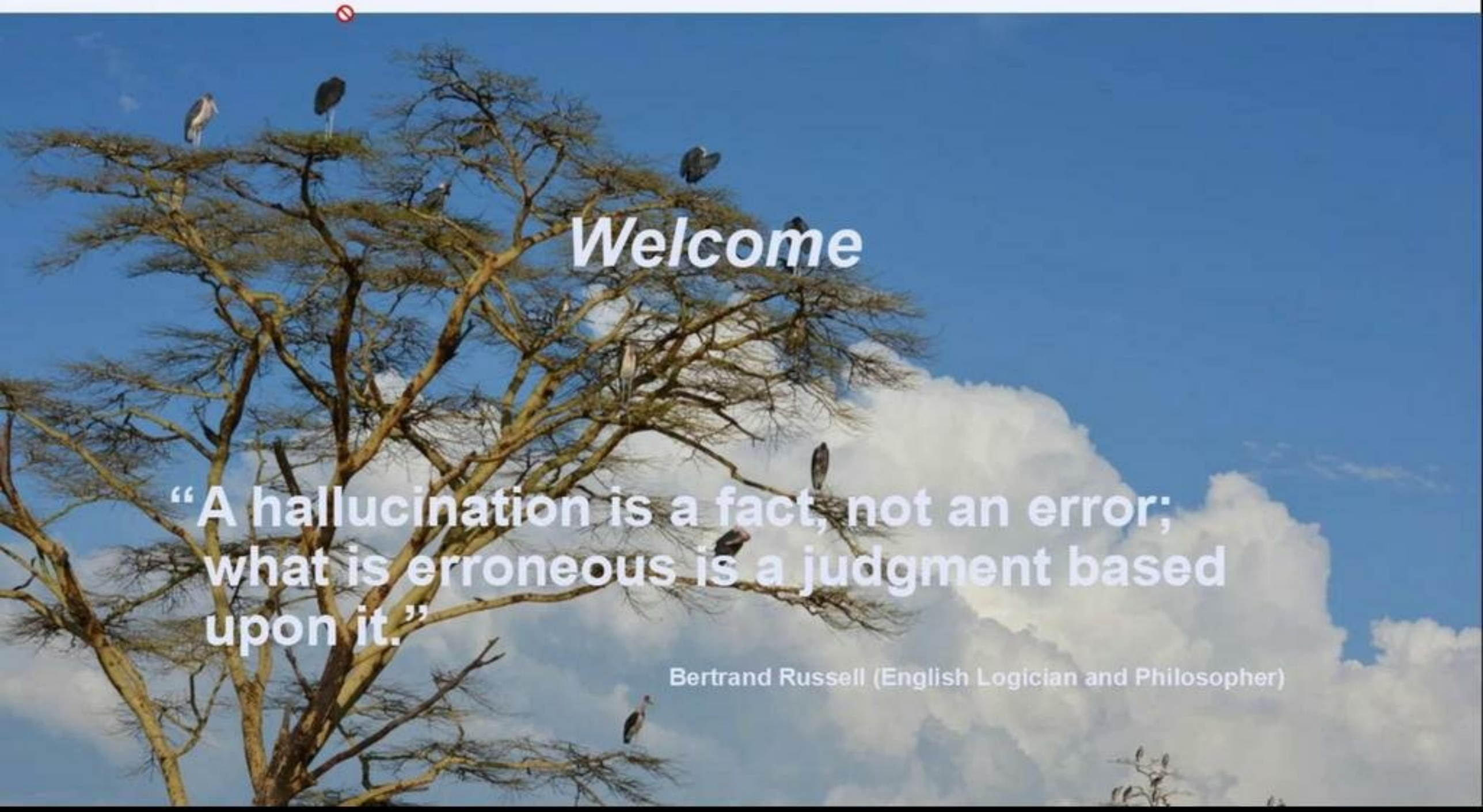

Welcome
“A hallucination is a fact, not an error; what is erroneous is a judgment based upon it.”
Bertrand Russell (English Logician and Philosopher)

FUNDAMENTALS IN DATA VISUALIZATION AND INTERFACE DESIGN
Abbas Moallem
The only true wisdom is in knowing you know nothing.
Socrates

TUTORIAL PROGRAM

Fundamentals in Data Visualization and Interface Design

Abbas Moallem, Ph.D.

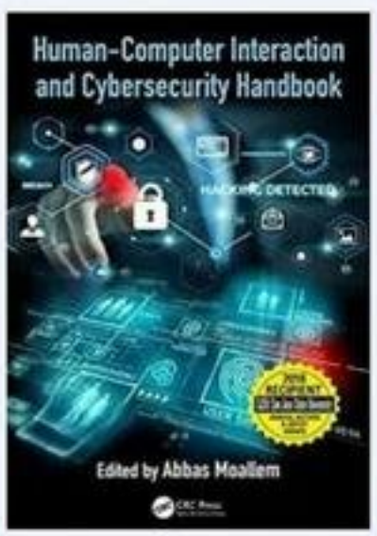
Abbas Moallem, Ph.D.

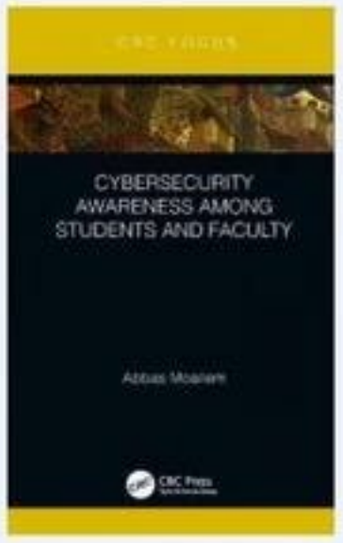
- Executive Director, UX Experts LLC
- Adjunct Professor ISE Department, San Jose State University
- California State University East Bay, and Santa Clara University

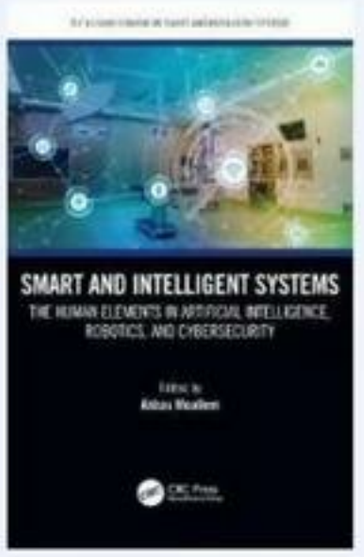
Education

- *Ph.D. Human Factors and Ergonomics, University of Paris, France*
- *M.S. Human Factors & Ergonomics University of Paris, France*
- *M.S. Biomechanics, University of Paris, France*

2020, 2019 and 2018 Books







More about Abbas

HCI International

Communication Chair

Applied Human Factors and Ergonomics and the Affiliated Conferences

Communication Chair

INTERNATIONAL CONFERENCE ON HCI FOR CYBERSECURITY, PRIVACY AND TRUST

Program Chair

Editorial Board

THE HUMAN ELEMENT IN SMART AND INTELLIGENT SYSTEMS SERIES

A NEW BOOK SERIES FROM CRC PRESS

Series Editor: Dr. Abbas Moallem

Series Editor

Awards

Annual Authors & Artist Awards 2019, Annual Authors & Artist Awards 2018, NETGEAR Innovation Award 2012, SJSU Certificate of Appreciation in Teaching , Tumbleweed MVP Award, PeopleSoft Hero Award

Few Words About Me

Lam RESEARCH

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cisco

ORACLE

POLYCOM
TOGETHER. GREAT THINGS HAPPEN.

Tumbleweed
SECURE CONTENT DELIVERY

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Book Series

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THE HUMAN ELEMENT IN SMART AND INTELLIGENT SYSTEMS SERIES

A NEW BOOK SERIES FROM CRC PRESS

Series Editor: Dr. Abbas Moallem

Aim and Scope

The role of the human element in all aspects of smart and intelligent systems

Interacting with computerized systems is present in all aspects of our daily lives. These interactions are even more present and essential for work in enterprises. With the growing complexity of computerized systems, the interaction of humans with each one becomes paramount to the success of system performance. Machine learning and understanding patterns of human behavior are main areas of research in interdisciplinary and multidisciplinary studies.

This series aims to cover the role of the human element in all aspects of smart and intelligent systems. It will include a broad range of reference works, textbooks, and handbooks. We look for single-authored works and edited collections. Both introductory and advanced materials for students and professionals will be included.

Features of this series

1. How emerging technologies are changing human behavior.
2. The impact of social networking on political and social systems.
3. The growing role of Artificial Intelligence in the service industry.
4. Understanding the human element in designing smart systems.
5. Security and privacy issues of intelligent systems.

PROPOSALS MAY BE SUBMITTED TO:

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Cindy Renee Carelli
Executive Editor
CRC Press – Taylor & Francis Group
cindy.carelli@taylorandfrancis.com

We welcome submissions in the area of automated driving, smart networks and devices, cybersecurity, data visualization and analysis, social networking, smart cities, smart manufacturing, trust and privacy, artificial intelligence, cognitive intelligence, pattern recognition, smart services, computational intelligence, smart services and robotics. Both introductory and advanced material for students and professionals will be included.

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Today's Agenda

- **Introduction** (10 Mins)
  - **Brief History of Visualization**
  - **What is Visualization?**
  - **Why Is Visualization Important?**
- **Fundamental Principles of Visualization and Dashboard Design**
  - **Architecture and Concepts & principles** (45 Minutes)
  - **Components: Charts, Grids, Text, Visual Design** (45 Minutes)
  - **Visual Designs: Typography, Colors, Icons, Communication** (45 Minutes)
- **Evaluating Dashboard User Interfaces** (30 Minutes)
- **Activity** (45 Minutes)
- **Quizzes** (10 Minutes)
- **Q & A** (10 Minutes)

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- **Quizzes** (10 Minutes)
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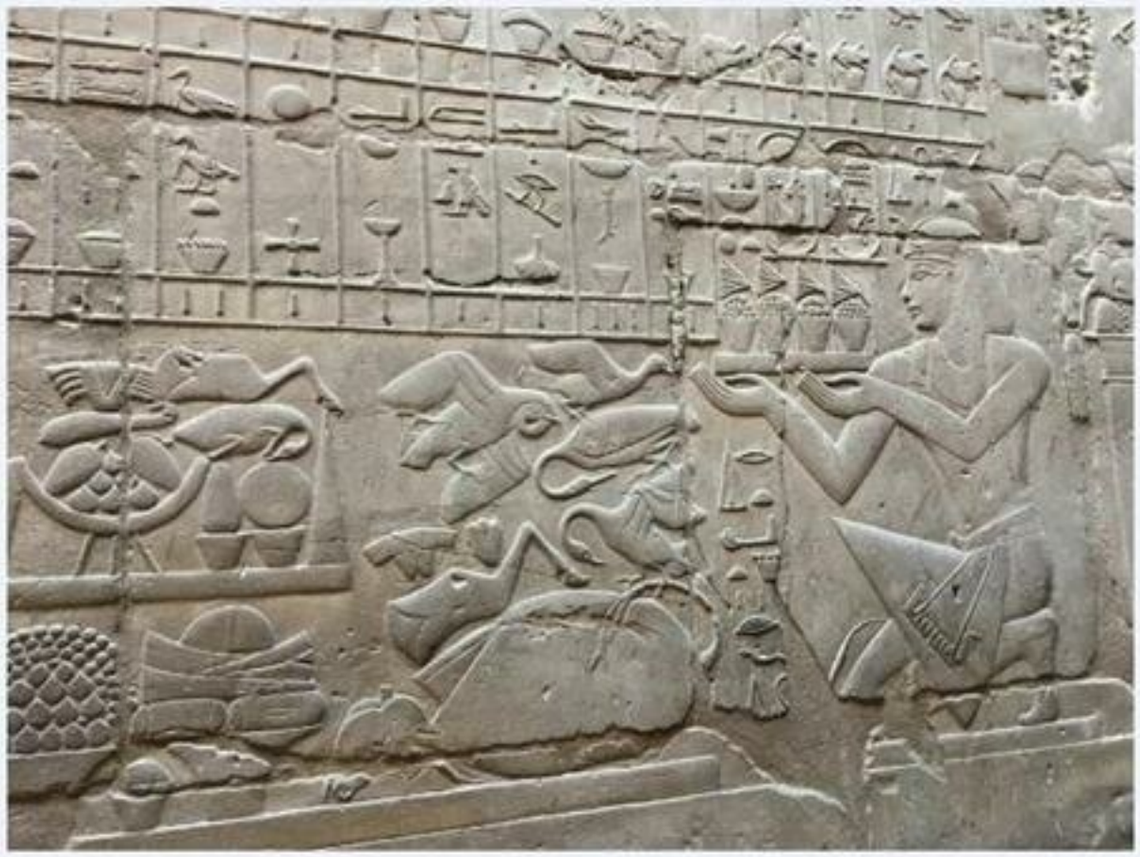
Introduction to Information Visualization

