



Introduction to Data Visualization & Visual Perception

Adapted for CNIT 5700 – Fall 2018

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@HighVizAbility



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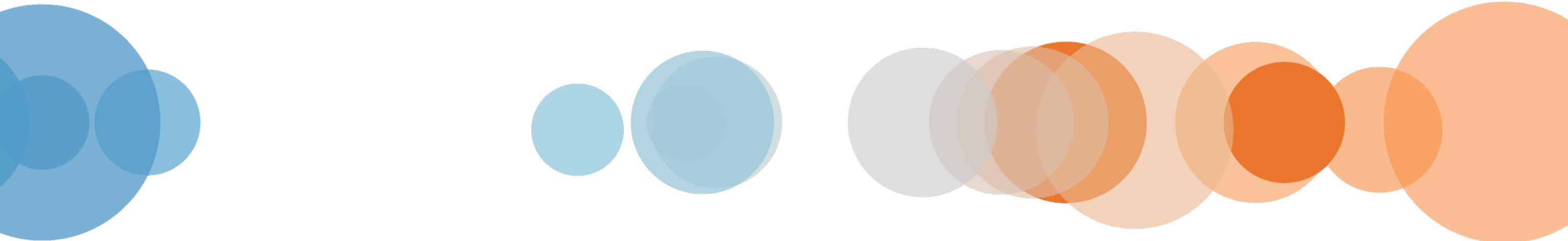
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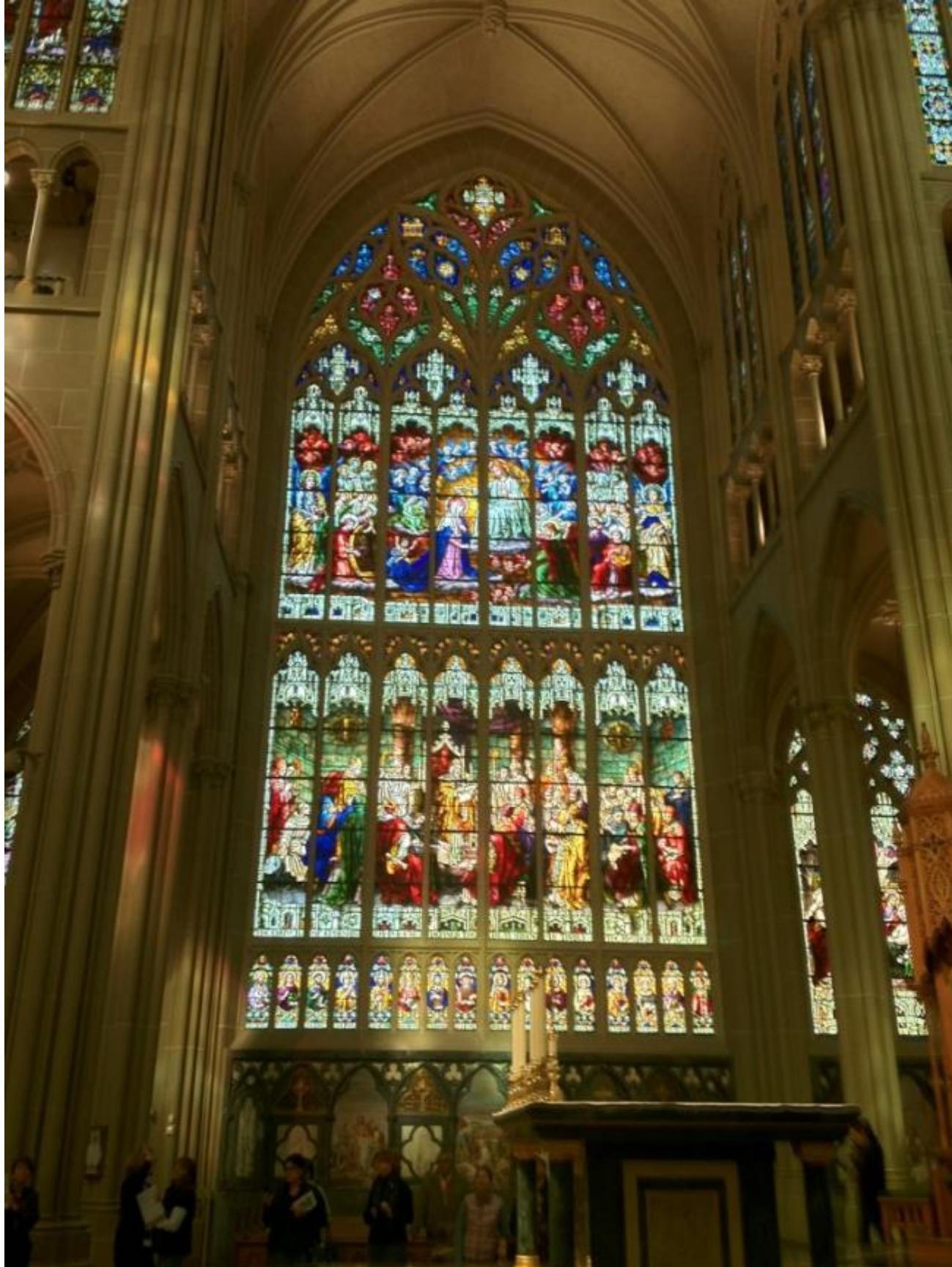
By completing the course modules, students will:

- Define data visualization and express its value as a tool for understanding our world
- Describe the fundamental aspects visual perception and these relate to data visualization
- Learn the history of data visualization, important people in the field, and contemporary practitioners
- Understand the preattentive attributes, the embedded meaning of color and size, and the two thinking systems that we use to process the world around us

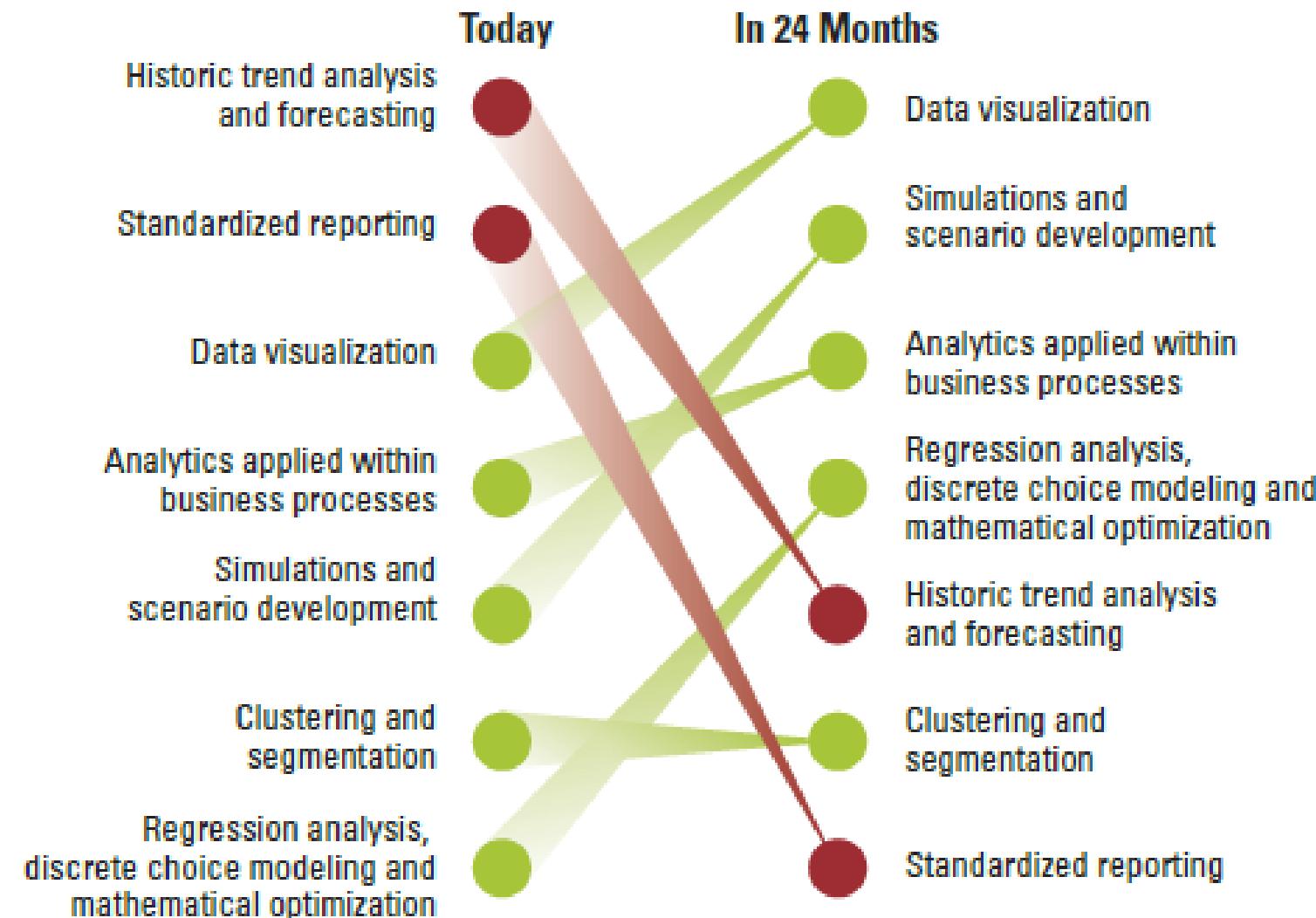
What is Data Visualization?

And Why is it Important?





Analytics: A New Path to Value – MIT 2010



Respondents were asked to identify the top three analytic techniques creating value for the organization, and predict which three would be creating the most value in 24 months.

Source: Big Data, Analytics and the Path From Insights to Value
MIT Sloan Management Review, December 2010

Visual analytics is a growing field...

“...2014 will be a critical year in which the task of making ‘hard types of analysis easy’ for an expanded set of users...will continue to dominate BI market requirements.”

– Gartner 2014 Magic Quadrant for Business Intelligence and Analytics Platforms

Visual analytics is a growing field...

- Data visualization classes now taught at universities
 - Has become part of Business Analytics, Statistics, Information Systems, Business Administration and Econometrics.
- Companies adding visual analyst positions
 - Visually trained business analysts with a data orientation
 - Growing ranks of data “storytellers” and “data visualization” positions

Current Data Visualization Jobs (July 2017)

Data Visualization Designer/Storyteller at Facebook

Data Visualization Expert as a Leading Hedge Fund

Data Visualization Manager at Deloitte

Source: Indeed.com

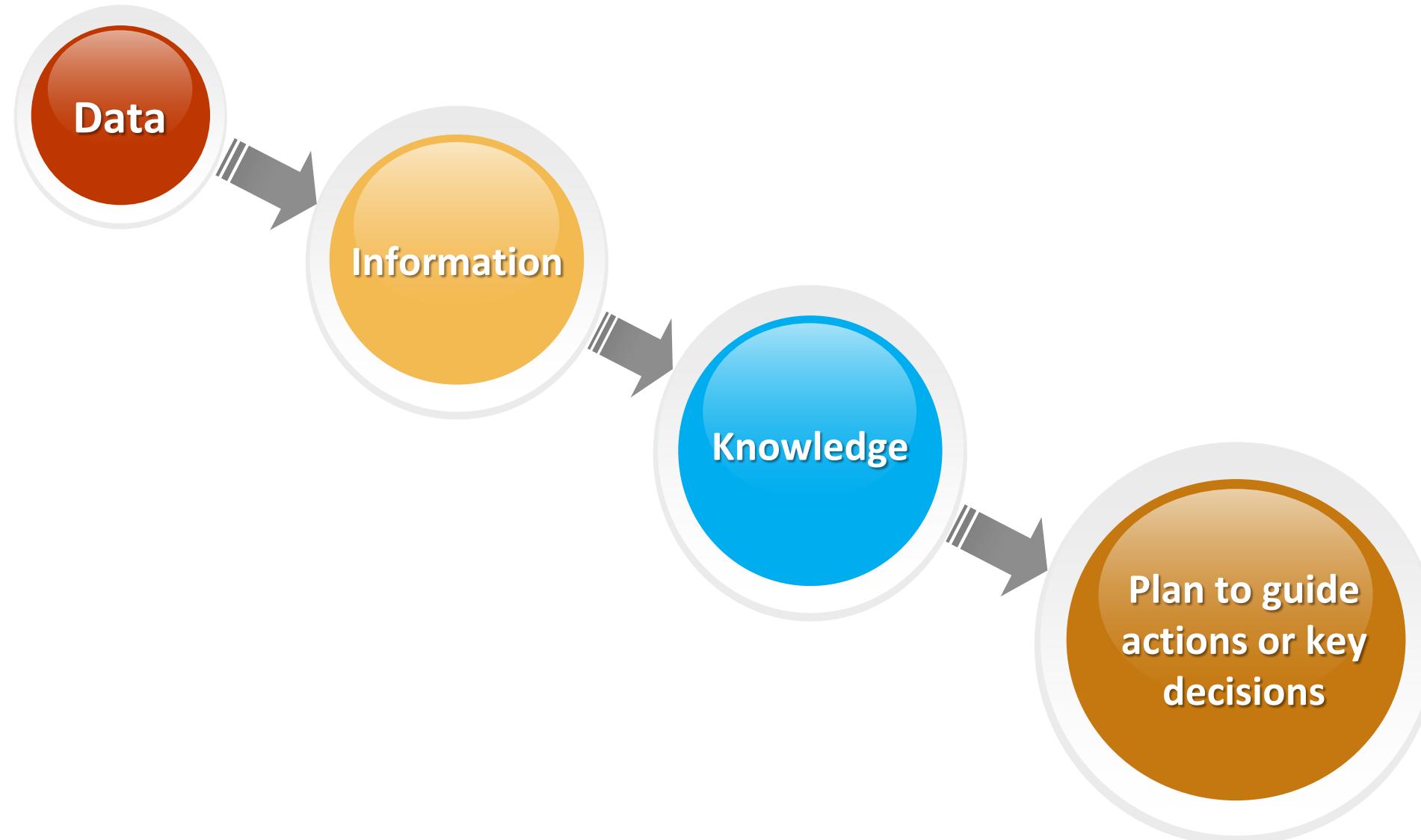
“In God we trust, all others bring data.”

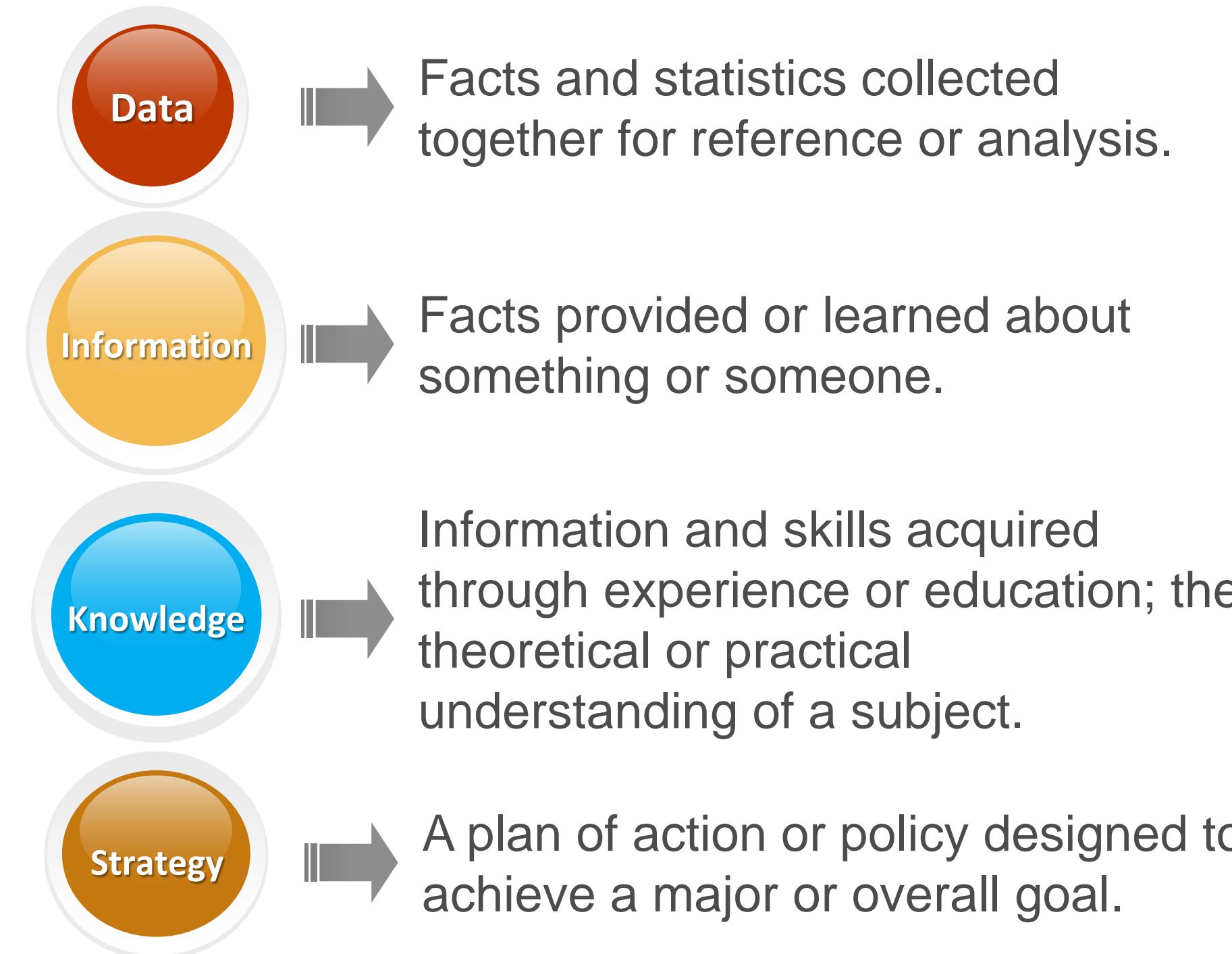
- W. Edwards Deming



Business Intelligence

Moving from data to action....





How many times does the digit 7 appear?

5	2	8	3	6	1	9	3	6	2	5	3	7	4	3	8	3
8	5	8	9	6	2	1	4	4	3	9	3	6	5	2	4	9
1	0	2	7	5	2	8	3	6	1	6	2	9	3	8	3	8
5	8	4	7	2	0	3	7	3	5	4	7	1	8	2	0	1
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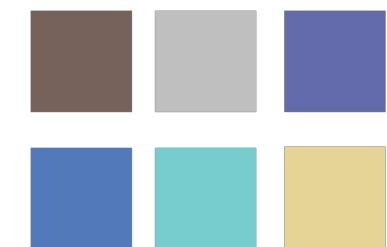
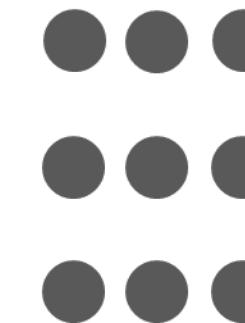
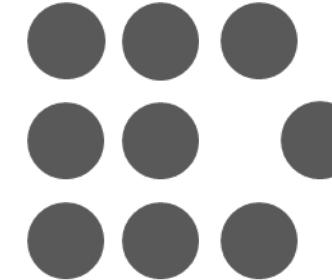
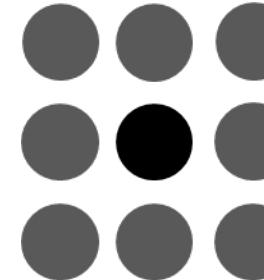
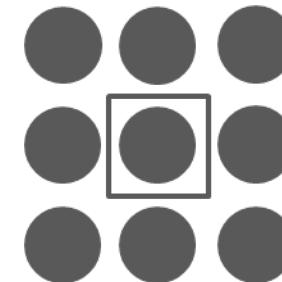
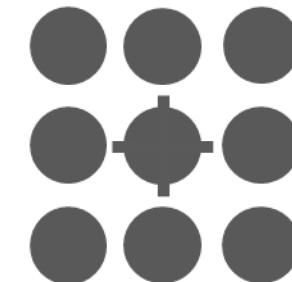
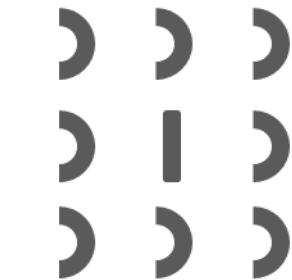
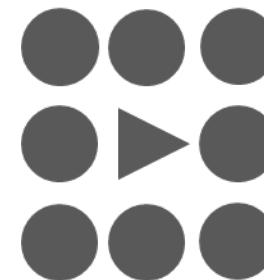
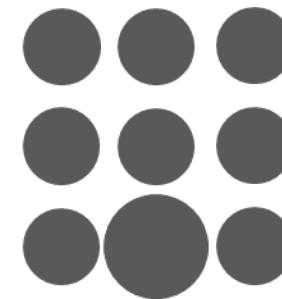
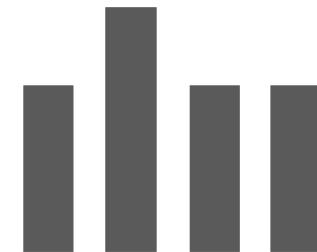
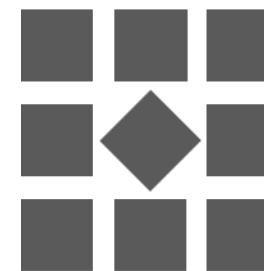
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56789 color

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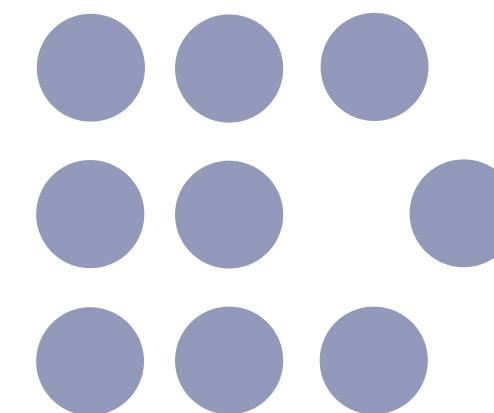


Preattentive attributes of visual perception and use of color

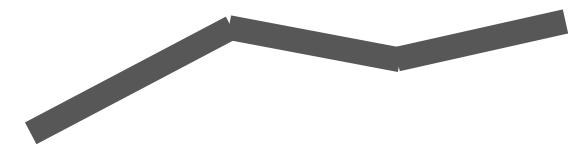
Precise Quantitative Comparisons



Length or Width



2D Position



7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
5	2	8	3	6	1	9	3	6	2	5	3	4	3	8	3	8
5	8	9	6	2	1	4	4	3	9	3	6	5	2	4	9	1
0	2	5	2	8	3	6	1	6	2	9	3	8	3	8	5	8
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3	6	4	3	9	1	0	8	9	5	3	4	5	3	2	5	2
8	3	6	1	6	2	4	6	2	5	9	1	5	2	6	3	6

7 **7** **7** **7** **7** **7** **7** **7** **7** **7** **7** **7** **7** **7** **7** **7**

