



48 - Using Gestalt Psychology to Display Quantitative Information with a Neural Networks Chaser

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2019 Valuation Actuary Symposium

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Session 48, Using Gestalt Psychology to Display Quantitative Information with a Neural Networks Chaser

August 27, 2019



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- **Do not** speak on behalf of the SOA or any of its committees unless specifically authorized to do so.
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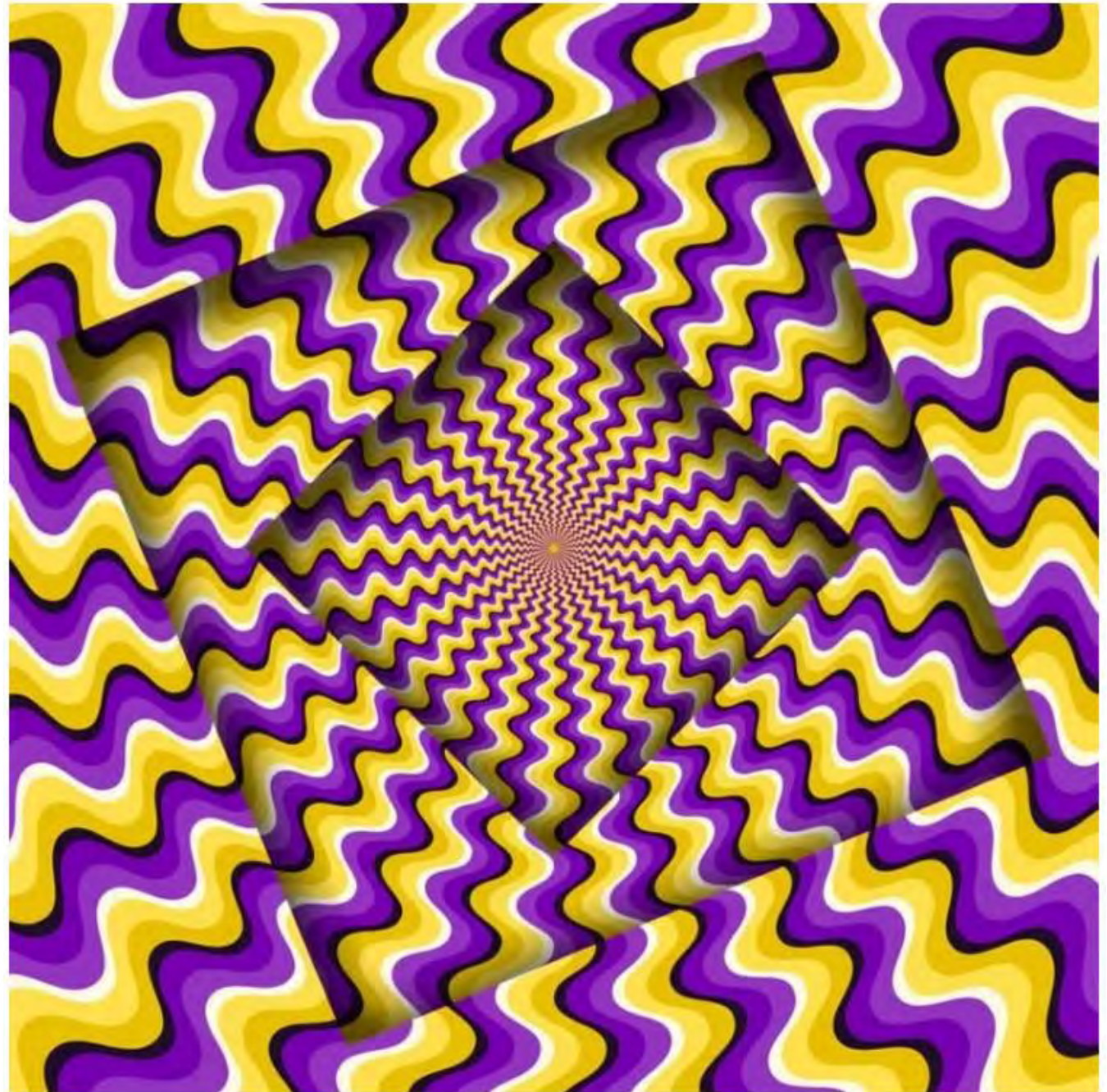
Using Gestalt Psychology to Display Quantitative Information with a Neural Networks Chaser



ACTUARIAL & ANALYTICS CONSORTIUM

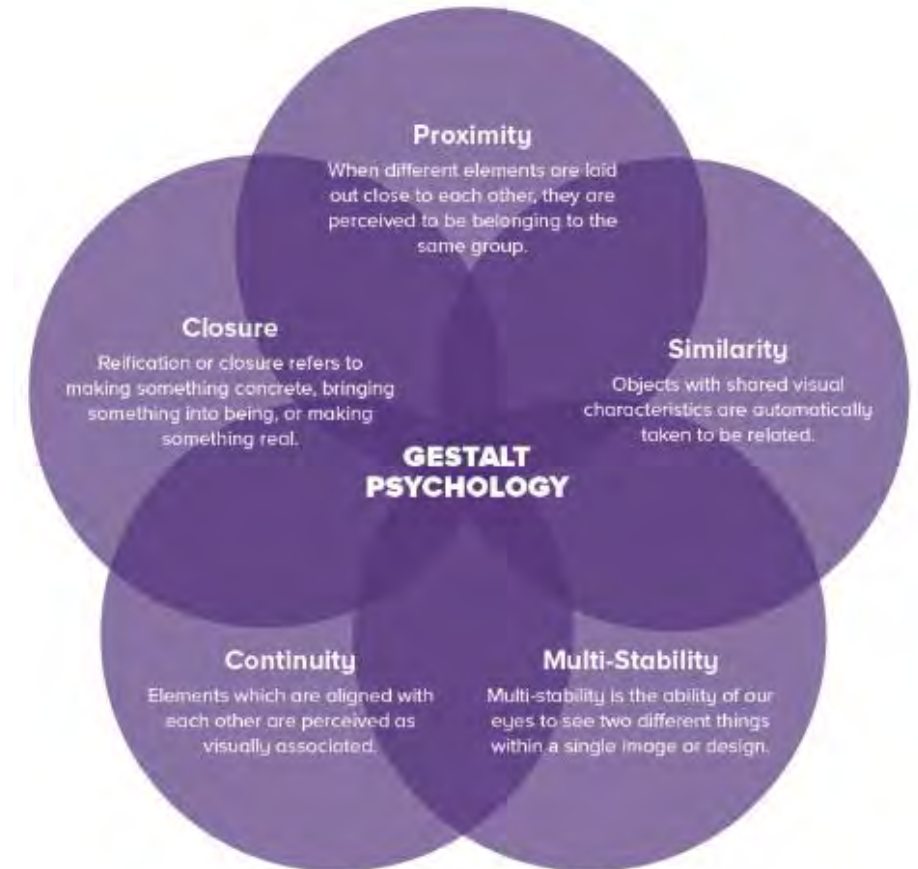
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Agenda

- Define Gestalt Psychology
- Pioneers in the Field of Gestalt
- Discuss Applications of Principles
- Examine Best & Worst Visualizations
- Cognitive Map of the Brain
- Summary of Best Practices



Gestalt Psychology – Basic Tenet

Whole \neq \sum Parts

Why?

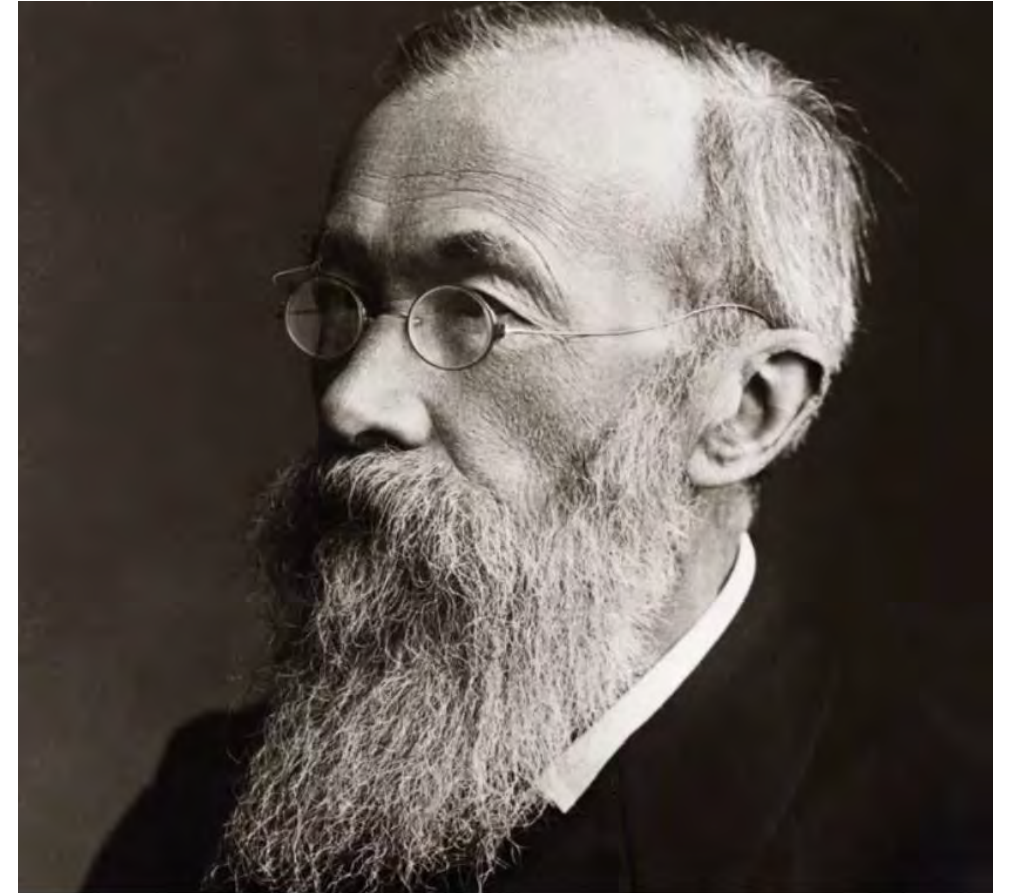
1. We don't perceive the world in pieces.
2. The mind perceives objects as part of a greater whole.
3. Objects are perceived as part of more complex systems



Gestalt Psychology & Displaying Quantitative Information

Wilhelm Wundt

- The Father of Psychology
- Developed world's 1st experimental psychology lab
- Applied scientific methods to study the human mind and behavior
- Psychology was initially defined as a mixture of philosophy and biology making it a separate science
- Gestalt psychology was a response to structuralism, a school of thought that broke down mental processes into components. **The Whole = Σ Parts!**



Gestalt Psychology & Displaying Quantitative Information

Source: <https://www.verywellmind.com/who-is-the-father-of-psychology-2795249>

Max Wertheimer

- One Three Founders of Gestalt Psychology
- Influenced subfields of
 - Sensation
 - Perception
 - Experimental Psychology
- Gestalt psychology takes a holistic approach to study perception which led to the school of perceptual organization. This school explains how smaller objects group to form larger ones.
- **The Whole > Σ Parts!**




Gestalt Psychology & Displaying Quantitative Information

Source: <https://www.verywellmind.com/max-wertheimer-biography-1880-1943-2795528>

Kurt Koffka

- One Three Founders of Gestalt Psychology
- Promoted theory in Europe & introduced to the U.S.
- He systemized the theory into a coherent body of theories and extended its ideas to Developmental Psychology
- He theorized that infants first perceive and respond holistically and only later are able to perceive individual sensations that comprise the whole
- Opposed by German academia for his Gestalt ideas



Kurt Koffka

- Born March 18, 1886
- Died Nov 22, 1941
- Born in Berlin, Germany
- Psychologist
- Another of the founders of Gestalt psychology
- Learning theorist

Wolfgang Kohler

- One Three Founders of Gestalt Psychology
- Behavior must be studied in all its complexity rather than separated into discrete components.
- Unlike Wertheimer and Koffka, Kohler concentrated on animal research and applied Gestalt theories to animal learning and perception
- Known for the Gestalt *Law of Transposition*, where test subjects transpose their original experience to a new set of circumstances. This law is based on his experiments with chickens trained to eat grains from different colored sheets of paper.

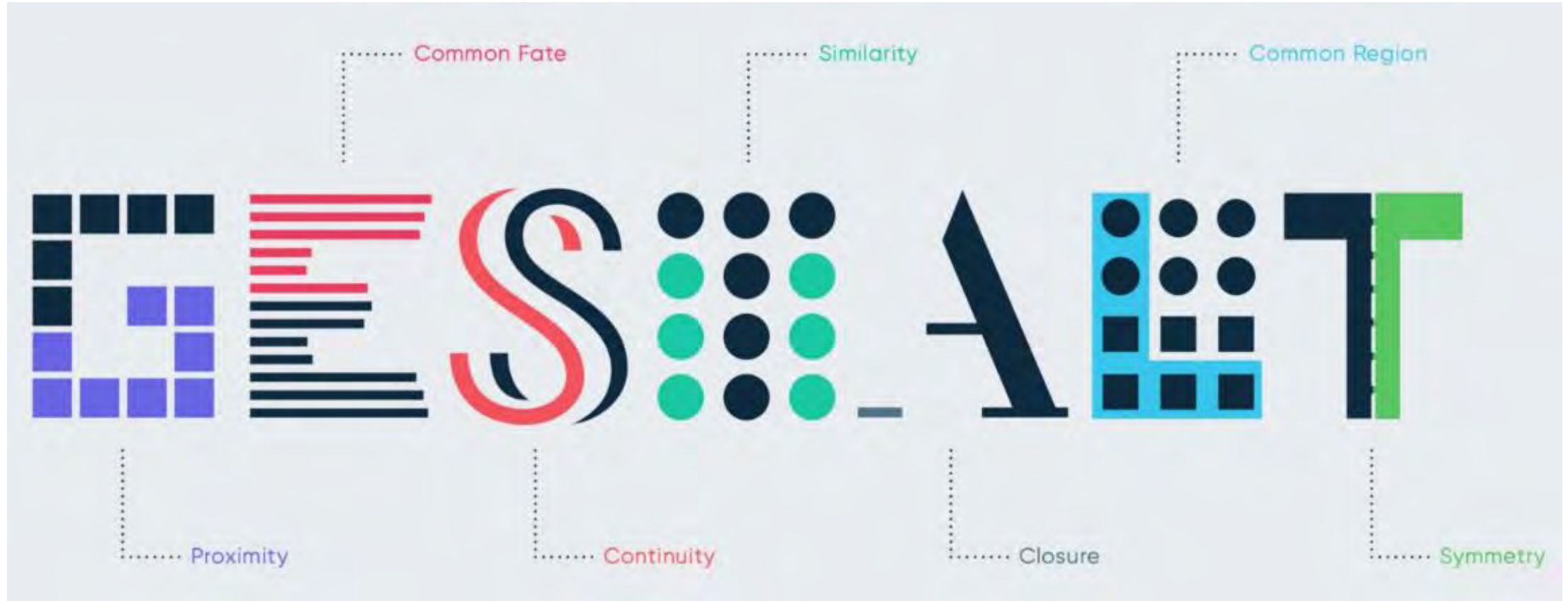
Wolfgang Kohler: Key Ideas



<http://www.brynmawr.edu/Acads/Psych/rwozniak/312.html>

- ◇ Problem Solving is essential to learning
- ✧ Learner must be able to make meaningful connections
- ✧ Learner is active
- ✧ Learner responds to meanings to create their own intellectual connection
- ✧ Learning happens inside one's brain, its invisible

Gestalt Psychology Principles



Source: <https://medium.muz.li/gestalt-principles-in-ui-design-6b75a41e9965>

Gestalt Psychology & Displaying Quantitative Information



Gestalt Principle of Proximity



What Is the Law of Proximity?


The law of proximity describes how the human eye perceives connections between visual elements. Elements that are close to each other are perceived to be related when compared with elements that are separate from each other.

The law of proximity allows us to use whitespace, for example, to build perceived relationships between different elements.


Proximity

Elements that are **placed closer together** are perceived as being more related than those spaced further apart.

Before



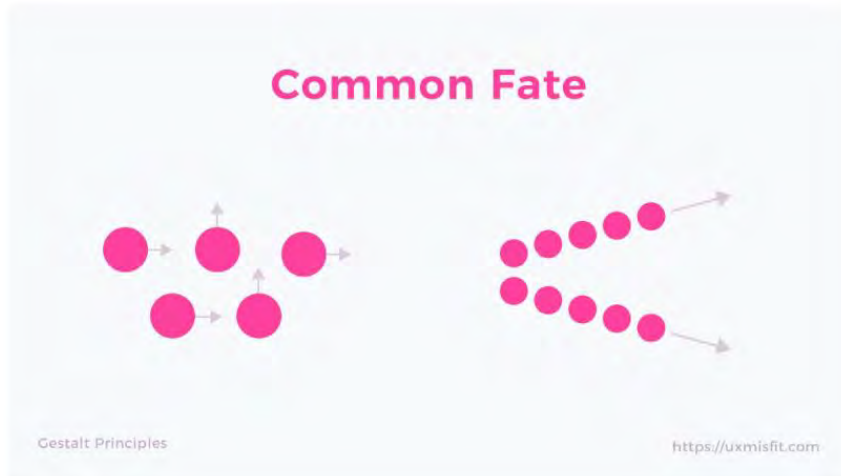
After



Principle of Common Fate

What Is the Law of Common Fate?

This principle is fundamental in motion design. Every meaningful animation uses common fate to guide users' eye in the right way. This helps to connect content with triggered action.