Early Human Ancient Cave Art

Egyptian



Greek Combat Sport

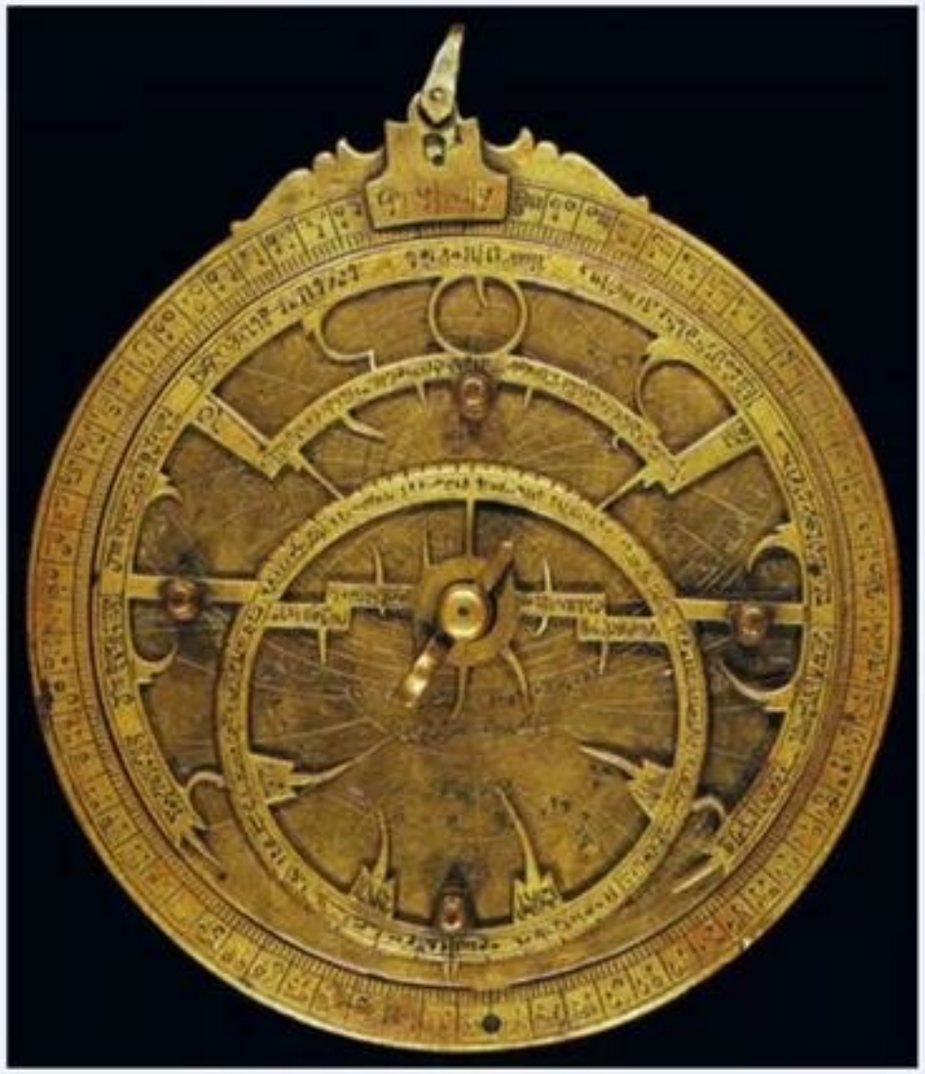
Persian Persepolis

Persian Carpets

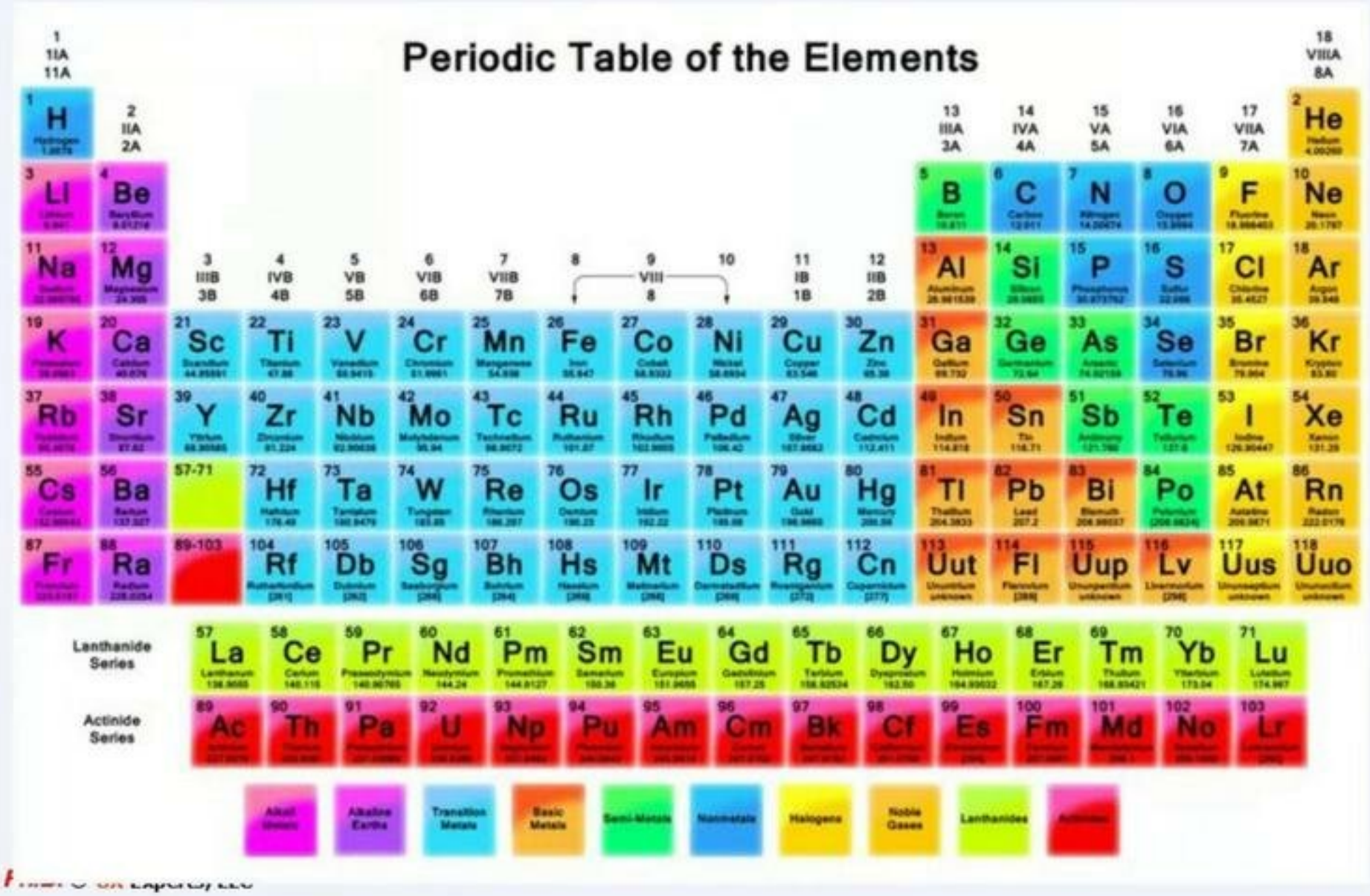
Persian Carpets

Ancient Chinese Art

Astronomy



Periodic Table



Minard's map, showing Napoleon's march on Moscow

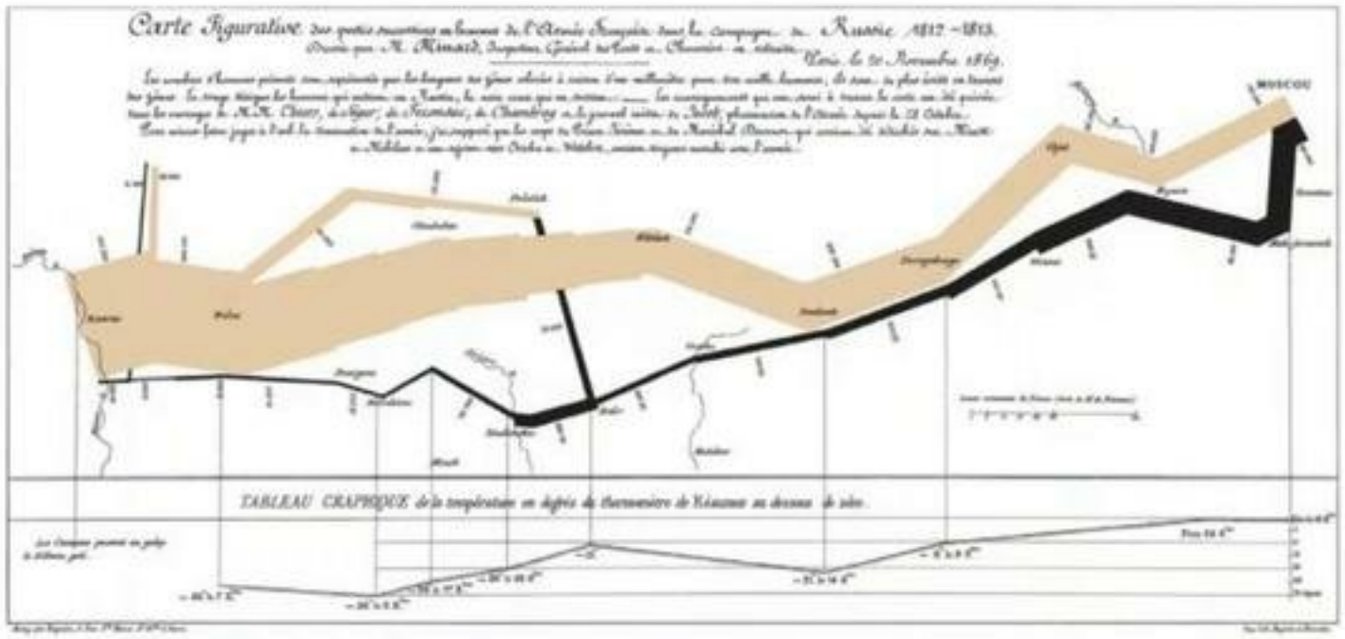


Figure 1.11. Minard's map, showing Napoleon's march on Moscow. The width of the line conveys the size of the army at that location. Color indicates the direction of movement. The temperature is plotted at different points along the retreat at the bottom. (Image courtesy Wikimedia Commons.)

Florence Nightingale's

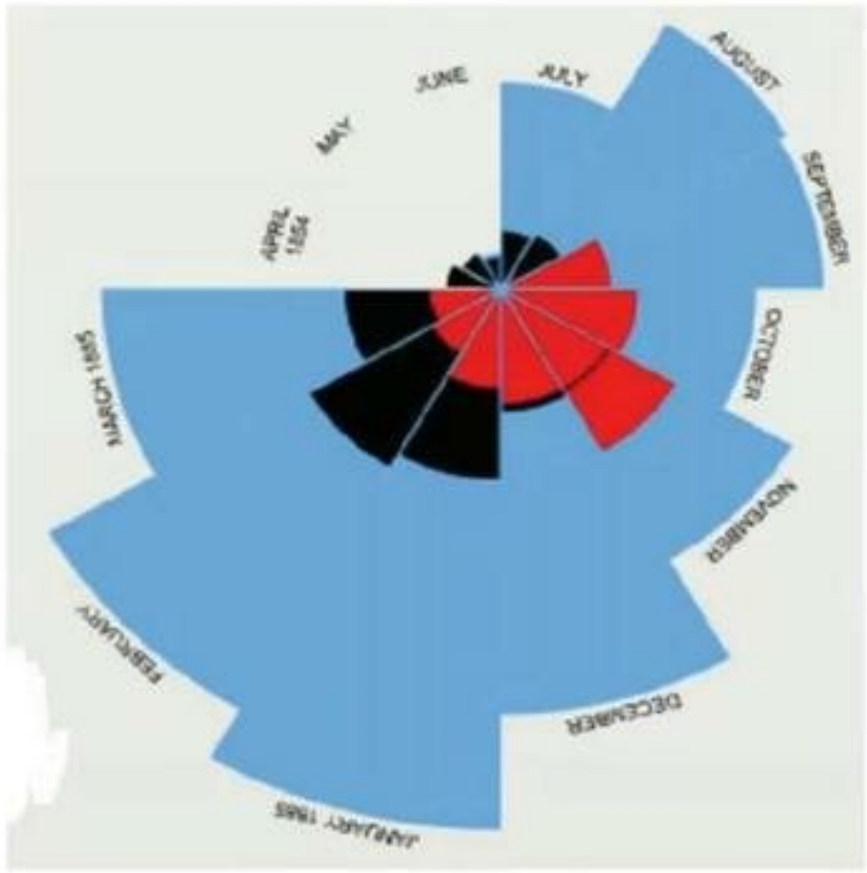


Figure 1.14. Florence Nightingale's coxcomb chart showing monthly deaths from battle and other causes. Blue represents the deaths from disease, red represents deaths from wounds, and black represents all other deaths. (From an interactive on-line tool at http://understandinguncertainty.org/node/213.)

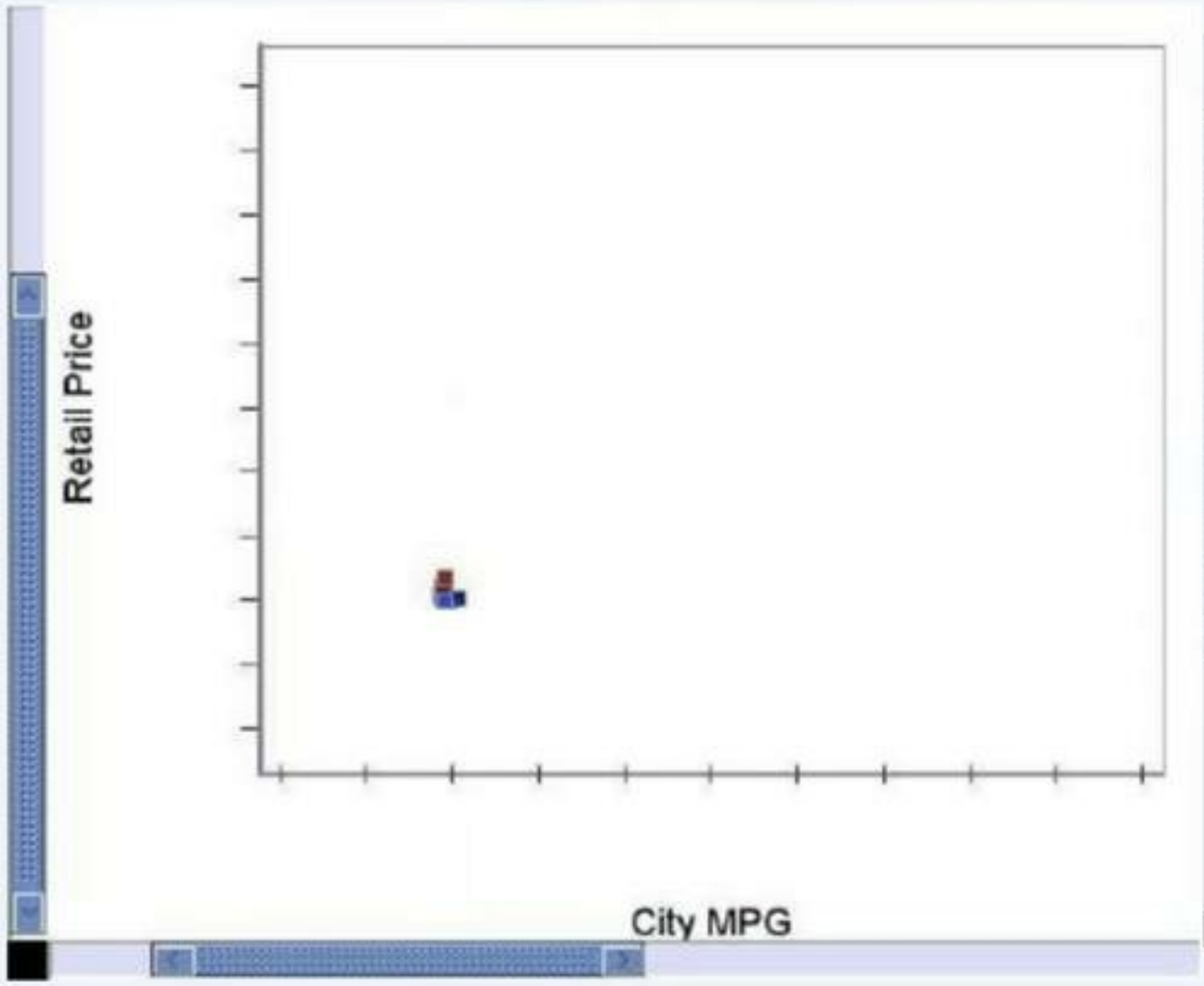
What Is Visualization?

