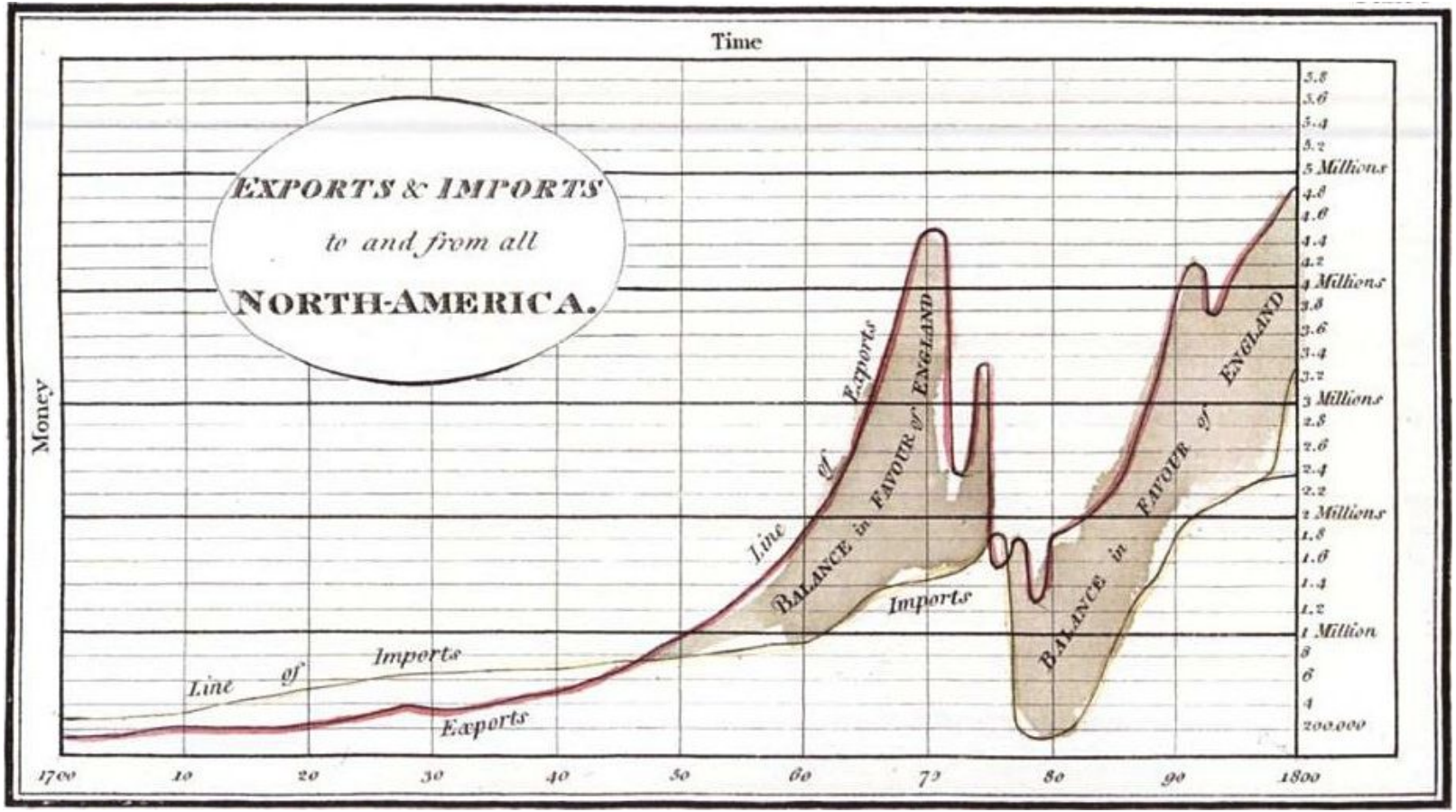
The beginning of more familiar visualizations?

With the advent of what we now term statistics and probability theory, more familiar visualizations become popular - let's take a look at these in small groups. We will assign you to Zoom rooms to discuss this.

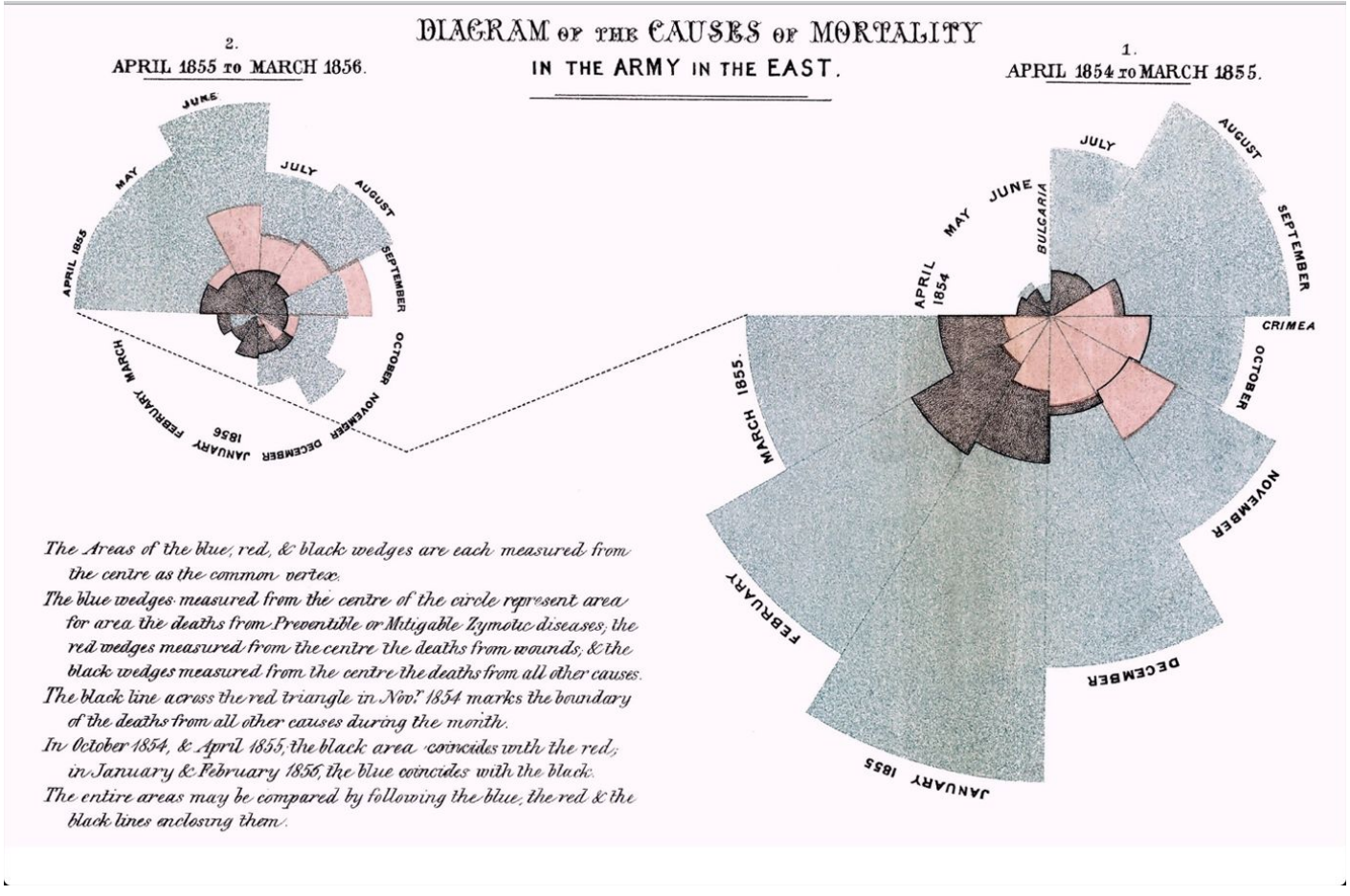
In your zoom room discuss:

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?