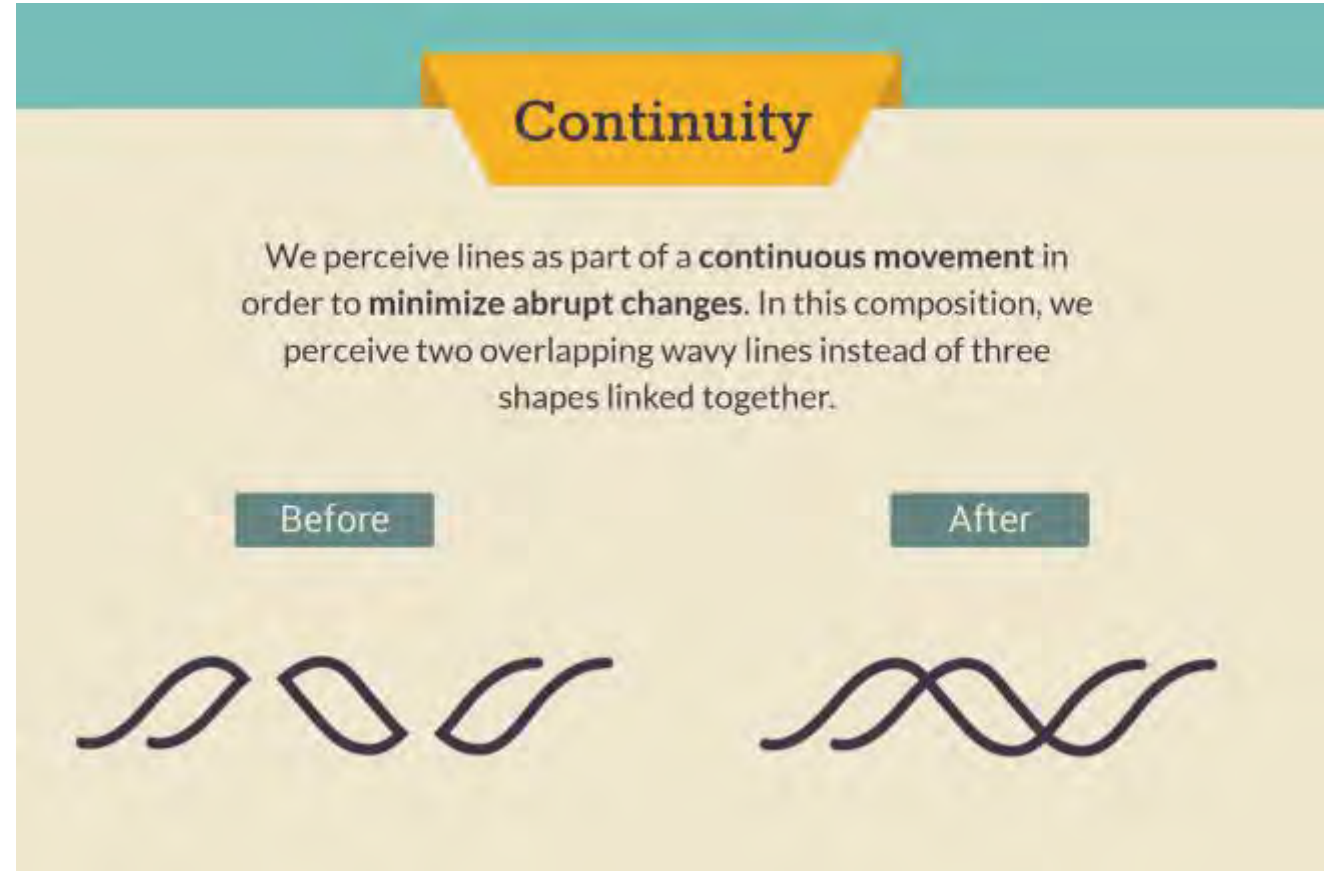


The bubbles move right and upward. We perceive this as an improvement in Life Expectancy with increase in GDP. The elements that move in the same direction are perceived to have the same fate.

What Is the Law of Continuity?

Explains how our brain experiences visual line of elements that are grouped together. There is a tendency to perceive a line continuing its established direction.

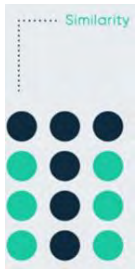
The edge of any shape continues into the space and meets up with other shapes or the edges of other plane. We are more apt to follow the direction of an established pattern rather than deviate from it.



Continuity

We perceive lines as part of a **continuous movement** in order to **minimize abrupt changes**. In this composition, we perceive two overlapping wavy lines instead of three shapes linked together.

Before **After**

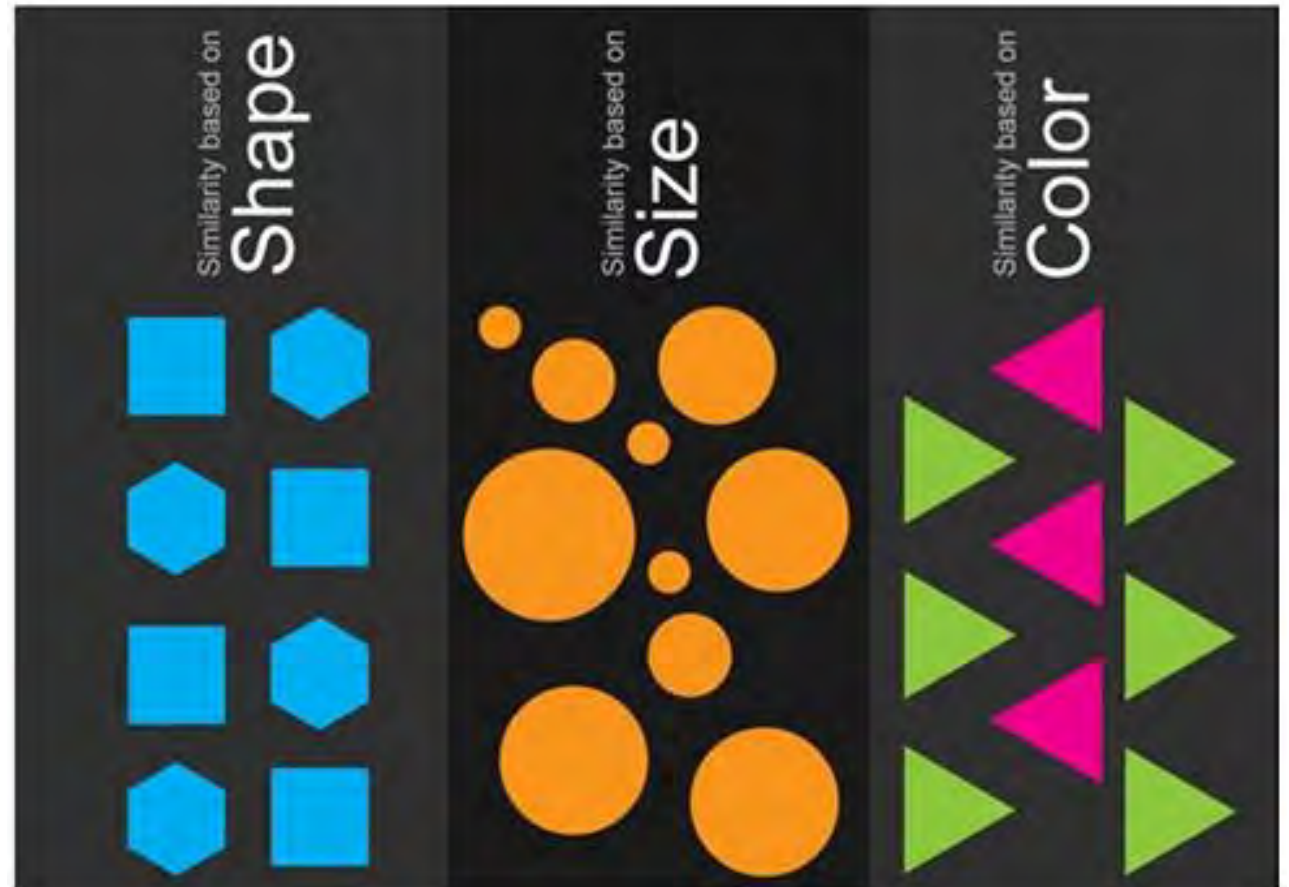


Principle of Similarity

What Is the Law of Similarity?

The human eye tends to build a relationship between similar elements within a design. Similarity can be achieved using basic elements such as shapes, colors, and size.

The brain seems to craft a link between elements of a similar nature. Then, we perceive them in a relationship with each other, separating them from other elements in a design. Human eyes are good at filling in “gaps” or connecting “dots”. It happens naturally.





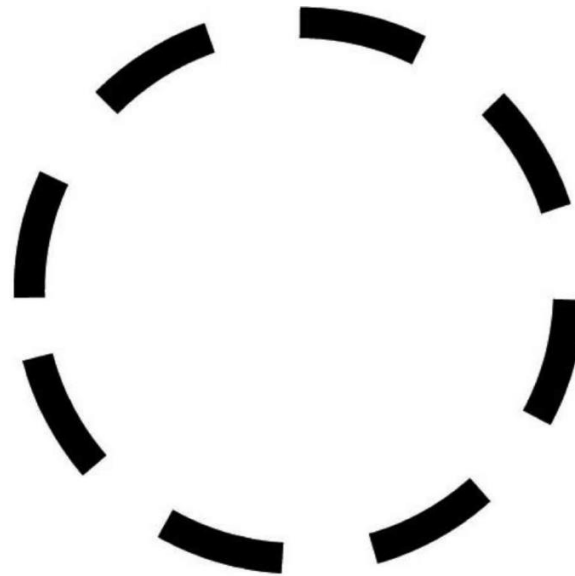
Principle of Closure

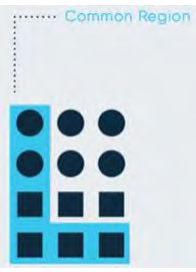


What Is the Law of Closure?

Gestalt psychologists believe that the brain tends to perceive forms and figures in their complete appearance despite the absence of one or more of their parts, either hidden or totally absent.

We can infer the brain's tendency to ignore the gaps and see the figure as a circle. **Previous experience** with the figure or form facilitates our natural tendency to perceive an incomplete or partially hidden object as the same object that's stored in our memory.





Principle of Common Region

What Is the Law of Common Region?

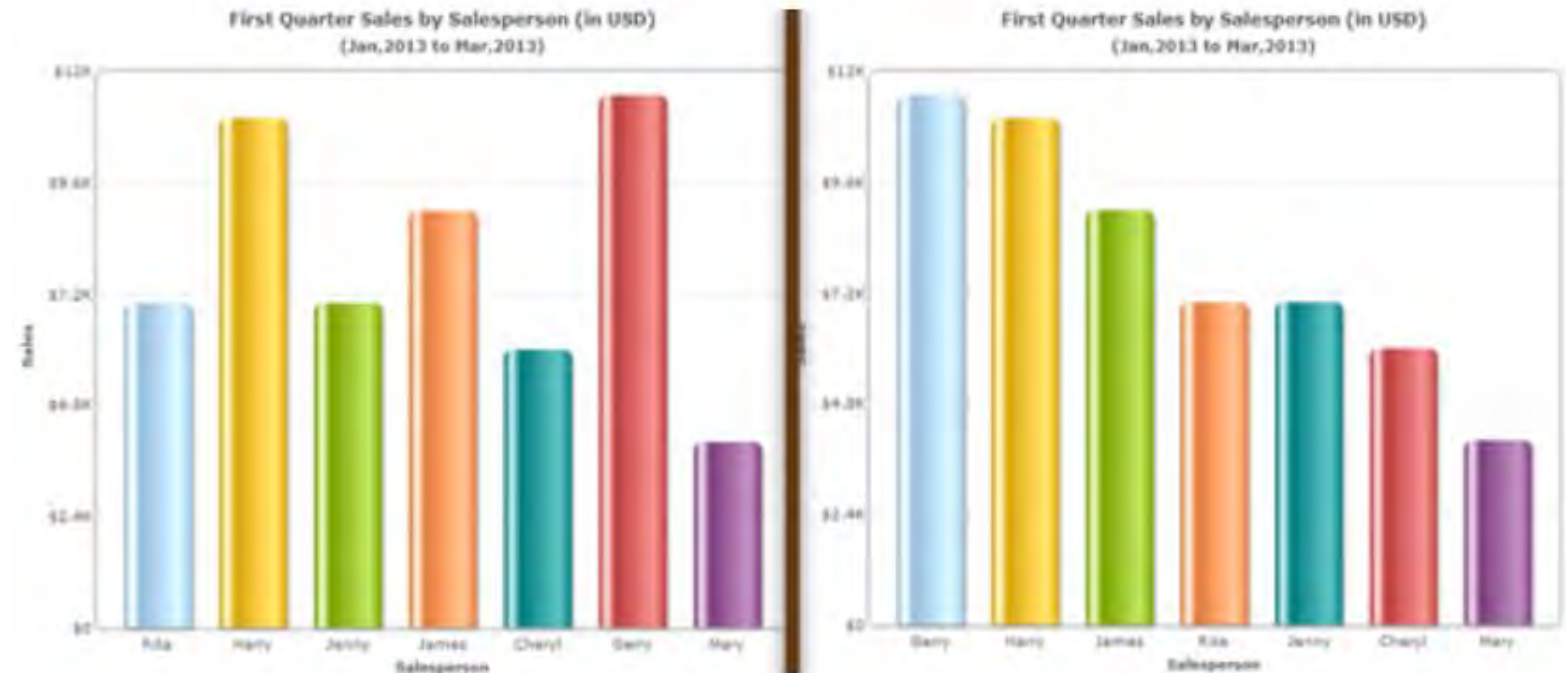
Elements tend to be perceived into groups if they are sharing an area with a clearly defined boundary.

First proposed by Gestalt psychologists to account for the observation that humans naturally perceive objects as organized patterns and objects, a principle known as **Prägnanz**. Gestalt psychologists argued that these principles exist because the mind has an innate disposition to perceive patterns in the stimulus based on certain rules.



Gestalt Law of Prägnanz

The human brain loves simplicity and it tends to process simple patterns — patterns that are regular, even, and orderly — faster than patterns that are more complex



Source: <https://www.webfx.com/blog/web-design/data-visualization-gestalt-laws/>



Principle of Symmetry

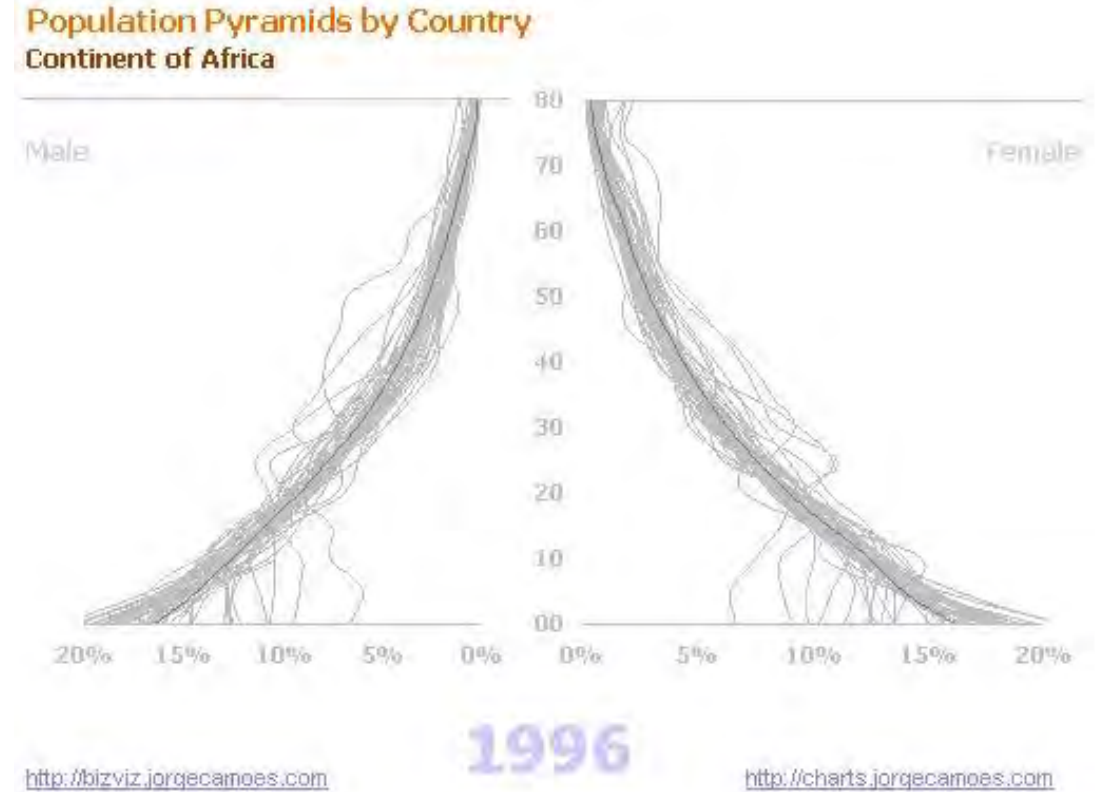


What Is the Law of Symmetry?

Grouping law that states that elements that are symmetrical to each other tend to be perceived as a unified group.

Objects that are symmetrical with each other will be more likely to be grouped together than objects not symmetrical with each other. This is a lawful statement of the role of symmetry in determining figure-ground perception.

As a result, designs with symmetry are easy on the eyes and help create more balanced compositions.



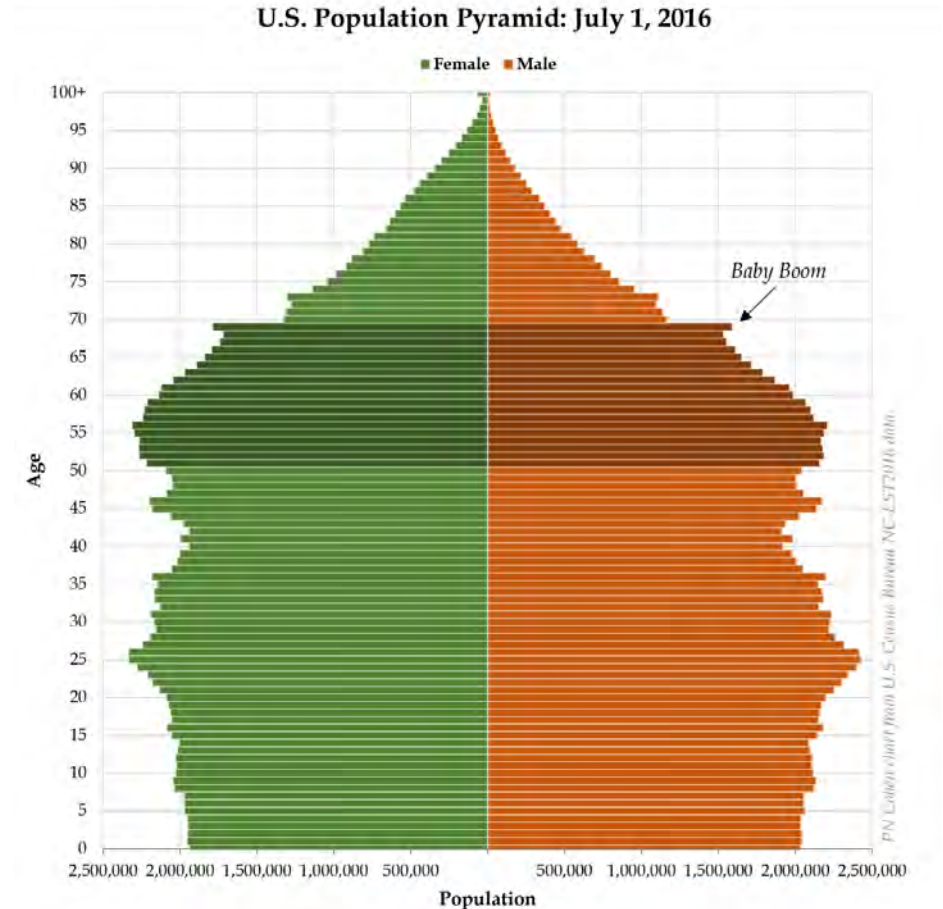
Source: <https://excelcharts.com/data-visualization-excel-users/gestalt-laws/>



Principle of Symmetry



Only one population can be observed in this graph.