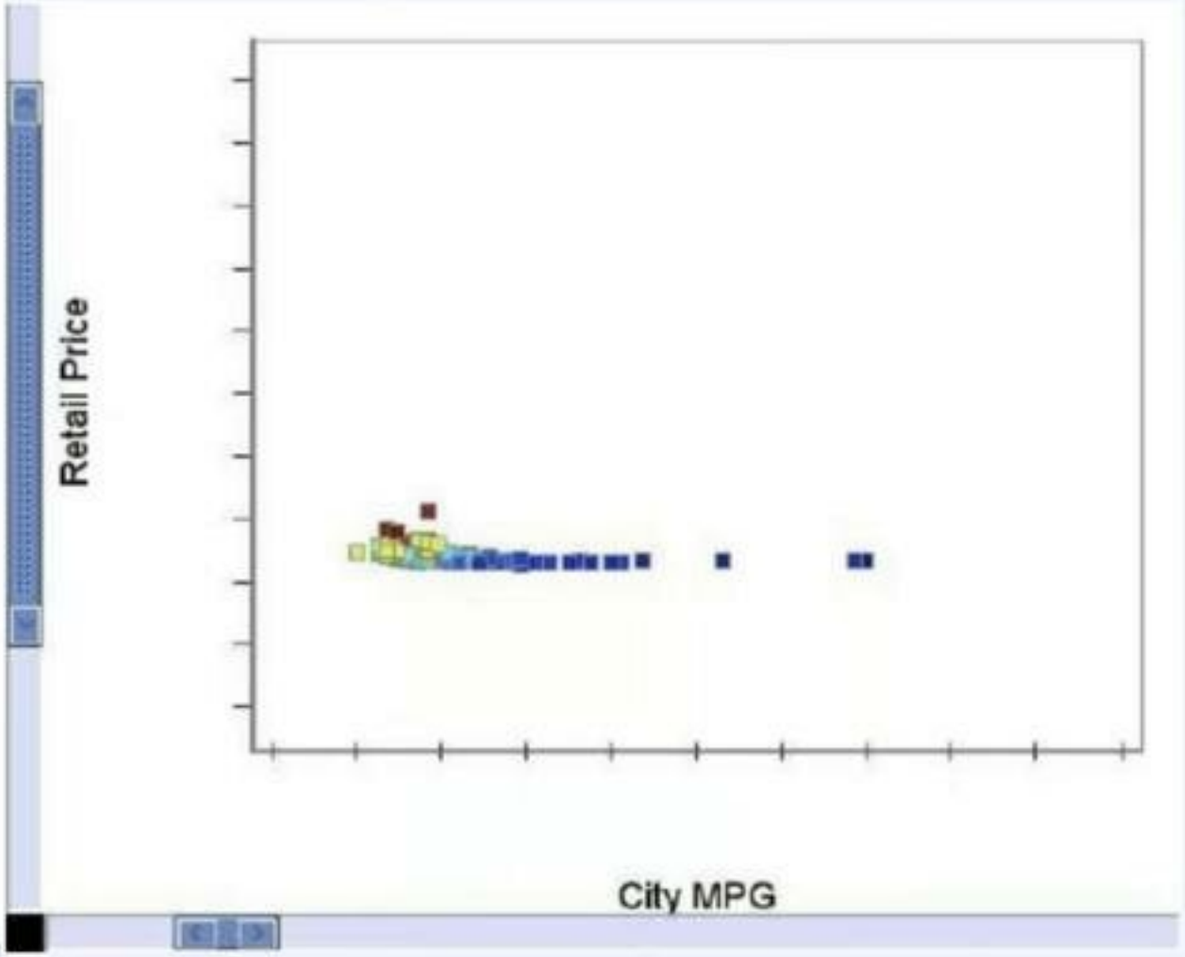
- **The communication of information using graphical representations.**
- **A single picture can contain a wealth of information and can be processed much more quickly than a comparable page of words.**
- **This is because image interpretation is performed in parallel within the human perceptual system, while the speed of text analysis is limited by the sequential process of reading.**
- **Pictures can also be independent of local language, as a graph or a map may be understood by a group of people with no common tongue.**

Information Visualization

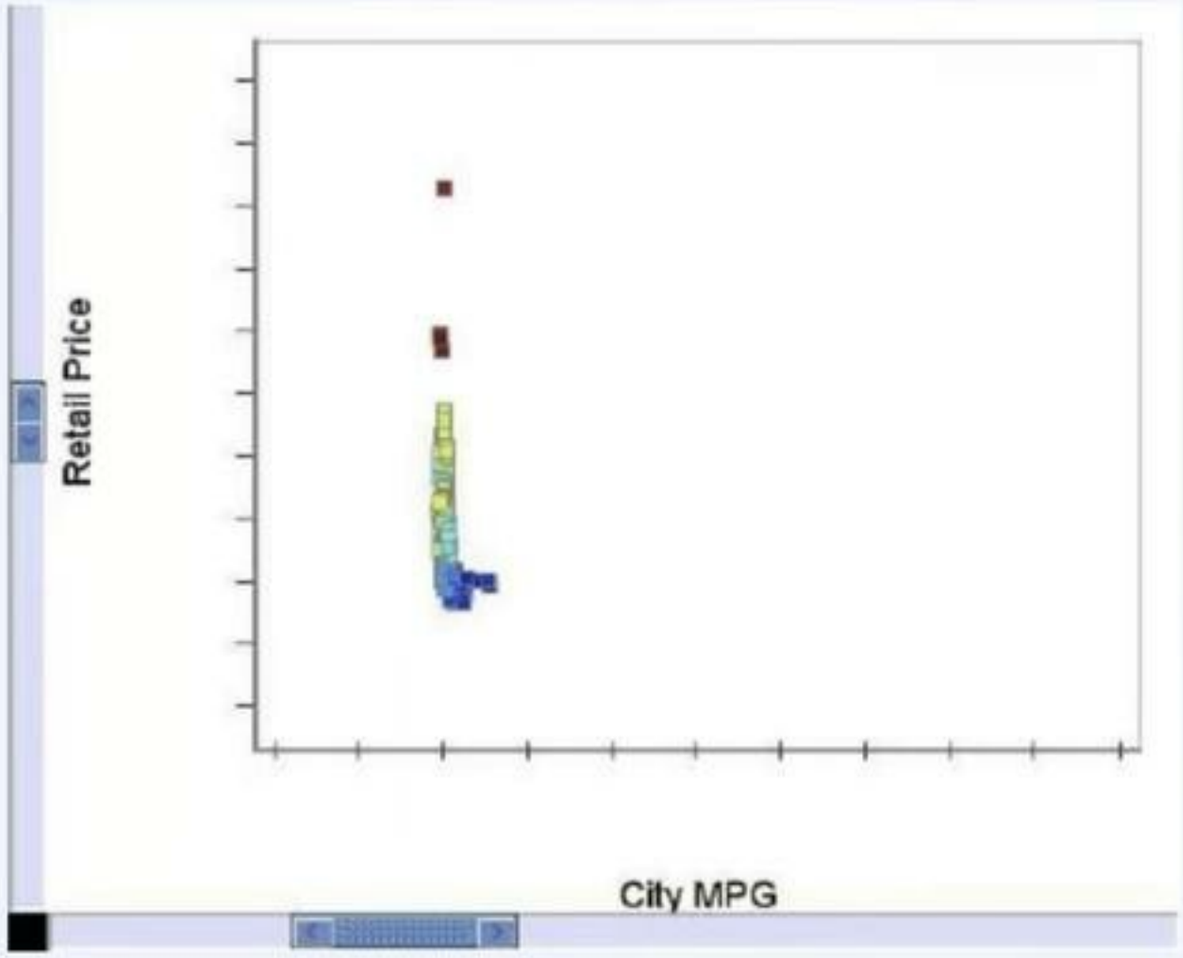
- **Information visualization is interactive**
- **User will have tools to adjust the display in order to gain a more meaningful understanding of the data being presented**
- **Represents abstract data**
- **Amplifying cognition**
  - **The intellectual processes in which information is obtained, transformed, stored, retrieved, and used (Card, 2003).**
- **Enable augmented cognition**

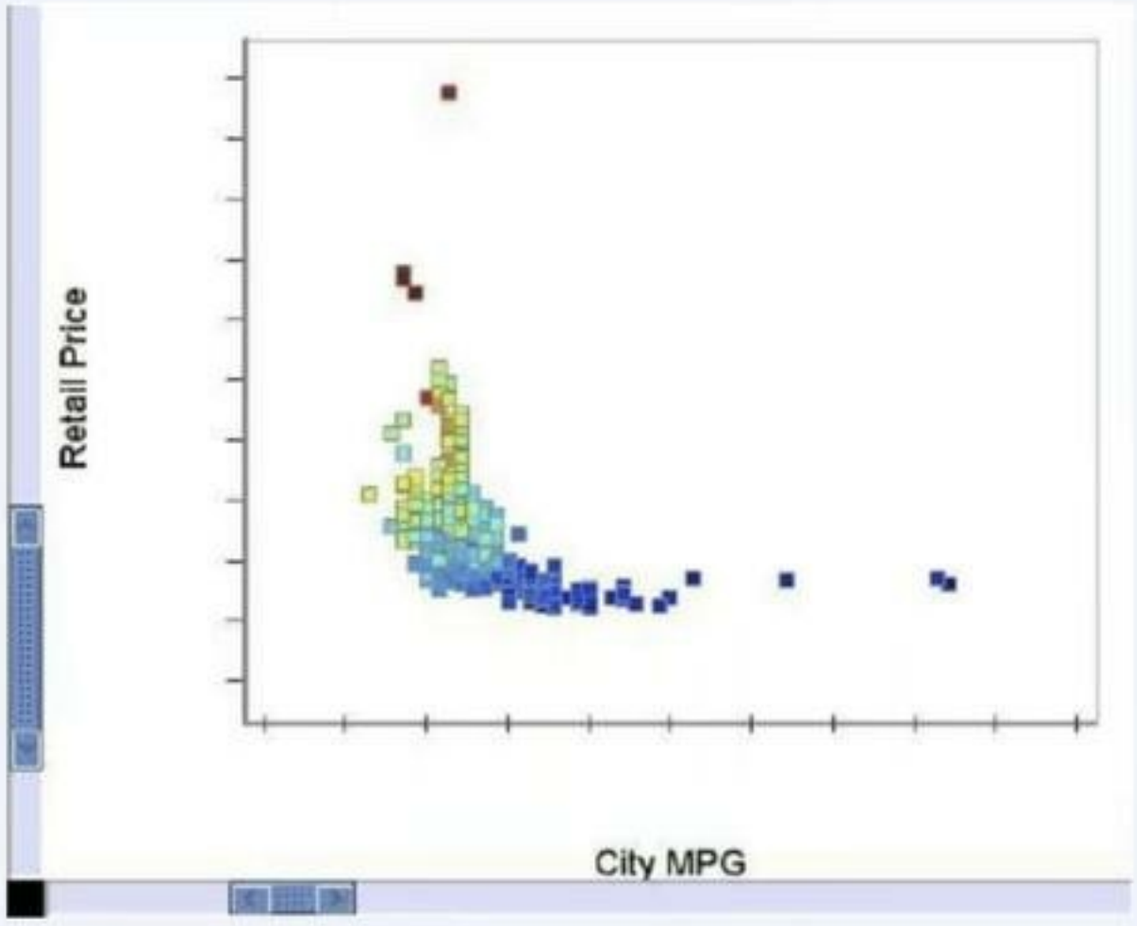
The same data plotted with different scales





The same data plotted with different scales





The same data plotted with different scales

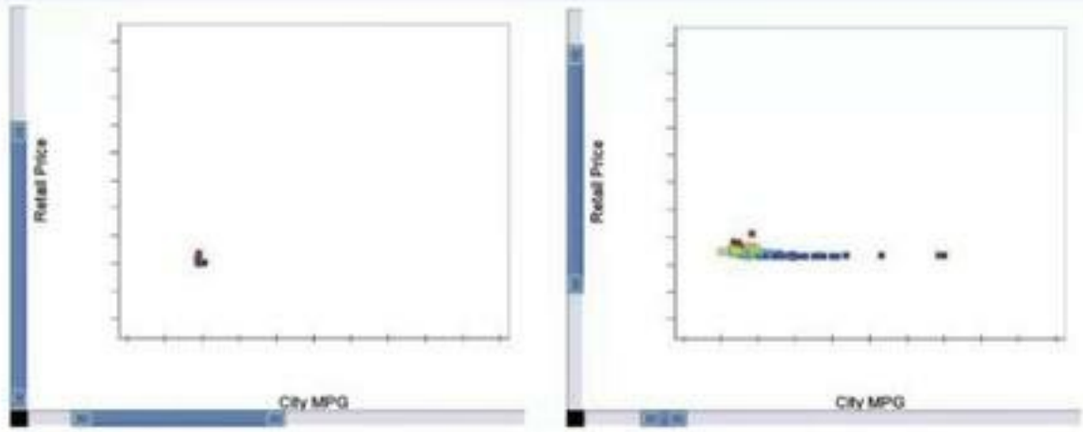
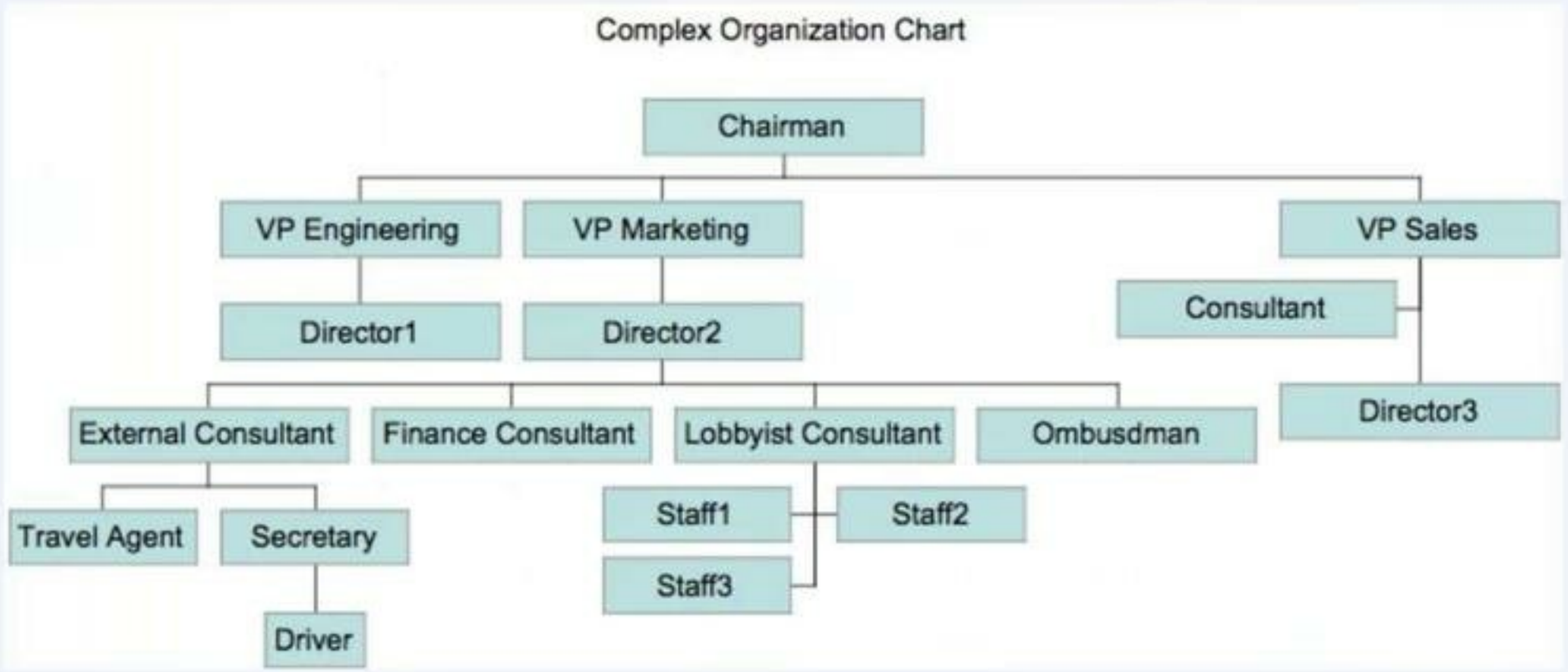
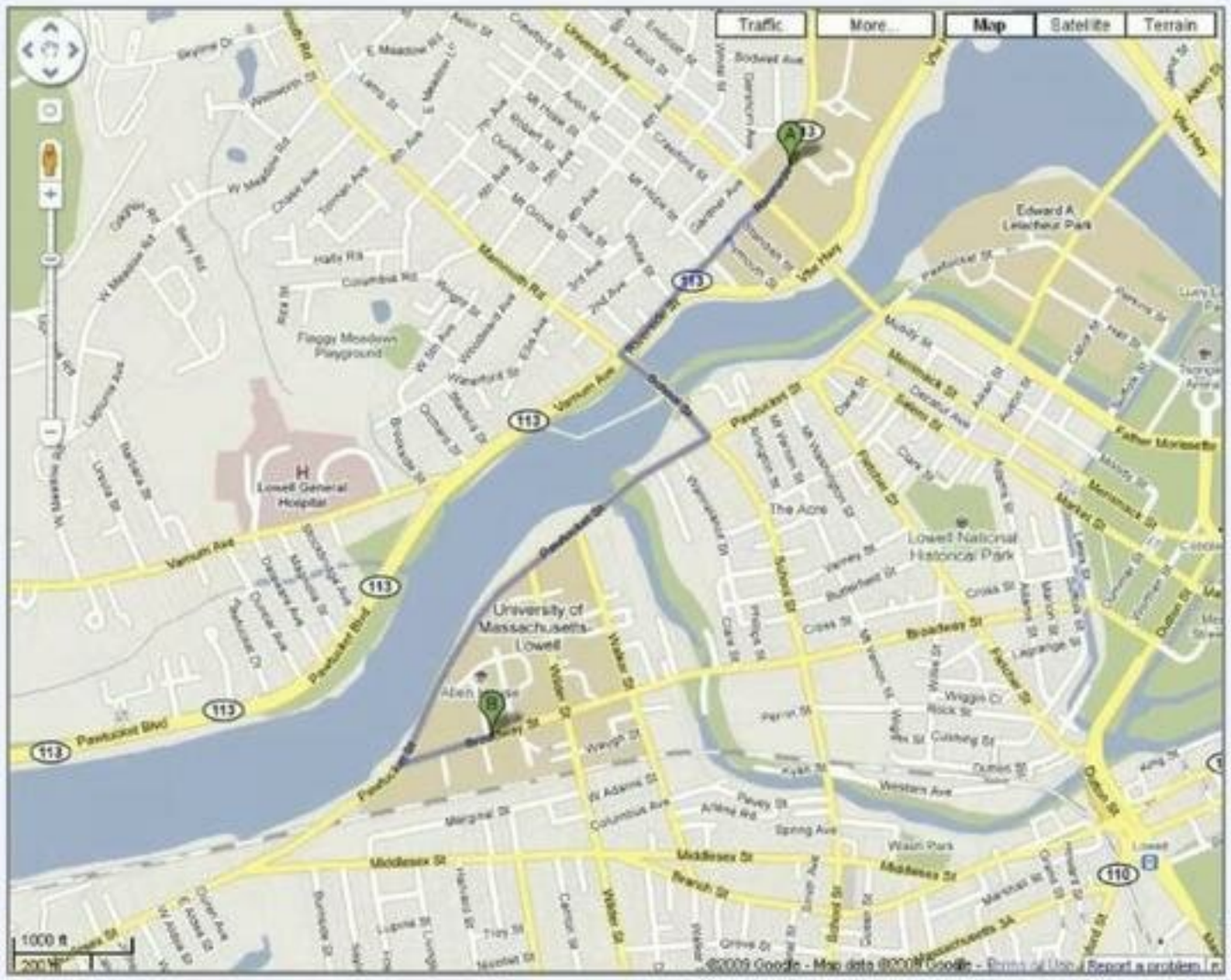