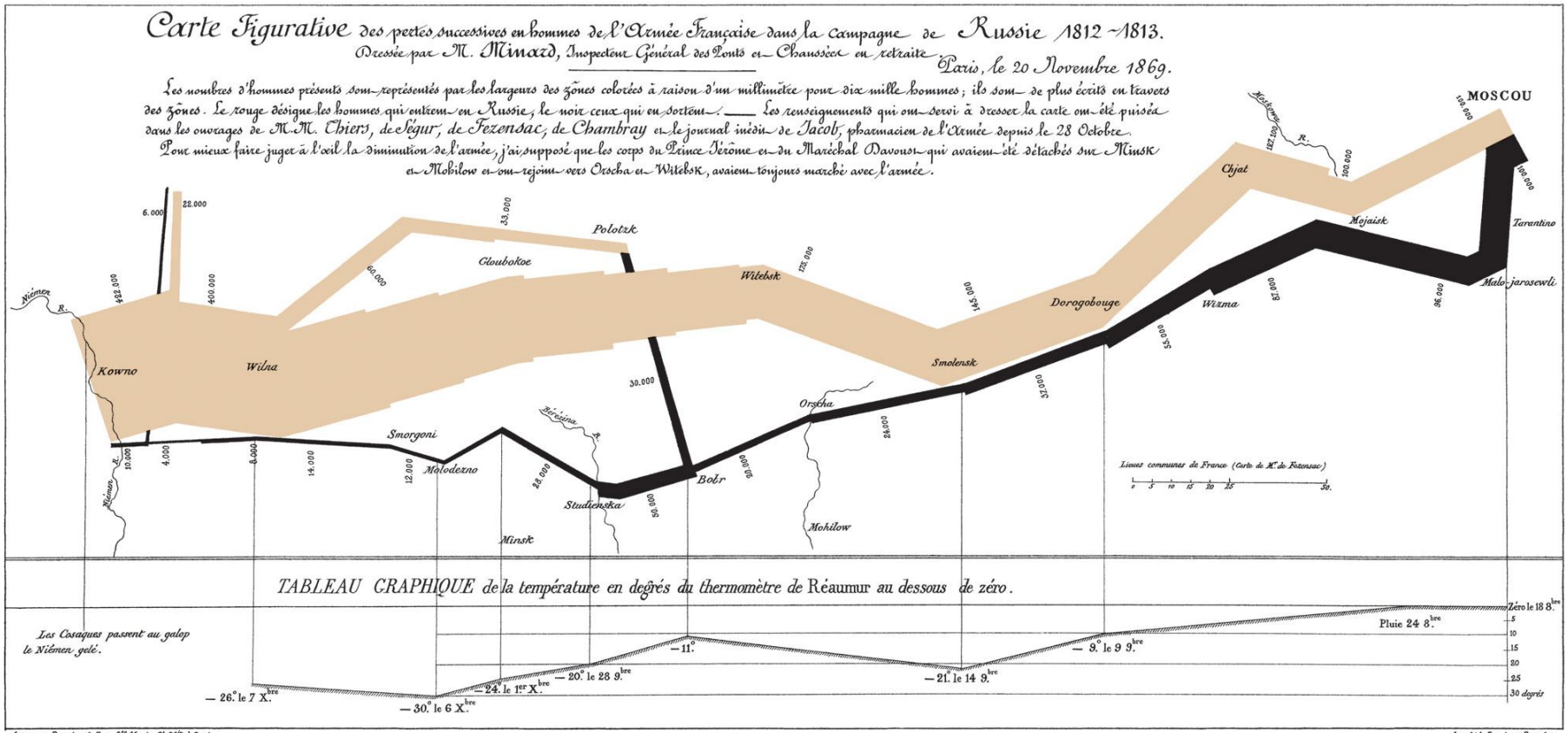
William Playfair's Charts - 1786



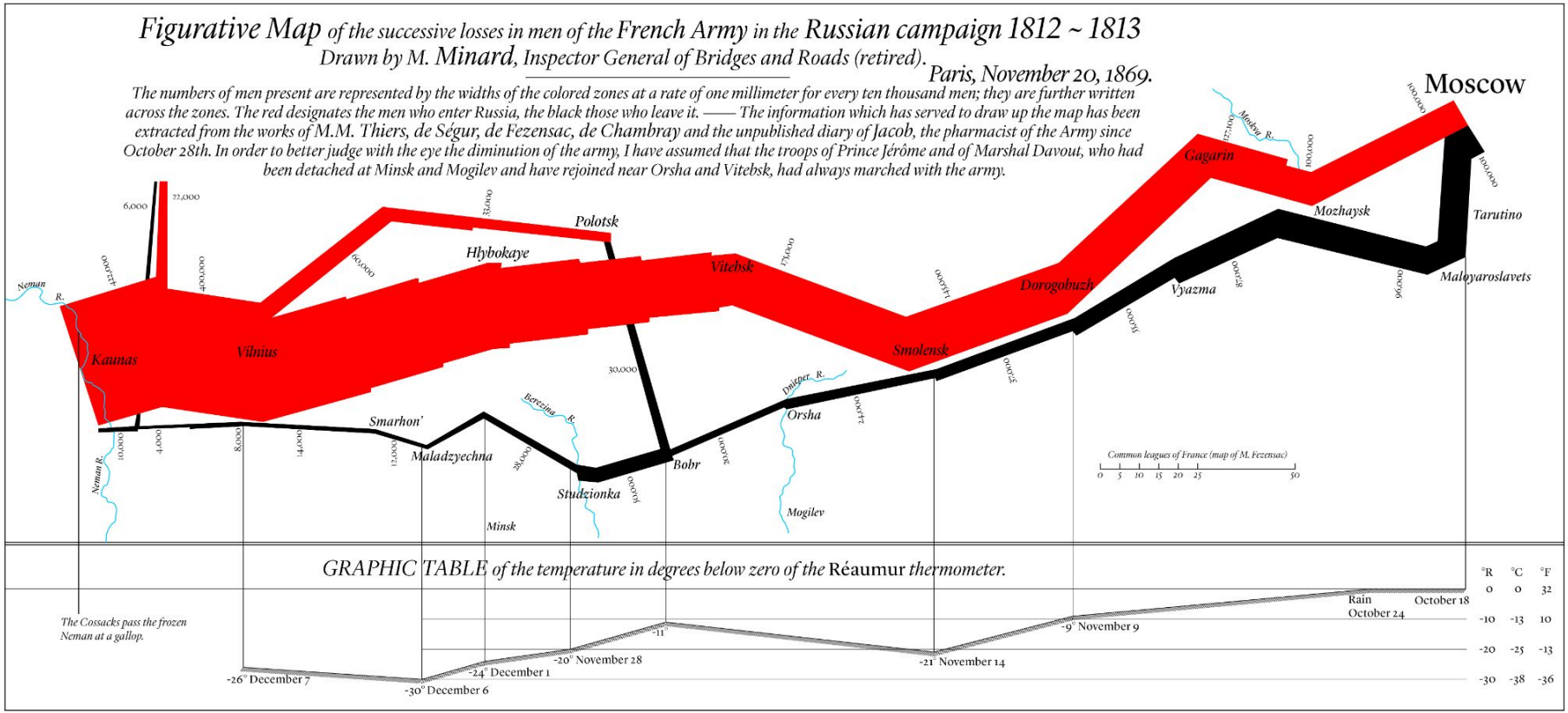
Florence Nightingale's Report ~1858



The “Minard Map” (original) - 1869



The “Minard Map” (English version) - 1869



What did these all have in common?

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- The main point of these data graphics were to convince someone (mostly a government) of certain ideas or realities to push forward a policy
- Their choice of presentation is made to **create conversation** around a certain topic.