5 2 8 3 6 1 9 3 6 2 5 3 4 3 8 3 8

5 8 9 6 2 1 4 4 3 9 3 6 5 2 4 9 1

0 2 5 2 8 3 6 1 6 2 9 3 8 3 8 5 8

4 2 0 3 3 5 4 1 8 2 0 1 2 5 3 6 4

3 9 1 0 8 9 5 3 4 5 3 2 5 2 8 3 6

1 6 2 9 3 8 3 8 5 8 4 2 0 3 3 5 4

1 8 2 0 1 9 6 2 1 4 4 3 9 3 6 5 2

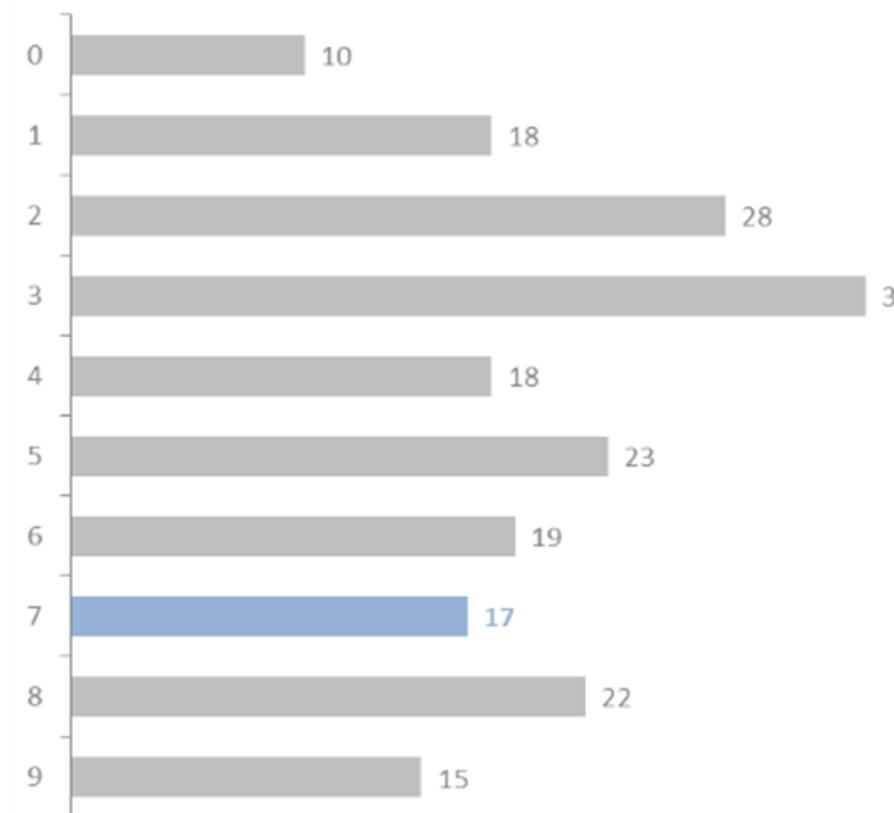
4 9 1 0 2 5 2 8 3 6 1 6 2 9 3 8 3

8 5 4 8 2 0 3 3 5 4 1 8 2 0 1 2 5

3 6 4 3 9 1 0 8 9 5 3 4 5 3 2 5 2

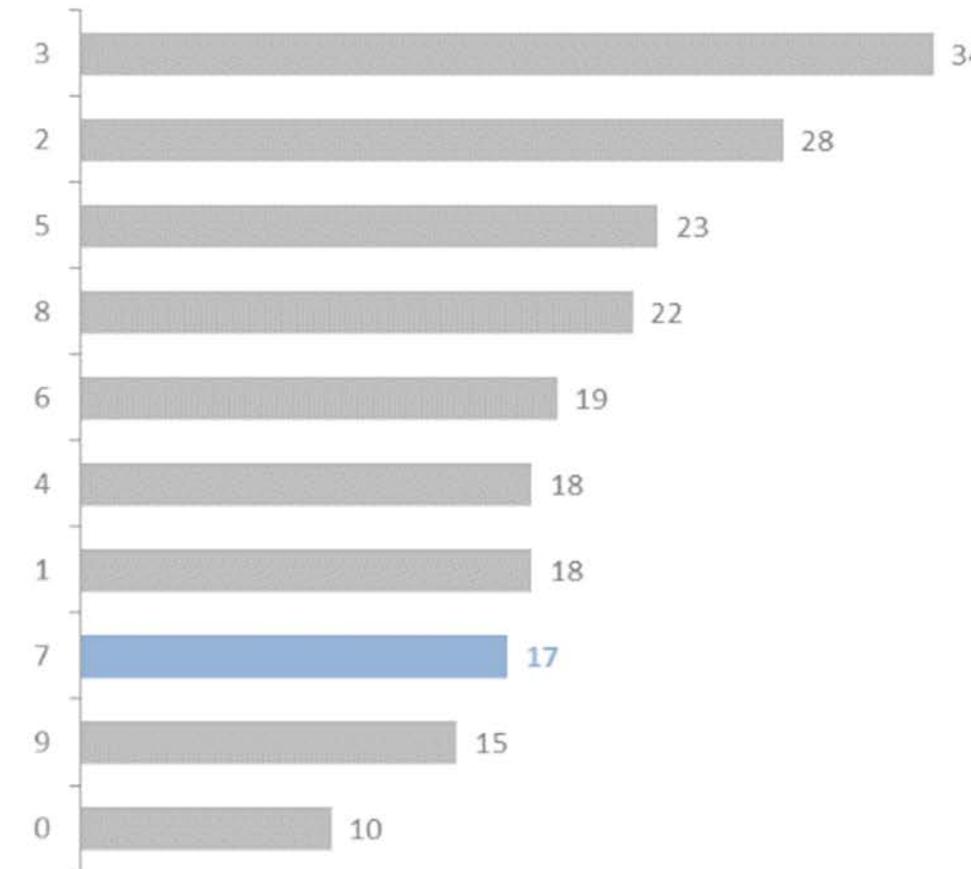
8 3 6 1 6 2 4 6 2 5 9 1 5 2 6 3 6

of times digit 7 appears: 17



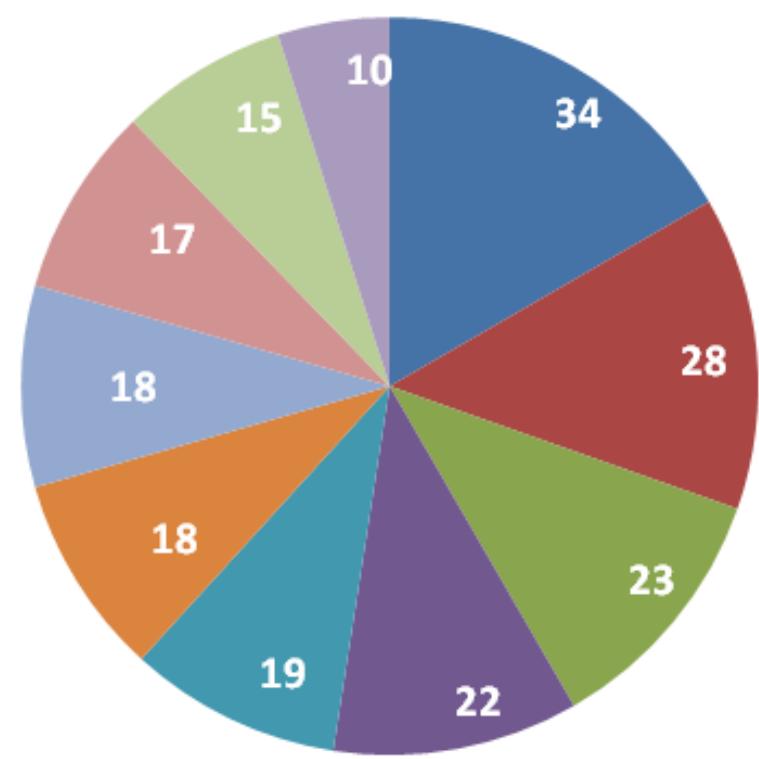
7 7 7 7 7 7 7 7 7 7 7 7 7
5 2 8 3 6 1 9 3 6 2 5 3 4 3 8 3 8
5 8 9 6 2 1 4 4 3 9 3 6 5 2 4 9 1
0 2 5 2 8 3 6 1 6 2 9 3 8 3 8 5 8
4 2 0 3 3 5 4 1 8 2 0 1 2 5 3 6 4
3 9 1 0 8 9 5 3 4 5 3 2 5 2 8 3 6
1 6 2 9 3 8 3 8 5 8 4 2 0 3 3 5 4
1 8 2 0 1 9 6 2 1 4 4 3 9 3 6 5 2
4 9 1 0 2 5 2 8 3 6 1 6 2 9 3 8 3
8 5 4 8 2 0 3 3 5 4 1 8 2 0 1 2 5
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8 3 6 1 6 2 4 6 2 5 9 1 5 2 6 3 6

of times digit 7 appears: 17

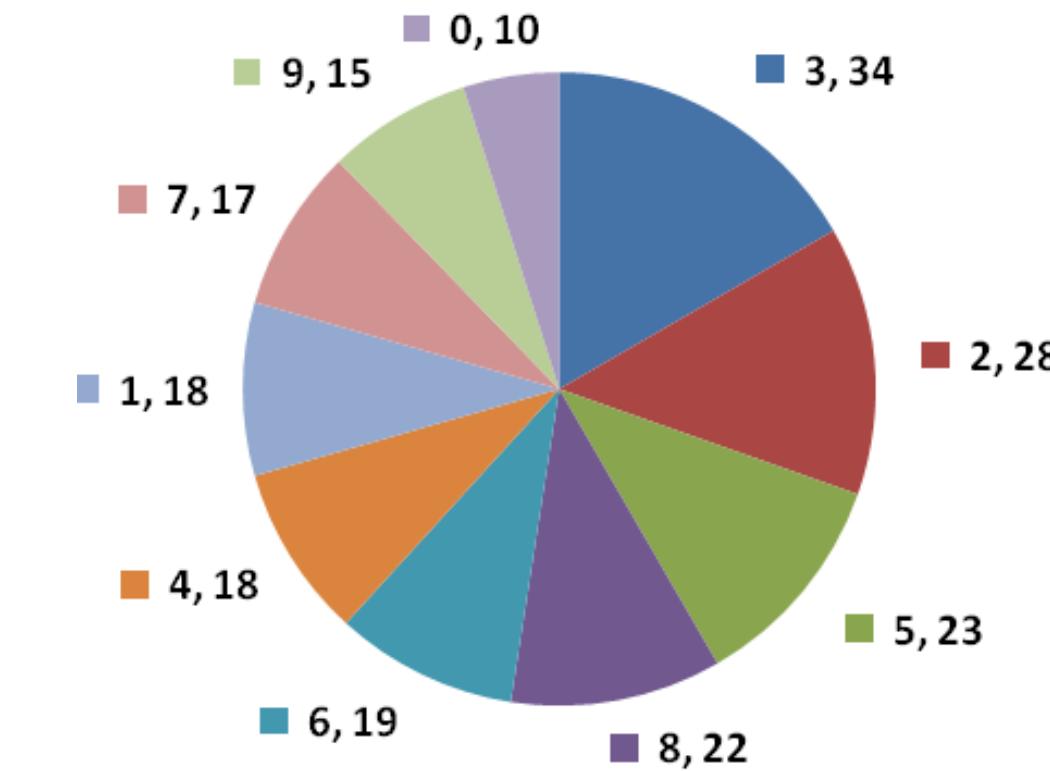


7 7 7 7 7 7 7 7 7 7 7 7 7 7
5 2 8 3 6 1 9 3 6 2 5 3 4 3 8 3 8
5 8 9 6 2 1 4 4 3 9 3 6 5 2 4 9 1
0 2 5 2 8 3 6 1 6 2 9 3 8 3 8 5 8
4 2 0 3 3 5 4 1 8 2 0 1 2 5 3 6 4
3 9 1 0 8 9 5 3 4 5 3 2 5 2 8 3 6
1 6 2 9 3 8 3 8 5 8 4 2 0 3 3 5 4
1 8 2 0 1 9 6 2 1 4 4 3 9 3 6 5 2
4 9 1 0 2 5 2 8 3 6 1 6 2 9 3 8 3
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3 6 4 3 9 1 0 8 9 5 3 4 5 3 2 5 2
8 3 6 1 6 2 4 6 2 5 9 1 5 2 6 3 6

of Times



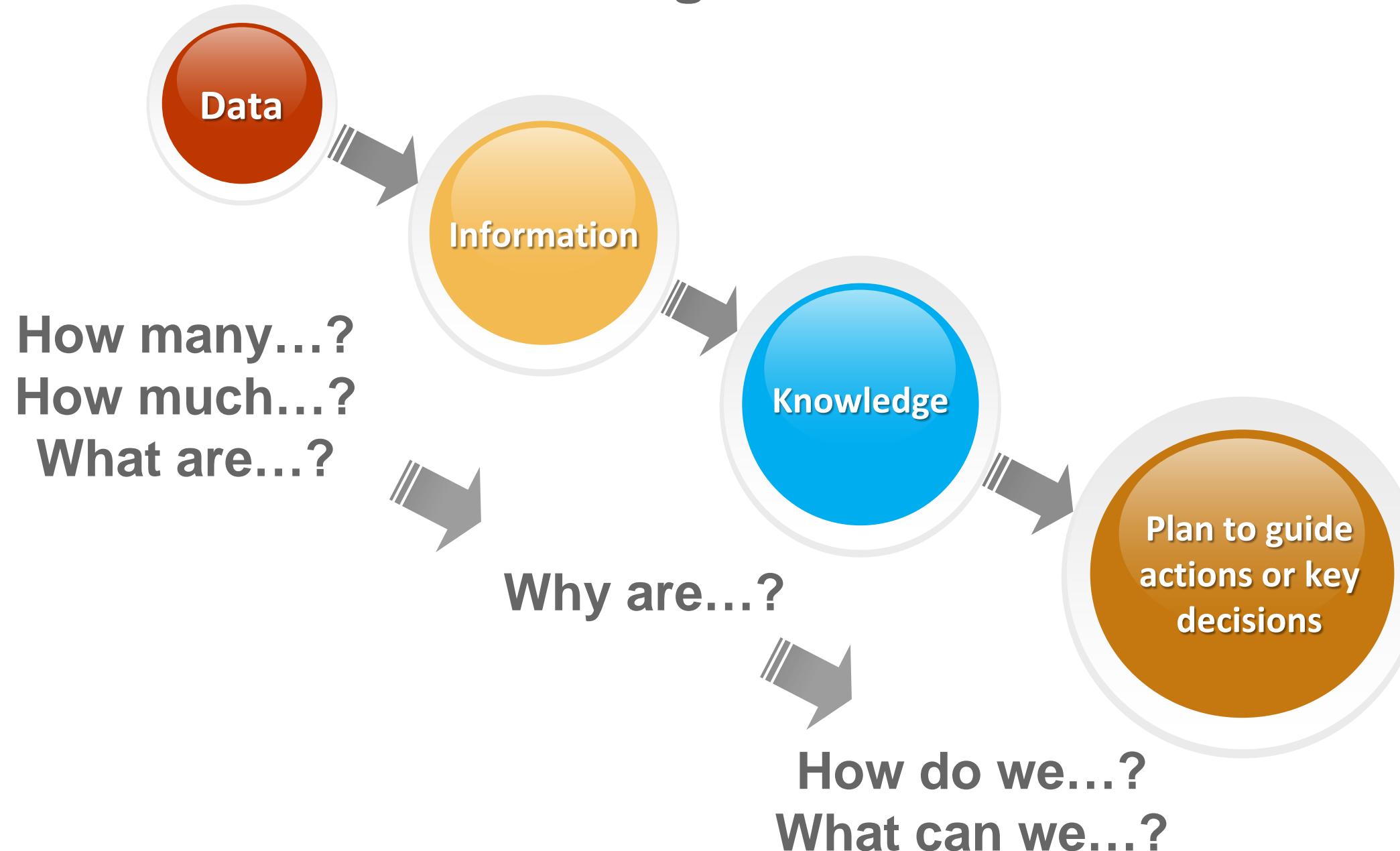
of Times



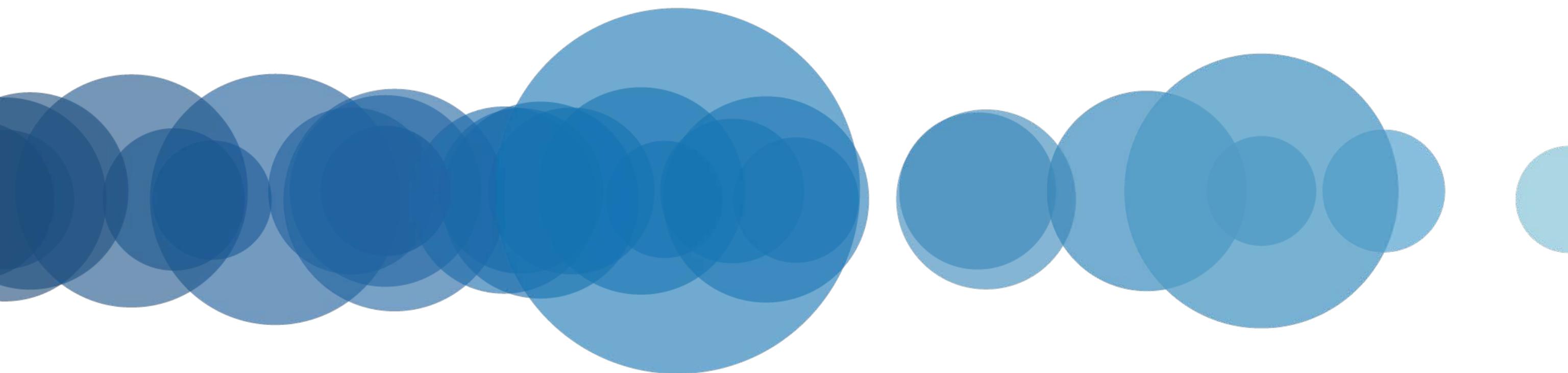
- Label problems
- Color problems
- Hard to make visual comparisons
- Do we get the same Information?

Business Intelligence

Moving from data to action....



A Brief History of Data Analytics



The Early Years – 2nd Century CE



A copy of the *Almagest* from the 9th century, in Greek, on parchment

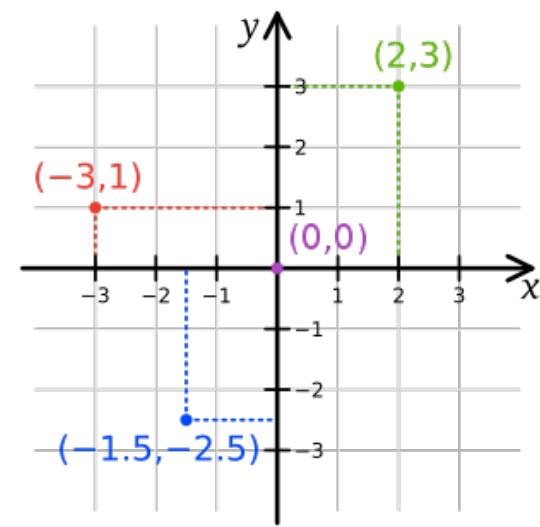
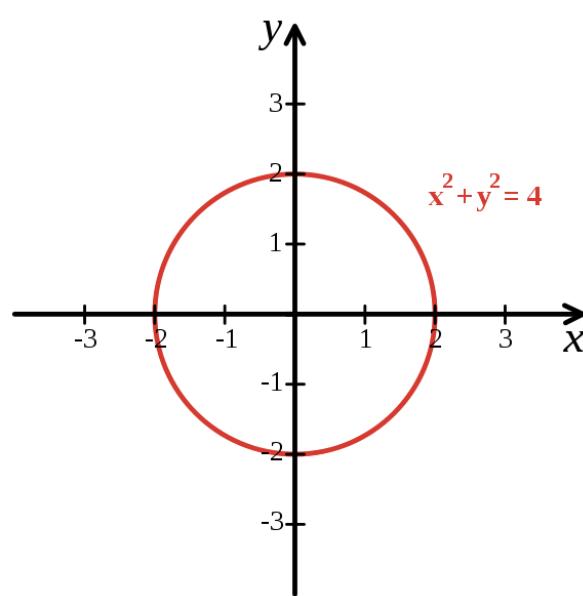


- Claudius Ptolemy publishes the *Almagest* around 150 CE in Egypt, providing a thorough treatise on astronomy, solar, lunar, and planetary theory¹
- **Earliest preserved use of a table;** held detailed astronomical information²

René Descartes

(1596-1650)

- Invented a method of presenting number-based data using 2-D coordinate scales²
- Originally designed to allow algebraic equations to be expressed visually, linking Euclidean geometry and algebra^{3,4}
- Later became known as the Cartesian coordinate system³

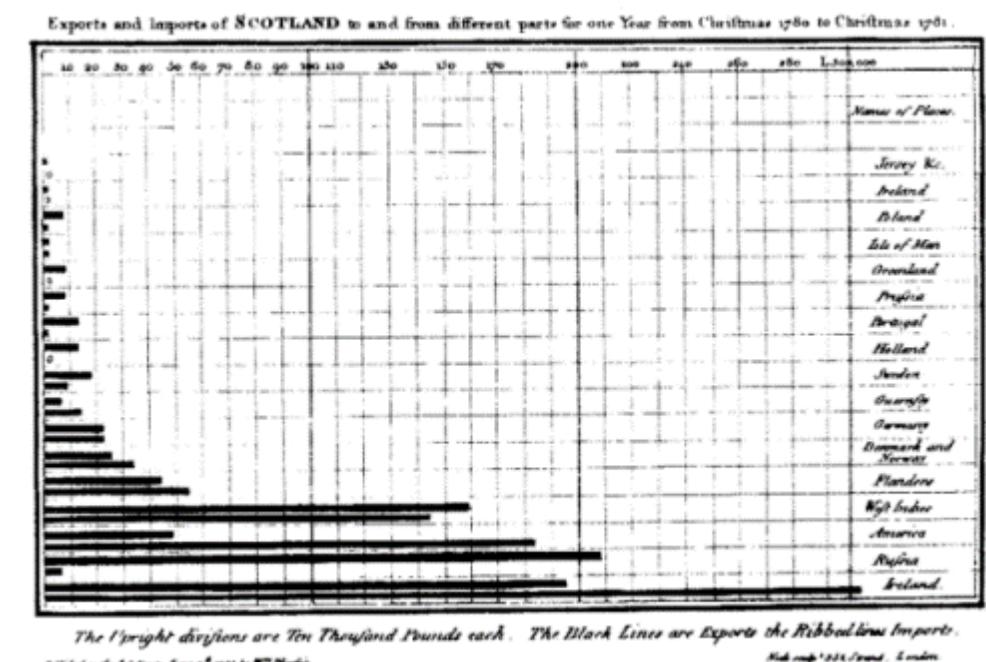
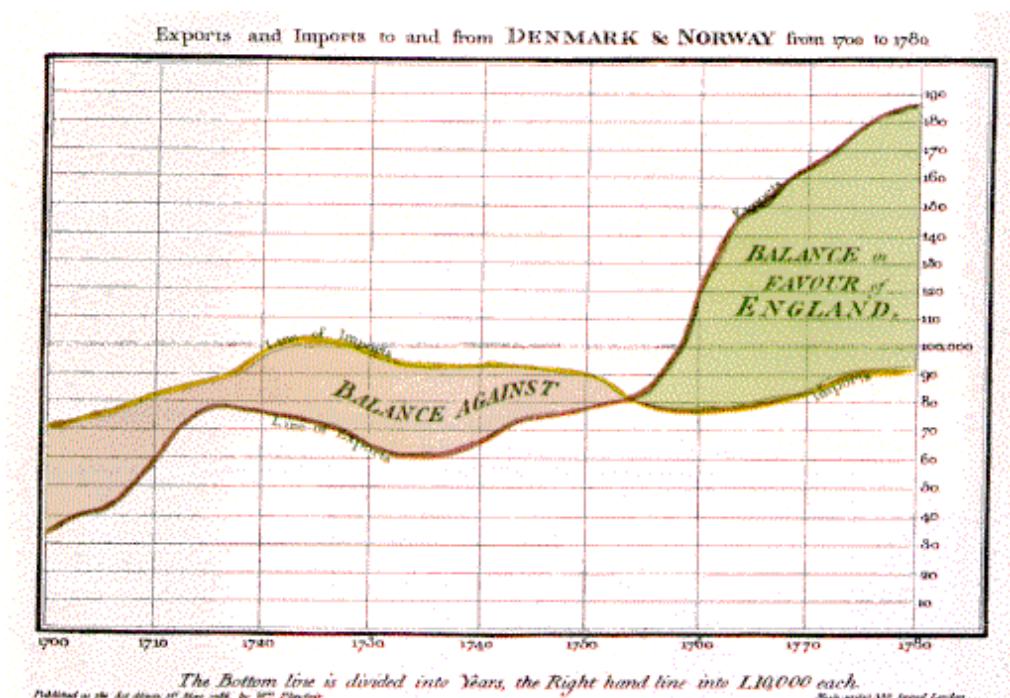


Late 18th – Early 19th Century

William Playfair

(1759-1823)

- Scottish engineer and political economist⁵
- Founder of graphical methods of statistics
- Developed new designs and improved existing methods to provide “systematic visual representations of his ‘linear arithmetic.’”⁶
- Created the time-series line graph, bar chart, and pie chart.⁷

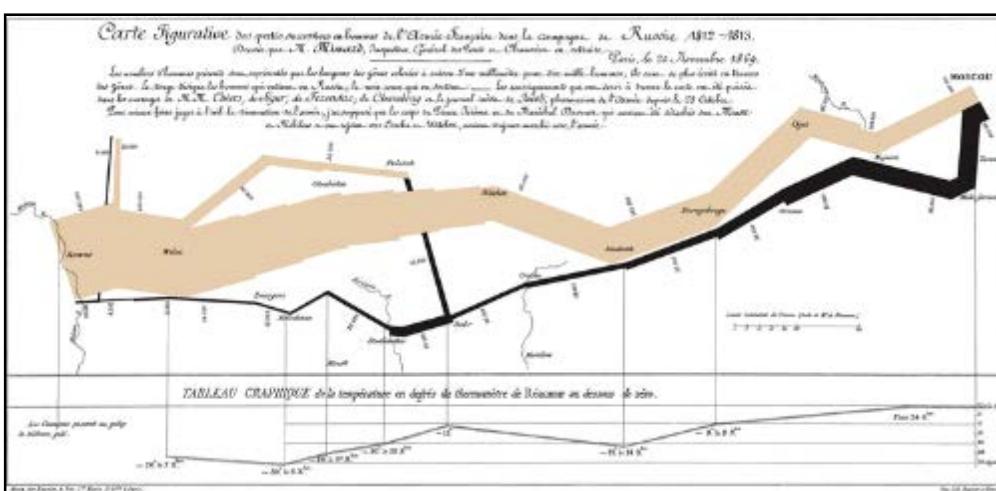
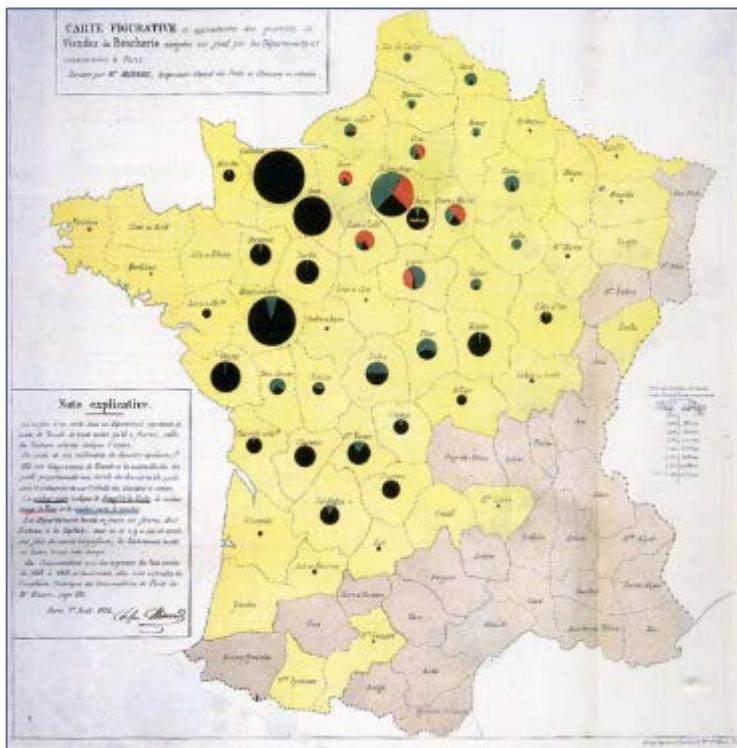


Early 19th Century

Charles Minard

(1781-1870)

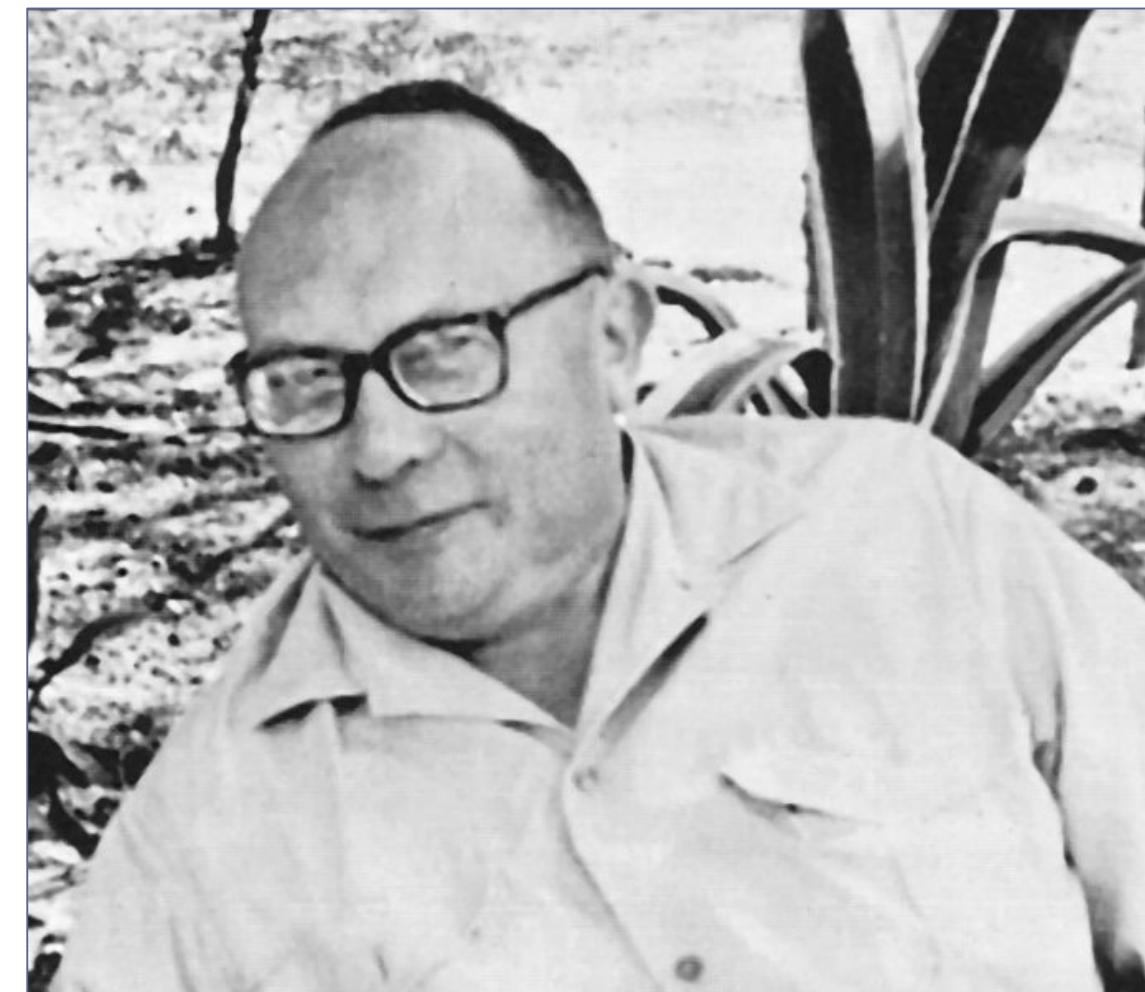
- French civil engineer; produced an array of graphics that combine a many data points into a compelling visual story
- Produced 70+ depictions including thematic maps and graphic tables between 1844-1870.⁷
- Map of Napoleon's Russian campaign regarded by some as the “best statistical graphic ever drawn.”⁸