Figure 1.1. The same data plotted with different scales is perceived dramatically differently: (a) Equally (uniformly) large scale in both x and y. (b) Large scale in y. (c) Large scale in x. (d) Scale determined by range of x- and y-values.

Information Visualization Vs. Data Visualization



Maps


Traffic
More...
Map
Satellite
Terrain
Edward A Leiacheur Park
Flaggy Meadown Playground
Lowell General Hospital
University of Massachusetts-Lowell
Lowell National Historical Park
The Acre
Pawtucket Blvd
Vanum Ave
Middlesex St
Broadway St
Western Ave
Wash Park
1000 ft
200 m
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Visualization Process

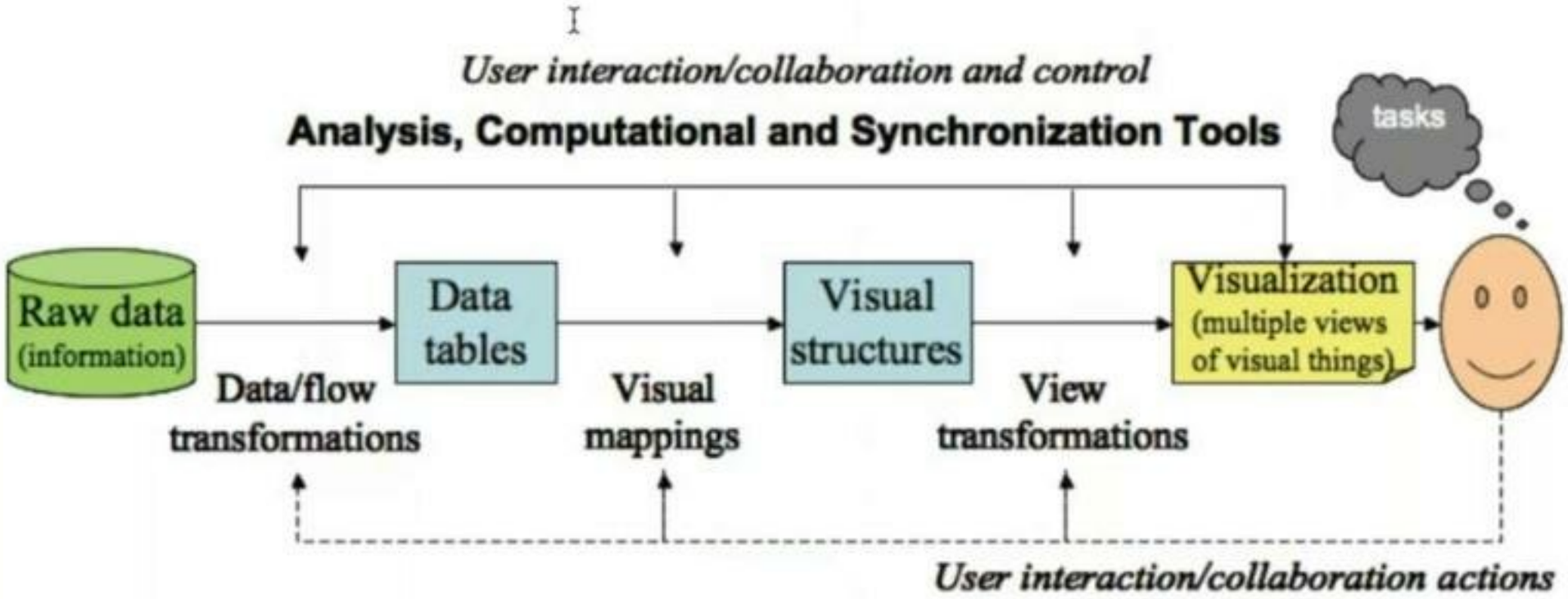


Figure 4.1. Our reference visualization pipeline. (Image modified from [59].)

Data Science

- **Data science is a "concept to unify statistics, data analysis, machine learning and their related methods" in order to "understand and analyze actual phenomena" with data. It employs techniques and theories drawn from many fields within the context of mathematics, statistics, computer science, and information science.**

Example

Corporate
Regional
Detail Data
Enterprise Performance Management Dashboard
Profit Margin
0%
10%
20%
30%
15.18%
Current Profit Margin of 15.18% compares with industry benchmark of 34.95%.
Revenue
0.0M
3.0M
6.0M
9.0M
12.0M
15.0M
12458970.4
Current Revenue of $12,458,970 compares with Forecast of $ 11,746,766.
Revenue Per Employee
0K
200K
400K
600K
800K
1,000K
$377,545
Current Revenue Per Employee of $377,545 is based on current headcount of 33.
$1,400,000
$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$0
($200,000)
Jan 2010 Feb 2010 Mar 2010 Apr 2010 May 2010 Jun 2010 Jul 2010 Aug 2010 Sep 2010 Oct 2010 Nov 2010 Dec 2010
Revenue $875 $873 $951 $961 $1,043 $997 $993 $1,024 $1,081 $1,207 $1,215 $1,239
Revenue Forecast $963 $786 $970 $999 $1,011 $788 $794 $871 $1,027 $1,292 $1,057 $1,189
Variance ($88) $87 ($19) ($38) $31 $209 $199 $154 $54 ($85) $158 $50
* All values are in thousands of U.S. dollars

UI Design Analogies

Let's use an analogy to better understand the issues

*How easy is it to read th*s *it to read this text?*

Scene I A desert place Thunder and
When shall we three meet again In t
When the hurlyburly's done When th
will be ere the set of sun First Witch
heath Third Witch There to meet wit
Second Witch Paddock calls Third V
Hover through the fog and filthy air

sert place.

ning. *Enter three Witches*

ee meet again
ng, or in rain?

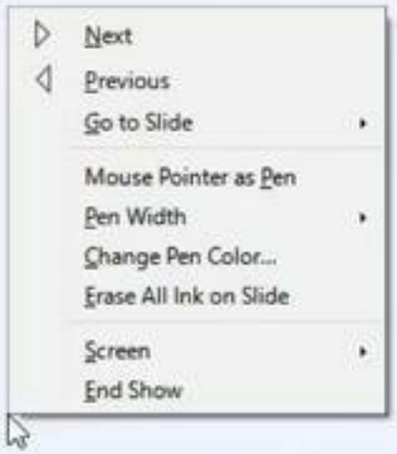
rly's done,
lost and won.

ıe set of sun.

h Macbeth.

in!

ul is fair;
: fog and filthy air.



Now, how easy is it to read this text?

SCENE I. A desert place.

Thunder and lightning. Enter three Witches

First Witch
When shall we three meet again
In thunder, lightning, or in rain?
Second Witch
When the hurlyburly's done,
When the battle's lost and won.
Third Witch
That will be ere the set of sun.
First Witch
Where the place?
Second Witch
Upon the heath.
Third Witch
There to meet with Macbeth.
First Witch
I come, Graymalkin!
Second Witch
Paddock calls.
Third Witch
Anon.
ALL
Fair is foul, and foul is fair;
Hover through the fog and filthy air.

Exeunt

UI Design Analogies

Let's use an analogy to better understand the issues

How easy is it to read this text?

Scene I A desert place Thunder and lightning Enter three Witches First Witch When shall we three meet again In thunder lightning or in rain Second Witch When the hurlyburly's done When the battle's lost and won Third Witch That will be ere the set of sun First Witch Where the place Second Witch Upon the heath Third Witch There to meet with Macbeth First Witch I come, Graymalkin Second Witch Paddock calls Third Witch Anon. ALL Fair is foul and foul is fair Hover through the fog and filthy air Exeunt

Now, how easy is it to read this text?

The Tragedy of Macbeth

Act 1, Scene 1

SCENE I. A desert place.

Thunder and lightning. Enter three Witches

First Witch
When shall we three meet again
In thunder, lightning, or in rain?
Second Witch
When the hurlyburly's done,
When the battle's lost and won.
Third Witch
That will be ere the set of sun.
First Witch
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Third Witch
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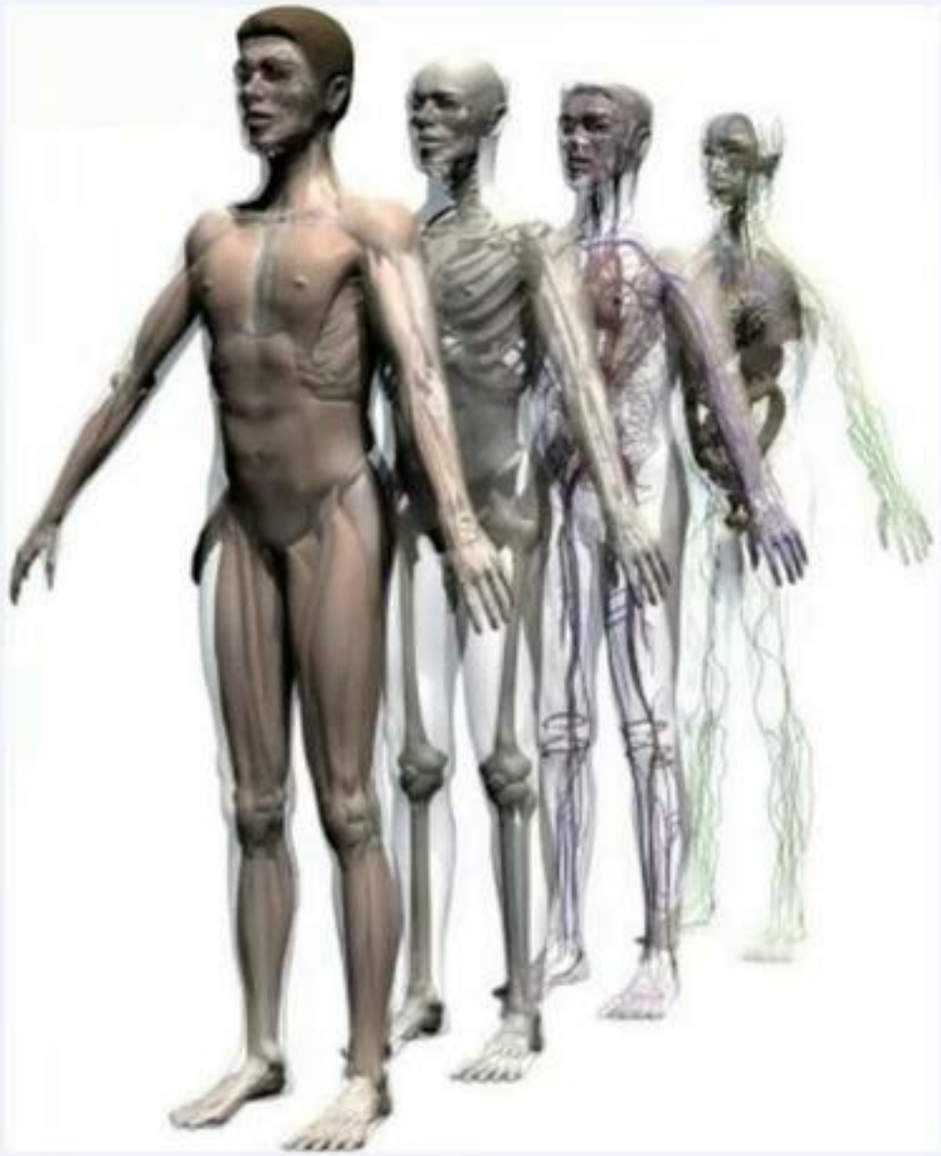
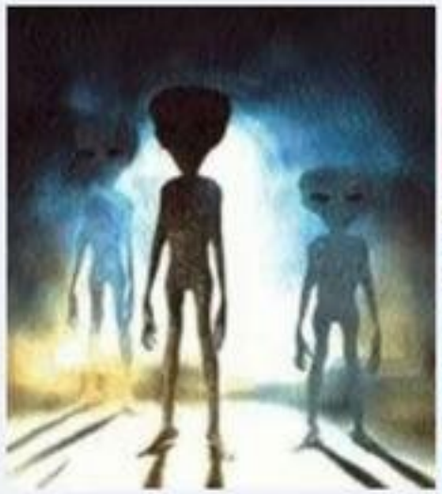
Hover through the fog and filthy air.