Gestalt Psychology & Displaying Quantitative Information

Figure – Ground Perception

What do you see?

Silhouettes or
Rubin Vases?



M.C. Escher & Figure/Ground

Our perception of figure vs. ground is not completely determined by scene characteristics.

It also depends on the viewer's focus of attention.



M. C. Escher exploited figure/ground ambiguity in his art.

Source: <https://www.verywellmind.com/what-is-figure-ground-perception-2795195>

M.C. Escher & Figure/Ground

Metamorphose II Figure/Ground + Tessellations

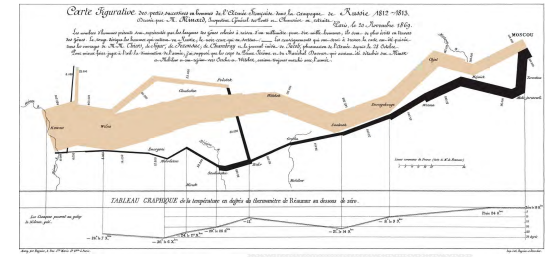


Gestalt Psychology



Applications to Visualizations

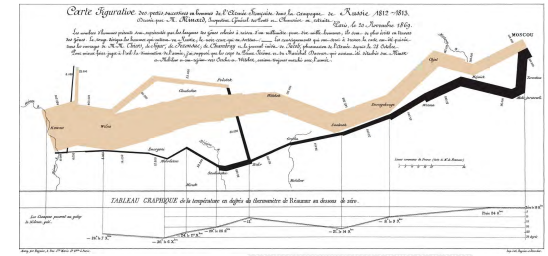
A Little History



Napoleon led at least 450,000 Grande Armée soldiers into battle, crossing the Niemen River, surviving the journey back with fewer than 25,000 soldiers, defeated, with no victory, except for the people of France with his eventual exile to Elba.

The journey of the line ends where it began at the Niemen River but diminished in health and brilliance of color.

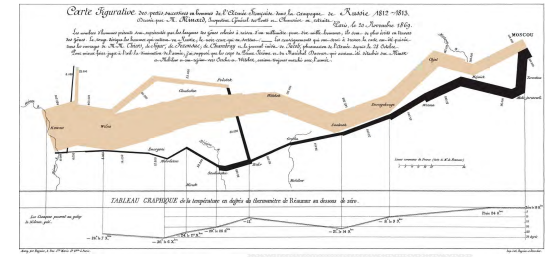
Why the G.O.A.T?



Tufte's Six Fundamental Principles of Analytical Design:

3. **Multivariate Analysis** – *Several attributes critical to understanding the brutality of the war are identified: Army Size, Longitude, Latitude, Direction of Movement, Temperature, Dates.*

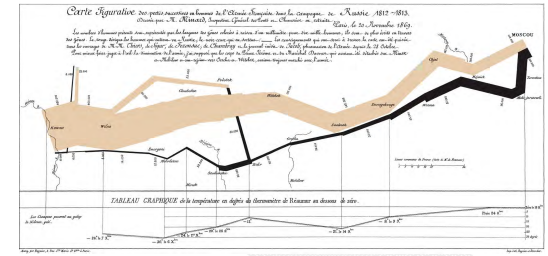
Why the G.O.A.T?



Tufte's Six Fundamental Principles of Analytical Design:

4. **Integration of Evidence** – *Attributes are weaved together with a connective narrative.*
5. **Documentation** – *Parties responsible for the work product are identified for interrogation of the credibility of the work.*

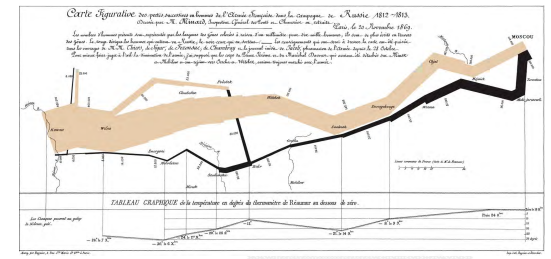
Why the G.O.A.T?



Tufte's Six Fundamental Principles of Analytical Design:

6. **Content** – *Inclusion of information which alone sufficiently increases knowledge and enables decision making, without design devices or gimmicks.*

Why the G.O.A.T?



A Possible 7th Fundamental Principles of Analytical Design:

7. Perspective – *A common technique of artists is to continually stand back from a work to check the perspective and make sure it is developing as desired.*

Note: Terrain did not add to the information content of graphic.

Psychological *Flow*

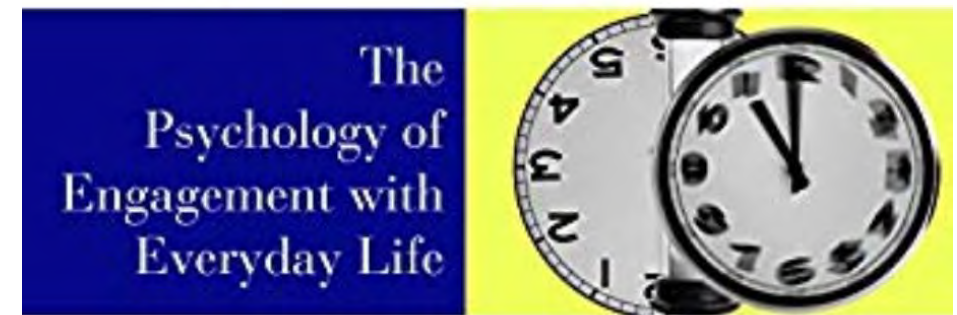
Positive psychologist, *Mihaly Csikszentmihalyi* defines psychological flow as “*a state of complete and total immersion in an activity and all sense of space and time is lost.*”

Flow Activities:

1. *Sports – Runner’s High, Being in the Zone*
2. *Esthetic Rapture – Rappers Freestyling*
3. *Musicians – Classical, Jazz, Rock & Roll, etc.*
4. *Meditation – Out of Body Experience*
5. *Video Games – Fortnite, Candy Crush*

Behavioral Considerations in InsurTech Designs

Finding *Flow*



MIHALY CSIKSZENTMIHALYI
Author of *Flow and Creativity*

APA Definition of Addiction

Addiction is a complex condition, a brain disease that is manifested by compulsive substance use despite harmful consequence.

Behavioral Considerations in InsurTech Designs

AMERICAN PSYCHIATRIC ASSOCIATION

DRUG ADDICTION IS PREVENTABLE

Drug education and prevention efforts aimed at children and adolescents can be effective in reducing drug misuse.
Learn more at apapsy.ch/addiction.

 RISK FACTORS	 PROTECTIVE FACTORS
Aggressive behavior in childhood	Good self-control
Poor social skills	Positive relationships
Availability of drugs at school	School anti-drug policies
Lack of parental supervision	Parental monitoring and support
Drug experimentation	Academic competence
Community poverty	Neighborhood pride

APA Definition of Addiction



Symptoms of substance use disorder are grouped into four categories:

- 1. Impaired control:** a craving or strong urge to use the substance; desire or failed attempts to cut down or control substance use
- 2. Social problems:** substance use causes failure to complete major tasks at work, school or home; social, work or leisure activities are given up or cut back because of substance use

APA Definition of Addiction



Symptoms of substance use disorder are grouped into four categories:

- 3. Risky use:** substance is used in risky settings; continued use despite known problems
- 4. Drug effects:** tolerance (need for larger amounts to get the same effect); withdrawal symptoms (different for each substance)

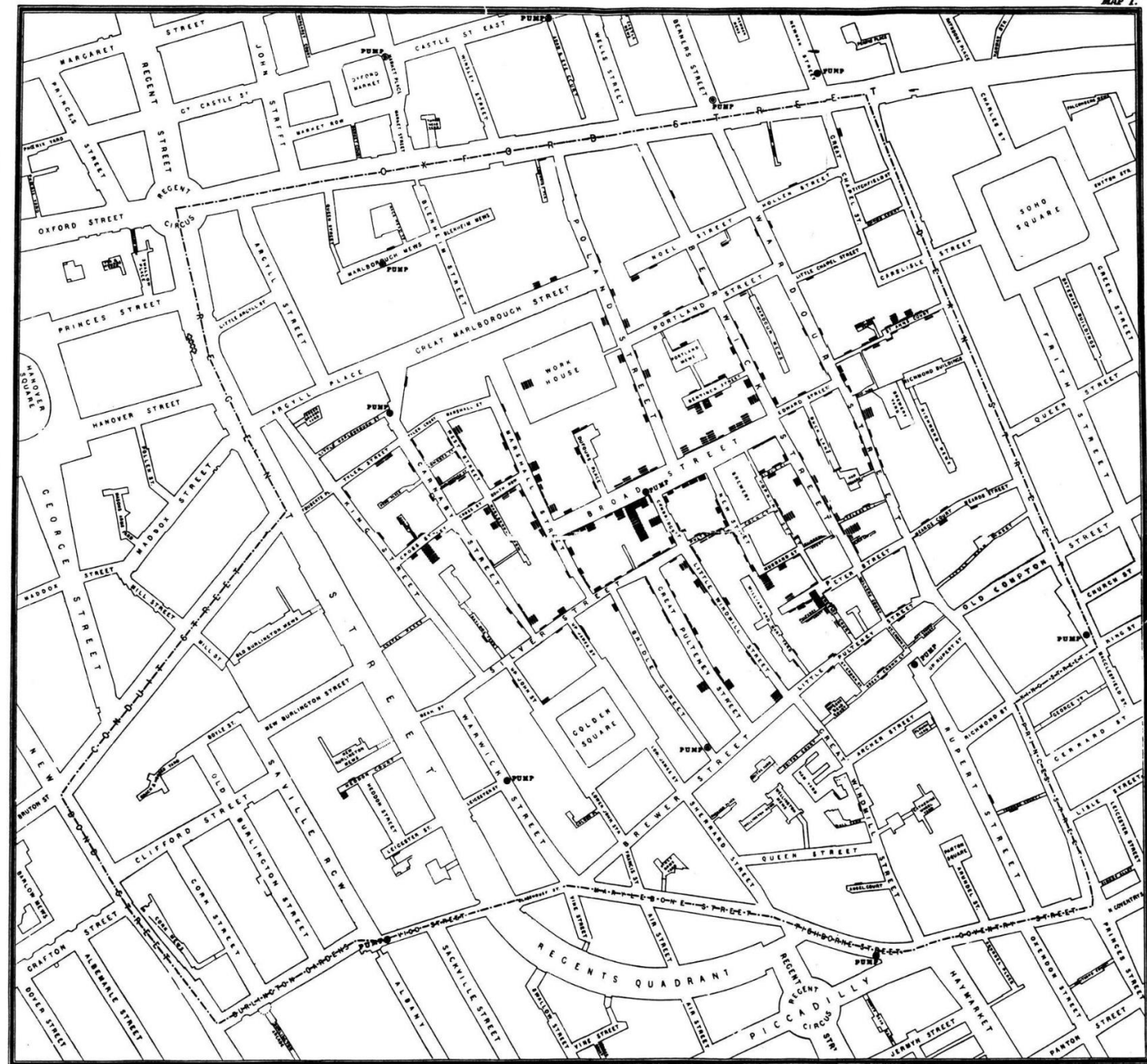
Gestalt Psychology



Other Great Visualizations According to Tableau

Source: <https://www.tableau.com/learn/articles/best-beautiful-data-visualization-examples>

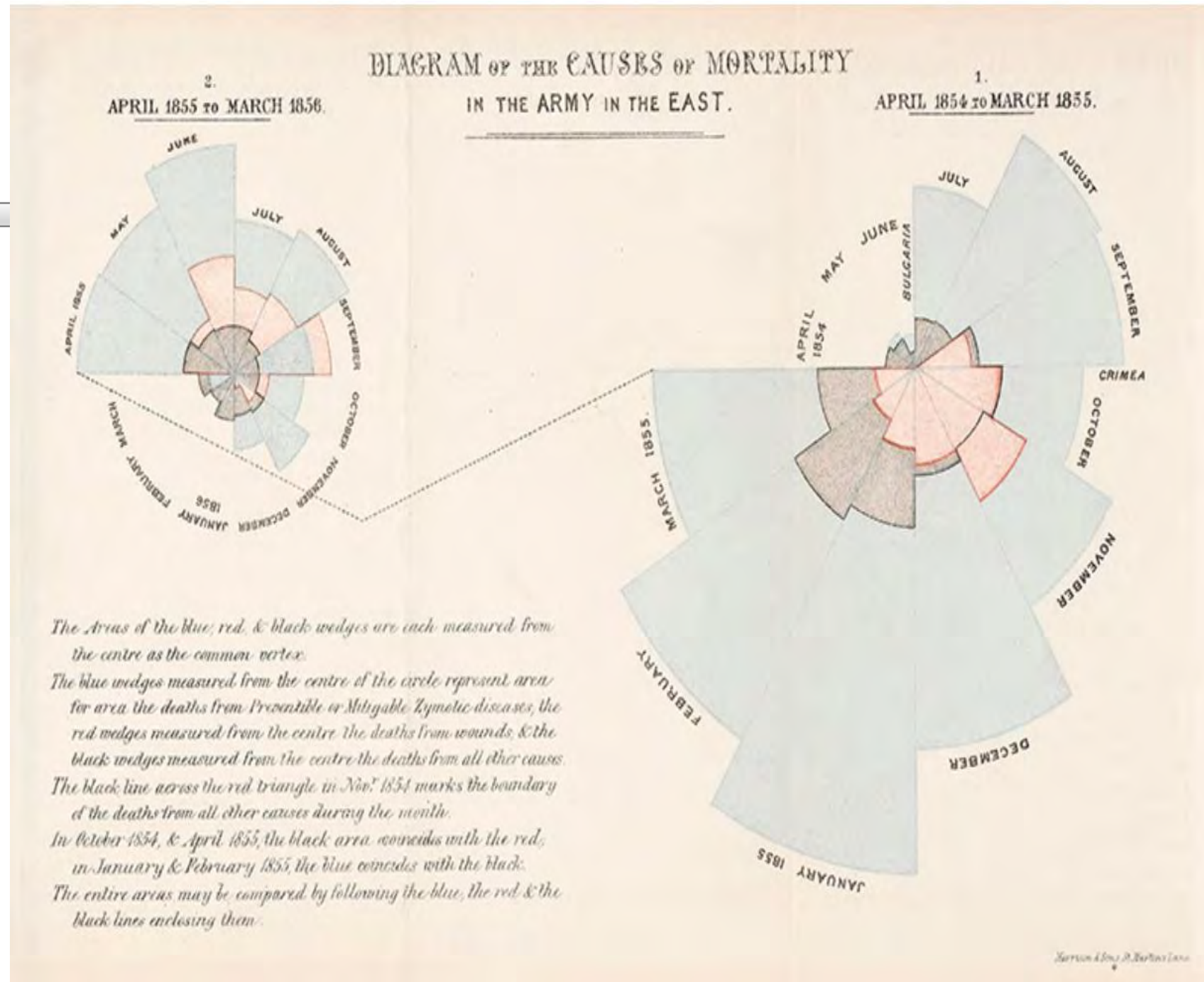
1854 Broad Street Cholera Outbreak Map



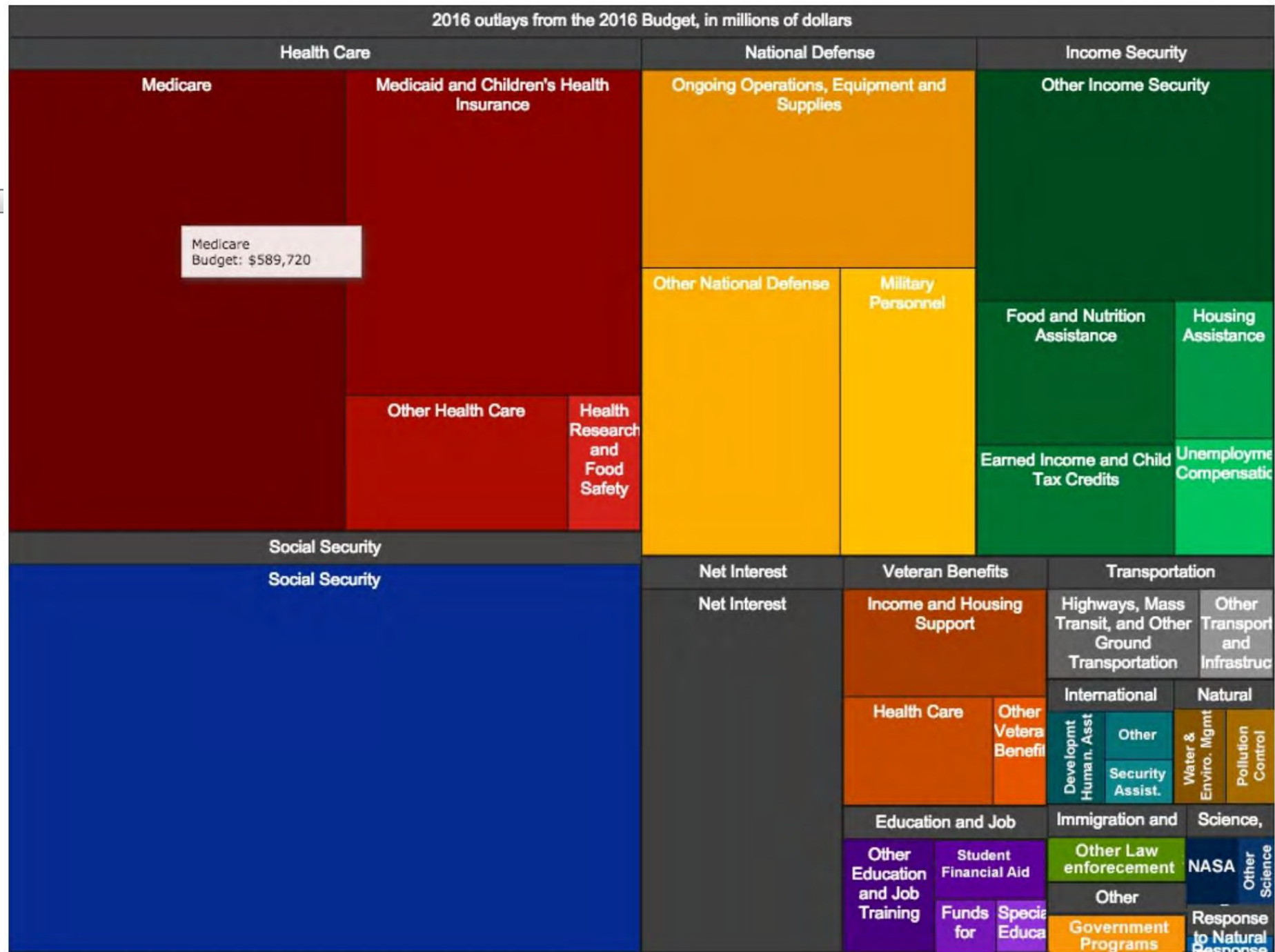
Causes Of Death In The Crimean War

It shows that far more soldiers died from preventable epidemic diseases (blue) than from wounds inflicted on the battlefield (red) or other causes (black).