Most real life visualizations are made for a purpose - and how we tell these stories about our work has impacts on the communication of our findings.

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

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- What about interactive graphics? Are these better?

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- If so, then which ones?
- Is 3D better than 2D?
- What about interactive graphics? Are these better?

The answers to these lie in who is your audience, and what point are you trying to make.

As we make visualizations then, instead we should ask ourselves...

1. Is the graphic explanatory or exploratory?

- **Explanatory** – you are trying to make a point, ask yourself 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 and research will be exploratory and then you finalize into an explanatory graphic.

Based on Frankel and DePace, 2012.

2. How will this 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.

Know your audience, what do they know? What do they need explained?

Based on Frankel and DePace, 2012.

3. What is the first thing you want them to see?

- 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 is for them.

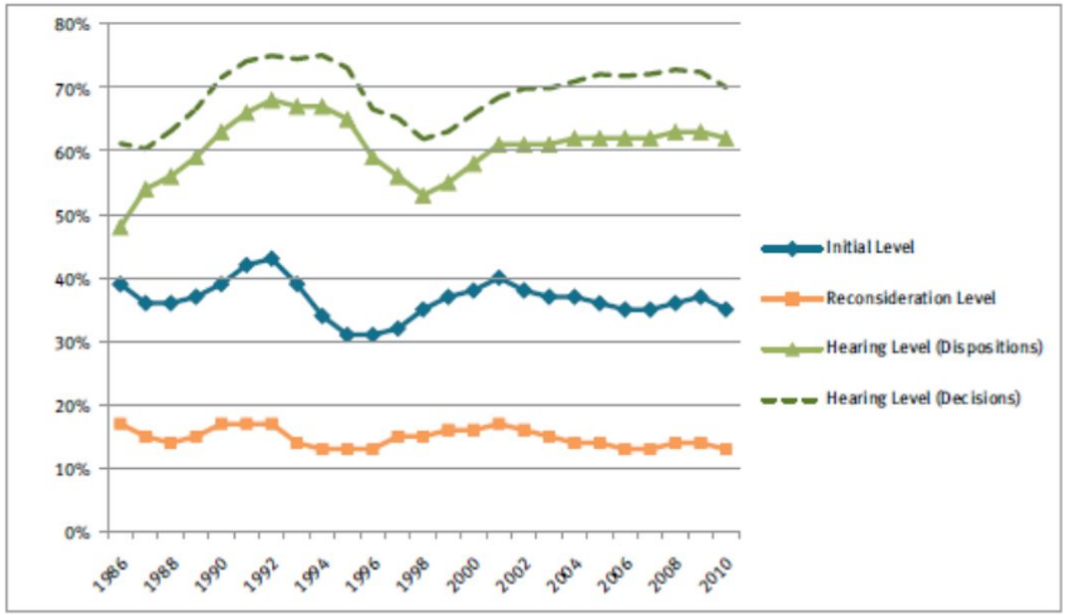
For example...

Based on Frankel and DePace, 2012.

Example of accentuating communication

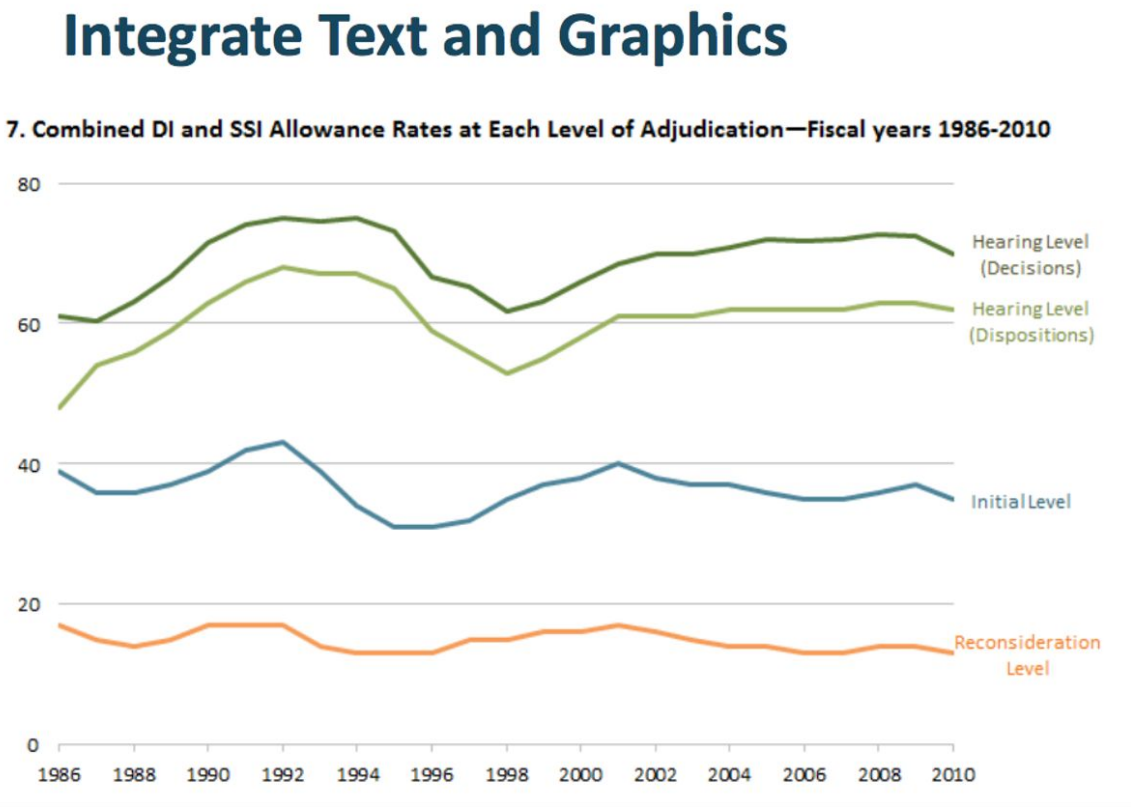
Integrate Text and Graphics

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



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

Example of accentuating communication



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

Once you've an idea of what you are presenting, and to whom

Consider the following design elements

Compose

- Organizing elements, defining relationships

Abstract

- Define and represent meaning

Color

- Choose your color(s) to highlight relationships, label, attract or downplay interest

