scientific visualizations

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CUSP/CCPP


@fedhere


CCPP
CENTER FOR COSMOLOGY
AND PARTICLE PHYSICS

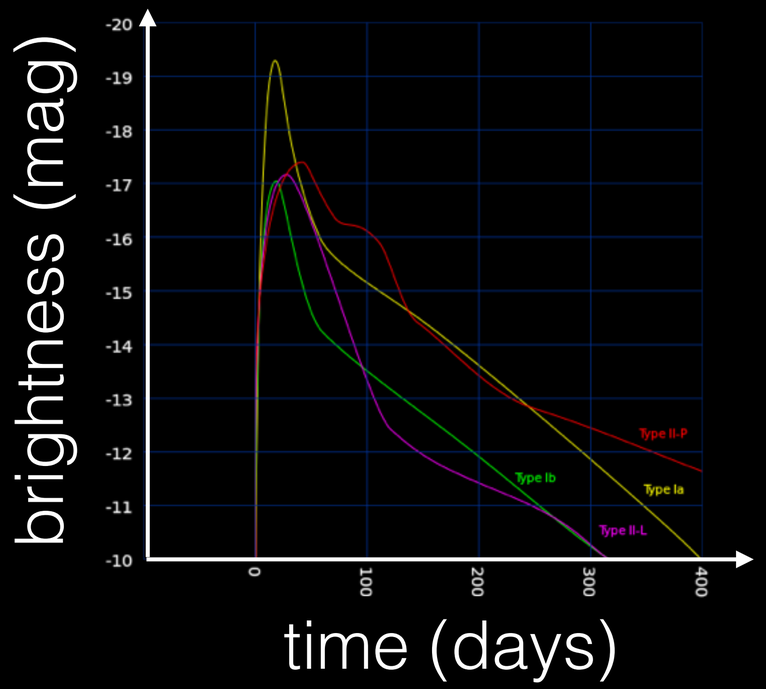
CCPP: Center for Cosmology and Particle Physics

CCPP
CENTER FOR COSMOLOGY
AND PARTICLE PHYSICS

I am trained as an astrophysicist, and as an astropysicist I study time-domain phenomena:

things that change in time, particularly stellar explosions, called Supernovae. From the time behavior we try to infer physics.

I study large datasets



CUSP

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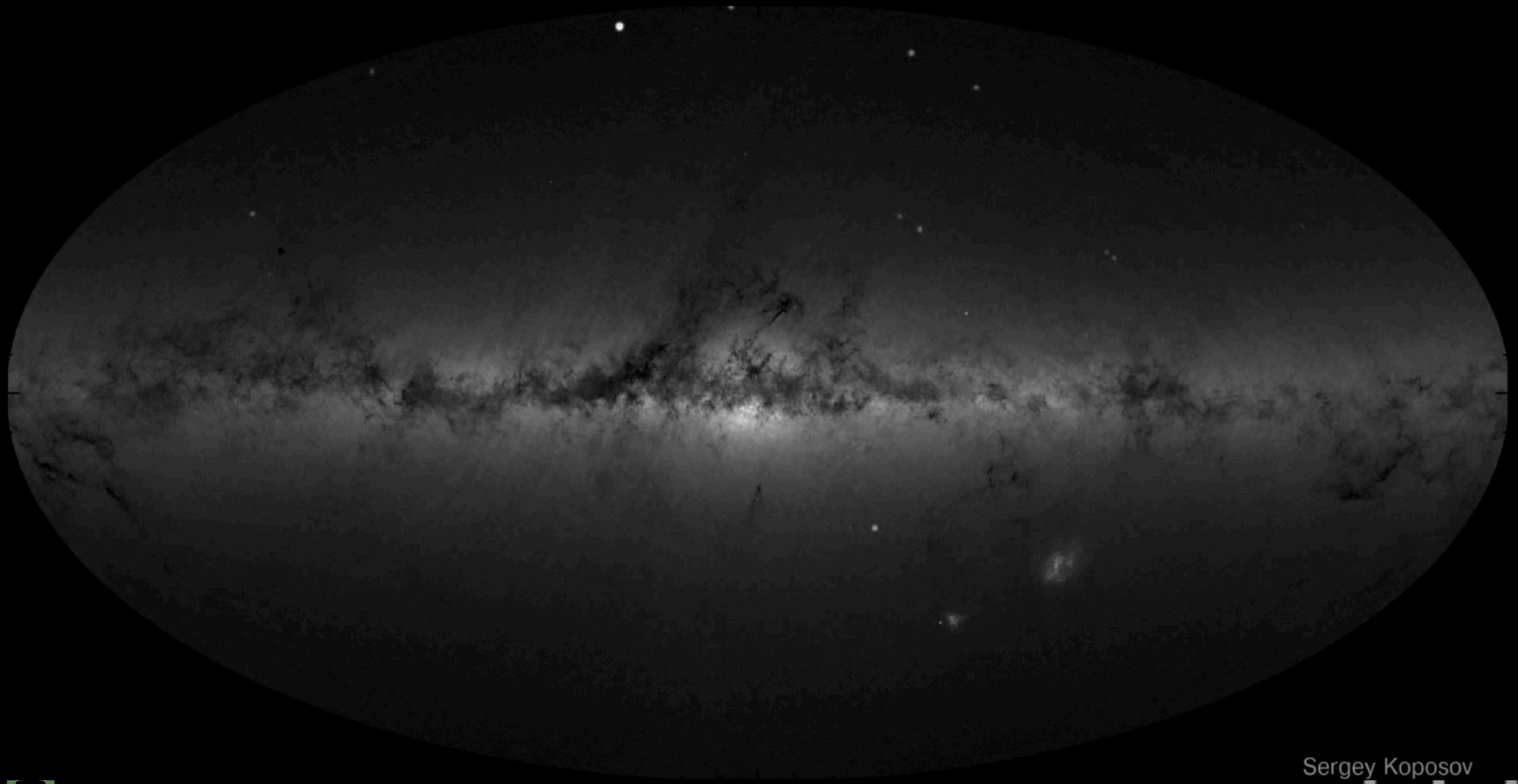
AND PARTICLE PHYSICS



Sergey Koposov
CENTER FOR COSMOLOGY
AND PARTICLE PHYSICS

CUSP: New York City as a laboratory

CUSP CENTER FOR URBAN SCIENCE+PROGRESS

CUSP is a unique public-private research center that uses NYC as its laboratory and classroom to help cities around the world become more productive, livable, equitable, and resilient.

CUSP observes, analyzes, and models NYC to optimize outcomes, prototype new solutions, formalize new tools and processes, and develop new expertise.

CUSP

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- Descriptive data viz
  - Lie with statistics
  - Tufte's rules

- Exploratory data viz
  - Jer Thorp

- Psychophysics

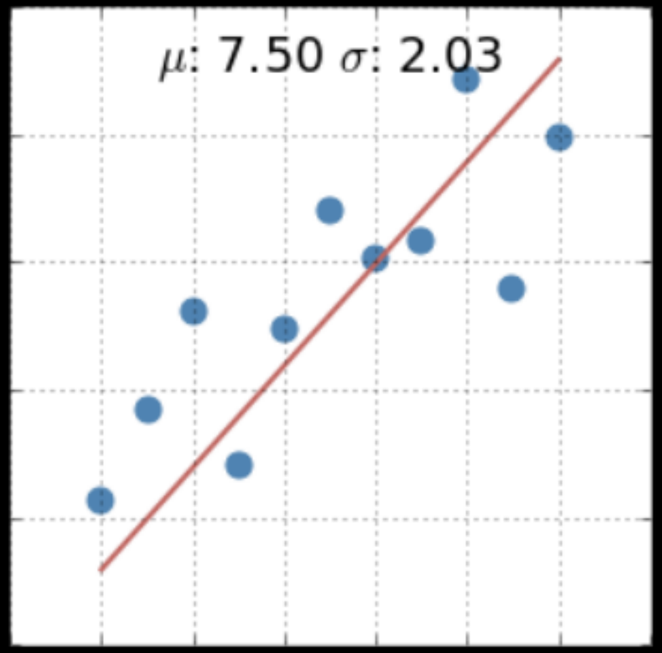
- Esthetics vs(??) functionality
  - color blindness
  - the third dimension

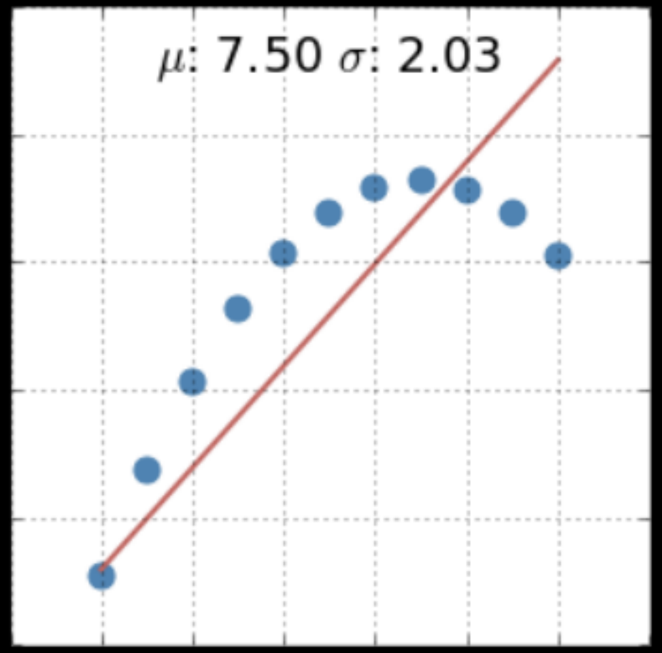
- Interactivity

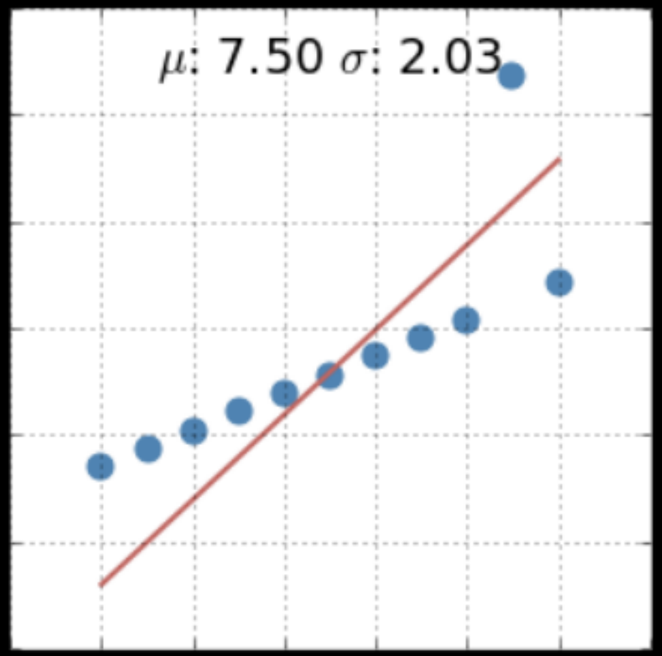
why?

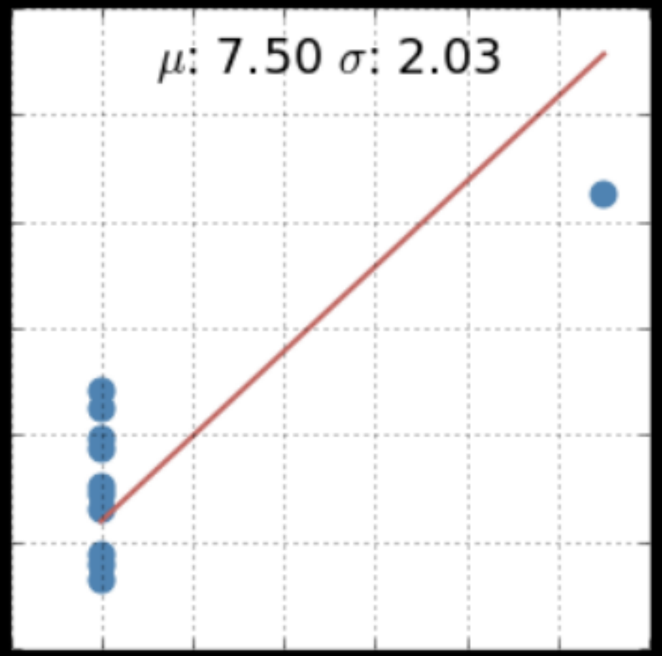
I		II		III		IV	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.13	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

What's this??









Anscombe's quartet

(Francis Anscombe, 1973) comprises four datasets that have nearly identical simple descriptive statistics, yet appear very different when graphed. Each dataset consists of eleven (x,y) points.

```
from PIL import Image
im = Image.open('sectret.png')
pixels = list(im.getdata())
import numpy as np
data = np.asarray(im)

data[:,:,0]
```

```
array([[38, 35, 39, ..., 25, 33, 39],
       [44, 41, 42, ..., 25, 31, 37],
       [47, 45, 42, ..., 31, 35, 39],
       ...,
       [47, 55, 69, ..., 63, 66, 69],
       [33, 38, 51, ..., 56, 63, 69],
       [26, 20, 28, ..., 39, 44, 48]], dtype=uint8)
```

computers understand data as numbers, we do not.

```
pl.figure(figsize=(10,10))
pl.imshow(data[500:1500,500:1500,0], cmap=plt.get_cmap('bone'))
pl.xticks([])
pl.yticks([])
```

we visualize to
communicate (Tufte)
and
explore (Thorp)

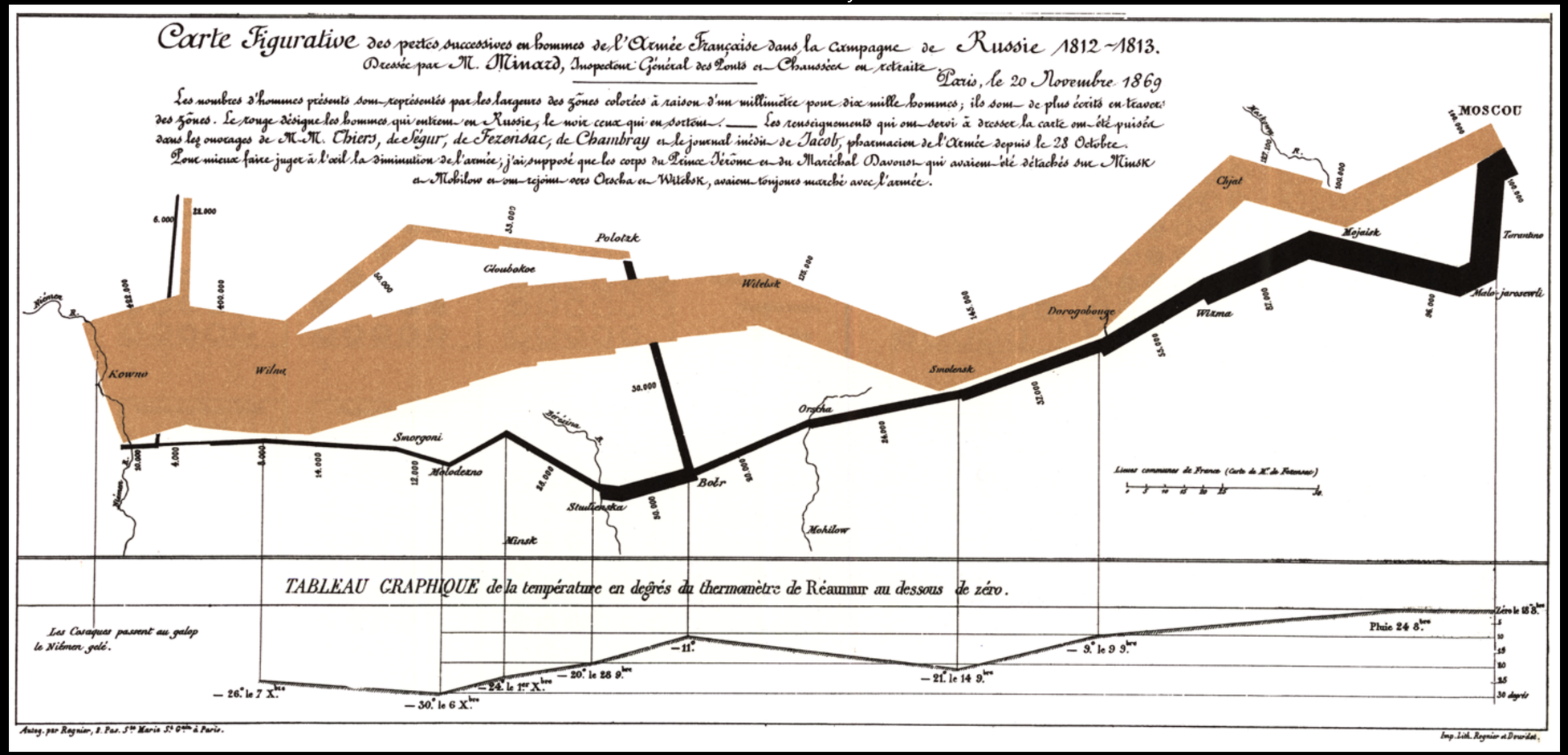
how?

a few historical plots

a few historical plots

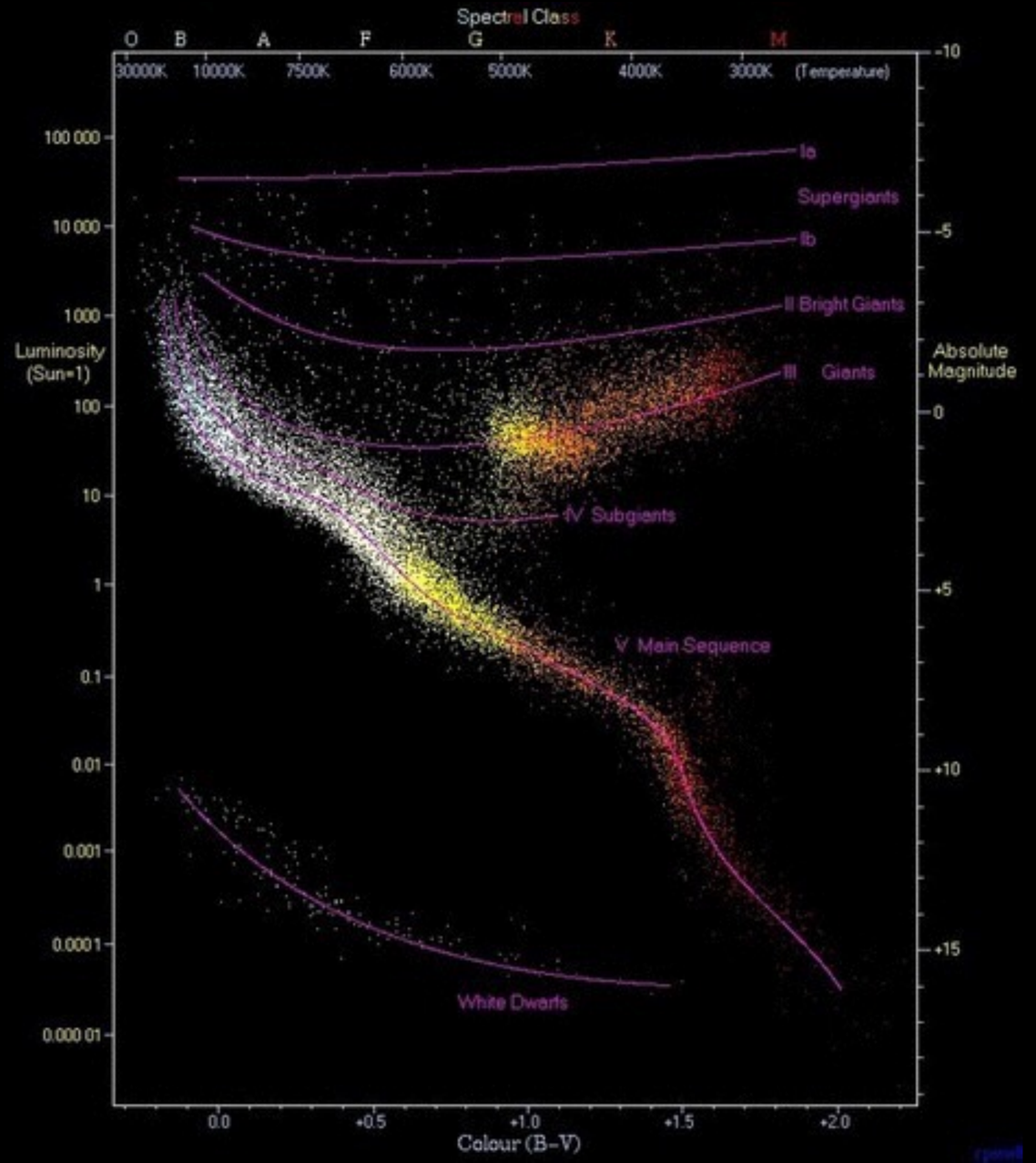
Figurative Map of the successive losses in men of the French Army in the Russian campaign 1812-1813.

Drawn by Mr. Minard, Inspector General of Bridges and Roads in retirement. Paris, 20 November 1869.
The numbers of men present are represented by the widths of the colored zones in a rate of one millimeter for ten thousand men; these are also written beside the zones. Red designates men moving into Russia, black those on retreat. — The informations used for drawing the map were taken from the works of Messrs. Chiers, de Ségur, de Fezensac, de Chambray and the unpublished diary of Jacob, pharmacist of the Army since 28 October.
In order to facilitate the judgement of the eye regarding the diminution of the army, I supposed that the troops under Prince Jèrôme and under Marshal Davoust, who were sent to Minsk and Mobilow and who rejoined near Orscha and Witebsk, had always marched with the army.



a few historical plots

Life of a Star



a few historical plots

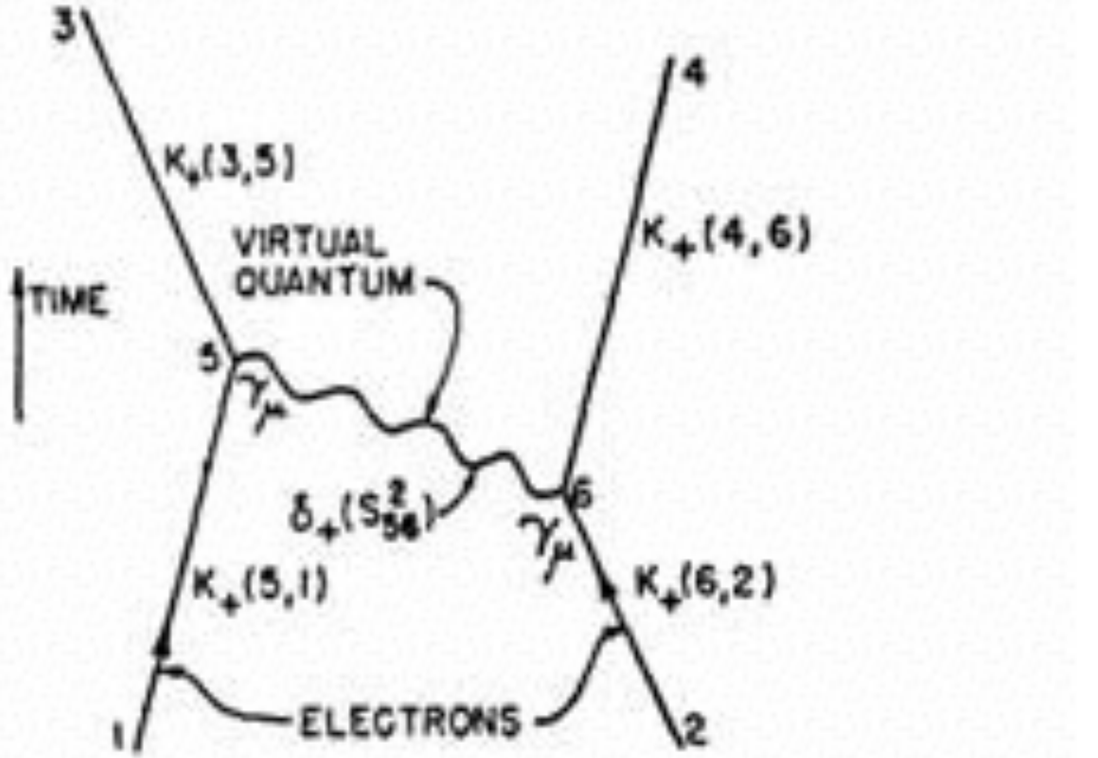


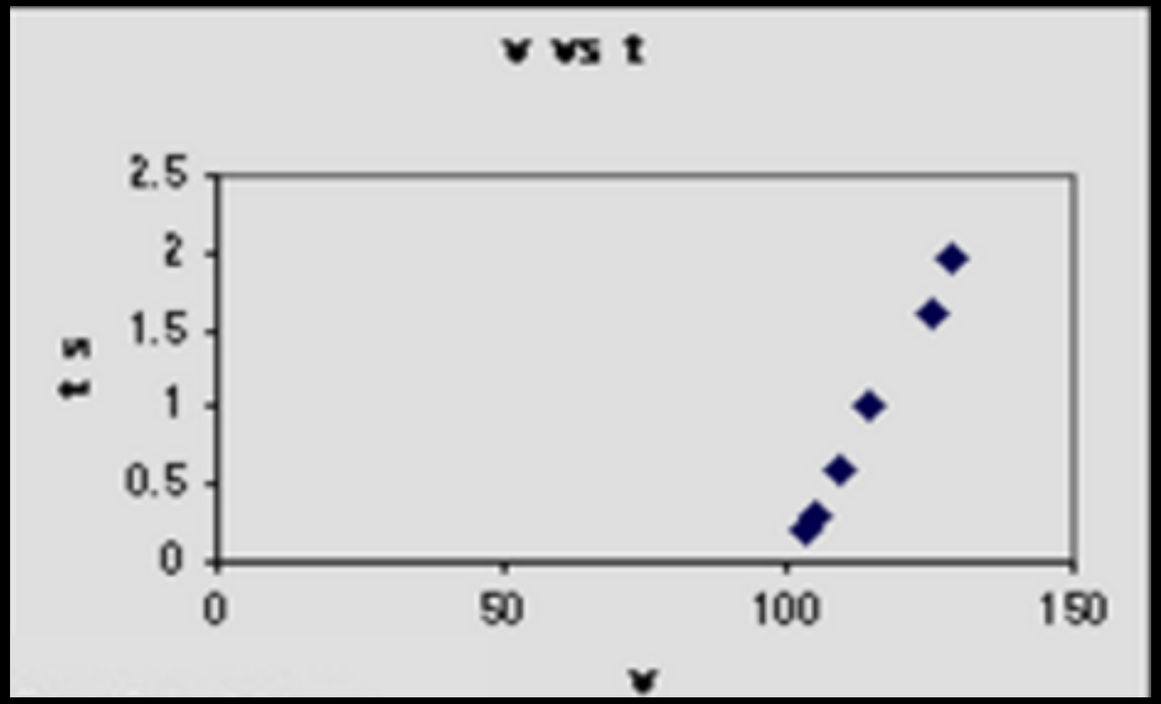
FIG. 1. The fundamental interaction Eq. (4). Exchange of one quantum between two electrons.

Feynman diagrams

https://inspirehep.net/record/1082448/plots

what makes a *bad* visualization?

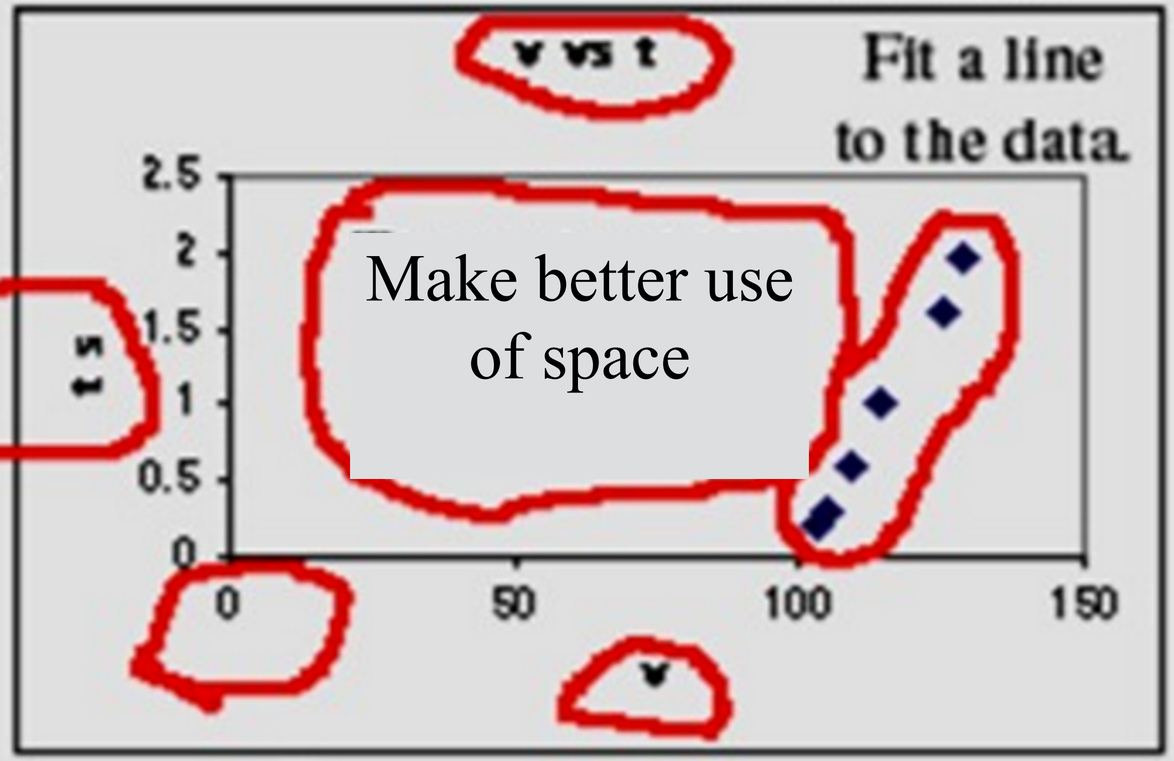
Ambiguity, distortion (misleading), distraction.



6 wrong things with this plot…

The entire graph is too small.

The title should be better. This graph is t versus v, not v versus t.



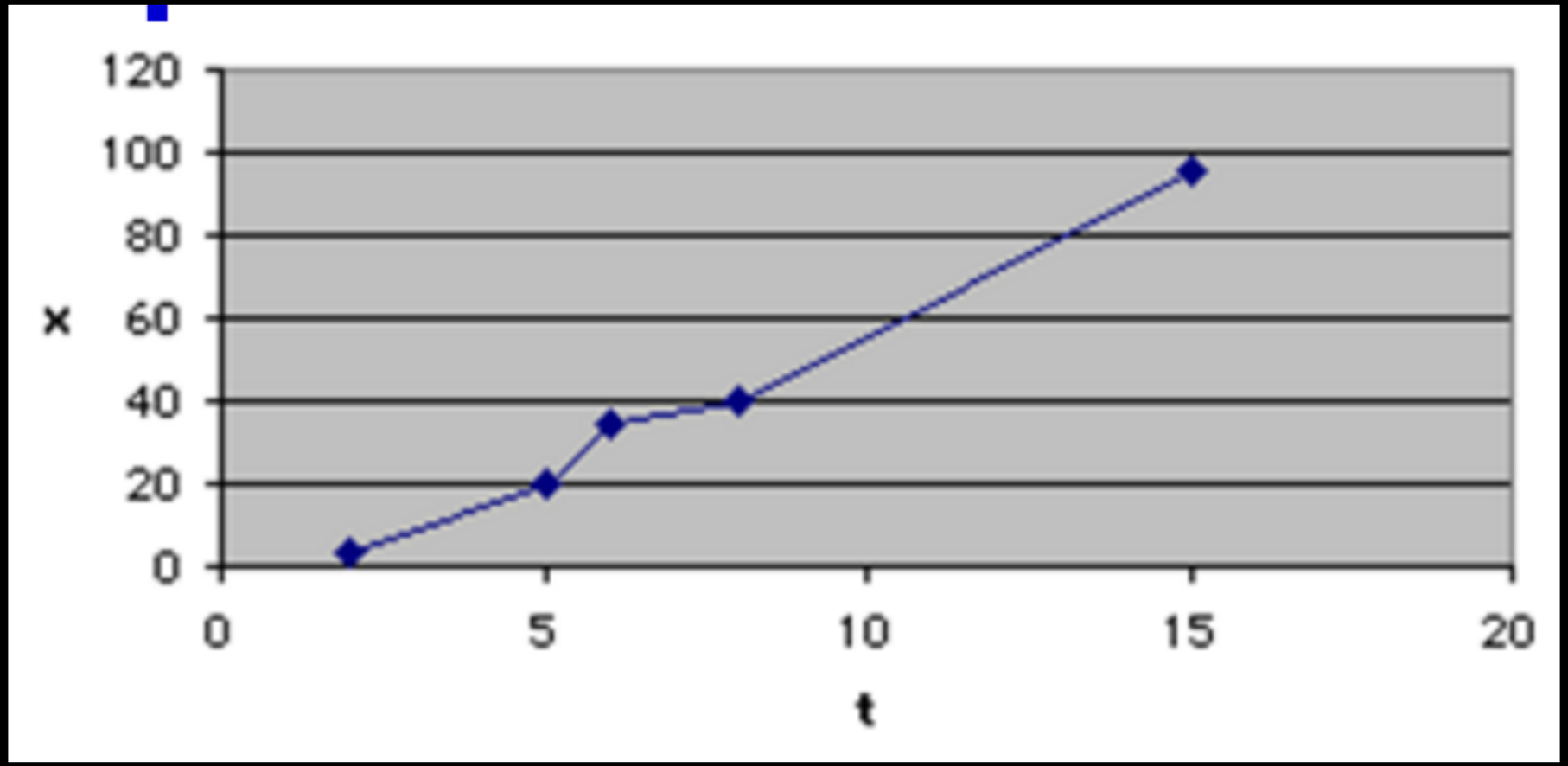
The axis label should have words, and the units should be in parentheses.

The first data occurs at v = 100, so the scale can begin at 100.

The axis label should have words and units in parentheses.

Prof. Vern Lindberg

http://www.geol.lsu.edu/jlorenzo/geophysics/graphing/graphingpart3.html



6 wrong things with this plot…

Prof. Vern Lindberg

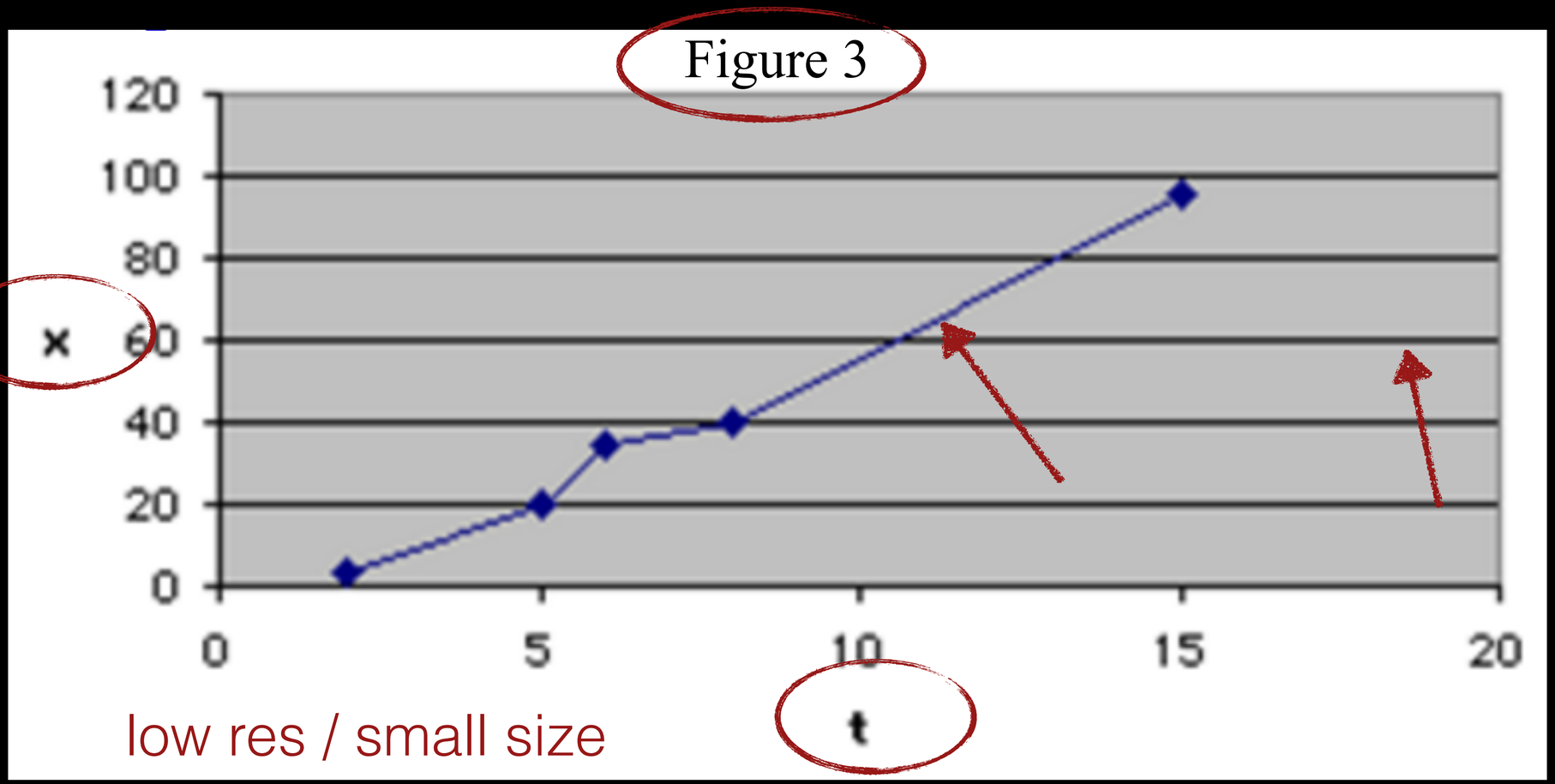


Figure 3
120
100
80
x
60
40
20
0
0
5
10
15
20
t
low res / small size

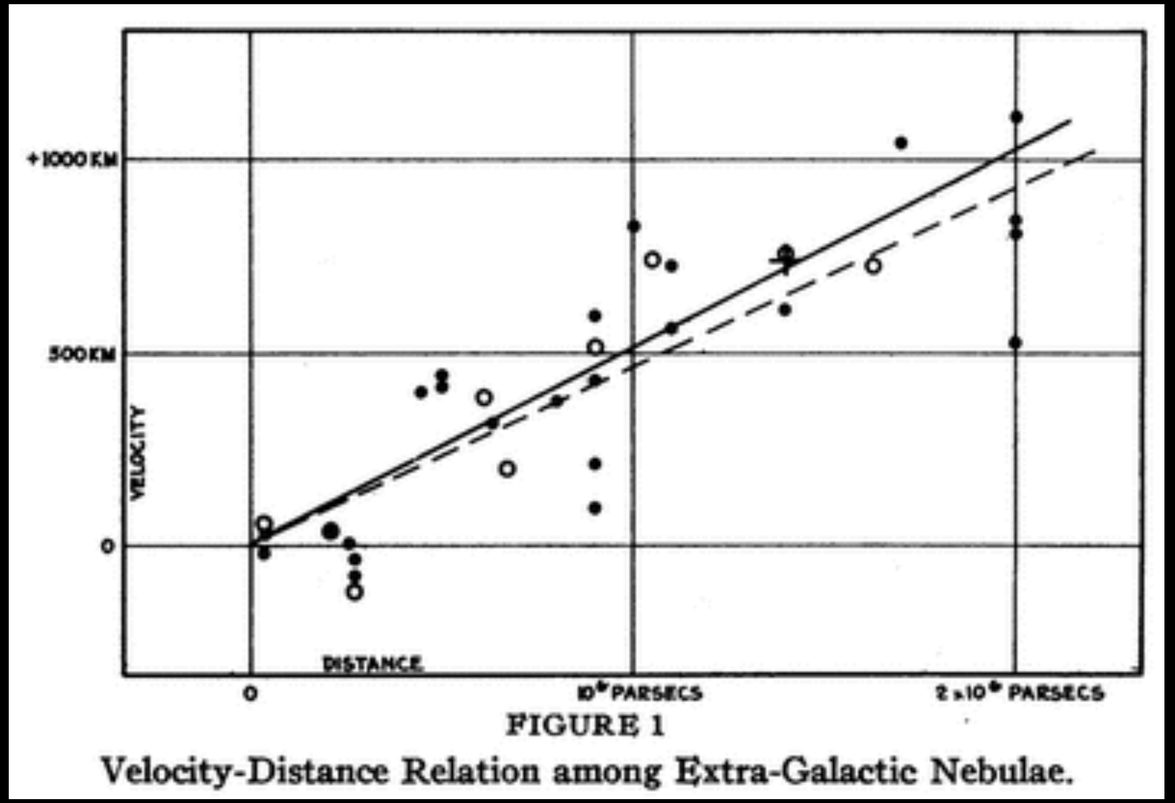


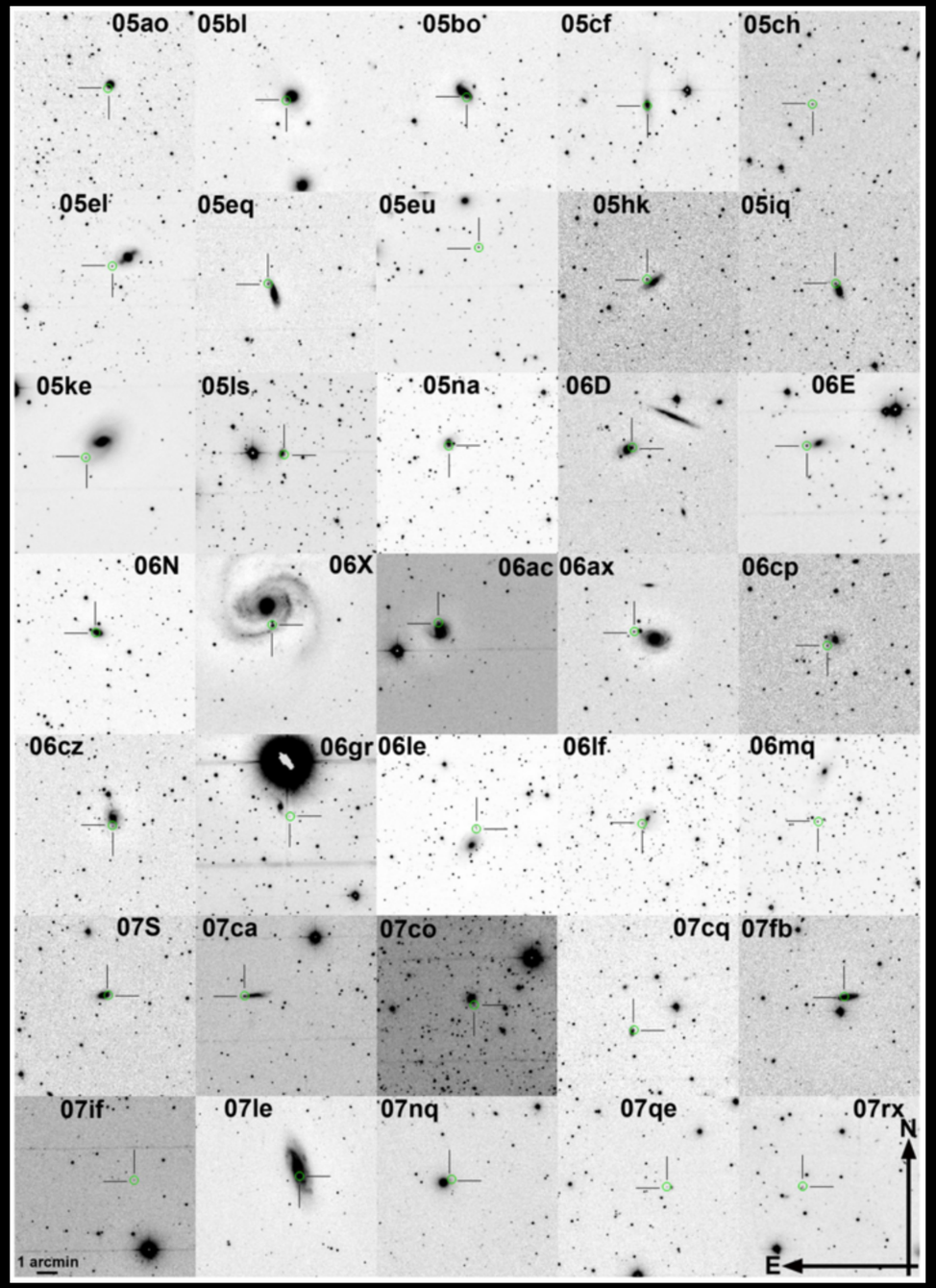
FIGURE 1

Velocity-Distance Relation among Extra-Galactic Nebulae.