Major Causes of Death;
Typhus, Typhoid, Cholera,
and Dysentery



Interactive Government Budget



LANGUAGES IN THE WORLD

2.678 living languages in the world placed in their birthplace

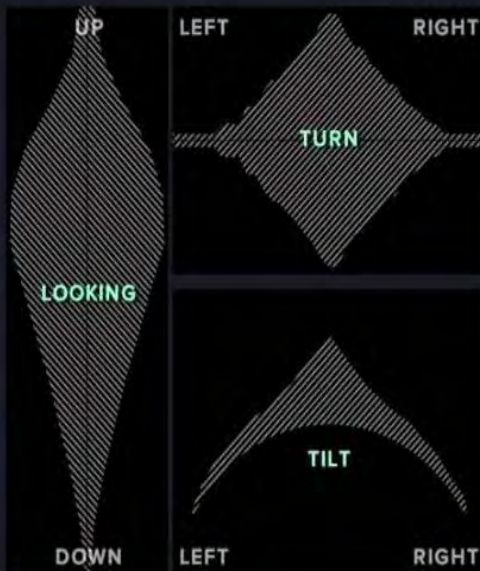


After Babylon

DEMOGRAPHICS



POSE



FEATURES



MOOD



Selfiecity

3200 of 3200 selfies.

[Normal](#) [Crop](#) [Crop & rotate](#)



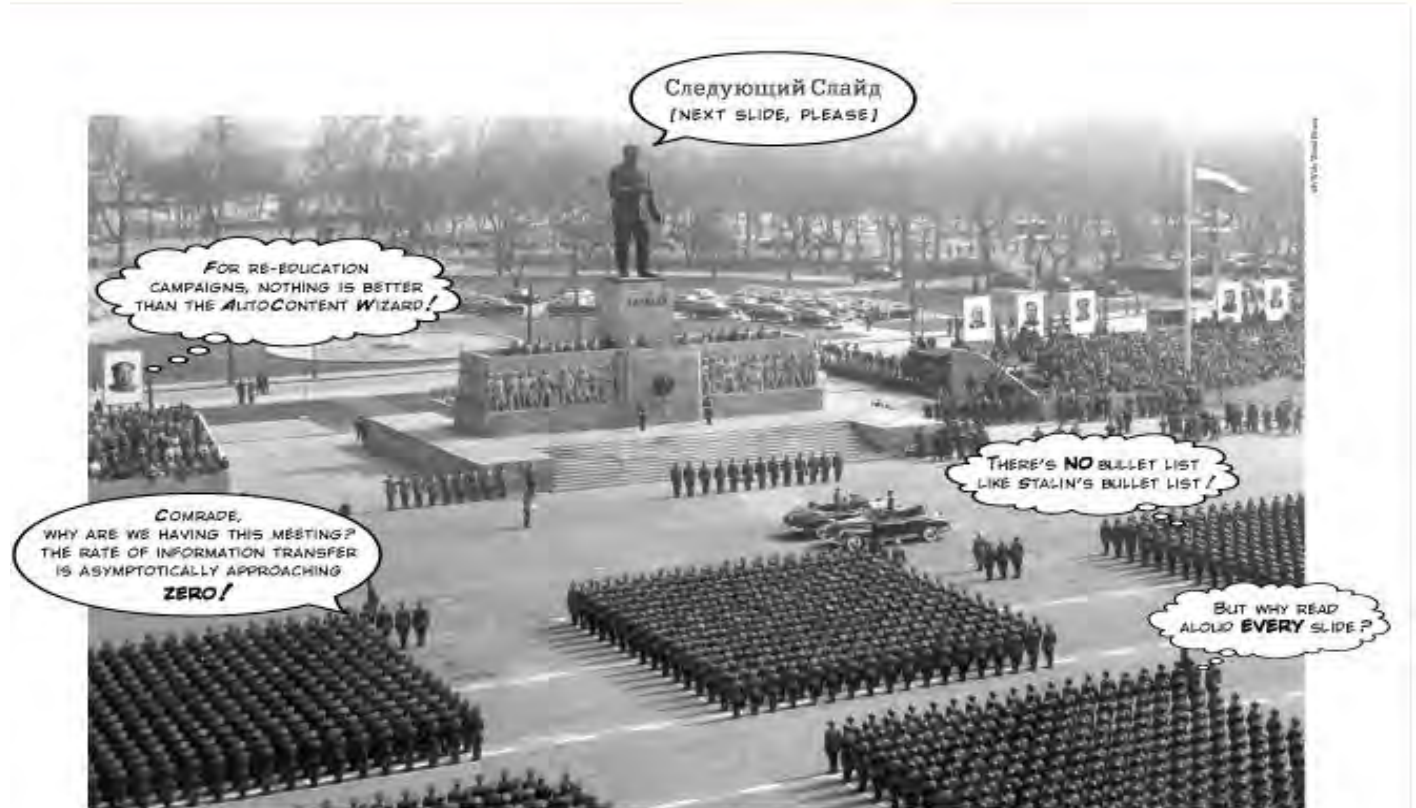
Principle of Proportional Ink

"The representation of numbers, as physically measured on the surface of the graphic itself, should be directly proportional to the numerical quantities represented." – Edward Tufte

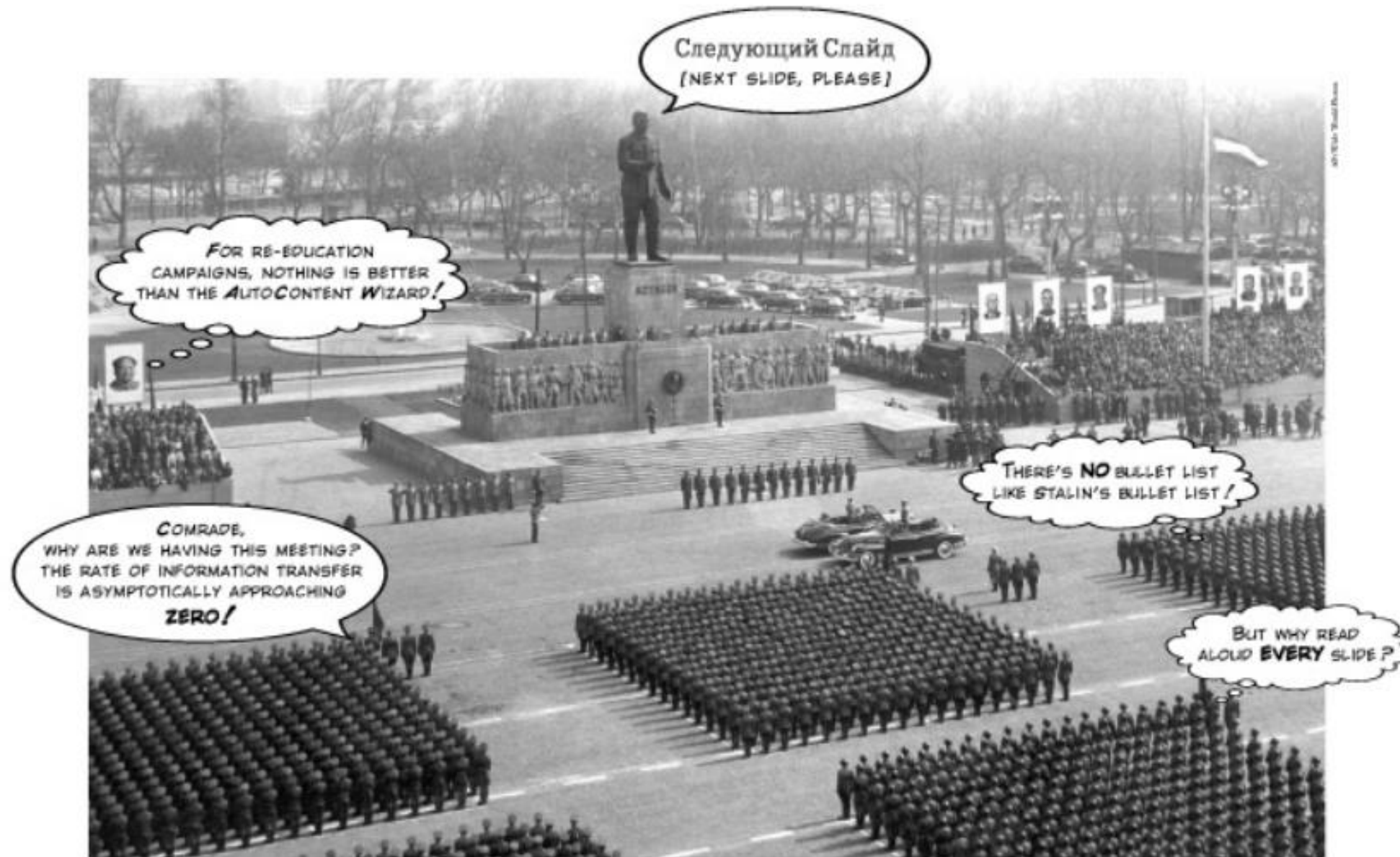


Edward Tufte

American statistician



Edward Tufte, *The Cognitive Style of PowerPoint*



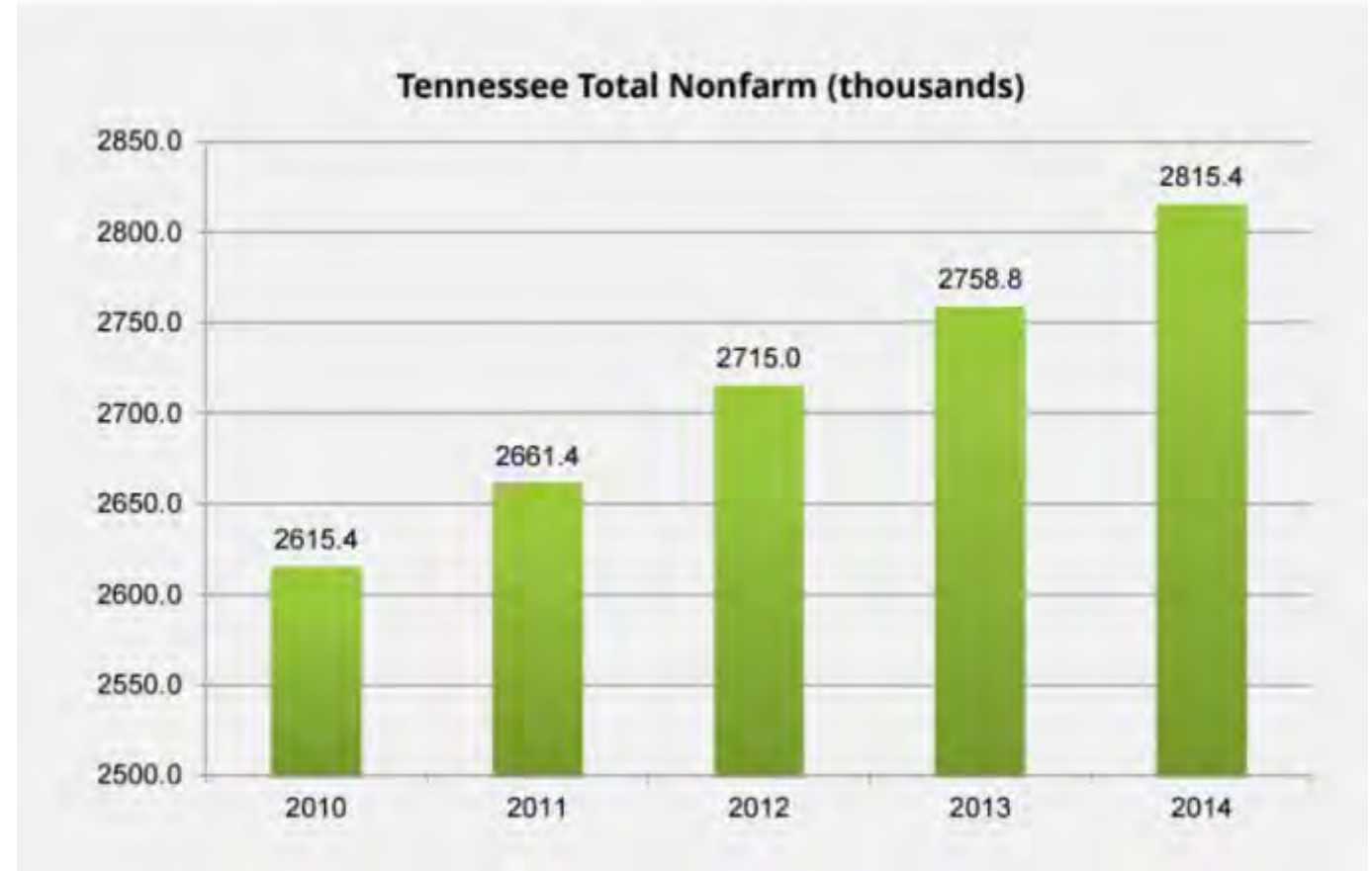
Edward Tufte, *The Cognitive Style of PowerPoint*

Principle of Proportional Ink

The principle of proportional ink is violated by bar charts with axes that fail to reach zero.

In this chart the value for 2014 is approximately 1.08 times the value for 2010, but because the vertical axis has been truncated, **the bar for 2014 uses approximately 2.7 times as much ink as the bar for 2010.**

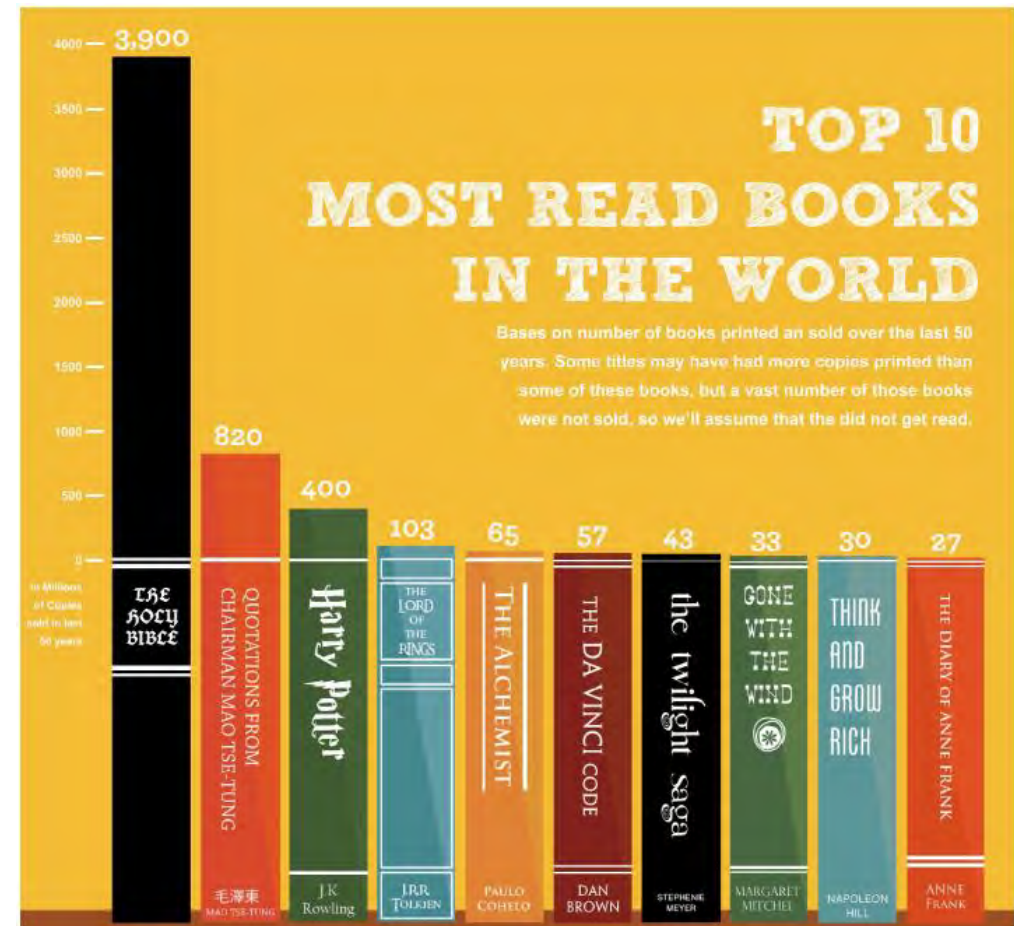
This is not proportional ink!



Principle of Proportional Ink

The visual problem with this graph is that the portion of each bar used to display the title of each book is situated entirely below zero!