Layer

- Overlap multiple levels to represent relationships

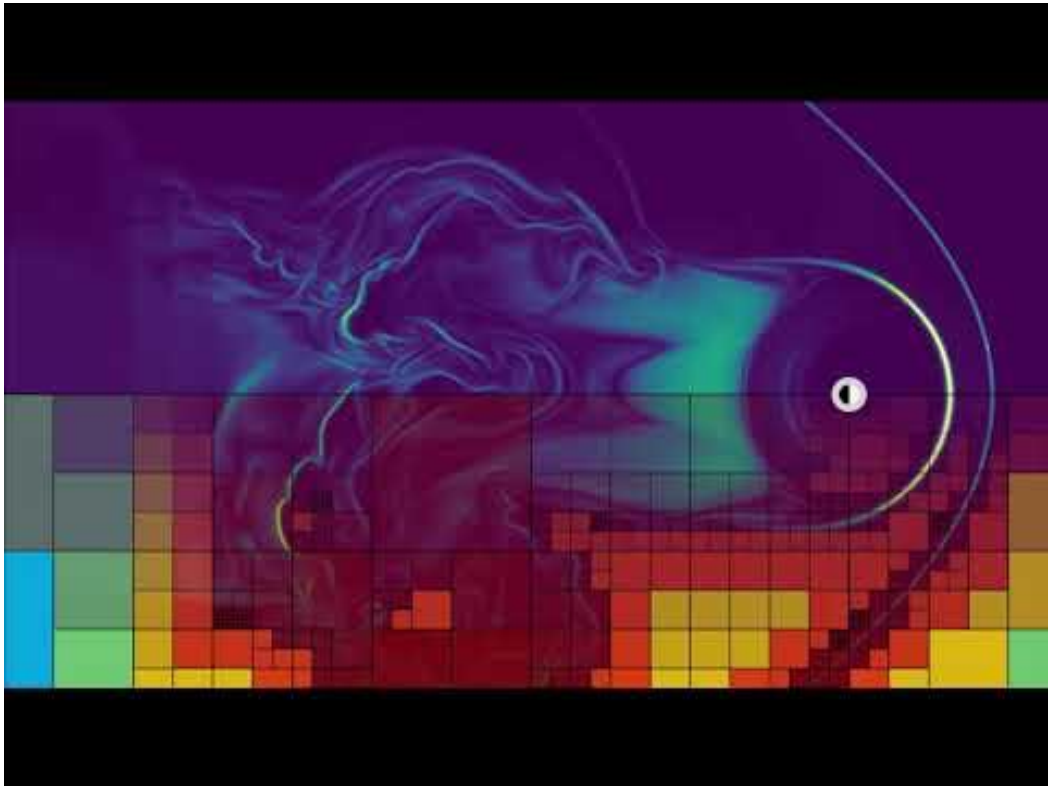
Refine

- Edit and simplify to the most direct communication possible

Based on Frankel and DePace, 2012.

Element 1. Composition

What relationships are you highlighting?



You can multiple aspects used together to highlight specific interesting findings.

Source: D. Welling, UT Arlington.
https://www.youtube.com/watch?v=8bgkgQITFO8

Element 1. Composition

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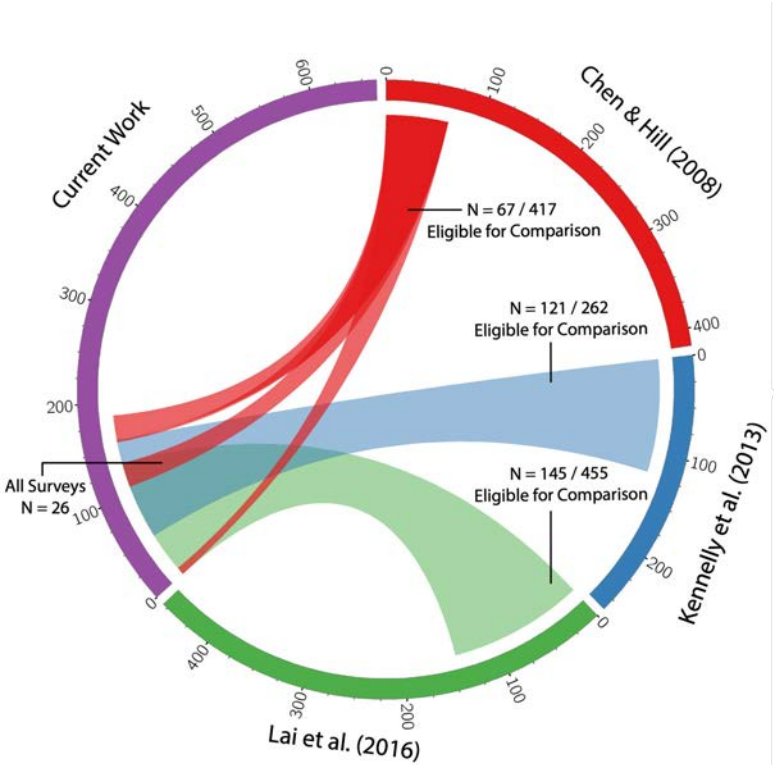


You can have a single figure display a flow

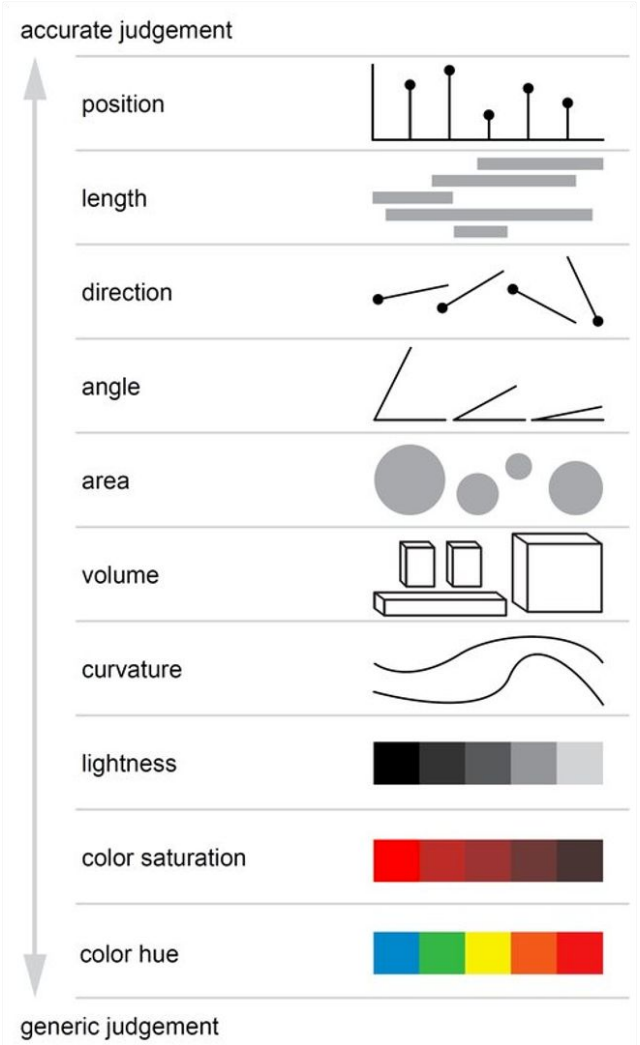
This is a relational diagram, made with a program called Circos – here the flow is first circular then across as designated by the connection lines.

Source Azari+ 2018.

Element 2. Abstraction

How are you representing relationships?

*Some **general guidelines** from graphics study on accuracy perception by Cleveland & McGill 1984*