Edwin Hubble

January 17, 1929

Velocity-Distance Relation among Extra-Galactic Nebulae. Radial velocities, corrected for solar motion, are plotted against distances estimated from involved stars and mean luminosities of nebulae in a cluster. The black discs and full line represent the solution for solar motion using the nebulae individually; the circles and broken line represent the solution combining the nebulae into groups; the cross represents the mean velocity corresponding to the mean distance of 22 nebulae whose distances could not be estimated individually.


05ao
05bl
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05cf
05ch
05el
05eq
05eu
05hk
05iq
05ke
05ls
05na
06D
06E
06N
06X
06ac
06ax
06cp
06cz
06gr
06le
06lf
06mq
07S
07ca
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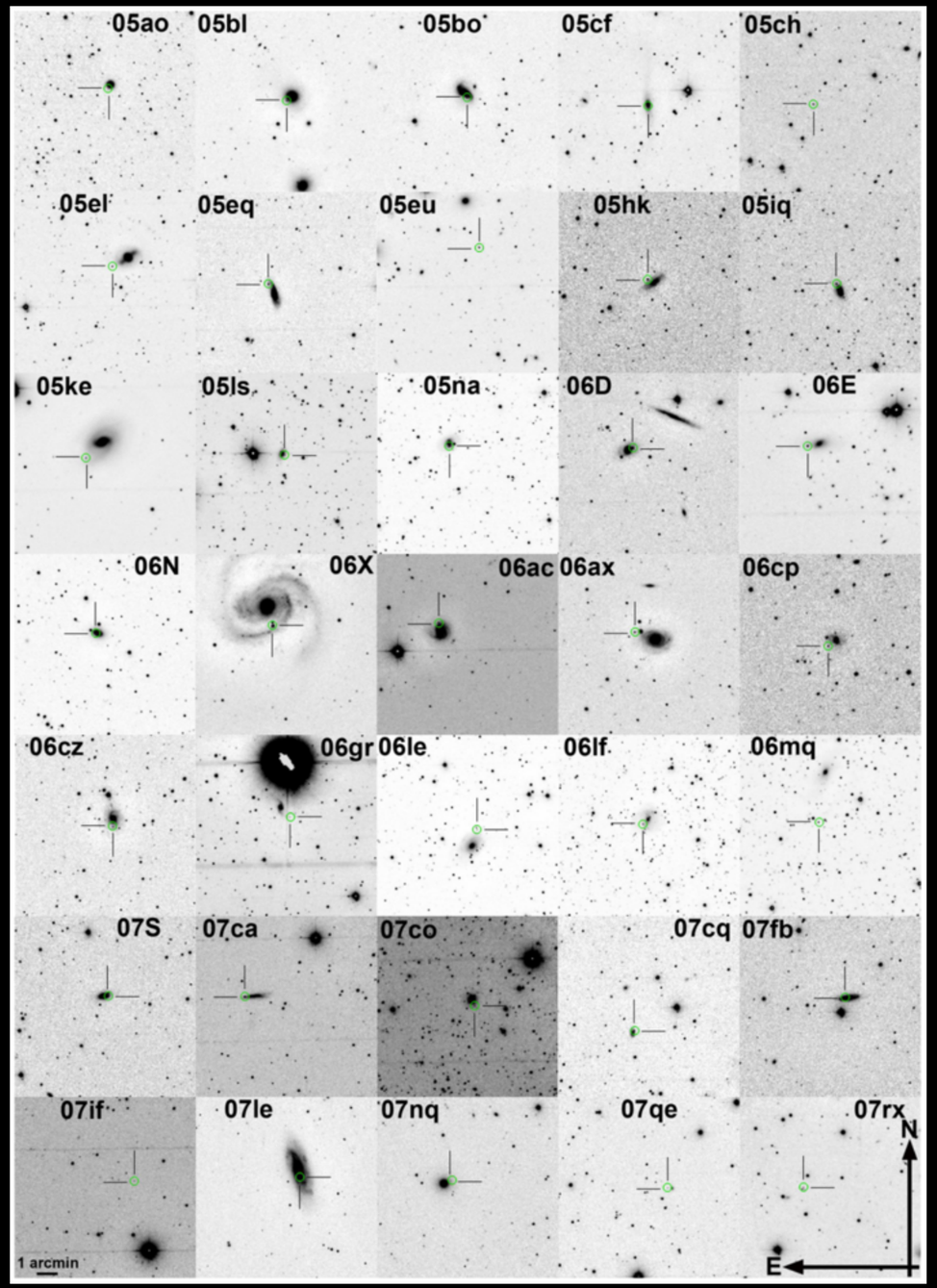
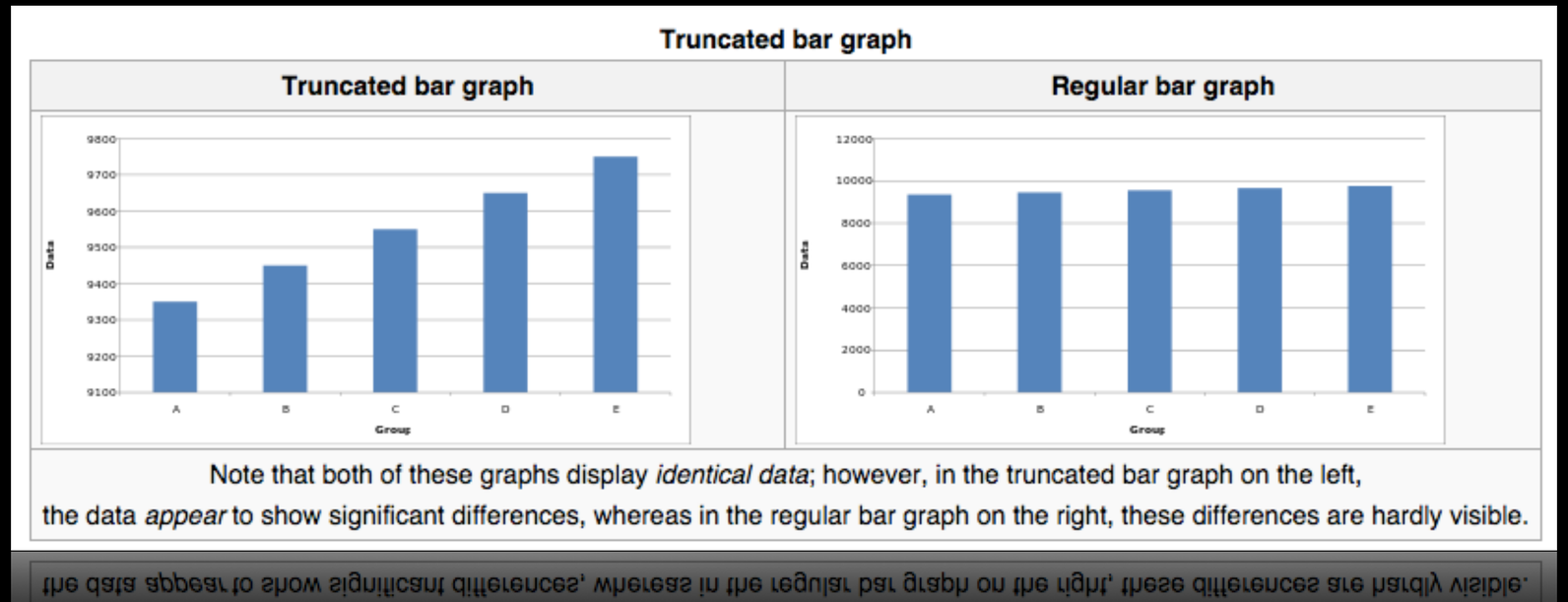
07cq
07fb
07if
07le
07nq
07qe
07rx
1 arcmin
N
E



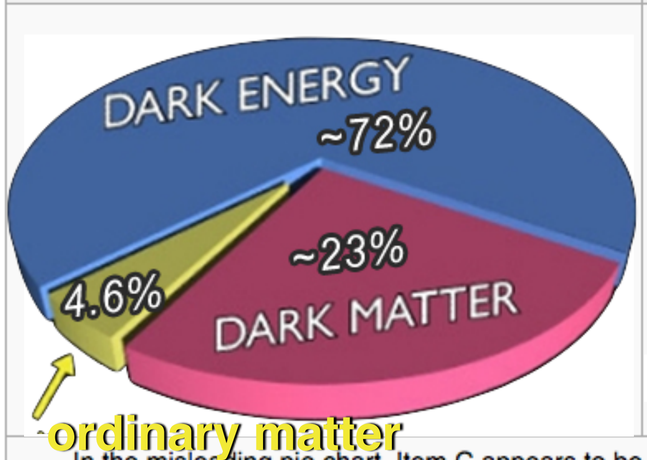
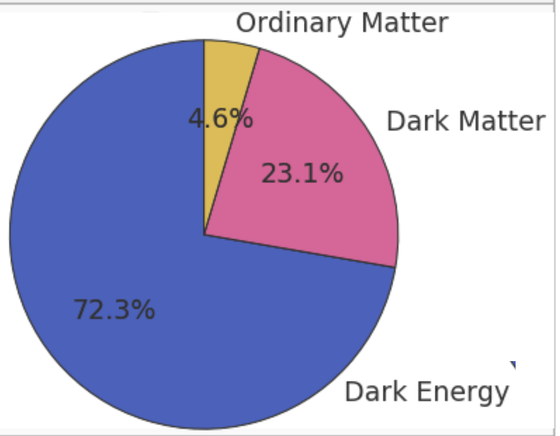
Ambiguity different stretch

Ambiguity, distortion (misleading), distraction.

http://gizmodo.com/how-to-lie-with-data-visualization-1563576606

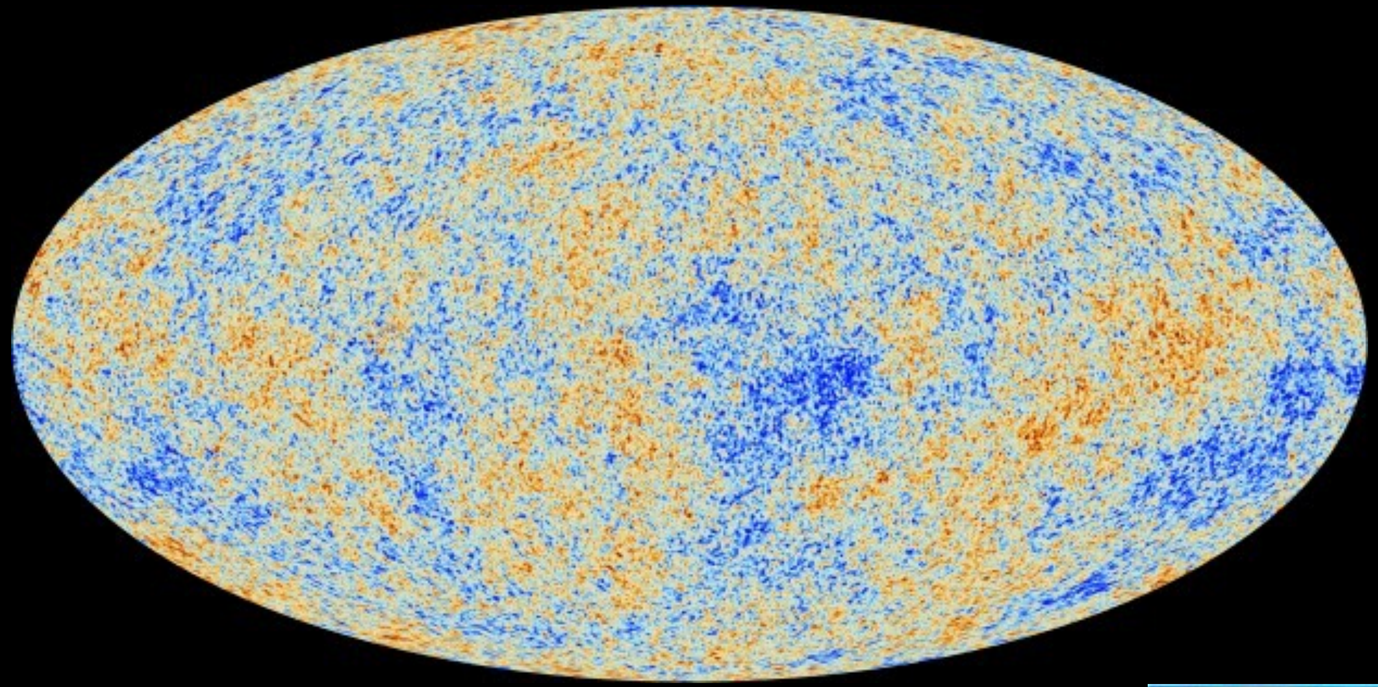


Comparison of pie charts

Misleading pie chart	Regular pie chart
	

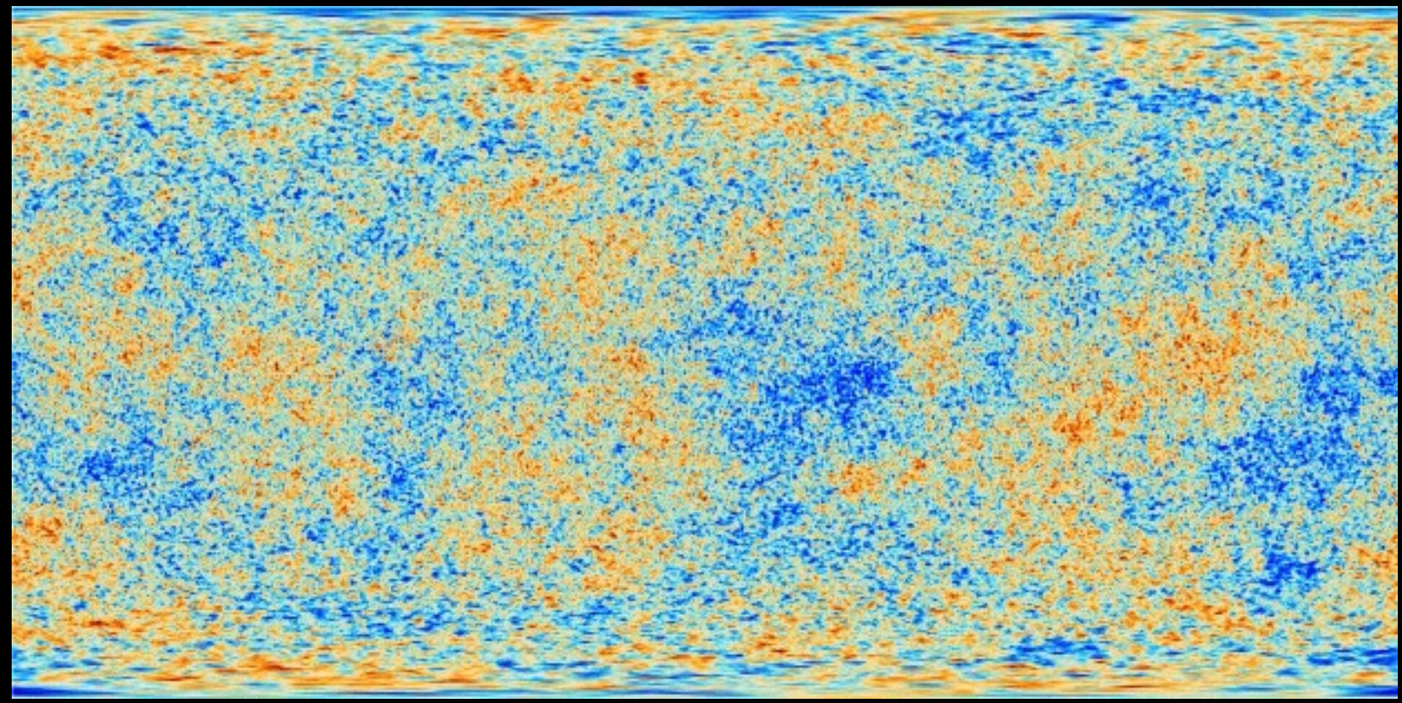
In the misleading pie chart, Item C appears to be at least as large as Item A, whereas in actuality, it is less than half as large.

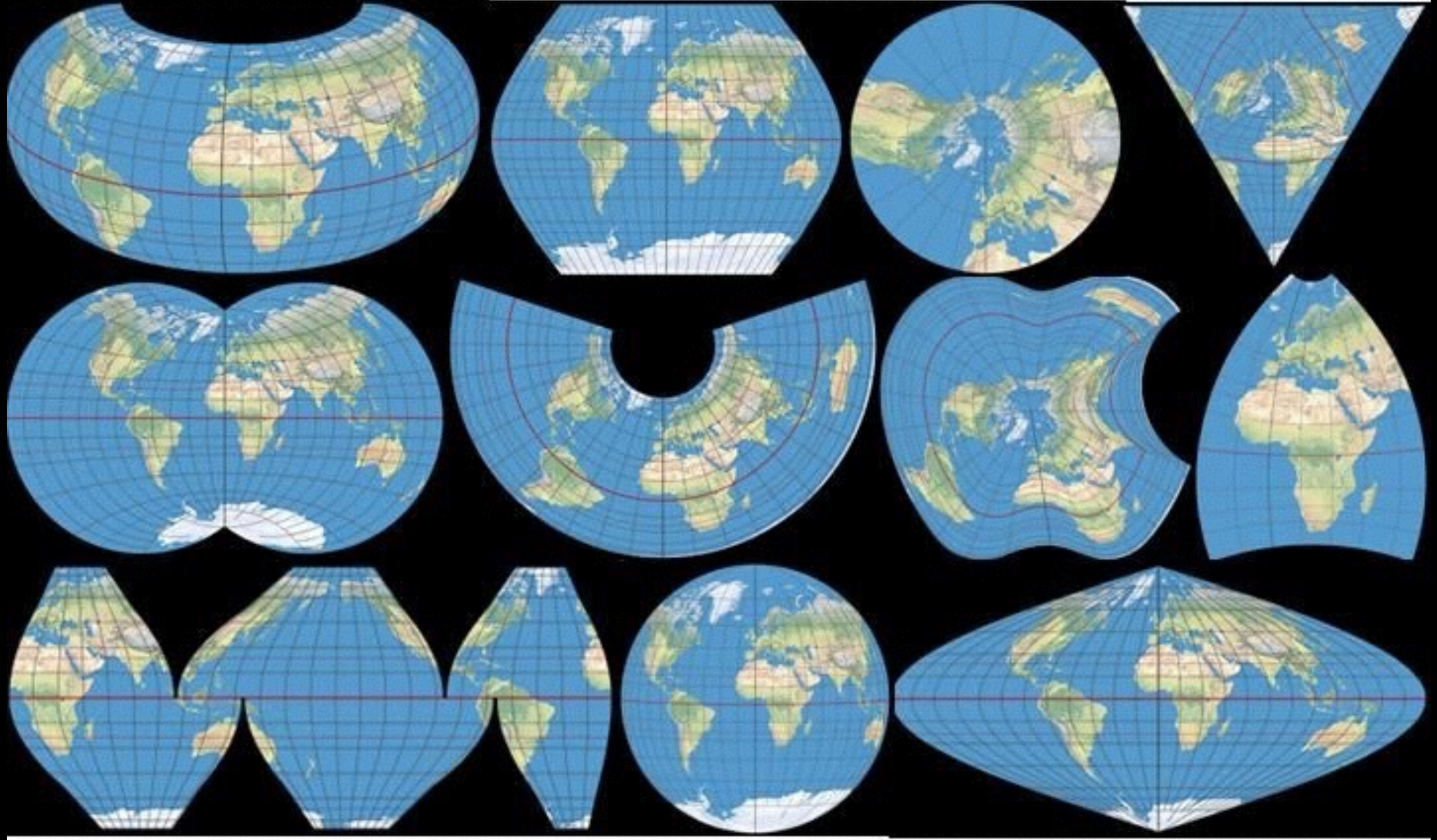
http://planck.caltech.edu/epo/epo-planckScience5.html



Mollweide projection

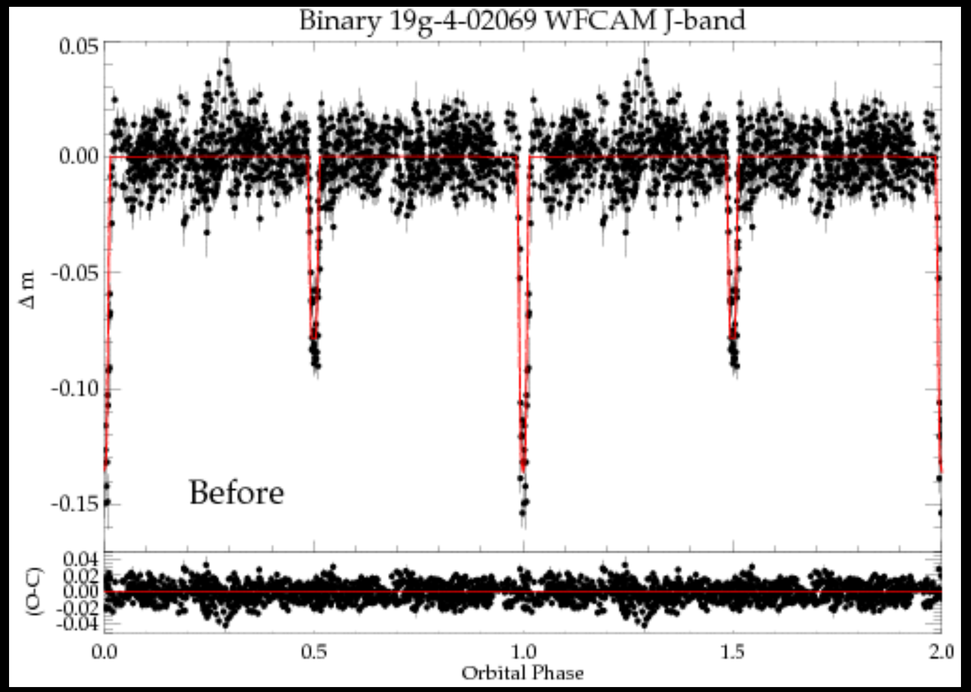
equirectangular projection

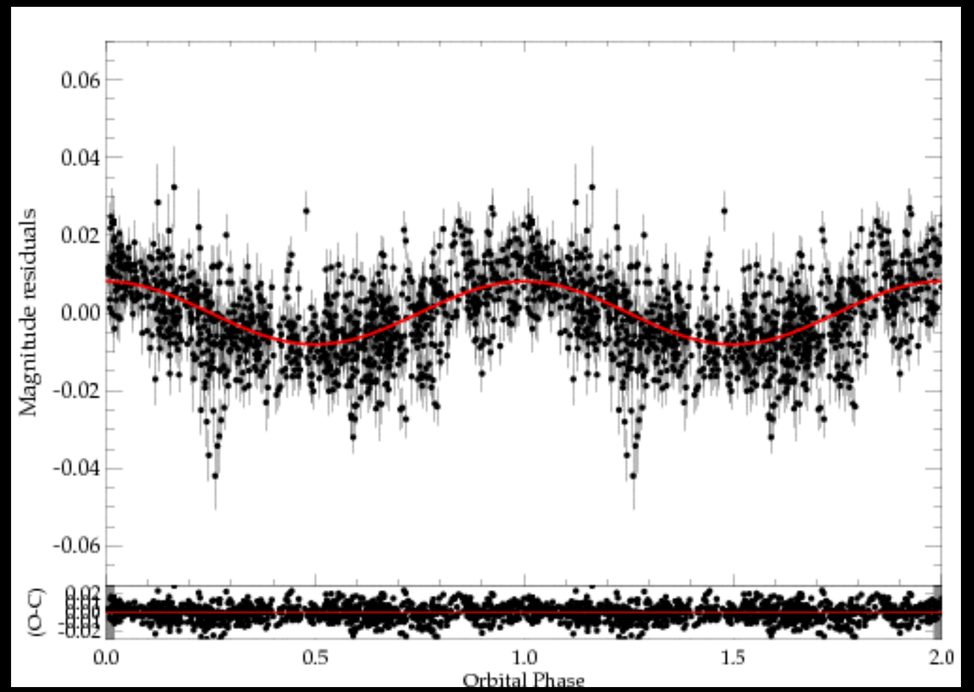




Source: http://www.mapthematics.com/ProjectionsList.php

A highly unequal-mass eclipsing M-dwarf binary in the WFCAM Transit Survey
Nefs, S.V. et al. MNRAS. 431 (2013) 3240 arXiv:1303.0945 [astro-ph.SR]





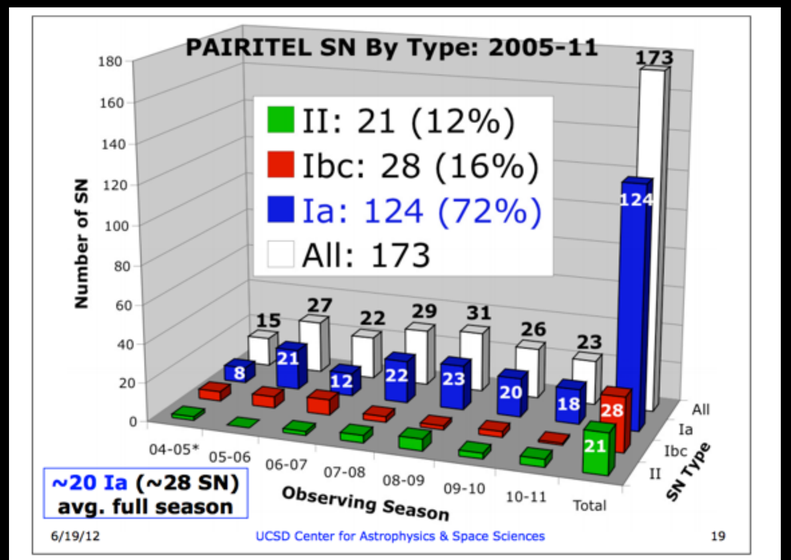
Ambiguity, distortion (misleading), distraction.

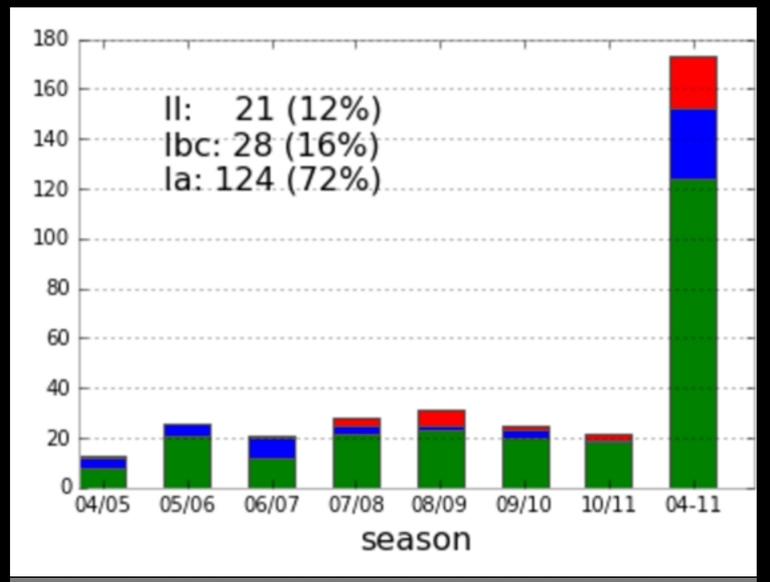
http://i.imgur.com/RzYaLZg.gif

http://www.nodexlgraphgallery.org/Pages/Graph.aspx?graphID=56967

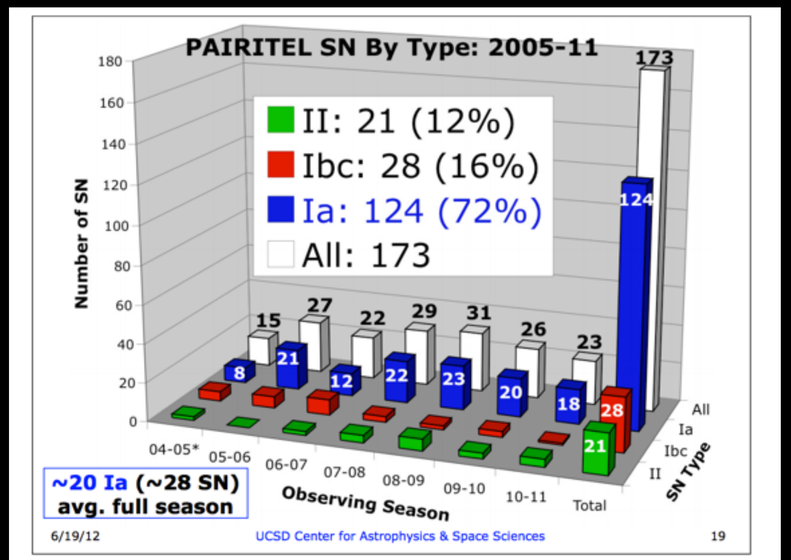

Violent crime rates
1990=100
Philadelphia
Houston
Phoenix
San Diego
Dallas
Los Angeles
New York
120
100
80
60
40
20
0
1990
95
2000
05
08
Sources: Federal Bureau of Investigation; The Economist
POLICE
NYPD

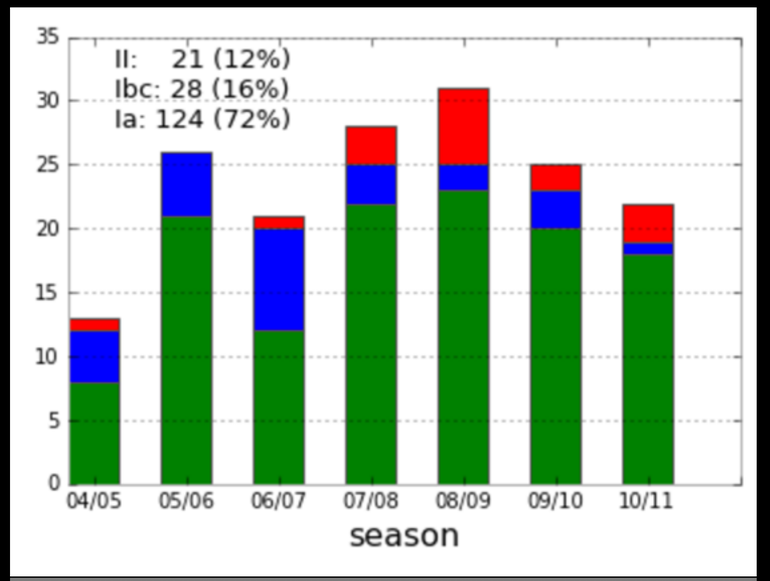
Ambiguity, distortion (misleading), distraction.





Ambiguity, distortion (misleading), distraction.





what makes a good vis

	1999.1.1	65 months	2004.4.28	low	high		2003.4.28	12 months	2004.4.28	low	high
Euro foreign exchange	$	1.1608		1.1907	.8252	1.2858	$	1.1025		1.1907	1.0783	1.2858
Euro foreign exchange	¥	121.32		130.17	89.30	140.31	¥	132.54		130.17	124.80	140.31
Euro foreign exchange	£	0.7111		0.6665	.5711	0.7235	£	0.6914		0.6665	0.6556	0.7235

Edward Tufte

Tufte’s rules:

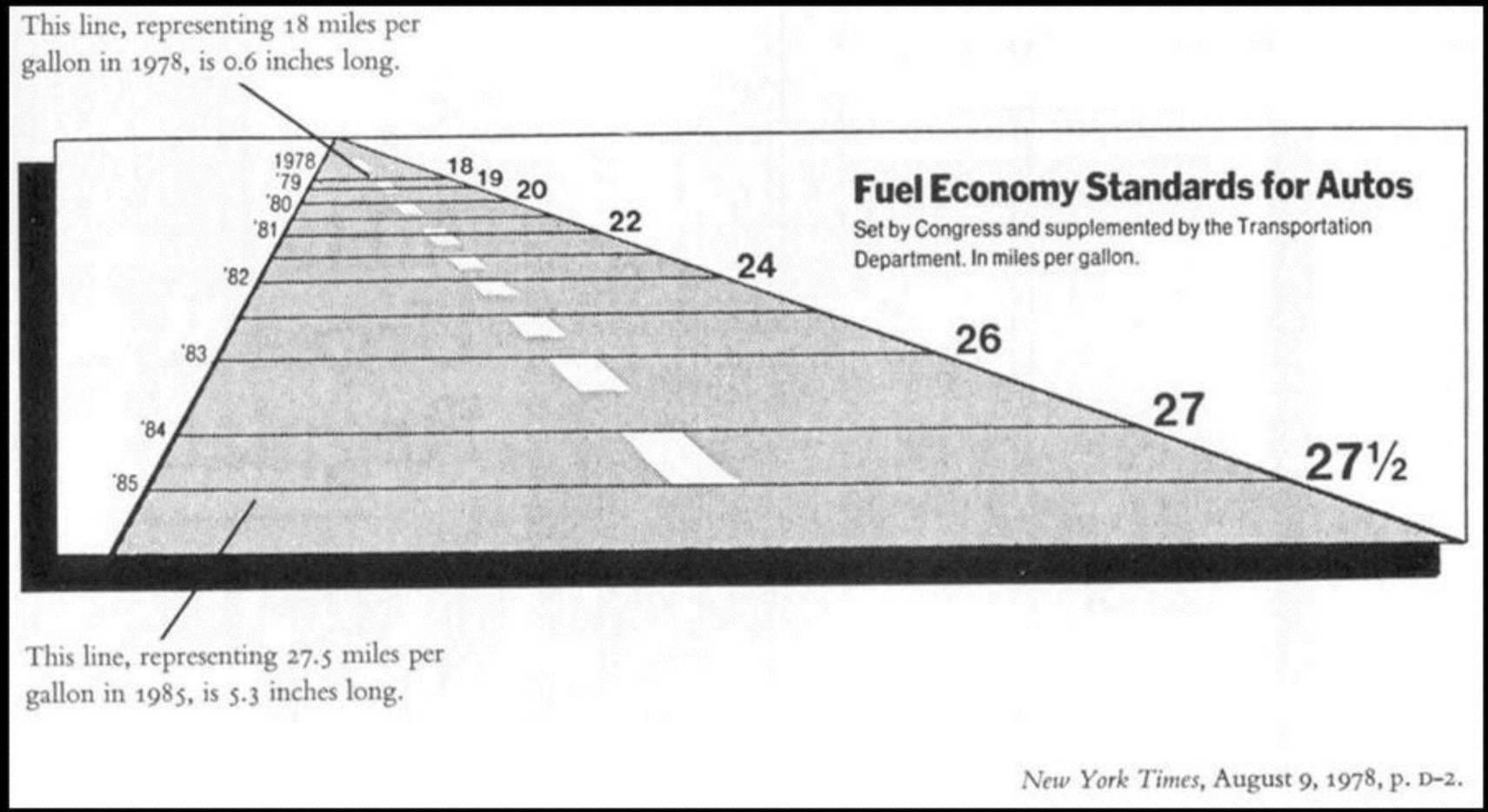
Lie factor

$$\frac{\text{size of the effect in the graphic}}{\text{size of the effect in the data}}$$

Tufte's rules:

Lie factor

$$\frac{\text{size of the effect in the graphic}}{\text{size of the effect in the data}}$$

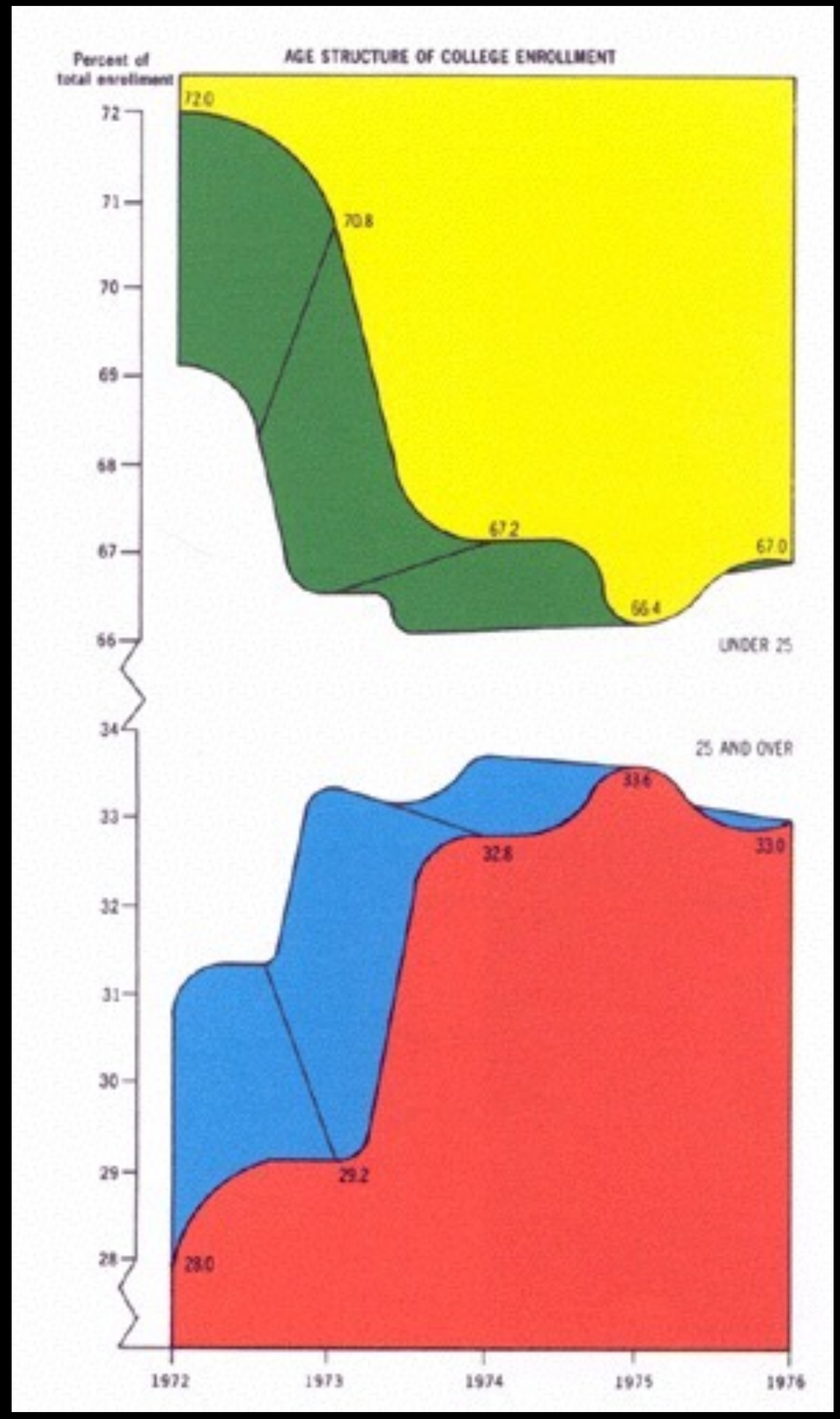



57%
of Europeans are worried their personal information is not safe.
Symantec.