Jacques Bertin

(1918-2010)

- French cartographer and theorist
- Author of many scientific maps, articles, and other papers on *semiology*, the study of signs, and how we process visual information
- 1967 – Published *Sémiologie Graphique* (Semiology of Graphics), asserting that our visual perception follows rules that can be followed



John Tukey

(1915-2000)

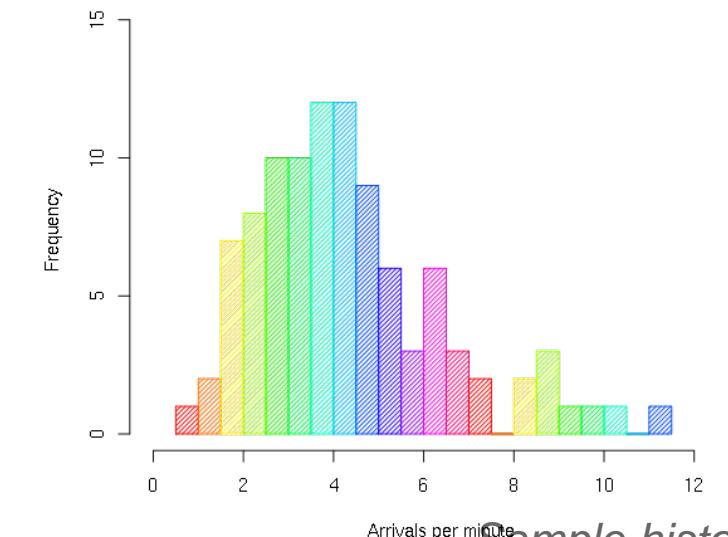
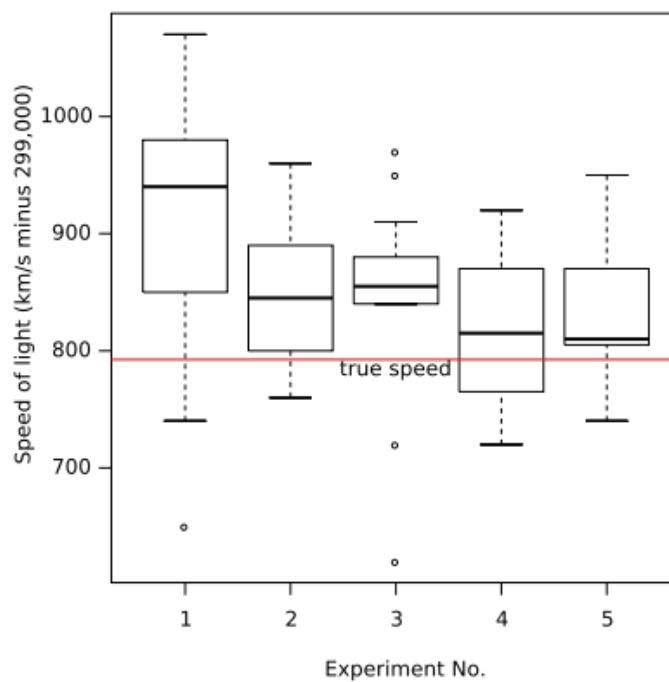
- American statistician
- Introduced the **box plot** in *Exploratory Data Analysis*, published in 1977
- Exploratory Data Analysis (EDA) emphasized presentation of the main characteristics of a data set in a visual, easy to understand form, without using a statistical model or hypothesis¹⁰



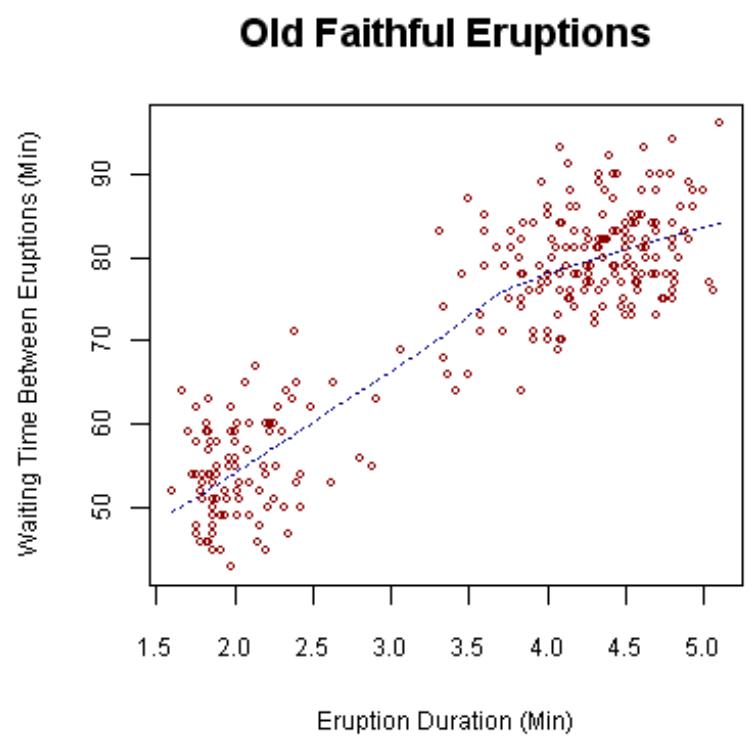
20th Century

Visualization techniques used in EDA include:

- Box plot
- Histogram
- Pareto chart
- Scatter plot



Sample histogram.



Sample scatter plot.

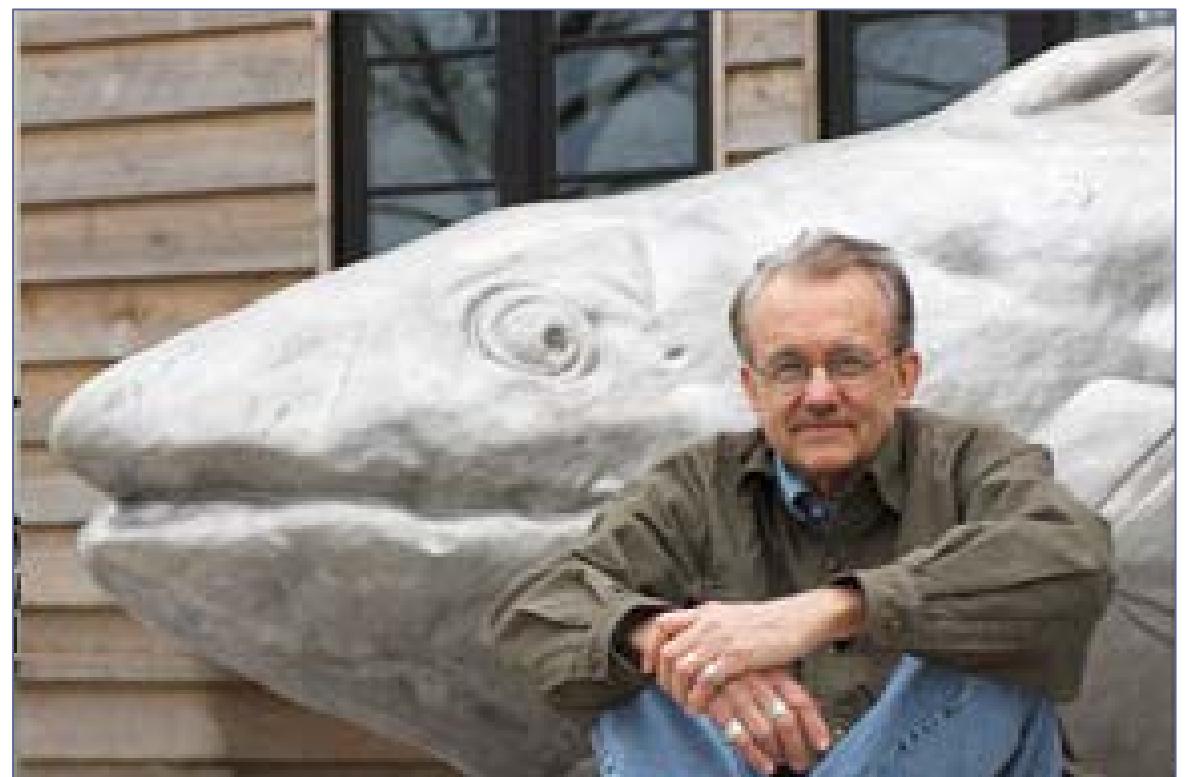
Tukey's advocacy for EDA encouraged the development of software for statistical computing like S, which inspired S-Plus and R.¹⁰

Contemporary Practitioners

Edward R. Tufte

(b. 1942)

- American statistician, sculptor, and Professor Emeritus of Political Science, Statistics, and Computer Science, Yale University
- Widely recognized expert in the fields of information design and visual literacy¹¹
- Credited as a pioneer in teaching the fundamental skills required for visual communication³

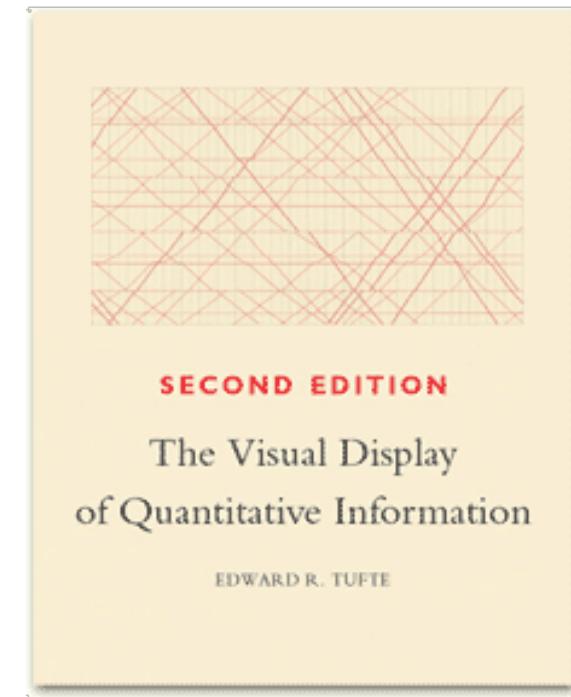


Contemporary Practitioners

Edward R. Tufte

The Visual Display of Quantitative Information (1983)

- Provides an essential reference for how effective design can positively influence understanding



Tufte also invented sparklines

Contemporary Practitioners

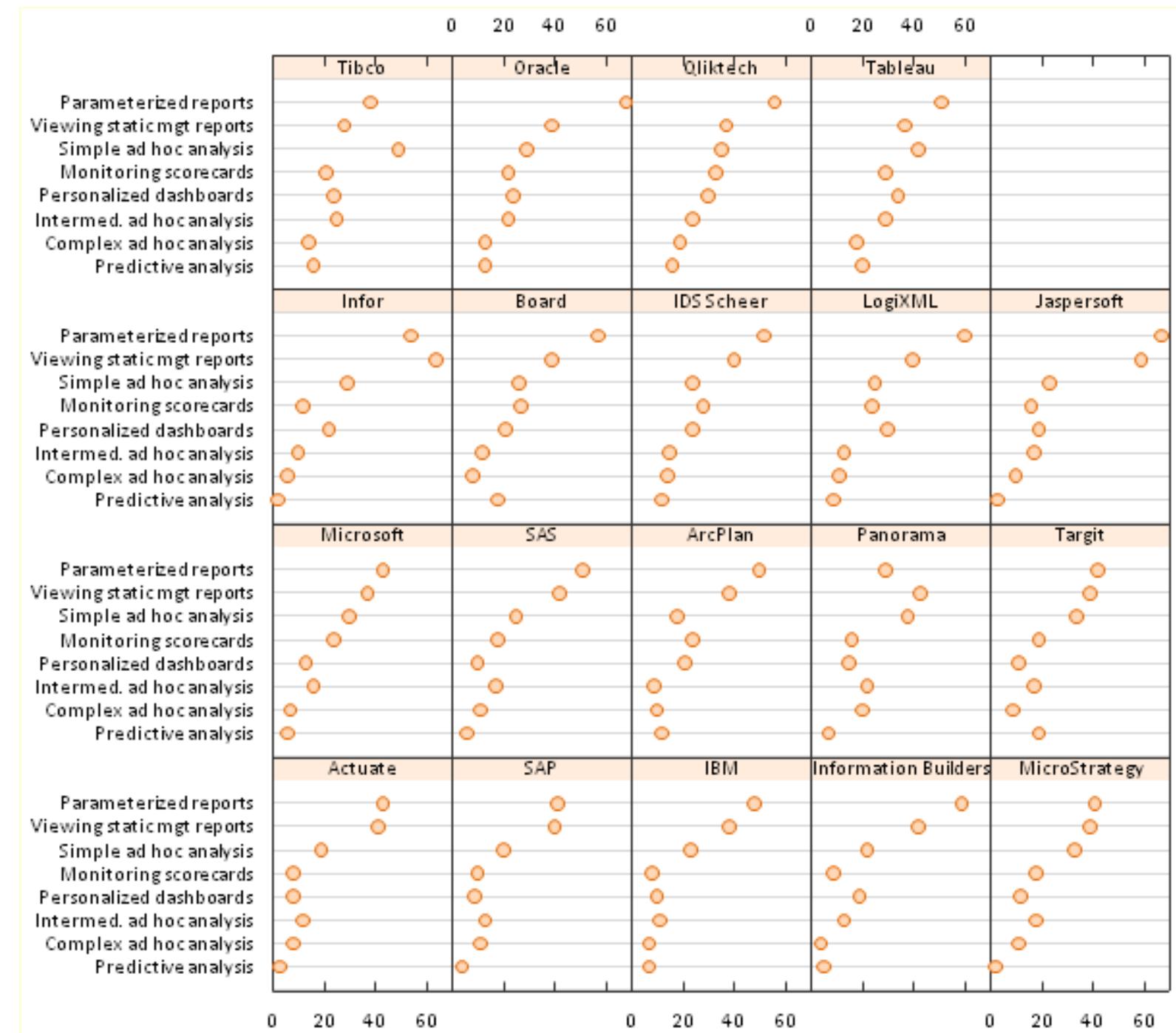


William S. Cleveland

- Professor of Statistics and Courtesy Professor of Computer Science at Purdue University; previously worked at Bell Labs
- Authored over 100 papers/publications including *Visualizing Data* (1993) and *The Elements of Graphing Data* (1994), to enhance awareness and provide examples of effective data presentation
- Initial developer of trellis charts, which make visualization possible in data sets with multiple variables

William S. Cleveland photo from <http://www.stat.purdue.edu/~wsc/>

Trellis Chart Example



Contemporary Practitioners

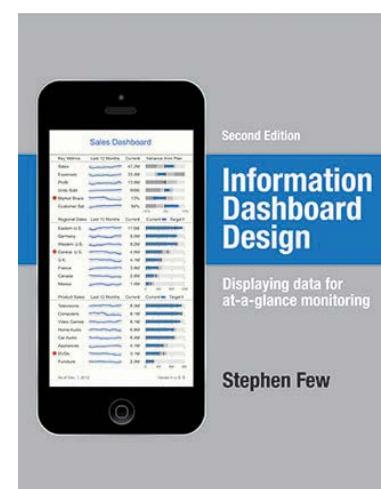
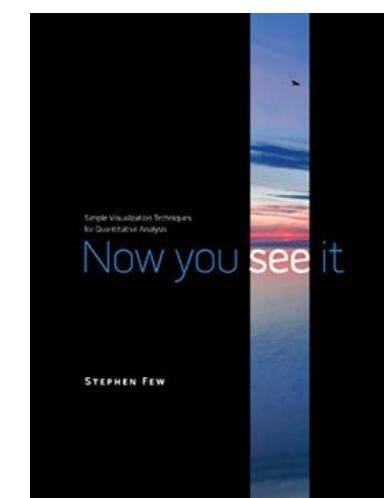
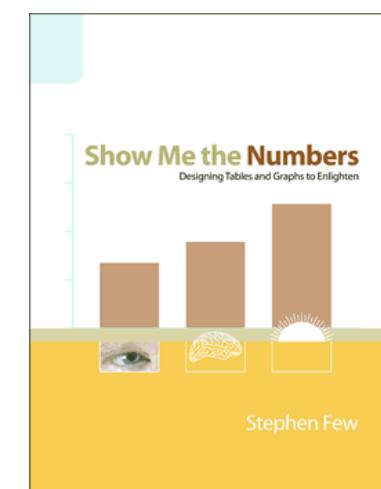
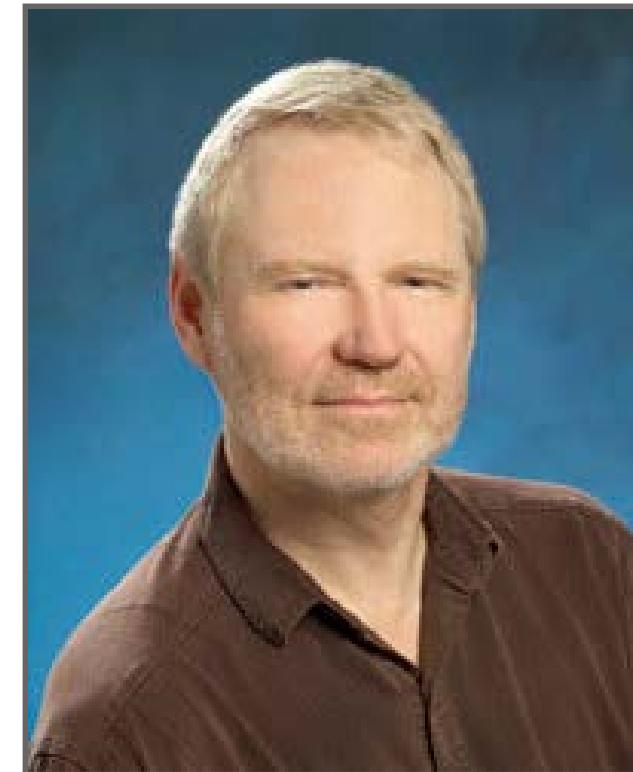
Stephen Few

Prolific writer and author with a focus on designing simple information displays that are effective and communicative.

Books include:

- *Show Me The Numbers* (2004)
- *Now You See It* (2009)
- *Information Dashboard Design, 2nd ed.* (2013)

Several of Few's examples will be used in class.



Other Critical Events

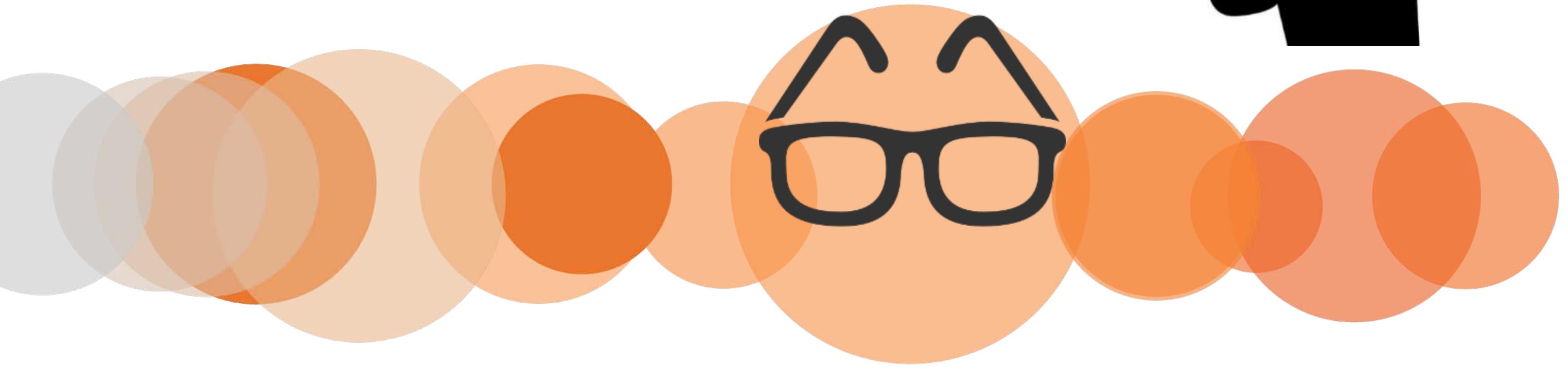


- 1984 - Apple Computer introduces the Macintosh
- The Macintosh was the first popular and affordable computer designed to display graphics in an interactive interface.³
- Innovations, like the graphical user interface and mouse, are invented at Xerox Palo Alto Research Center (Xerox PARC).

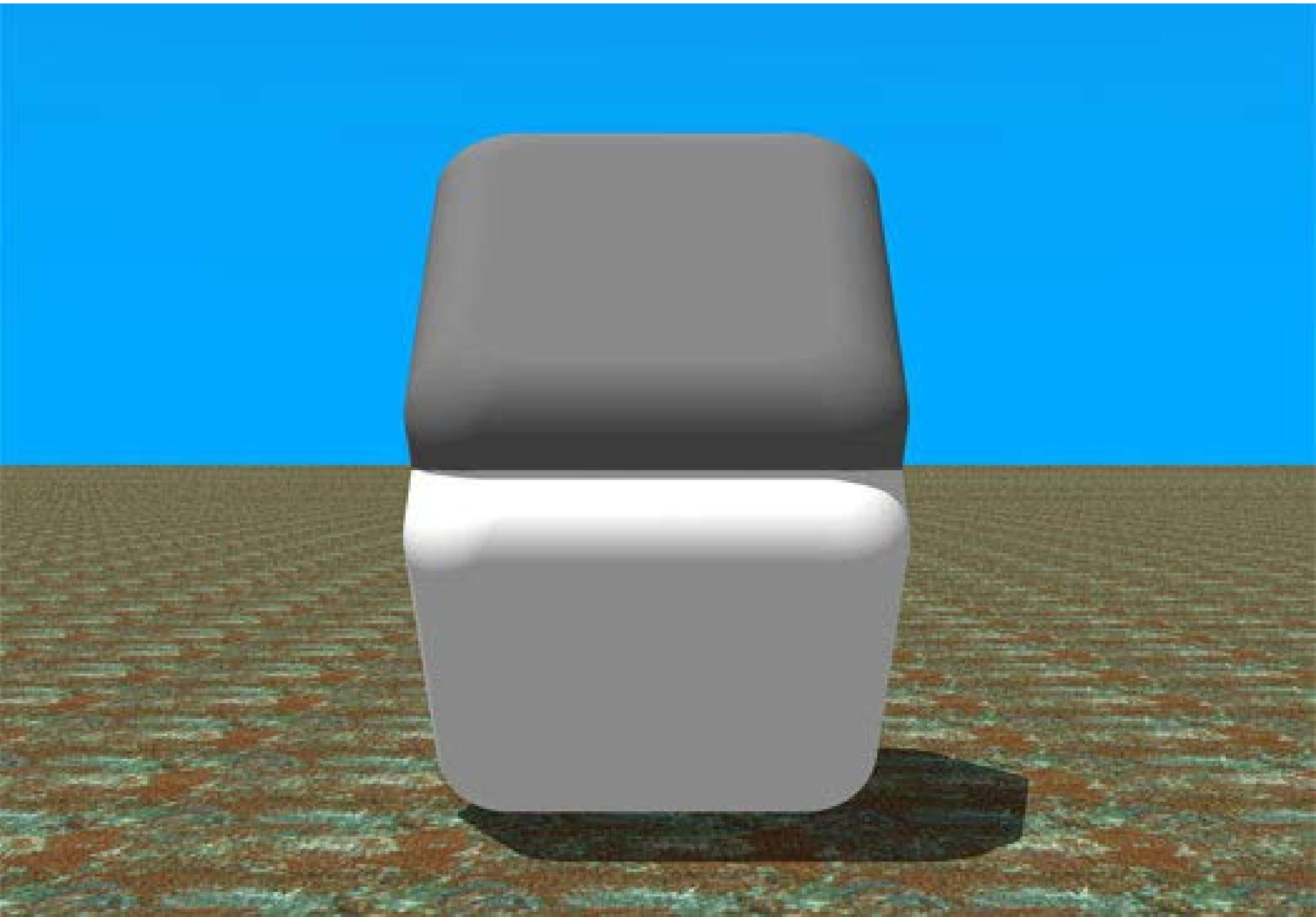
Visual Perception

“I See”

“Show me”



Optional Video Brain Games



Used by Permission of Dr. Beau Lotto (www.LottoLab.org)