Exeunt

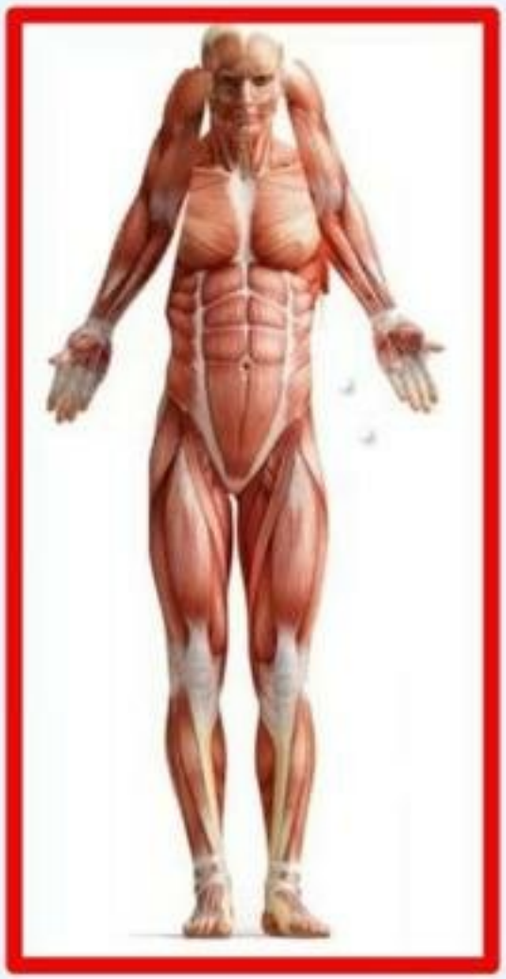
User Interface: Product Face



Product Face



Product Face

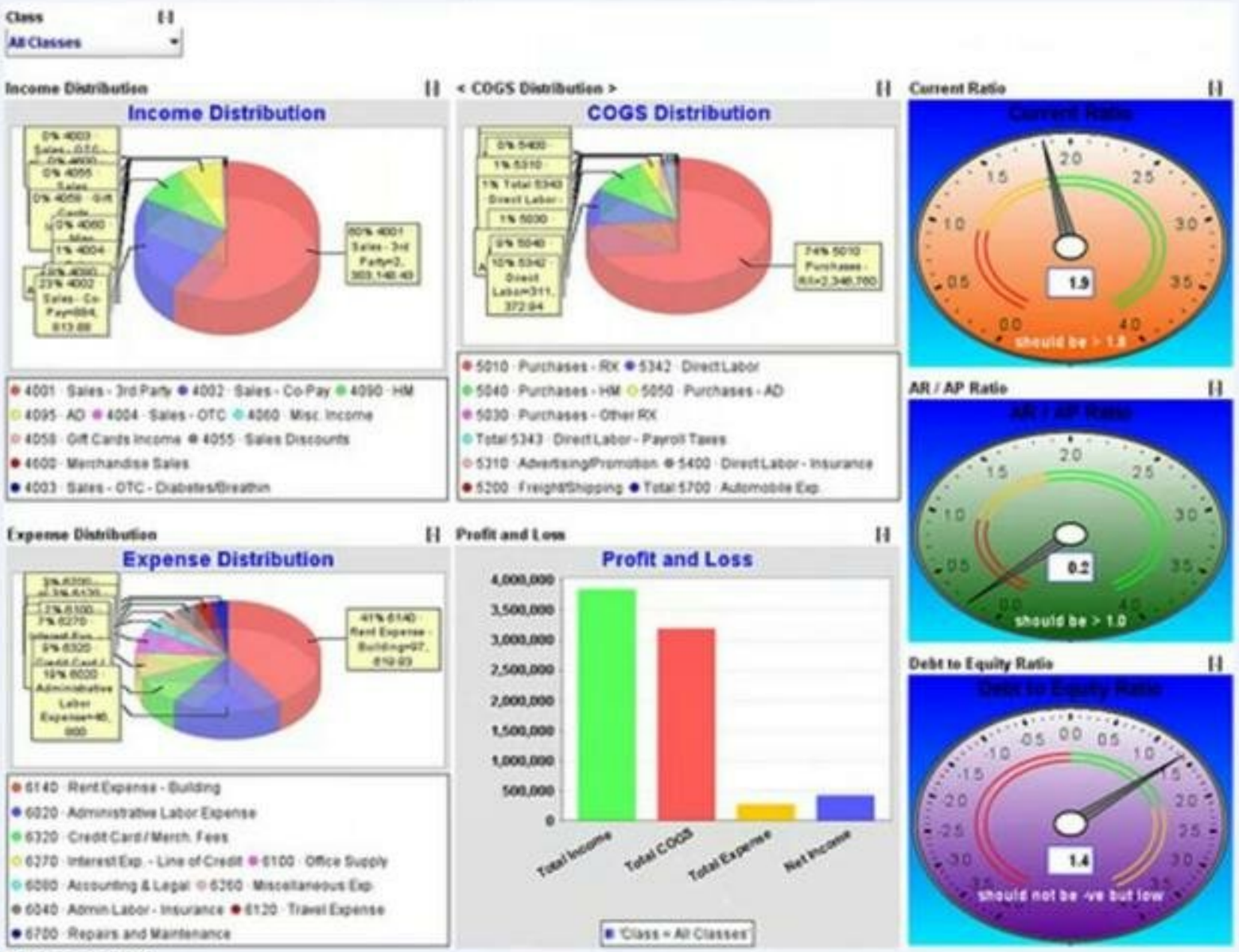


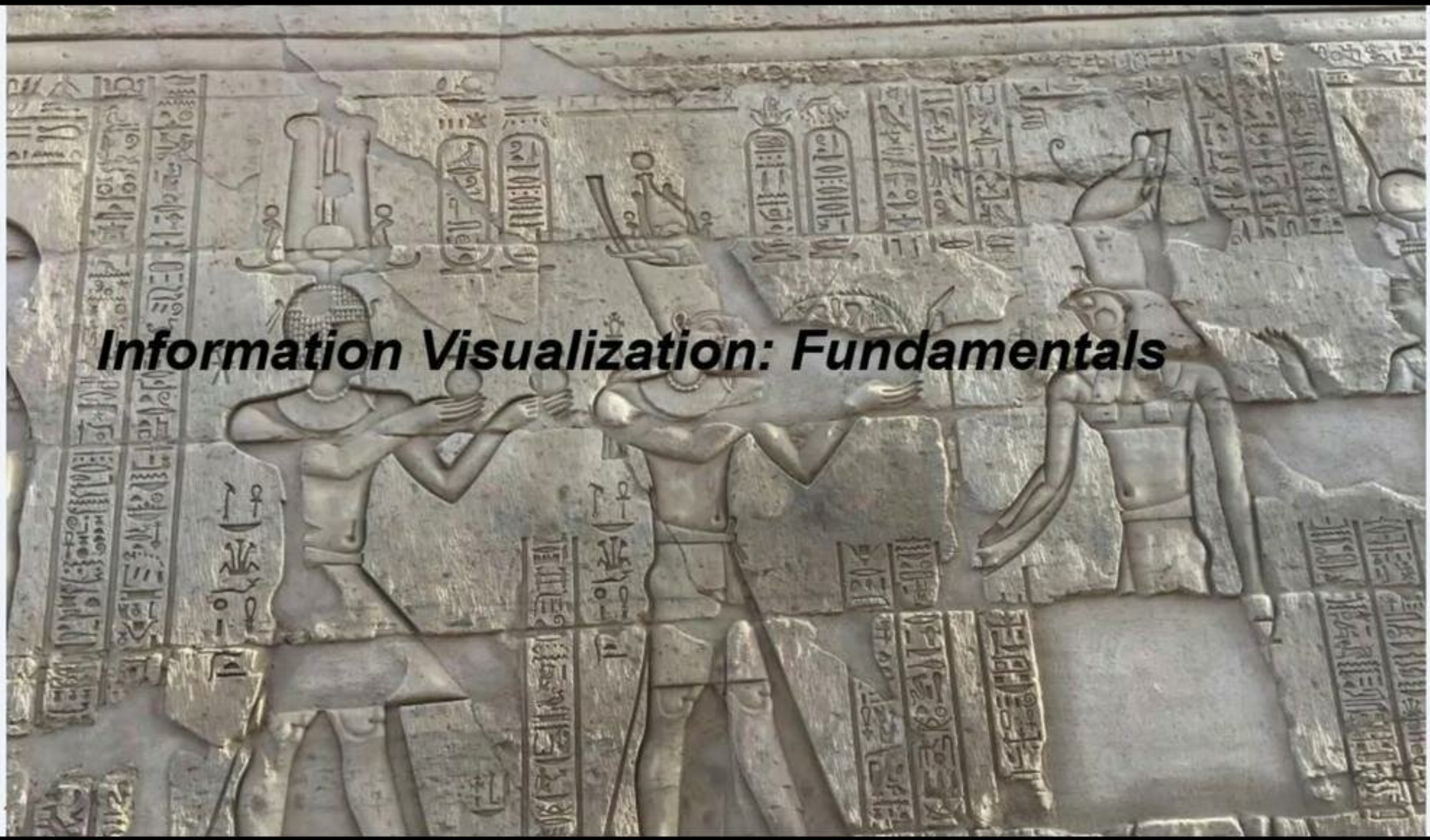
Design Option

New Visual Design

- **New Visual Style will not change the usability issues.**
- **Same Person -- Different Dress**

What do you think about this dashboard?





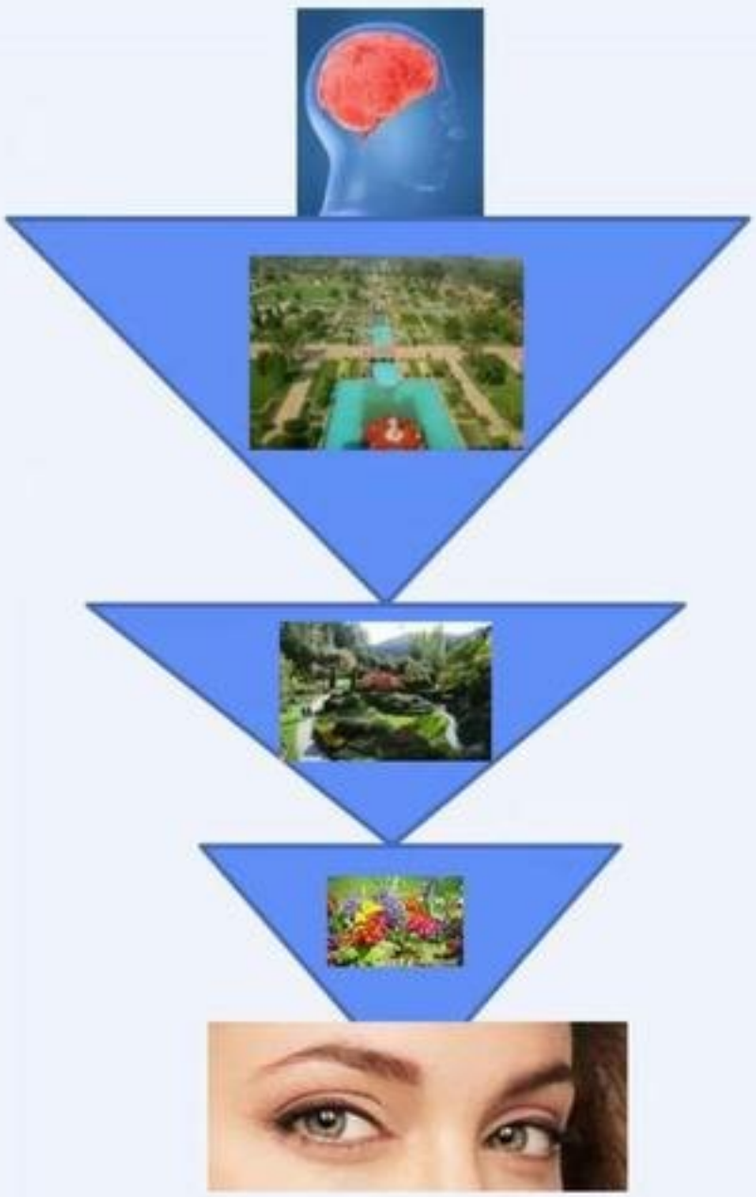
Information Visualization: Fundamentals

PROCESSING MODEL

Bottom-up, Top-down

Top-down perception

- Knowledge, expectations, or thoughts influence perception
- Constructivism: we structure the world
- Perception is not determined simply by stimulus patterns; rather it is a dynamic searching for the best interpretation of the available data." (Gregory, 1966)



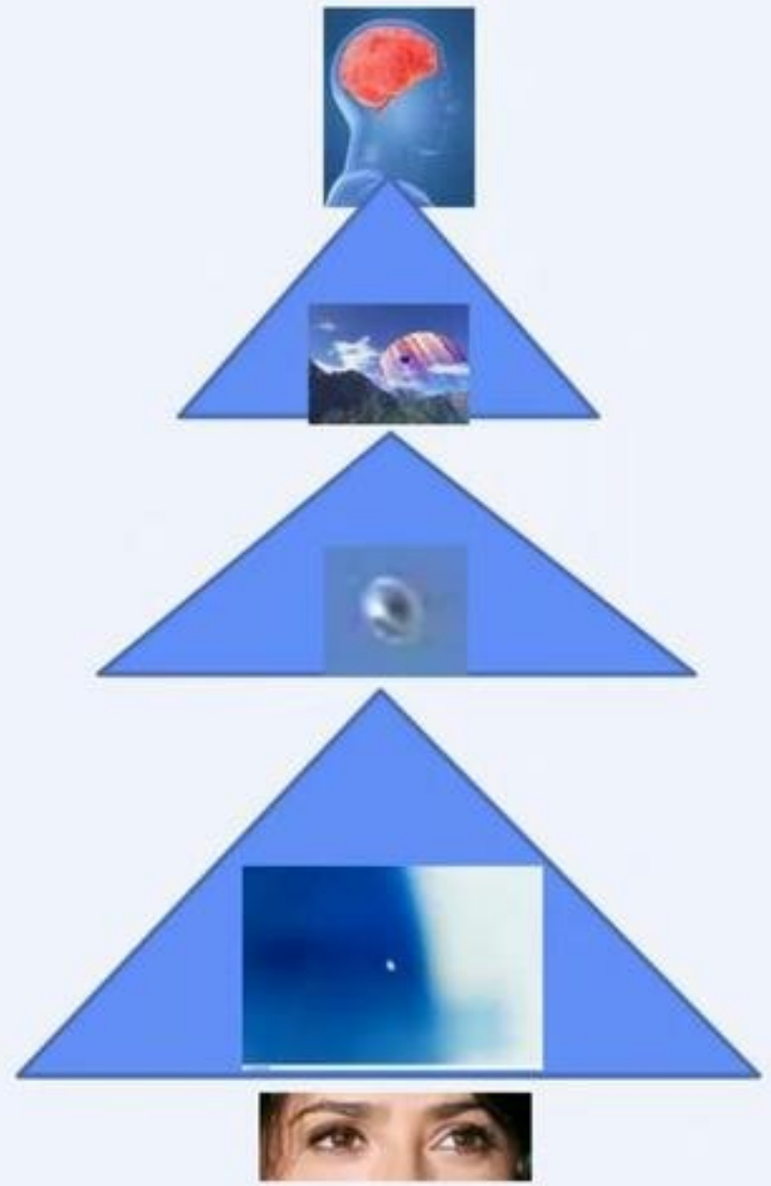
Top-down and Bottom-up

721846
4992

A should be on
B should be on
C should be on
D should be off

Bottom-up perception

- **Physical characteristics of stimulus.**
- **Realism.**



Top- down and Bottom- up

Then it may be better to use small text.