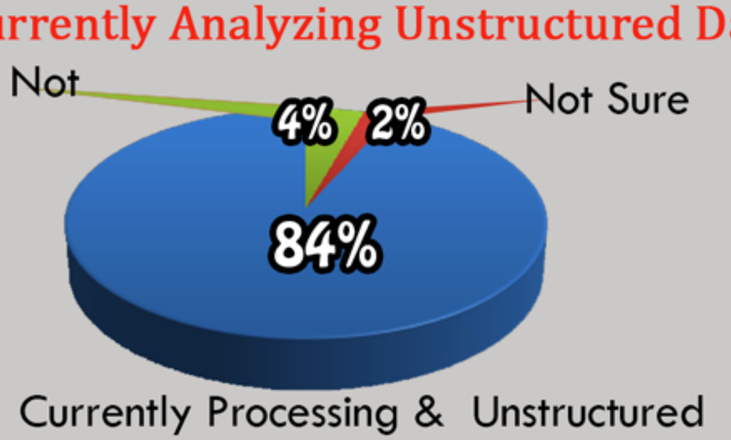
Tufte’s rules:

Chart Junk

the excessive and unnecessary use of graphical effects



4 The Rise of Unstructured and Semistructured Data Analytics

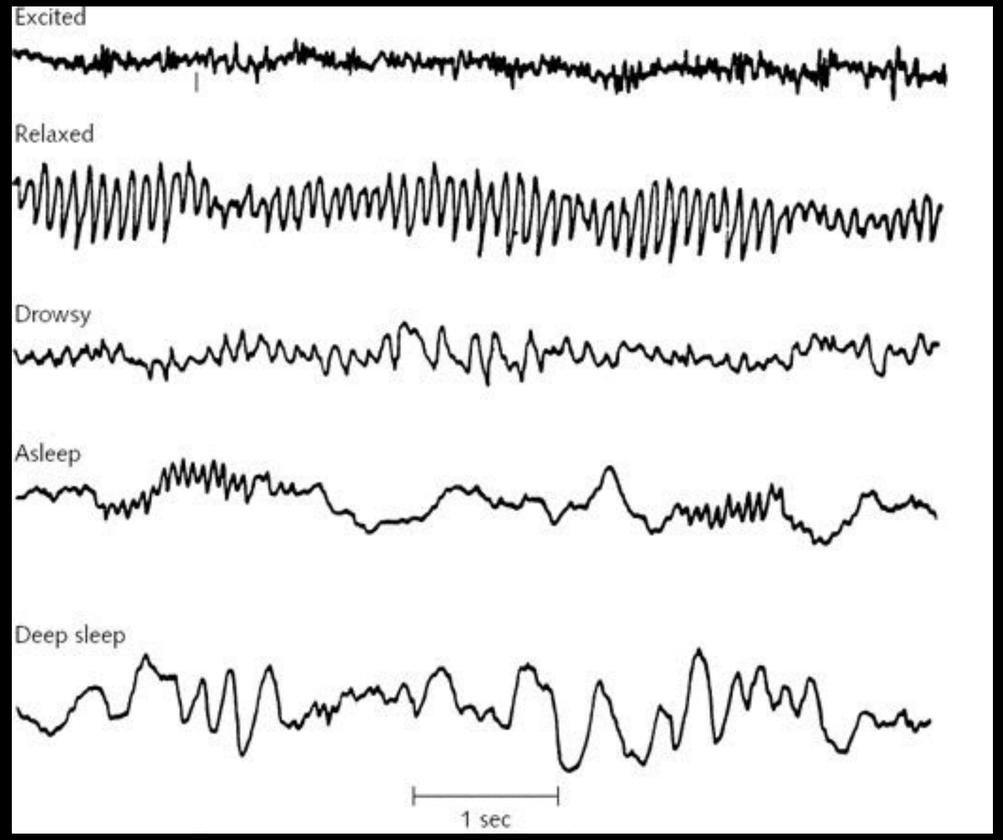


The 'Peer Research – Big Data Analytics' survey clearly reports that there is a huge growth when it comes to unstructured & semistructured data analytics.

Tufte's rules:

Data-ink ratio

$$\frac{\text{amount of data}}{\text{amount of ink}}$$



STATE OF **CREATIVITY IN EDUCATION:** AN ADOBE SURVEY

Sample Size: 1014 educators representing 13 countries across Asia Pacific

Attitudes & Aspirations

Current and Desired State of Creativity

62% Educators strongly felt that they should be creative regardless of the subjects they teach

35% Strongly felt fostering creativity is educators' primary responsibility

21% Strongly felt that parents are primarily responsible for creativity

58% Ideally wanted to spend time fostering creativity in the classroom

45% Educators spent their time fostering creative skills in their classroom in the last one year

Barriers & Enablers

What Hinders and Helps Creativity

57% Are hamstrung by an education system that is not geared towards creativity

49% Blame it on lack of resources

29% Blame it on lack of time

36% Believe the biggest barrier to creativity is a system that is heavily reliant on testing and assessment

43% Felt the current education system was either outdated or restrictive or both

41% Educators believe tools and training for educators are the most critical need to promote creativity

Tools & Techniques

Methods to Foster Creativity

85% Respondents felt that technology and digital tools play an important role

34% Indicated that they were very prepared to adapt their teaching methodology to leverage digital tools

Innovation & Growth

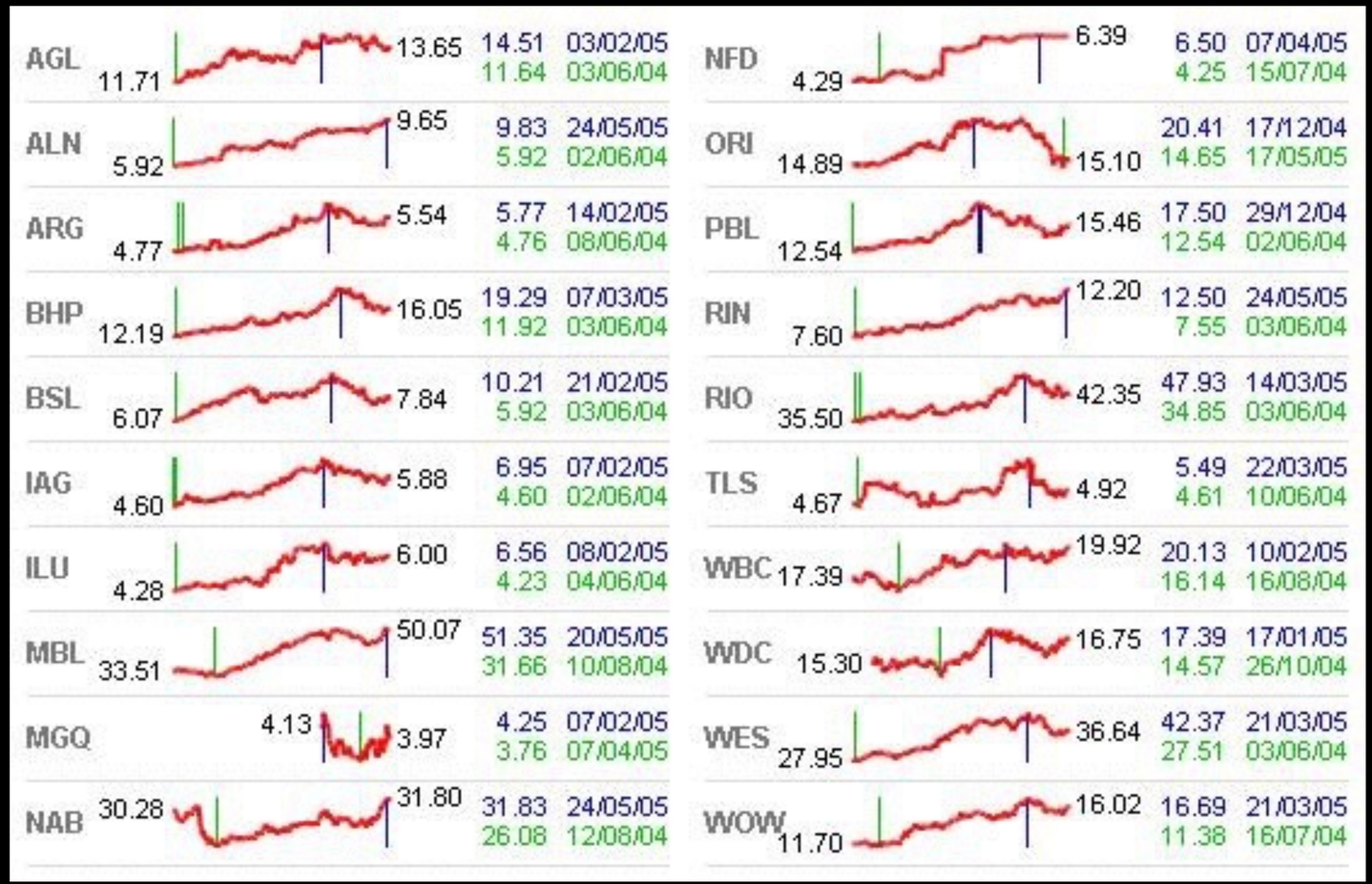
Impact on Country's Success

8.4 Rating on a scale of 1 to 10; on how important it was to infuse creativity in education to ensure their country's long-term success

5.0 Rating on a scale of 1 to 10; on the efficiency of the current education system in developing a new generation of innovators

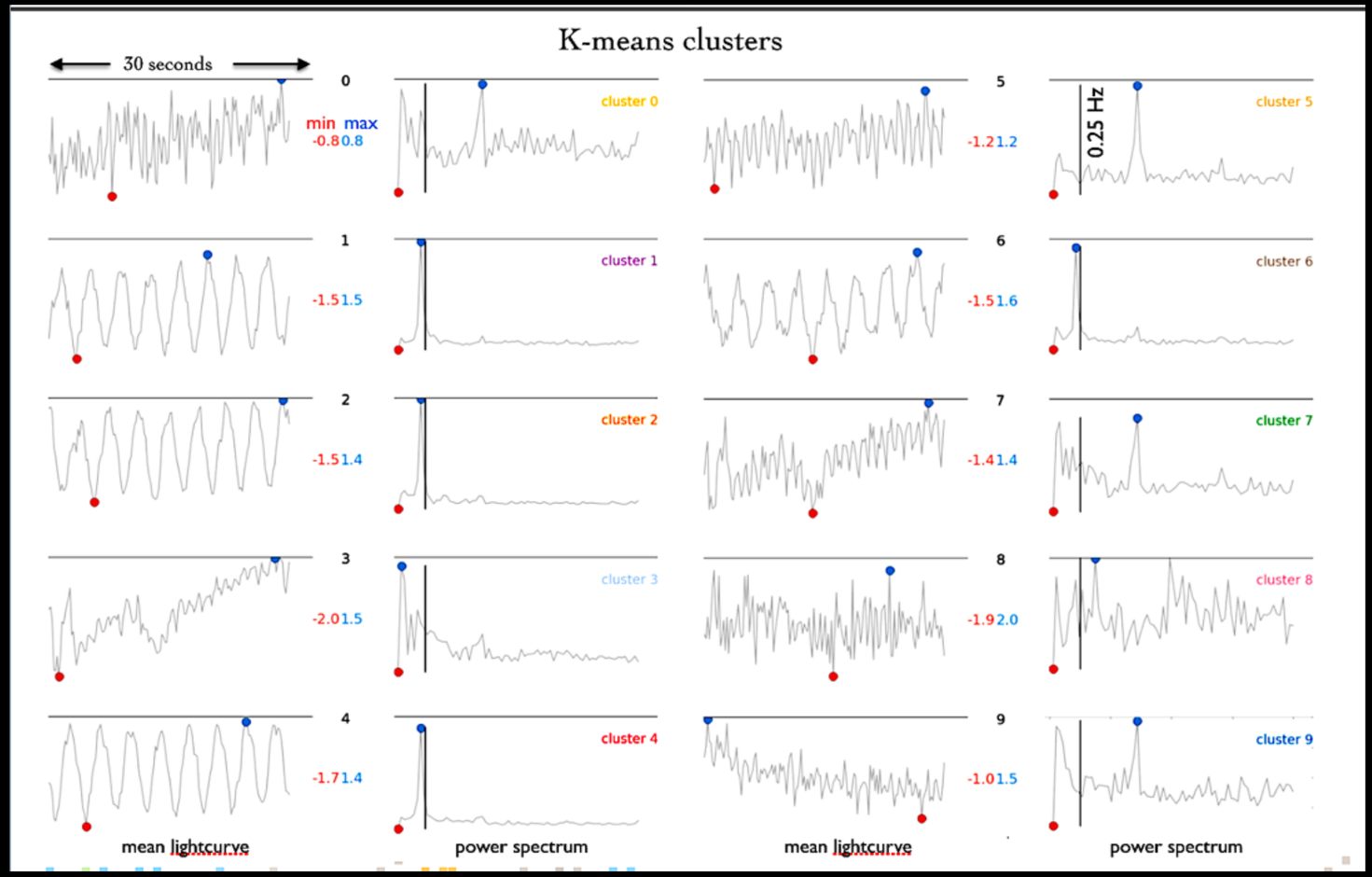
Tufte’s rules:

Small Multiples encourage comparison



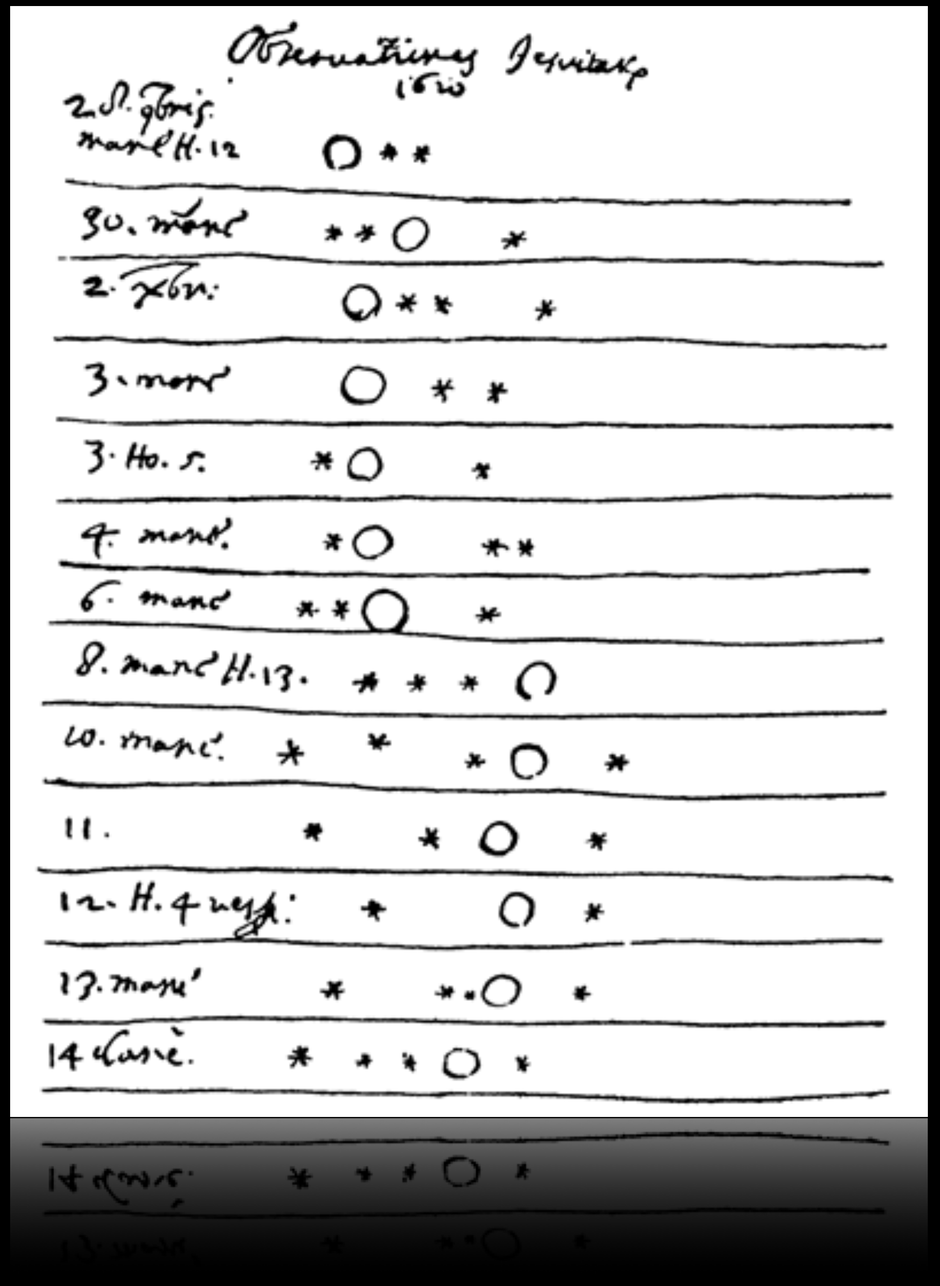
sparkline graph

Tufte’s rules:

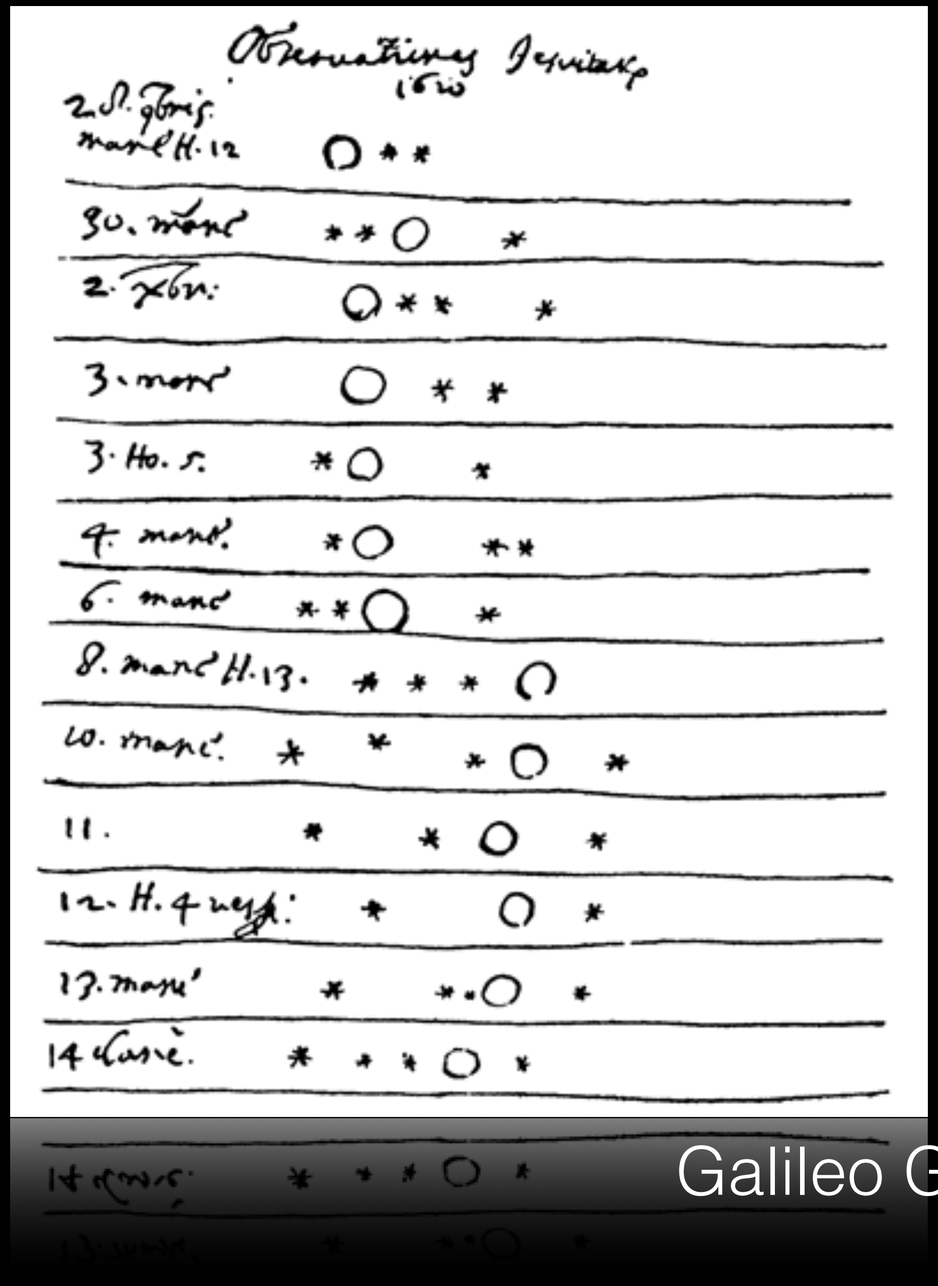


sparkline graph

Small Multiples

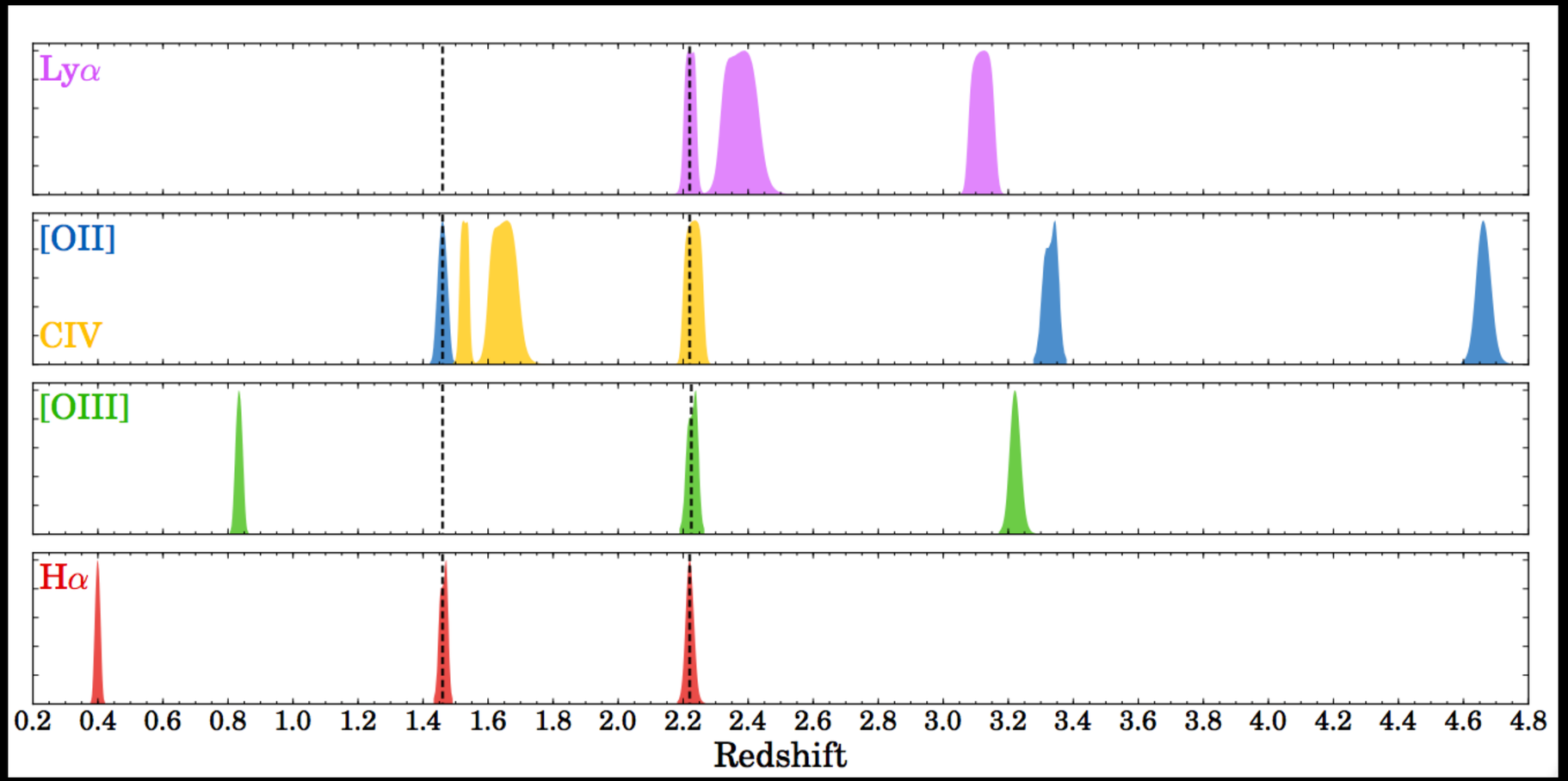


Small Multiples



Galileo Galilei, Jupiter moons, 1610

Small Multiples



https://arxiv.org/pdf/1702.04721.pdf

Small Multiples

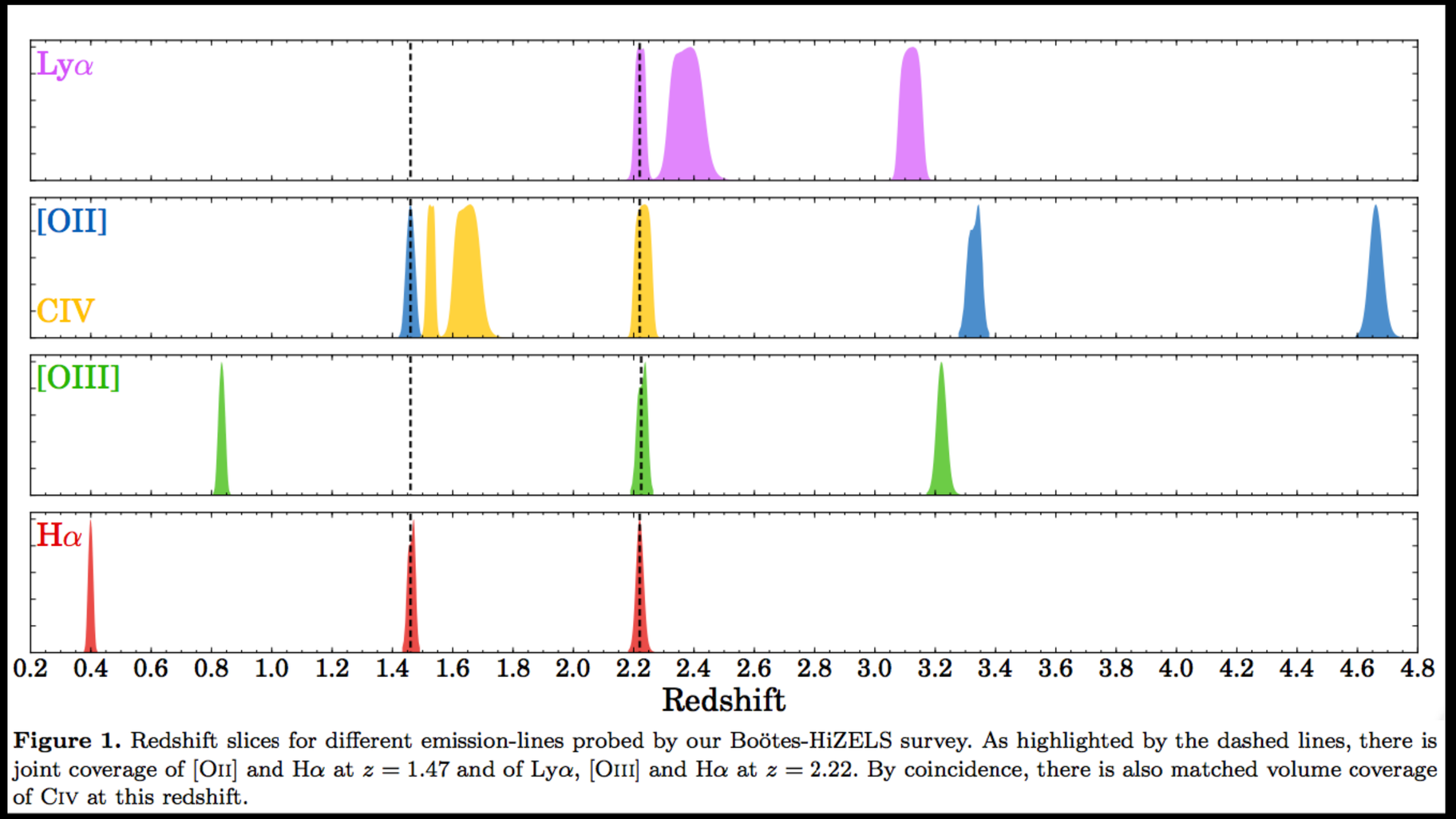
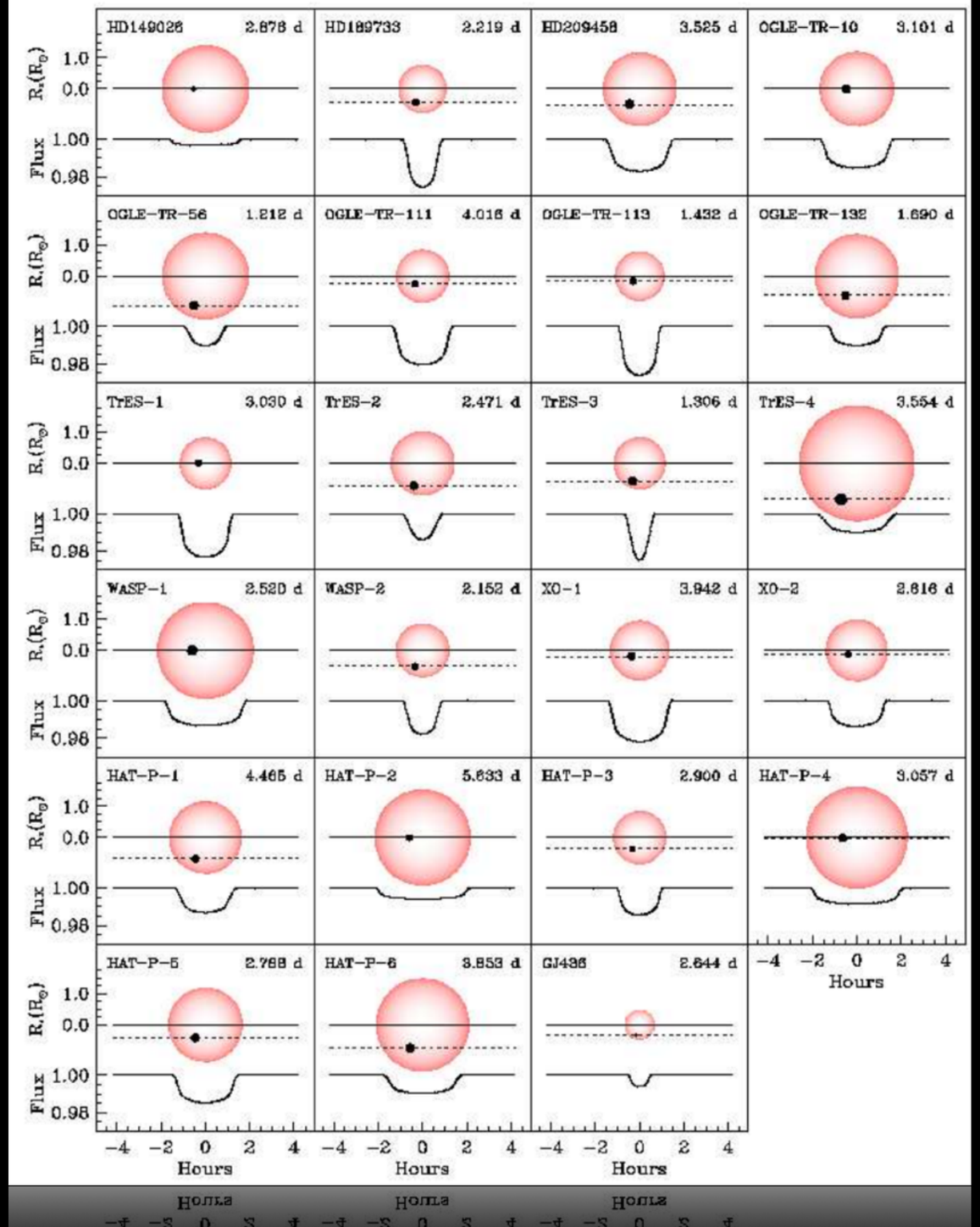


Figure 1. Redshift slices for different emission-lines probed by our Boötes-HiZELS survey. As highlighted by the dashed lines, there is joint coverage of [OII] and Hα at $z = 1.47$ and of Lyα, [OIII] and Hα at $z = 2.22$. By coincidence, there is also matched volume coverage of CIV at this redshift.

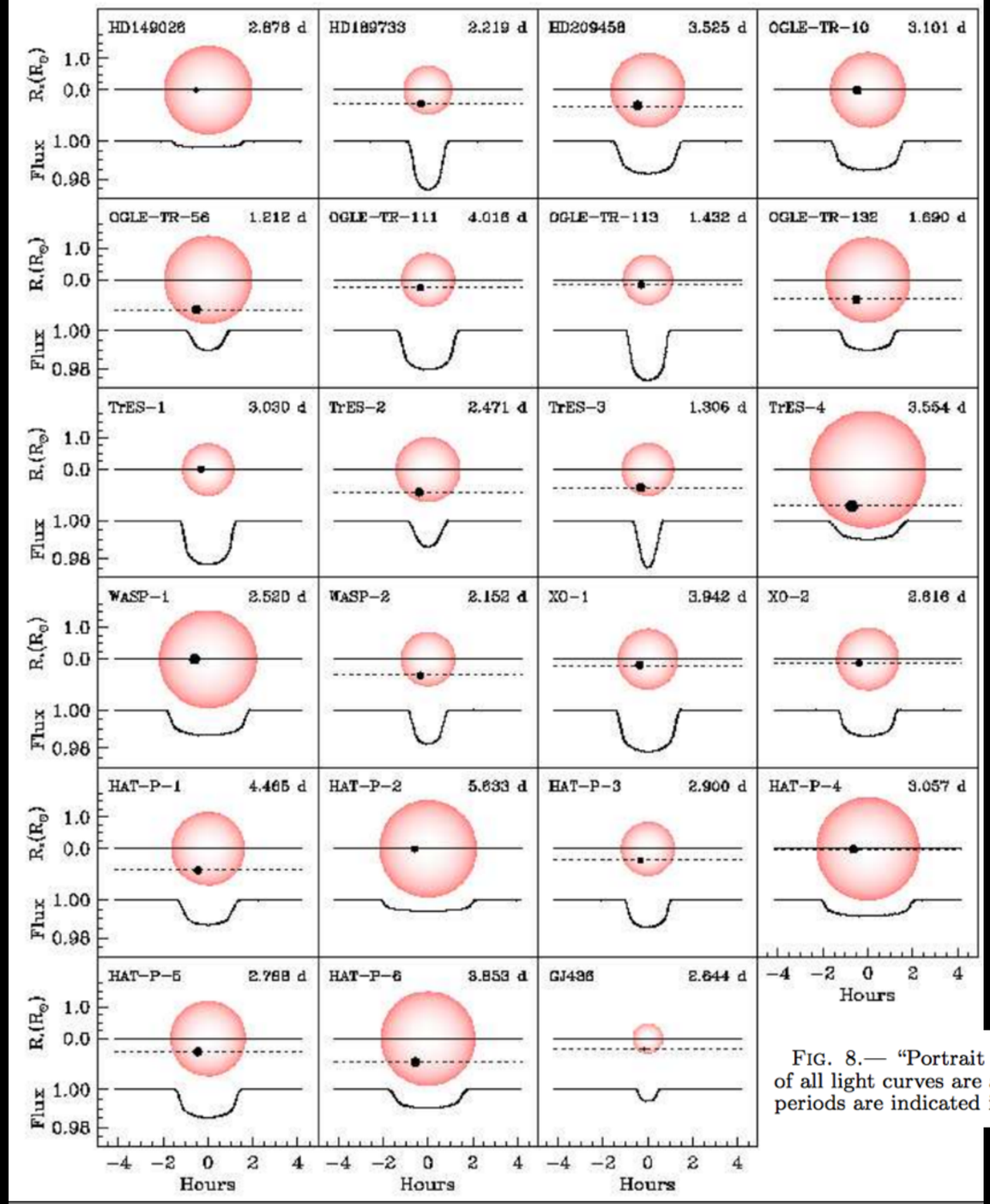
https://arxiv.org/pdf/1702.04721.pdf

Bootes-HiZELS: an optical to near-infrared survey of emission-line galaxies at z = 0.4 – 4.7
Jorryt Matthee+ 2017



Small Multiples

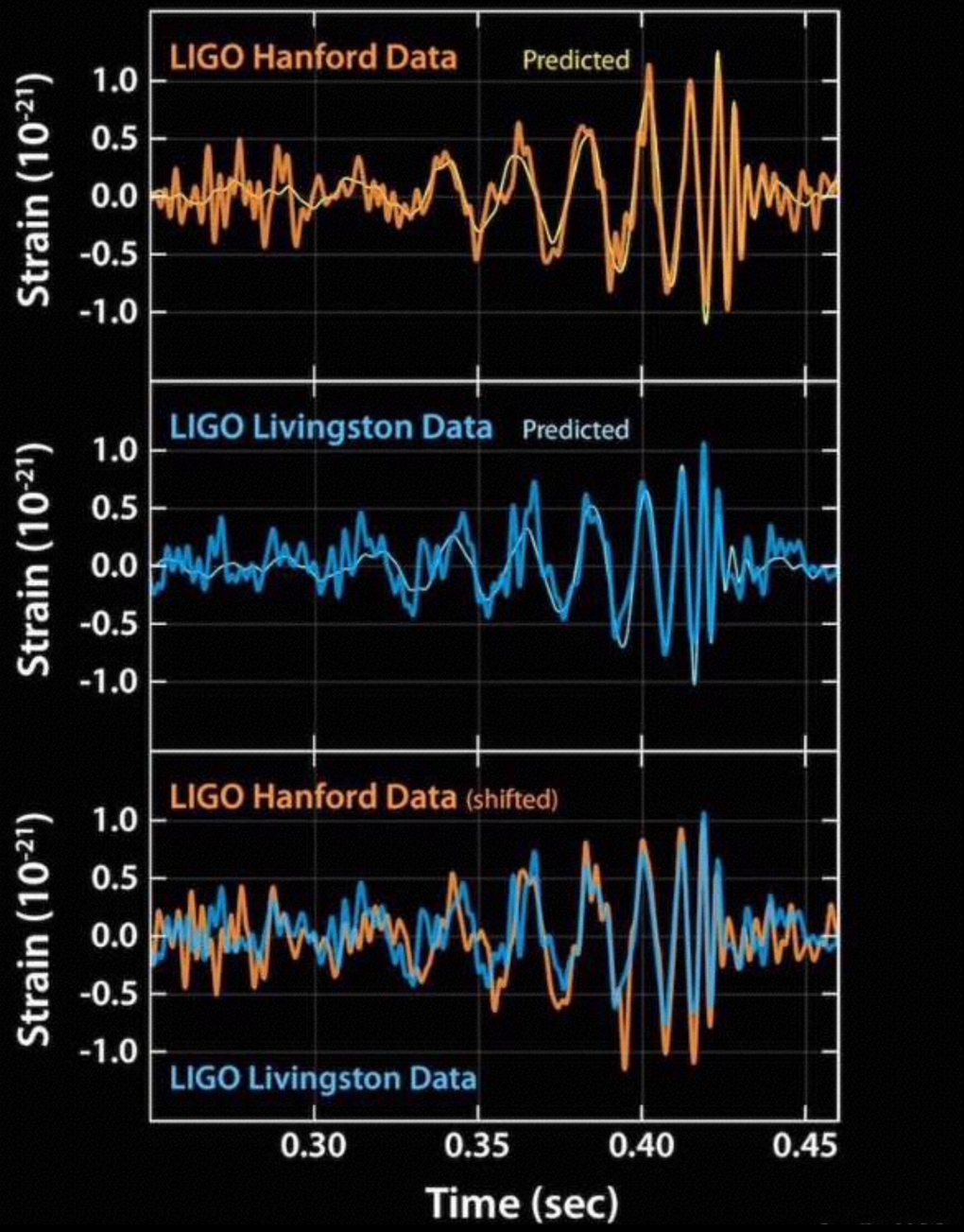
Small Multiples



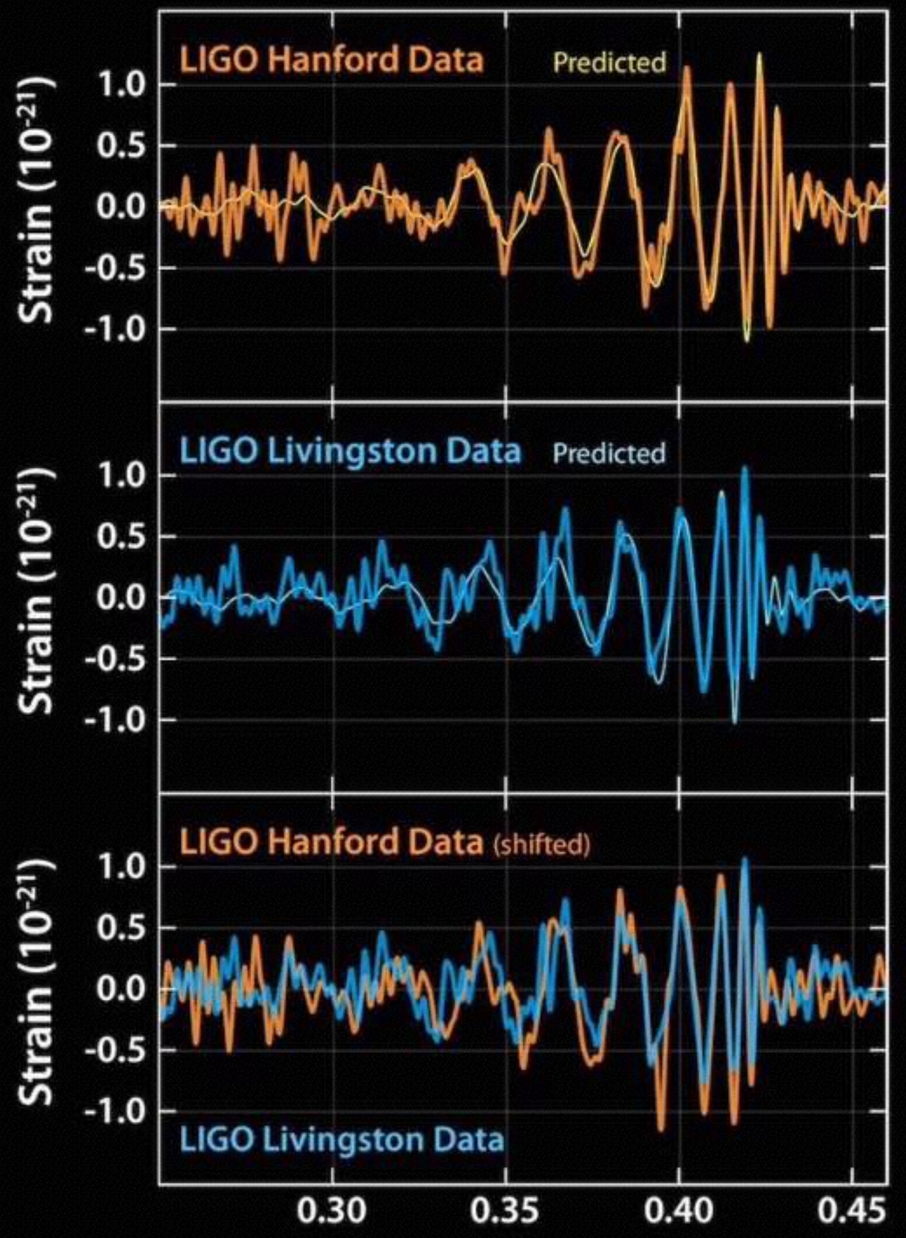
IMPROVED PARAMETERS FOR EXTRASOLAR TRANSITING PLANETS
Guillermo Torres, Joshua N. Winn, and Matthew J. Holman
2008

FIG. 8.— "Portrait gallery" of transiting extrasolar planets. Star and planet sizes are shown to scale. The vertical and horizontal axes of all light curves are also on the same scale. Planet trajectories are shown with their measured impact parameters (dotted lines). Orbital periods are indicated in each panel.