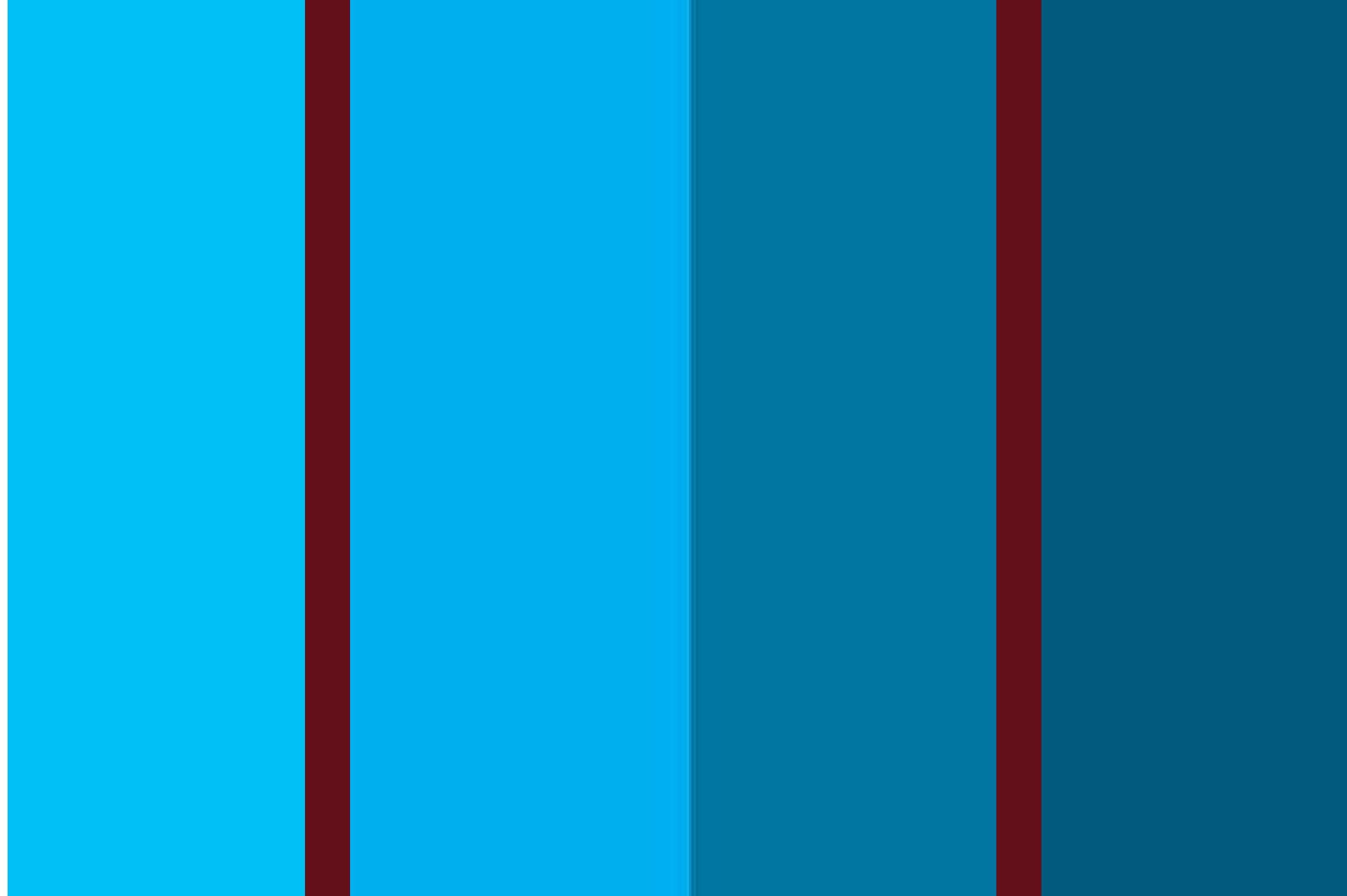
DATA

DATA

DATA

DATA

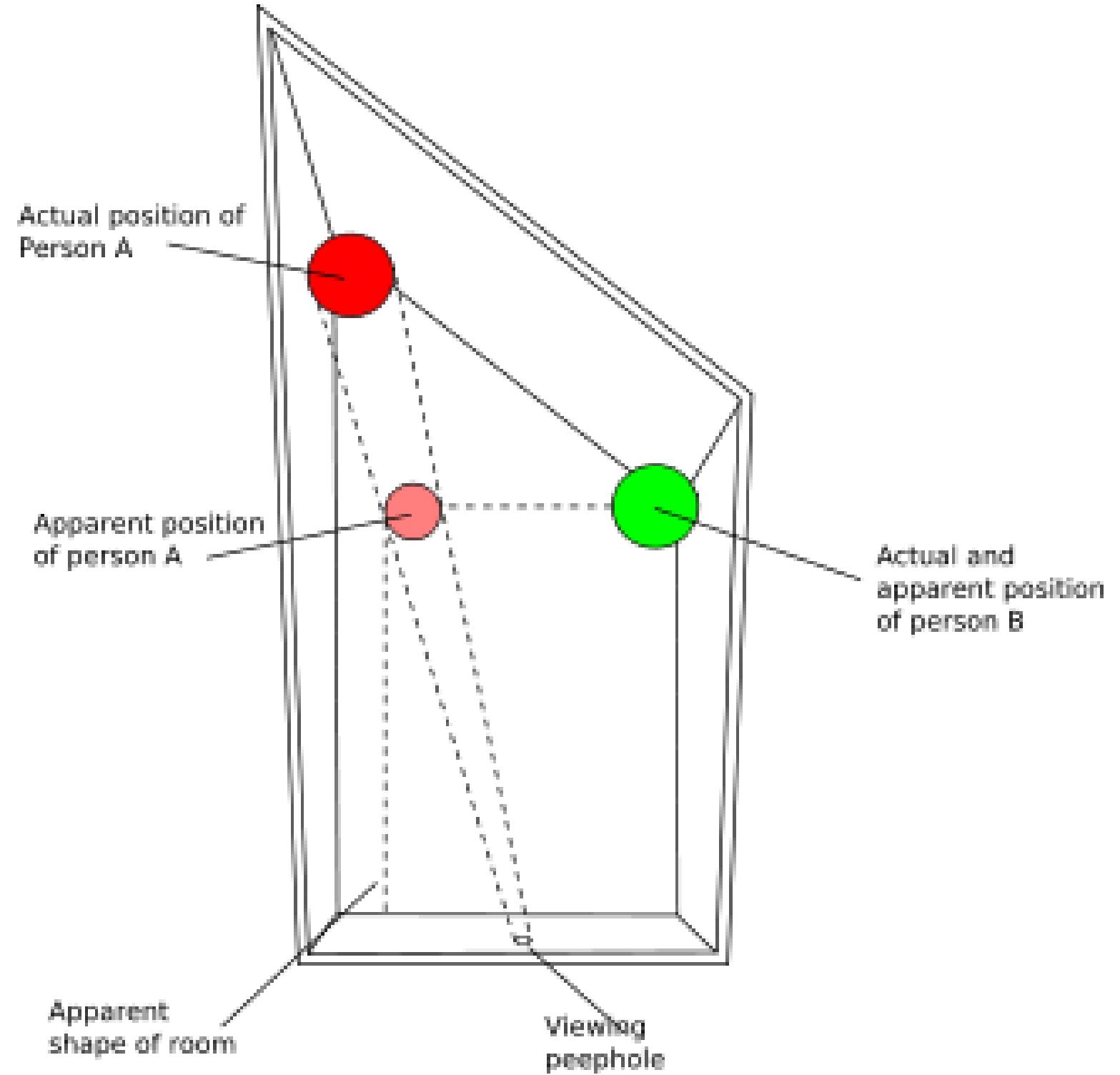






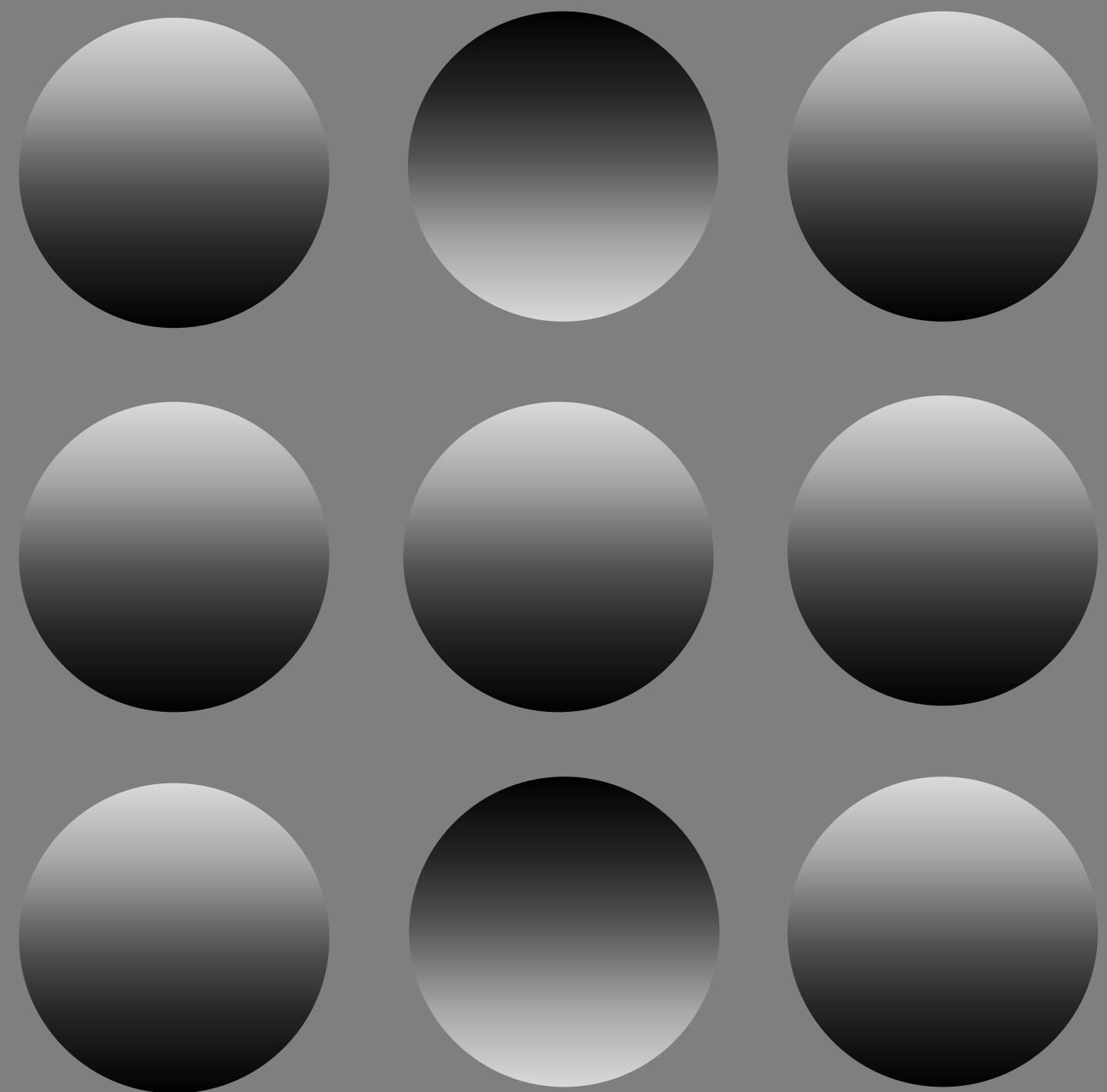








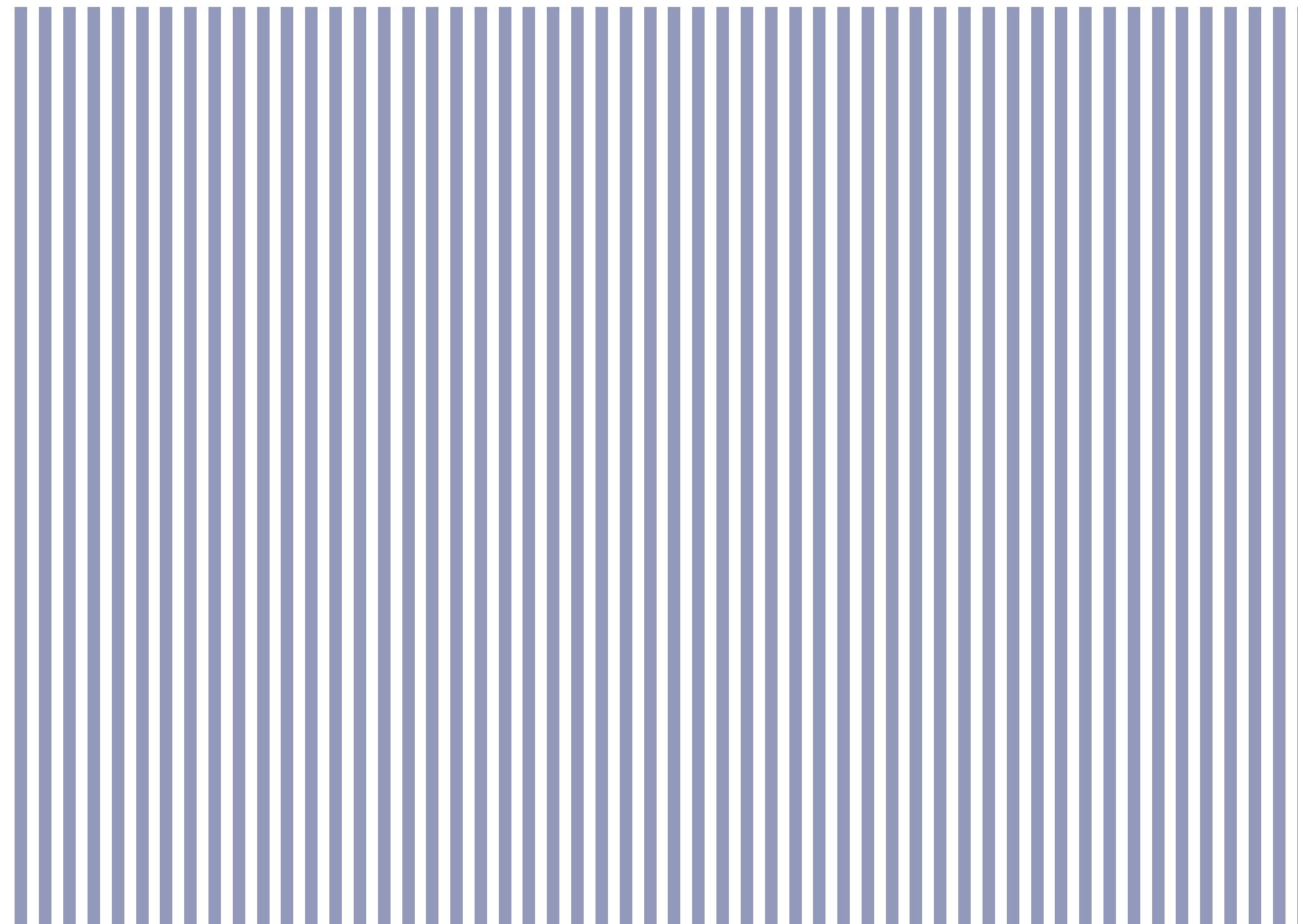
Source: Wiki Commons (Lotus, Illinois Railroad Tracks)

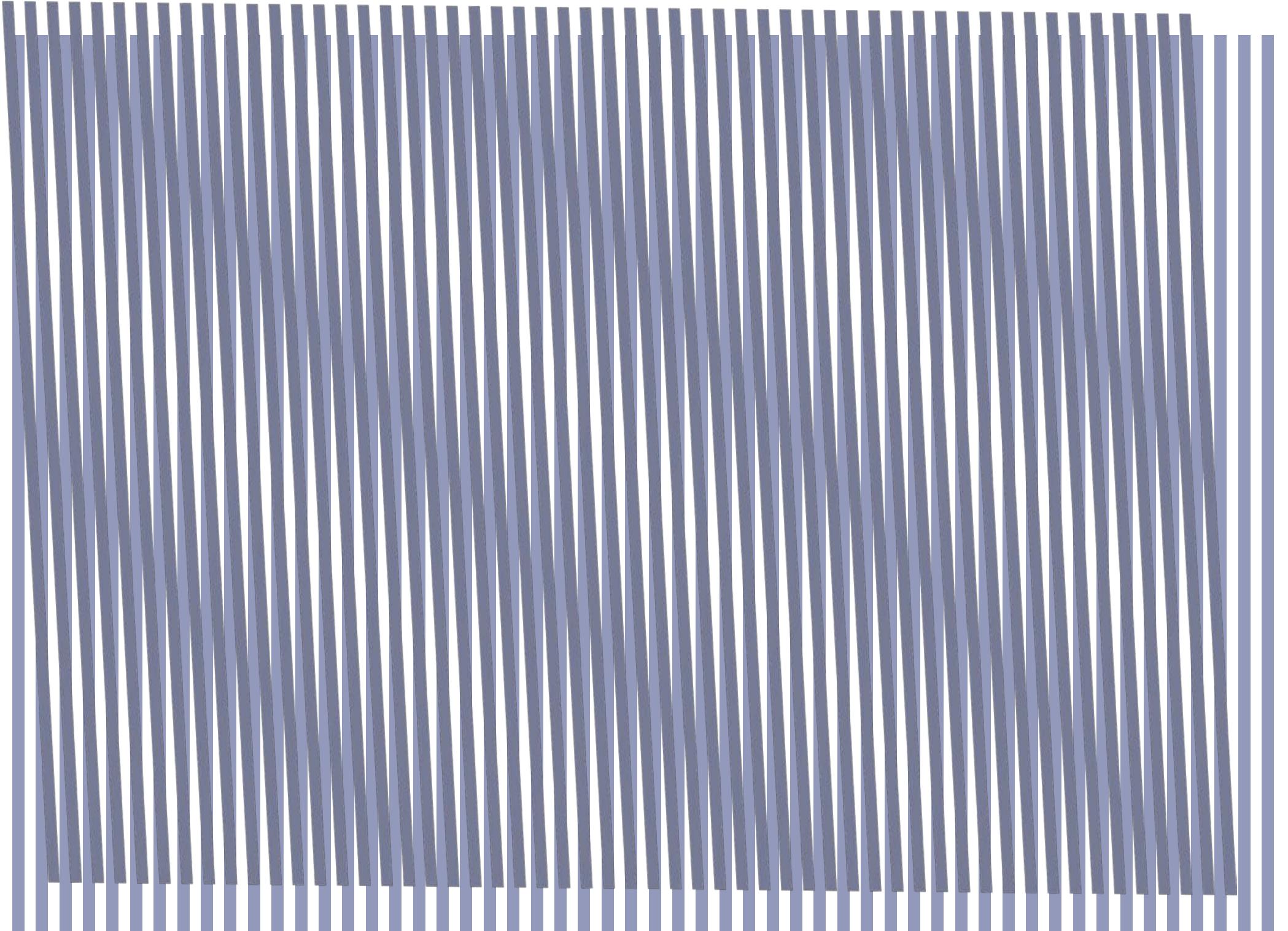


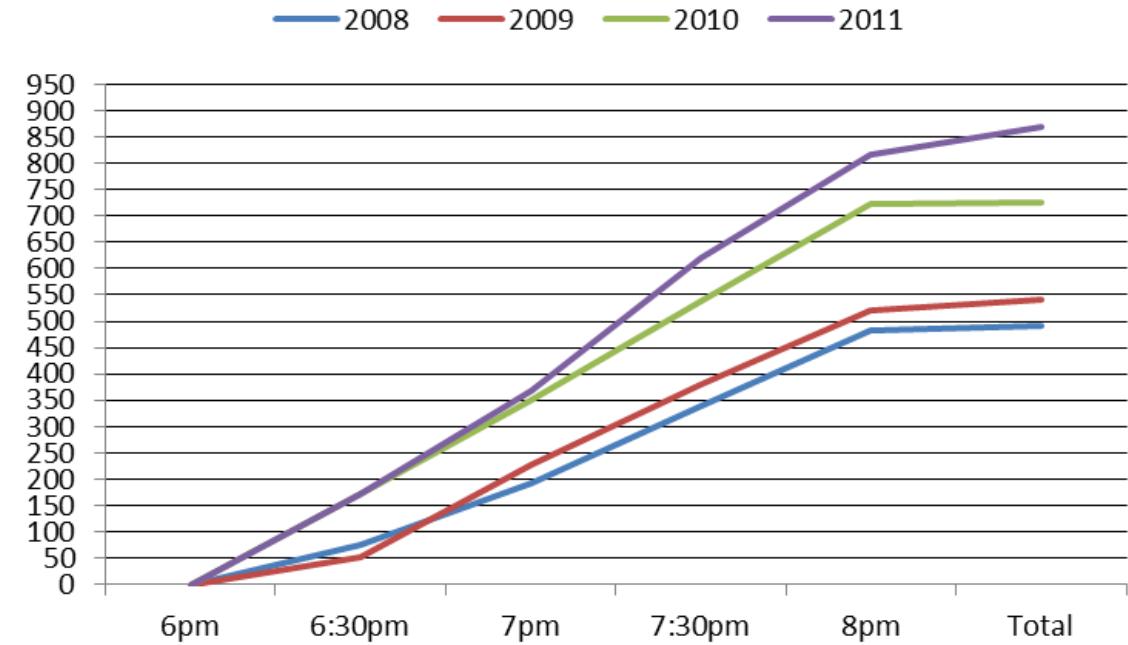


Source: Wikipedia (from the Lunar and Planetary Institute: <http://www.lpi.usra.edu>)

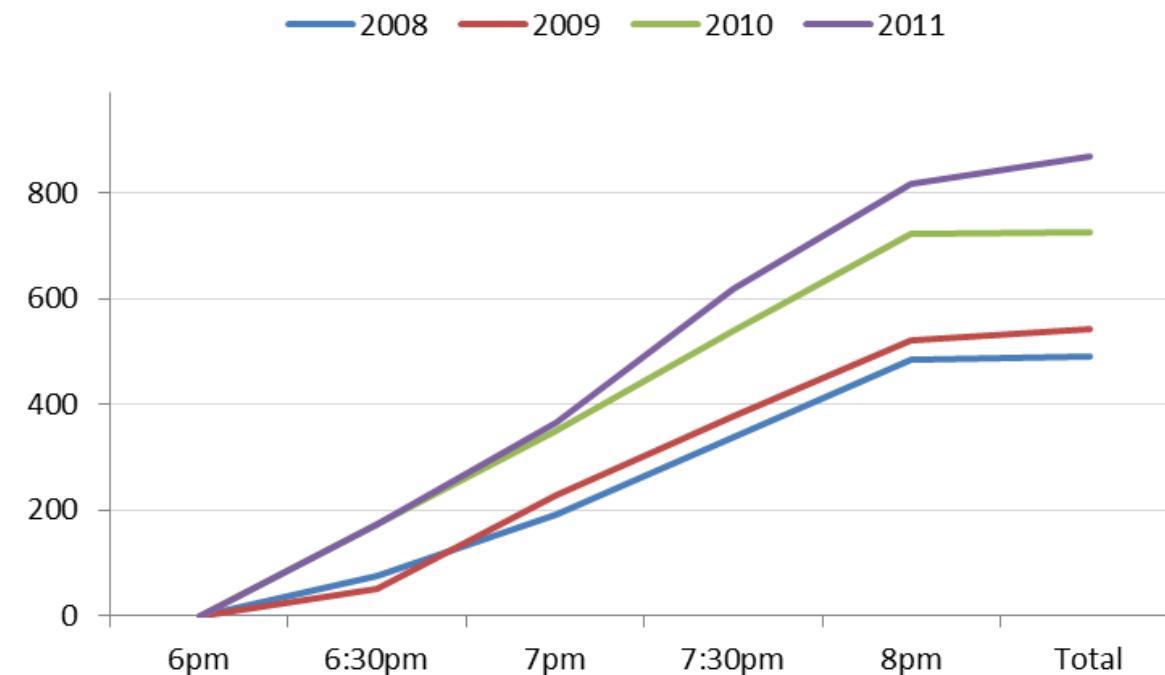
The Moiré effect



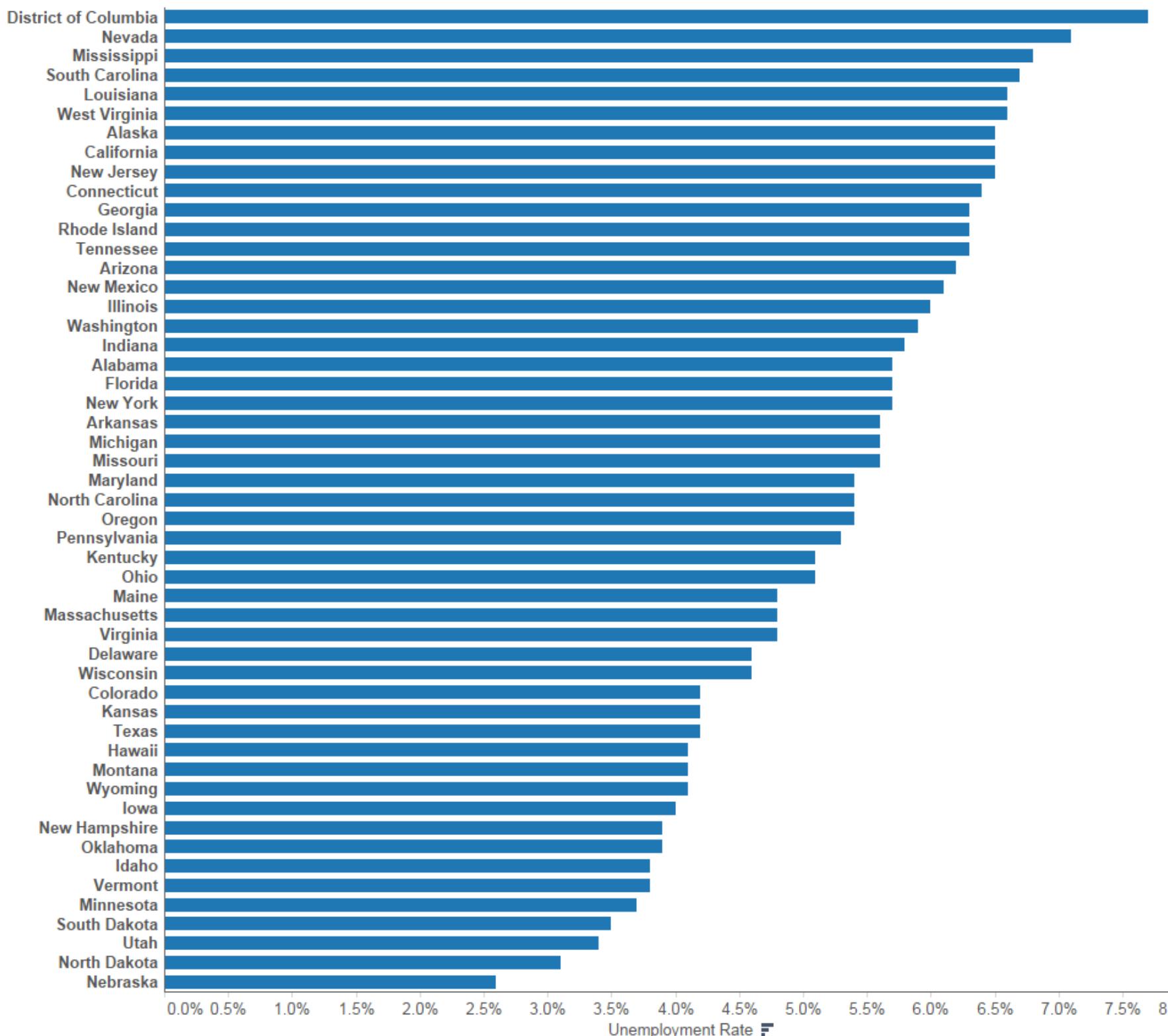




Gridlines spaced
and muted



Unemployment by State



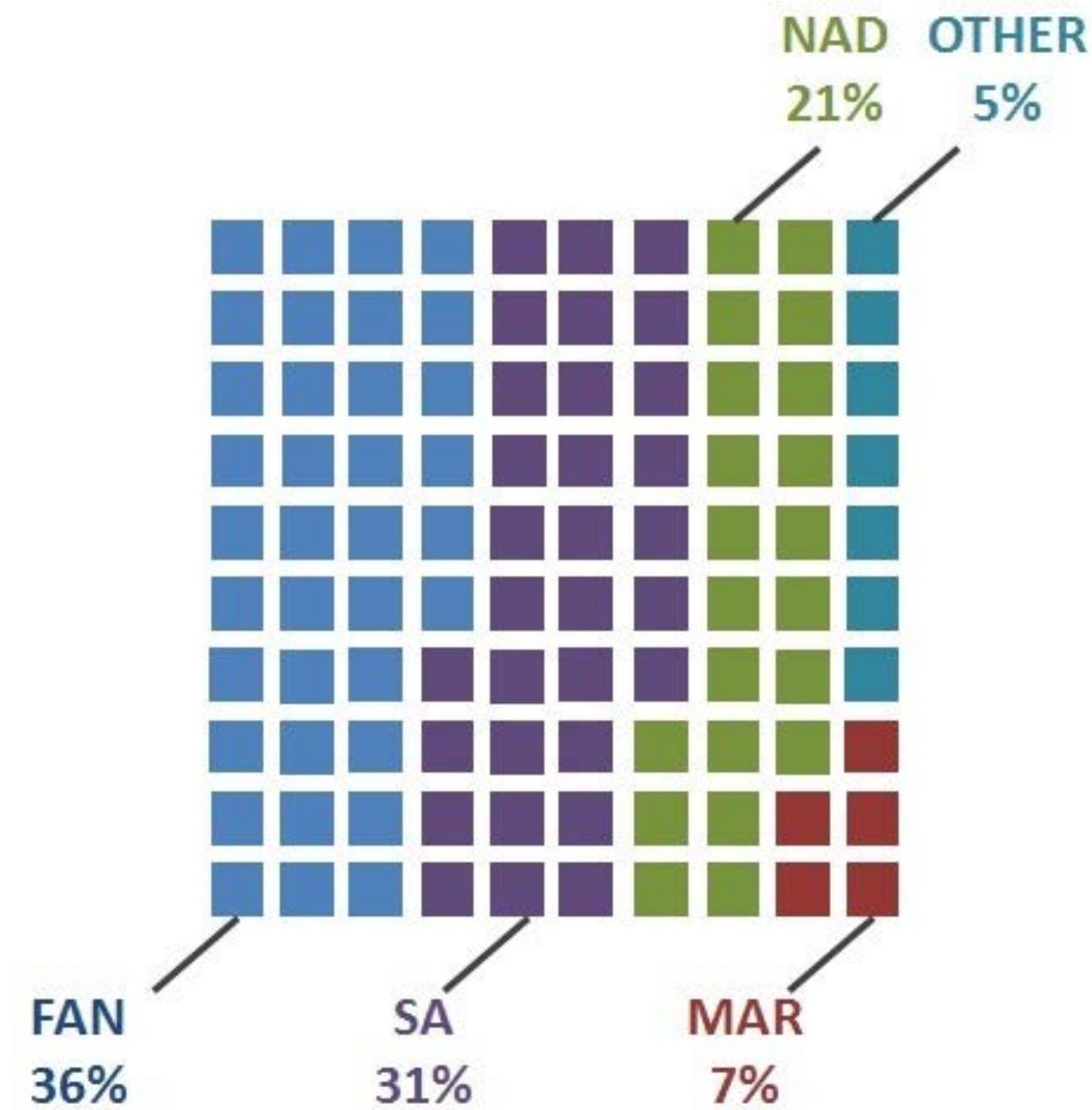
The Hermann effect

(the scintillating grid)