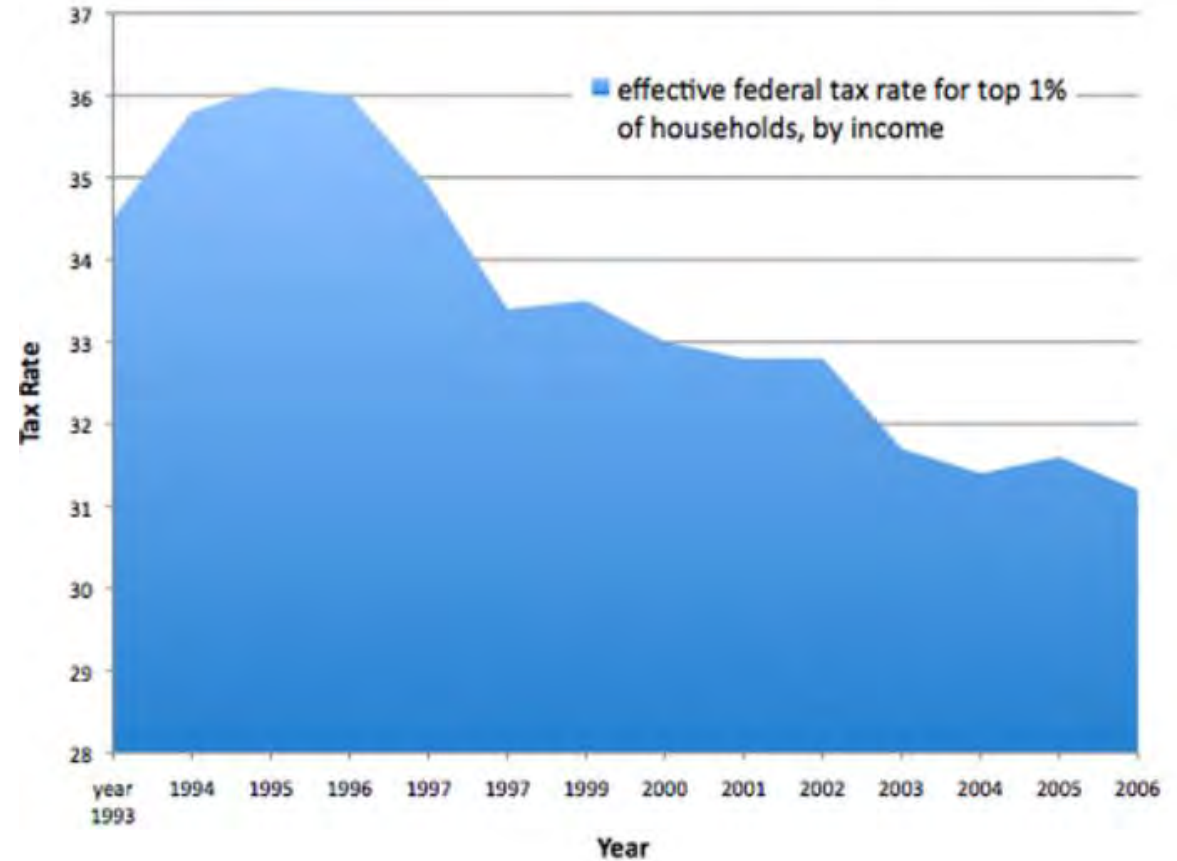
As a result, the bars for *The Diary of Anne Frank* and for *The Da Vinci Code* differ in height by only a fraction of a percent, despite the fact that the latter has sold more than twice as many copies as the former.



Principle of Proportional Ink

Line graphs need not include zero on the dependent variable axis. Why not? The answer is that line charts don't use shaded volumes to indicate quantities; rather, they use positions that indicate quantities.

The principle of proportional ink therefore does not apply, because the amount of ink is not used to indicate the magnitude of a variable.



Principle of Proportional Ink

The power of the bubble chart is that by using color and size as well as vertical and horizontal position, one can simultaneously encode four different attributes for each item in the dataset.

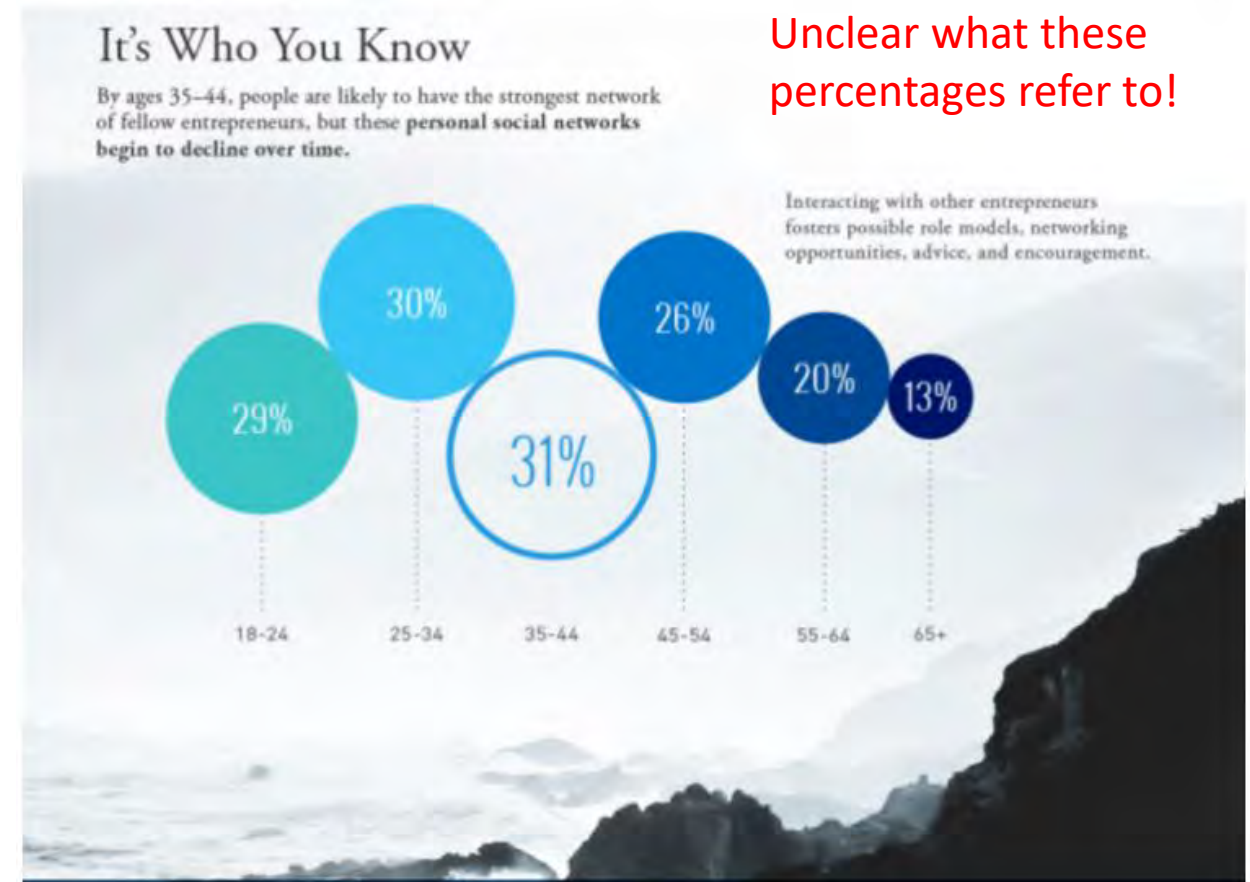
Unfortunately, psychophysical studies reveal that most people underestimate the difference in area of two disks.



Principle of Proportional Ink

Some bubble charts that go far beyond what any psychophysical study would justify, making the radius of the disk proportional to the value that disk represents.

In this bubble chart, the disk representing people aged 45-54 years olds has a value of 26%, whereas the disk representing those aged 65+ has a value of one-half of that, 13%. According to the principle of proportional ink, the 65+ disk should have one half the area of the 45-54 disk.

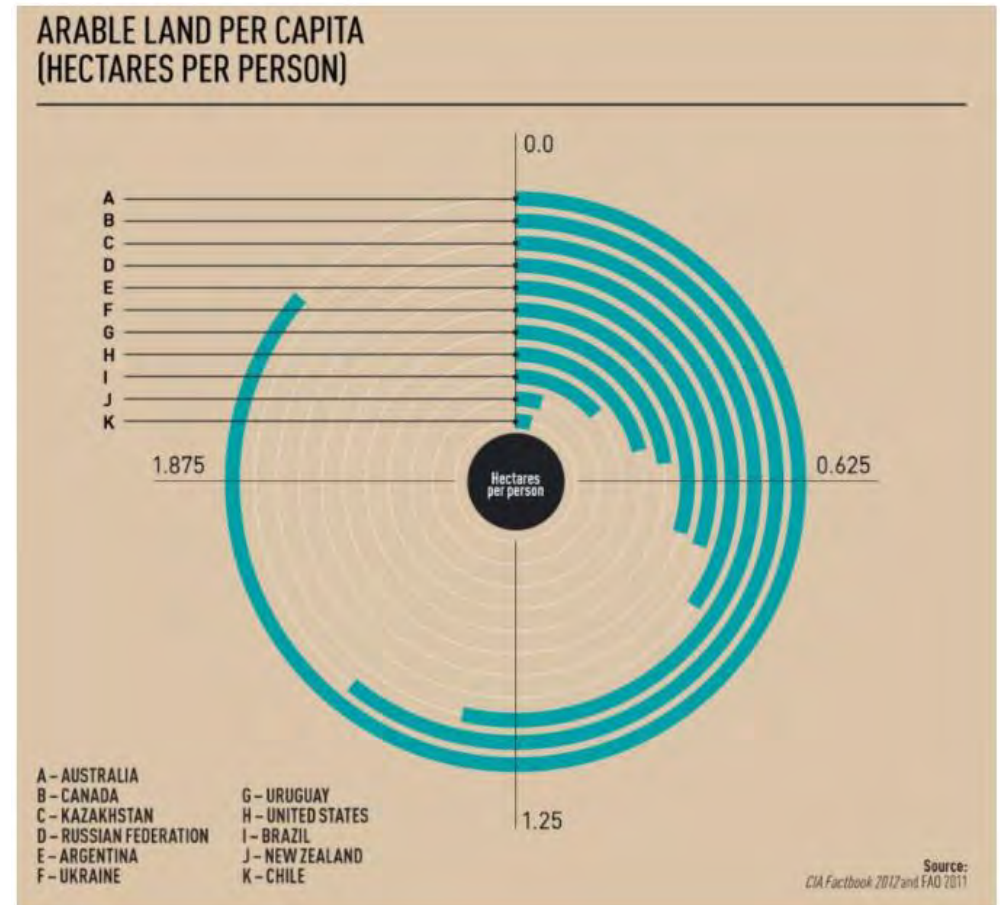


Unclear what these percentages refer to!

Principle of Proportional Ink

This is a striking illustration of how a graph can exaggerate differences by violating the principle of proportional ink.

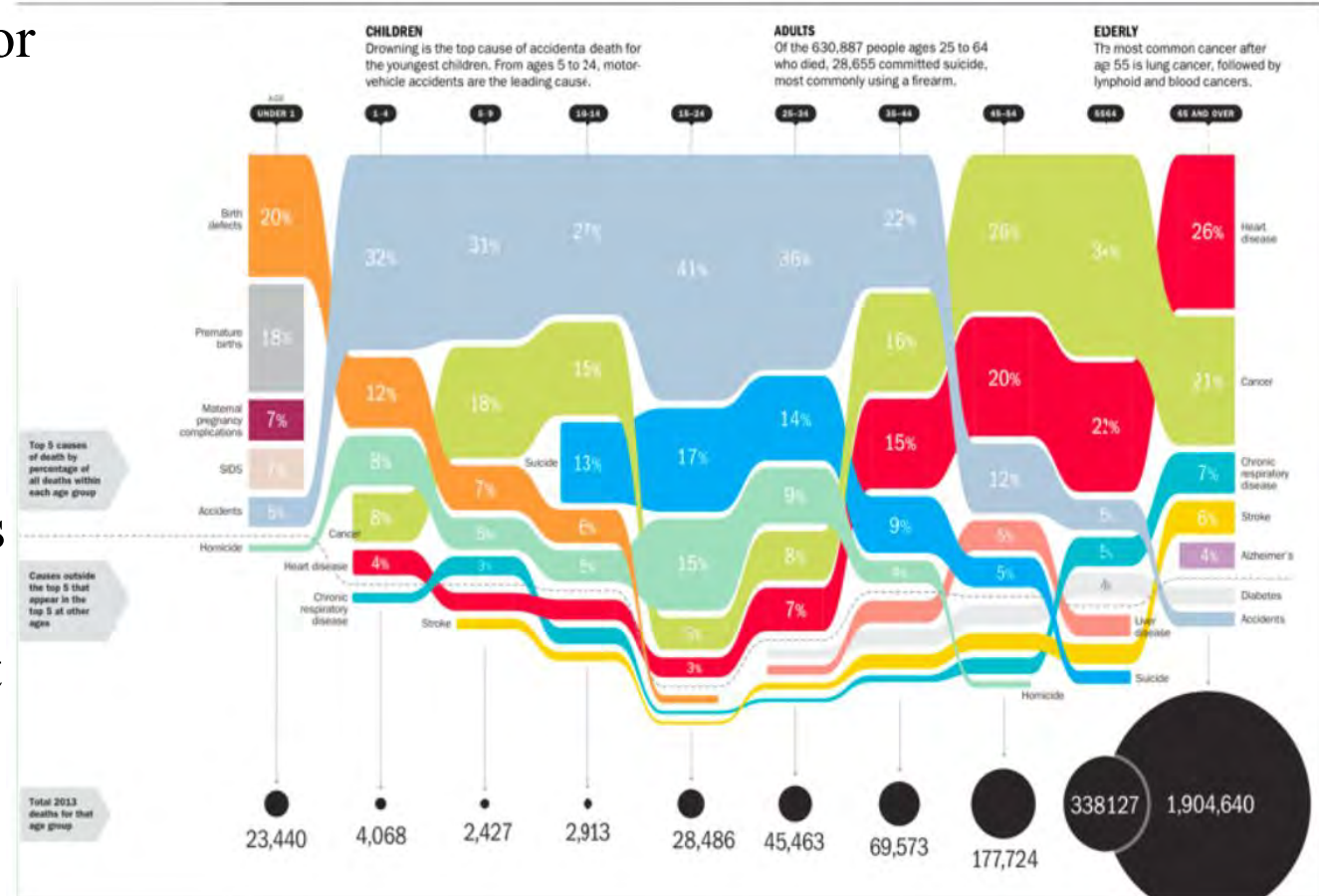
The problem with this type of visualization is that the geometry of the circle assigns a disproportionate amount of ink to bars further on the outside.



Principle of Proportional Ink

The problem is the massive blue-gray region for ages 1-4 in comparison to the tiny sliver for ages 65-and-older, implies accidents pose a far more grave risk to toddlers than to the elderly. Not so!

The chance of dying due to accident is much higher for the elderly than for toddlers, but this source of mortality is swamped by the even more exaggerated chance of dying due to heart disease, cancer, and other maladies that only very rarely affect children.



Principle of Proportional Ink

- Should not be used to represent data with only one independent variable.
- The end-caps extend the effective visual length of each bar.
- The angle at which the graph is arrayed can make it difficult to assess the lengths of the bars.
- When the bars are stacked atop or in front of one another, as in the image above, the sides of some bars are fully visible and the sides of others are partially obscured.

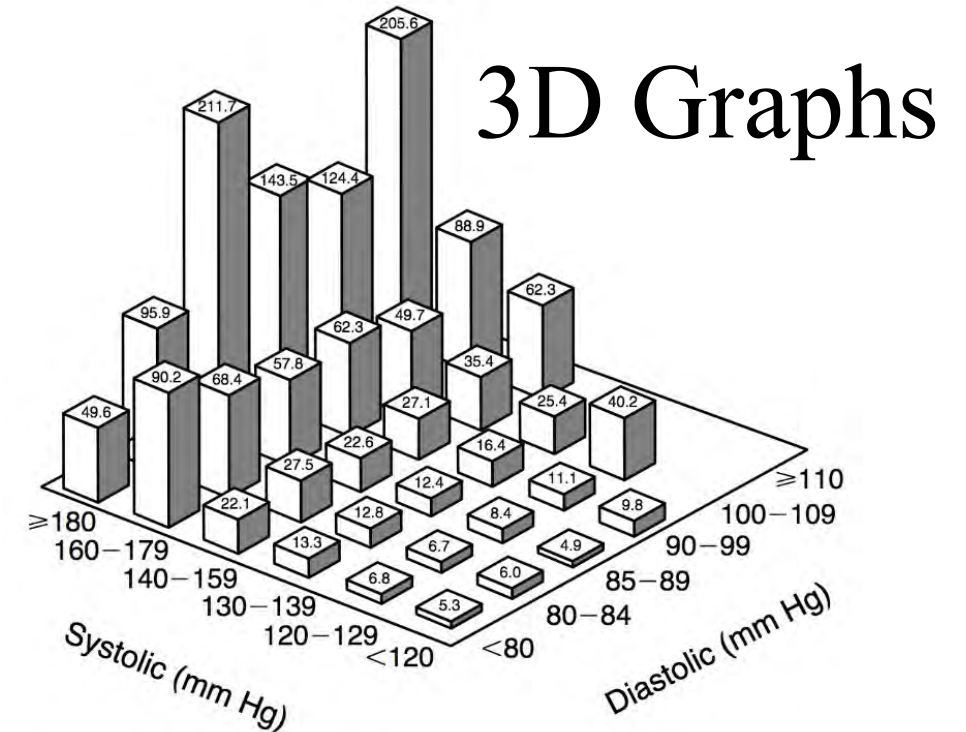
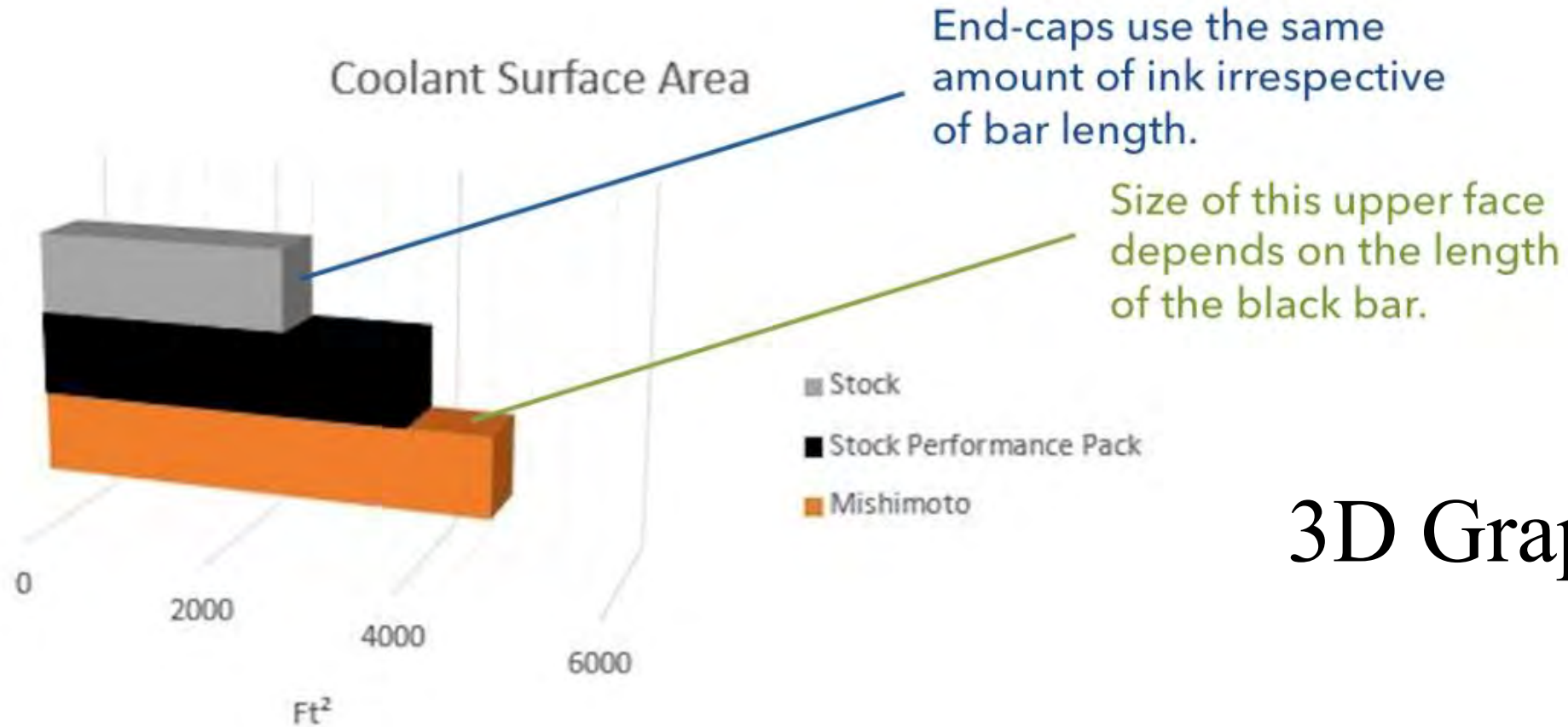


Figure 2. Age-Adjusted Rate of End-Stage Renal Disease Due to Any Cause per 100,000 Person-Years, According to Systolic and Diastolic Blood Pressure in 332,544 Men Screened for MRFIT.