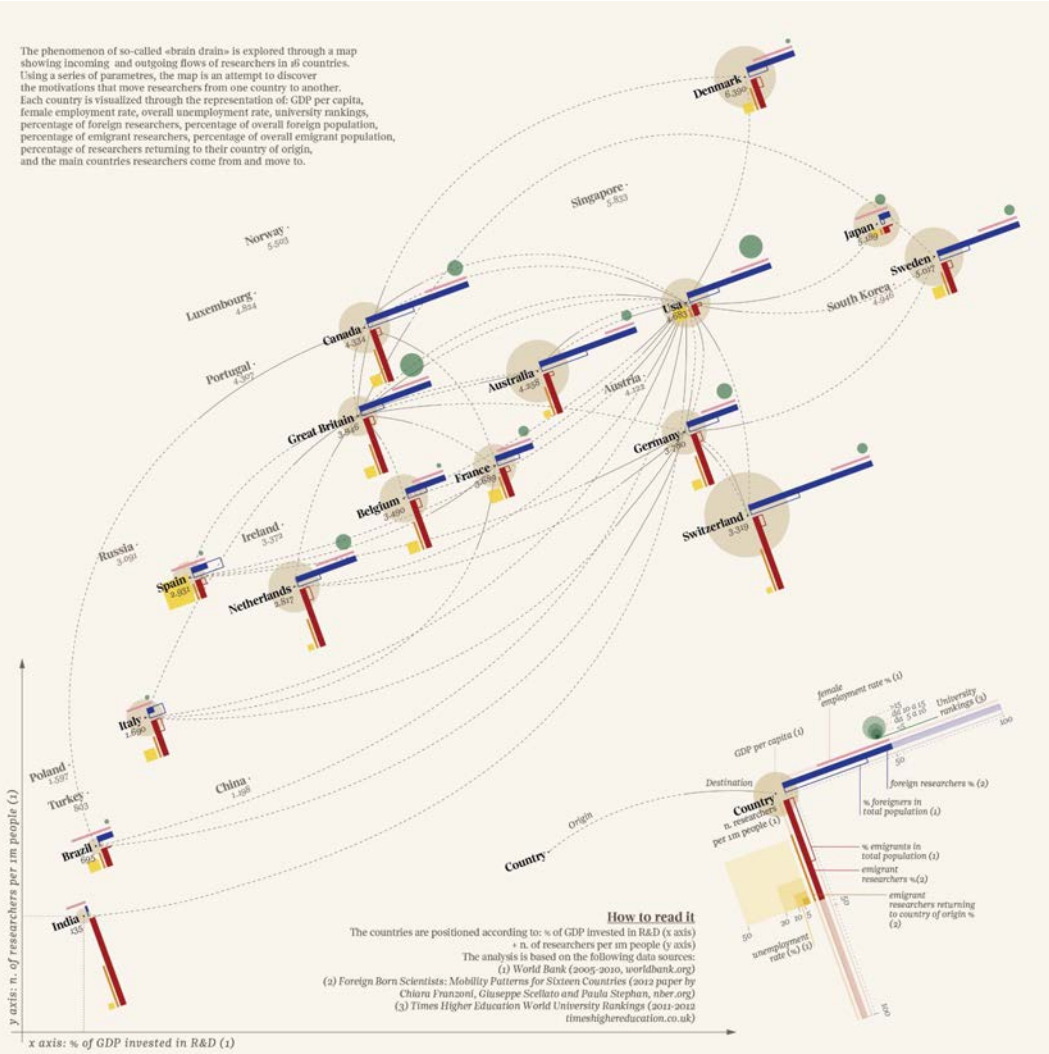


Source: Adapted from Cleveland & McGill – From https://www.gabrielaplucinska.com/blog/2017/8/7/pie-charts

Element 2. Abstraction

How are you representing relationships?

You can get creative in this space about representing data, for example this visualization is inspired by abstract art.



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

Element 3. Color

Use color to highlight, show relationships, convey meaning

Often we spend the most time in visualizations on color, as we have shown there are other elements but color tends to be one of the first things we notice.

We will explore how to generate this visualization in the lab afterwards.

Source: abbyazari.github.io

Element 3. Color

Use color to highlight, show relationships, convey meaning

There are some general guidelines: Mars makes sense to be red, but usually red means something is "hot", blue means "cold"

When dealing with land vs ocean you want to be careful which is blue, etc

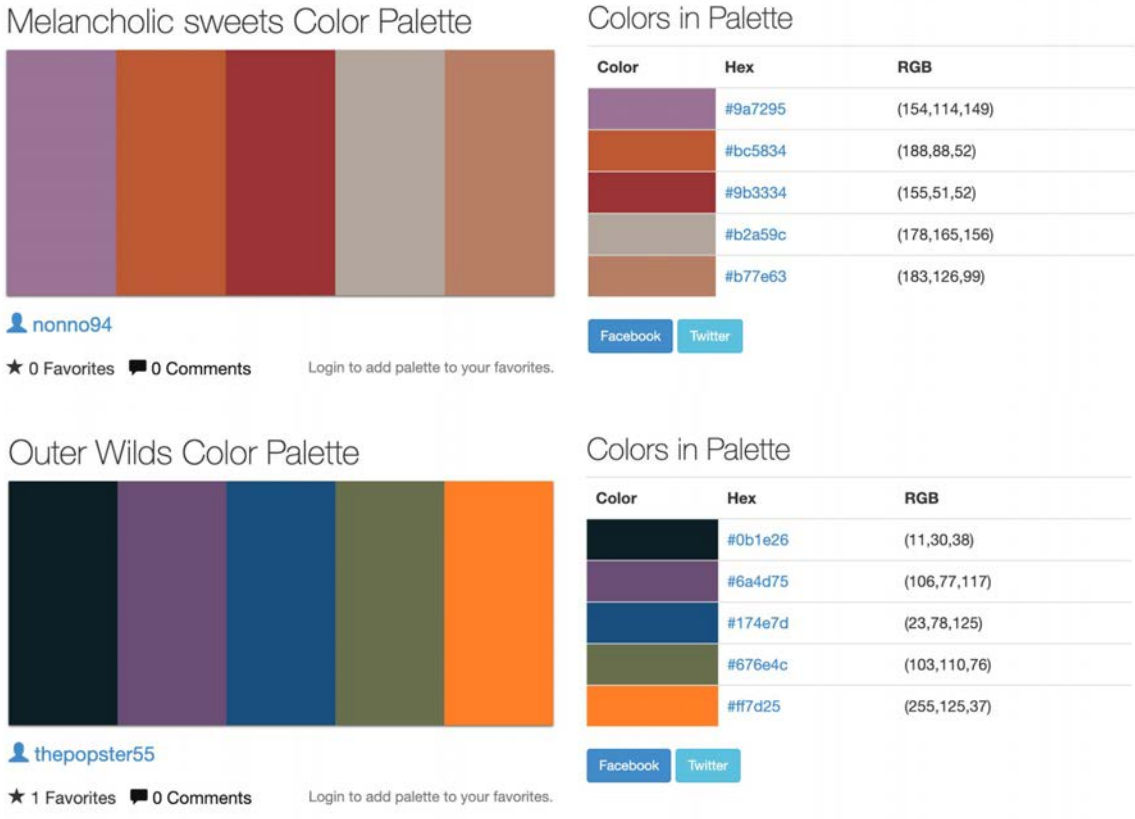
Old Guitarist – Pablo Picasso

Based on Adams, 2008.

Element 3. Color

Suggestions for building color harmony

- 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?



Examples from color-hex.com/color-palettes/

Based on Adams, 2008.

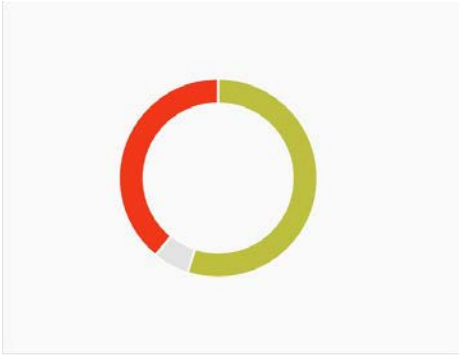
Element 3. Color

People see, and process information, differently from each other.

Some general guidelines

- Try to avoid red and green colors in combination
- Bright and harsh color contrasts (e.g. bright green vs muted green) can be challenging for sensory sensitivities

NOT IDEAL



BETTER

NOT IDEAL

BETTER

From Rost, 2020 - blog.datawrapper.de/beautifulcolors/

Element 3. Color

People see, and process information, differently from each other.