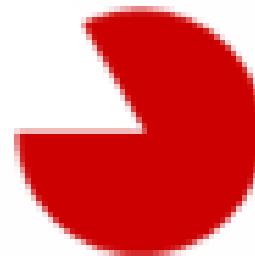
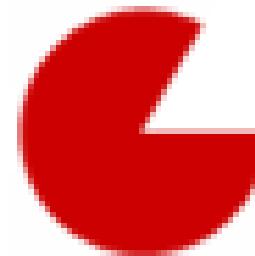
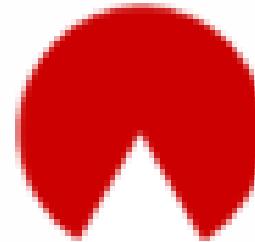
Unit Chart

(notice Hermann effect)



Gestalt Principle - Closure

(Kanizsa triangle)



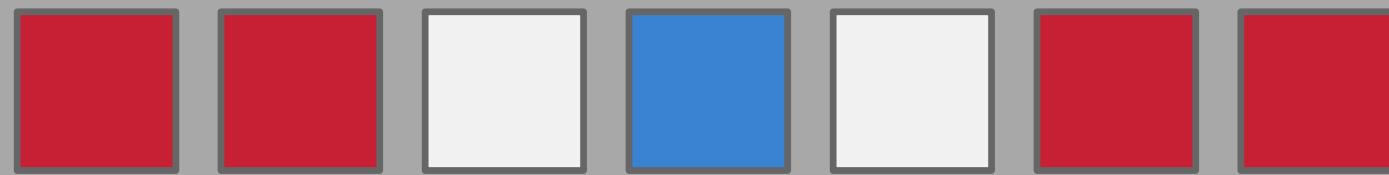
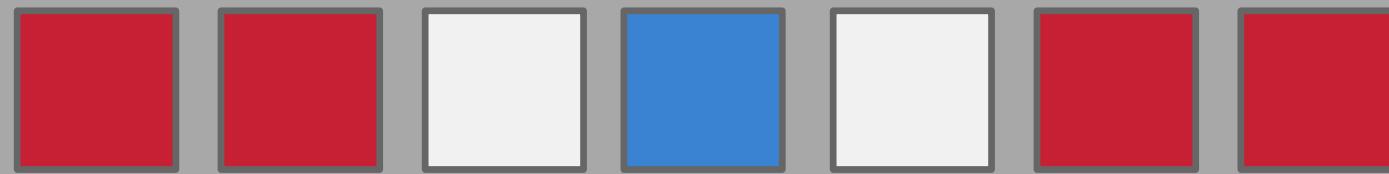
Gestalt Principle - Closure

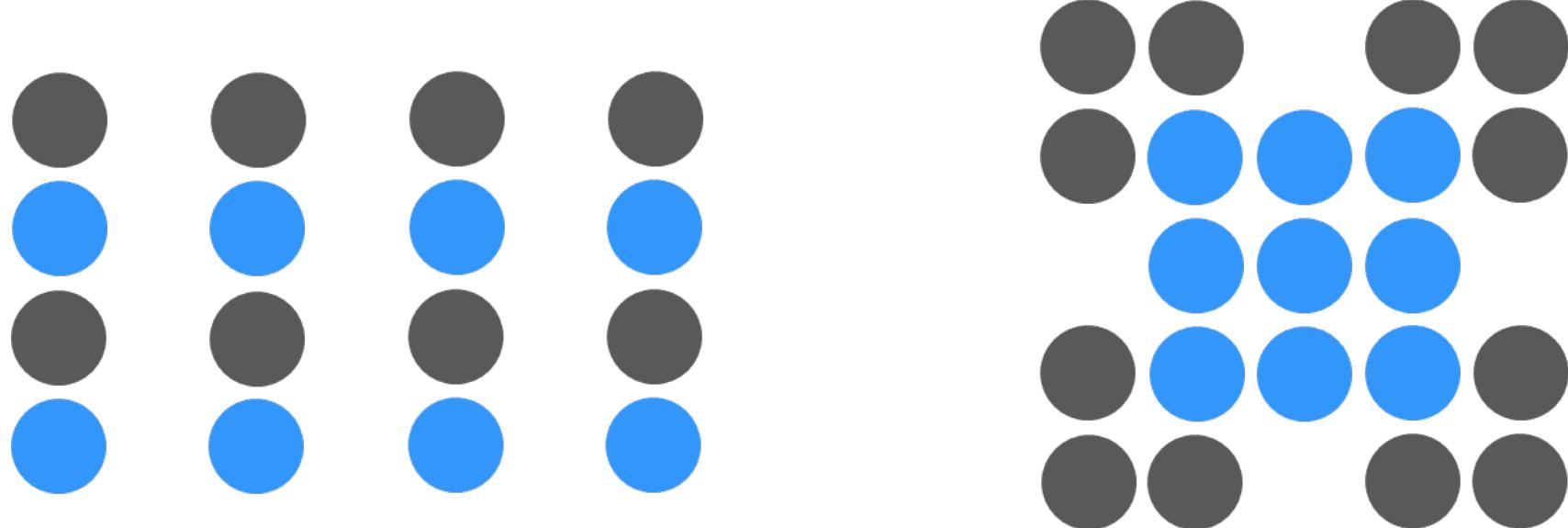
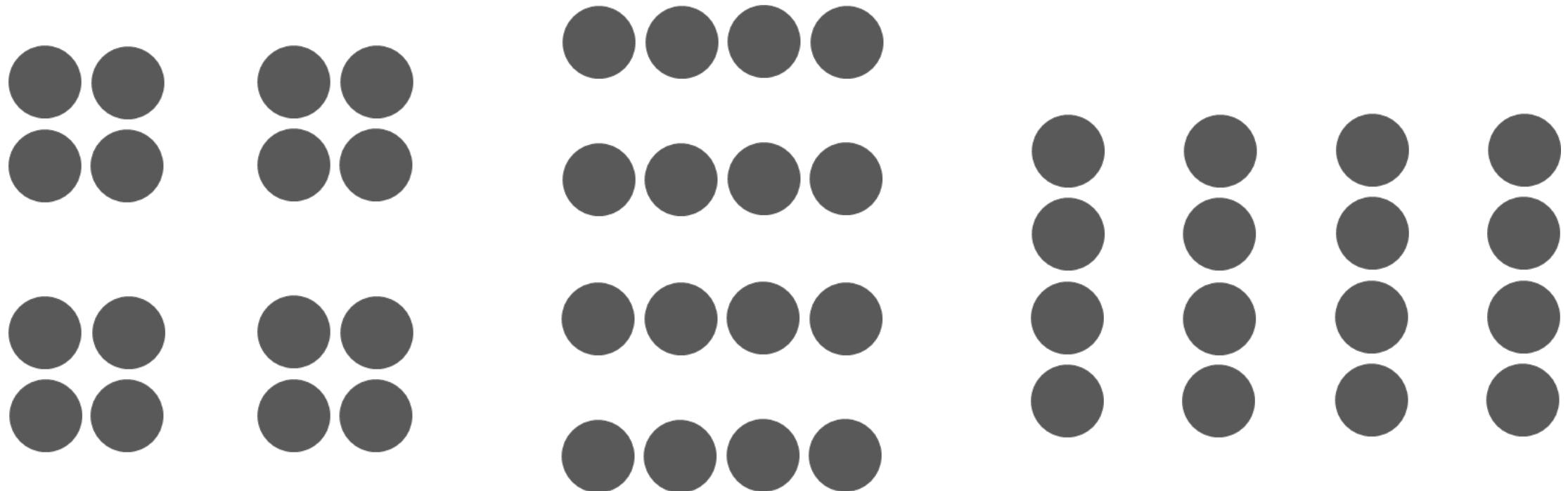


What letter is this?

T
C /- T

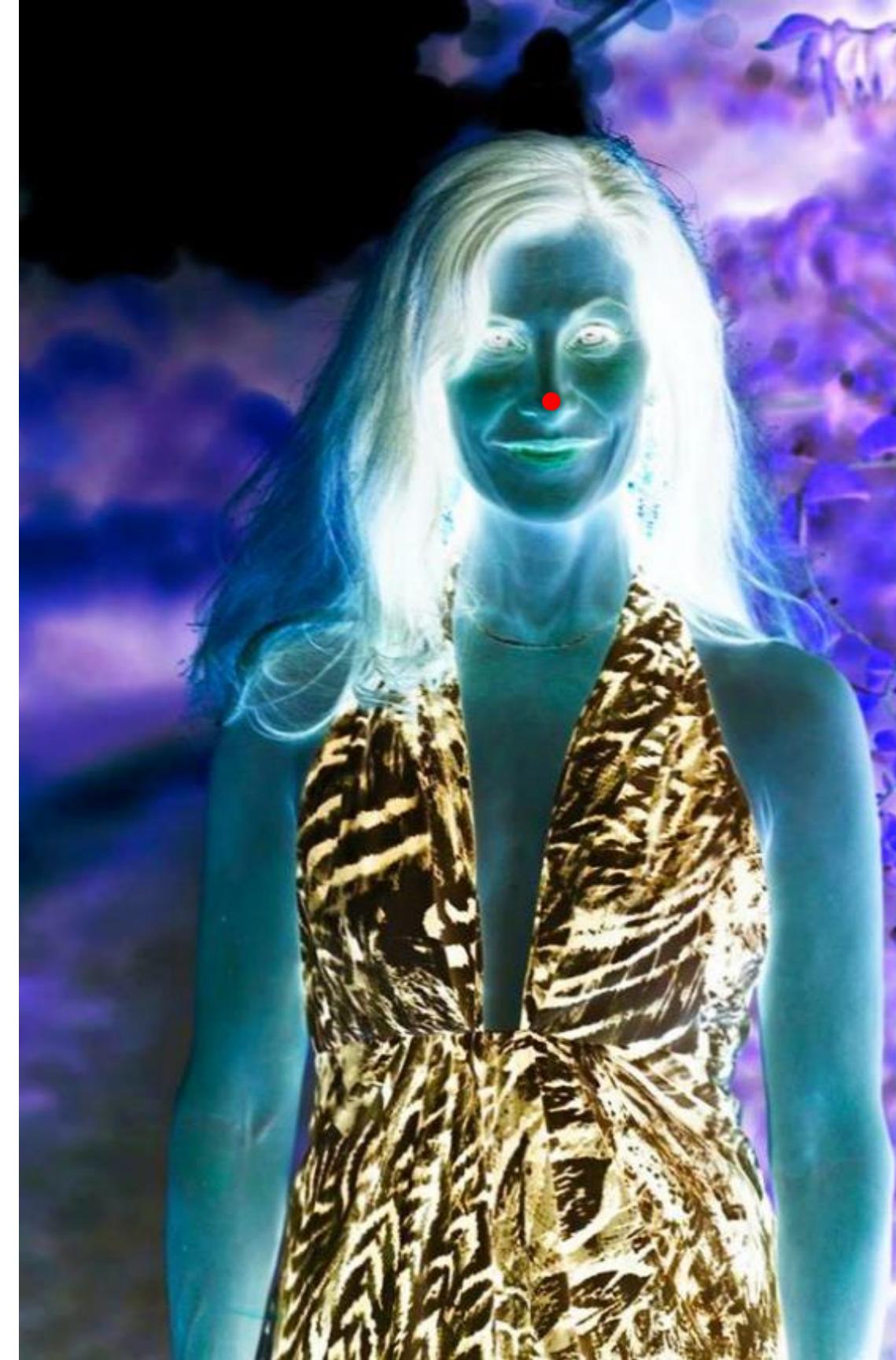
E











Putting it all together

- We live in a world that is rich with data
- Tools let us look at the past, present, and “try out” future scenarios
- Ultimately, we want to understand our world and make better choices, change behavior, grow wealth, improve quality of life, etc.
- We discover *how* to do these things by asking questions through data...

Putting it all together

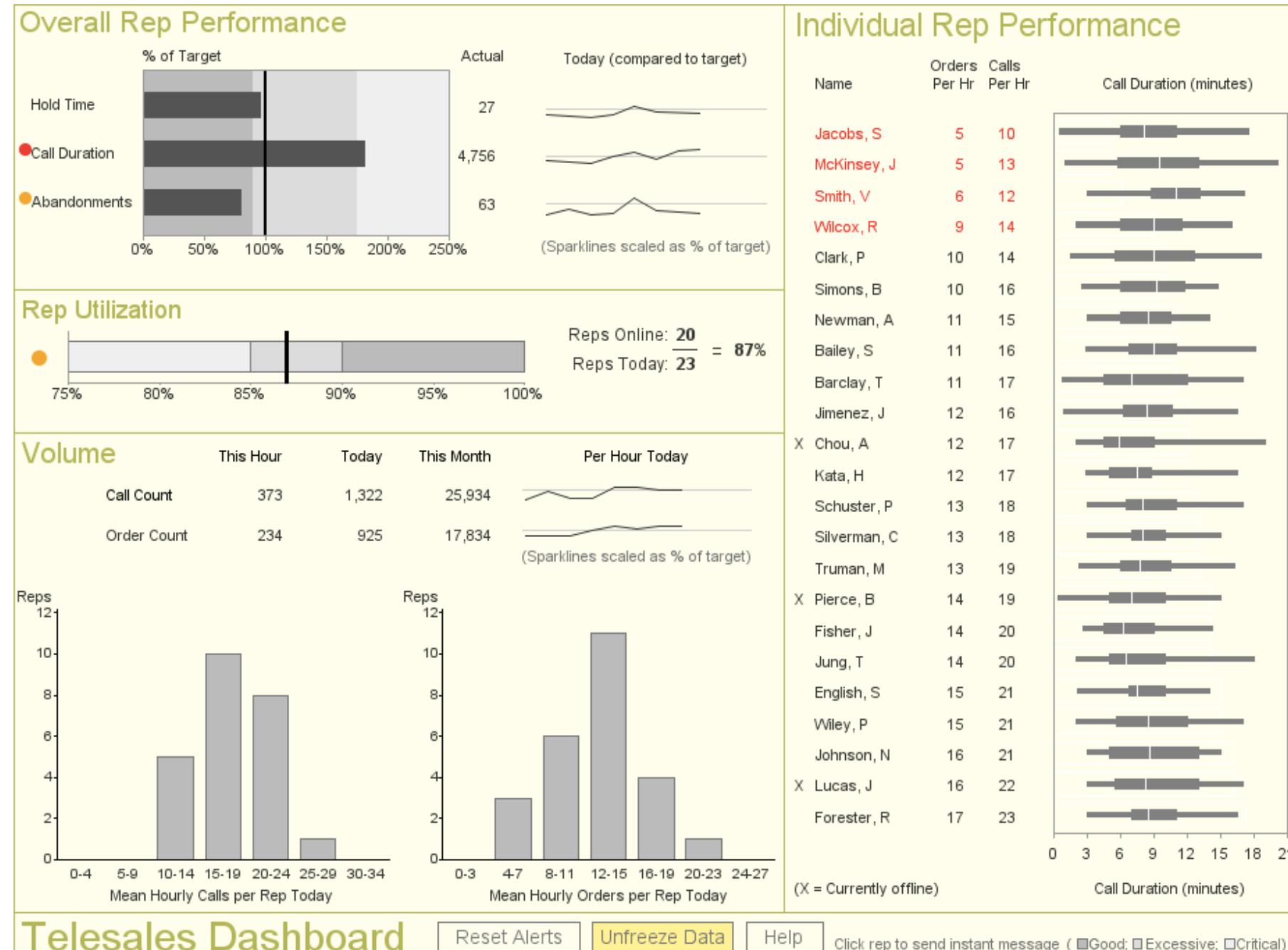
- The understanding and interpretation of data is an activity of human cognition
 - Asking questions, discovering patterns, drawing meaning from the data
 - Creative, visually-driven process; also requires empirical and mathematical skills
 - Requires subject matter knowledge
 - Built-in rules (or at least, guidelines) affect the way we process information

Easy, right? Not so fast...

- Software promises to reveal the answers...but...
 - Computers can't figure out what our data means,^[L] how it connects to the business or problem,^[L] and what to do
 - Data needs are changing (e.g., big data)
 - Users expect “iPhone easy”
- We don't train for visual intelligence

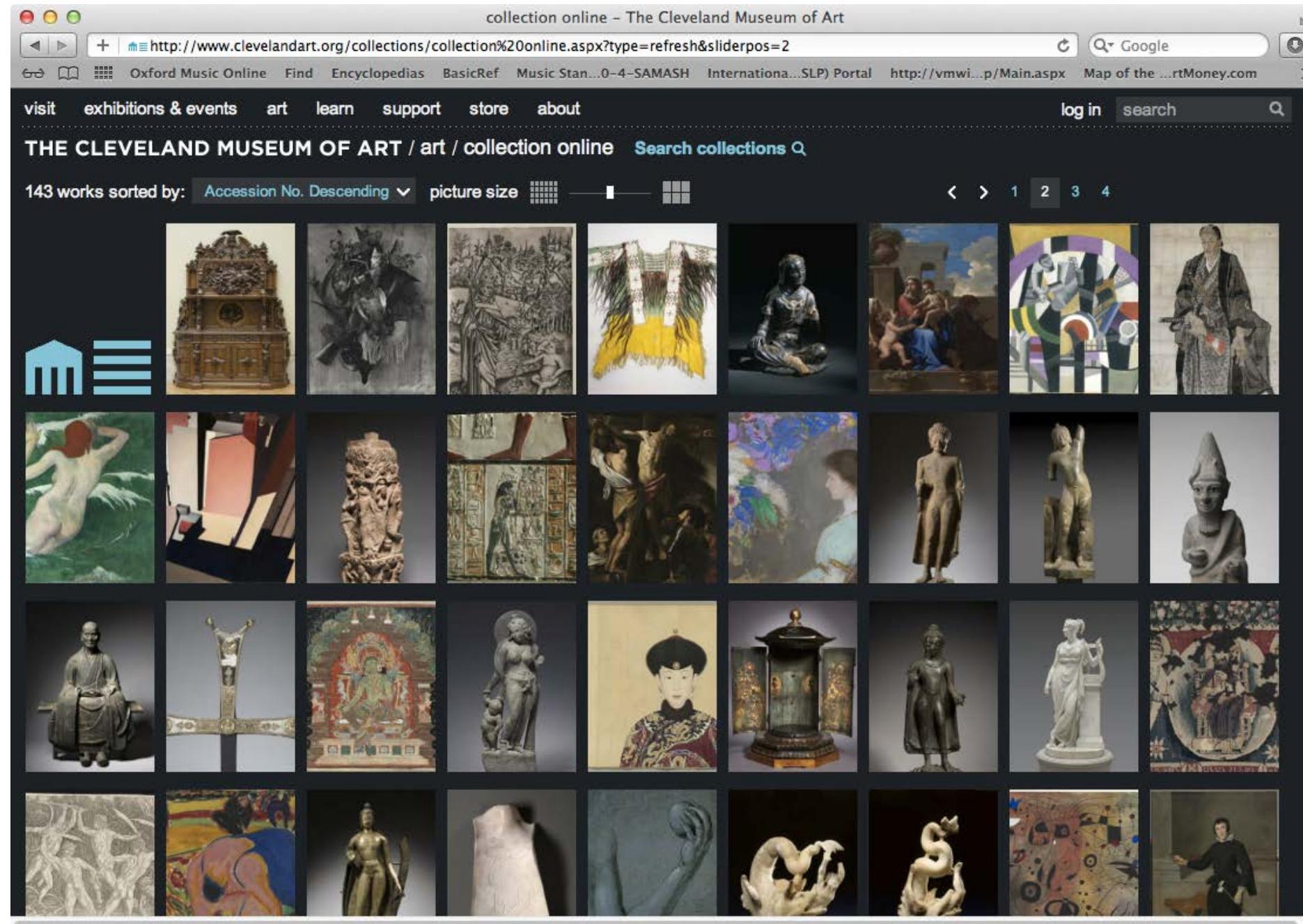
Data + tools + brains >>> business intelligence

Most people agree that this is data visualization...



Source: *Information Dashboard Design* (2 Ed.) by Stephen Few

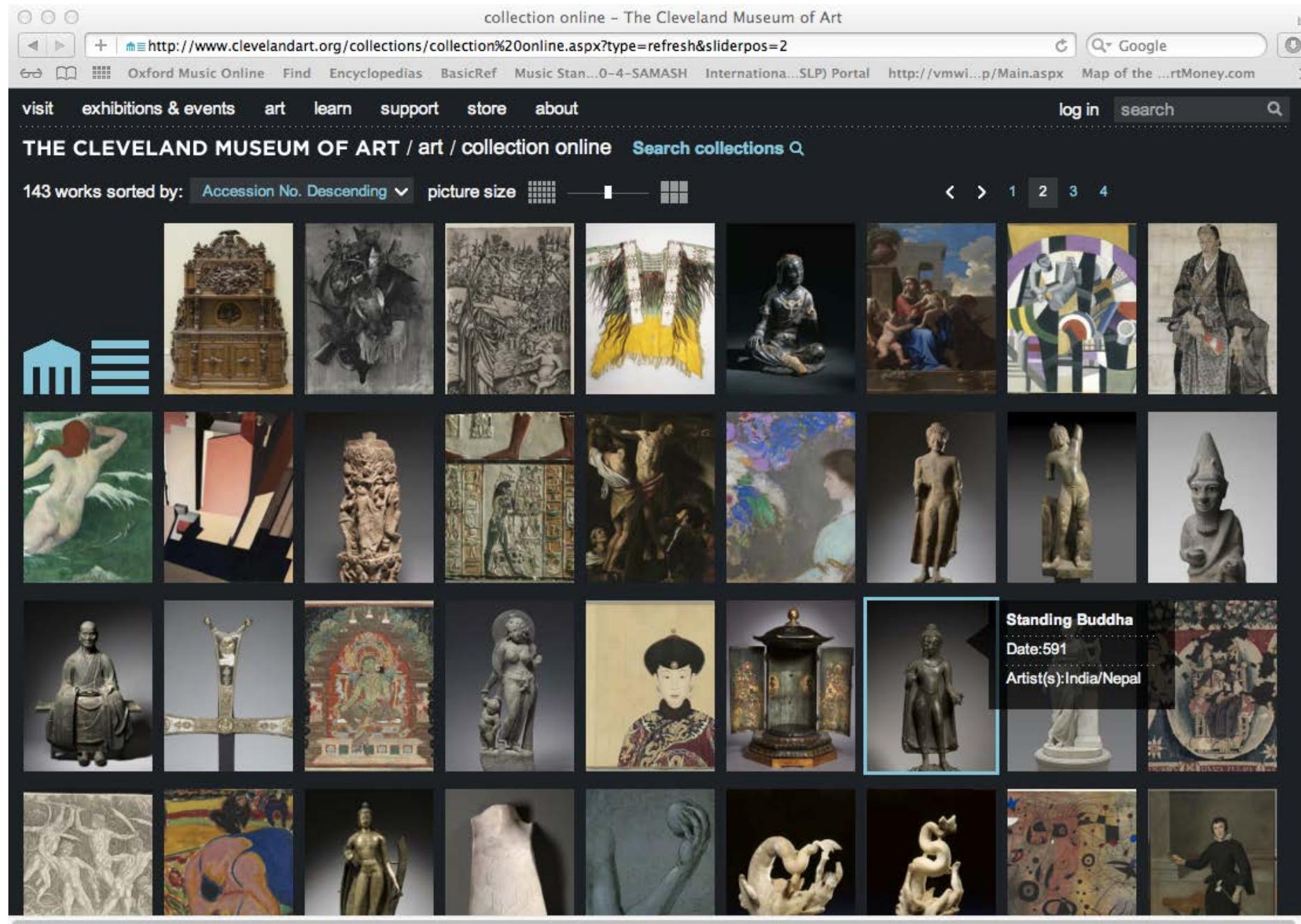
Stretching our thinking about data...



...what about this?

Source: <http://www.clevelandart.org/art/collection/search>

Stretching our thinking about data...