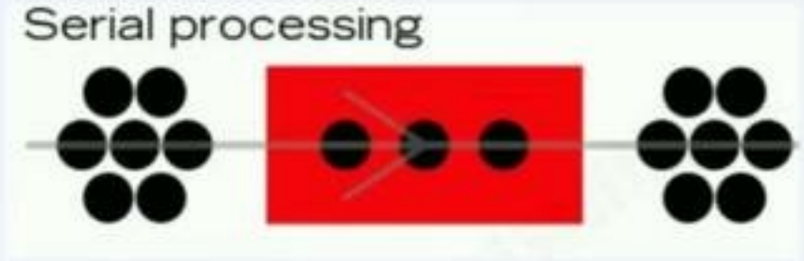
PROCESSING MODEL

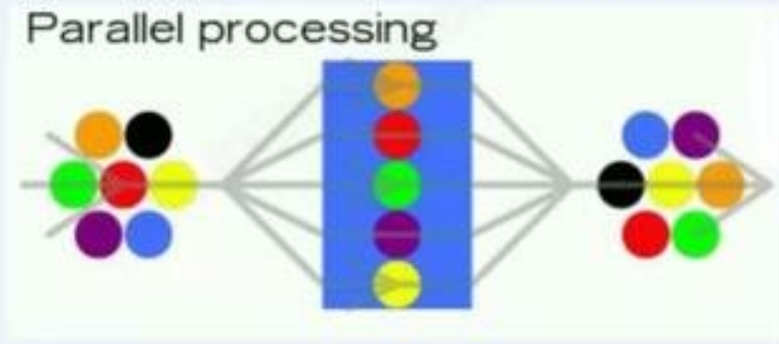
Parallel Processing

Serial Processing

Parallel & Serial Processing

Graphical information displays can often be processed in parallel, as opposed to textual displays, which are processed serially.





Serial Processing

Which country has the highest GNI?

Gross National Income

Country	2014
Australia	1,444,201
Brazil	2,429,720
Canada	1,785,099
China	10,096,966
France	2,844,284
Germany	3,853,623
India	2,027,964
Italy	2,147,247
Japan	5,339,076
Mexico	1,237,533
Russia	1,930,634
South Korea	1,365,797
Spain	1,366,027
United Kingdom	2,801,499
United States	17,611,491

Serial Processing

Which country has the highest GNI?

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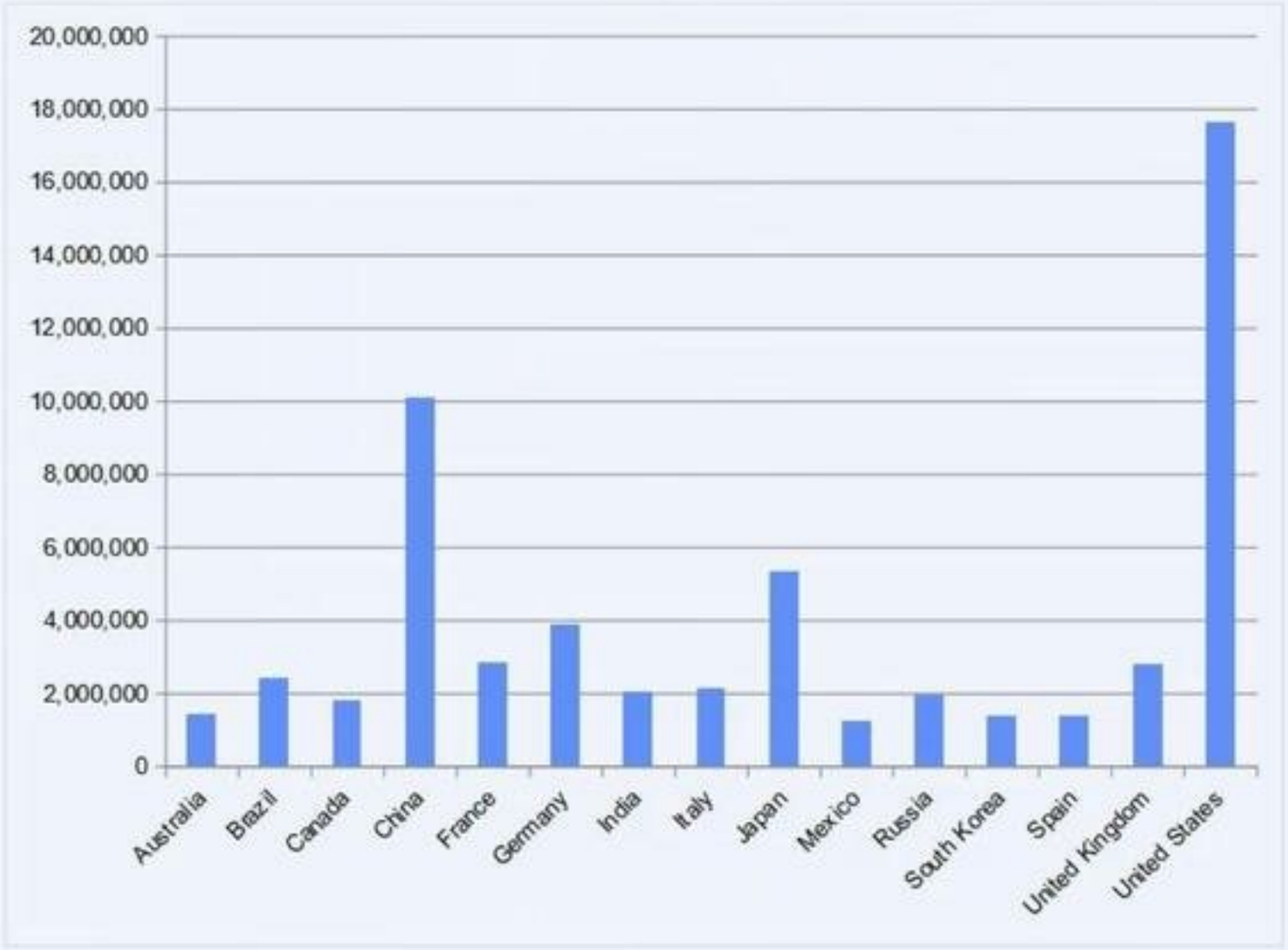
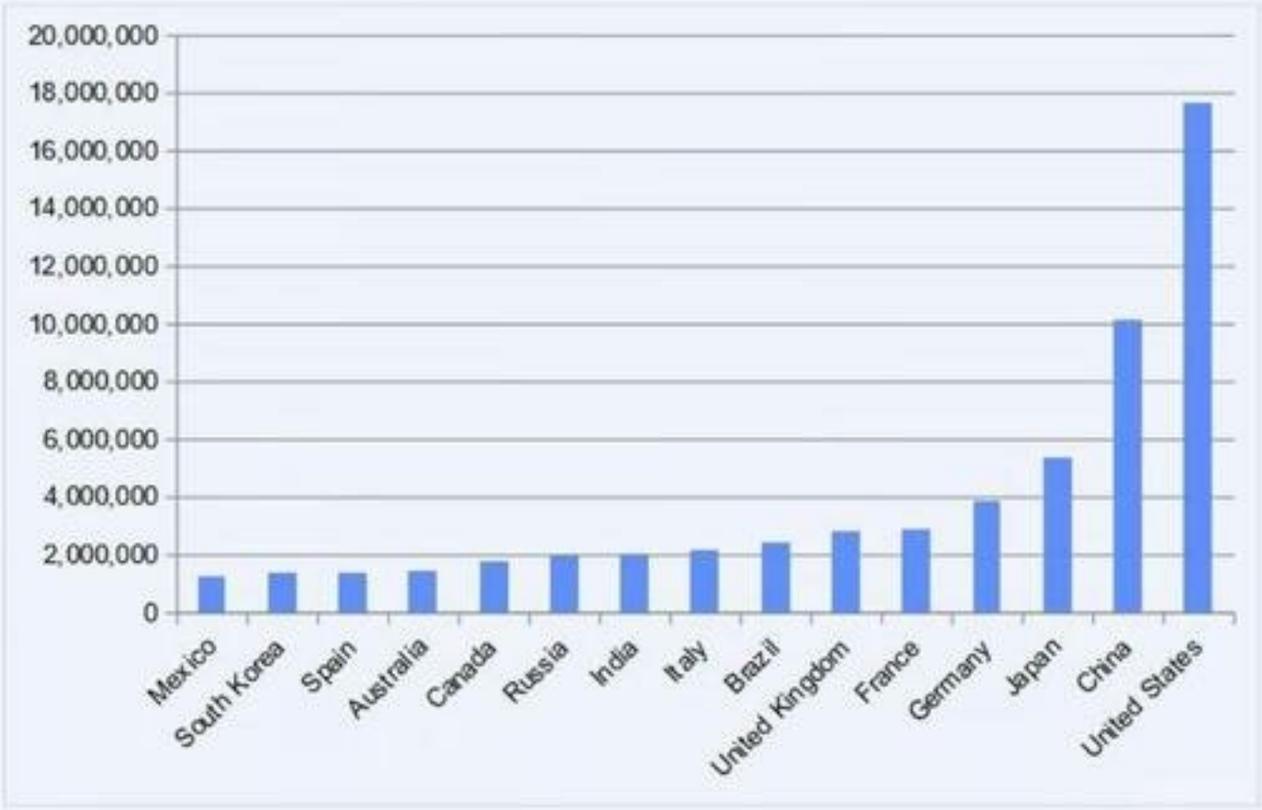
Parallel Processing

Which country has the highest GNI?



Parallel Processing

Which country has the highest GNI?



SEARCH MODEL
SIGNAL DETECTION METHODS
AND THEORY

Signal Detection Methods and Theory

- On the occurrence of the trial event, the subject sets the information presented and decides whether this information is sufficient to warrant a signal present response. sample of information is assumed to provide a value along continuum of evidence states regarding the likelihood of the signal being present.
- The noise trials form a probability distribution of states, as do the signal trials. The decision that must be made on a trial can be characterized as whether the event is from the signal or noise distribution.
- The subject is presumed to adopt a criterion value of evidence above which he or she responds signal present and below which he or she responds signal absent.

Serial Search Model

- **Search any visual filed for something, we distinguish between.**
- **Target .**
- **Non-Target (distraction/Noise).**

- **Search is serial when each item is inspected in turn to determine whether it is not a target.**

Signal Detection Methods and Theory

- **In a signal detection task, some event is classified as a signal and the subject's task is to detect whether the signal is present.**
  - **Trials on which it is not present are called noise ,**
  - **The proportion of trials on which the signal is correctly identified as present is called the hit rate,**
  - **and the proportion of on which the signal is incorrectly identified as present is called the false alarm rate.**
  - **By using the hit rate and false alarm it is possible to evaluate whether the effect of a variable is on discriminability or response bias.**

Example Vigilance Task

a subject is asked to monitor a display for certain changes in it (e.g., the occurrence of a rare (stimulus).

- The most common finding for vigilance tasks is called decrement:
  - the hit rate decreases as the time on the task increases.
  - the primary cause of the vigilance decrement is an increasingly strict response criterion.
  - That is, the false alarm rate as well as the hit rate decreases as a function of time on task.
  - Perceptual sensitivity seems to be affected as well when the task requires the subject to compare rapidly presented events to information in memory to identify the events as a signals or nonsignals.

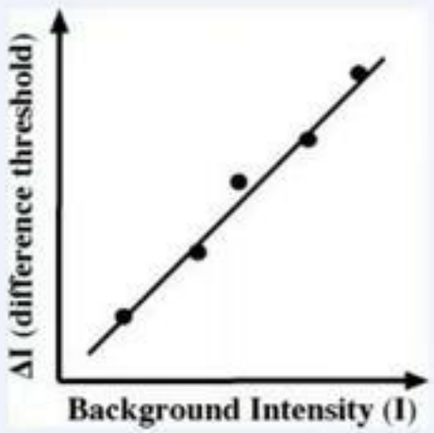
Serial Search Model

- **Average time to find target**
  - **T = (N X I) / 2**
  - **I = Average inspection**
  - **N = Total number of item**

Discrimination, Discriminability and Redundancy Gain

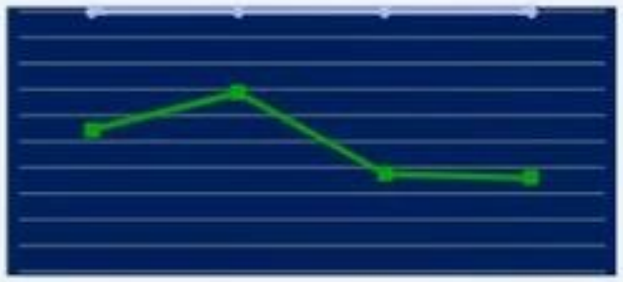
Discrimination

- **Ability to discriminate between one of the two signals rather than to detect the existence of a signal.**
- **Just Noticeable Difference or JND**
- **Weber's Law**