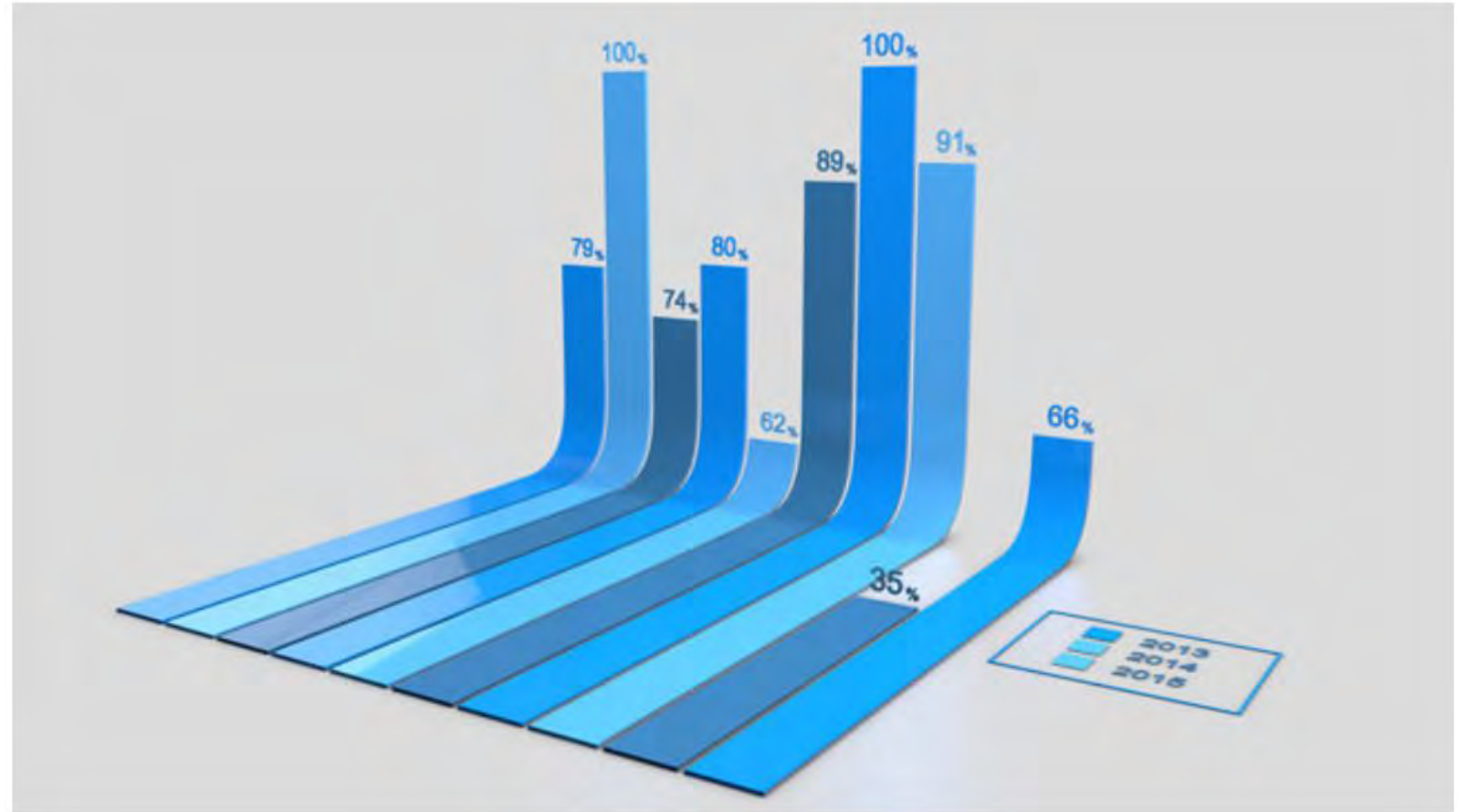
Principle of Proportional Ink



3D Graphs

Principle of Proportional Ink

3D Graphs

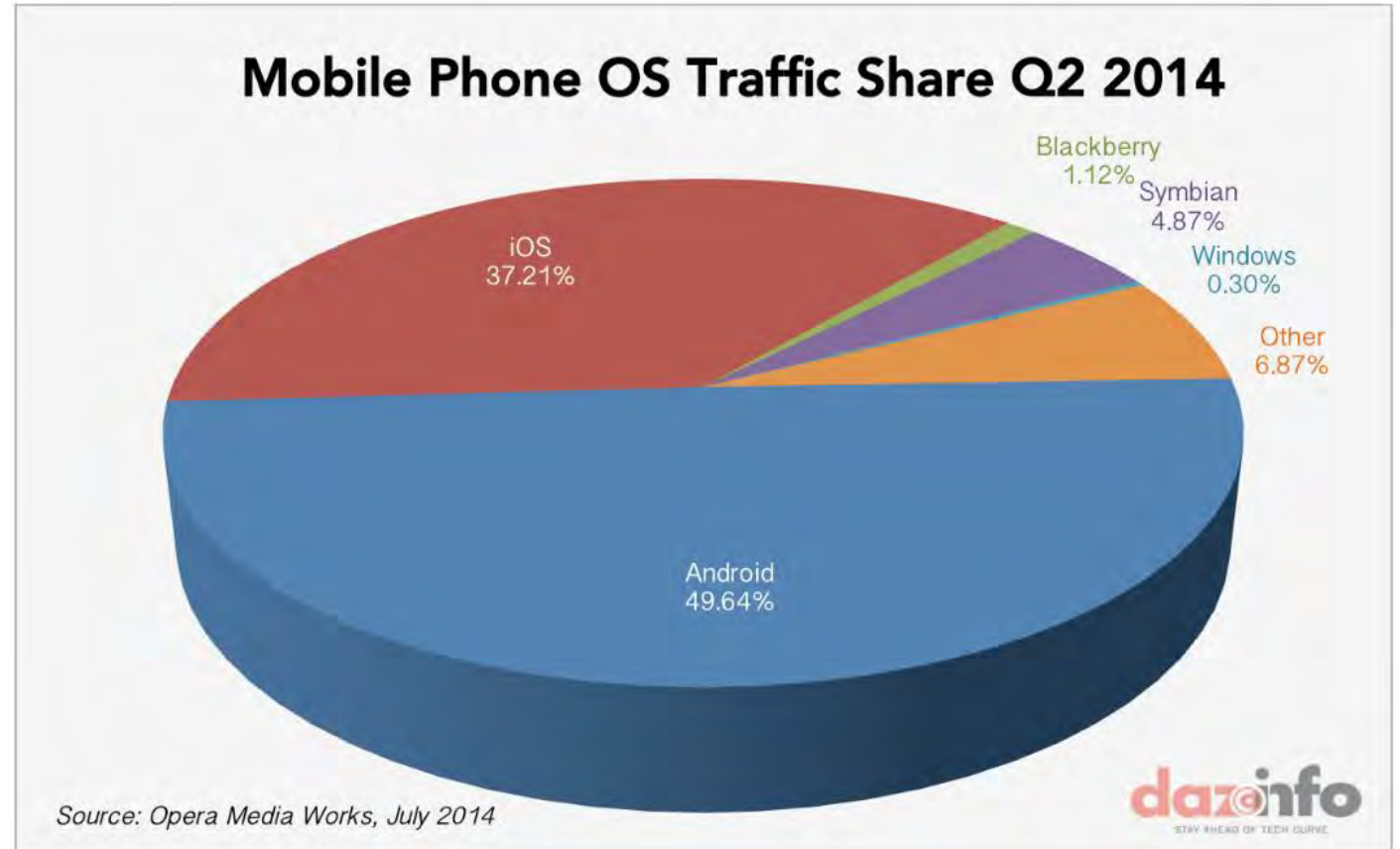


Gestalt Psychology & Displaying Quantitative Information

Principle of Proportional Ink

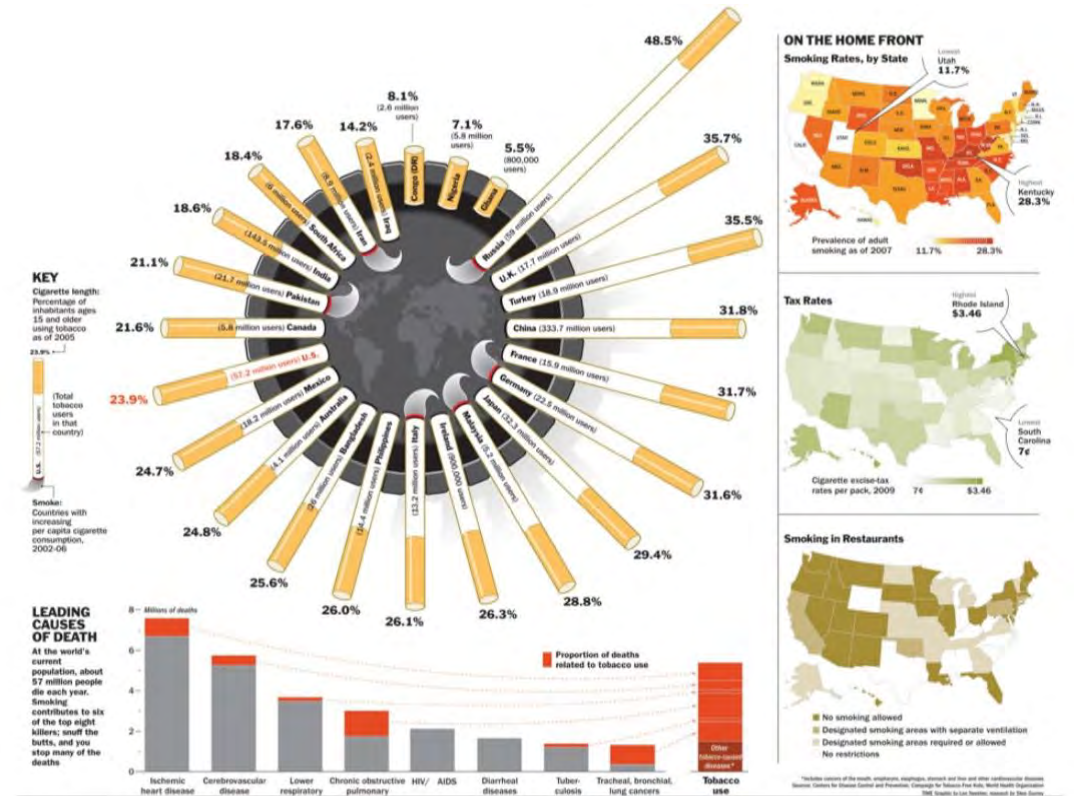
3D Pie Charts

- The front edge can be seen but not the back edge.
- The perspective makes the front wedge look bigger than the other wedges.



Why the W.O.A.T?

- Difficult to track mathematically
- Spiraling od cigarettes is misleading of geographical impact of smoking
- Cigarette butts appear to violate principle of proportional ink wrt smokers. There is no scale to compare.
- There is no differentiation in the size and coloring of the flames to represent increasing per capita smoking rates.



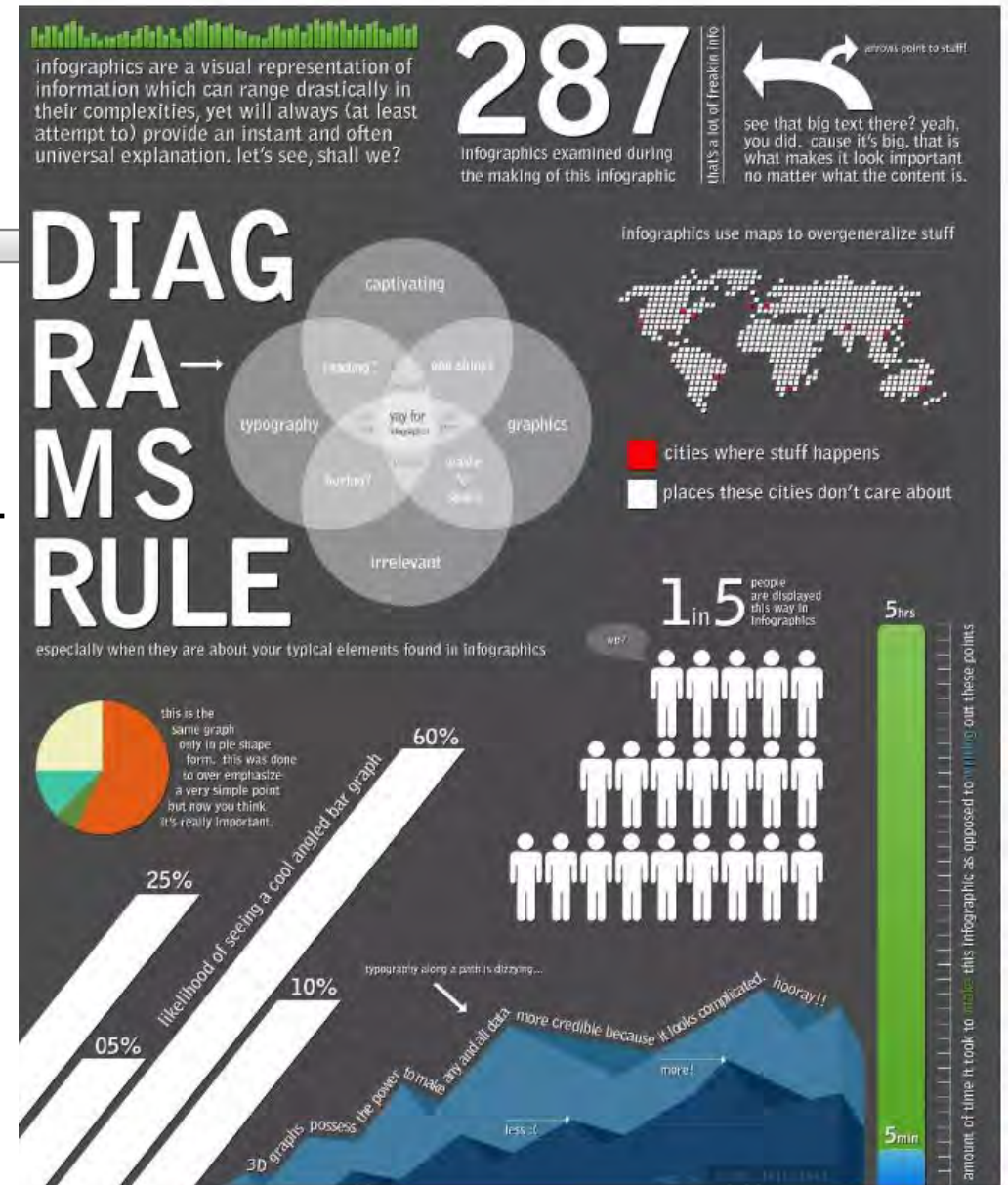
Infographics

A misleading visualization can render good data totally irrelevant.
- Jevin West

Best Practices

1. Use Reputable & Current Data Sources
2. Properly Cite Your Sources
3. Proofread Extensively
4. Use Color Sparingly
5. Don't Overcrowd the Graphic
6. Use Arrows & Lines to Direct Viewers
7. Be Creative – Think New & Unconventional
8. Use Narrative Storytelling to Boost Interest

Gestalt Psychology & Displaying Quantitative Information



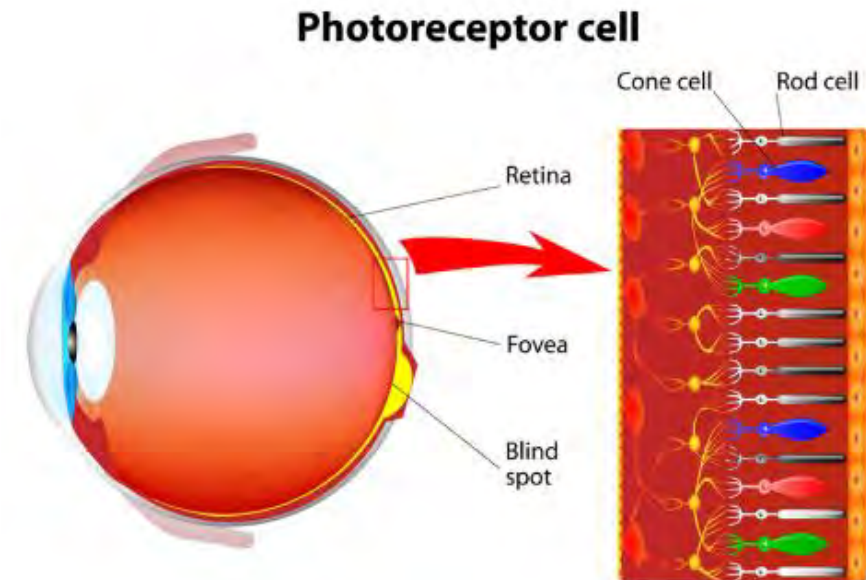
Our Color Vision is Limited – *Jeff Johnson*

Two Types of Light Receptor Cells:

1. Rods detect light levels but not colors,
2. Cones detect color. There are three types:
 1. Sensitive to Red Light
 2. Sensitive to Green Light
 3. Sensitive to Blue Light

This suggests our color vision is similar to video cameras and computer displays, which detect or project a wide variety of colors through combinations of red, green, and blue pixels.