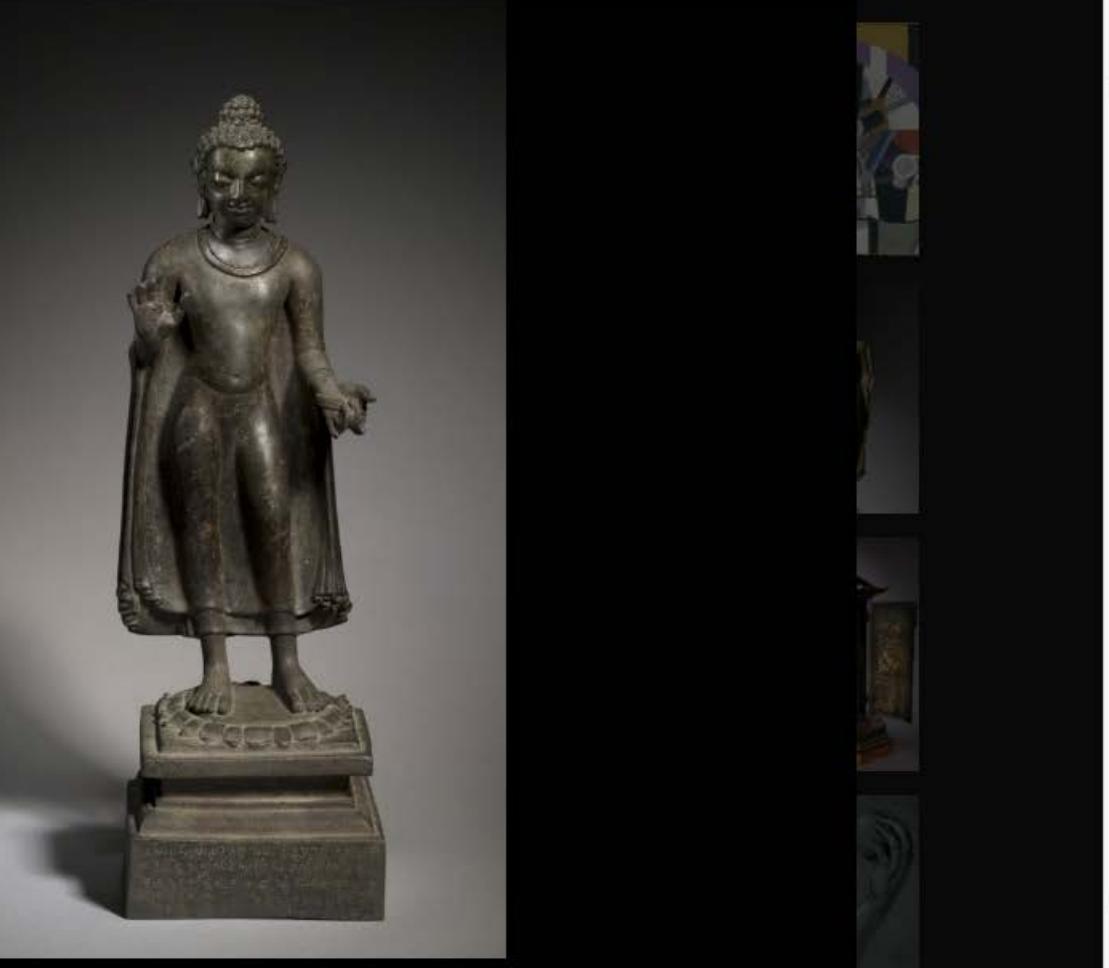


...what about this?

Source: <http://www.clevelandart.org/art/collection/search>

http://www.clevelandart.org/collections/collection%20online.aspx?type=refresh&sliderpos=2

Oxford Music Online Find Encyclopedias BasicRef Music Stan...0–4-SAMASH Internationa...SLP) Portal http://vmwi...p/Main.aspx



Close X

Standing Buddha

India/Nepal, Gupta/Licchavi period

Date: 591

Medium: bronze

Dimensions: Overall - h:45.80 cm (h:18 inches)

Department: Indian and South East Asian Art

Type of art work: Sculpture

Credit Line: Purchase from the J. H. Wade Fund

- [Overview](#)
- [Comments \(0\)](#)
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- [Share](#)

collection online – The Cleveland Museum of Art

http://www.clevelandart.org/collections/collection%20online.aspx?type=refresh&sliderpos=2

Oxford Music Online Find Encyclopedias BasicRef Music Stan...0–4–SAMASH Internationa...SLP Portal http://vmwi...p/Main.aspx

Dimensions: Overall - h:45.80 cm (h:18 inches)

Department: Indian and South East Asian Art

Type of art work: Sculpture

Credit Line: Purchase from the J. H. Wade Fund

Accession No.: 1968.40

Location: Not on view

11150 East Boulevard
Cleveland, Ohio 44106

info@ClevelandArt.org

Copyright © 2011 Cleveland Museum of Art. All rights reserved.

Metal sculptures are rare in early Indian art, and the fact that this bronze can be dated to the year 591 by reading the inscription only adds to the sculpture's importance, as very few dated images of that period exist. It reflects the style of classical Sarnath images of the Gupta period: the Buddha wears transparent garments that reveal the modeling of the body underneath and stands with one hand raised in a gesture of blessing (abhaya mudra) while the other supports the hem of the monastic garment. This style inspired Himalayan and Southeast Asian sculpture, as evidenced by the Mon-Dvaravati Buddha in the collection. However, the bronze's facial features appear somewhat fleshier than those of Sarnath images, casting doubt that the sculpture was made in Sarnath proper. The Buddha is small enough to have been produced in India and carried to Nepal, where it was inscribed.

Inscription: Dated inscription (corresponding to 632) engraved on front of base and extending to its right side: translation "This (image) is the pious gift of the Buddhist nun named Parisuddhamati in the village Ladita. Whatever merit accrues from this (gift) may it lead to the supreme enlightenment of all living beings. (This gift was made) in the year 313 (300.10.3). (It is the wish) that (a certain ascetic) Purnnaka belonging to the monastery in the locality of Chaityakuta should be fed."

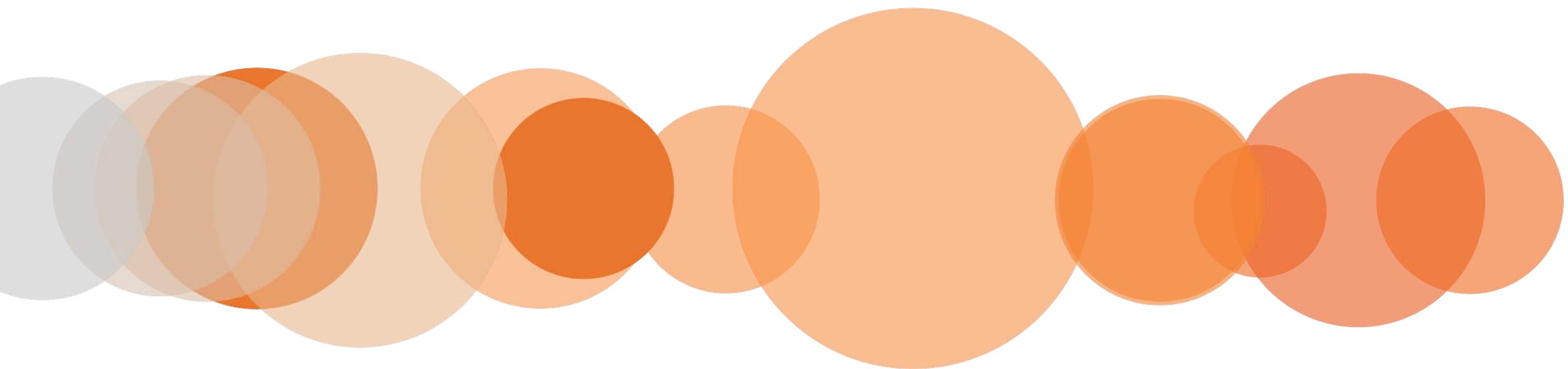
Join our online community or Log in to add a tag for this object.

Research objects further on the library's website.

Concluding Thoughts

- Ultimately, we're trying to understand our world and make better choices, change behavior, enhance wealth, or improve quality of life.
- Learning more about the way our brains work, how we perceive and process data, and improving how we practice visualization
is essential to achieving these goals.

The Building Blocks of Data Visualization



We are born with an enhanced visual path to cognition

- Approximately 70% of sense receptors are in our eyes
- 40% of the cerebral cortex is involved in processing visual information
- The visual connection to the brain has more bandwidth than other paths
- Visual perception is intimately connected to understanding
- This is reflected in language
 - “I see what you’re talking about...”
 - “Sketch out the idea...”
 - “Seeing is believing...”

Our brain is powerful... but working memory is limited

- Long-term memory is very important
- Working memory limited to a small number of “chunks”
- Visualization allows us to consolidate complex statistics so we can process more data simultaneously (seeing the forest along with the trees)
- The picture is not the end goal – It’s what we do with it that is important

Making sense of our visual world...

According to Bertin, our perception of data on a typical printed page is associated with the following visual variables:⁹

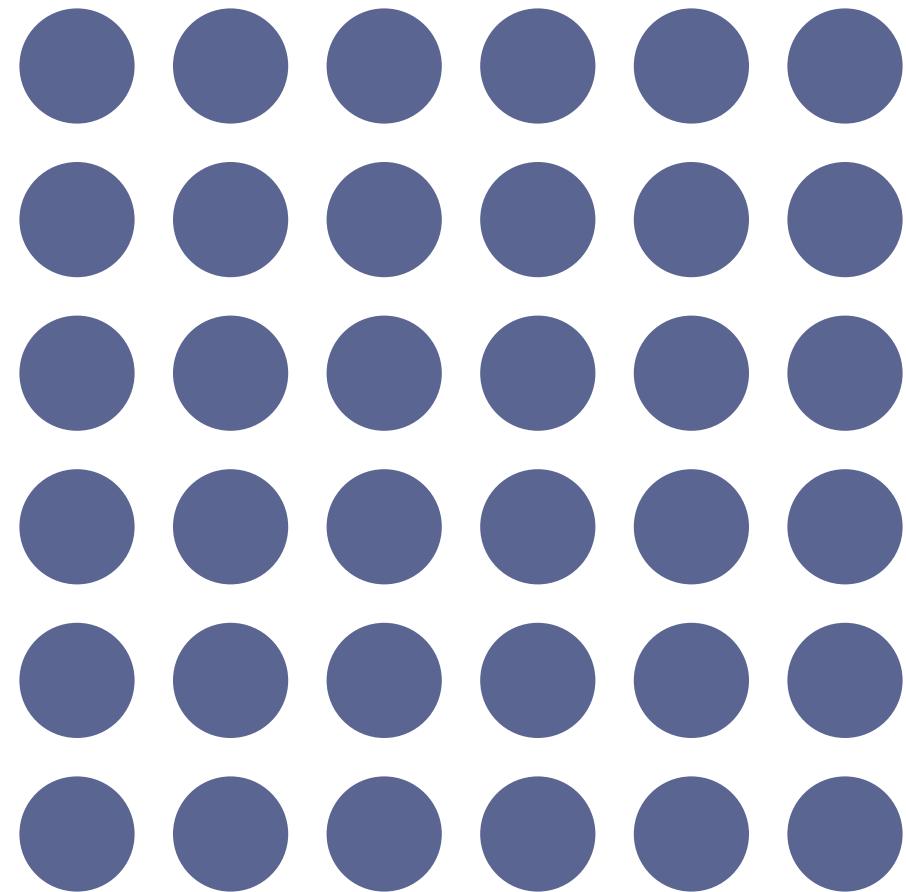
- **Shape**
- **Texture**
- **Orientation**
- **Value**
- **Color**
- **Size**

...and the two planar dimensions (x and y)
which are encoded in **Position** and **Order**.

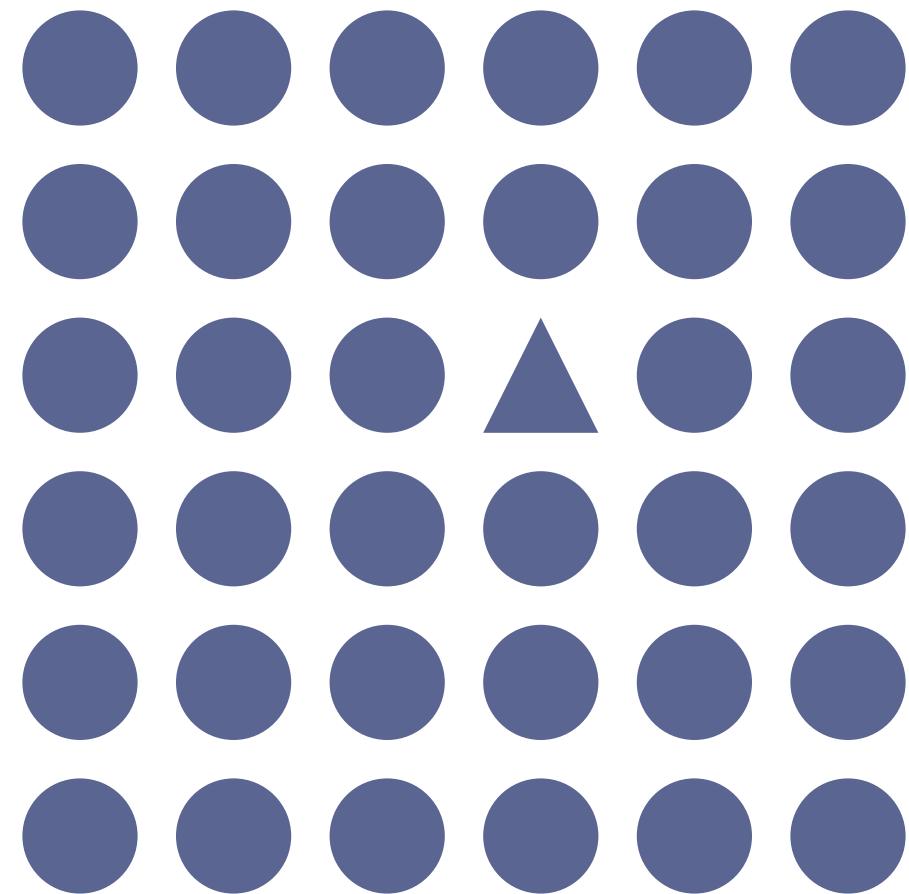
Based on the contemporary preponderance of digital technology, these factors have also become critical:

- **Motion** – animated presentation of frames of data
- **Medium** – the physical strata on which data is displayed
- **Context** – the sensory and emotional environment

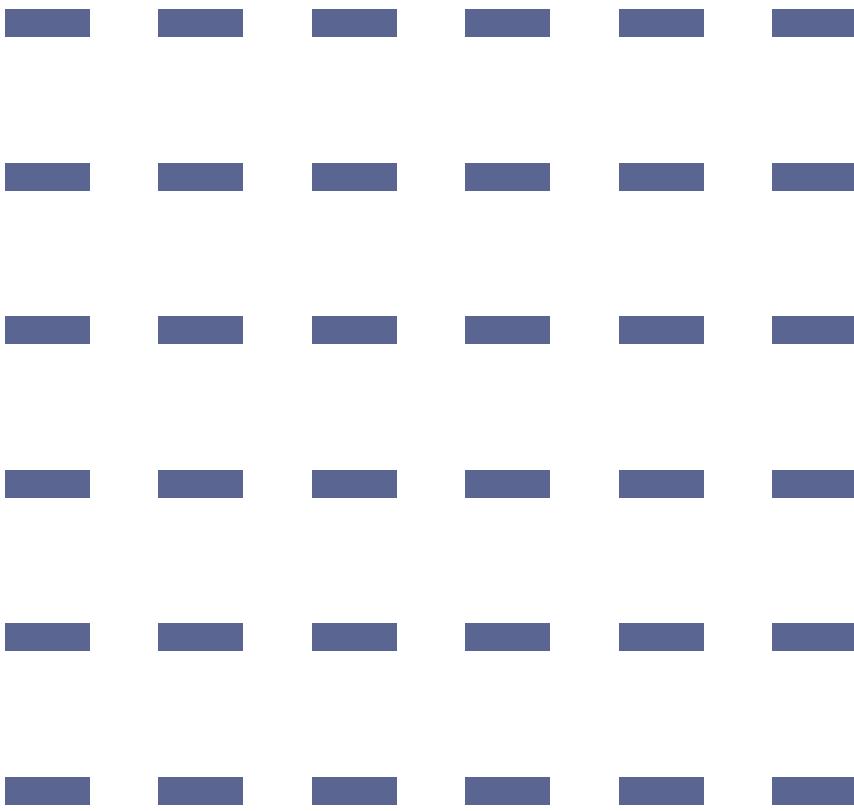
Shape



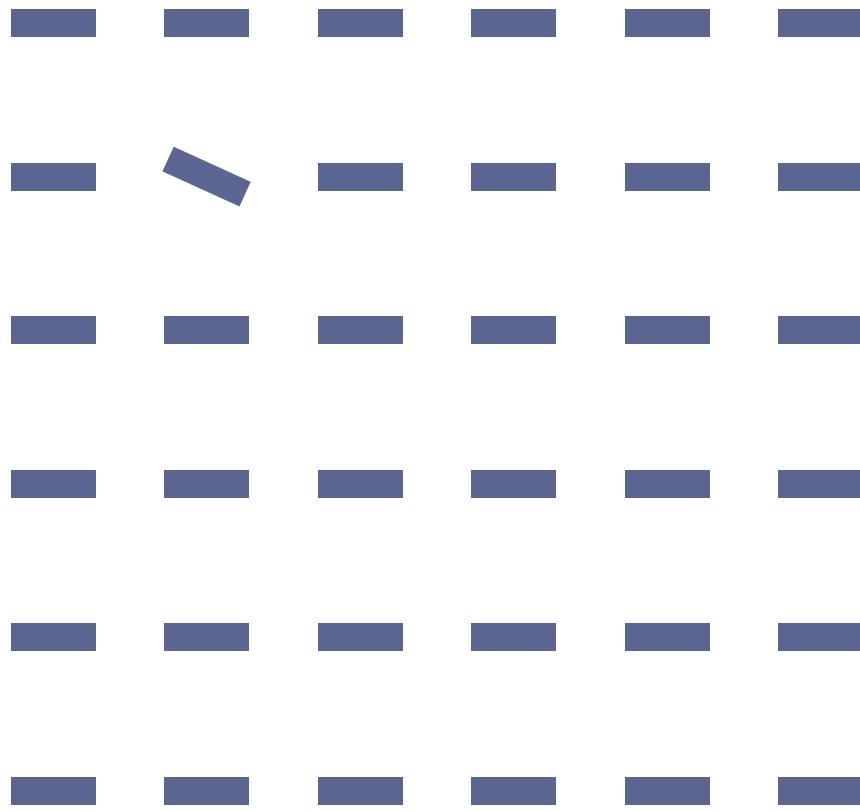
Shape



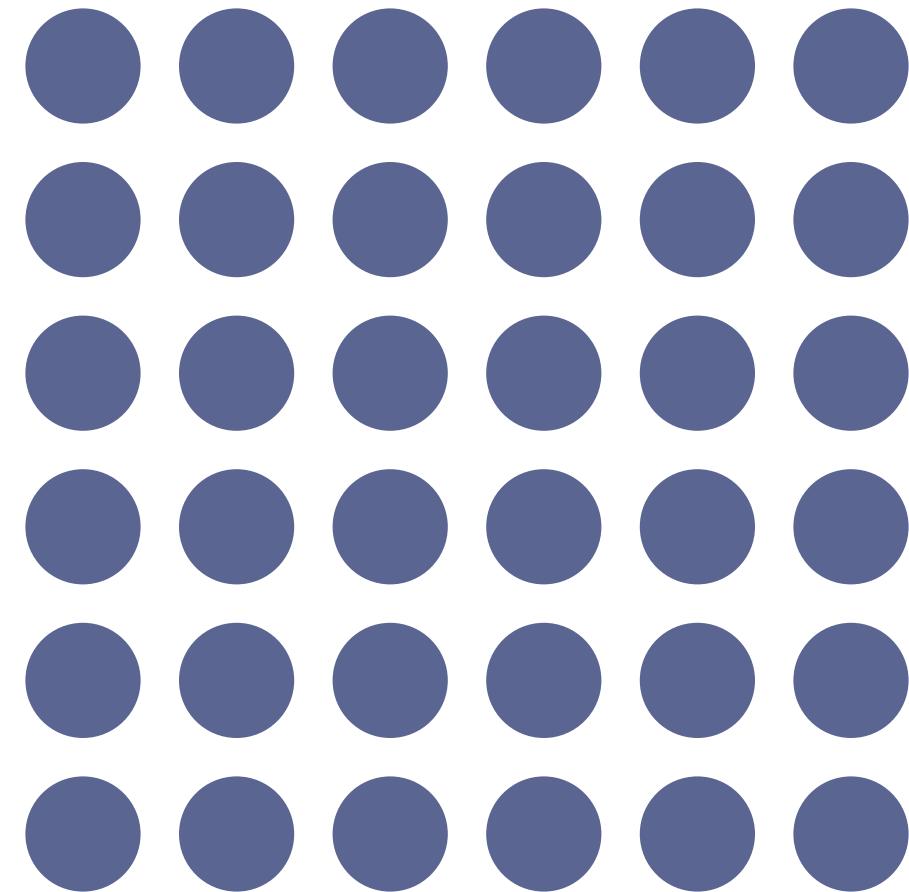
Orientation



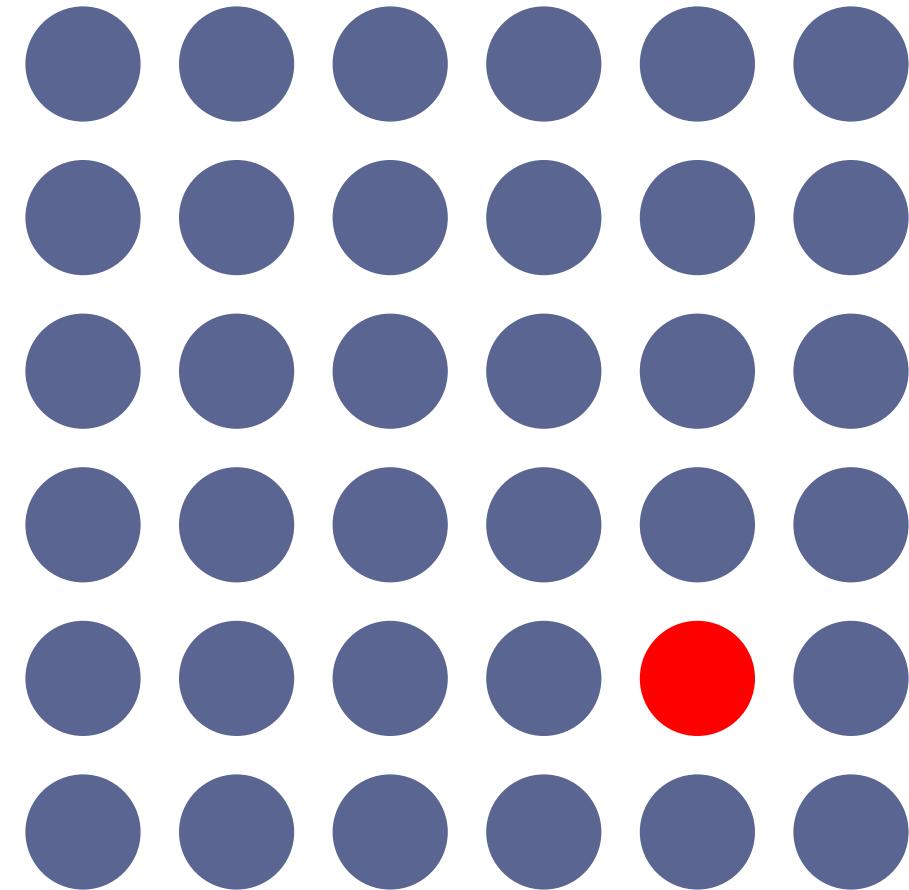
Orientation



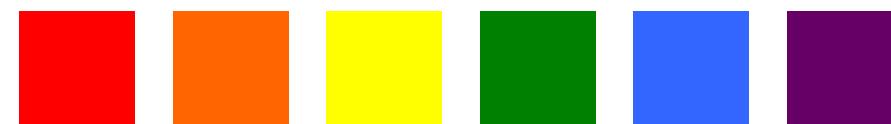
Color (Hue)



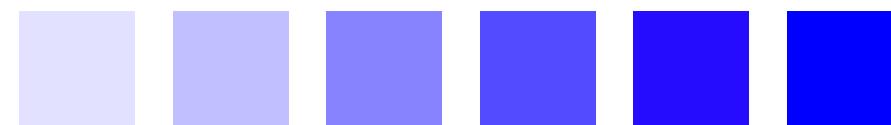
Color (Hue)



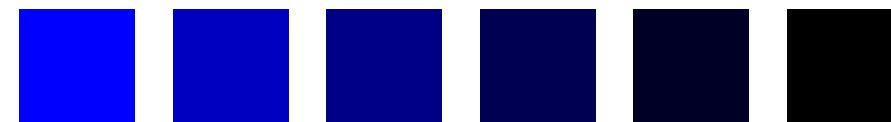
Changes to the **HUE** (color)



Changes to the **SATURATION** (intensity)



Changes to the **Value** (brightness)