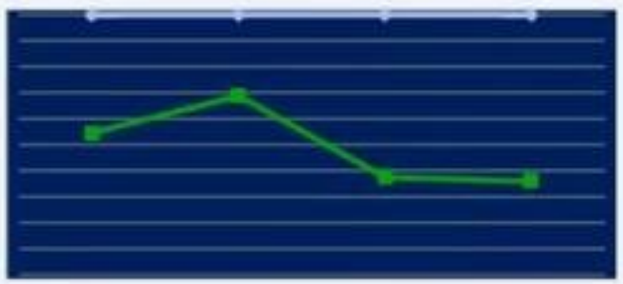


Redundancy Gain

Altitude



Attitude

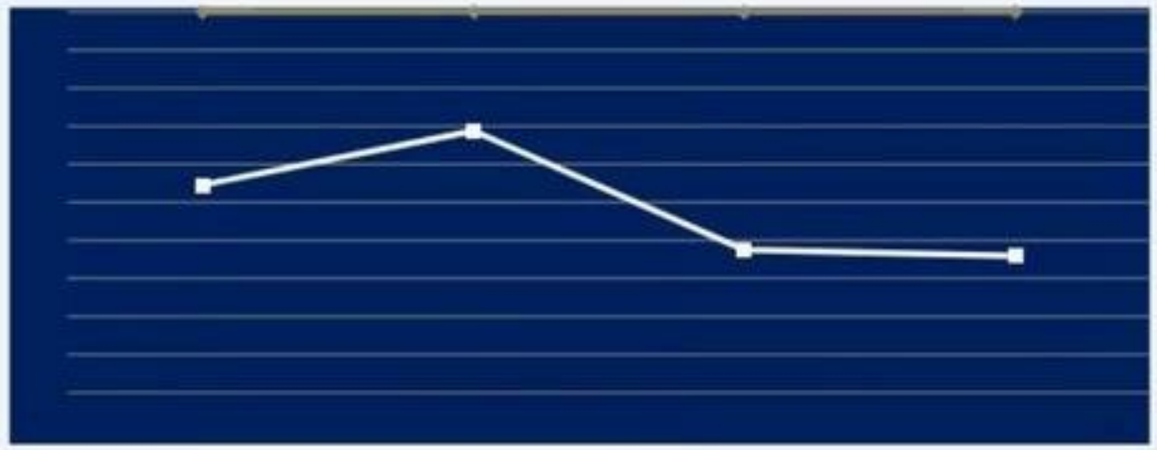


Redundancy is not simply the same as repetition

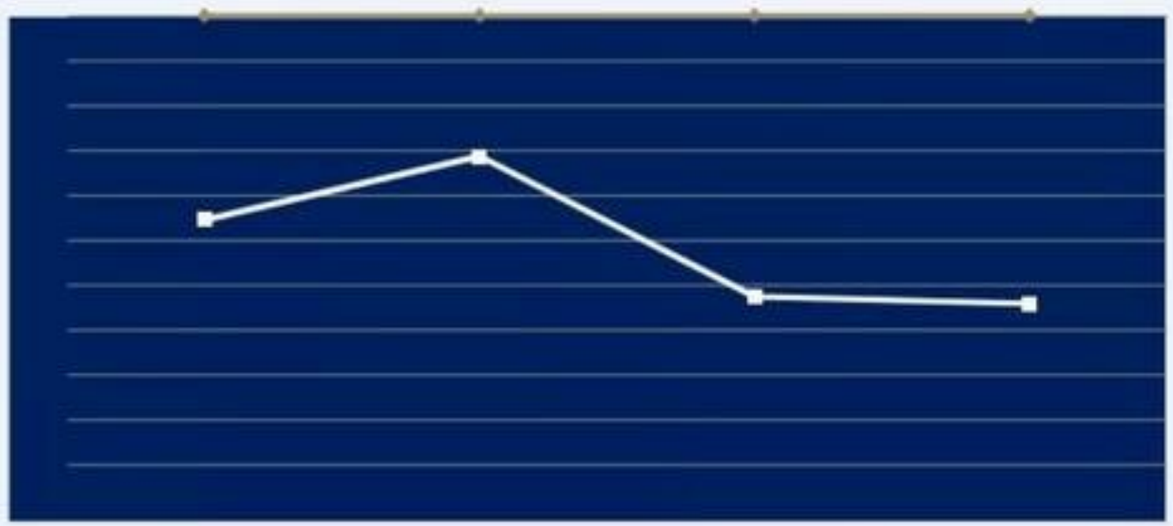
Alternative Physical forms

Discriminability

Altitude



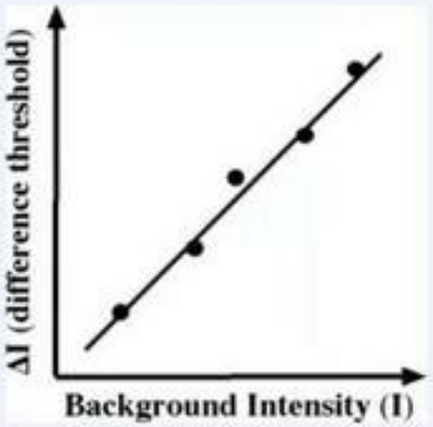
Attitude



Weber's Law

The Weber–Fechner law attempts to describe the relationship between the physical magnitudes of stimuli and the perceived intensity of the stimuli.

- Ernst Heinrich Weber (1795–1878)
- Gustav Theodor Fechner (1801–1887) later

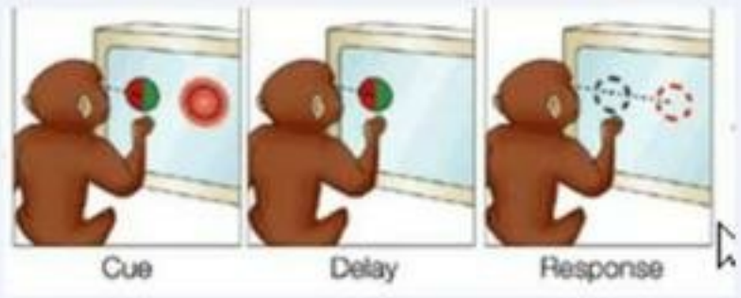


Weber's Law states that the ratio of the increment threshold to the background intensity is a constant. So when you are in a noisy environment you must shout to be heard while a whisper works in a quiet room. And when you measure increment thresholds on various intensity backgrounds, the thresholds increase in proportion to the background.

$$\frac{\Delta I}{I + a} = K$$

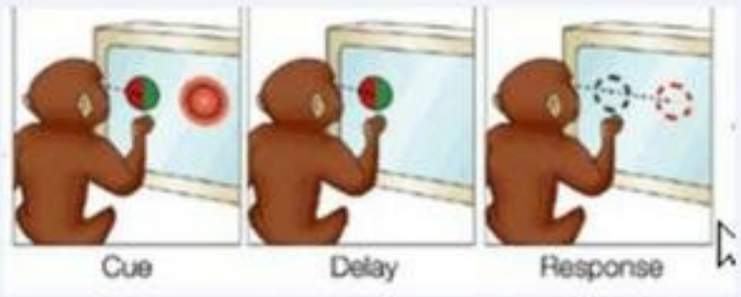
What is Response Selection?

Hick-Hayman Law



Response Selection

- **Refers to the processes involved in determining what response is made to a particular stimulus.**
- **It is affected by the variables of a number of alternatives, stimulus-response compatibility.**
- **As the number of stimulus-response alternative increases, reaction time increases as a logarithmic function of the number of alternatives (Hick, 1952; Hyman 1953).**



Hick-Hyman Law

- **Developed simultaneously by Hick (1952) and Hyman (1953)**
- **Given a set of *n* stimuli, associated one-for-one with *n* responses, the time to react (*RT*) to the onset of a stimulus and make the appropriate response is given by:**

$$RT = a + b \log_2(n)$$

- **$\text{Log}_2(n)$ has units "bits"**
- ***a* and *b* are constants determined empirically through linear regression**

Hick-Hayman Law

- **Choice Reaction Time**
  - Given a set of "n" stimuli, associated one for one with "n" responses, the time to react (RT) to the onset of a stimulus and to make the appreciate response is given by:
  - $RT = a + b \log_2 (n)$
  - Where a is the base processing time and be is the amount that RT increases with increases in N.

The slop of the Hick-Hyman function is influenced by many factors. For example, the slope decreases as subjects become practiced at a task.

Hick-Hyman Law Example

- **Question:**
  - If n = 26, what is RT?

- **Answer:**
  - $RT = 0.2 \log_2(26) = 0.940$ seconds

- **Is this useful?**

How long will take to find “Sesco”?

- Irina Messier
- Lucius Pahl
- Candis Eslick
- Lillian Nicolson
- Treva Croston
- Elden Orban
- Susy Ewalt
- Dinorah Lathem
- Louanne Eland
- Petronila Leek
- Emely Sesco
- Shon Devries
- Kiara Bebout
- Randal Sommer
- Krysta Towle
- Gwenn Dudash
- Raymundo Axford
- Verlie Whitesides
- Jonathon Cotton
- Terrilyn Erdman

n = 19, what is RT?

Answer:

$RT = 0.2 \log_2(19) = 0.25$ seconds

Visual Components

- Layout
- Organizations
- Charts
- Encoding
- Rapid Perception,
- Salience

Layout

Constructivism

- **An epistemology or a philosophical framework**
- **Theory of learning**
  - **Argues humans construct meaning from current knowledge structures.**
  - **These arguments about the nature of human learning guide constructivist learning theories and teaching methods of education.**

Constructivism

- **Jean Piaget**
  - **Swiss philosopher, natural scientist and developmental theorist (August 9, 1896 – September 16, 1980)**
- **Lev Vygotsky**
  - **Russian developmental psychologist and the founder of cultural-historical psychology (November 1896 – June 11, 1934)**
  - **Social interaction plays a fundamental role in the development of cognition.**
    - **Vygotsky (1978) states: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals." (p57)**

Constructivist Theories

- **Perception involves the intervention of representations and memories.**
- **What we see is not a replica or copy of the world such as the image that a camera would produce.**
- **Instead, the visual system constructs a model of the world by transforming, enhancing, distorting and discarding information.**

Effect of Construction

Provides us with a more constant view of the world than if we were merely to "see" the images that impinge on our retina.

Gestalt Principles

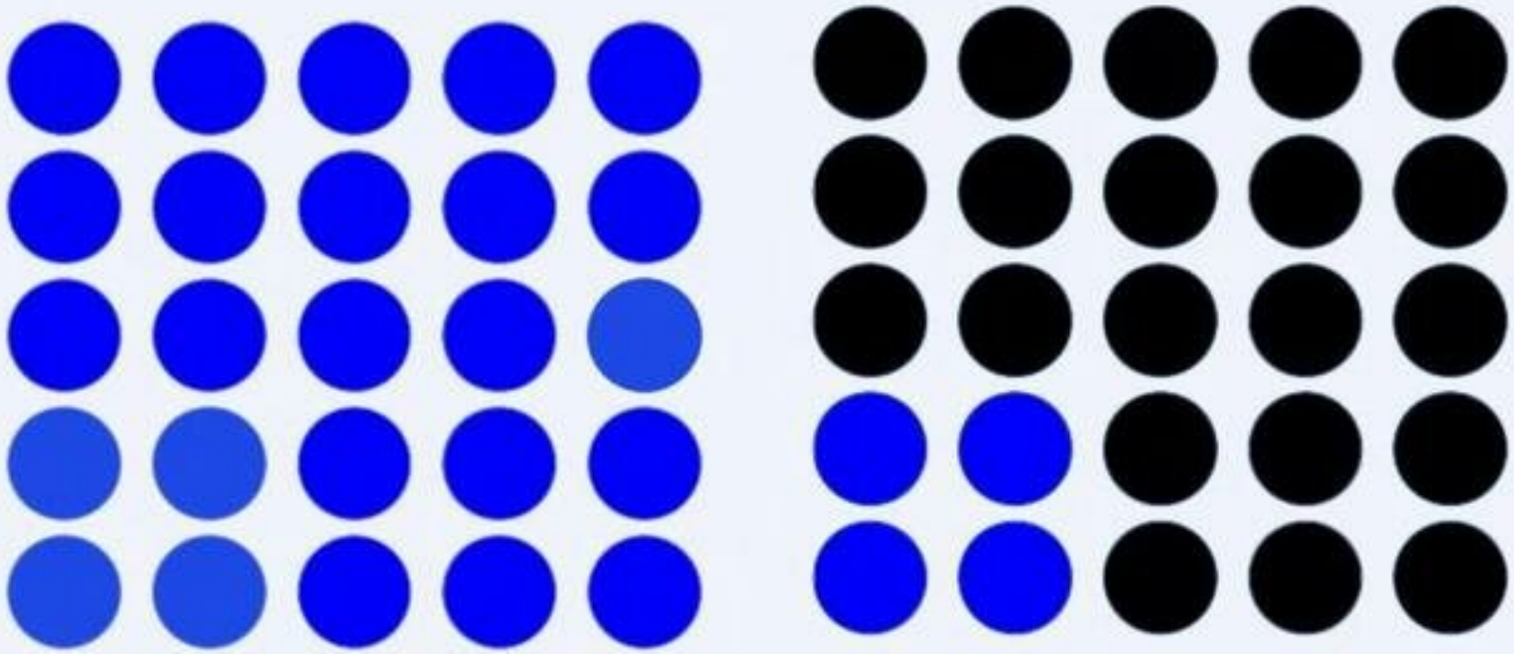
The ability to interpret the meaning of scenes and objects based on innate laws of organization, or Gestalt principles.

Objects in a scene appear to group pre-attentively according to certain laws or principles.

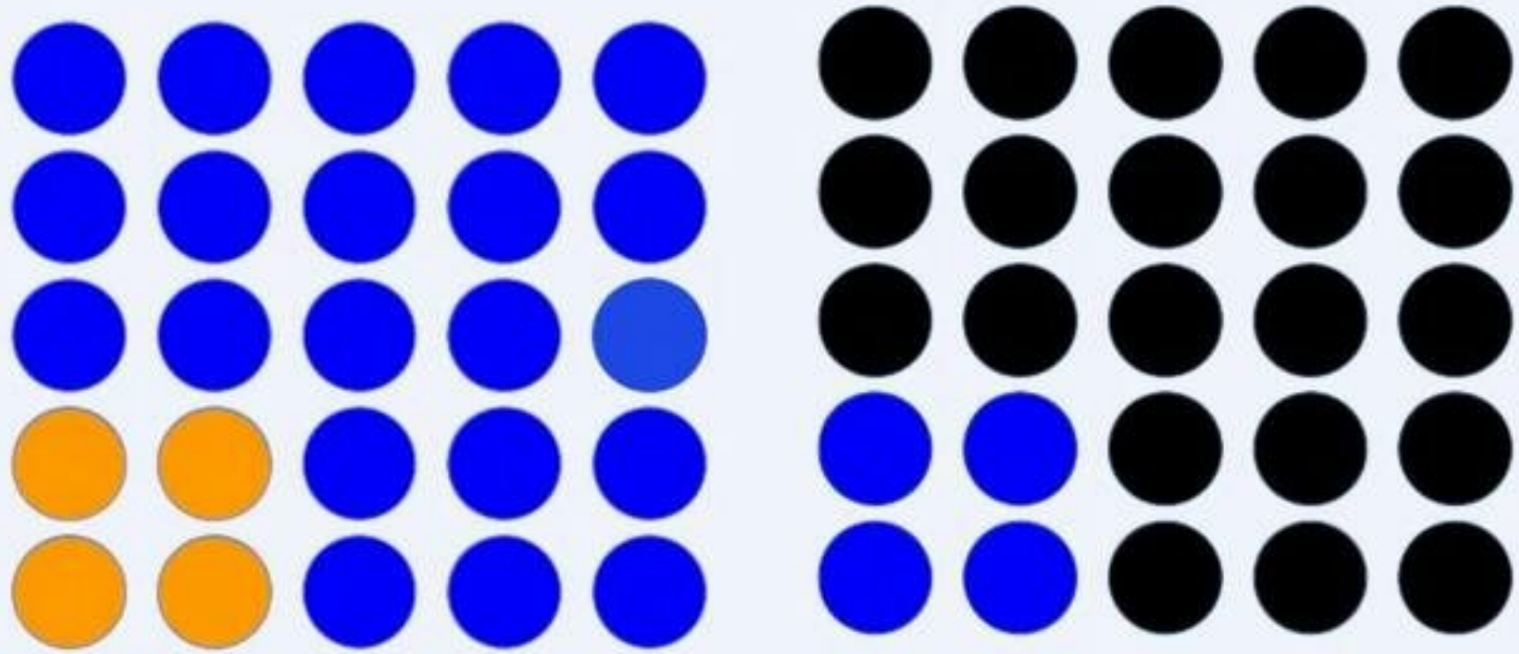
Gestalt Principles

- **Proximity: Perceiving a whole as organized into subsets or groupings, which in turn are organized into parts**
- **Similarity: Objects with similar properties (e.g. shape, color)**
- **Closure: Completing missing parts of a figure**
- **Good Continuation: Objects that define smooth lines or curves**
- **Symmetry: Objects that form symmetrical patterns**
- **Periodicity: Objects that form periodic patterns**