Small Multiples



Small Multiples



LIGO, Gravitational waves, 2016

http://titaniumphysicists.brachiolopemedia.com/

Tufte’s rules:

1. The representation of numbers, as physically measured on the surface of the graph itself, should be directly proportional to the numerical quantities represented-***effect size***

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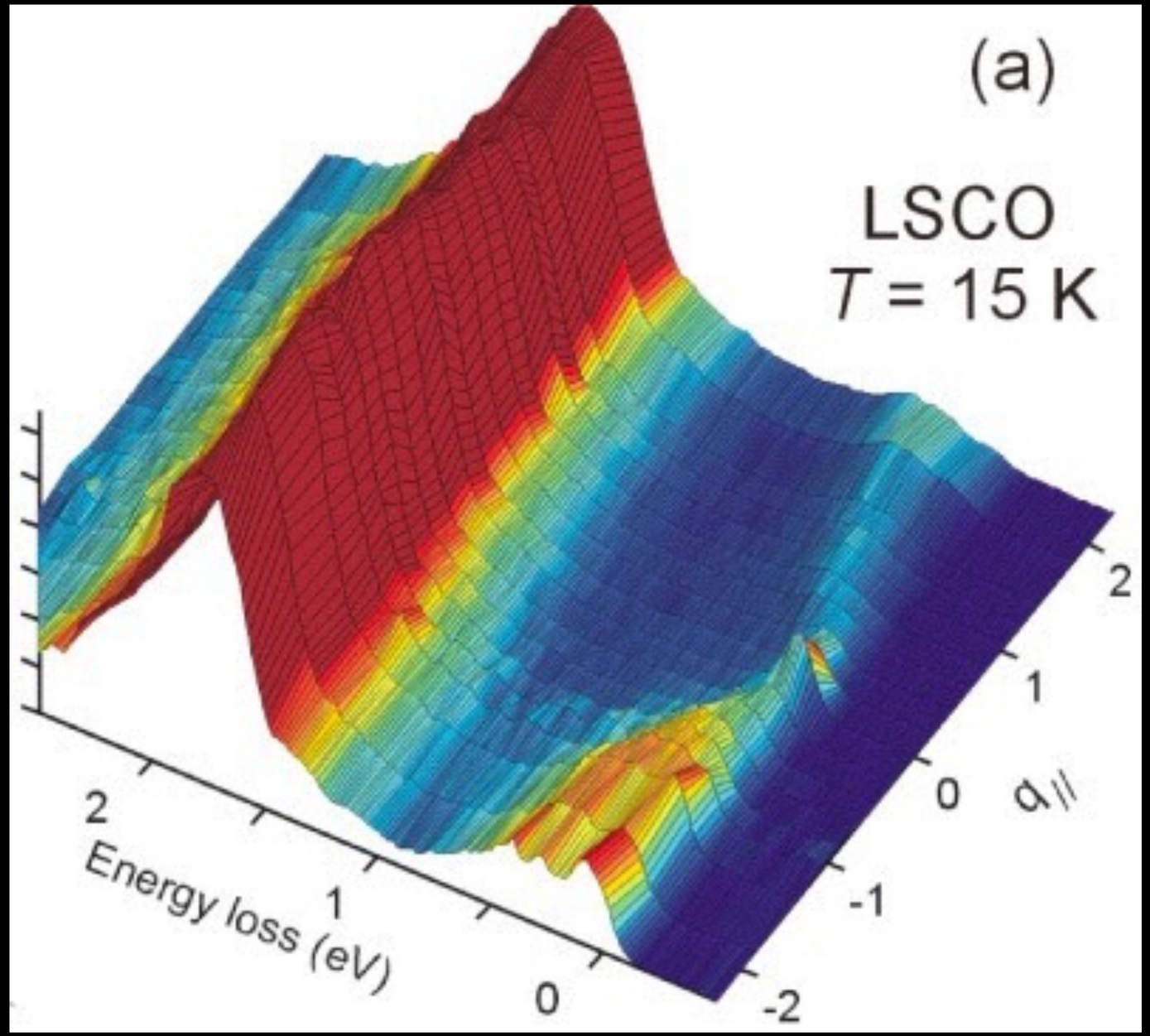
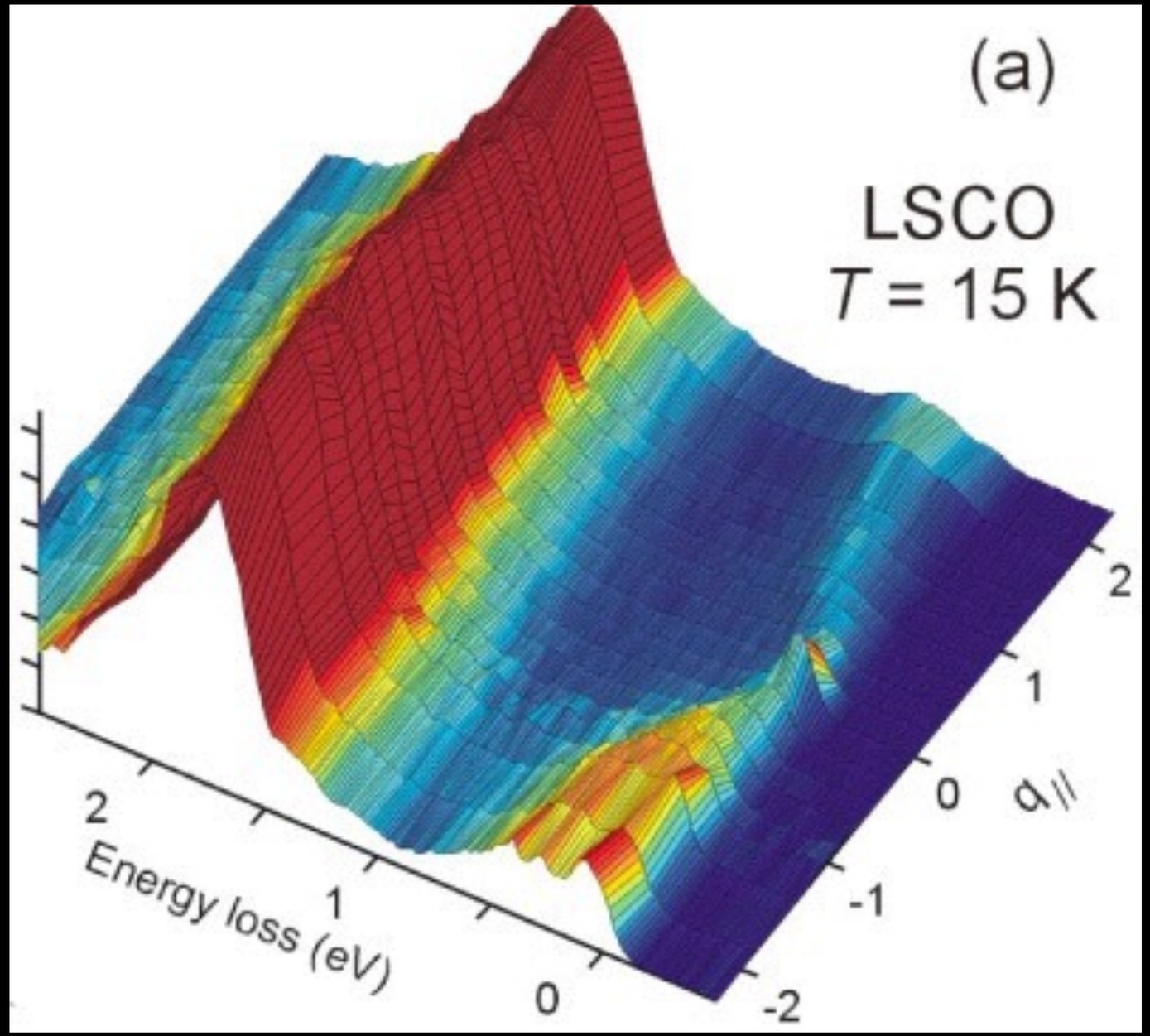
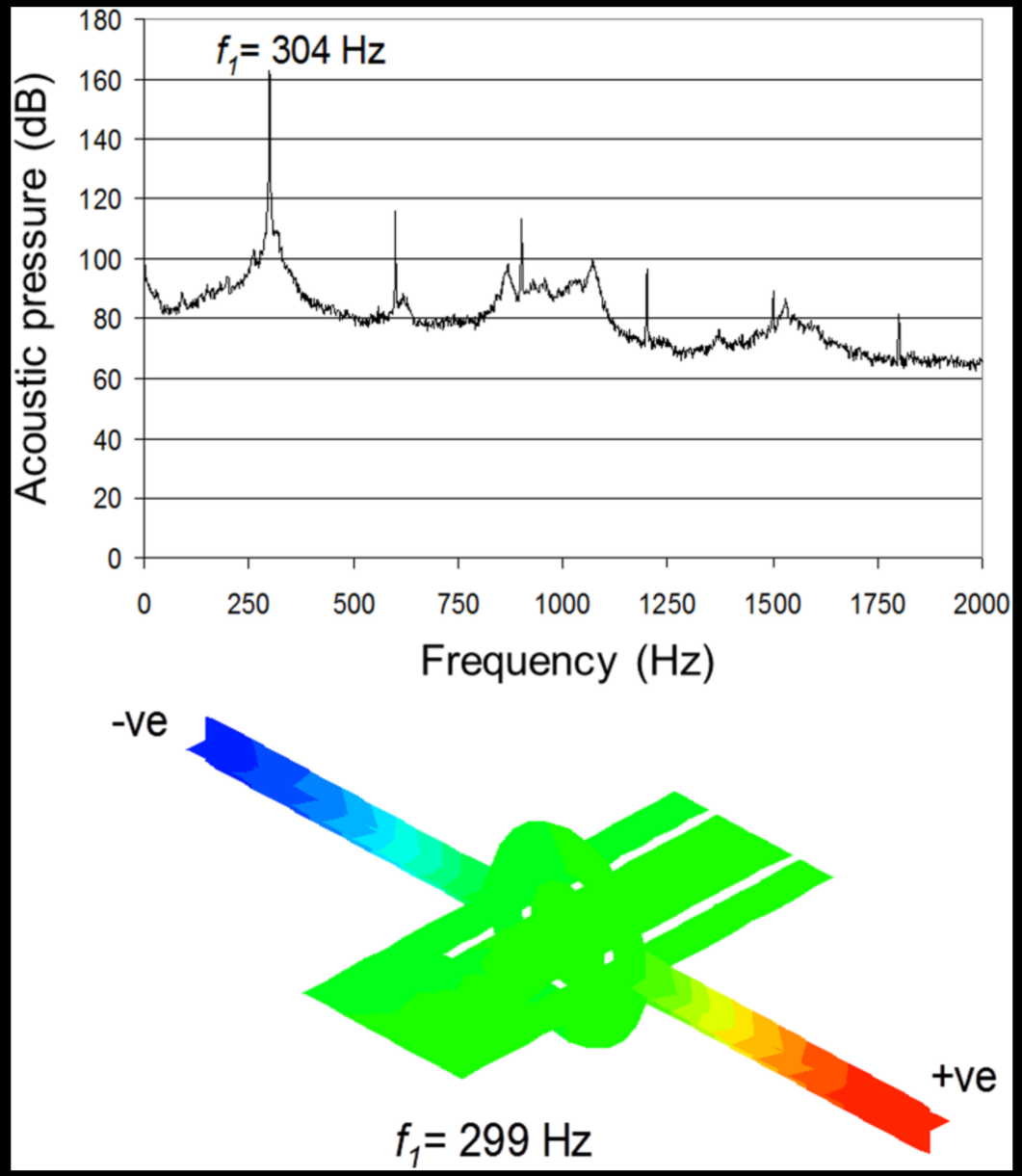
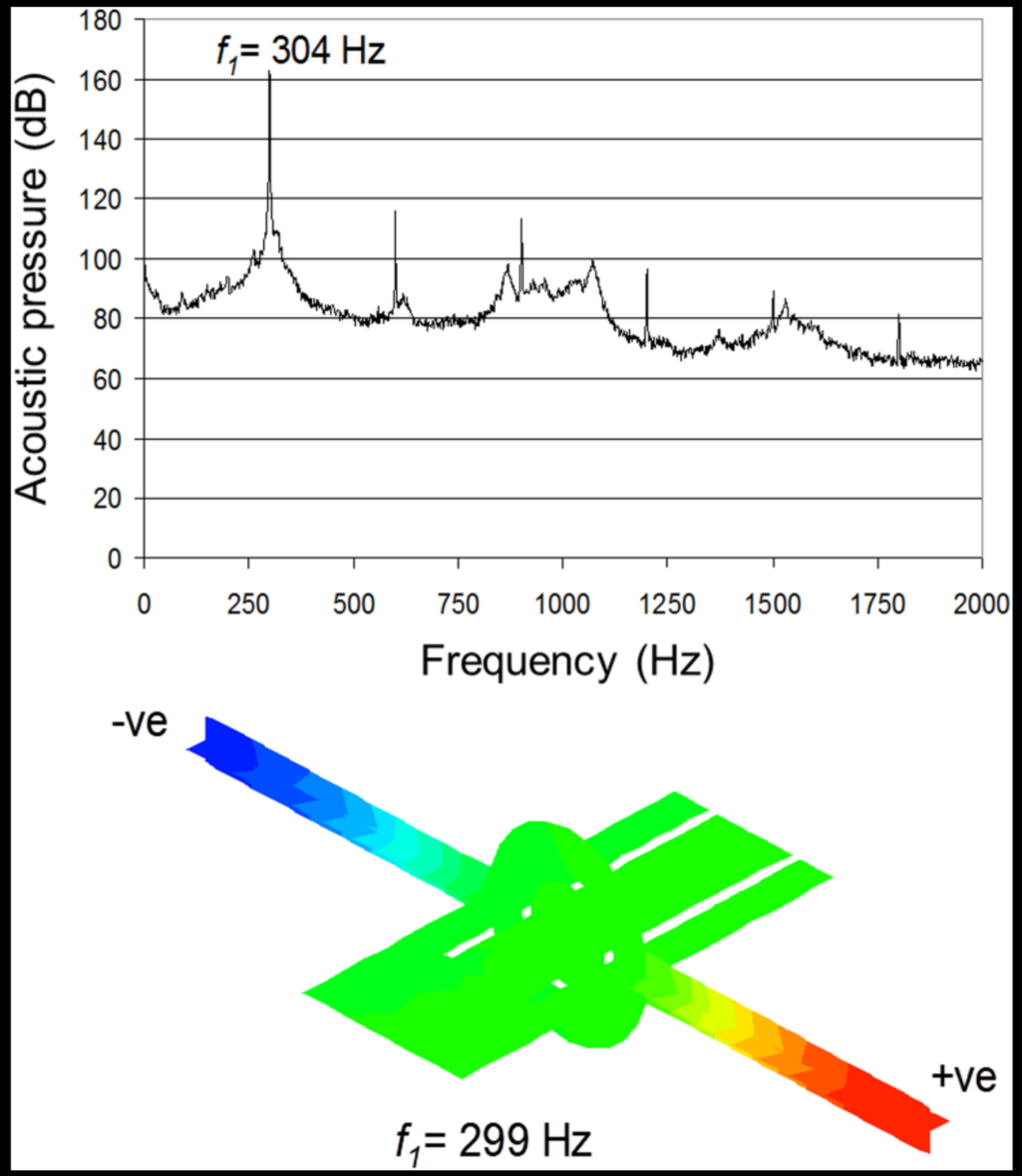
5. The number of information carrying (variable) dimensions depicted should not exceed the number of dimensions in the data. Graphics must not quote data out of context.


(a)
LSCO
T = 15 K
2
1
0
-1
-2
q//
2
1
0
Energy loss (eV)

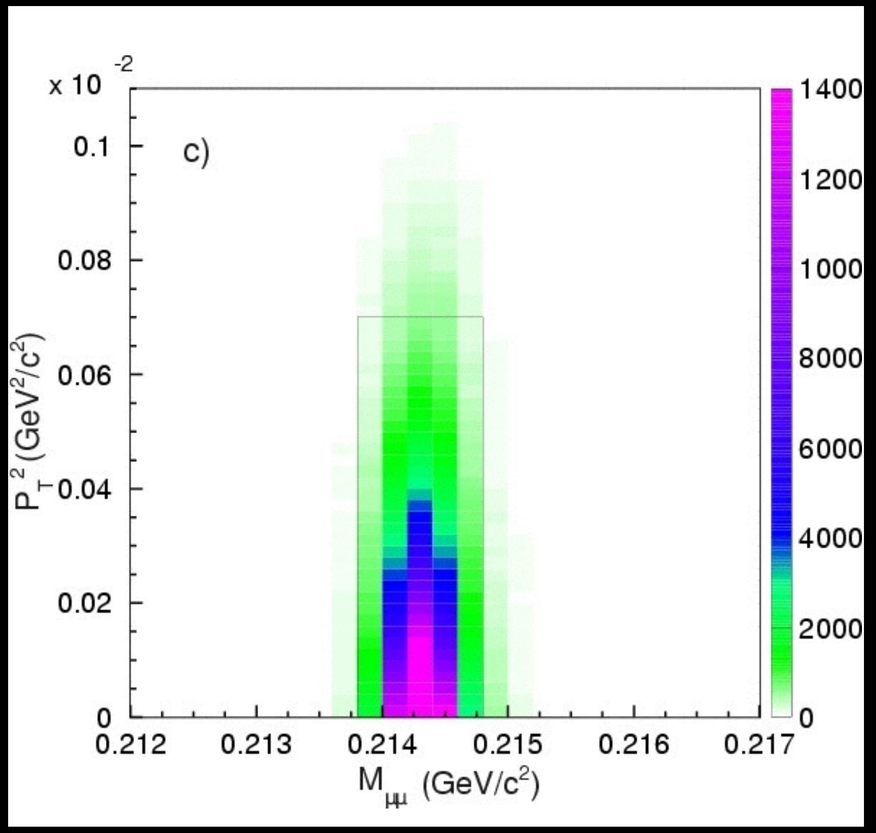


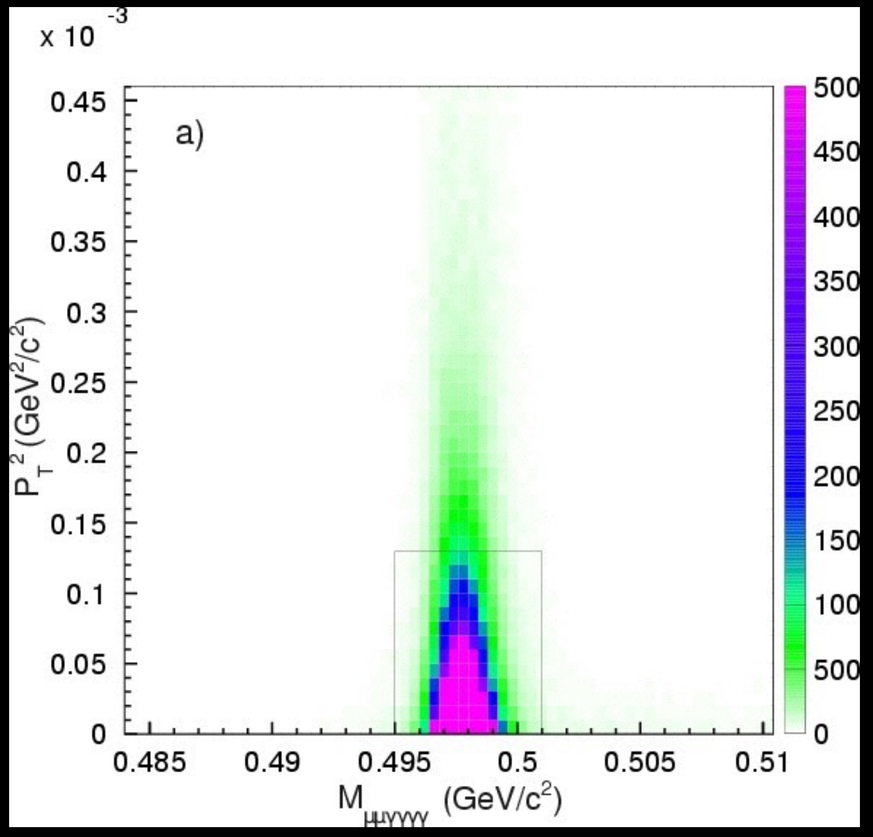
3 variables, 4 graphical elements

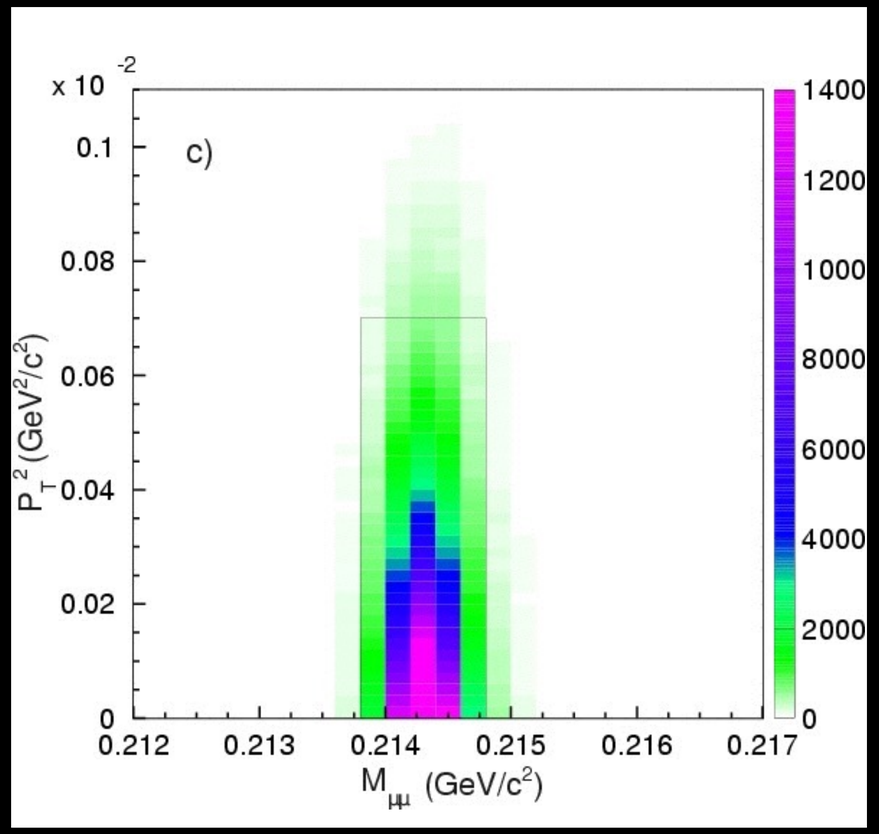

f_1= 304 Hz
Acoustic pressure (dB)
180
160
140
120
100
80
60
40
20
0
0
250
500
750
1000
1250
1500
1750
2000
Frequency (Hz)
-ve
+ve
f_1= 299 Hz

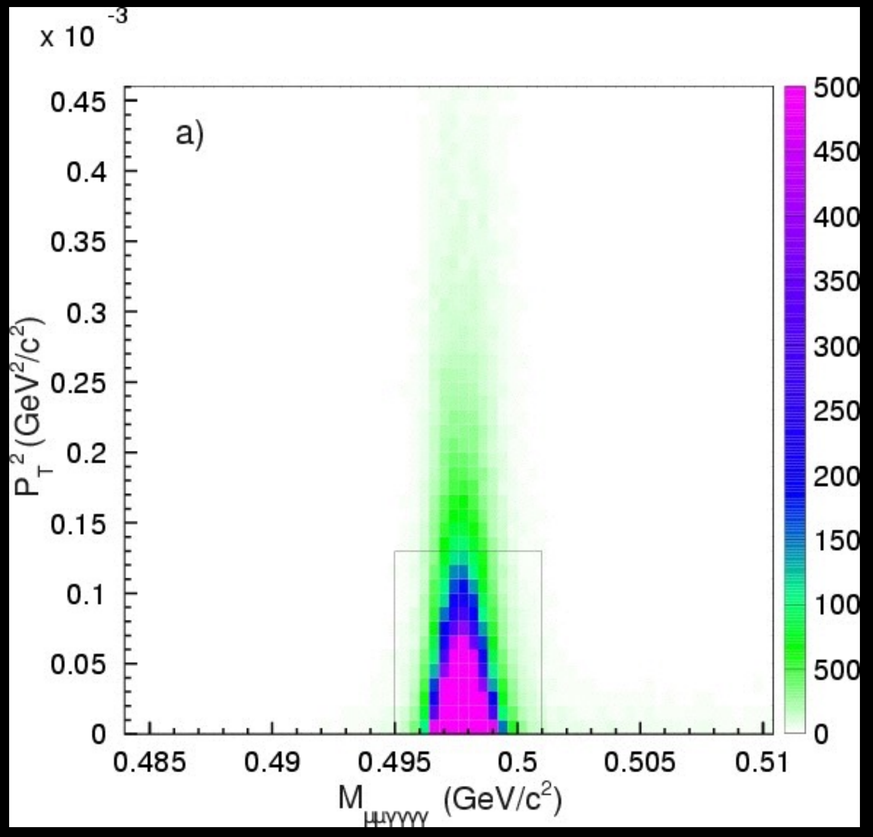


Show data variation, not design variation-***chart junk***


x 10 -2
c)
0.1
0.08
0.06
0.04
0.02
0
P_T^2 (GeV^2/c^2)
0.212
0.213
0.214
0.215
0.216
0.217
$M_{\mu\mu}$ (GeV/c^2)
1400
1200
1000
8000
6000
4000
2000
0


x 10 -3
a)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
P_T^2 (GeV^2/c^2)
0.485
0.49
0.495
0.5
0.505
0.51
$M_{\mu\mu\gamma\gamma}$ (GeV/c^2)
500
450
400
350
300
250
200
150
100
500
0

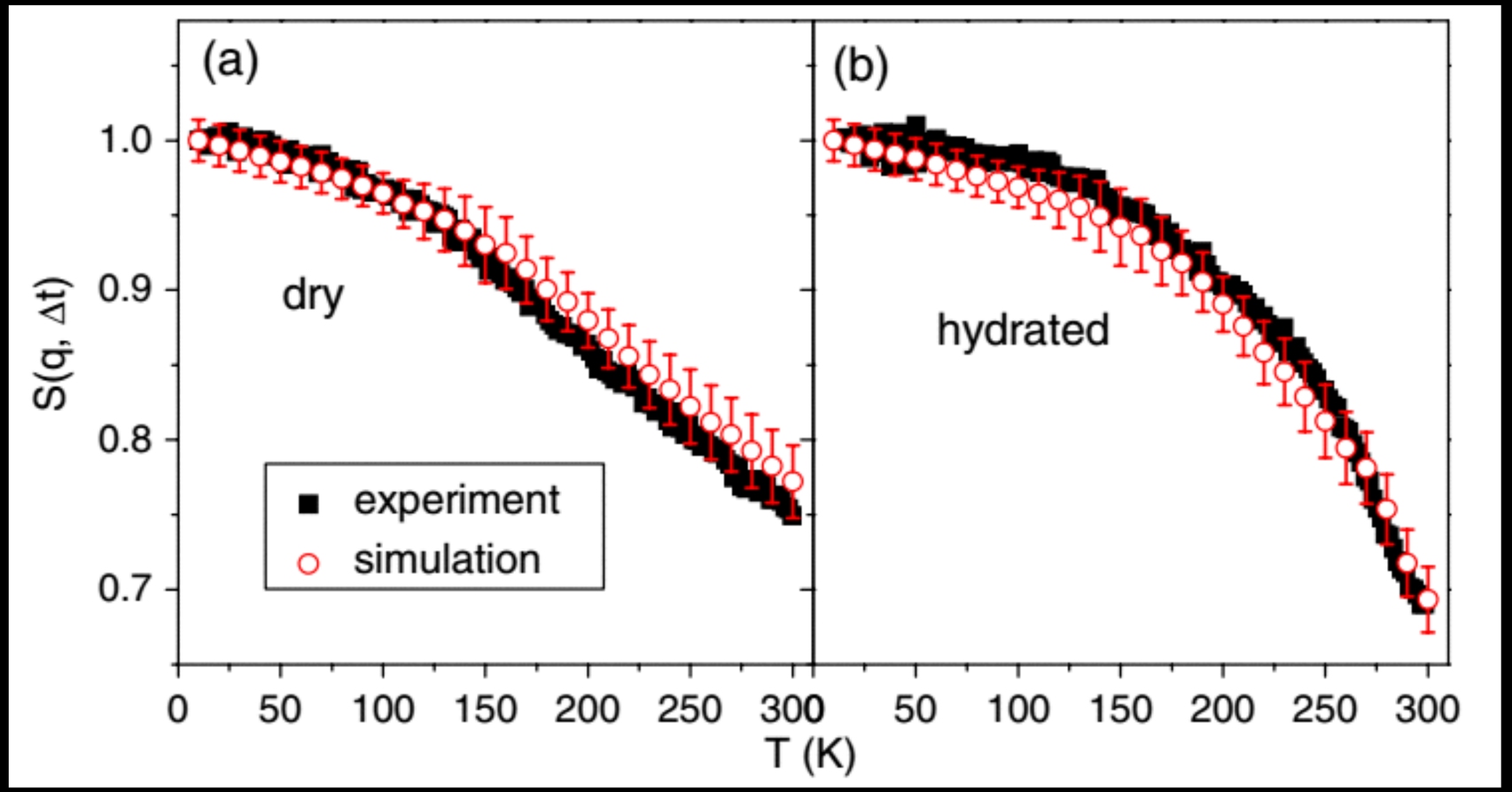




low data-ink ratio

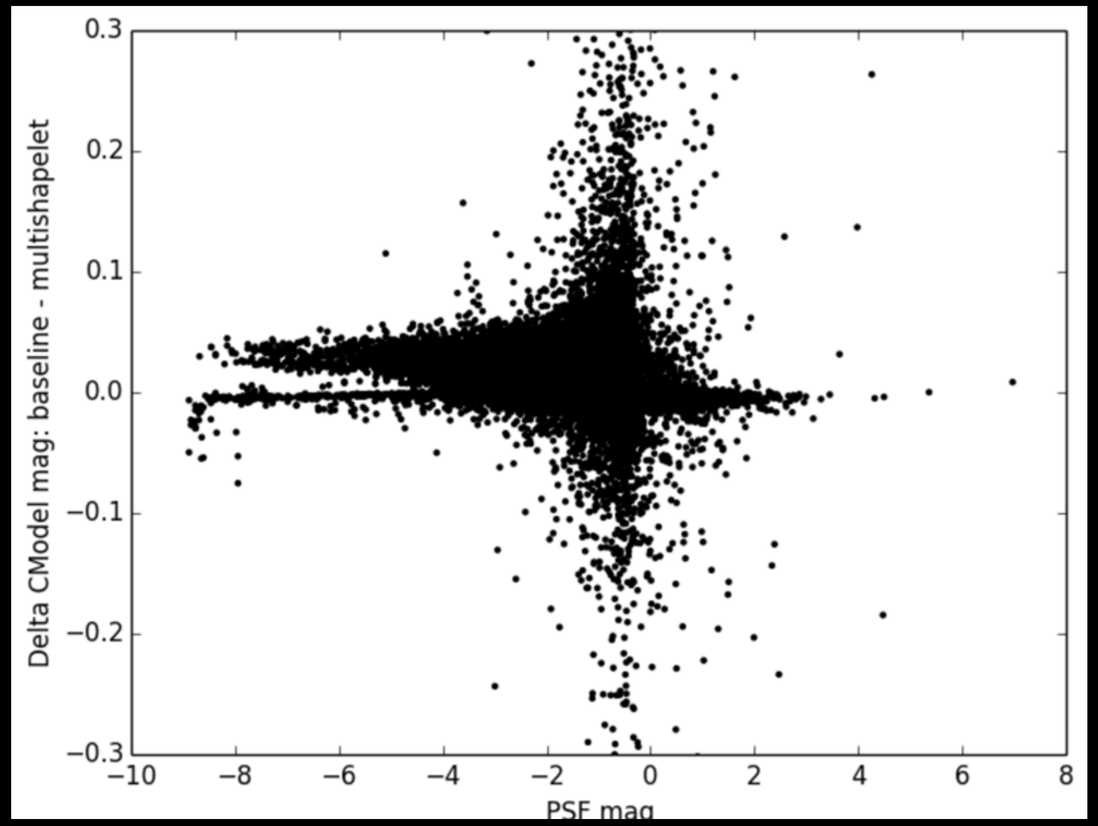
high effect size (rainbow)

http://ktev.fnal.gov/public/pubs/ktev/pi0pi0mm/plots/pi0pi0mm_plots.html



???

http://ins.sjtu.edu.cn/people/lhong/english/research.html



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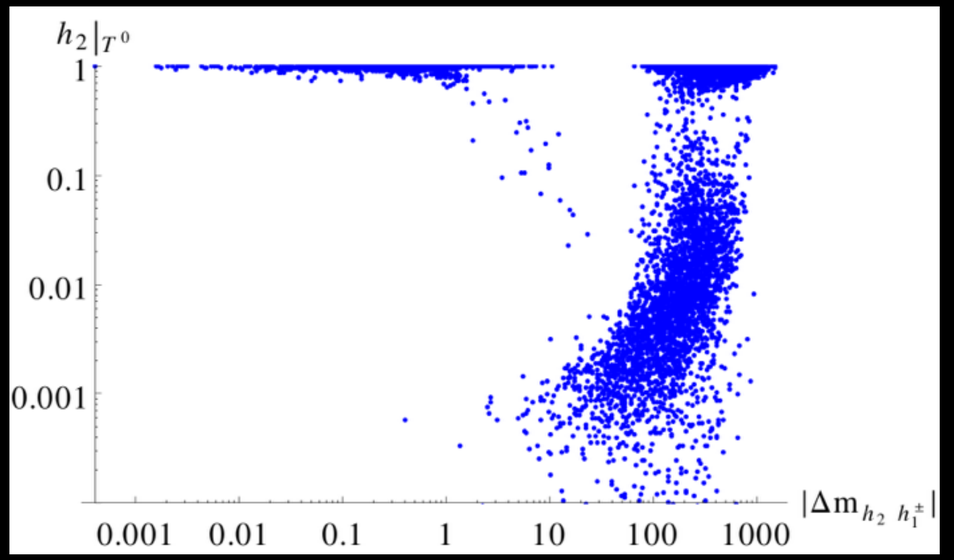
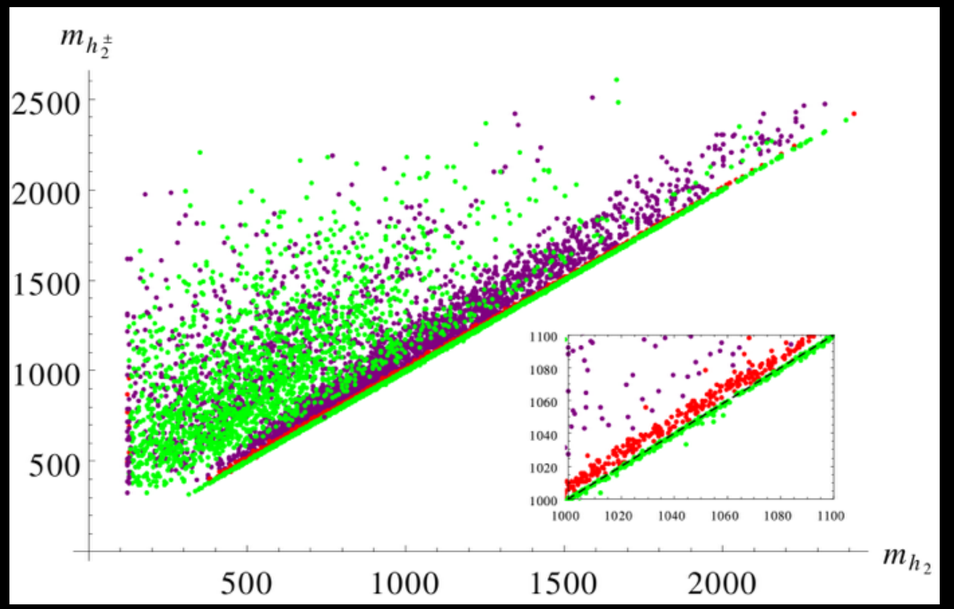
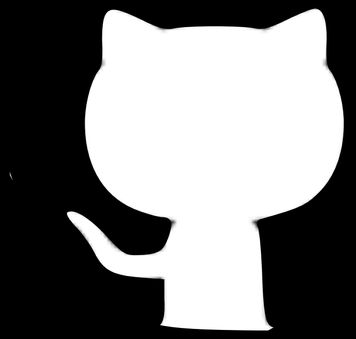




http://inspirehep.net/record/1411674/plots

in-class exercise

https://github.com/fedhere/UInotebooks/blob/master/visz/badPlotgoodPlot.ipynb



Jer Thorp

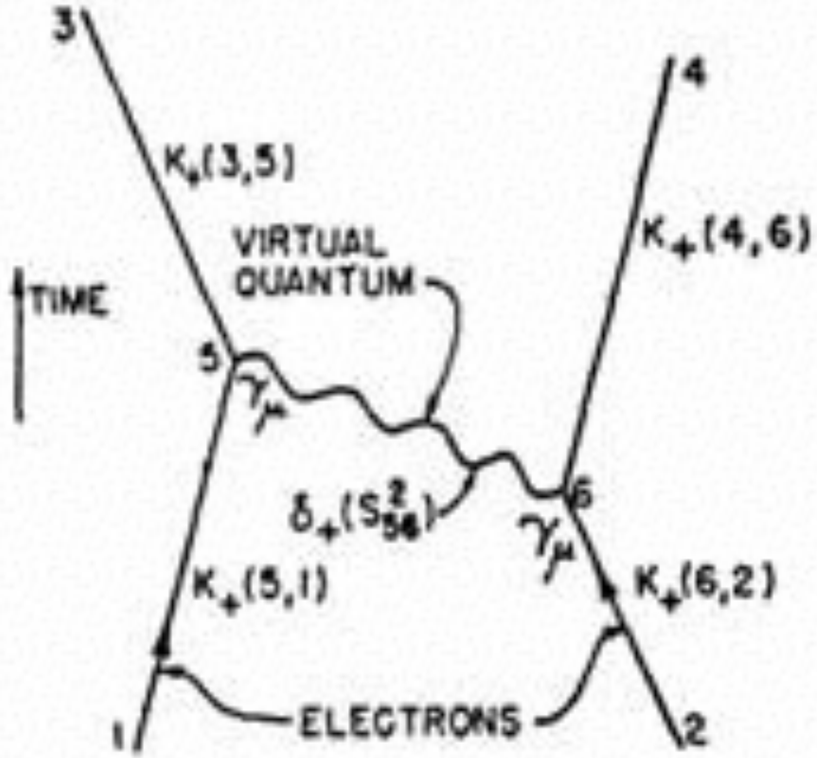


FIG. 1. The fundamental interaction Eq. (4). Exchange of one quantum between two electrons.