Relationships on a Traditional Color Wheel

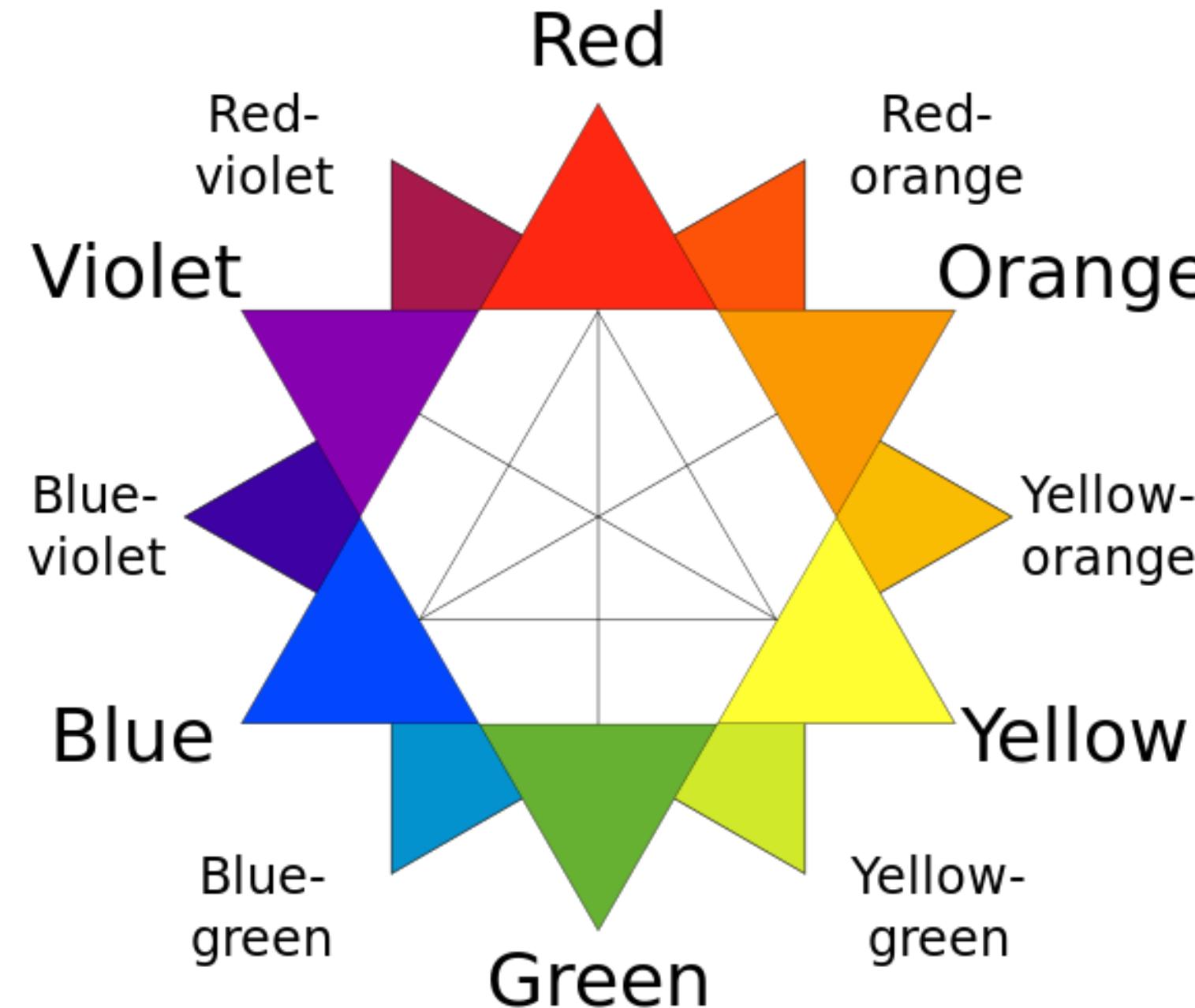


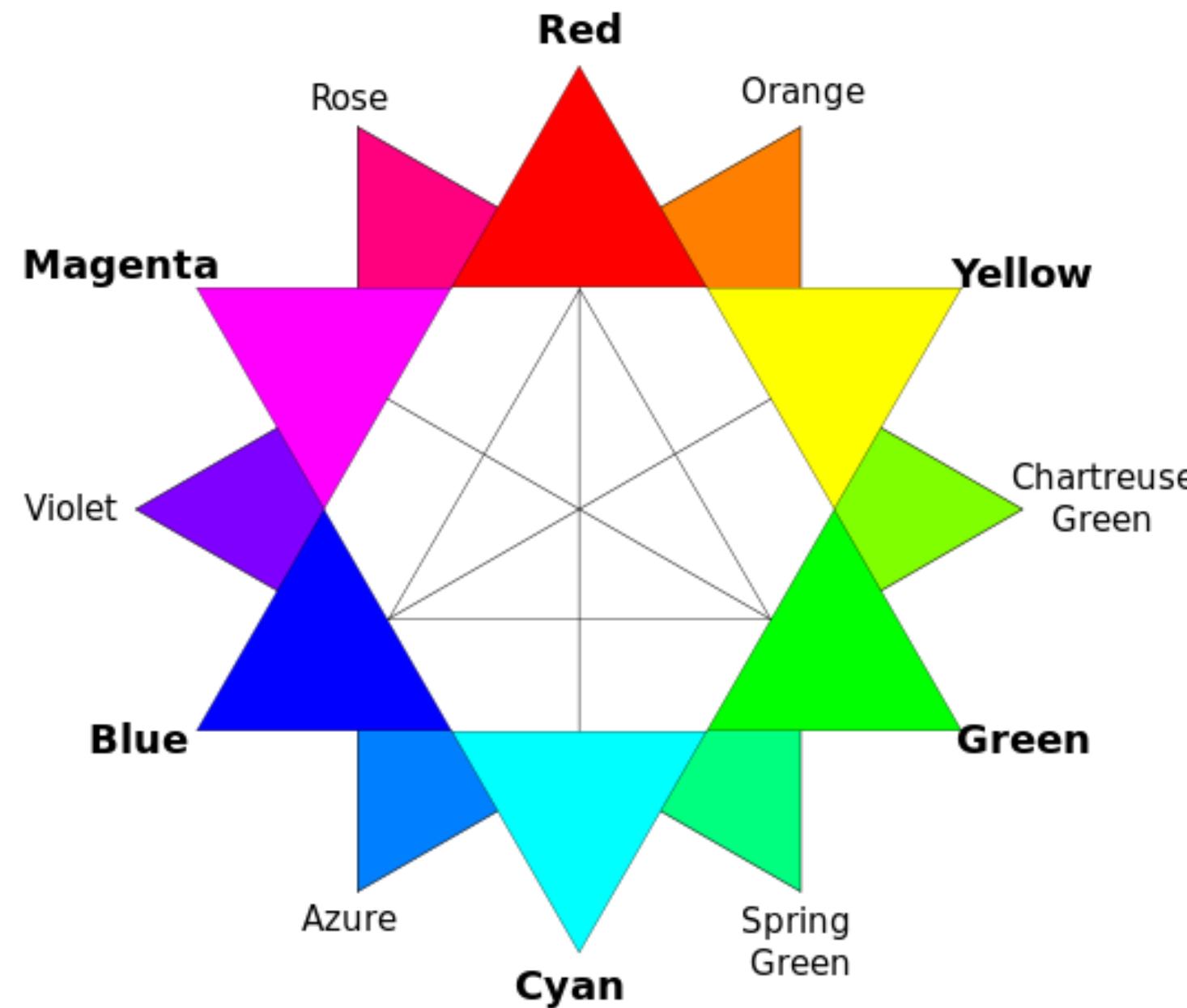
Image used under the Wikipedia
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<http://www.wikipedia.com>

The primary colors are red, yellow, and blue.

Classical painters would have used this arrangement to find compliments.

Relationships on a RGB Color Wheel

Image used under the Wikipedia
Creative Commons license.
<http://www.wikipedia.com>



*Computer displays use red, green, and blue elements.
This results in a shifted arrangement of complimentary colors.*

THE USE OF COLOR IN DATA VISUALIZATION

SEQUENTIAL

color is ordered from low to high



DIVERGING

two sequential colors with a neutral midpoint



CATEGORICAL

contrasting colors for individual comparison



HIGHLIGHT

color used to highlight something



ALERT

color used to get reader's attention



Does this color use enhance or detract?

AT&T 10:32 AM 71 %

THE WALL STREET JOURNAL.

AS PRINTED ON SATURDAY, AUGUST 7, 2010

Welcome, Eric Duell ***

Job Market Loses Steam With 14.6 Million Seeking Work

Private Sector Expands Slightly, but Governments Cut Jobs; Treasury Yields Dip

By Sudeep Reddy

The government's latest snapshot of the job market was bleak, a sign the economic recovery is running out of steam with 14.6 million Americans still searching for work.

Job growth proved anemic in July as governments cut jobs and private-sector employers barely expanded.

The economy shed 131,000 jobs, as 143,000 temporary Census workers fell off federal payrolls. Private-sector employment grew by 71,000 in July after a downwardly revised 31,000 in June. Government employment, not counting Census workers, fell by 59,000.

The unemployment rate held steady at 9.5% largely because people gave up hope of finding work and left the labor force.

The latest figures confirm the labor market has lost much of its momentum in recent months. The private sector has added 90,000 jobs a month on average so far this year, well below the 125,000 needed monthly just to keep up with

Change in nonfarm payrolls, in thousands Yield on the two-year Treasury note

July's change in jobs: -131,000 Friday's closing yield: 0.514%

Sources: Labor Department; Ryan ALM

Video Images

population growth, let alone recover the eight million jobs lost during the recession. Two-thirds of the private-sector job creation this year occurred in March and April, when the economy's trajectory appeared stronger.

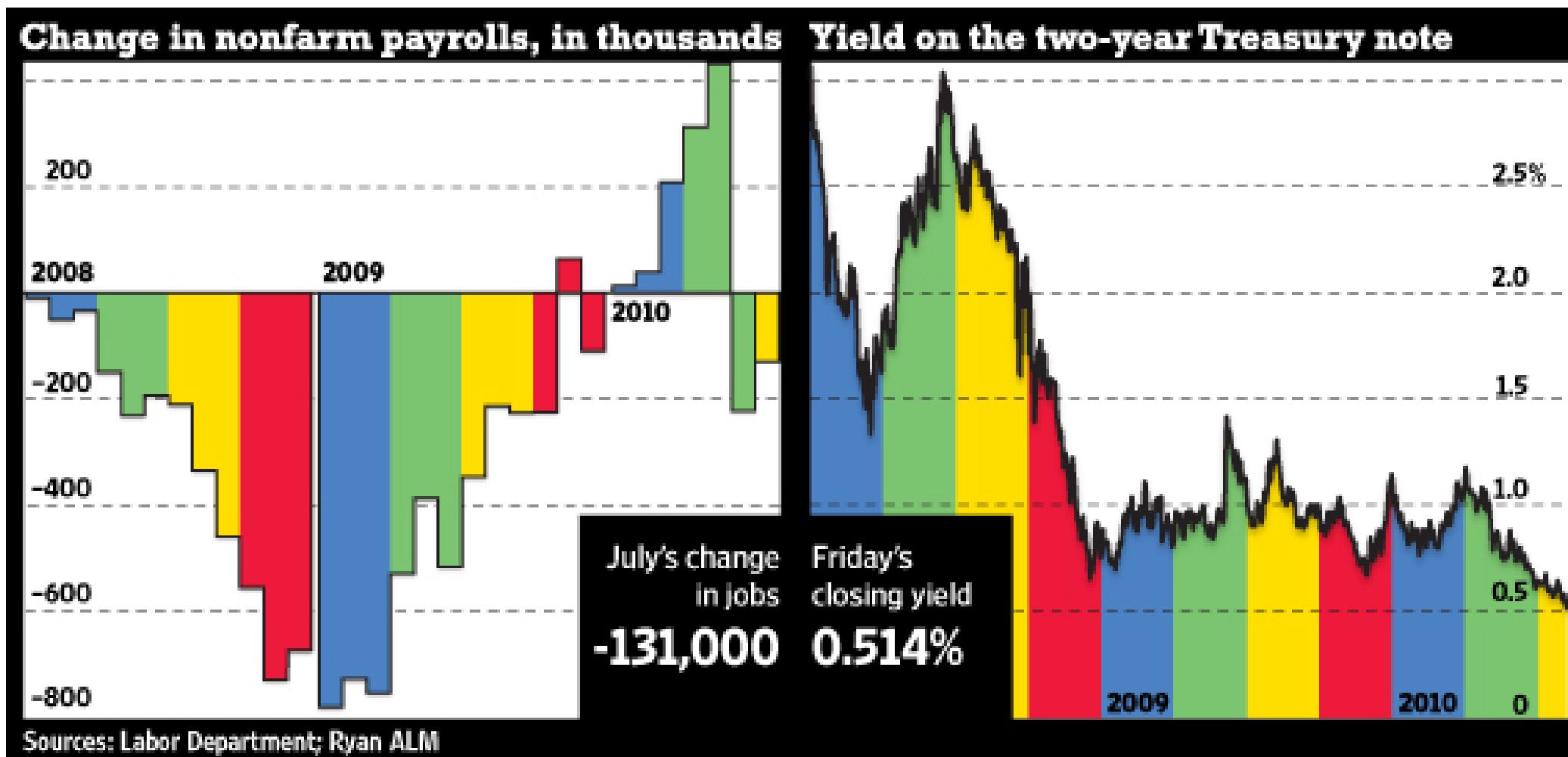
Article continues...

2011 BUICK REGAL ▾

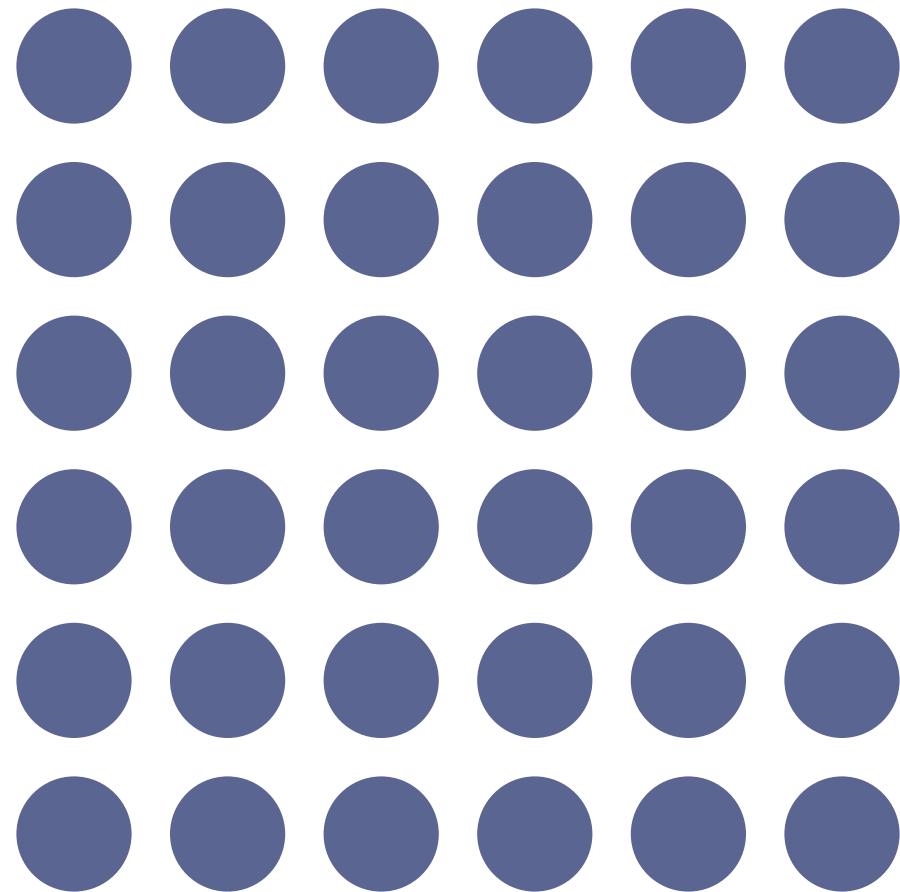
ISSUE 20% DOWNLOADED Tools Sections Next »

Front Section...
2 of 26 Articles
H-P Chief Quits in Scandal
Job Market Loses Steam With 14.6 Million Seeking Work
Busted Russian Spy Wants Old Life Back
Good Thing Hotels Don't Charge For Left-Behind Chargers
Fannie Mae Critic Sues Over Firing
Target Discovers Downside to Political Contributions
City Resorts to Pac-Man for a Reboot
As the East Roasts, the West Chills Out
Fed Board

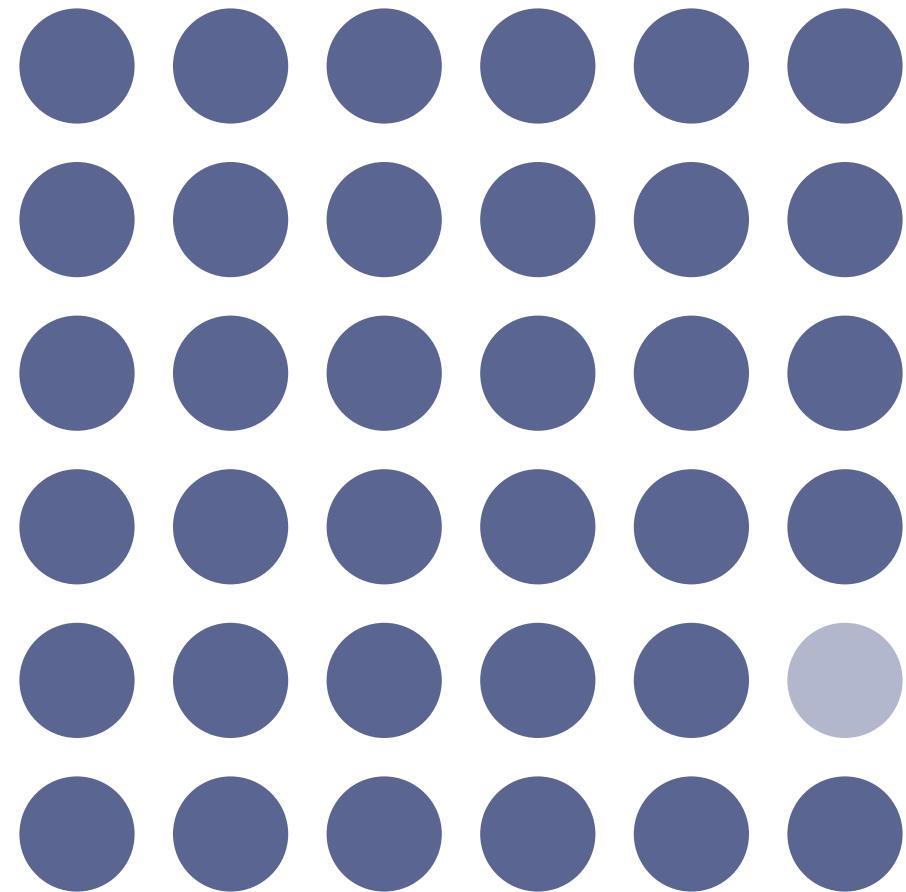
What does color even mean here?



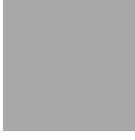
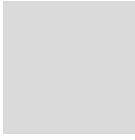
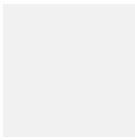
Color (Value)



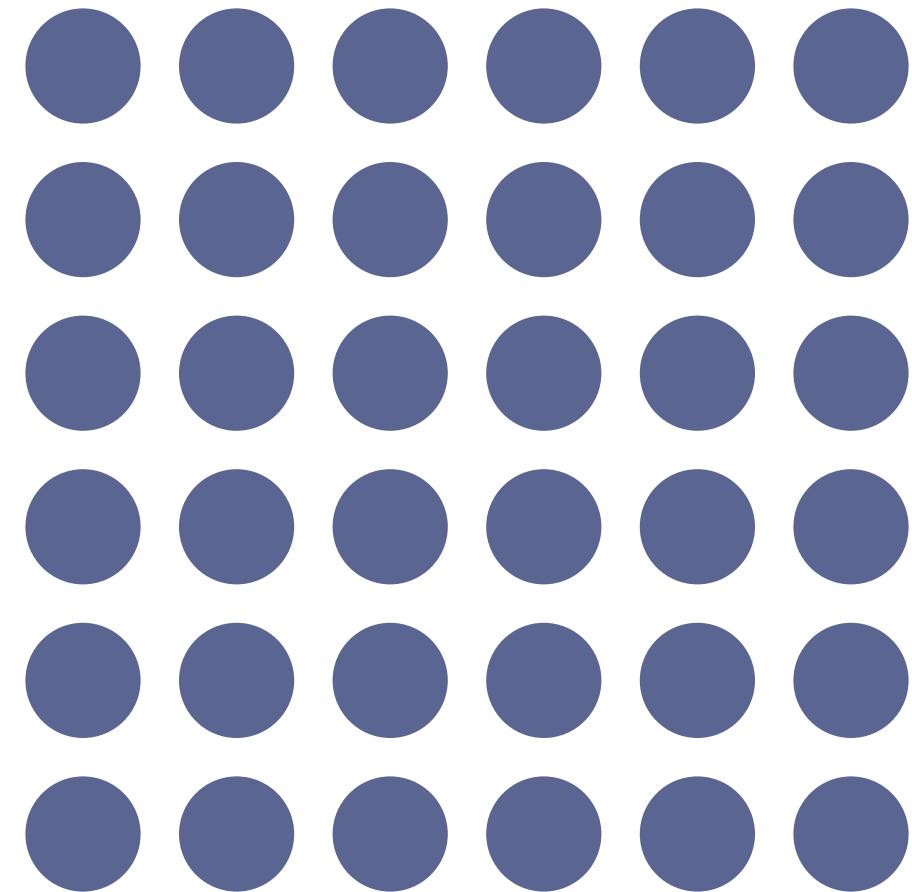
Color (Value)



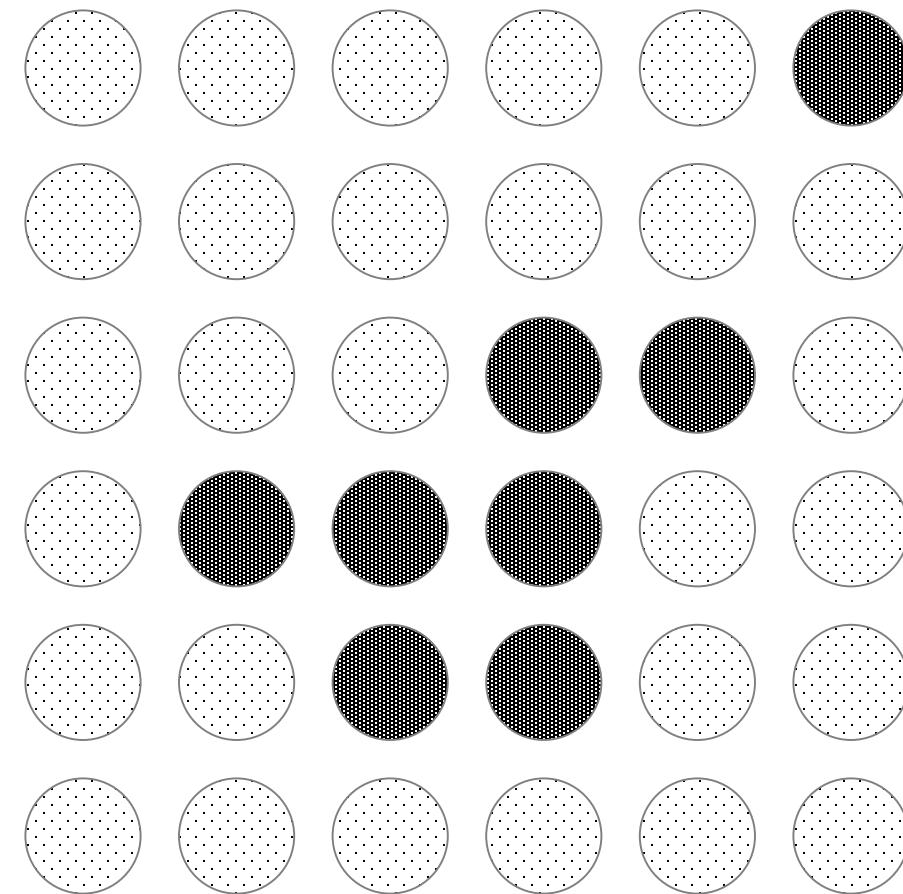
Color (Value)