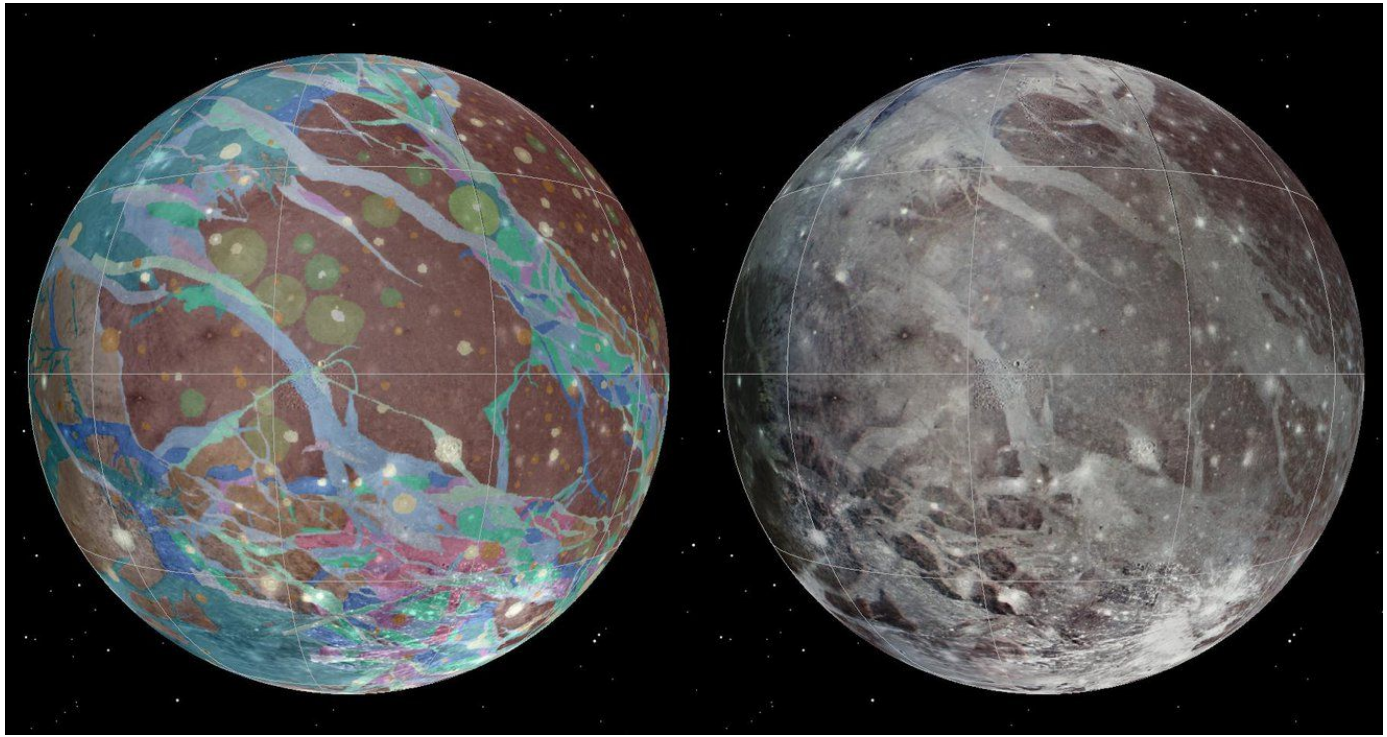
Some useful tools for simulating various color blindnesses:

- ColorOracle colororacle.org
- VizPalette projects.susielu.com/viz-palette

Element 4. Layering

Add layers to express meaning

These mosaic and geologic maps of Ganymede (a moon of Jupiter) were made with a compilation of spacecraft images.

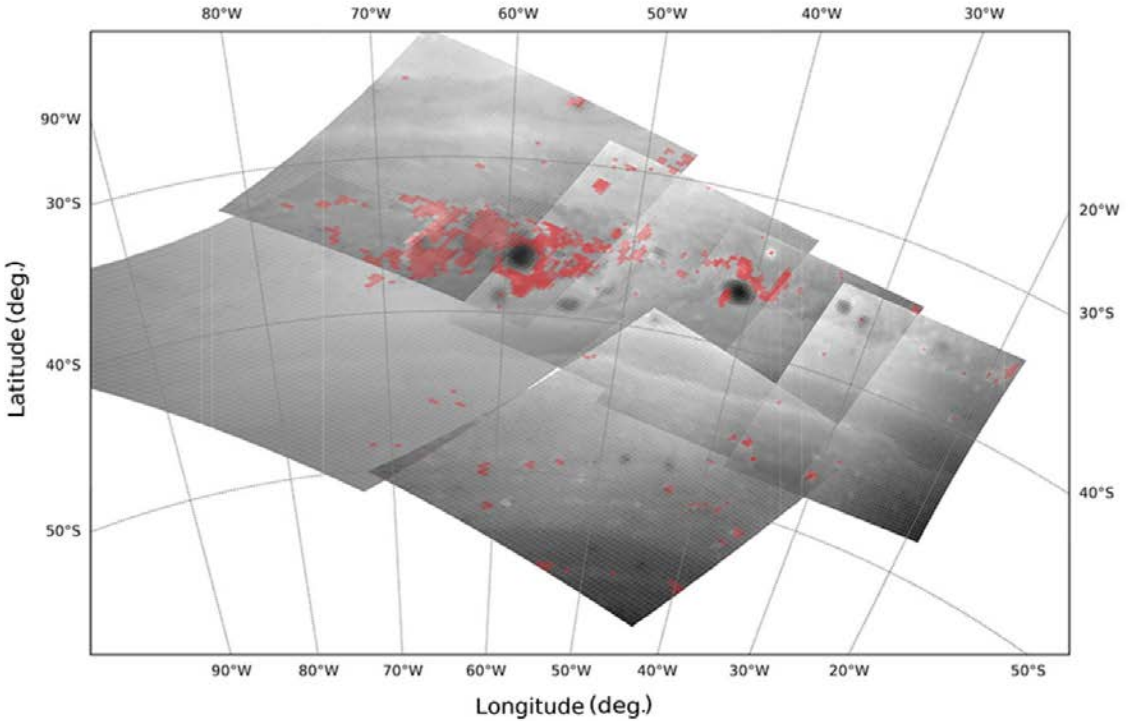


Source: USGS Astrogeology Science Center/Wheaton/NASA/JPL-Caltech

Element 5. Refining

Simplify to focus meaning

Layered composite highlighting specific locations at Saturn that were identified as stormy regions.



From Waldmann & Griffith, 2019. arxiv.org/abs/1904.12925

What have we learned so far?

When starting a visualization - consider what is the main point and who is my audience?

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

When making visualizations, consider how to use these elements to impart meaning:

- Composition
- Abstraction
- Color
- Layering
- Refining

Let’s put this into action -

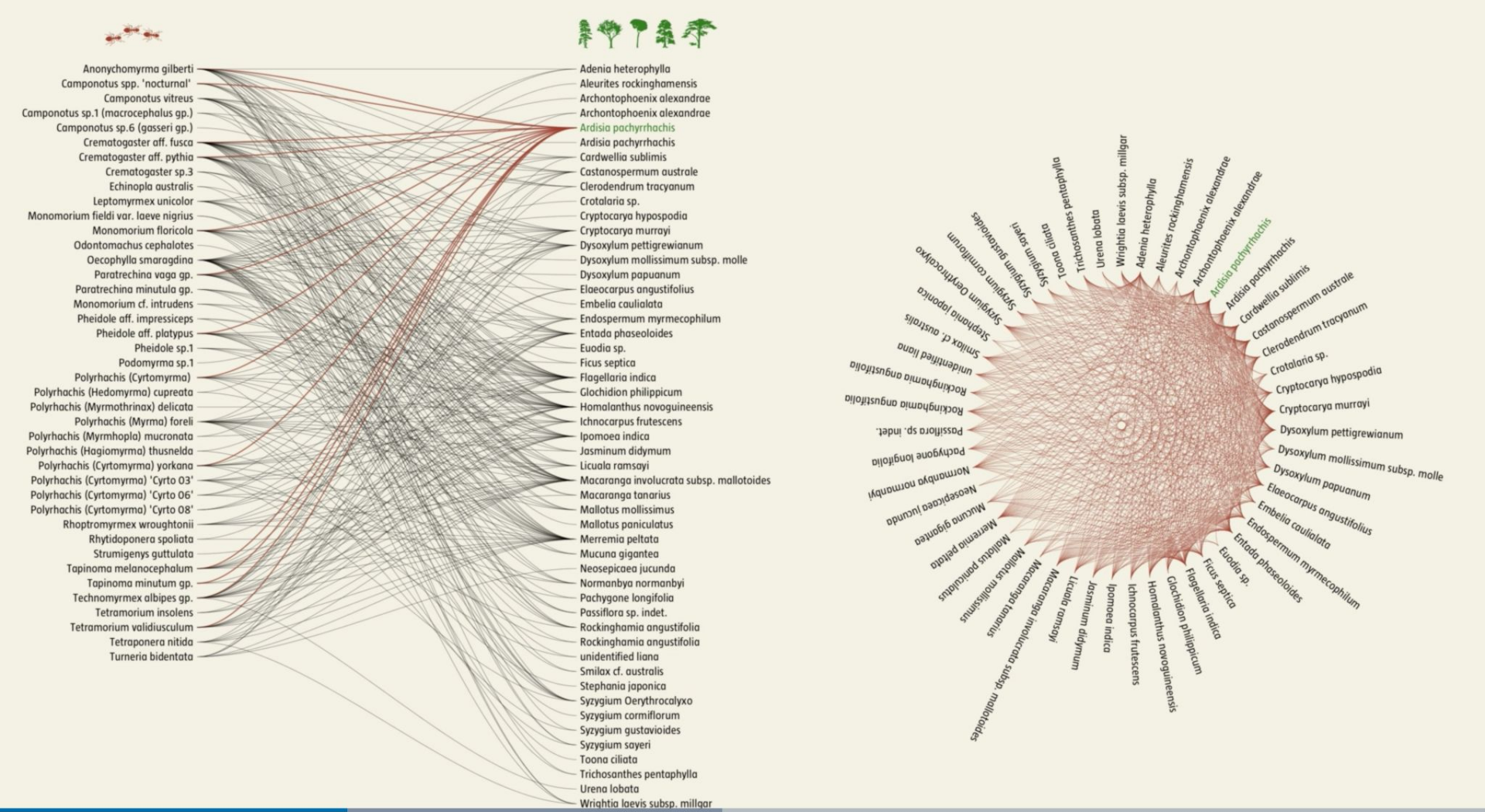
We will first watch this video:

http://players.brightcove.net/679256133001/NkgrDczuol_default/index.html?videoId=5373954480001

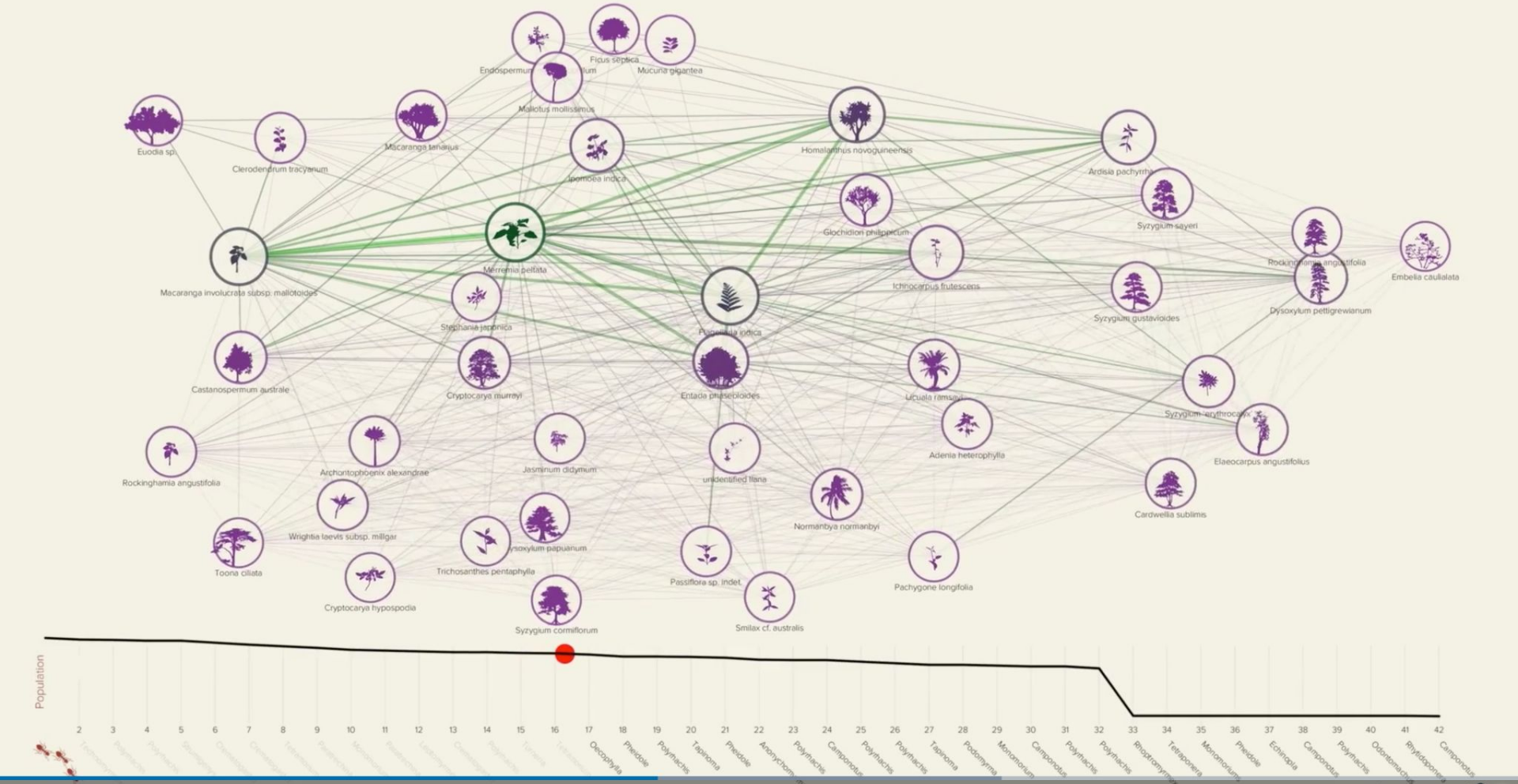
This won the NSF Expert’s Choice award in 2017 for best video visualization.

Then we will split into small groups to discuss how the designers of this video used for various aspects of this video.

- Composition
- Abstraction
- Color
- Layering
- Refining


Anonychomyrma gilberti
Camponotus spp. 'nocturnal'
Camponotus vitreus
Camponotus sp.1 (macrocephalus gp.)
Camponotus sp.6 (gasseri gp.)
Crematogaster aff. fusca
Crematogaster aff. pythia
Crematogaster sp.3
Echinopla australis
Leptomyrmex unicolor
Monomorium fieldi var. laeve nigrius
Monomorium floricola
Odontomachus cephalotes
Oecophylla smaragdina
Paratrechina vaga gp.
Paratrechina minutula gp.
Monomorium cf. intrudens
Pheidole aff. impressiceps
Pheidole aff. platypus
Pheidole sp.1
Podomyrma sp.1
Polyrhachis (Cyrtomyrma)
Polyrhachis (Hedomyrma) cupreata
Polyrhachis (Myrmothrinax) delicata
Polyrhachis (Myrma) foreli
Polyrhachis (Myrmhopla) mucronata
Polyrhachis (Hagiomyrma) thusnelda
Polyrhachis (Cyrtomyrma) yorkana
Polyrhachis (Cyrtomyrma) 'Cyrto 03'
Polyrhachis (Cyrtomyrma) 'Cyrto 06'
Polyrhachis (Cyrtomyrma) 'Cyrto 08'
Rhoptromyrmex wroughtonii
Rhytidoponera spoliata
Strumigenys guttulata
Tapinoma melanocephalum
Tapinoma minutum gp.
Technomyrmex albipes gp.
Tetramorium insolens
Tetramorium validiusculum
Tetraponera nitida
Turneria bidentata
Adenia heterophylla
Aleurites rockinghamensis
Archontophoenix alexandrae
Archontophoenix alexandrae
Ardisia pachyrrhachis
Ardisia pachyrrhachis
Cardwellia sublimis
Castanospermum australe
Clerodendrum tracyanum
Crotalaria sp.
Cryptocarya hypospodia
Cryptocarya murrayi
Dysoxylum pettigrewianum
Dysoxylum mollissimum subsp. molle
Dysoxylum papuanum
Elaeocarpus angustifolius
Embelia caulialata
Endospermum myrmecophilum
Entada phaseoloides
Euodia sp.
Ficus septica
Flagellaria indica
Glochidion philippicum
Homalanthus novoguineensis
Ichnocarpus frutescens
Ipomoea indica
Jasminum didymum
Licuala ramsayi
Macaranga involucrata subsp. mallotoides
Macaranga tanarius
Mallotus mollissimus
Mallotus paniculatus
Merremia peltata
Mucuna gigantea
Neosepicaea jucunda
Normanbya normanbyi
Pachygone longifolia
Passiflora sp. indet.
Rockinghamia angustifolia
Rockinghamia angustifolia
unidentified liana
Smilax cf. australis
Stephania japonica
Syzygium Oerythrocalyxo
Syzygium cormiflorum
Syzygium gustavioides
Syzygium sayeri
Toona ciliata
Trichosanthes pentaphylla
Urena lobata
Wrightia laevis subsp. millgar