Feynman diagrams:
designed to solve equations

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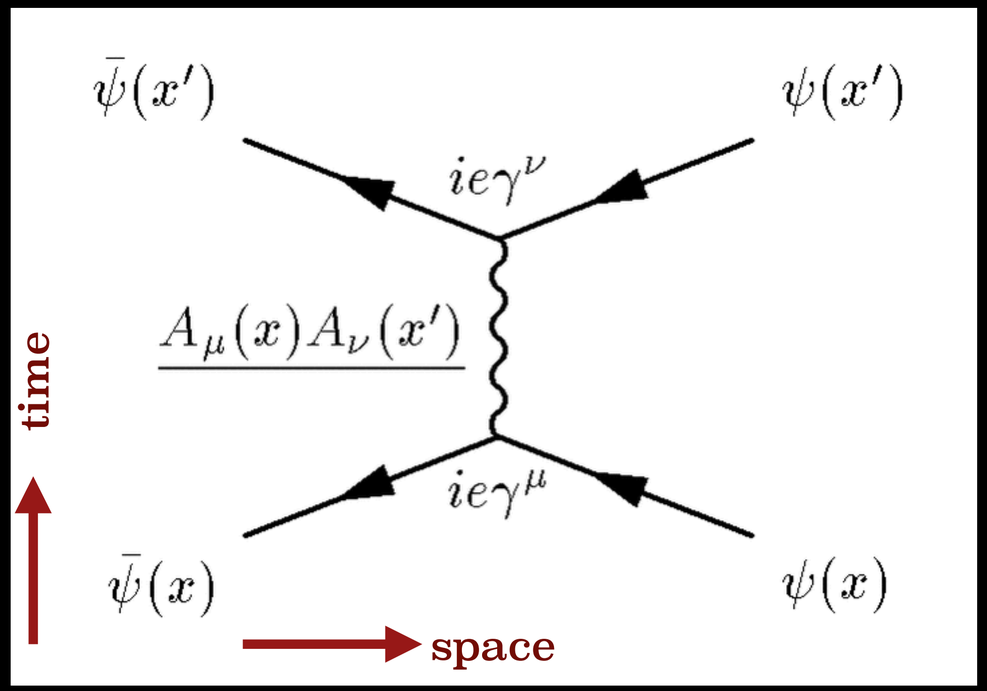
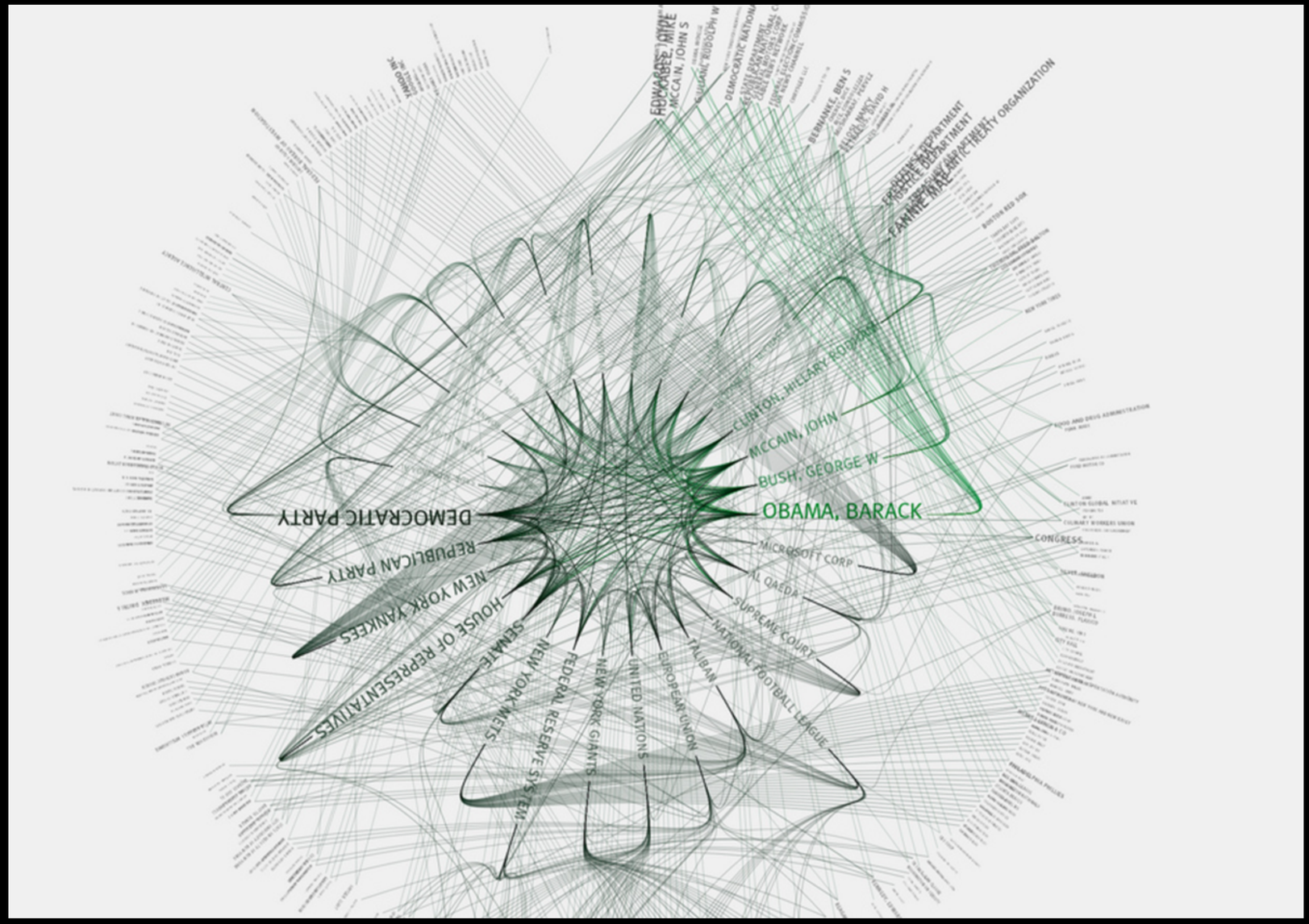


https://inspirehep.net/record/1082448/plots

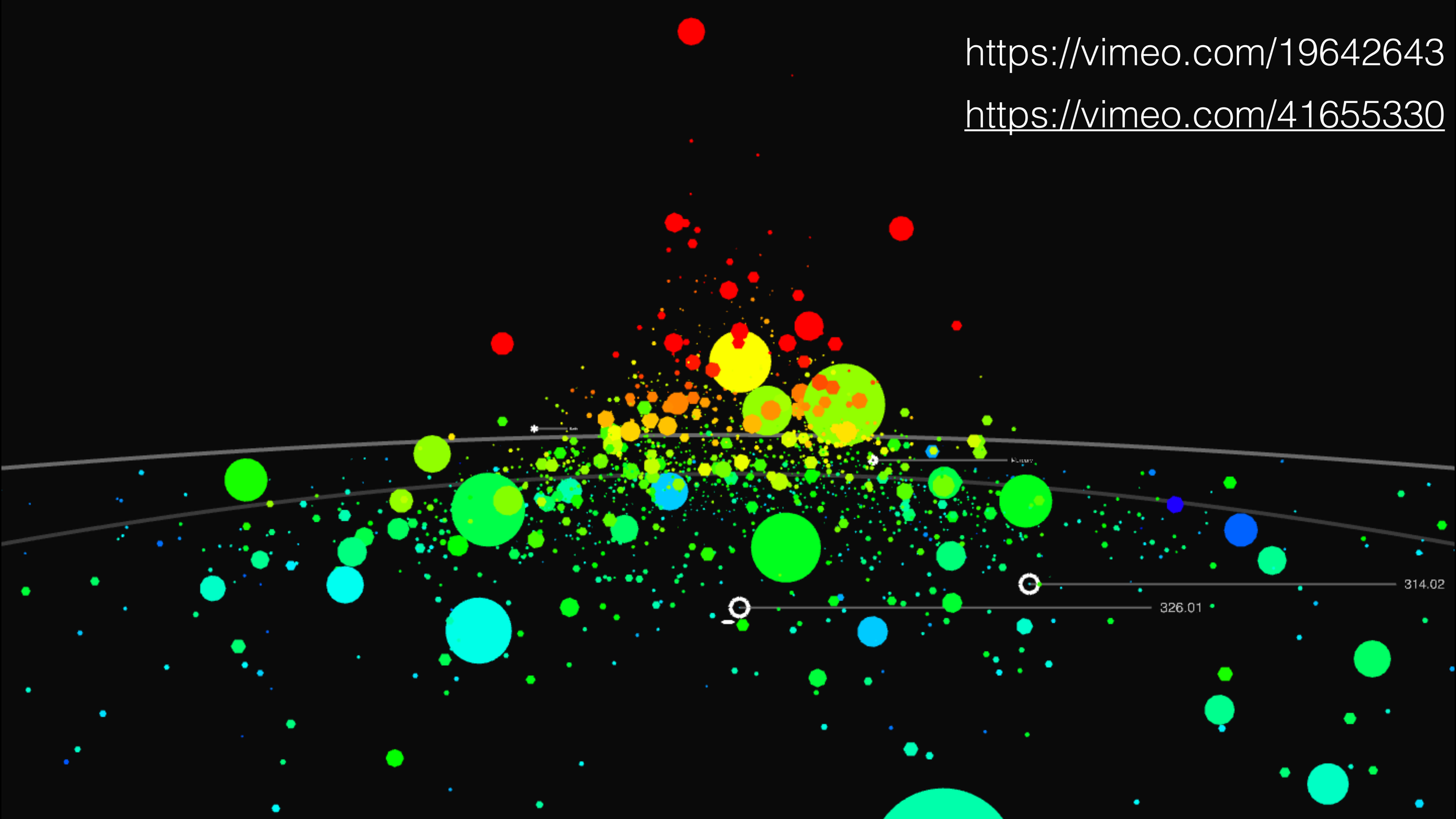
why the paradigm shift?

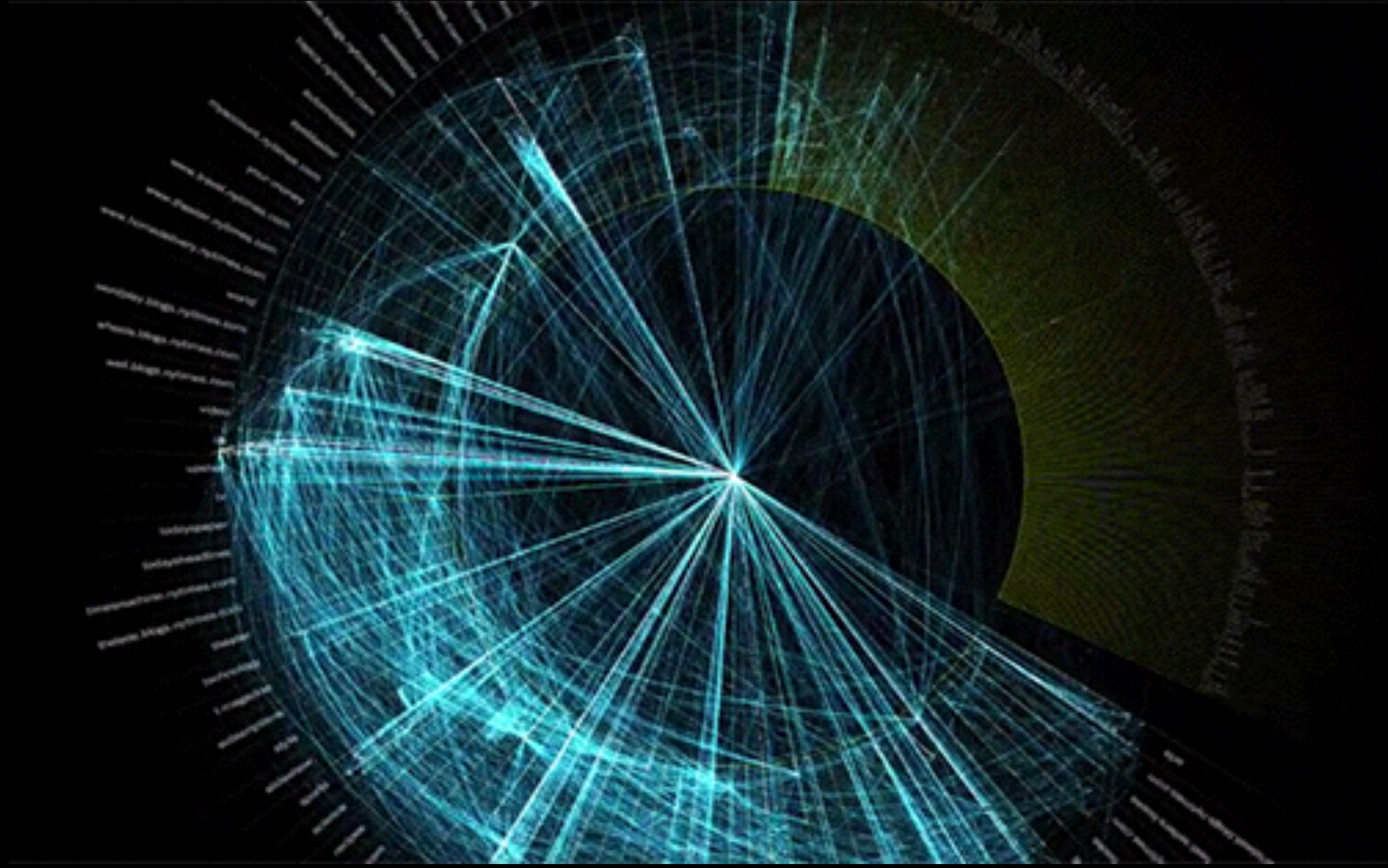
- growth of data : Big data require visualization for exploration
- growth of technology: better plotting tools, animation, VR

https://github.com/

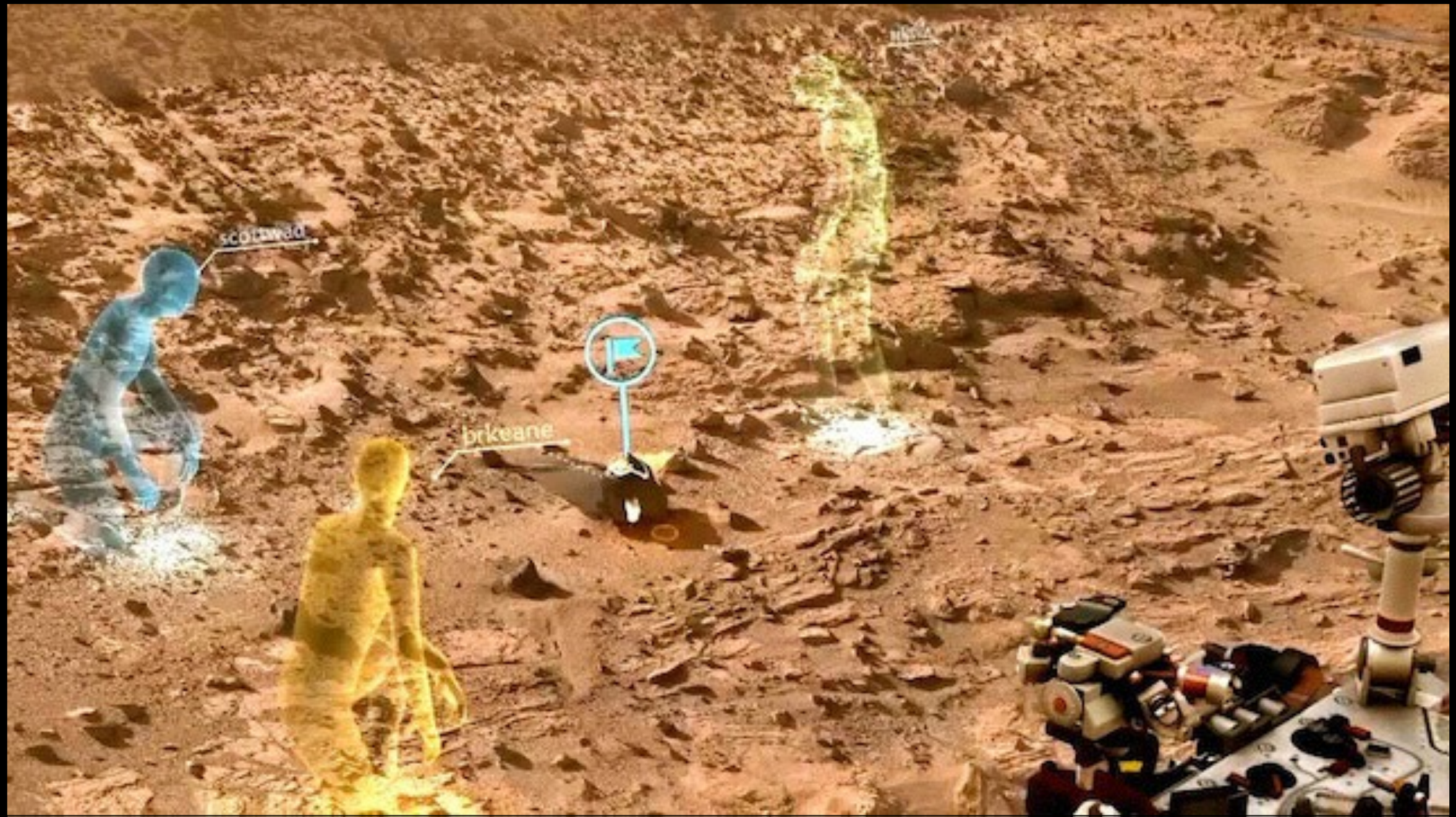


https://www.flickr.com/photos/blprnt/3289727424/in/album-72157614008027965/


https://vimeo.com/19642643
https://vimeo.com/41655330
314.02
326.01



http://nytlabs.com/projects/delta.html



VR and AR for education, communication, exploration http://opslab.jpl.nasa.gov/

Graphical Vocabulary

What graphical elements are available and what elements are appropriate to convey certain information?

The ideal of all research is:

1. precise investigation of each individual phenomenon — in isolation,

2. the reciprocal effect of phenomena upon each other — in combinations,

3. general conclusions which are to be drawn from the above two divisions.

My objective in this book extends only to the first two parts. The material in this book does not suffice to cover the third part which, in any case, cannot be rushed.

The investigation should proceed in a meticulously exact and pedantically precise manner. Step by step, this "tedious" road must be traversed — not the smallest alteration in the nature, in the characteristics, in the effects

Point, Line, and Plane, Wassily Kandinsky, 1926

point line area

position

size

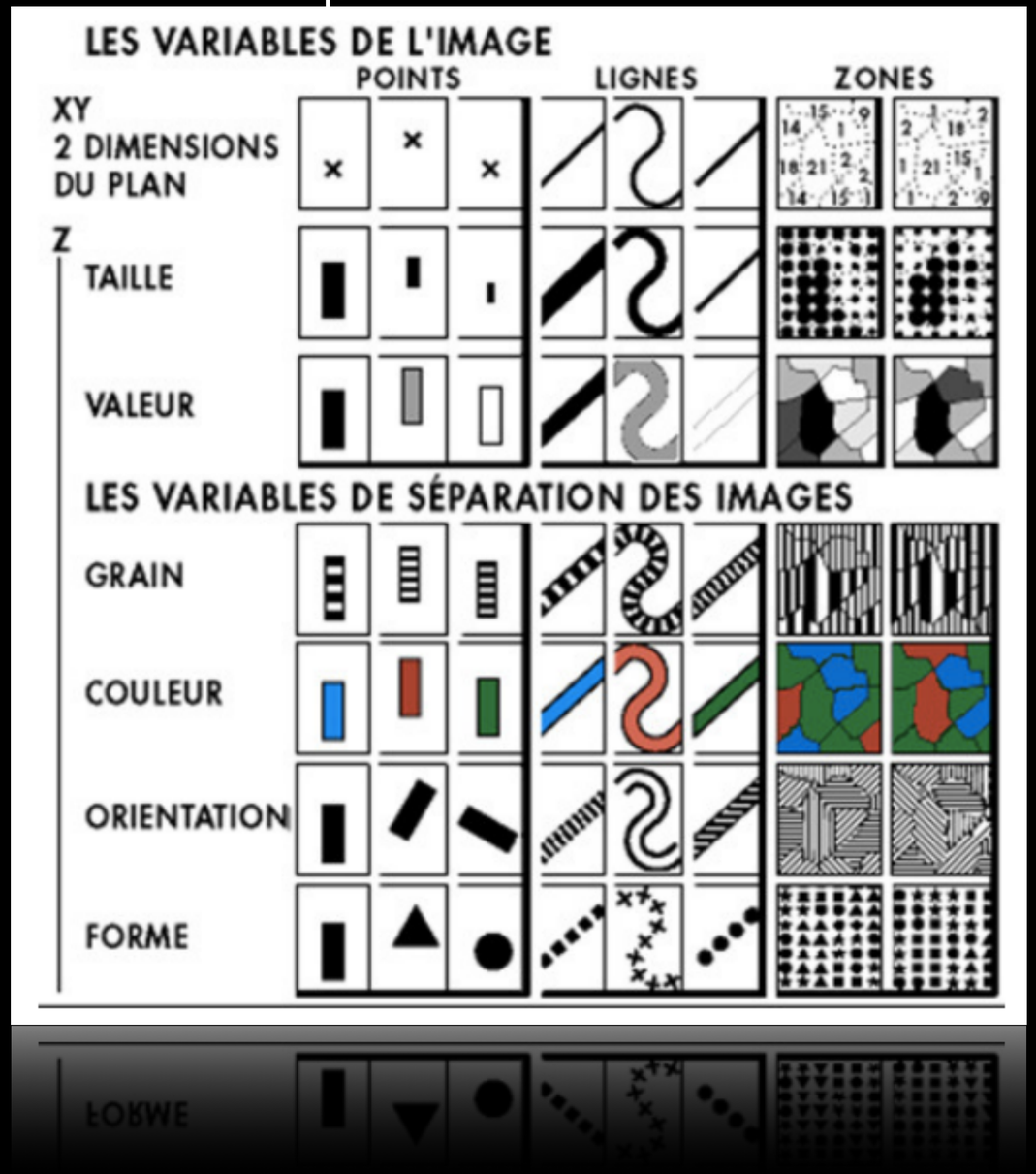
intensity

texture

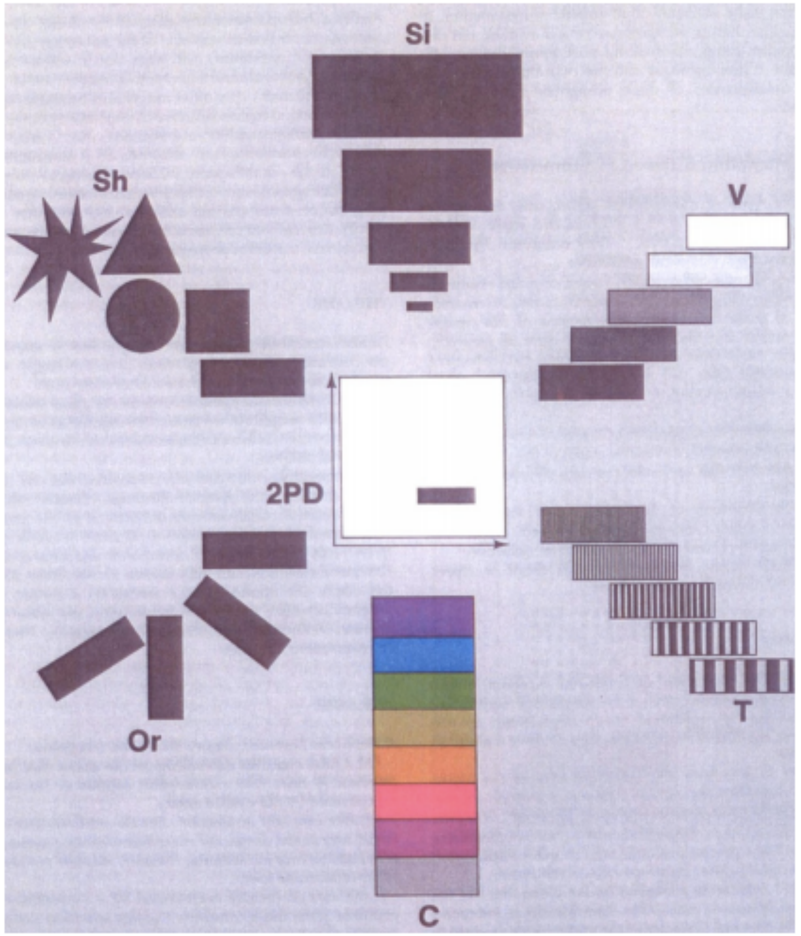
color

orientation

shape



Jacques Bertin: Semiology of Graphics, 1967 Gauthier-Villars, 1998 EHESS



- Size
- Value (Density)
- Texture
- Color
- Orientation
- Shape

- 3D
- Animation/Time

Bertin, Semiology of Graphics, 1967 Gauthier-Villars, 1983 UW Press

Data types

graphical elements work differently on different data types

- **Continuous:** **distance to the closest star (can take any value)**

  Continuous data may be:
  - **Continuous Ordinal:** Earthquakes (notlinear scale)
  - **Interval:** F temperature - interval size preserved
  - **Ratio**: Car speed - 0 is naturally defined

- **Discrete:** **any countable, e.g. number of brain synapses**

  Discrete data may be:
  - **Counts:** number of bacteria at time *t* in section *A*
  - **Ordinal:** survey response Good/Fair/Poor

- **Categorical:** **fermion - bosons: any object by class**

Data may also be:
- **Censored:** star mass >30 M_{sun}
- **Missing:** “Prefer not to answer” (NA / NaN)

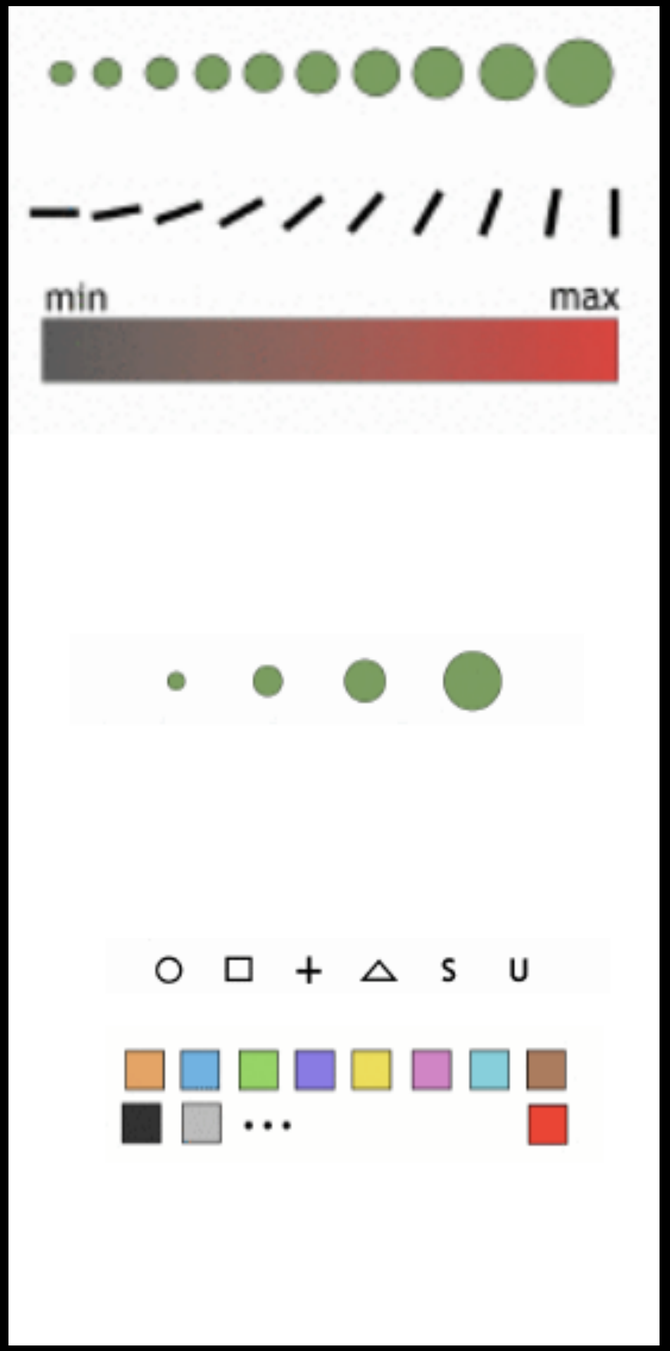
Data types

graphical elements work differently on different data types

continuous

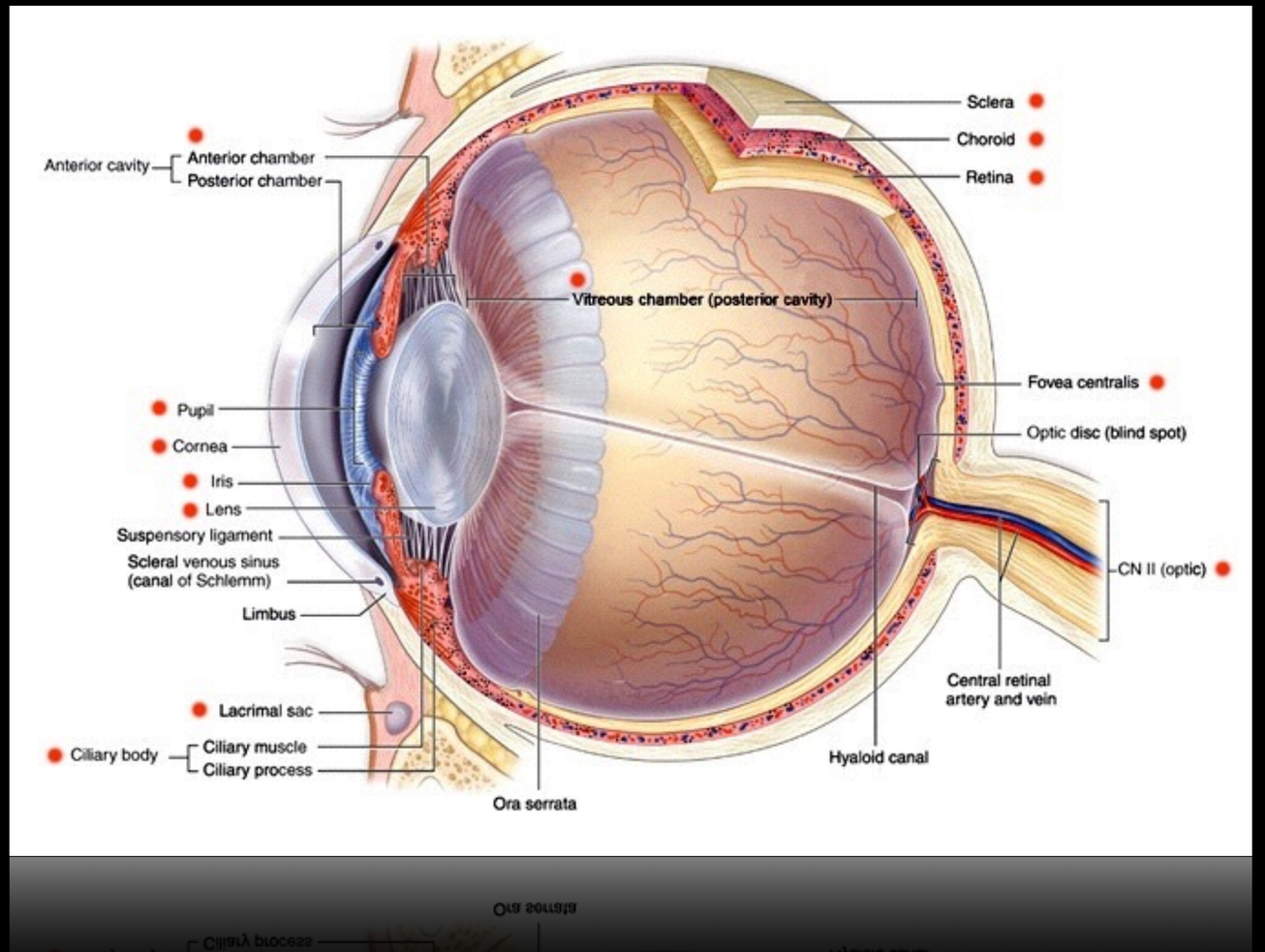
ordered

categorical



Psychophysics

The study of human perception



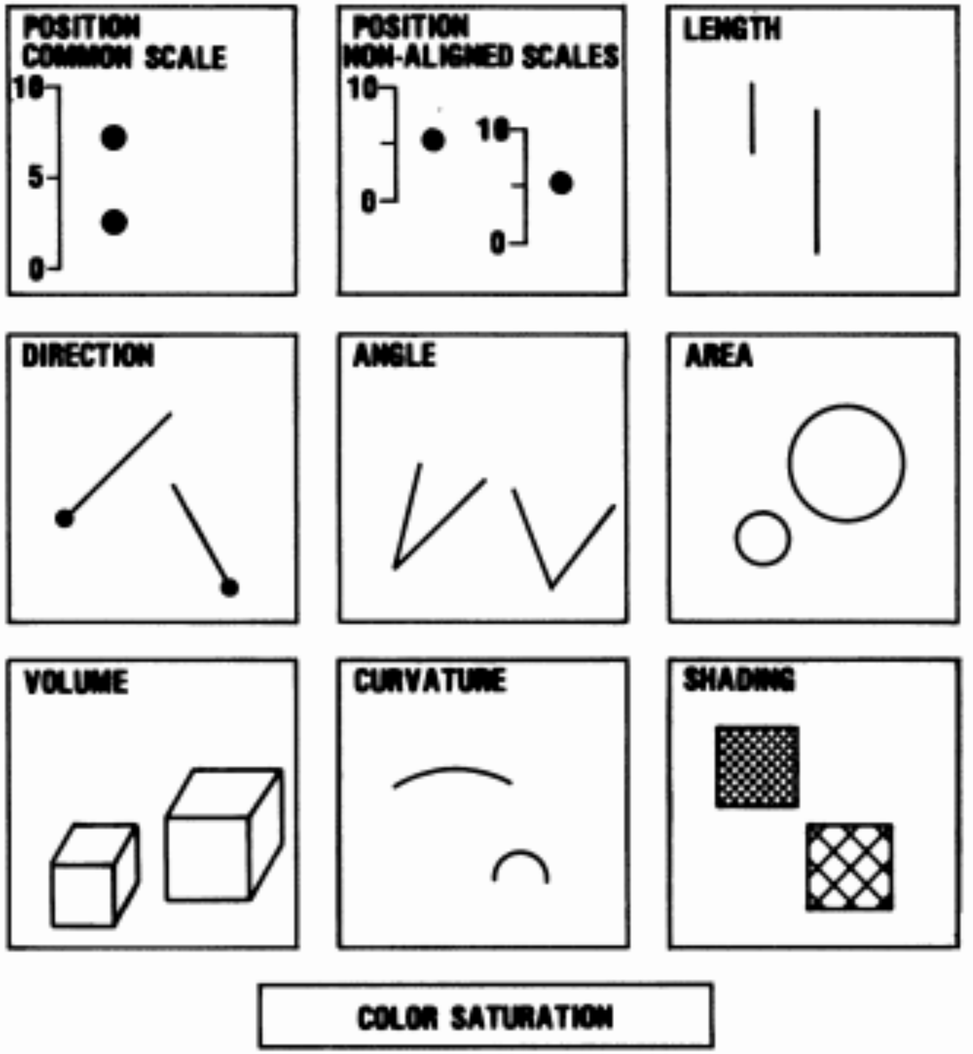


Figure 1. Elementary perceptual tasks.

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

WILLIAM S. CLEVELAND and ROBERT McGILL*

Stevens 1975

Psychophysical power law

The apparent magnitude of all sensory channels follows a power law based on the stimulus intensity

$$S = I^n$$

S sensation, I intensity

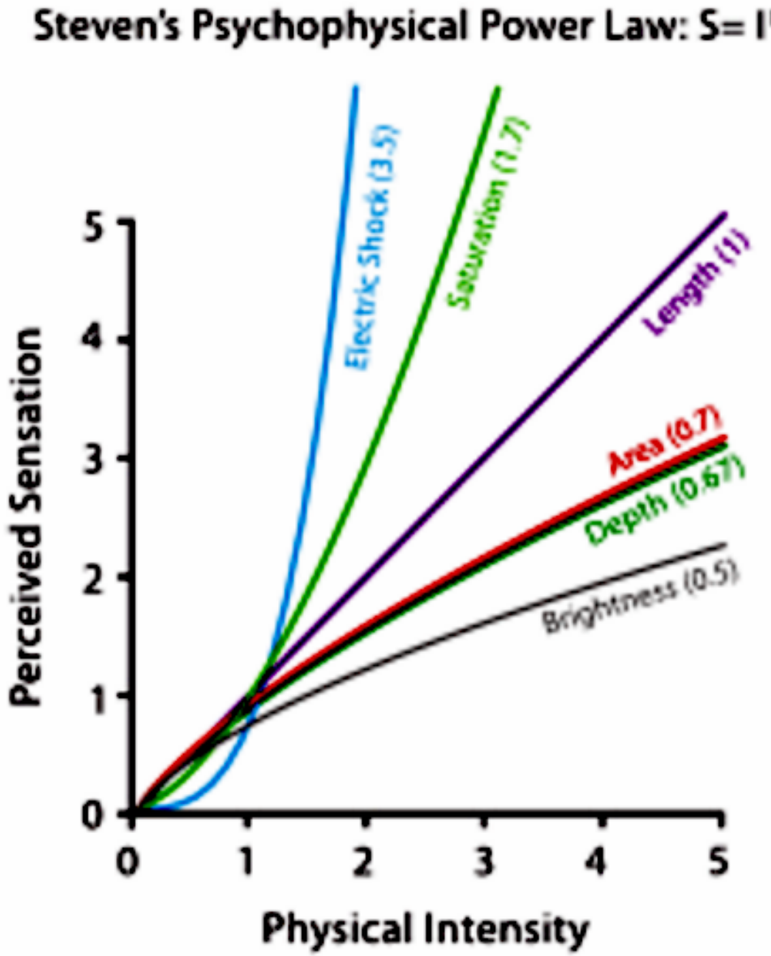
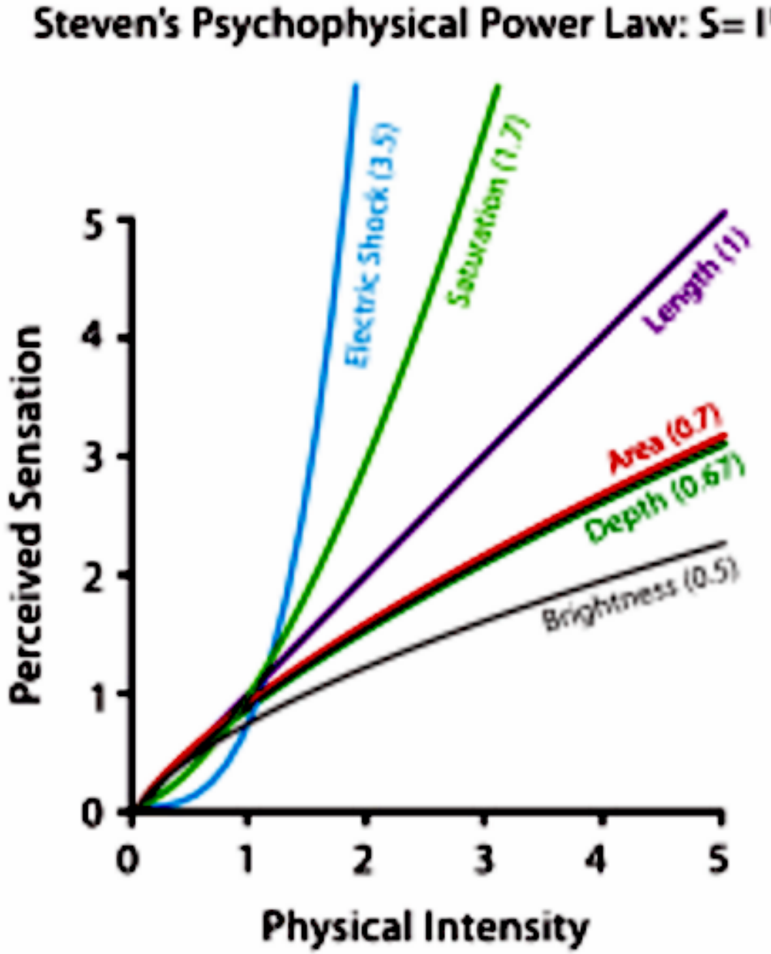
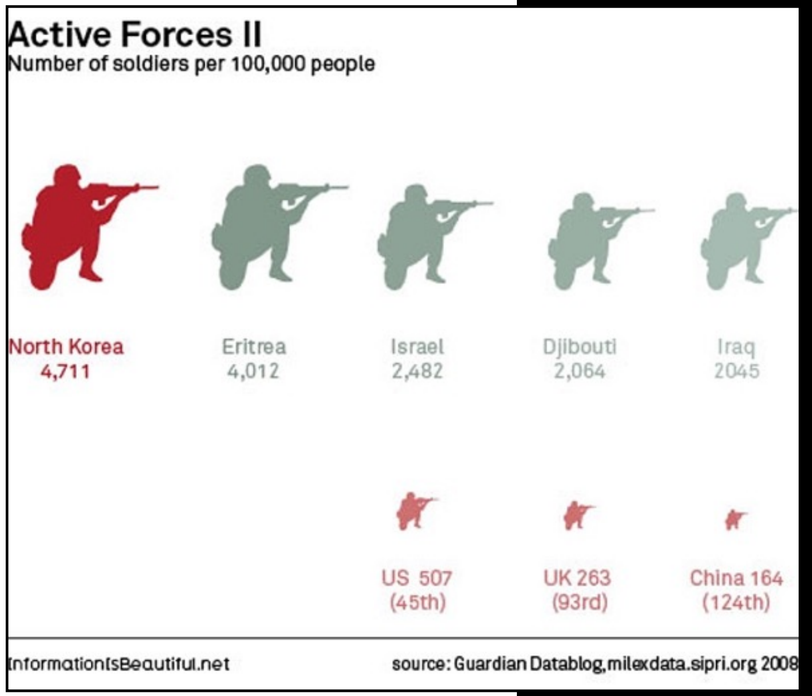


Figure 5.7. Stevens showed that the apparent magnitude of all sensory channels follows a power law $S = I^n$, where some sensations are perceptually magnified compared with their objective intensity (when $n > 1$) and some compressed (when $n < 1$). Length perception is completely accurate, whereas area is compressed and saturation is magnified. Data from Stevens [Stevens 75, p. 15].