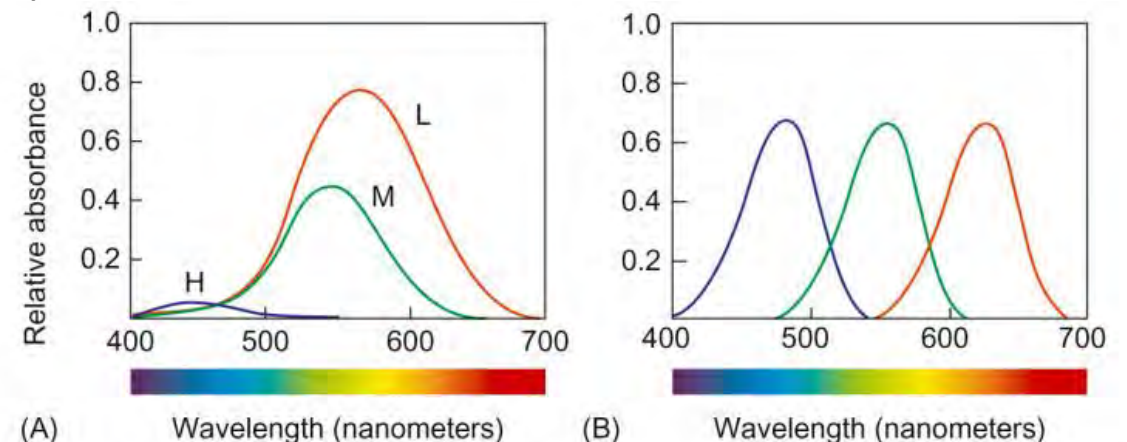
Gestalt Psychology & Displaying Quantitative Information



Our Color Vision is Limited – *Jeff Johnson*

The Truth About Rods & Cones

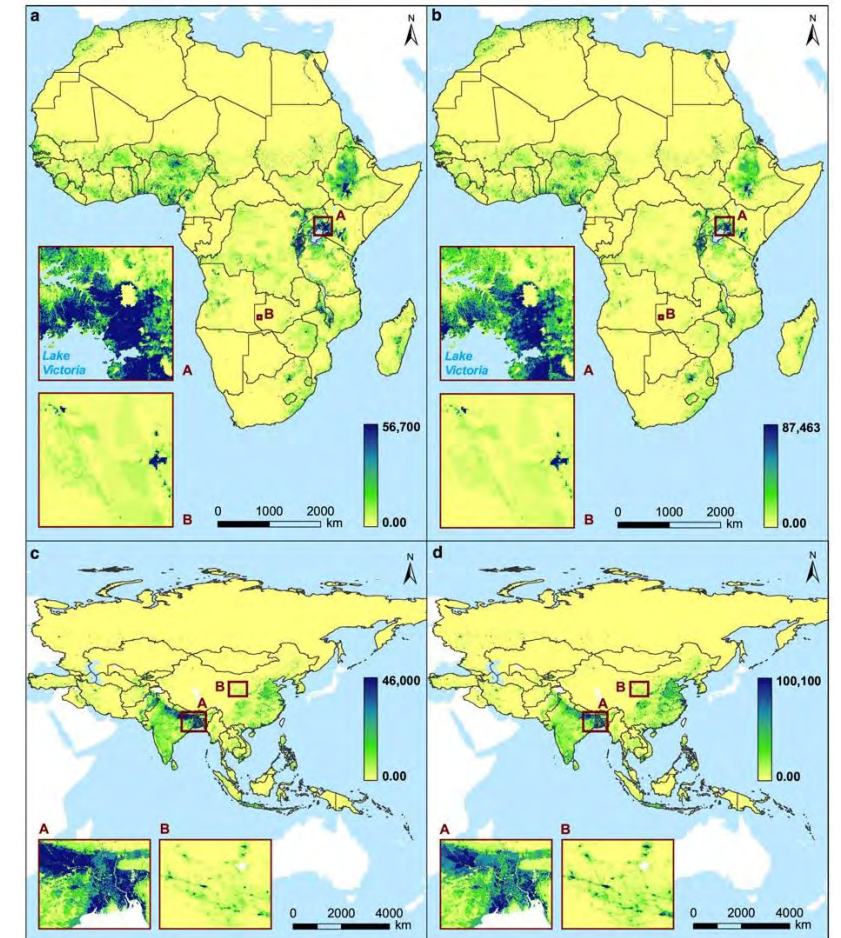
1. Those of us who live in industrialized societies hardly use our rods at all.
2. Rods function only at low levels of light.
3. Rods are for getting around in poorly lighted environments.
4. Most of the time, our vision is based entirely on which come in three frequencies:
 1. Low Frequency (Red)
 2. Medium Frequency (Green)
 3. High Frequency (Blue)



Sensitivity of the three types of retinal cones (A) versus artificial red, green, blue receptors (B).

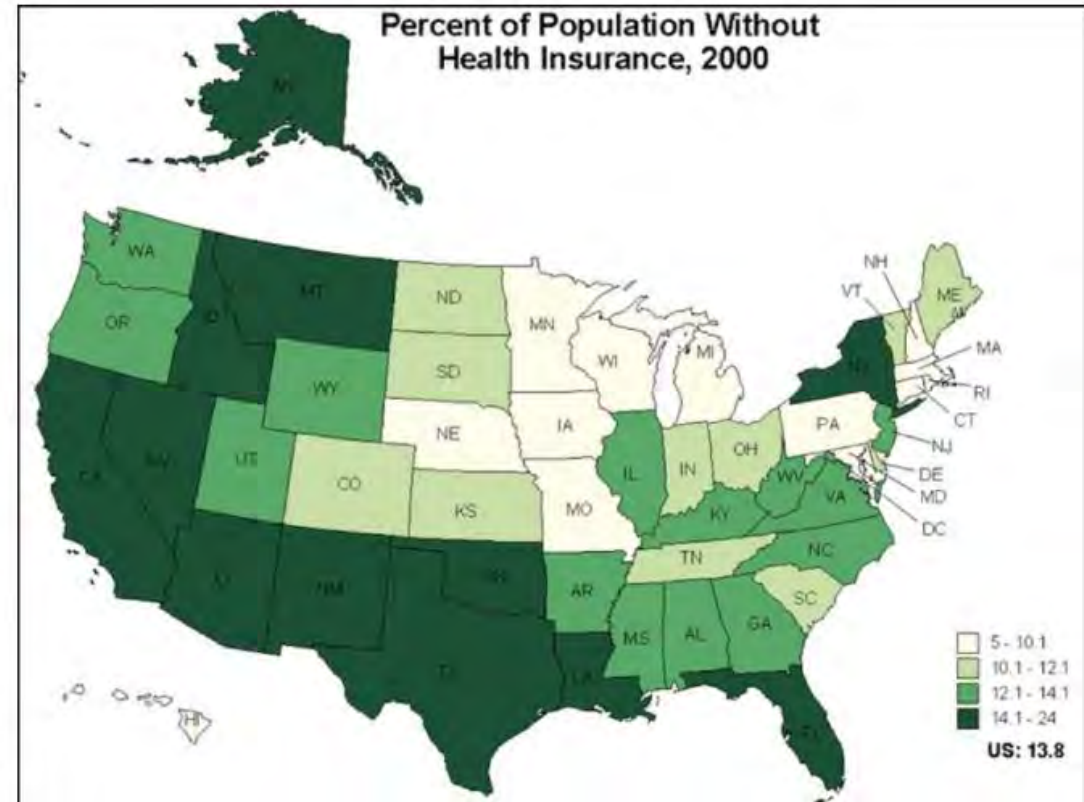
Our Color Vision is Limited – *Jeff Johnson*

- 1. Distinguish colors by saturation and brightness, as well as hue.** Avoid subtle color differences. Make sure contrast between colors is high.
- 2. Use distinctive colors.** Our visual system combines the signals from retinal cone cells to produce three color-opponent channels: red-green, yellow-blue, and black-white (luminance).
- 3. Avoid color pairs that color-blind people cannot distinguish.** Such pairs include dark red/black, dark red/dark green, blue/purple, light green/white.



Our Color Vision is Limited – *Jeff Johnson*

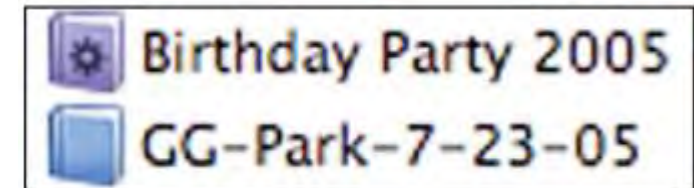
- Use the same color family
- Make sure color shades are distinct enough so the eye can easily see the differences.
- Make sure to add a color legend.



MinneapolisFed.org: Graph uses color differences visible to all sighted people, on any display.

Our Color Vision is Limited – *Jeff Johnson*

- 4. Use color redundantly with other cues.** Don't rely on color alone. If you use color to mark something, mark it another way as well. Apple's iPhoto uses both color and a symbol to distinguish “smart” photo albums from regular albums.
- 5. Separate strong opponent colors.** Placing opponent colors right next to or on top of each other causes a disturbing shimmering sensation, and so should be avoided.\



Reading is Unnatural

- Poor information design can disrupt reading & burden working memory, decreasing speed and comprehension.
- Difficult scripts and typefaces can disrupt reading and comprehension.
- Text on noisy background: Visual noise in and around text can disrupt recognition of features, characters, and words and therefore drop reading out of automatic feature-based mode into a more conscious and context-based mode



Centering Too Much Text

- Our eyes are trained to go back to the same horizontal position and down one line.
- Centering drops us out of automatic mode and slows us down greatly.
- Use sparingly in formal presentation. Informal use can be fun!



Exclusive Buyer Agency Offer
(No Cost) Service to Home Buyers!
Dan and Lida want to work for you *iff*!

Would you like to avoid sellers agents who are pushing, selling, and trying to make sales quotas?
Do you want your agent to **be on your side** and **not** the sellers side?
Do you expect your agent to be responsible **and professional**...?
If you don't like to have **your time wasted**, Dan and Lida want to work for you...
*If you understand that everything we say and do, is to save you time, money, and keep you out of trouble...
-and if you understand that some agents income and allegiances are in direct competition with your best interests...
-and if you understand that we take risks, give you 24/7 access, and put aside other paying business for you...
-and if you understand that we have a vested interest in helping you learn to make all the right choices...*

- then, call us now, because Dan and Lida want to work for you!!

FargoHomes.com centers text, thwarting automatic eye movement patterns.

Don't disrupt reading. Support it!

- Use restricted, highly consistent vocabularies – sometimes referred to in the industry as *plain language* or *simplified language*.
- Format text to create a visual hierarchy to facilitate easy scanning: use headings, bulleted lists, tables, and visually emphasized words.
- Ideally, minimize the need for reading, but structure it well.

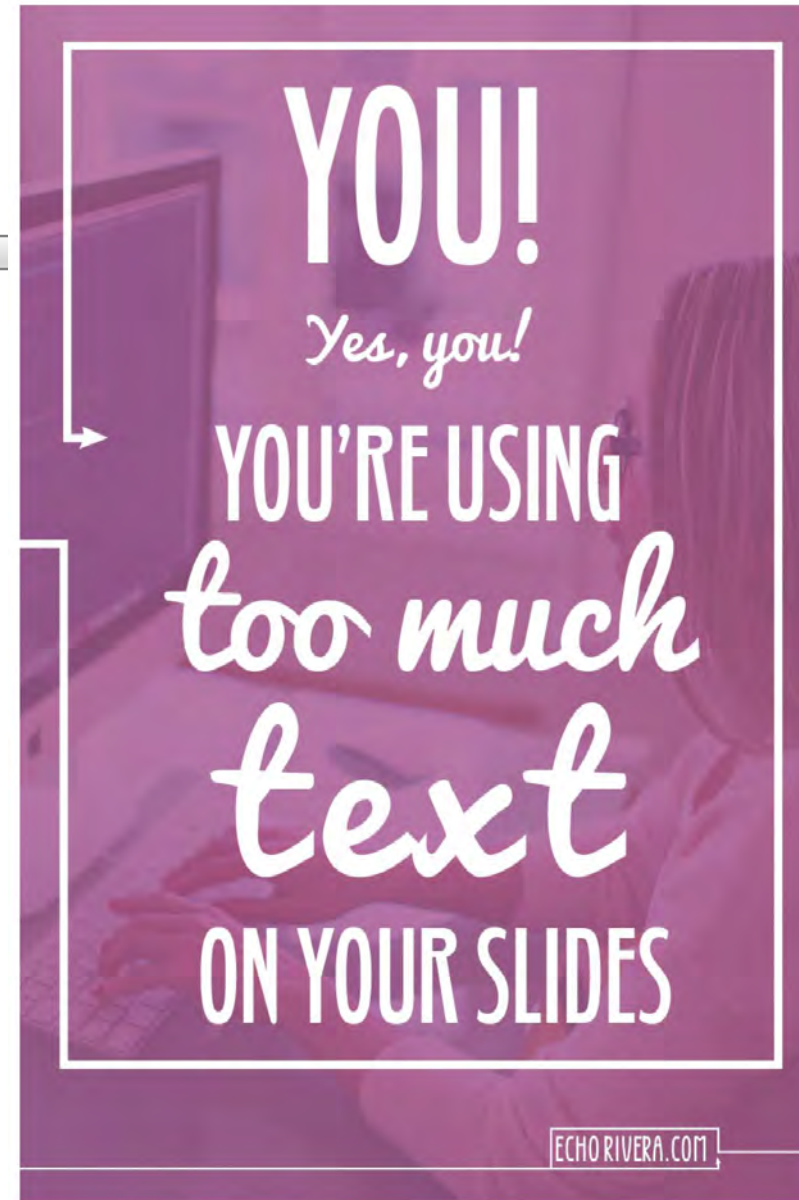


Microsoft Word's Help home page is easy to scan and read.

Just Too Much Text!

We have all been guilty of this at one time or another.

Just remember even smart people like simplicity!



SCORE 0 -- OMG Please End My Suffering


I often tell people that they should not treat their slides as their speaker notes. Most people think that might be an exaggeration. However, I RECENTLY watched a webinar where the presenter literally had all of their speaker notes on the slides.

EVERY SINGLE WORD they said was on the screen. In short paragraphs like this. We all had to read their whole presentation, word for word, chunks at a time!

There was also a lot of other things going on with their slides, like a template that took up a lot of space and visuals used in a less-than-effective way. I ended up minimizing the webinar and just listening because I couldn't stand it any longer.

Ineffective slide example / echorivera.com





Why Talk About Animal Welfare?

- Families without pets are more likely to have negative health outcomes including depression and anxiety
- Families without pets tend to have poorer outcomes over time
- Pets play a significant role in the long-term healthy outcomes of their owners
- Better health outcomes are reported by families with nice, calm, and friendly pets
- Anyone can be a good parent of their pets, even when they don't make a lot of money
- Interventions to improve how people parent their pets should focus on positive reinforcement, and consistent training
- Financial assistance and short wait times for veterinary care are related to better health outcomes
- Some vaccinations are required by law which are important for public health, but other vaccinations are not
- Some pet owners refuse to give the needed vaccinations and routine check ups.

Ineffective slide example / echorivera.com

Chinchillas are adorable animals

- ▶ Chinchillas are not well known in the United States, but they are really small, adorable, and friendly.
 - ▶ Did a survey with Coloradans
 - ▶ Worked with community agencies to find respondents and form a community advisory board - it was fun!
 - ▶ There was an episode of “Wildlife SOS,” a show about a wildlife rescue agency in the UK and the host was upset someone had a chinchilla a pet

Ineffective slide example / echorivera.com

Effective dog training involves:

- **Being patient**
- **Being consistent**
- **Using positive reinforcement**

How to get a SCORE 4 -- STELLAR SLIDES

Now I will take this last example and show you my transformation to move it from "OK, not bad!" to "STELLAR SLIDES."