1:07 / 4:48 1x


Endospermum
Ficus septica
Mucuna gigantea
Mallotus mollissimus
Euodia sp.
Clerodendrum tracyanum
Macaranga tanarius
Ipomoea indica
Homalanthus novoguineensis
Ardisia pachyrrhiza
Glochidion philippicum
Syzygium sayeri
Macaranga involucrata subsp. malloloides
Merremia peltata
Ichnocarpus frutescens
Rockinghamia angustifolia
Embelia caulialata
Dysoxylum pettigrewianum
Syzygium gustavioides
Stephania japonica
Phyllanthus indica
Castanospermum australe
Cryptocarya murrayi
Entada phaseoloides
Ucuala ramsayi
Syzygium erythrocalyx
Adenia heterophylla
Elaeocarpus angustifolius
Rockinghamia angustifolia
Archontophoenix alexandrae
Jasminum didymum
unidentified liana
Normanbya normanbyi
Cardwellia sublimis
Wrightia laevis subsp. millgar
Dysoxylum papuanum
Toona ciliata
Trichosanthes pentaphylla
Passiflora sp. indet.
Pachygone longifolia
Cryptocarya hypospodia
Syzygium cormiflorum
Smilax cf. australis
Population
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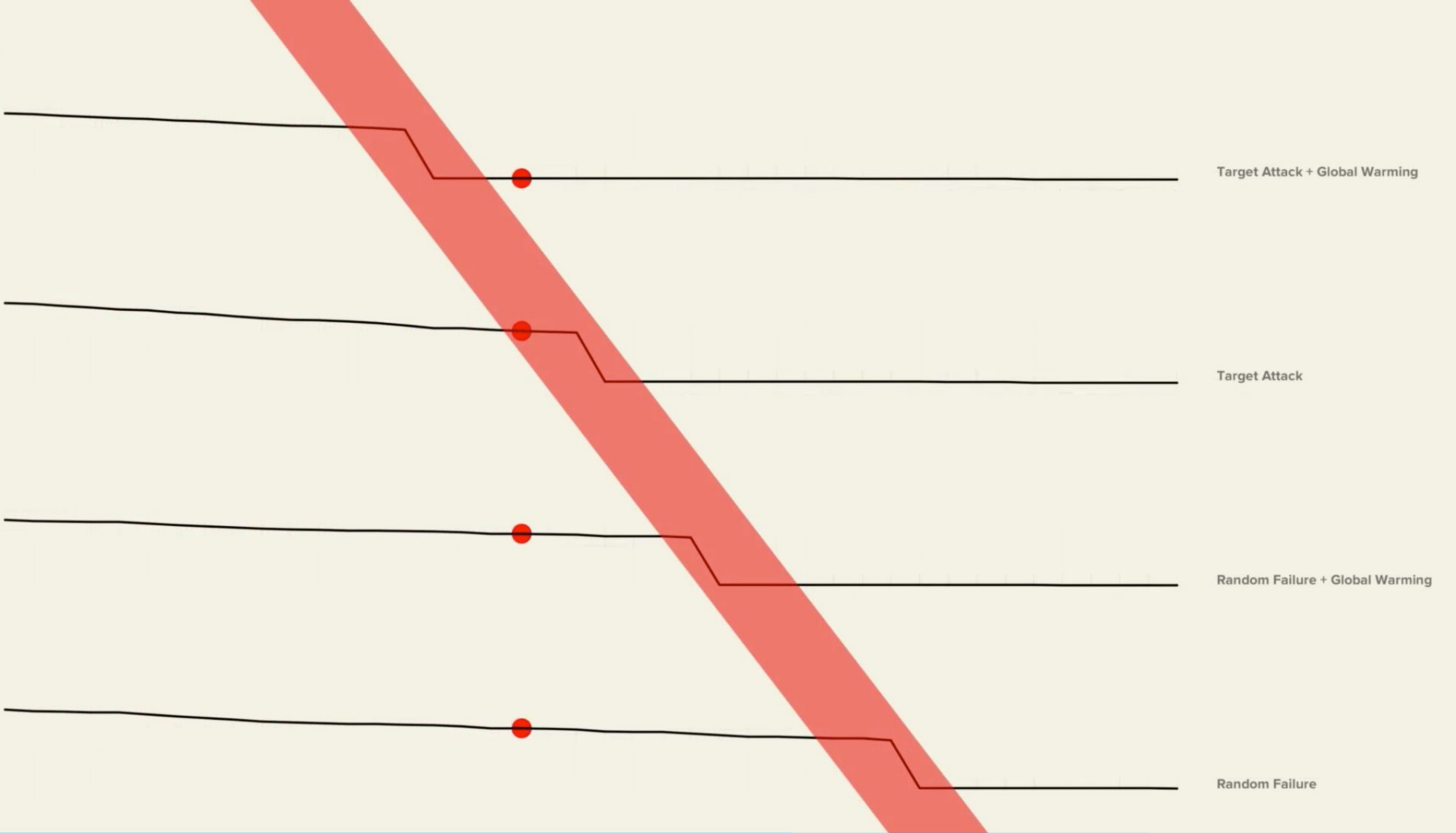
Oecophylla
Pheidole
Polyrhachis
Tapinoma
Pheidole
Anonychomyrma
Polyrhachis
Camponotus
Polyrhachis
Polyrhachis
Tapinoma
Podomyrma
Monomorium
Camponotus
Polyrhachis
Polyrhachis
Rhoptromyrmex
Tetraponera
Monomorium
Pheidole
Echinopla
Camponotus
Polyrhachis
Odontomachus
Rhytidoponera
Camponotus


Target Attack + Global Warming
Target Attack
Random Failure + Global Warming
Random Failure

Some additional informative resources

- Visual Strategies: A Practical Guide to Graphics and Engineers, Frankel and Depace – 2012.
- Color Design Workbook: A Real World Guide to Using Color in Graphic Design, Sean Adams, 2008.
- Milestones in the History of Thematic Cartography, Statistical Graphics, and Data Visualization, Friendly & Denis euclid.psych.yorku.ca/SCS/Gallery/milestone/
- Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. Cleveland & McGill 1984.
- W.E.B. DuBois' Visualizations and Infographics at the World Fair www.smithsonianmag.com/history/first-time-together-and-color-book-displays-web-du-bois-visionary-infographics-180970826/
- Articles within www.pictureasportal.com/pages/resources

That’s it! We will take a break before going to the lab session