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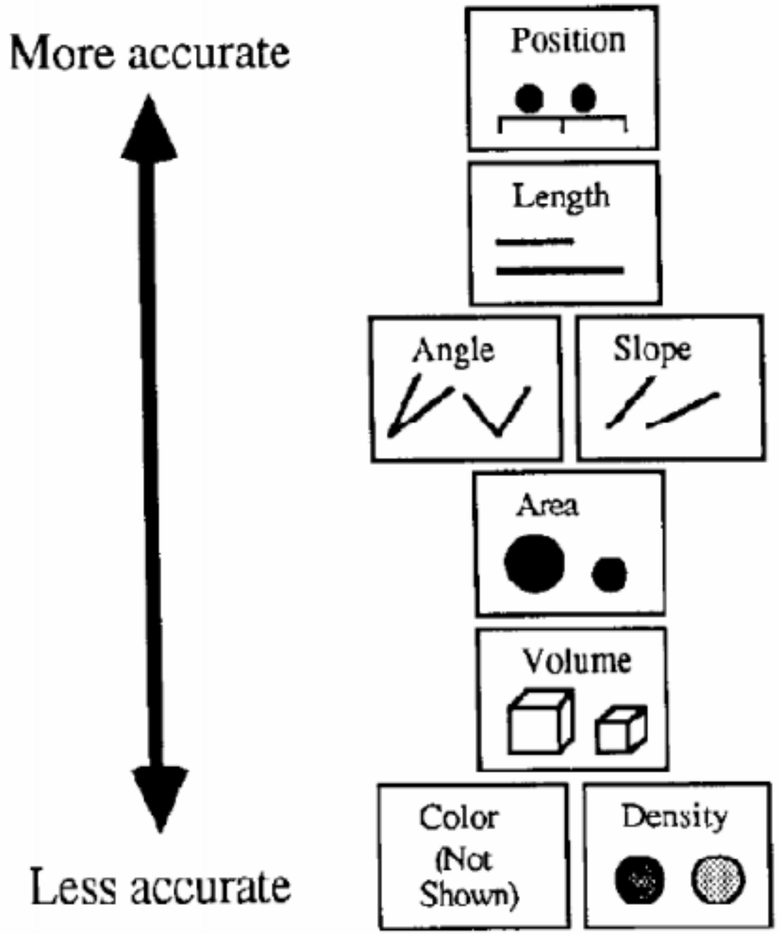
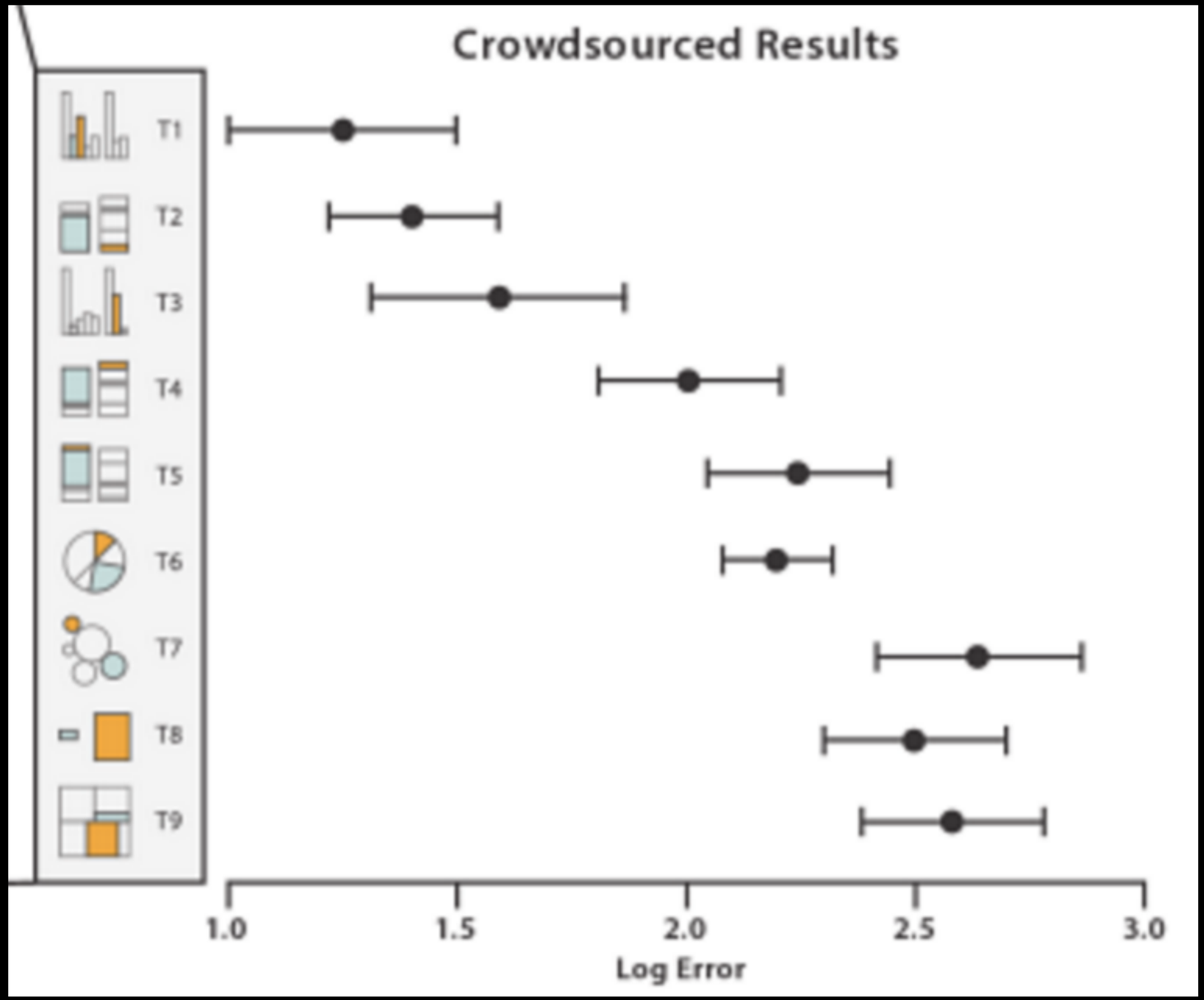
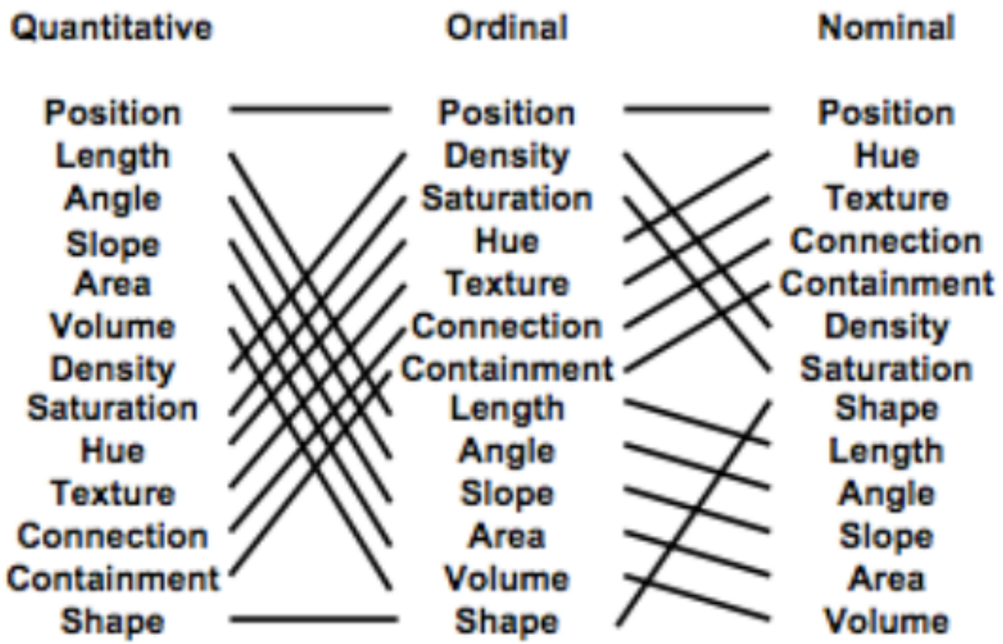


Automating the Design of Graphical Presentations of Relational Information ,Jock Mackinlay, ACM Transaction on Graphics, 1986

Cleveland & McGill, Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods 1984



Heer and Bostock 2010



[Mackinlay, Automating the Design of Graphical Presentations of Relational Information, ACM TOG 5:2, 1986]

Weber Law

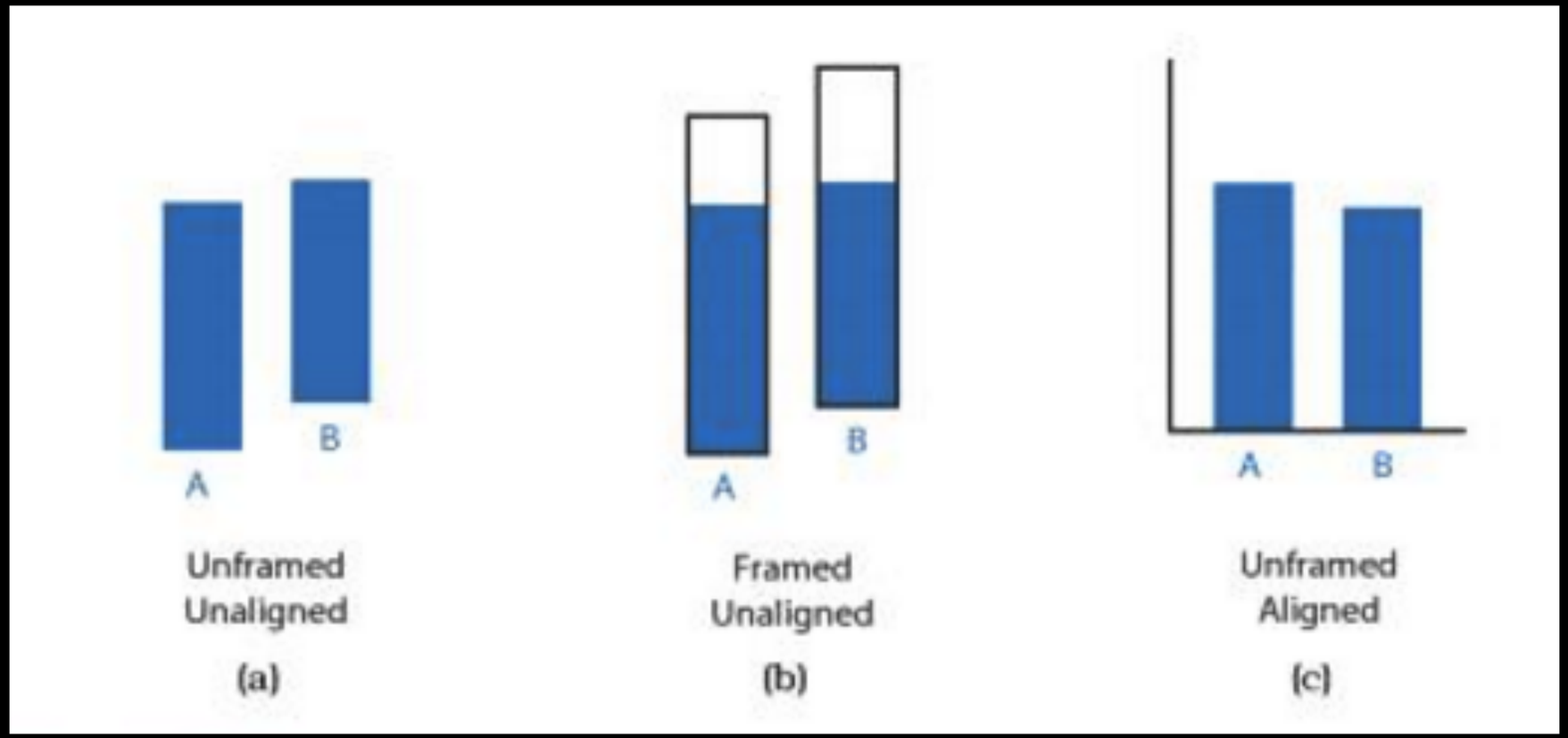
We judge based on relative differences

The detectable difference in stimulus intensity is a fixed percentage of the object magnitude

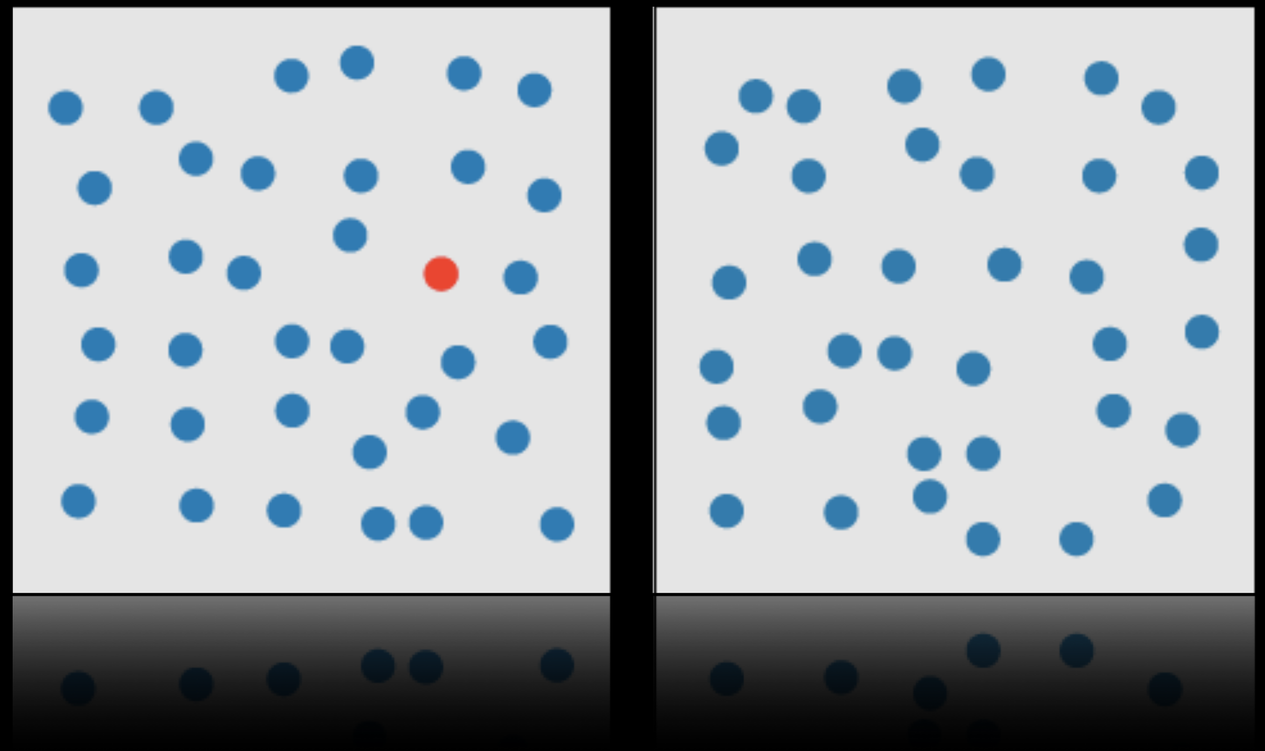
$$\delta I / I = K$$

I intensity, K constant

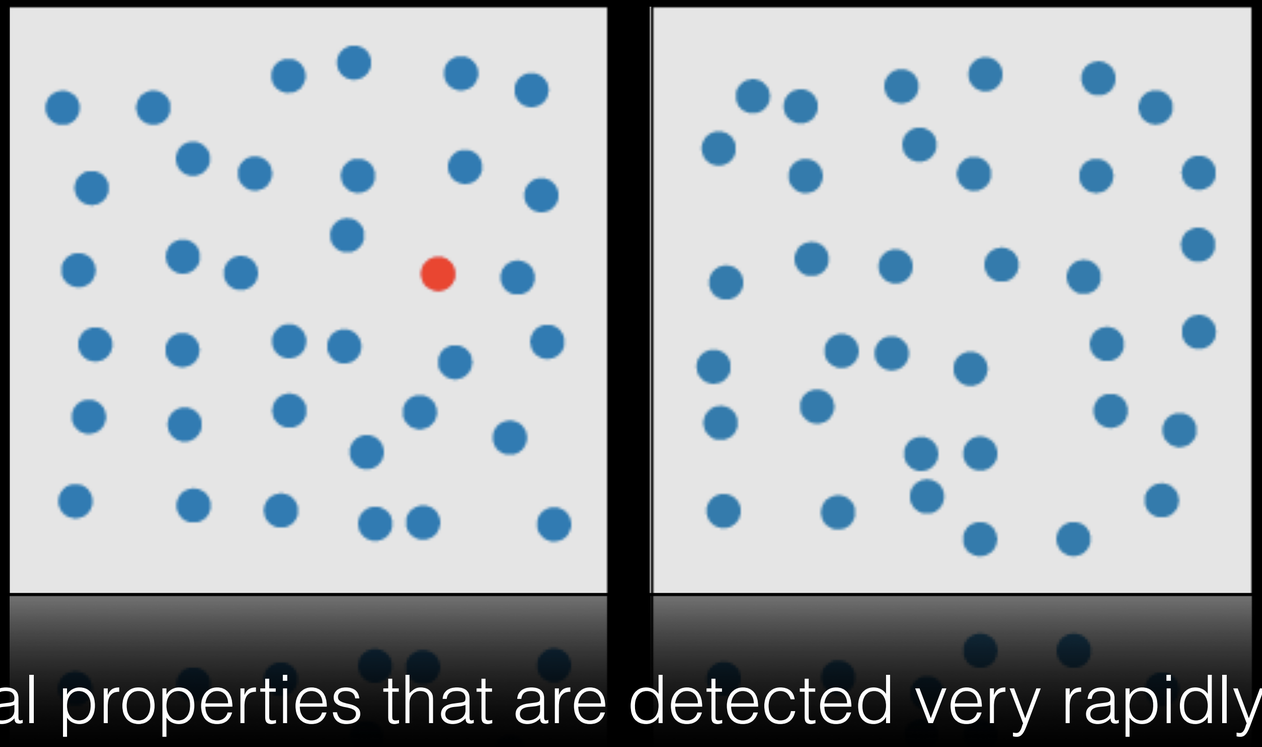

B
A
Unframed
Unaligned
(a)


A
B
Unframed
Unaligned
(a)
A
B
Framed
Unaligned
(b)
A
B
Unframed
Aligned
(c)

Preattentive tasks

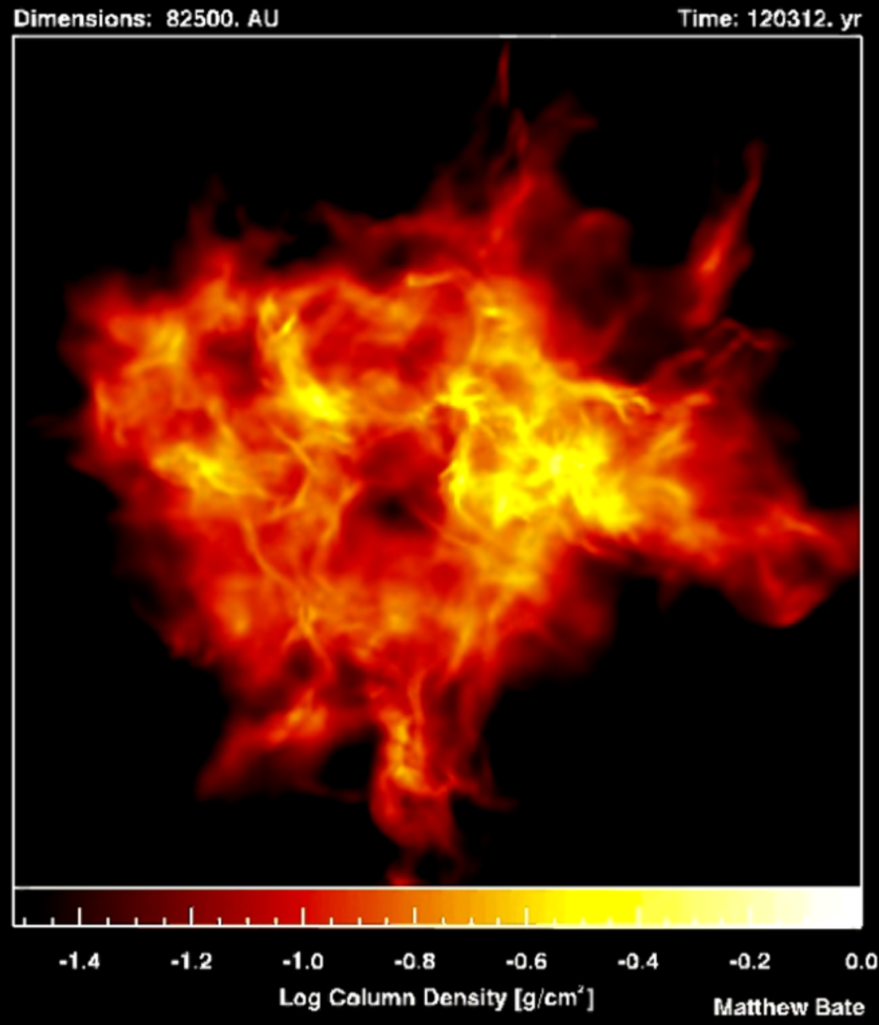


Preattentive tasks



a limited set of visual properties that are detected very rapidly and accurately by the low-level visual system.(tasks that can be performed on large multi-element displays in ***less than 200 to 250 milliseconds***)

http://www.csc.ncsu.edu/faculty/healey/PP/index.html#jscript_search



https://www.youtube.com/watch?v=YbdwTwB8jtc

selective attention issues:

you can only use one pre-attemptive task at a time:

the preattemptive tasks compete with each other

and you loose the ability to process them quickly if there are more than one.

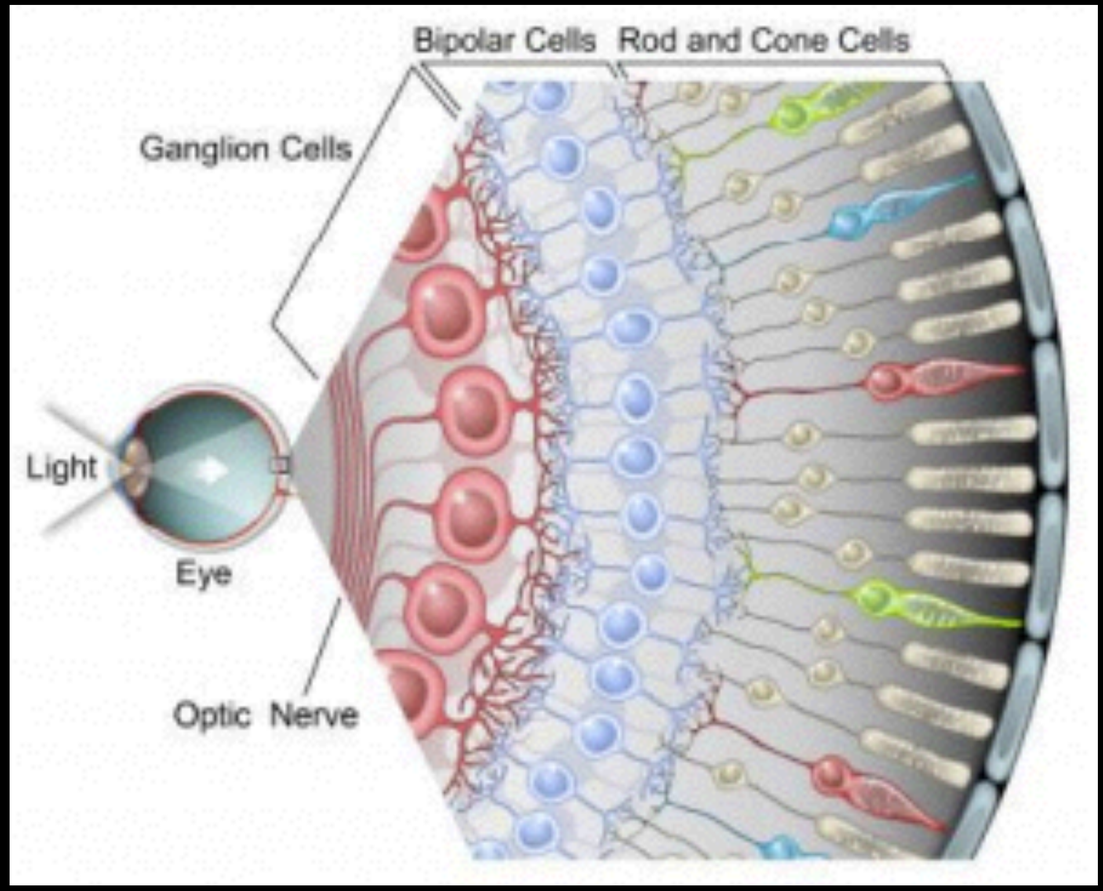
https://youtu.be/vJG698U2Mvo?t=3

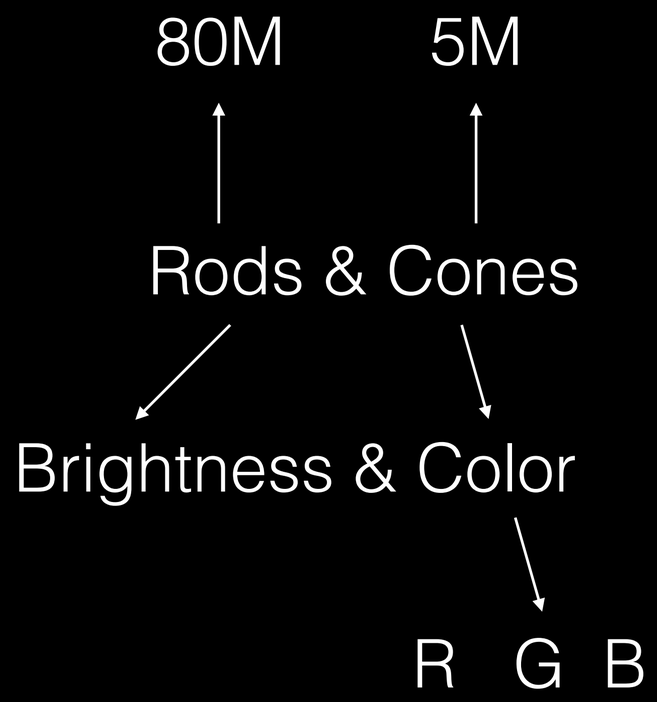
color theory
(and good practice)

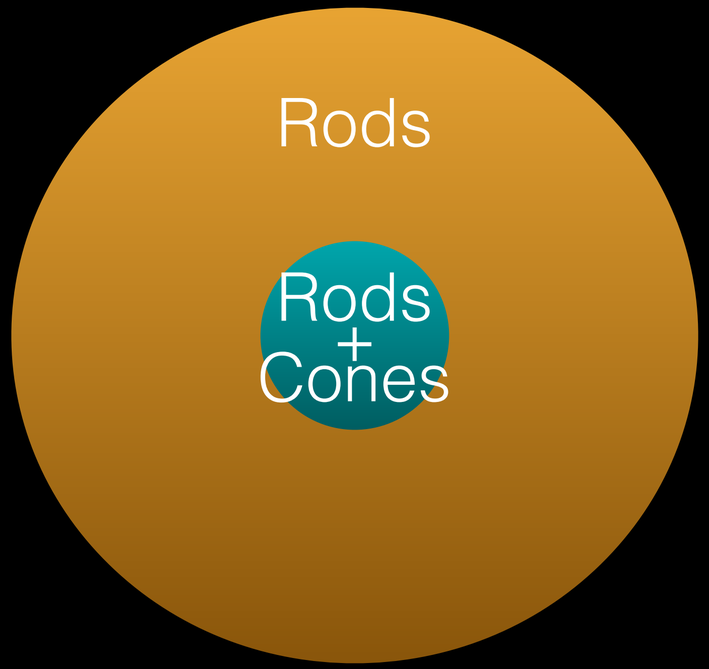
80M 5M

Rods & Cones

Brightness & Color



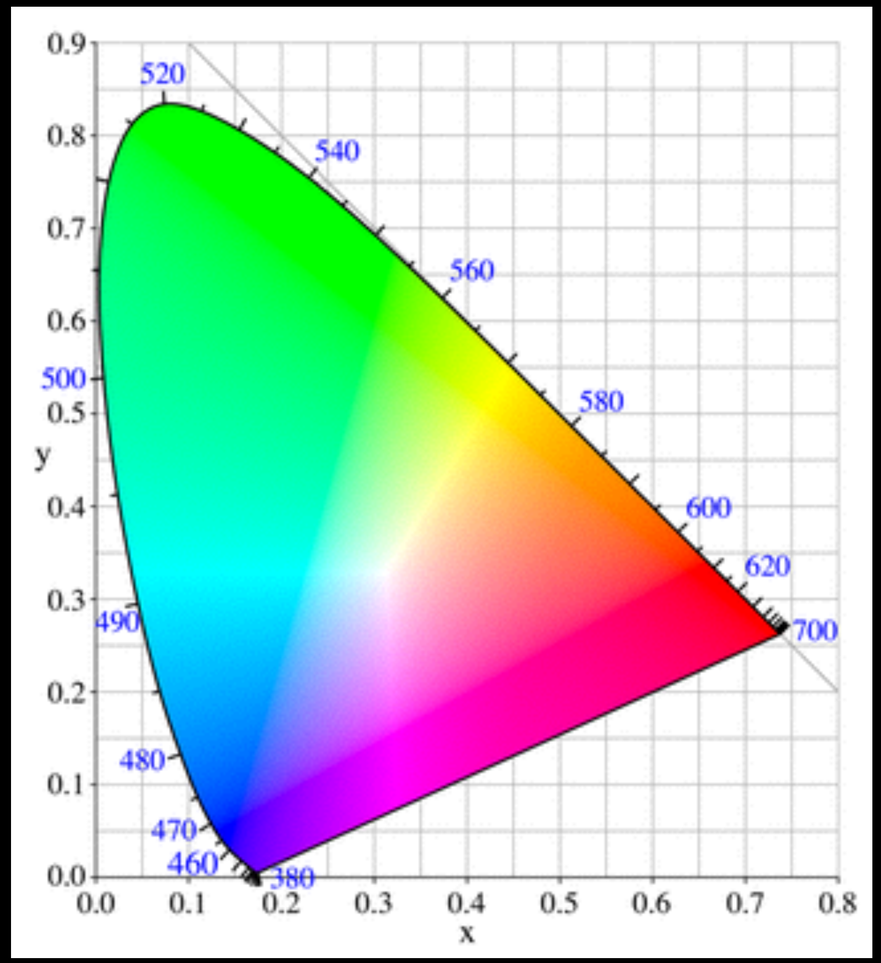




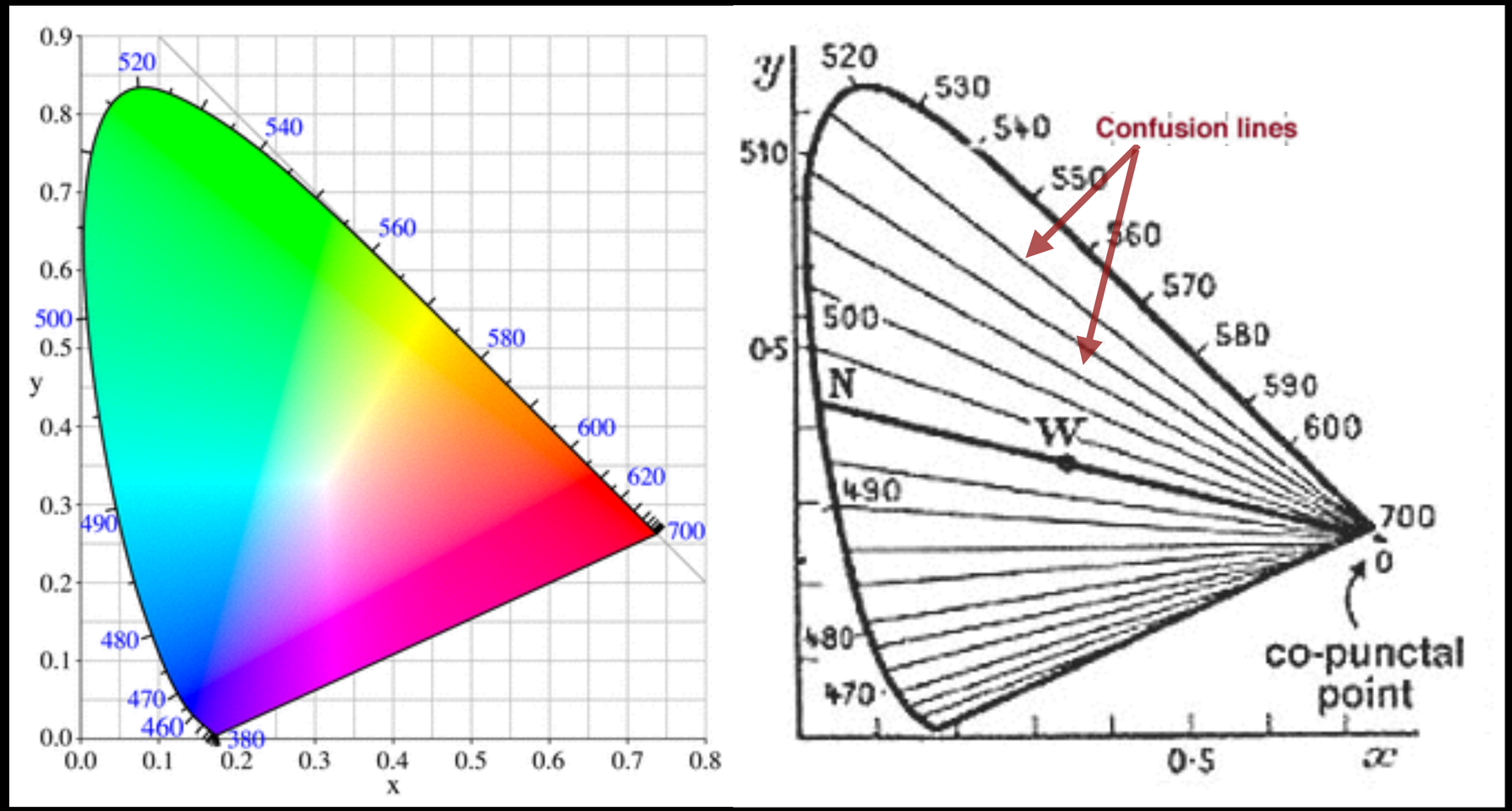
the message to the brain is:

black ⟷ white
yellow ⟷ blue
red ⟷ green

COLOR BLINDNESS

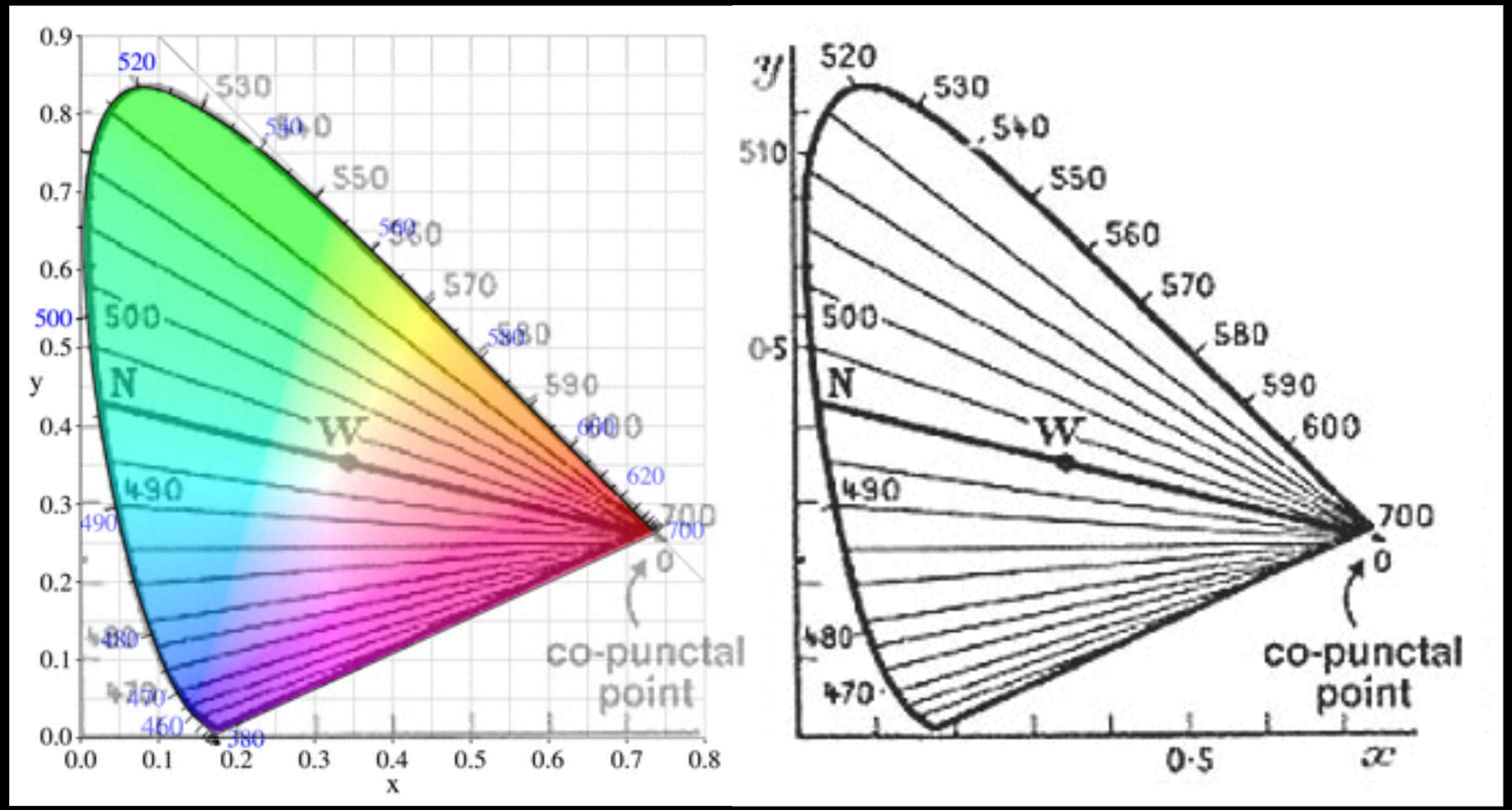


COLOR BLINDNESS



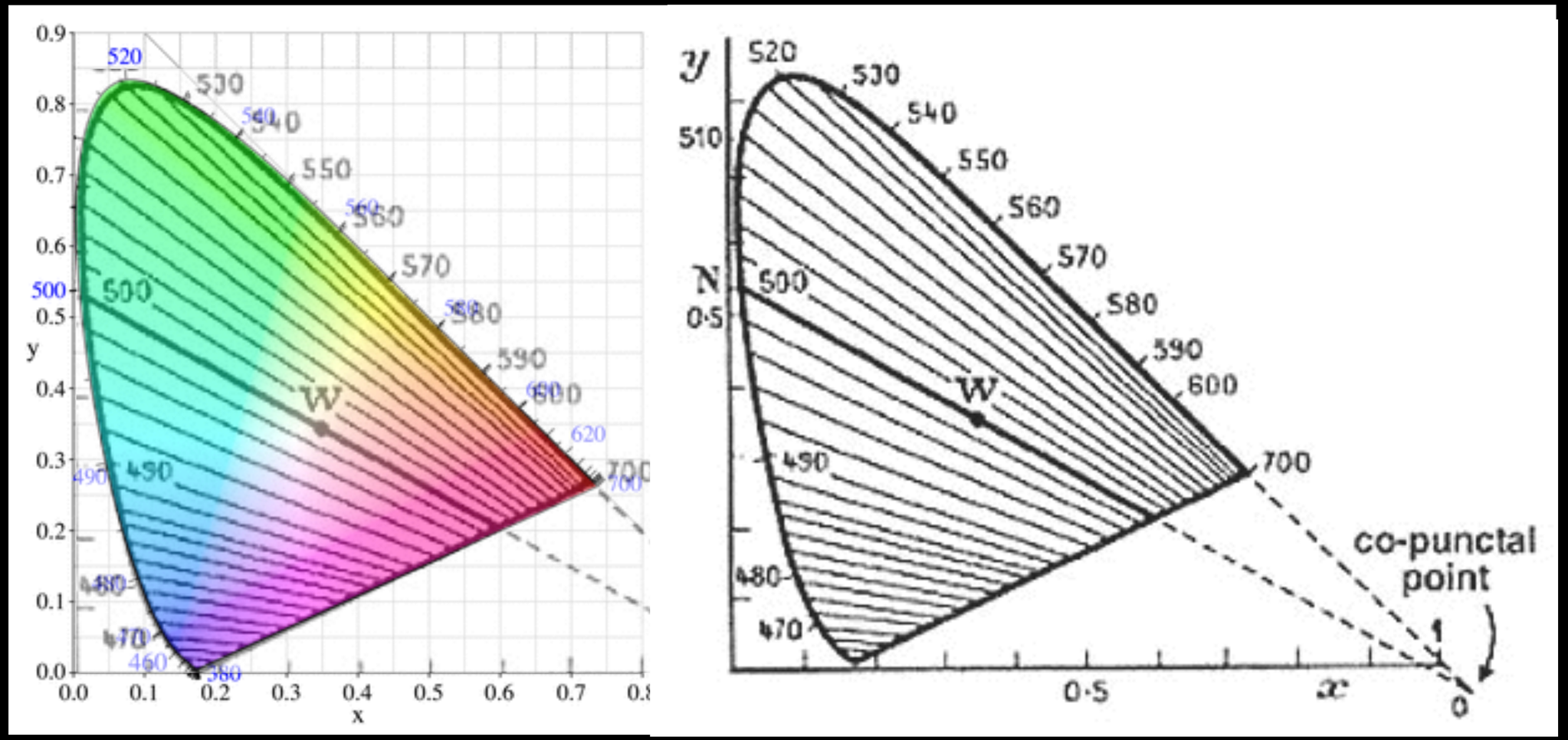
Protanopia

COLOR BLINDNESS



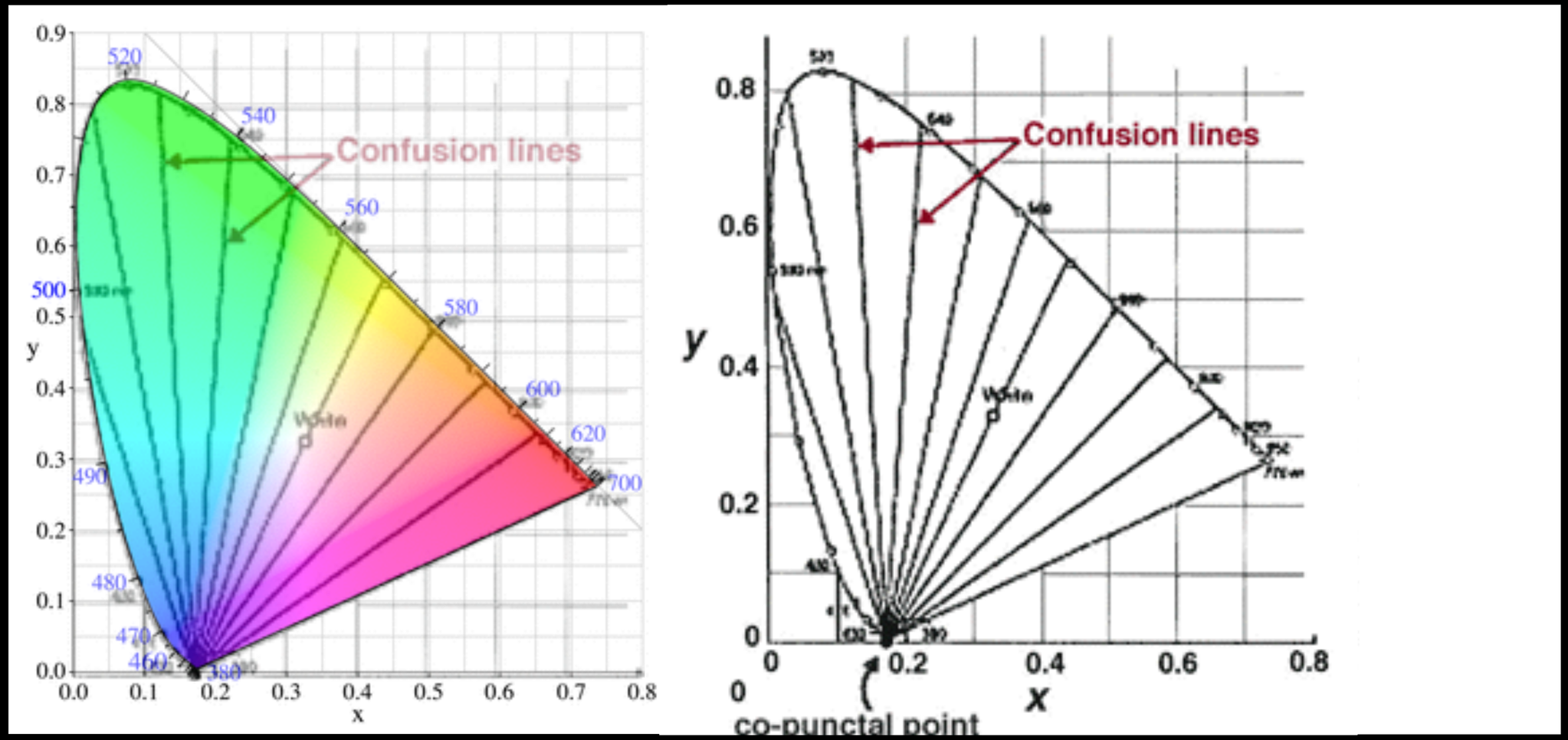
Protanopia
(red-blind)