Effective Dog Training



Patience

Consistency

+ reinforcement

slide example / echorivera.com

The Triune Brain Model (1950s)

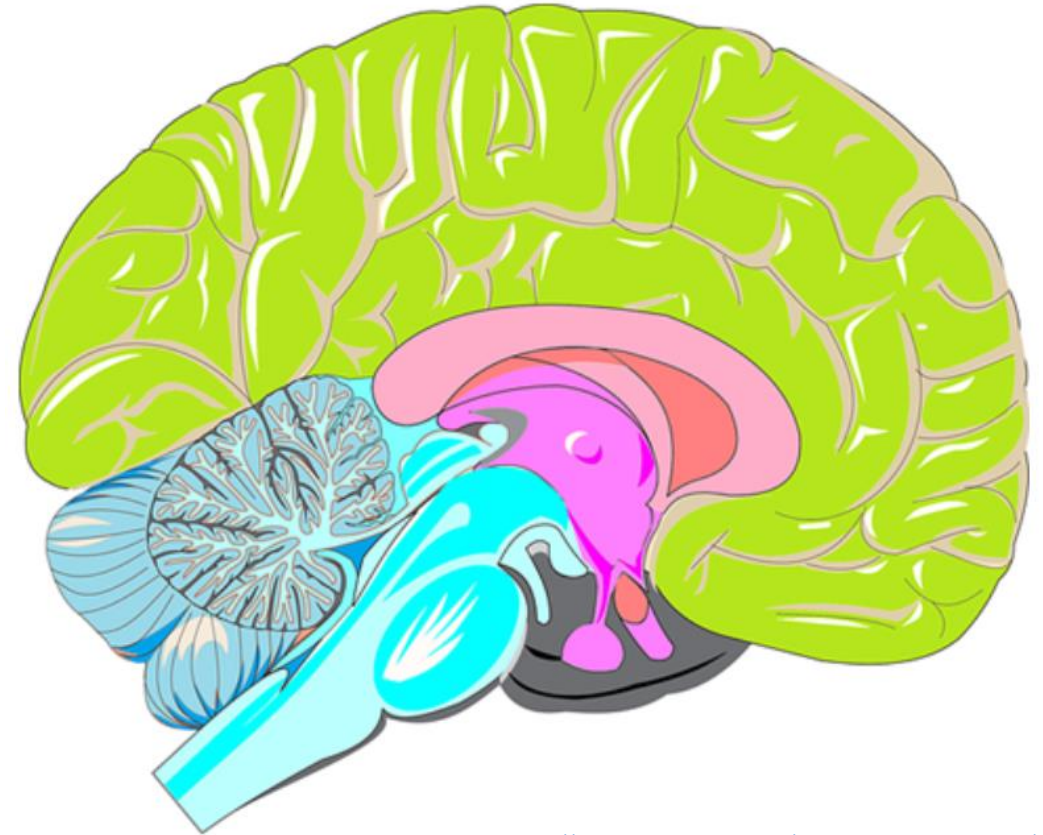


Dr. Paul D. MacLean came up with the idea of the triune brain as a way to explain the evolution of the human brain.

 **The R (Reptilian) Complex**

 **The Limbic System**

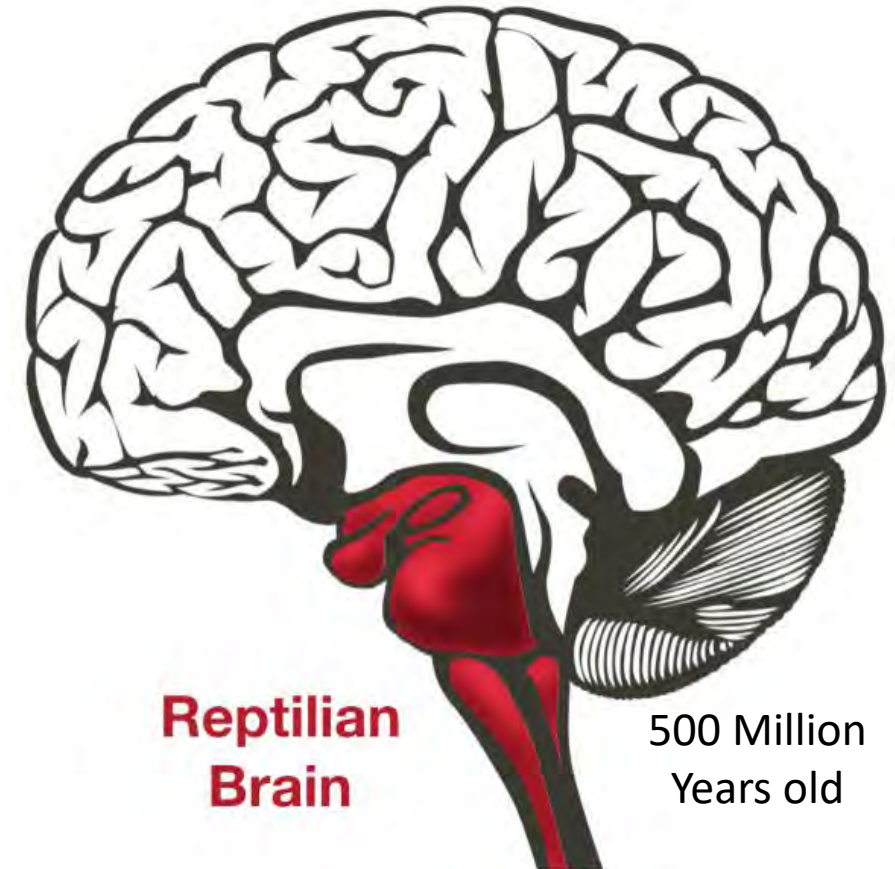
 **The Neocortex**



Source: <https://www.eruptingmind.com/beating-the-reptilian-brain/>

The Reptilian Brain

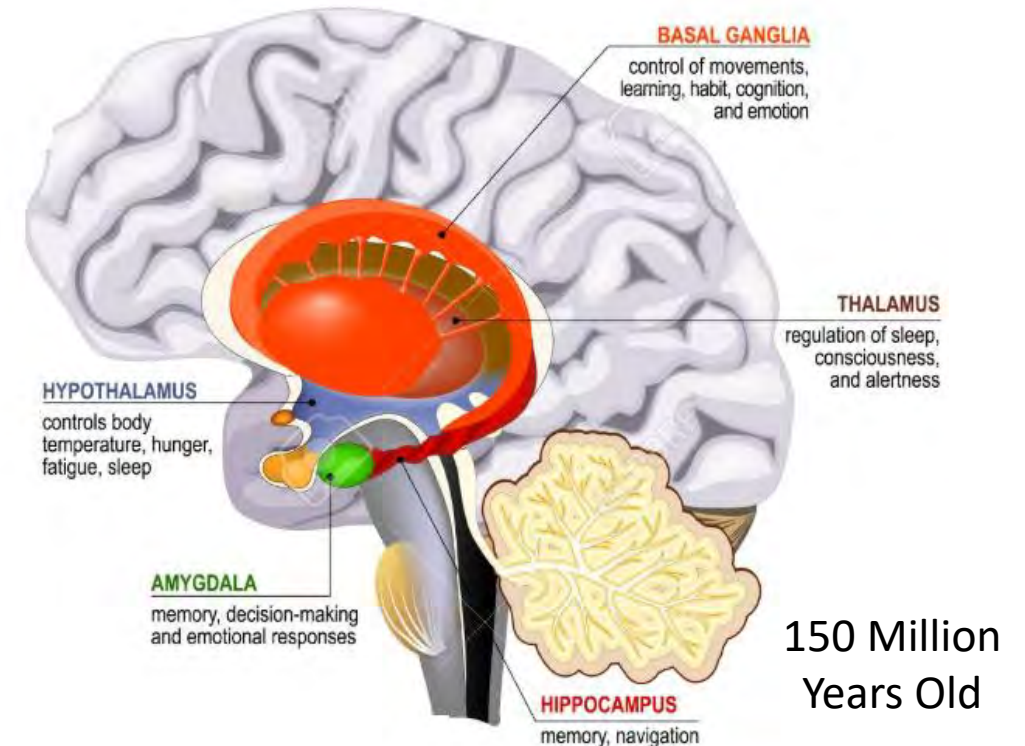
- The 1st and oldest part of the brain.
- Drives needs fundamental needs for: survival, mating, feeding, self-maintenance.
- Controls your autonomic bodily functions.
- Animalistic & primitive like that of reptiles.
- Part of your unconscious mind – System 1.



The Limbic System

- The Emotional Brain.
- Feelings driven by stimuli & creates chemical messages the connect information to memory.
- The stronger the emotional response, the stronger the memory.
- Responsible for motivating pleasure-seeking and pain-avoidance behavior. Learning from mistakes.

Limbic system



The Amygdala – The Godfather of Fear

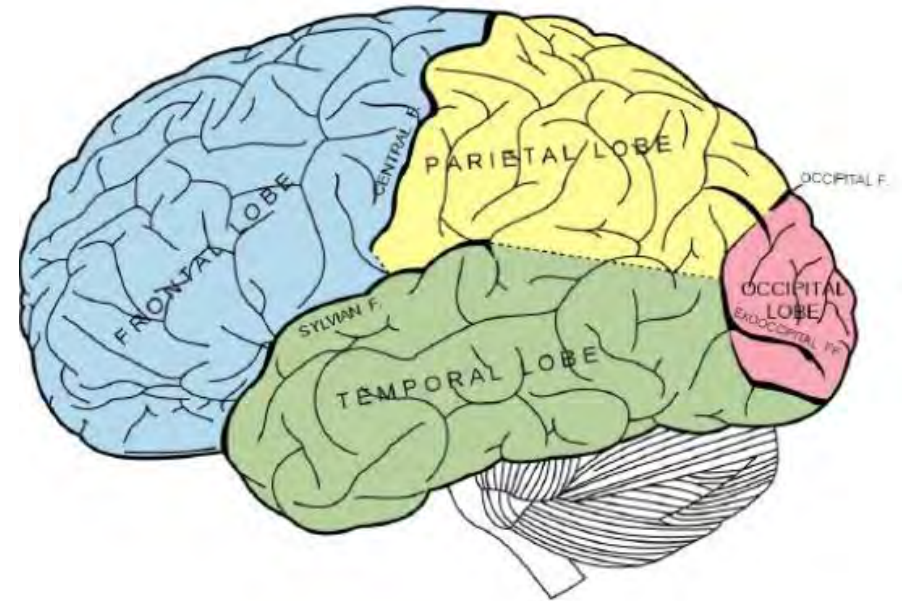
- Fear can cause the amygdala to send out urgent signals to every part of the brain, causing you to become more alert and ready to respond to any potential danger
- Automatic responses experiences during Fight or Flight take over
- There can be an issue with acting emotionally versus rationally and this can put us in peril too.



During times of fear your thinking brain can literally shut down and cause you to react in an entirely automatic and unconscious way.

The Neocortex

- The Thinking Brain.
- Controls higher level processes such as logic, reasoning, creativity, language and integration of sensory information.
- Can be overpowered by emotional brain. The amygdala exerts a lot of influence. If it is damaged, unpredictable behavior can result.
- Part of your conscious mind – System 2.

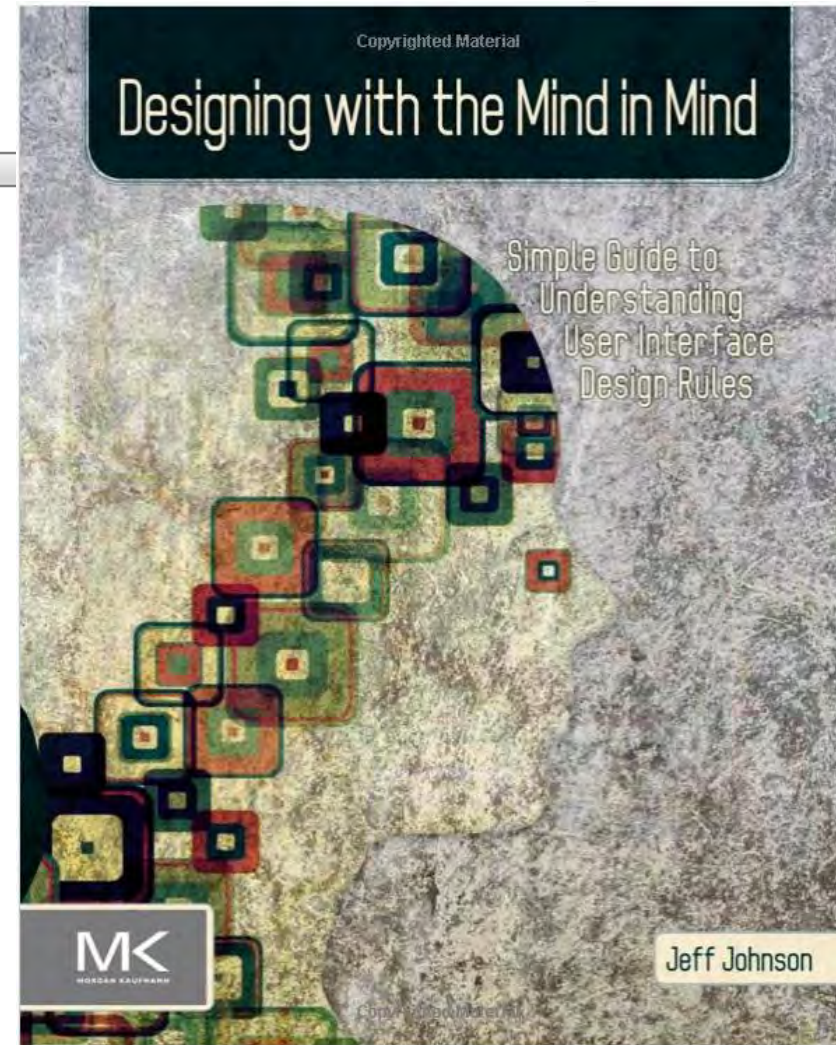


2 to 3 Million
Years Old

Summary

Designing with the
Mind in Mind
Simple Guide to Understanding
User Interface Design Rules

Jeff Johnson



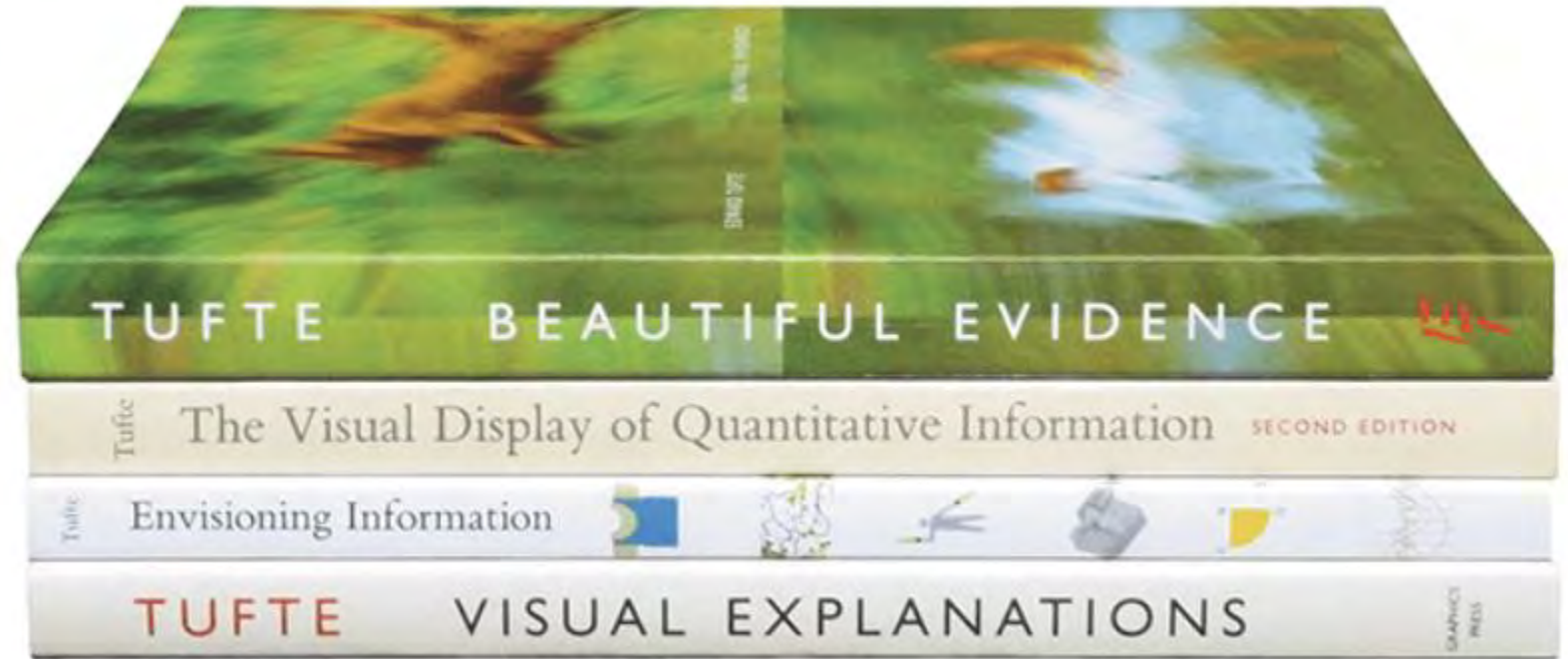
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The Godfather of Data Visualization



Edward Tufte

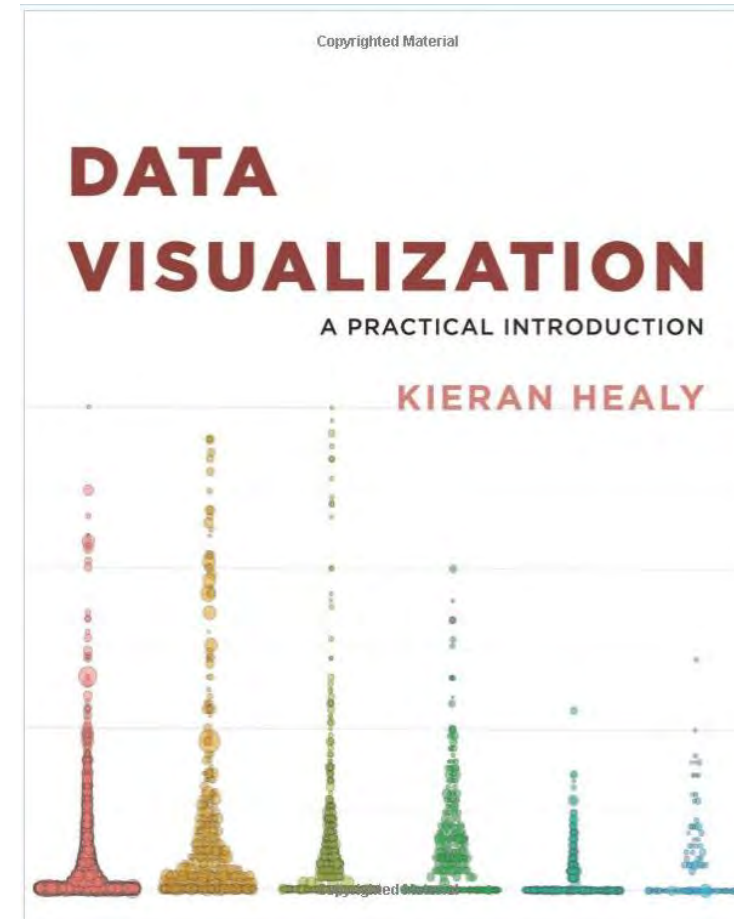
American statistician



Gestalt Psychology & Displaying Quantitative Information

Reference

- This book is a hands-on introduction to the principles and practice of looking at and presenting data using R and ggplot.
- It do not assume any prior knowledge of R.



Thank you for you interest!



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