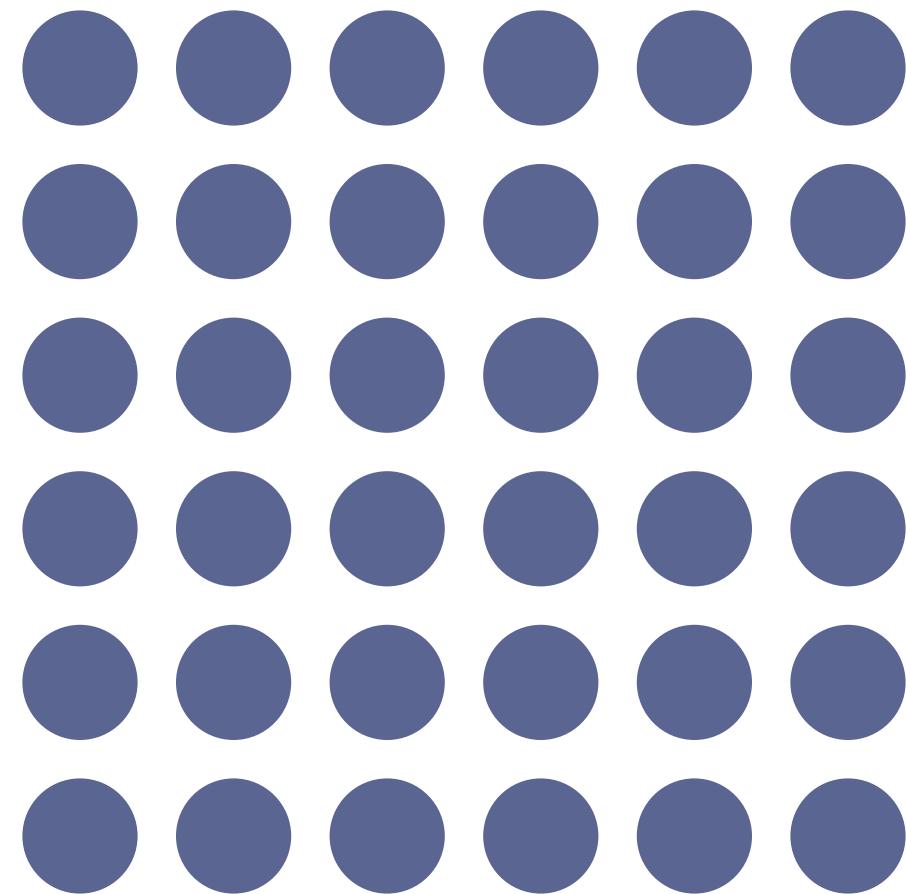
Texture



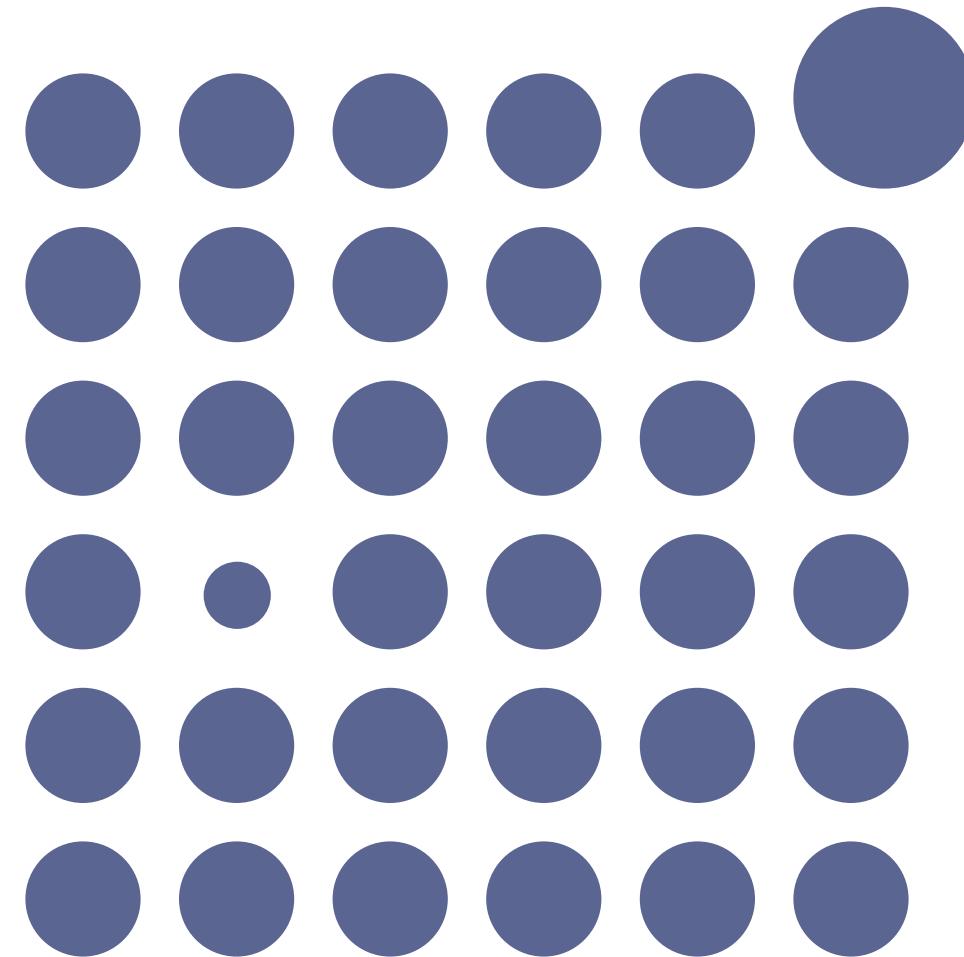
Texture



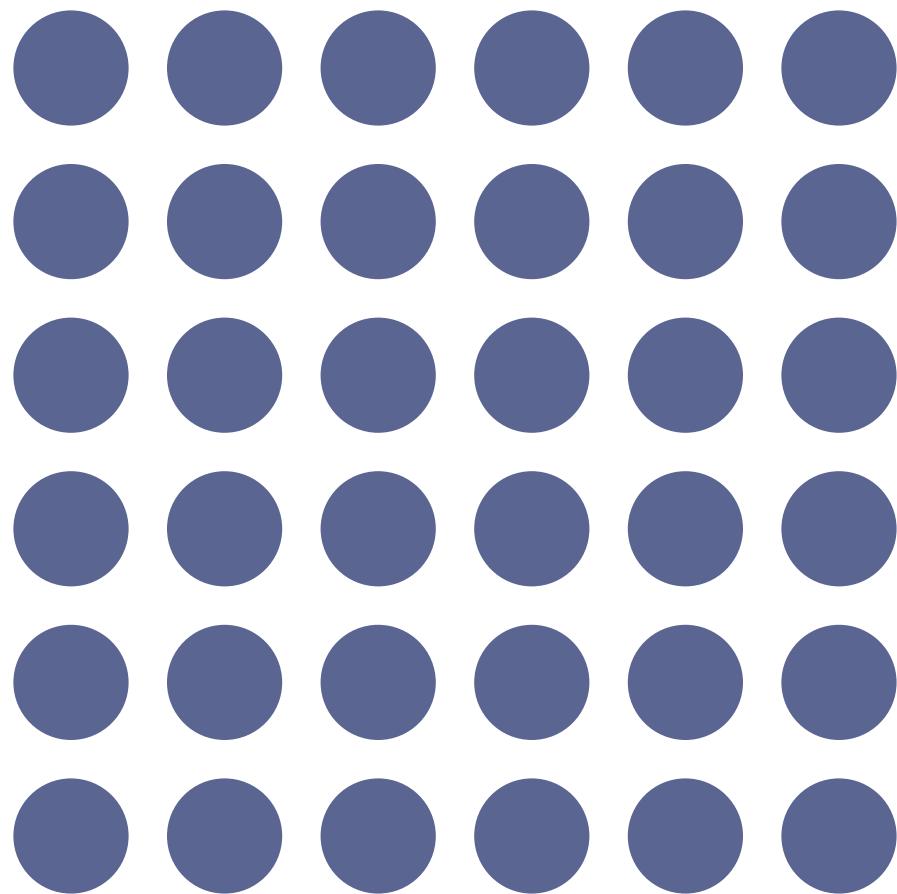
Size



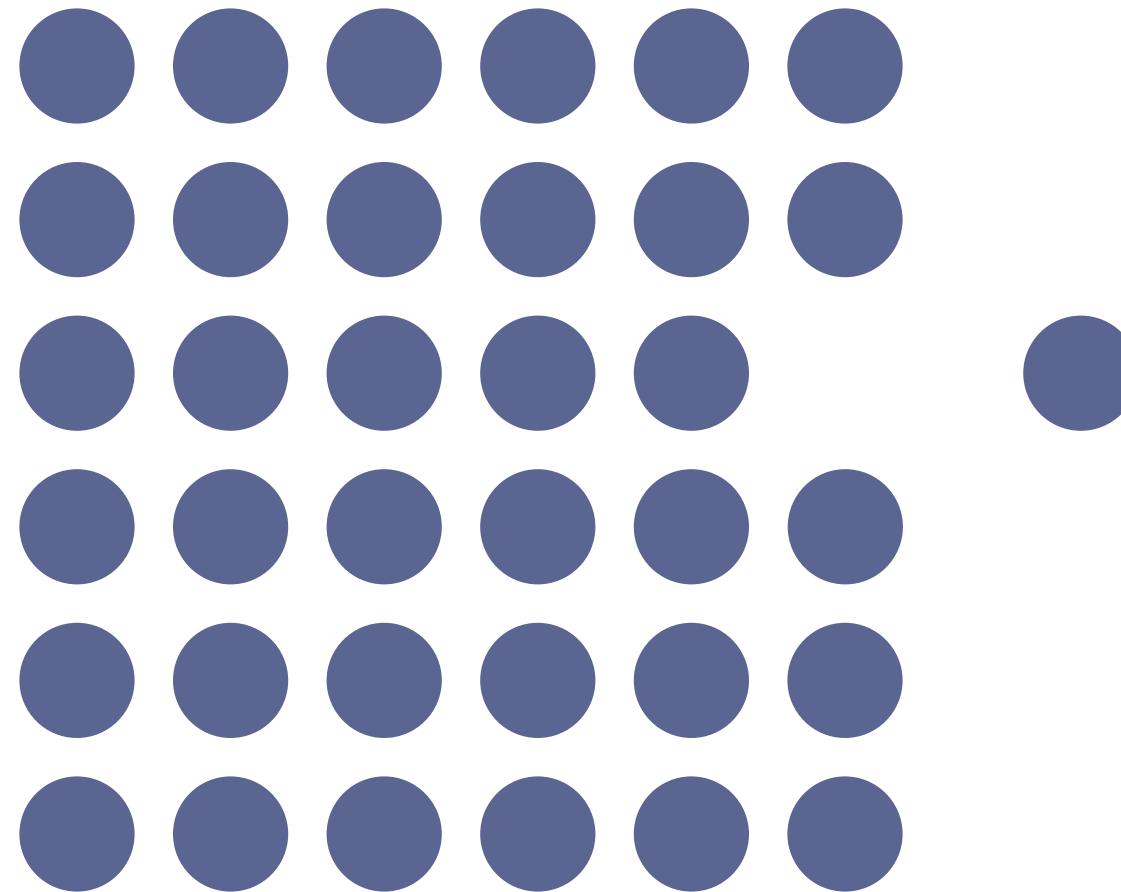
Size



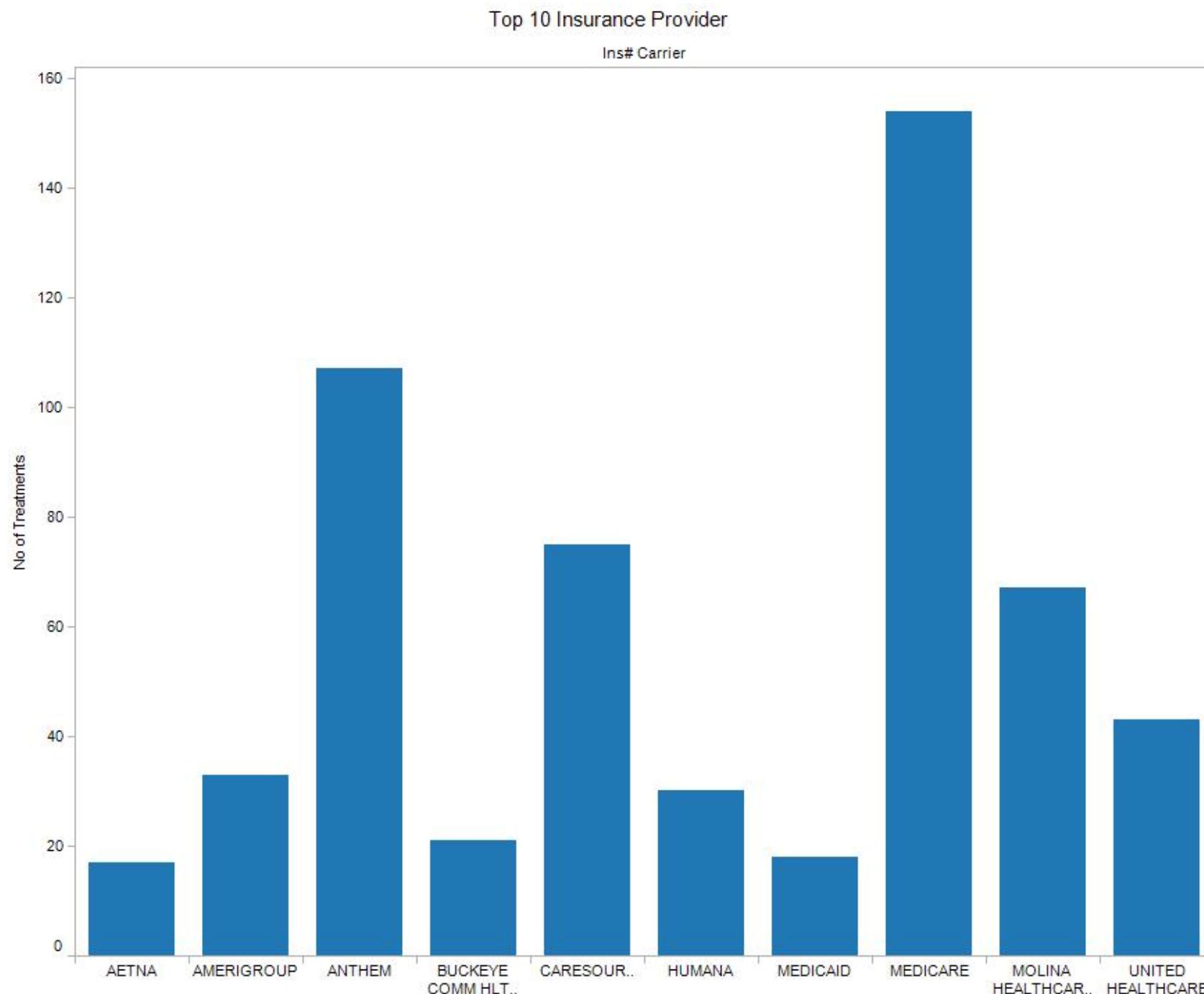
Position



Position



Order

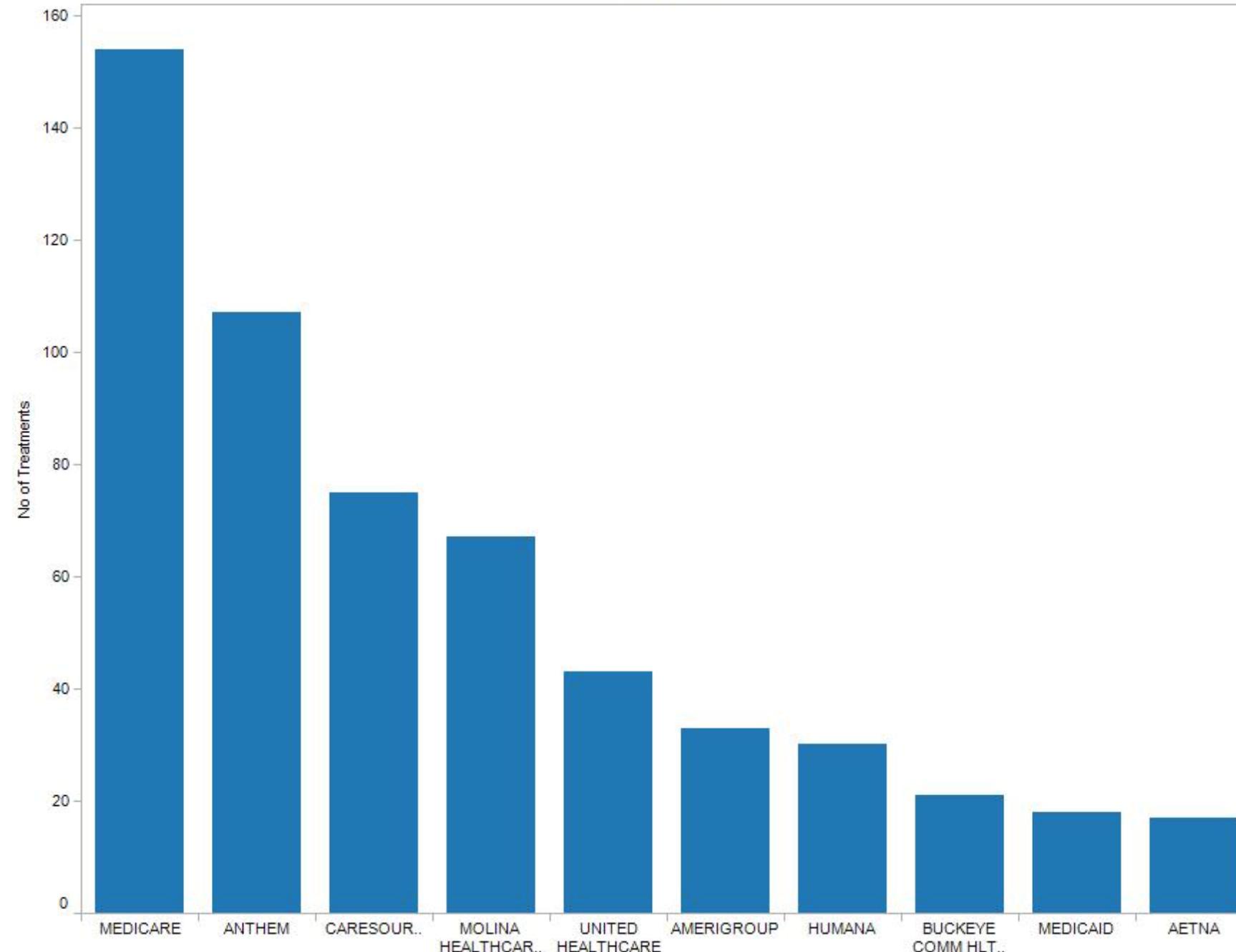


Sum of No of Treatments for each Ins# Carrier. The view is filtered on sum of No of Treatments and Ins# Carrier. The sum of No of Treatments filter keeps all values. The Ins# Carrier filter has multiple members selected.

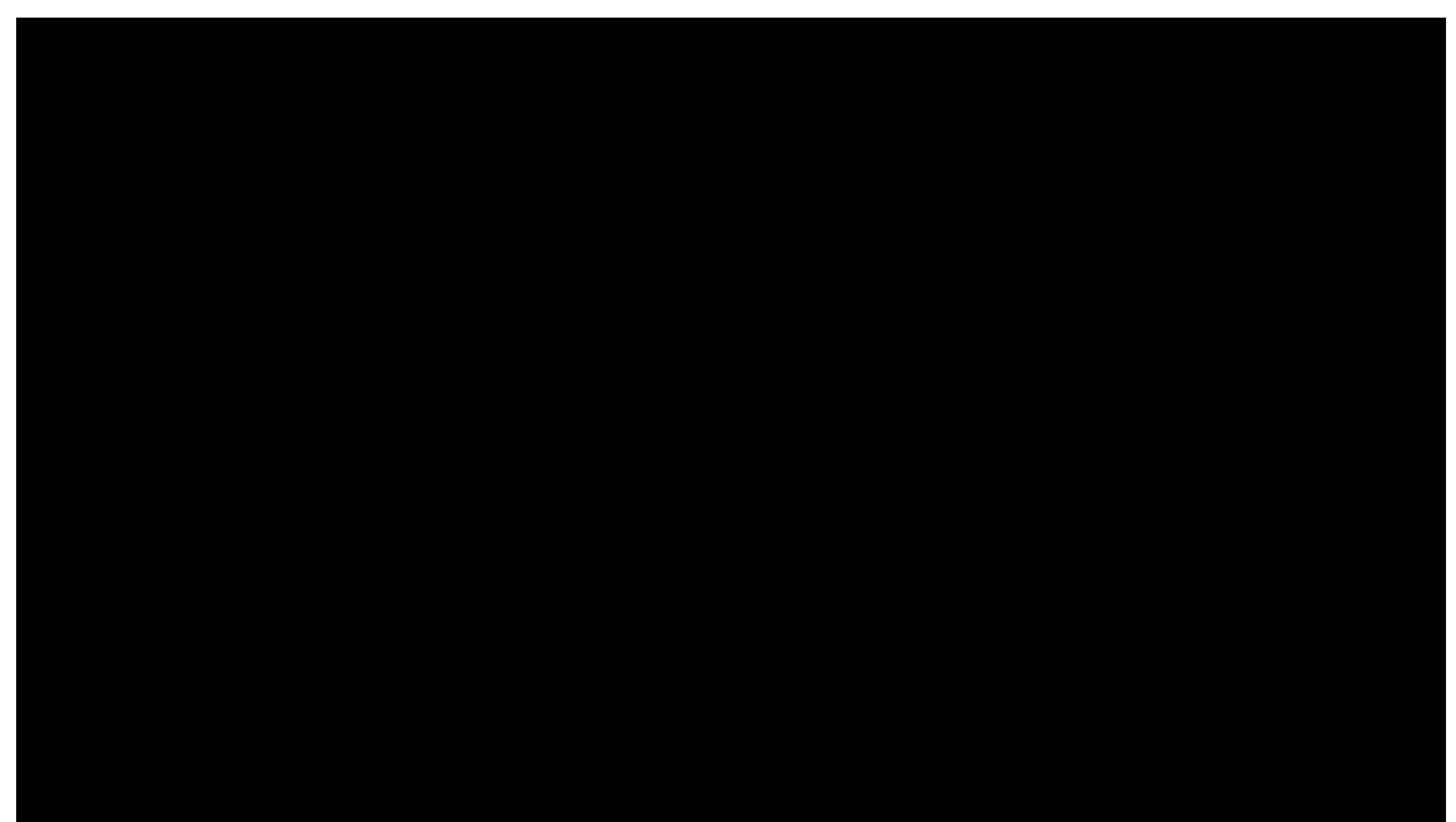
Order

Top 10 Insurance Provider

Ins# Carrier

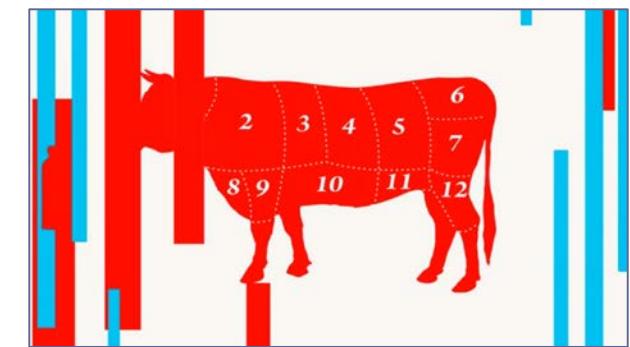
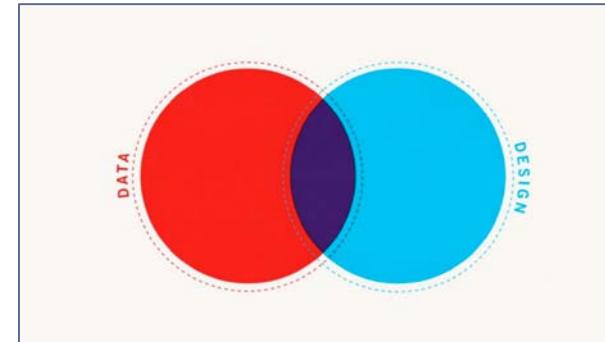
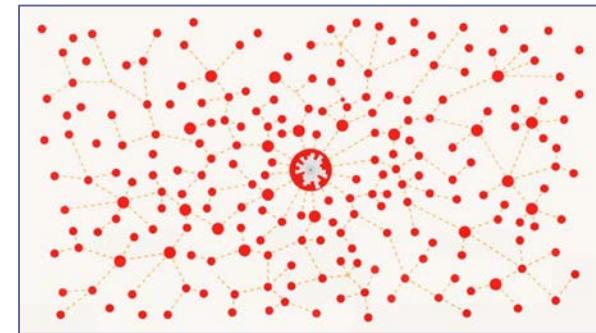
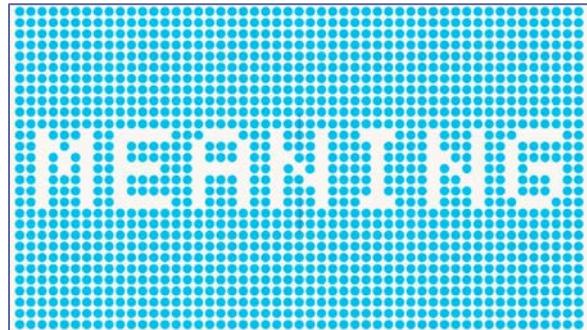


Sum of No of Treatments for each Ins# Carrier. The view is filtered on sum of No of Treatments and Ins# Carrier. The sum of No of Treatments filter keeps all values. The Ins# Carrier filter has multiple members selected.



As for the other factors...

What feelings did you experience during the video?



How is it different than what you feel now?

Motion, medium, and context are also influencers on how we perceive data and information.



We also have built in biases...

Psychologists recognize two “thinking systems” that we use to make sense of the world.

System 1 (bottom up) – operates automatically and quickly, with little or no effort and no sense of voluntary control

System 2 (top down) – allocates attention to the effortful mental activities that demand it, including complex computations

We also have built in biases...

- **System 1** generates impressions, intuitions, intentions, and feelings for system 2
- **System 2** can be engaged as needed to solve more complex problems or where System 1 runs into difficulty



What's happening here?

System 1 informs...
you get an automatic impression.

What's the answer?

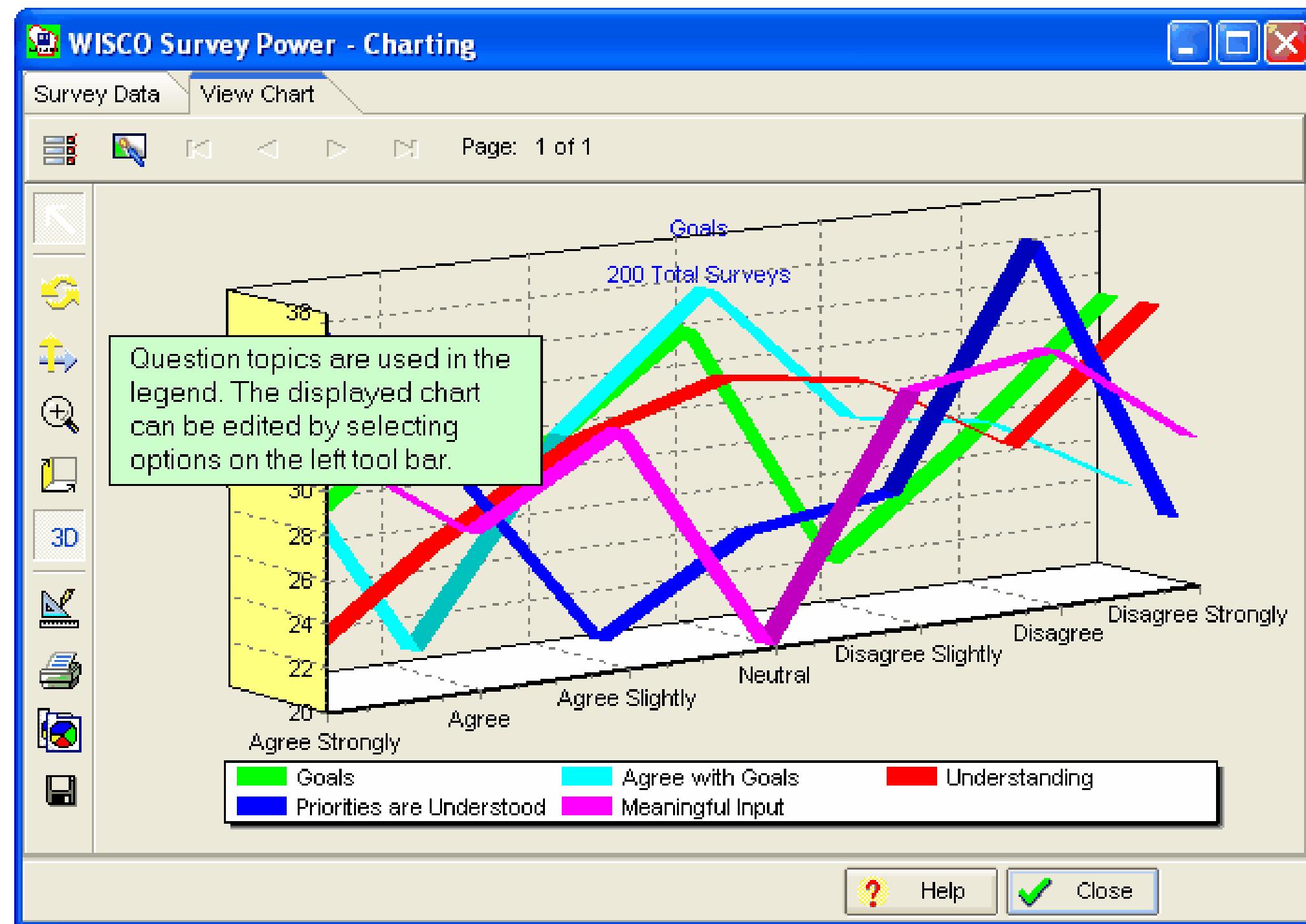
$$19 \times 23$$

What's the answer?

$$19 \times 23$$

System 2 shifts into gear to figure out the answer. (it's 437)

...and what happens now?



Impressions in system 1 affect the conclusions of system 2.

- Presentation impacts the way data is perceived
- Mood and emotions impact critical thinking
- Caution: over-simplification can result in distorted understanding

*We'll explore this further
in a future class.*

Citations

¹ From *Rome Reborn: The Vatican Library & Renaissance Culture*, Library of Congress website. Accessed on 2/18/2012. <http://www.loc.gov/exhibits/vatican/math.html>

² Few, Stephen (2007), *Data Visualization: Past, Present, and Future*, p.3

³ Wikipedia entry *René Descartes*, used under the Creative Commons-Share Alike 3.0 Unported license. Accessed on 2/18/2012. http://en.wikipedia.org/wiki/Rene_descartes

⁴ Wikipedia entry *Cartesian Coordinate System*, used under the Creative Commons-Share Alike 3.0 Unported license. Accessed on 2/18/2012

http://en.wikipedia.org/wiki/Cartesian_coordinate_system

⁵ Wikipedia entry *William Playfair*, used under the Creative Commons-Share Alike 3.0 Unported license. Accessed on 2/18/2012 http://en.wikipedia.org/wiki/William_Playfair

⁶ Tufte, Edward R. (2001), *The Visual Display of Quantitative Information*, Second Edition, p. 9

⁷ *The Oxford Dictionary of National Biography*, ©2004-12 Oxford University Press. Retrieved on 2/18/2012. <http://www.oxforddnb.com/view/printable/22370>

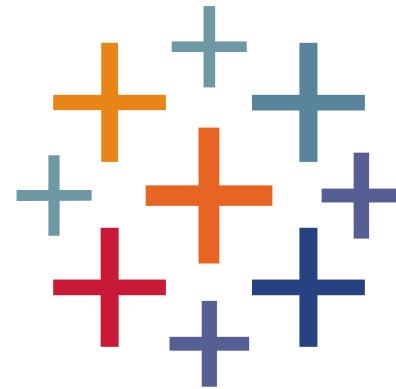
⁷ Friendly, Michael (2001), *Gallery of Data Visualization*, Electronic document, <http://www.datavis.ca/gallery/>, Accessed: 02/19/2012 22:20:39

⁸ Tufte, Edward R. (2001), *The Visual Display of Quantitative Information*, Second Edition, p. 40

⁹ Bertin, Jacques (1983), *Semiology of Graphics*, English translation by William J. Berg, pp. 42, 65

¹⁰ Wikipedia entry *Exploratory Data Analysis*, used under the Creative Commons-Share Alike 3.0 Unported license. Accessed on 2/19/2012. http://en.wikipedia.org/wiki/Exploratory_data_analysis

¹¹ Wikipedia entry *Edward Tufte*, used under the Creative Commons-Share Alike 3.0 Unported license. Accessed on 2/19/2012. http://en.wikipedia.org/wiki/Edward_Tufte



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