COLOR BLINDNESS



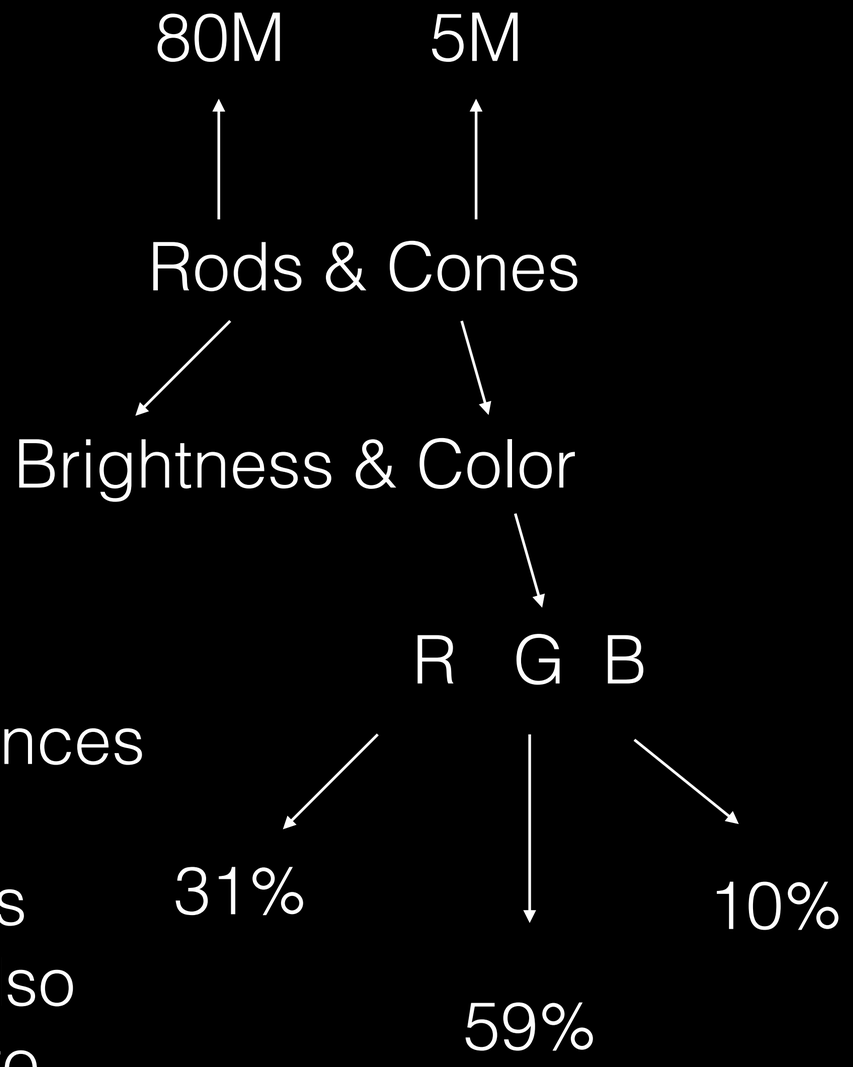
Deuteranopia
(green-blind)

COLOR BLINDNESS

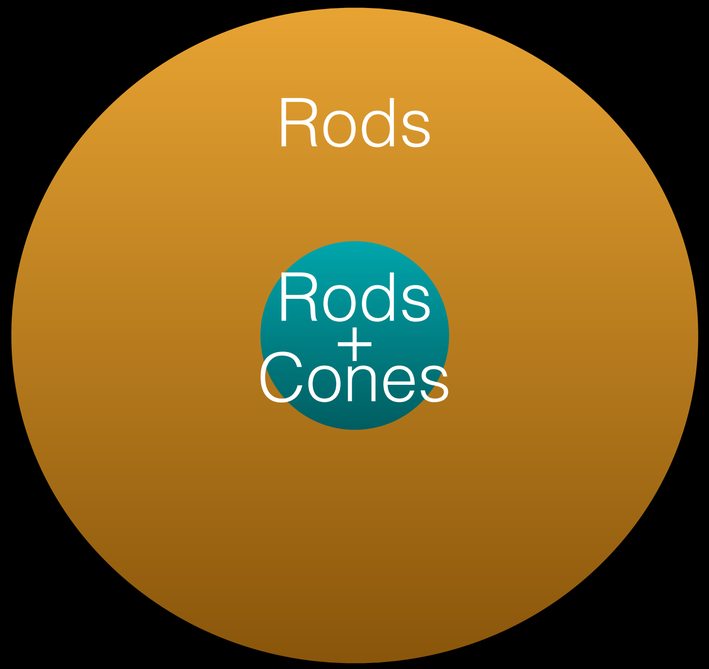


Tritanopia
(blue-blind)

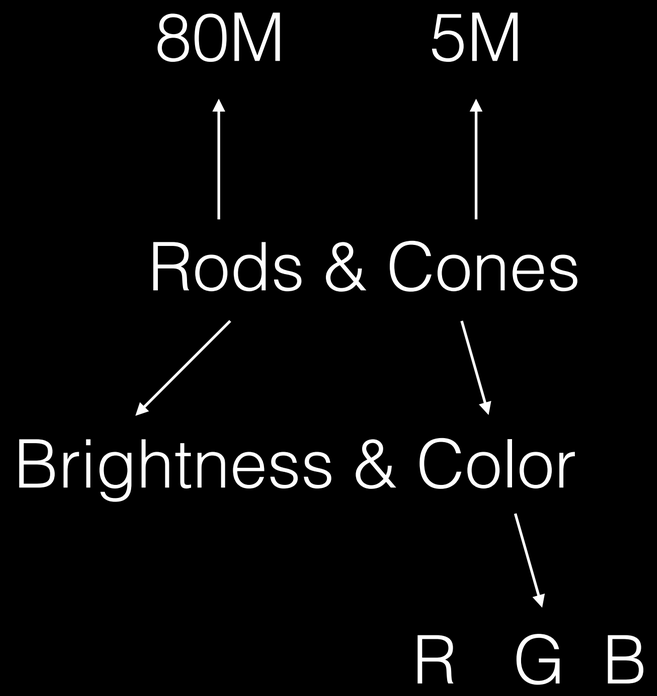
COLOR BLINDNESS

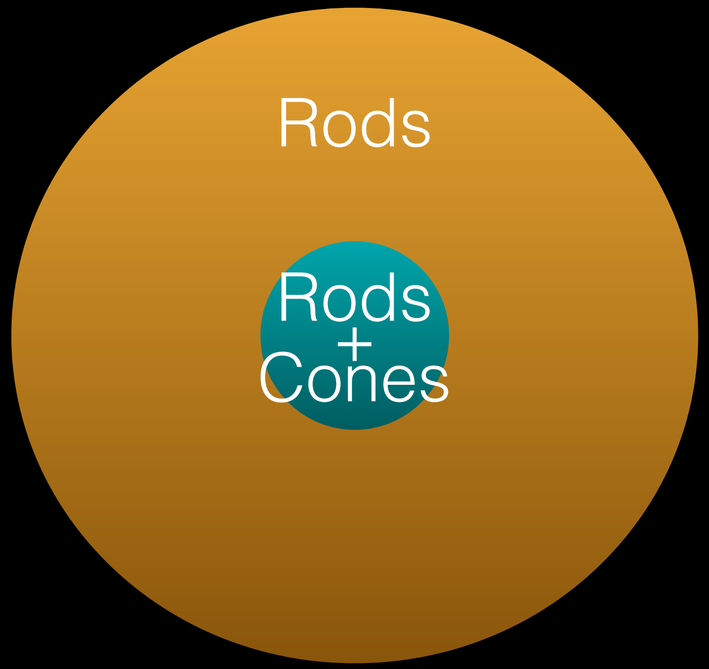


small differences can still be percieved as colors are also associated to brightness



COLOR BLINDNESS





use the http://colororacle.org/ app to test your plots for color-blindness

Kelly 1965 designed a list of 22 maximally contrasting colors for colorblind compliance (the “Kelly colors”): http://www.iscc.org/pdf/PC54_1724_001.pdf

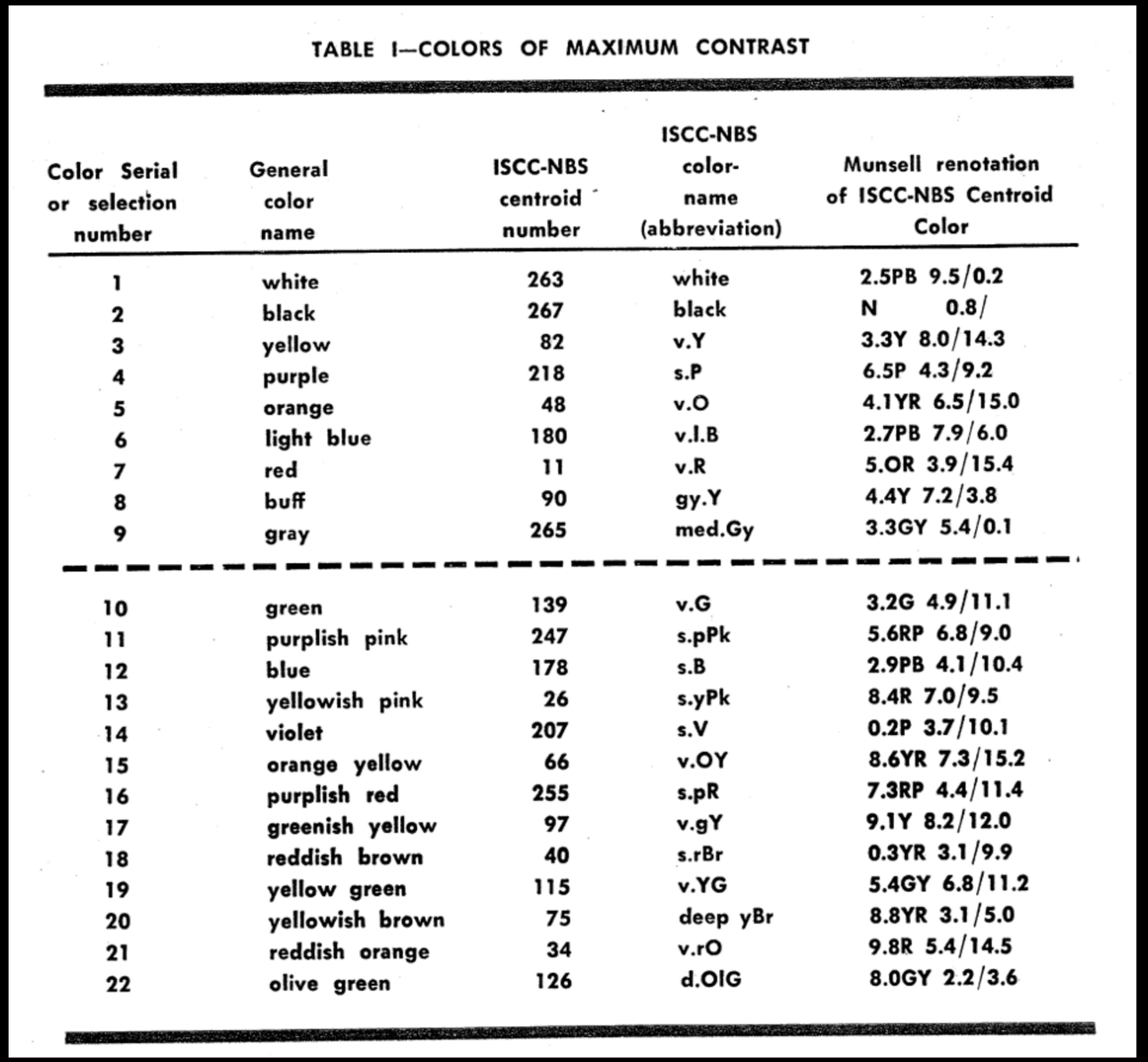


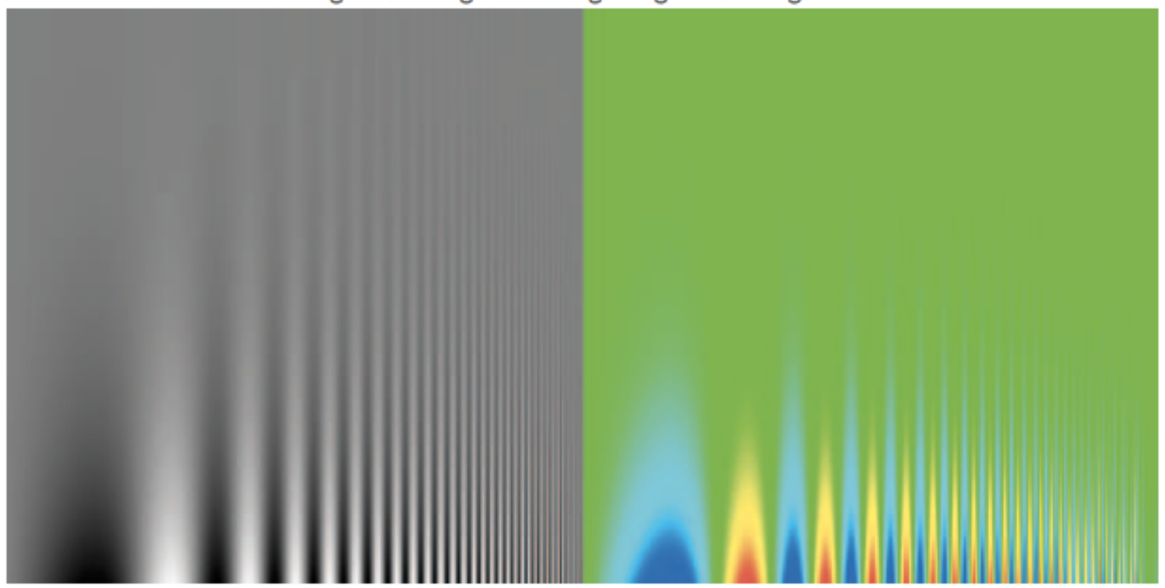
TABLE I—COLORS OF MAXIMUM CONTRAST

Color Serial or selection number	General color name	ISCC-NBS centroid number	ISCC-NBS color-name (abbreviation)	Munsell renotation of ISCC-NBS Centroid Color
1	white	263	white	2.5PB 9.5/0.2
2	black	267	black	N 0.8/
3	yellow	82	v.Y	3.3Y 8.0/14.3
4	purple	218	s.P	6.5P 4.3/9.2
5	orange	48	v.O	4.1YR 6.5/15.0
6	light blue	180	v.l.B	2.7PB 7.9/6.0
7	red	11	v.R	5.OR 3.9/15.4
8	buff	90	gy.Y	4.4Y 7.2/3.8
9	gray	265	med.Gy	3.3GY 5.4/0.1
10	green	139	v.G	3.2G 4.9/11.1
11	purplish pink	247	s.pPk	5.6RP 6.8/9.0
12	blue	178	s.B	2.9PB 4.1/10.4
13	yellowish pink	26	s.yPk	8.4R 7.0/9.5
14	violet	207	s.V	0.2P 3.7/10.1
15	orange yellow	66	v.OY	8.6YR 7.3/15.2
16	purplish red	255	s.pR	7.3RP 4.4/11.4
17	greenish yellow	97	v.gY	9.1Y 8.2/12.0
18	reddish brown	40	s.rBr	0.3YR 3.1/9.9
19	yellow green	115	v.YG	5.4GY 6.8/11.2
20	yellowish brown	75	deep yBr	8.8YR 3.1/5.0
21	reddish orange	34	v.rO	9.8R 5.4/14.5
22	olive green	126	d.OlG	8.0GY 2.2/3.6

"#023fa5", "#7d87b9", "#bec1d4", "#d6bcc0", "#bb7784", "#8e063b", "#4a6fe3", "#8595e1", "#b5bbe3", "#e6afb9", "#e07b91", "#d33f6a", "#11c638", "#8dd593", "#c6dec7", "#ead3c6", "#f0b98d", "#ef9708", "#0fcfc0", "#9cded6", "#d5eae7", "#f3e1eb", "#f6c4e1", "#f79cd4"

GOOD AND BAD COLOR SCHEMES

5. **Detail is actually harder to see in a rainbow.**
   The logic that it is easier to see detail in a range when you add colors seems to make sense, but in reality, more detail can be seen in a single hue image with a high brightness range.



(source)

http://blog.visual.ly/rainbow-color-scales/

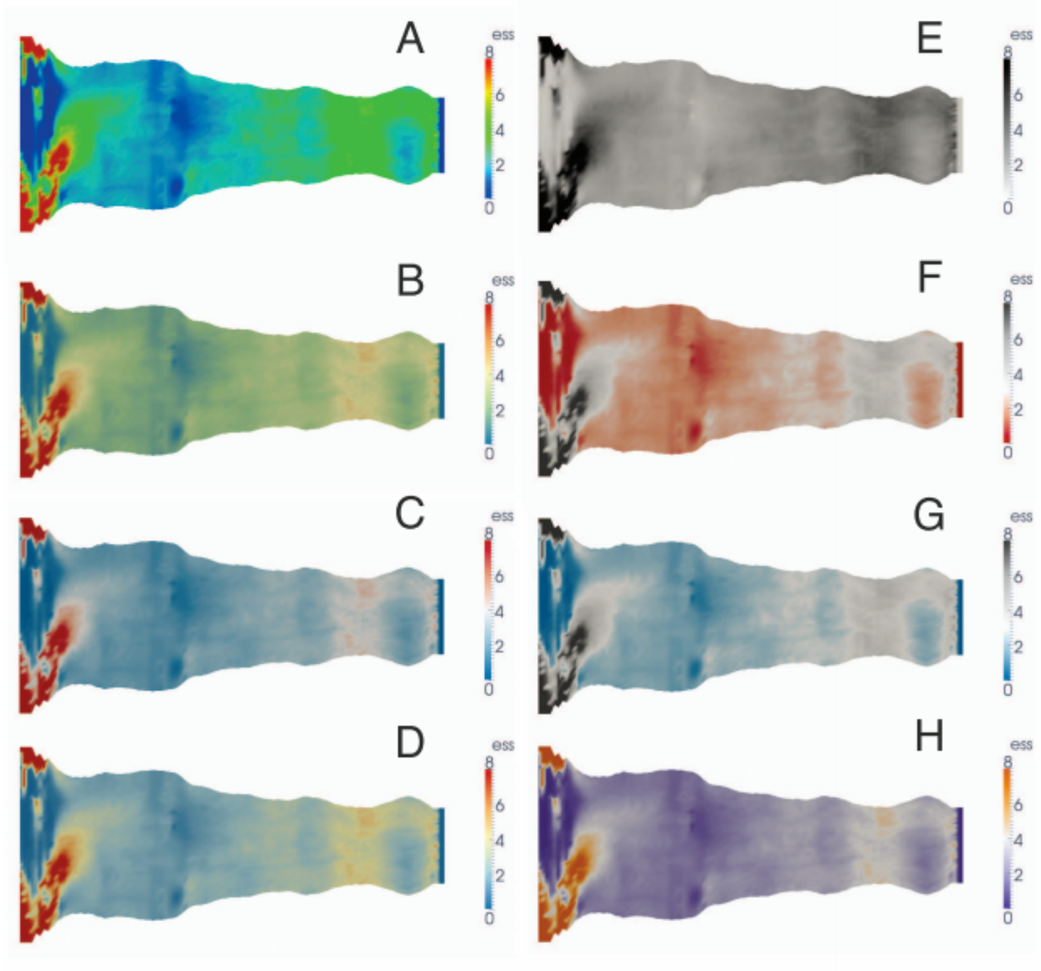
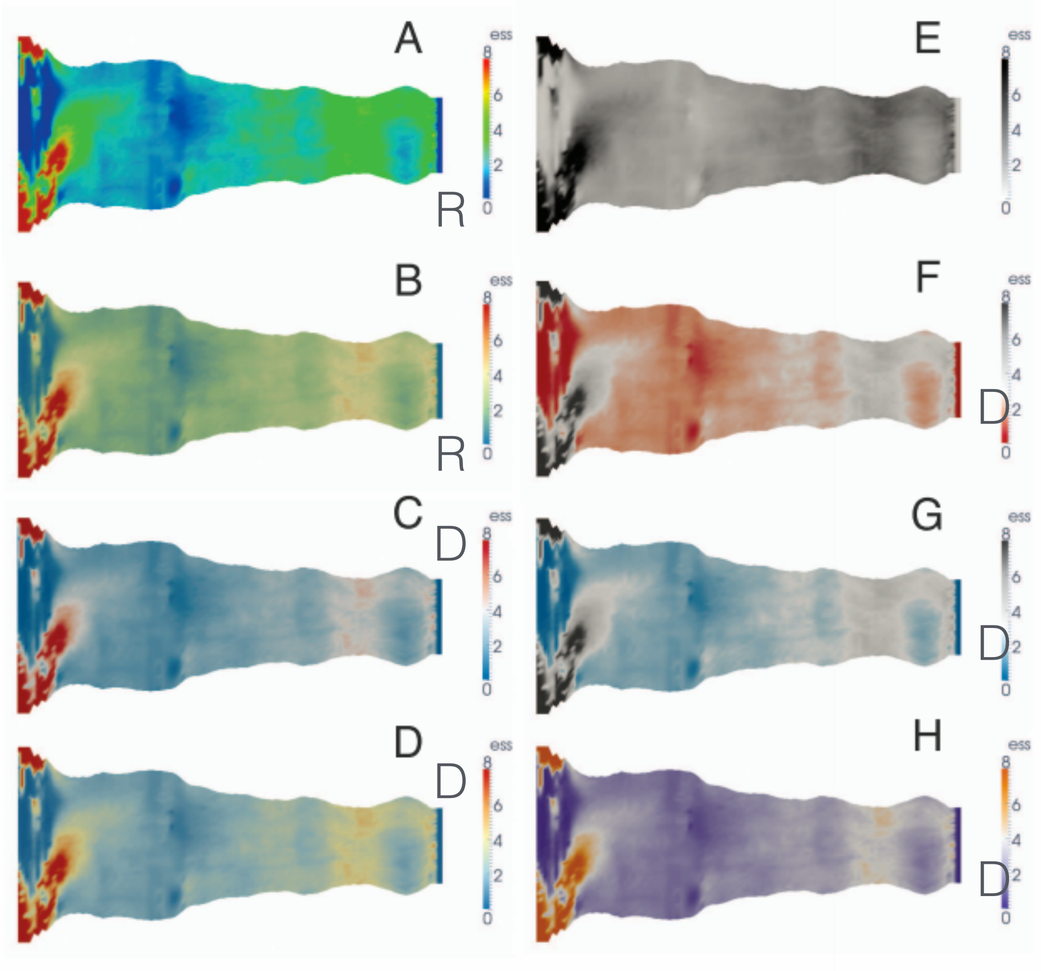


Fig. 4. Color schemes presented during the qualitative user study. The rainbow scheme (A) was preferred by most since it is what they are accustomed to viewing. The next most popular scheme was the red-black diverging scale (F). The grayscale image (E) was unanimously disliked since participants assume black-and-white images to be raw radiological data, while color indicates that the data has been processed or simulated.

very real
consequences
of the choice
of color maps
(Borkin et al. 2011)

http://www.eecs.harvard.edu/~kgajos/papers/2011/borkin11-infoviz.pdf



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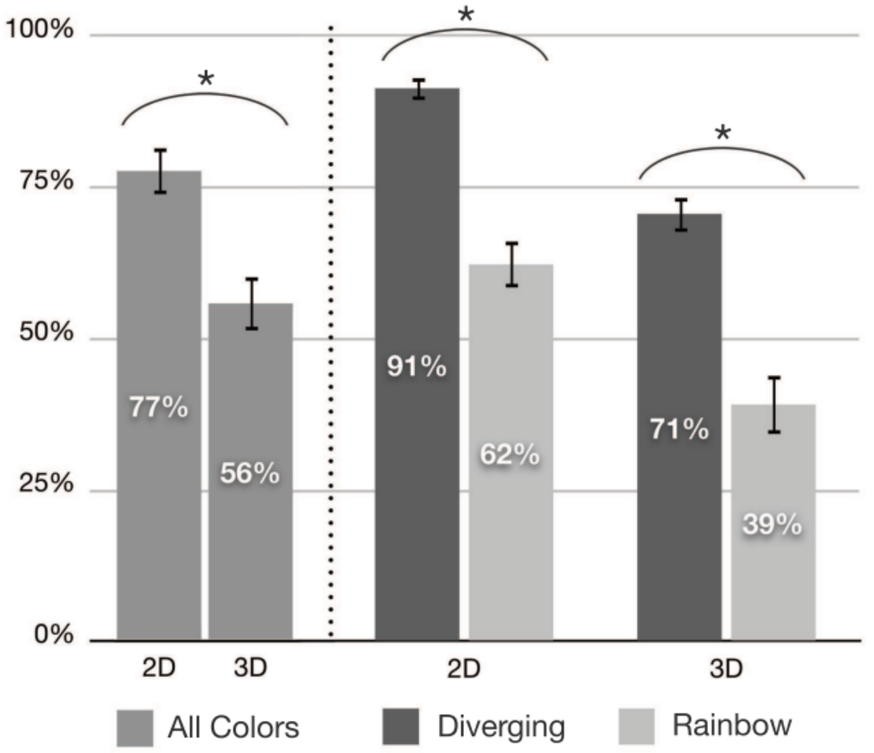
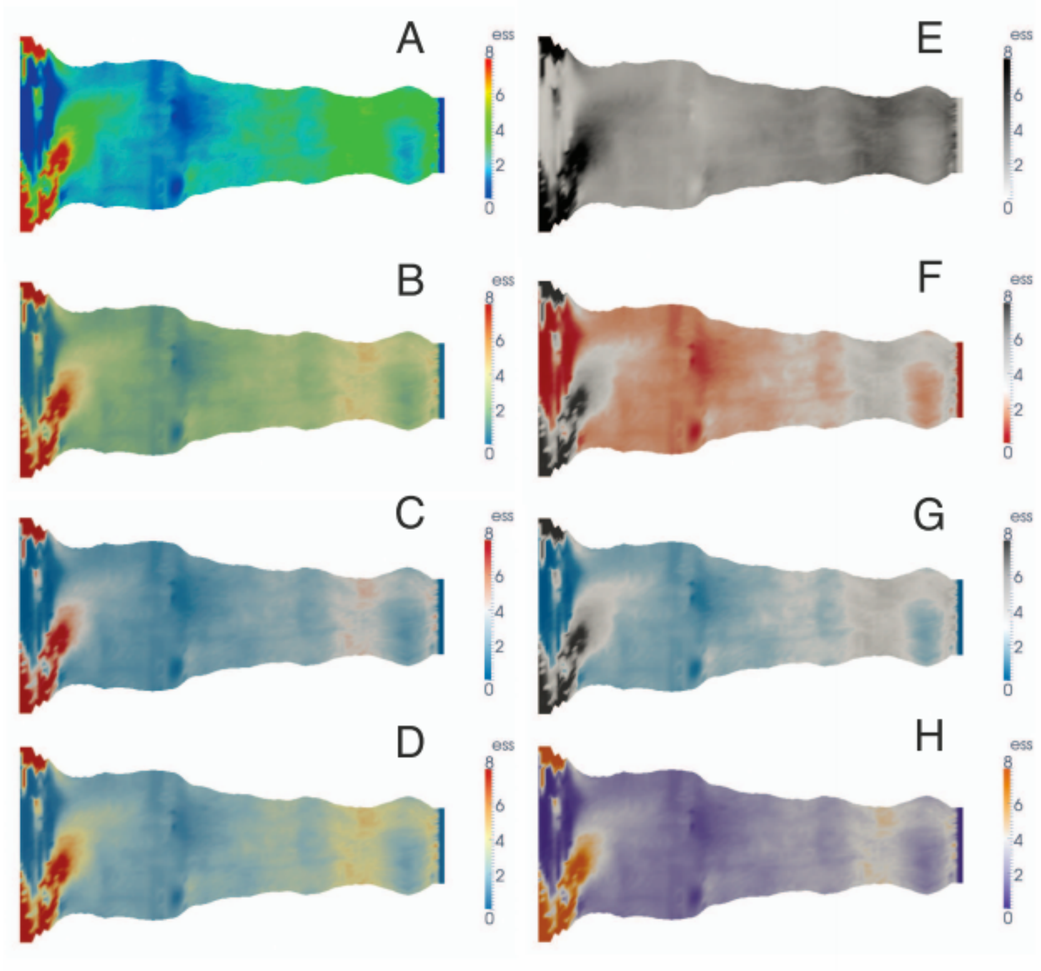


Fig. 7. **Average percent of low ESS regions identified** broken down by 2D and 3D representation, and color. Error bars correspond to the standard error and the asterisks indicate results of statistical significance. Participants were more accurate in 2D and when using the diverging color map.

http://www.eecs.harvard.edu/~kgajos/papers/2011/borkin11-infoviz.pdf



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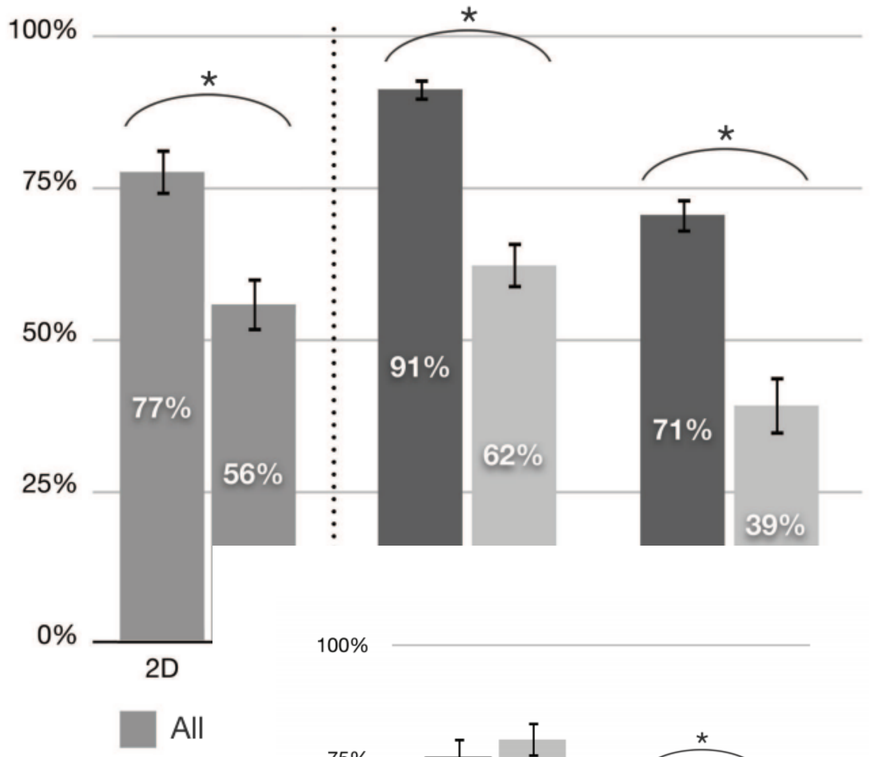


Fig. 7. **Average p**
by 2D and 3D re
the standard erro
nificance. Particip
diverging color ma

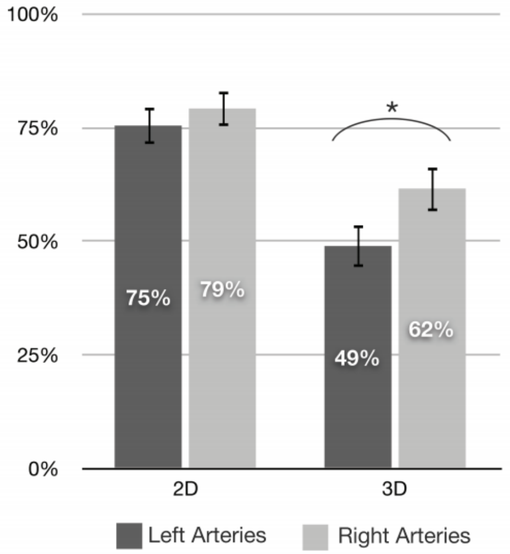
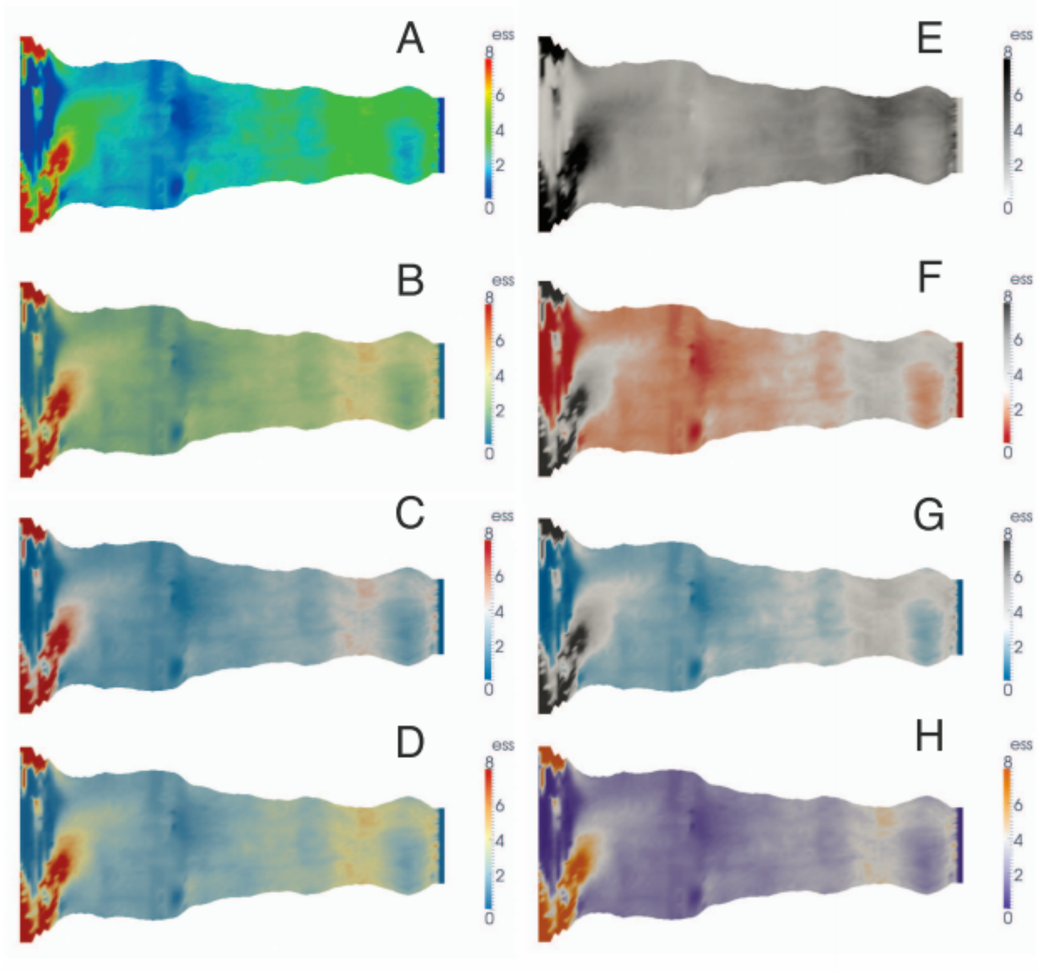


Fig. 8. **Average percent of low ESS regions identified** broken down by 2D and 3D representation, and left and right artery systems. Error bars correspond to the standard error and the asterisks indicate results of statistical significance. In 3D, users were less accurate identifying regions in the most complex data sets (i.e., left artery systems). Whereas in 2D, performance was the same regardless of task complexity.



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1) Never use Rainbow

rainbow

2) Use *diverging* color maps for data there the center value is "special" (e.g. 0, with data ranging from positive to negative. In a diverging cm the center of the range is white or black

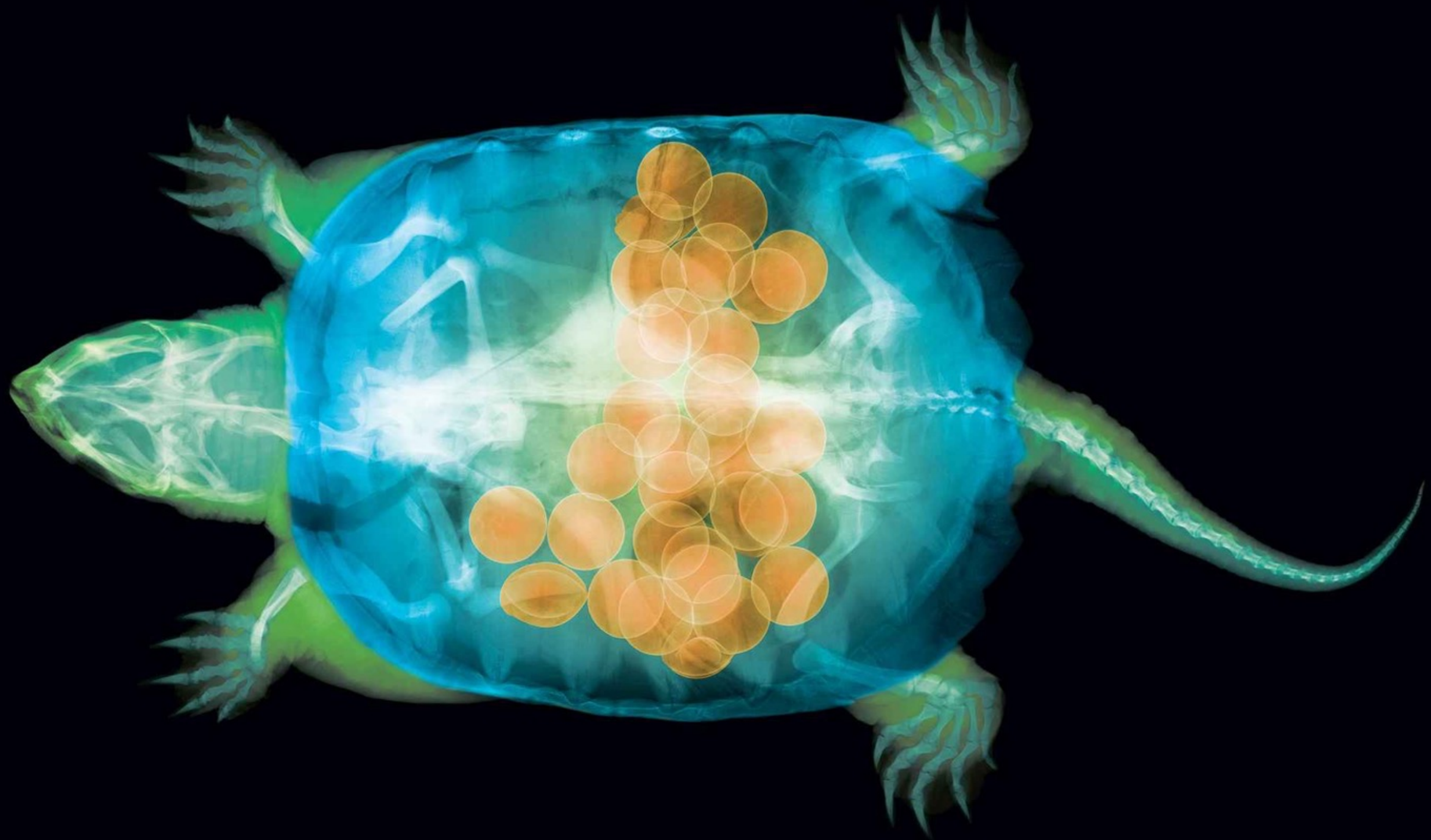
BrBG

3) Choose a *perceptually uniform* color map for continuous data that does not have a focal point (a special point inside the range)

viridis

4) Choose a sequantial cm if your data range represents a progression (reflects some intentity property of the data

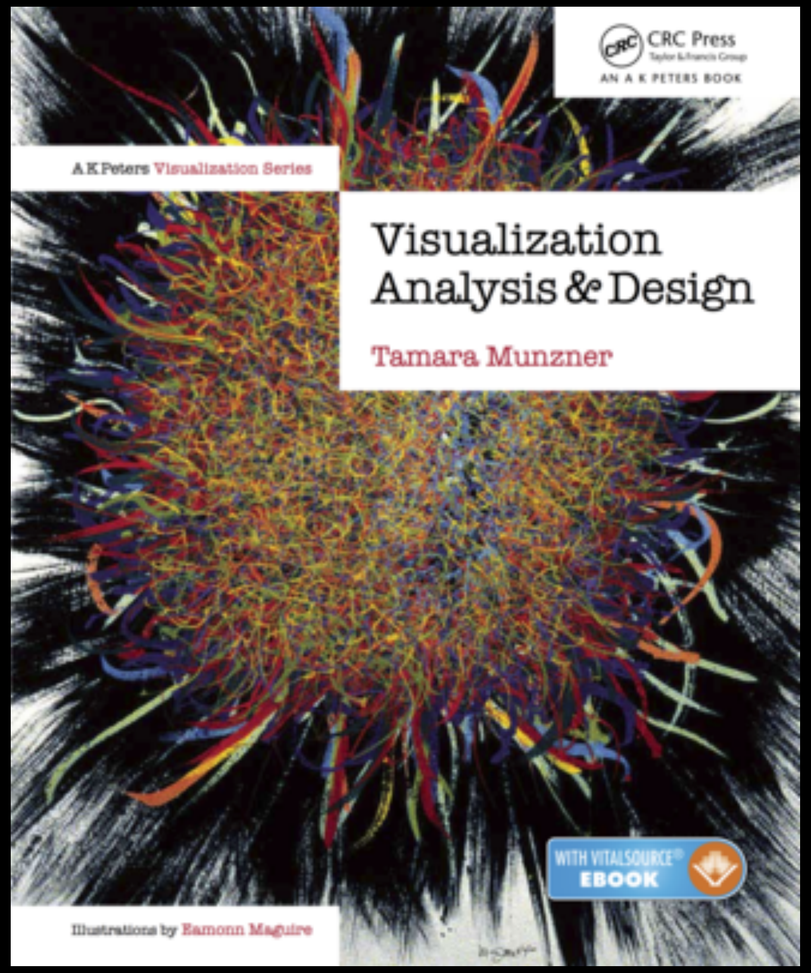
cool



http://www.popsci.com/2015-vizzies-science-visualizations-video-images?image=0

Rules of thumb for a good visualization

(largely based on
Tamara Munzner
Chap 6)



Function first, Form next

T. Munzner refers to this as “no unjustified beauty”

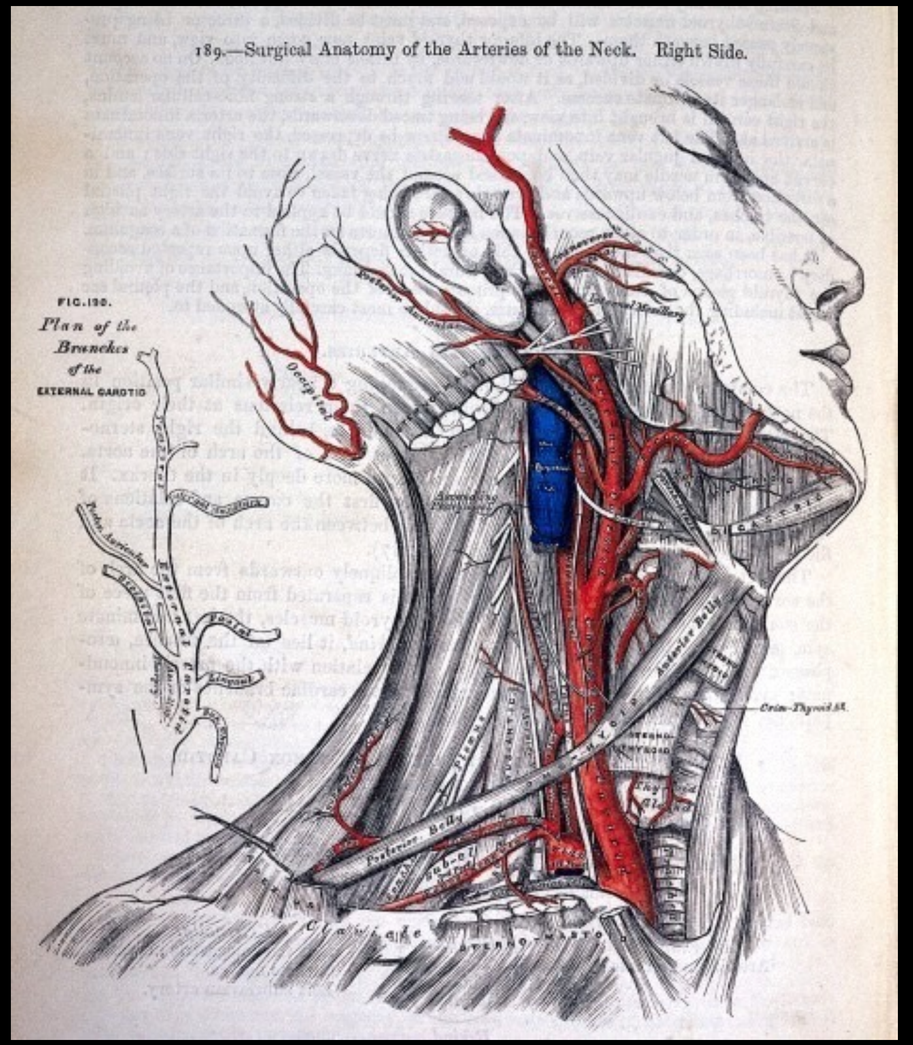
basically
AVOID CLUTTER

Get it right in Black & White

no unjustified color

consider designing your plot in BW first

functional use of colors



Maureen Stone

functional use of colors

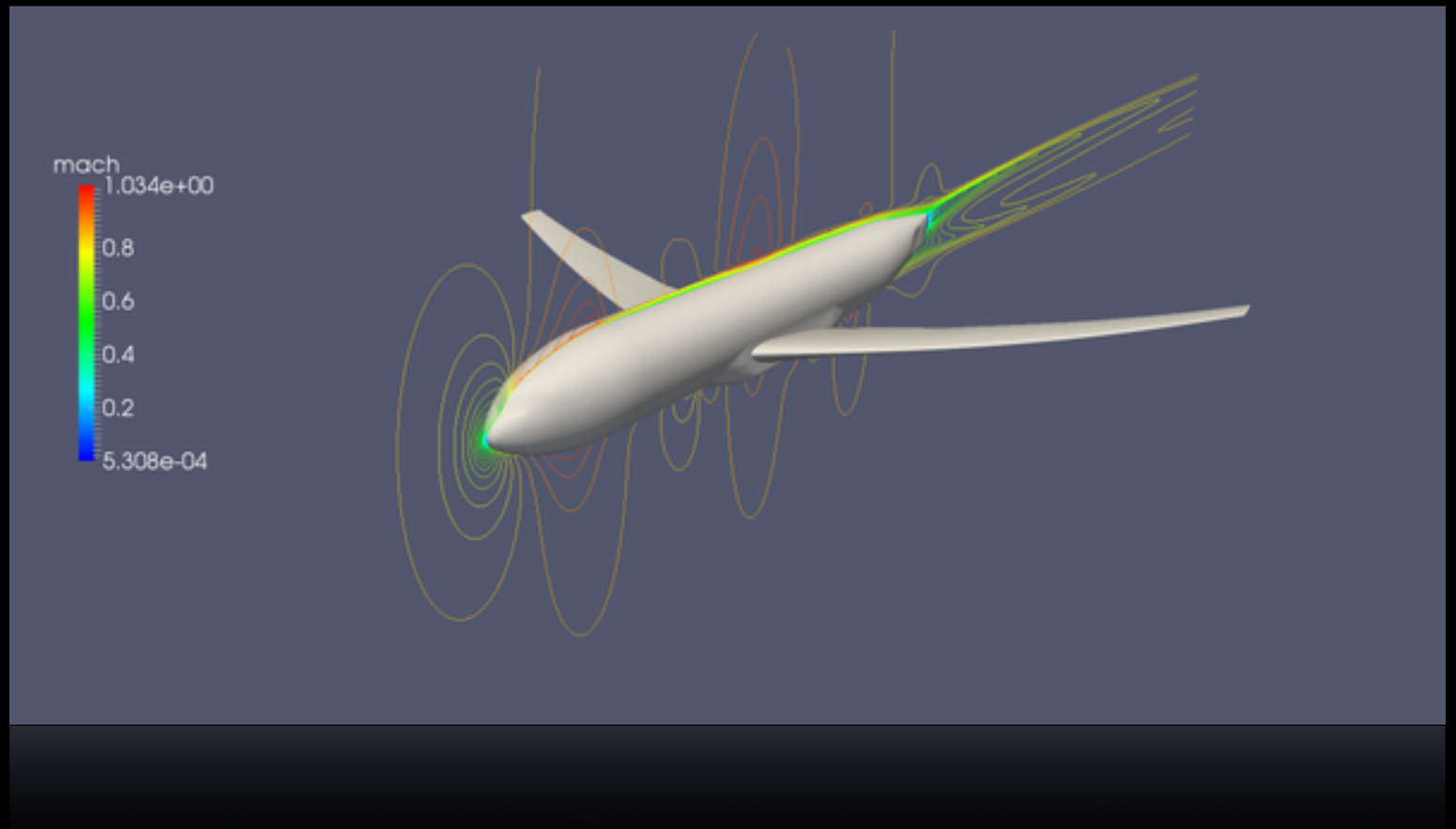
http://www.columbia.edu/~brennan/subway/SubDia.pdf

No Unjustified 3D

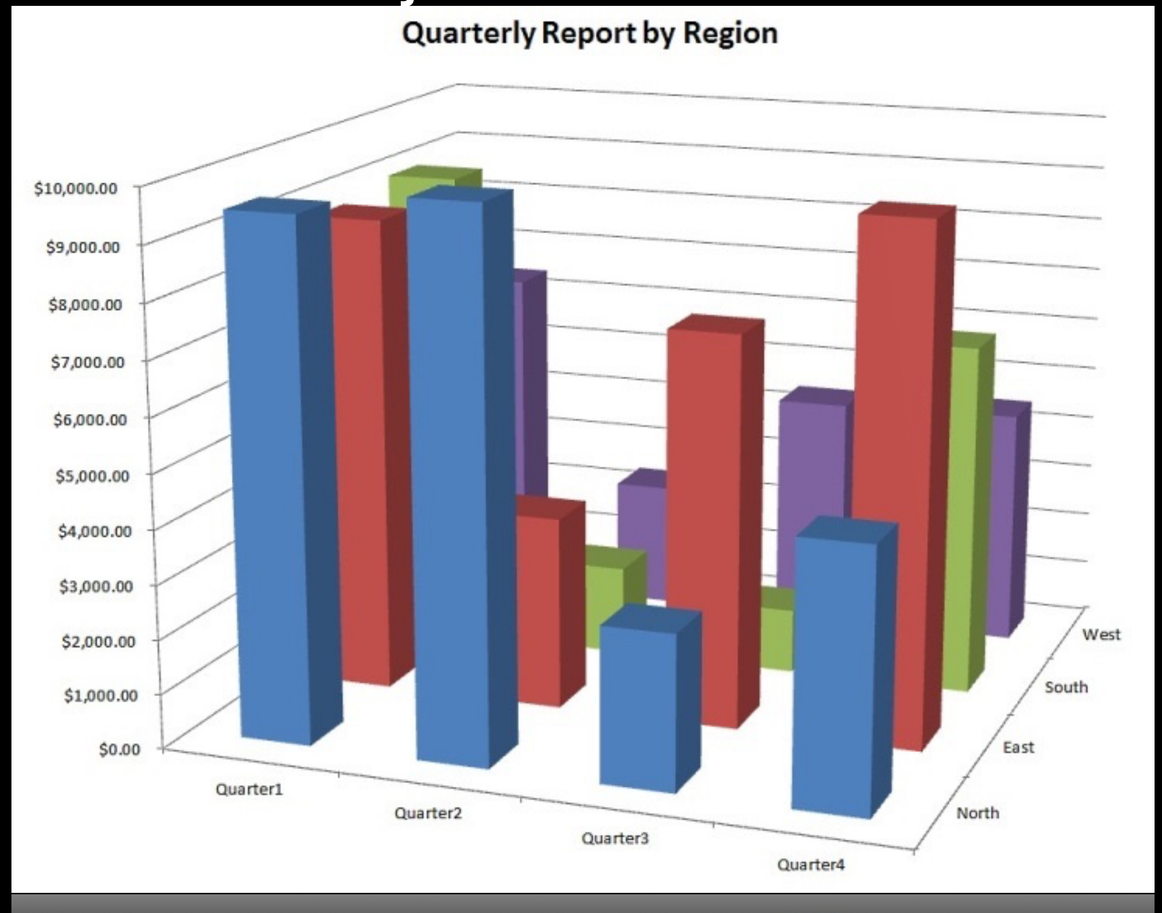
use 3D only if your 3rd dimention cannot be reduces.

Alternatives:

- color,
- small multiples,
- animation

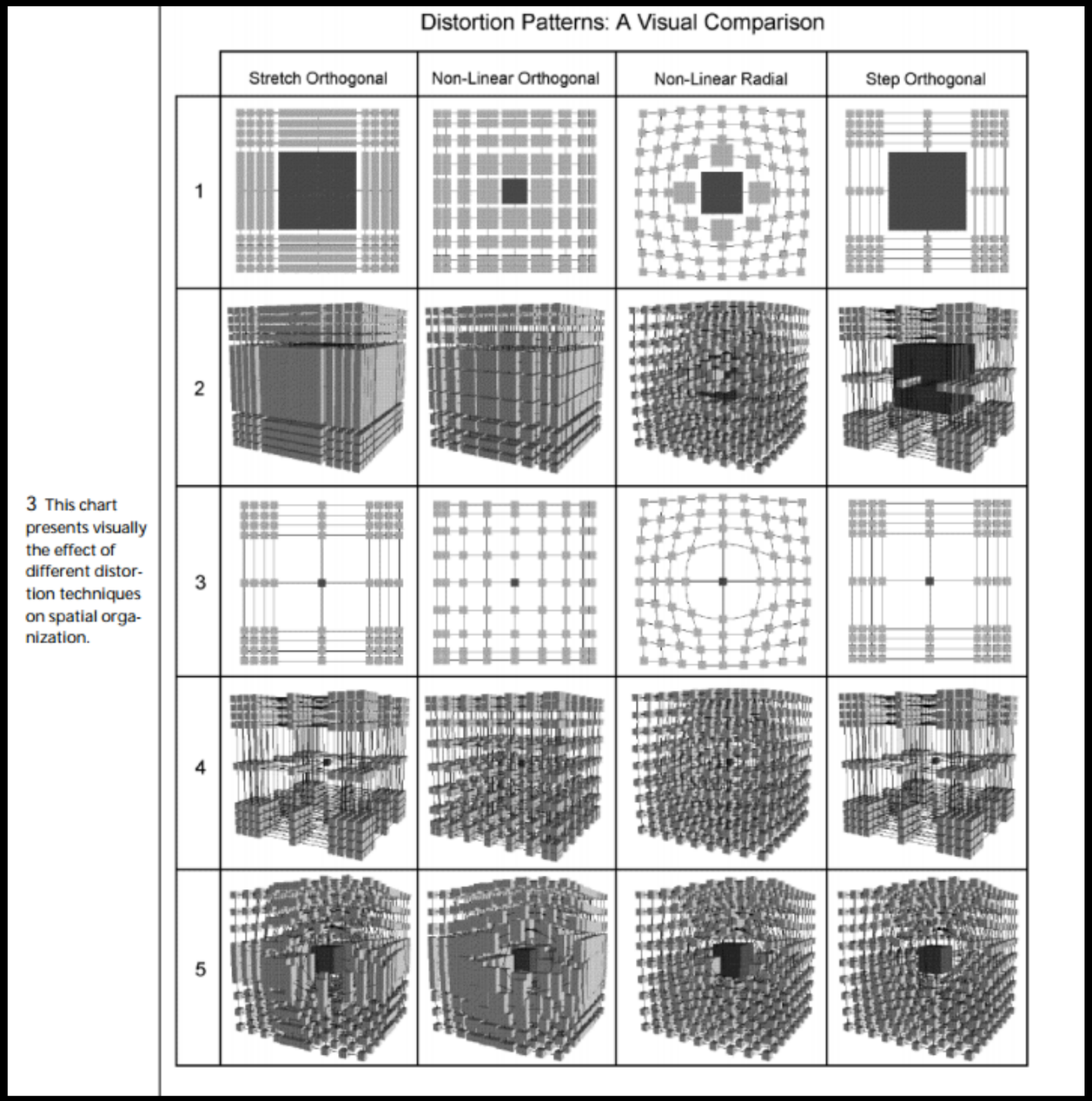


unjustified 3D



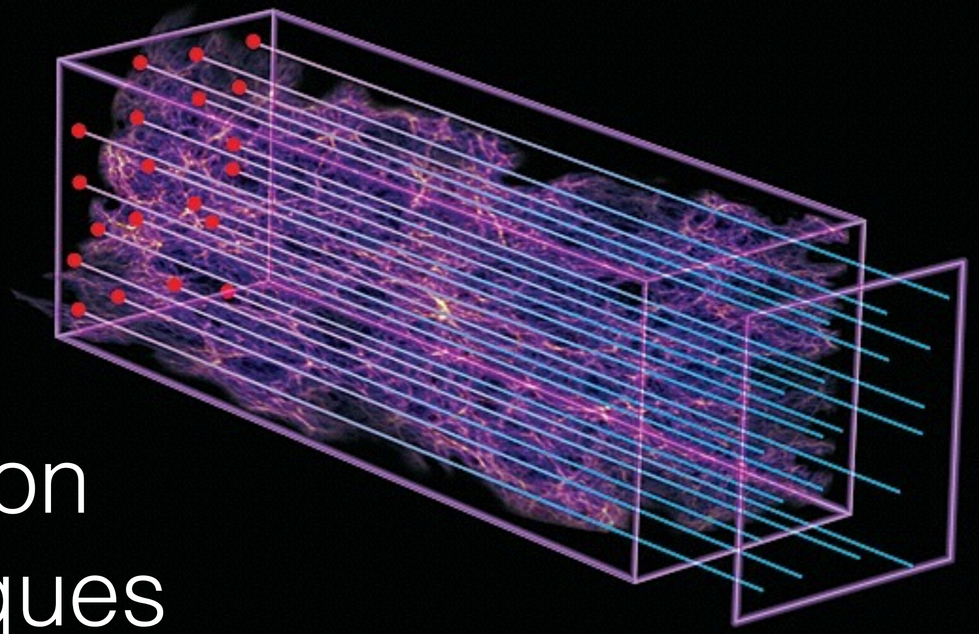
NEVER THIS!
issues:
- obstruction,
- clutter,
- deformation

distortion techniques

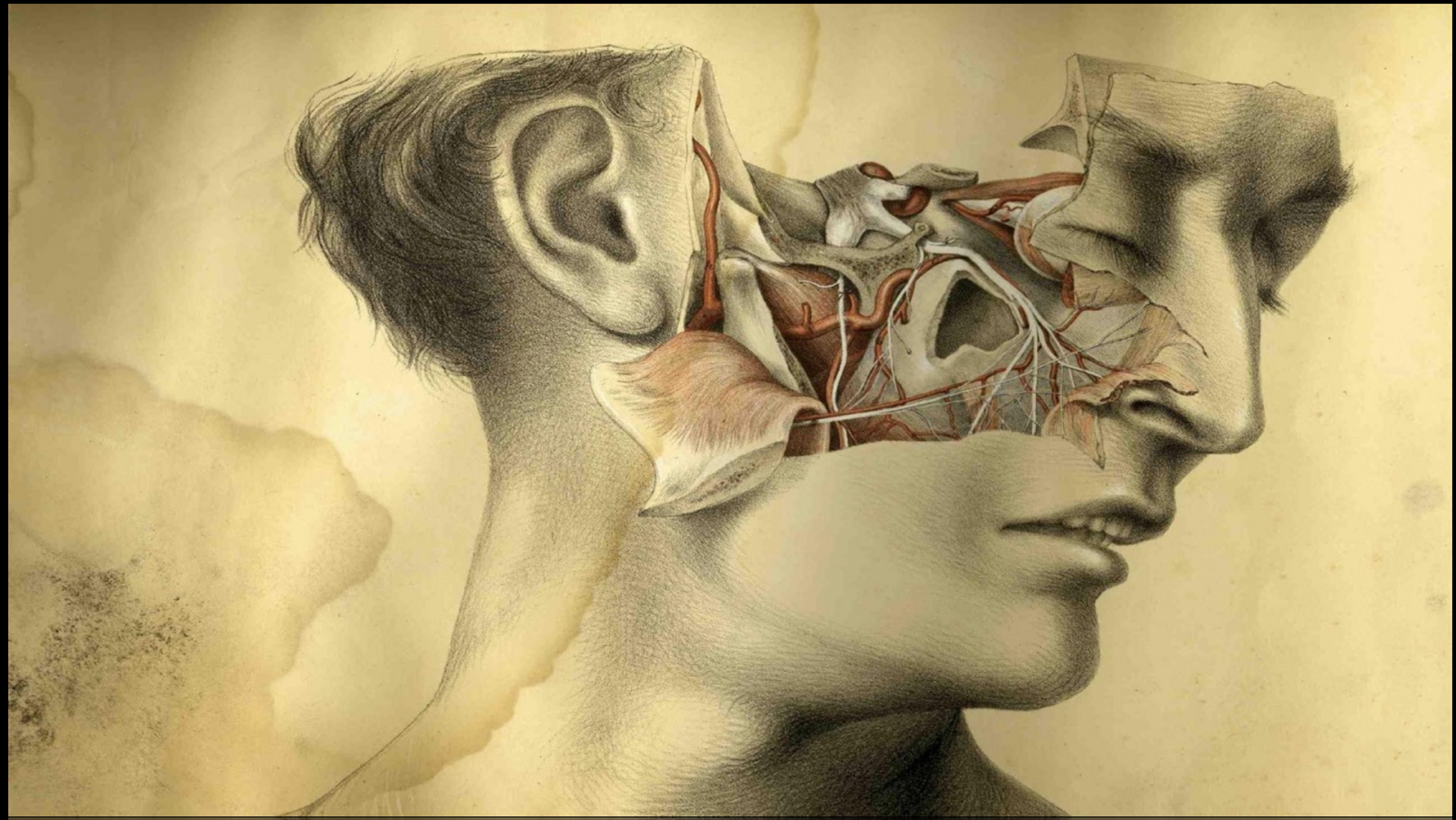


Extending Distortion Viewing Techniques from 2D to 3D Data.
Carpendale et al. CG&A 17(4):42-51, July 1997

https://www.sdss3.org/press/lyabao.php



distortion
techniques



distortion techniques

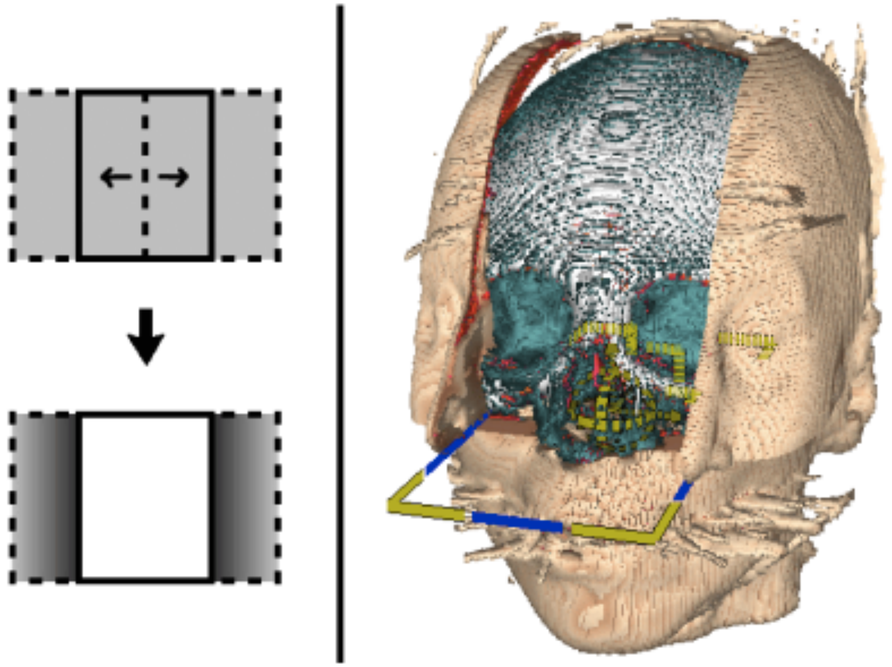
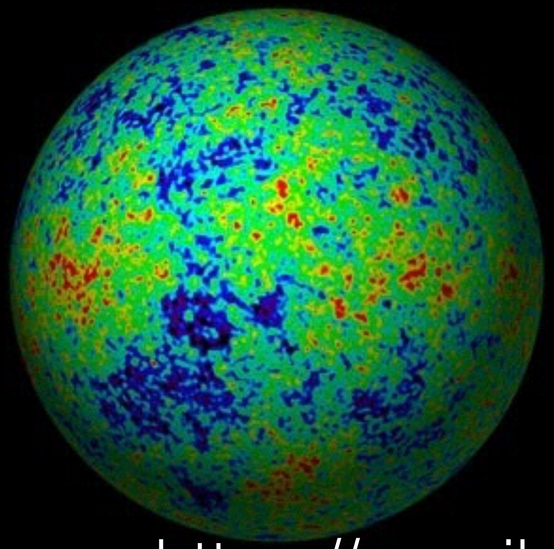


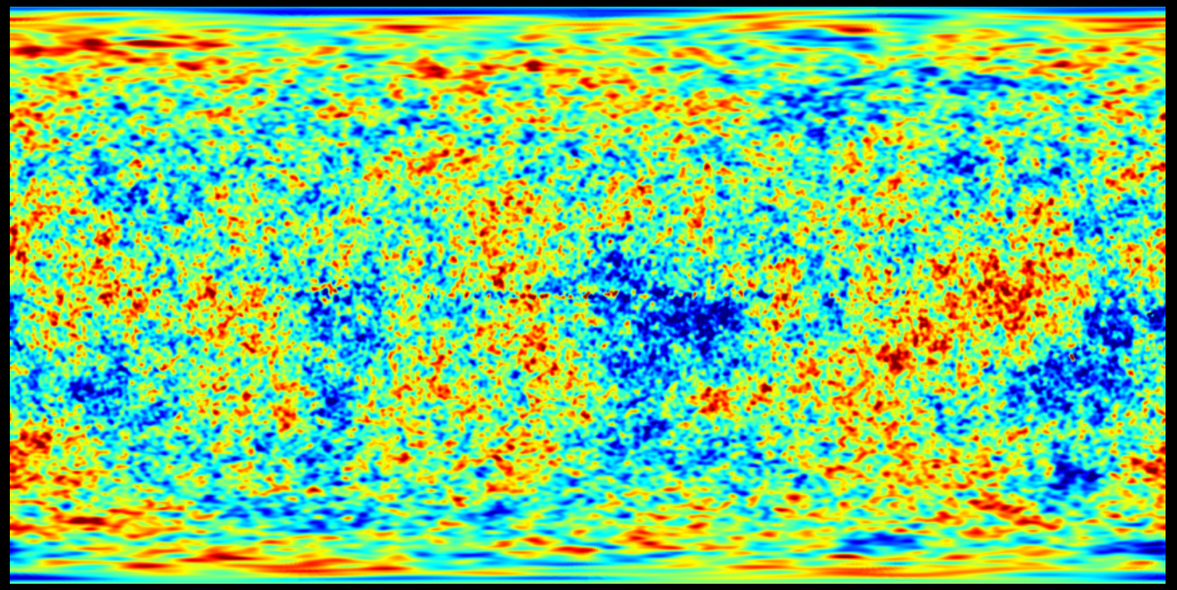
Figure 3.11: The Box Spreader. Left: voxels before and after deformation. All voxels contained in the box are pushed sideways, compressing surrounding voxels that are within twice the box's width. Right: the Box Spreader, acting only on layers outside the skull, cuts the upper face in half and pushes each half off the skull.

distortion techniques

An Investigation of Issues and Techniques in Highly Interactive Computational Visualization
Michael John MCGuffin

Mercator

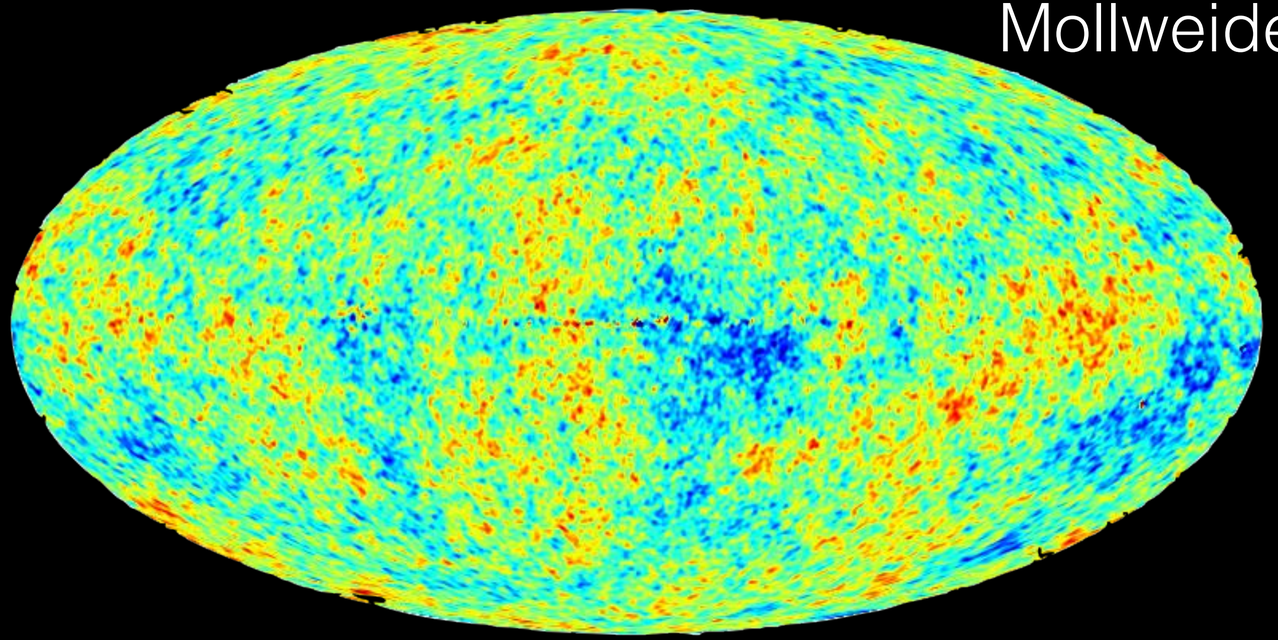




Hobo–Dyer

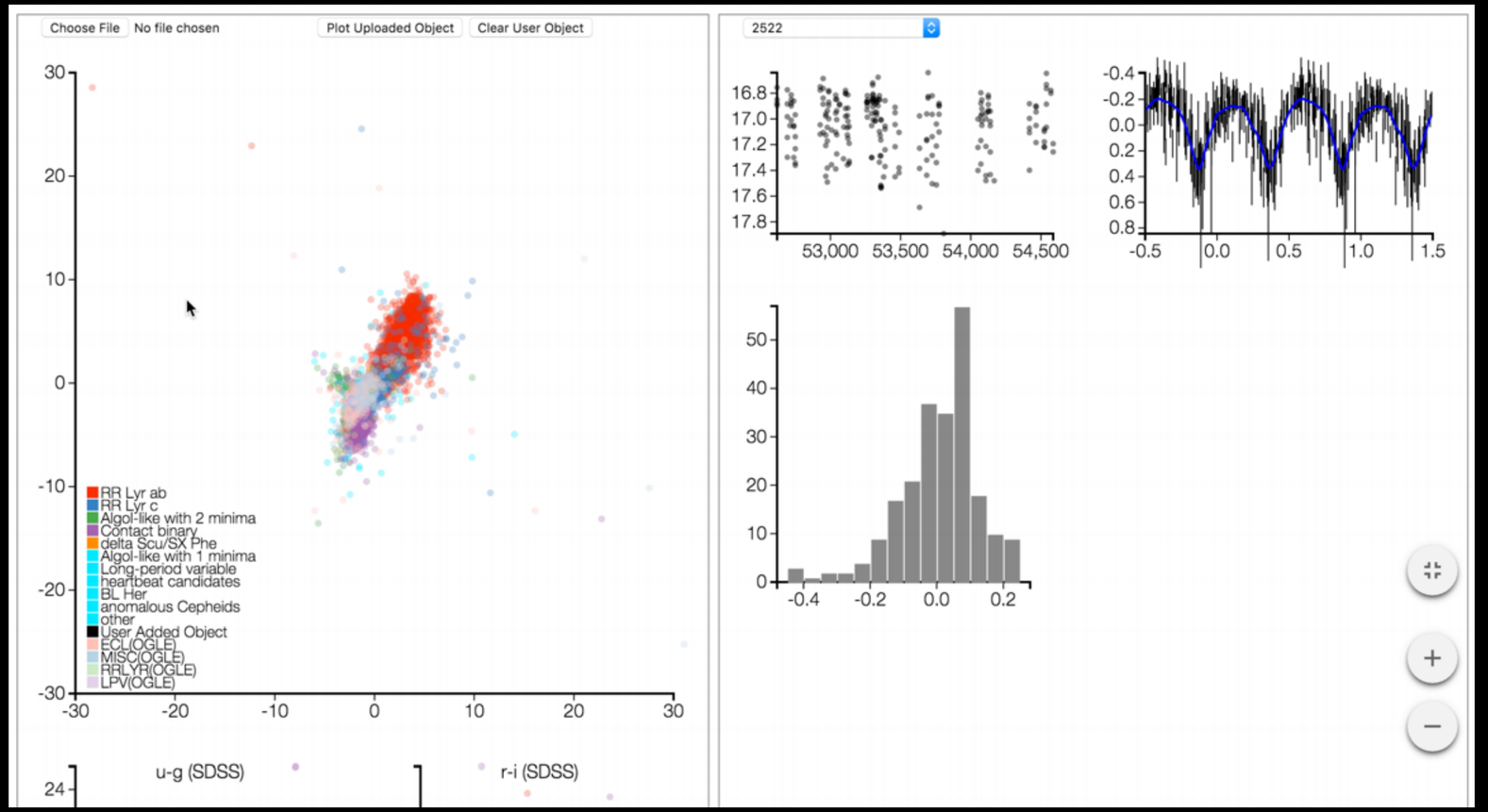
https://en.wikipedia.org/wiki/List_of_map_projections

Mollweide



distortion techniques

Visualizing highly dimensional data: consider animation if you can!



summary viz

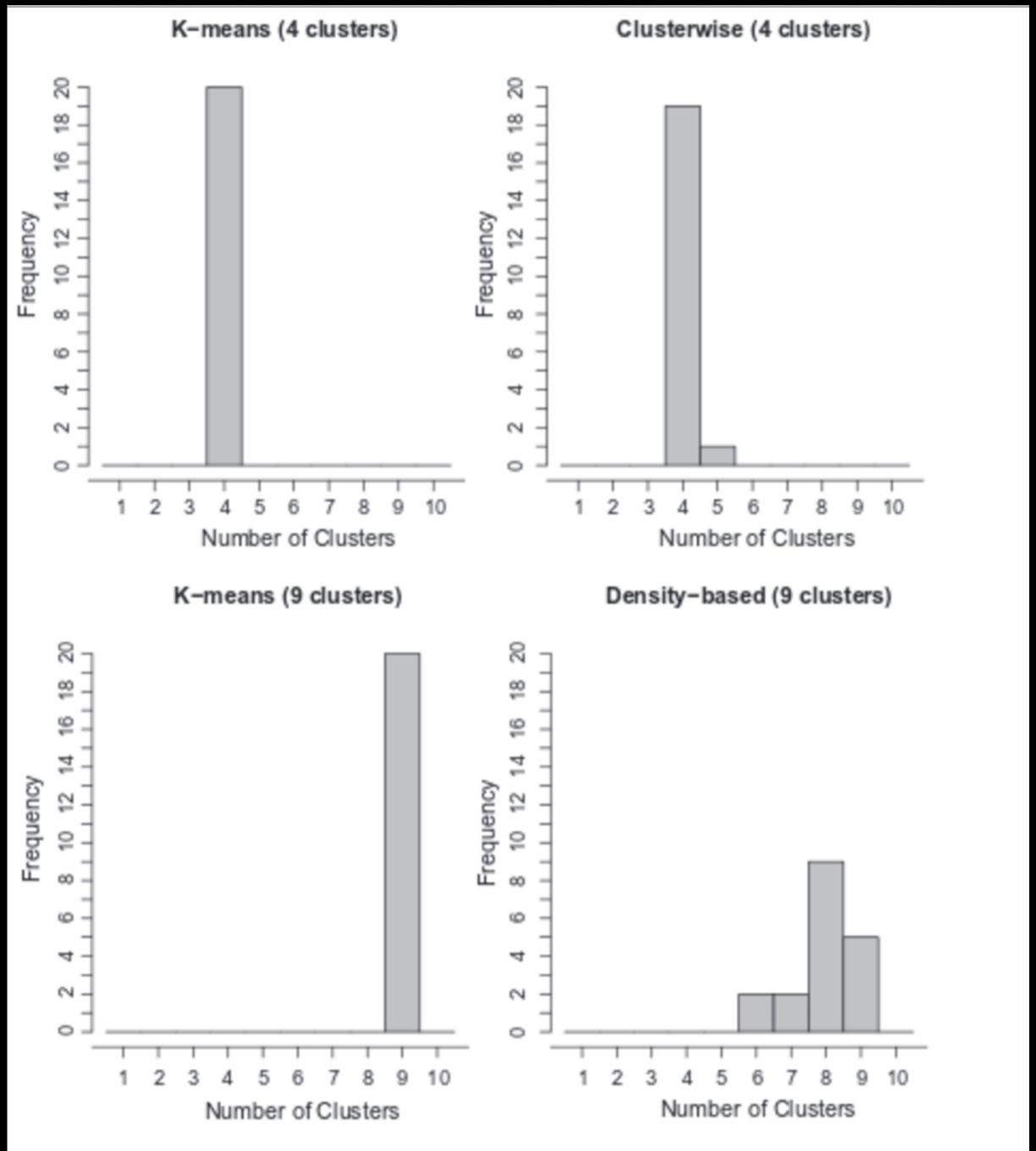
animation

https://www.youtube.com/watch?v=jgO0JU_I5-s&feature=youtu.be

Also:
No Unjustified 2D!

consider not plotting when you do no
need a plot!


Chris Prince
@Superdupercrisp
Follow
@fedhere "no unjustified 2-d"; this was in a journal article:
pbs.twimg.com/media/CSGohYuW…
RETWEET
1
LIKE
1
9:31 AM - 16 Nov 2015
Reply to @Superdupercrisp


K−means (4 clusters)
Clusterwise (4 clusters)
K−means (9 clusters)
Density−based (9 clusters)
Frequency
Number of Clusters
0 2 4 6 8 10 12 14 16 18 20
1 2 3 4 5 6 7 8 9 10

Eyes over Memory

no unjustified animation

Eyes over Memory

in some cases differences are better seen side-by-side

Eyes over Memory

in some cases differences are better seen side-by-side

Interactivity

interactive visualization rules of thumb:

Resolution over immersion

Details on demand

Avoid latency

Interactivity

Reduction

use animation/interactivity to allow switching between a comprehensive global view and a detailed reducted view

http://cosmo.nyu.edu/~fb55/vizs/astrotrend/arxiv2.html

I am primarily an artist:

I use empathy and sensibility to reach and interest people

Jer Thorp

Key Concepts:

Be thoughtful and make sure your visualizations are (in this order):

honest

clear

convincing

beautiful

Resources:

Edwaed tufte (anything)

Tamara Munzner
Visualization Analysis & Design, 2014
http://www.cs.ubc.ca/~tmm/talks/minicourse14/vad15london.pd

color maps http://
www.kennethmoreland.com/color-maps/
Kelly colors http://www.iscc.org/pdf/
PC54_1724_001.pdf

Point, Line, and Plane, Wassily Kandinsky, 1926

7 classical vis papers
http://fellinlovewithdata.com/guides/7-classic-foundational-vis-papers

7 Great Visualizations from History
http://data-informed.com/7-great-visualizations-history/

Six Lessons from the Bauhaus: Masters of the Persuasive Graphic
http://blog.visual.ly/six-lessons-from-the-bauhaus-masters-of-the-persuasive-graphic/