Gestalt Principles



Gestalt Principles



Example

A 13 C

12 13 14

13

The Gestalt Laws of Perceptual Organization

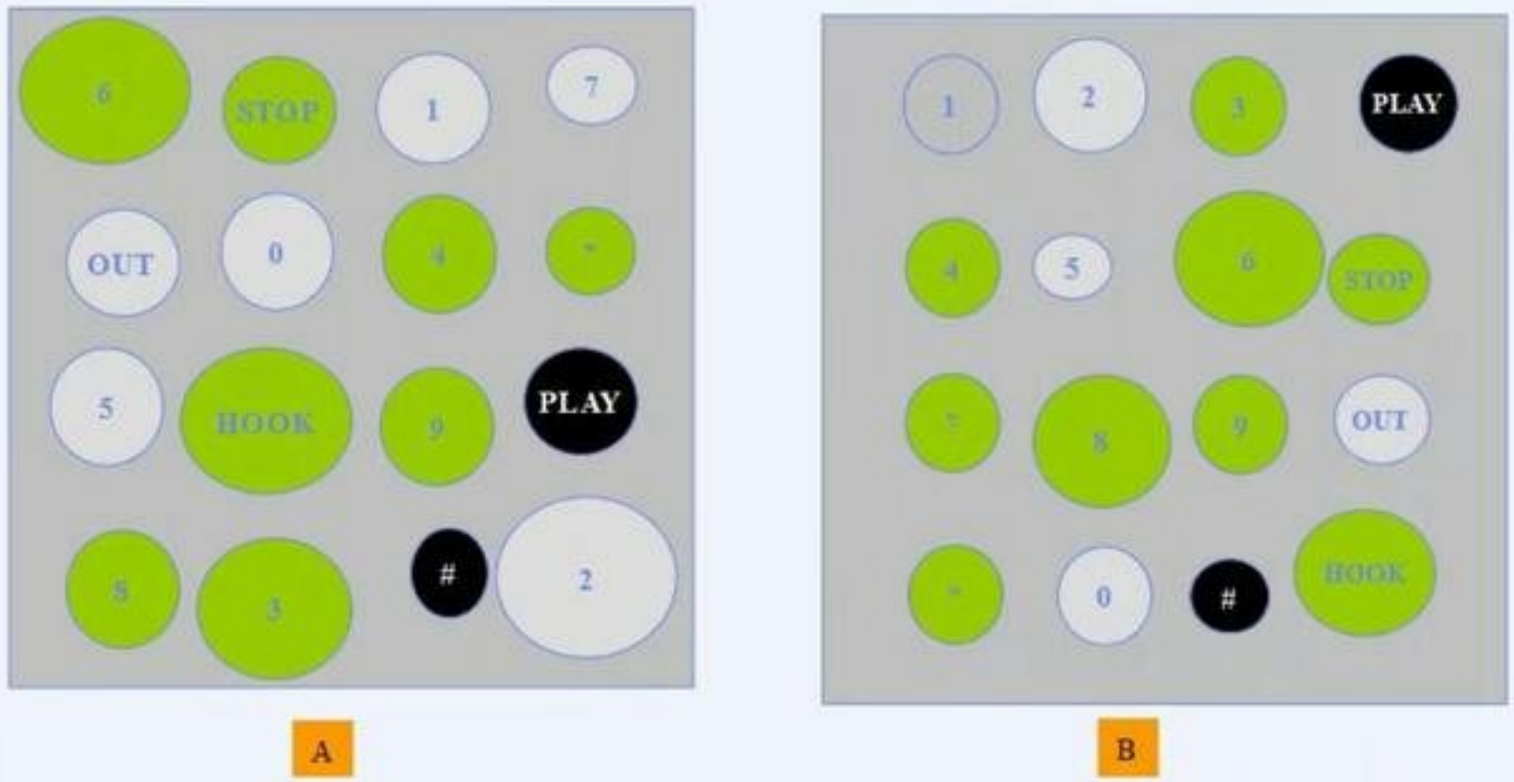
Describe what pattern principles are shown below:

(a)

(b)

(c)

Grouping



A

B

Adapted from Del Coates, 2003, Watches Tell More than Time

Grouping

C

D

Adapted from Del Coates, 2003, Watches Tell More than Time

Example

Pennsylvania
Bedford Motel/Hotel: Crinaline Courts
(814) 623-9511 S: $18 D: $20
Bedford Motel/Hotel: Holiday Inn
(814) 623-9006 S: $29 D: $36
Bedford Motel/Hotel: Midway
(814) 623-8107 S: $21 D: $26
Bedford Motel/Hotel: Penn Manor
(814) 623-8177 S: $19 D: $25
Bedford Motel/Hotel: Quality Inn
(814) 623-5189 S: $23 D: $28
Bedford Motel/Hotel: Terrace
(814) 623-5111 S: $22 D: $24
Bradley Motel/Hotel: De Soto
(814) 362-3567 S: $20 D: $24
Bradley Motel/Hotel: Holiday House
(814) 362-4511 S: $22 D: $25
Bradley Motel/Hotel: Holiday Inn
(814) 362-4501 S: $32 D: $40
Breezewood Motel/Hotel: Best Western Plaza
(814) 735-4352 S: $20 D: $27
Breezewood Motel/Hotel: Motel 70
(814) 735-4385 S: $16 D: $18

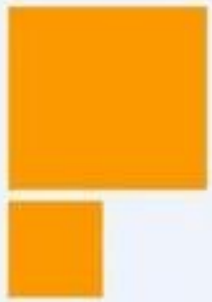
Example

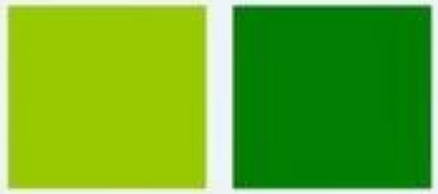
South Carolina

City	Motel/Hotel	Area code	Phone	Rates Single	Rates Double
Charleston	Best Western	803	747-0961	$26	$30
Charleston	Days Inn	803	881-1000	$18	$24
Charleston	Holiday Inn N	803	744-1621	$36	$46
Charleston	Holiday Inn SW	803	556-7100	$33	$47
Charleston	Howard Johnsons	803	524-4148	$31	$36
Charleston	Ramada Inn	803	774-8281	$33	$40
Charleston	Sheraton Inn	803	744-2401	$34	$42
Columbia	Best Western	803	796-9400	$29	$34
Columbia	Carolina Inn	803	799-8200	$42	$48
Columbia	Days Inn	803	736-0000	$23	$27
Columbia	Holiday Inn NW	803	794-9440	$32	$39
Columbia	Howard Johnsons	803	772-7200	$25	$27
Columbia	Quality Inn	803	772-0270	$34	$41
Columbia	Ramada Inn	803	796-2700	$36	$44
Columbia	Vagabond Inn	803	796-6240	$27	$30

Organization

Visual Attribute





Visual Attribute

Research shows that human eyes tend to move from:

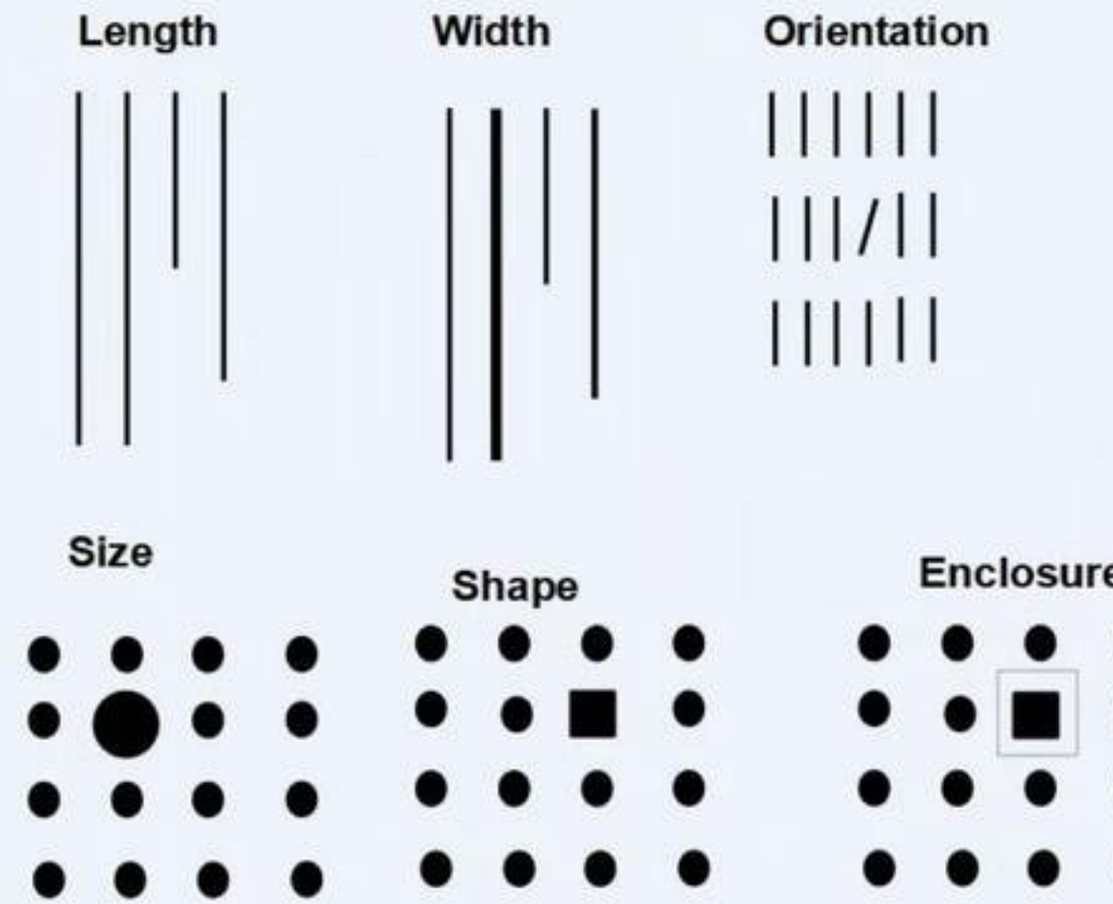
Large to small size

Irregular to regular shape

Dark to light shape

Saturated to unsaturated color

Visual Attribute- Form



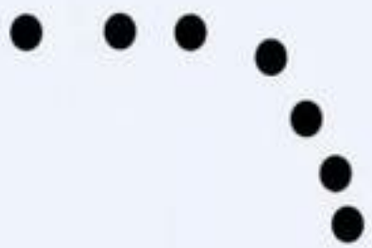
Stephen Few, Now You See it, 2013

Visual Attribute- Color

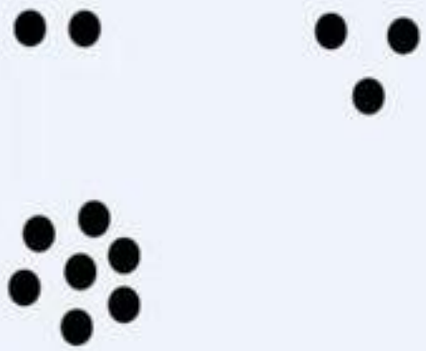
Stephen Few, Now You See it, 2013

Visual Attribute- Spatial Position

2 D Position



Spatial Grouping



Stephen Few, Now You See it, 2013

Tribute for Quantitative Data

Category	Attribute	Quantitative
Color	Hue Intensity	No Yes, but limited
Position	2-D Position	Yes
Form	Orientation Line length Line width Size Shape Added marks Enclosure	No Yes Yes, but limited Yes, but limited No No No
Motion	Flicker	Yes, based on speed, but limited

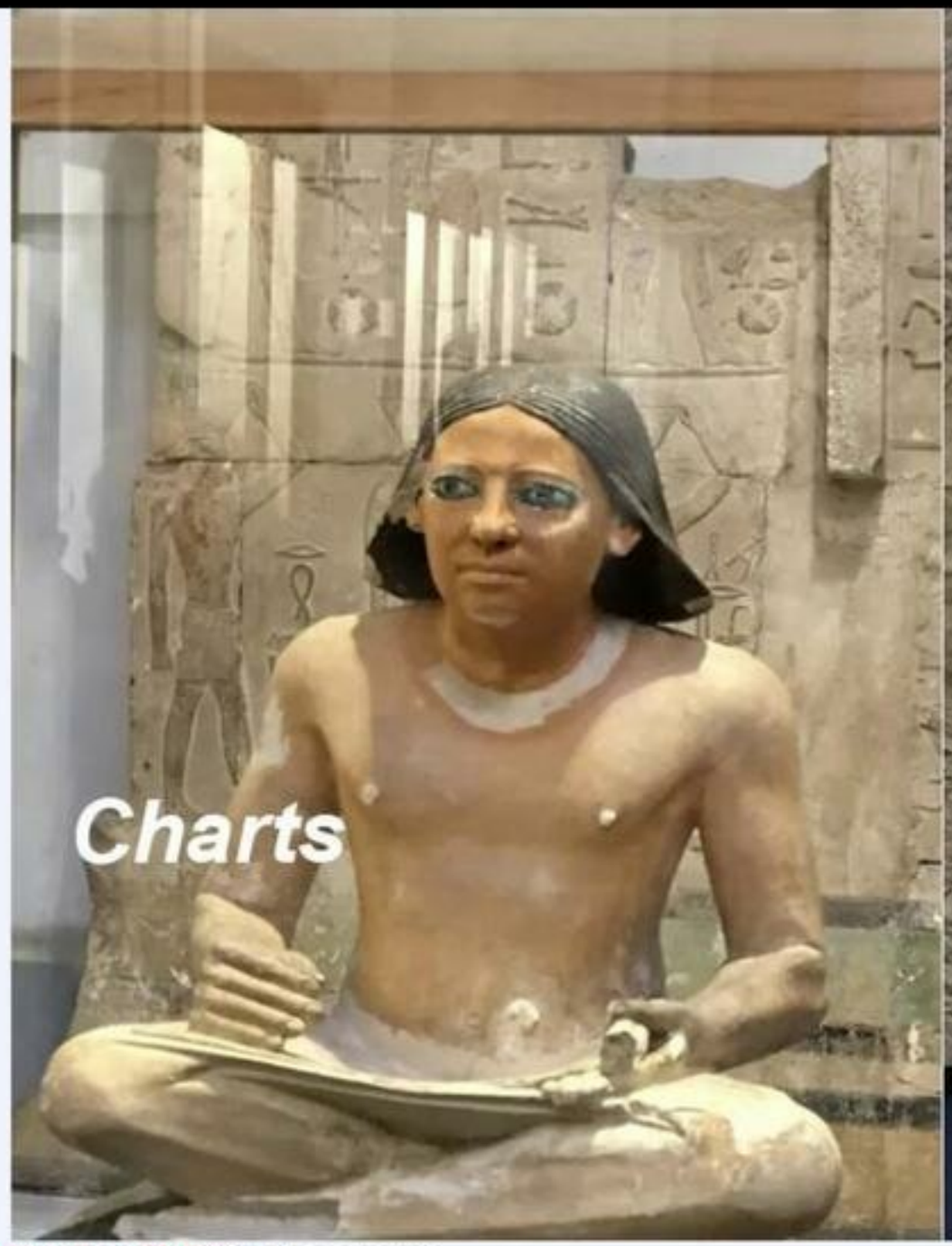
Stephen Few, Information Dashboard Design , 2006

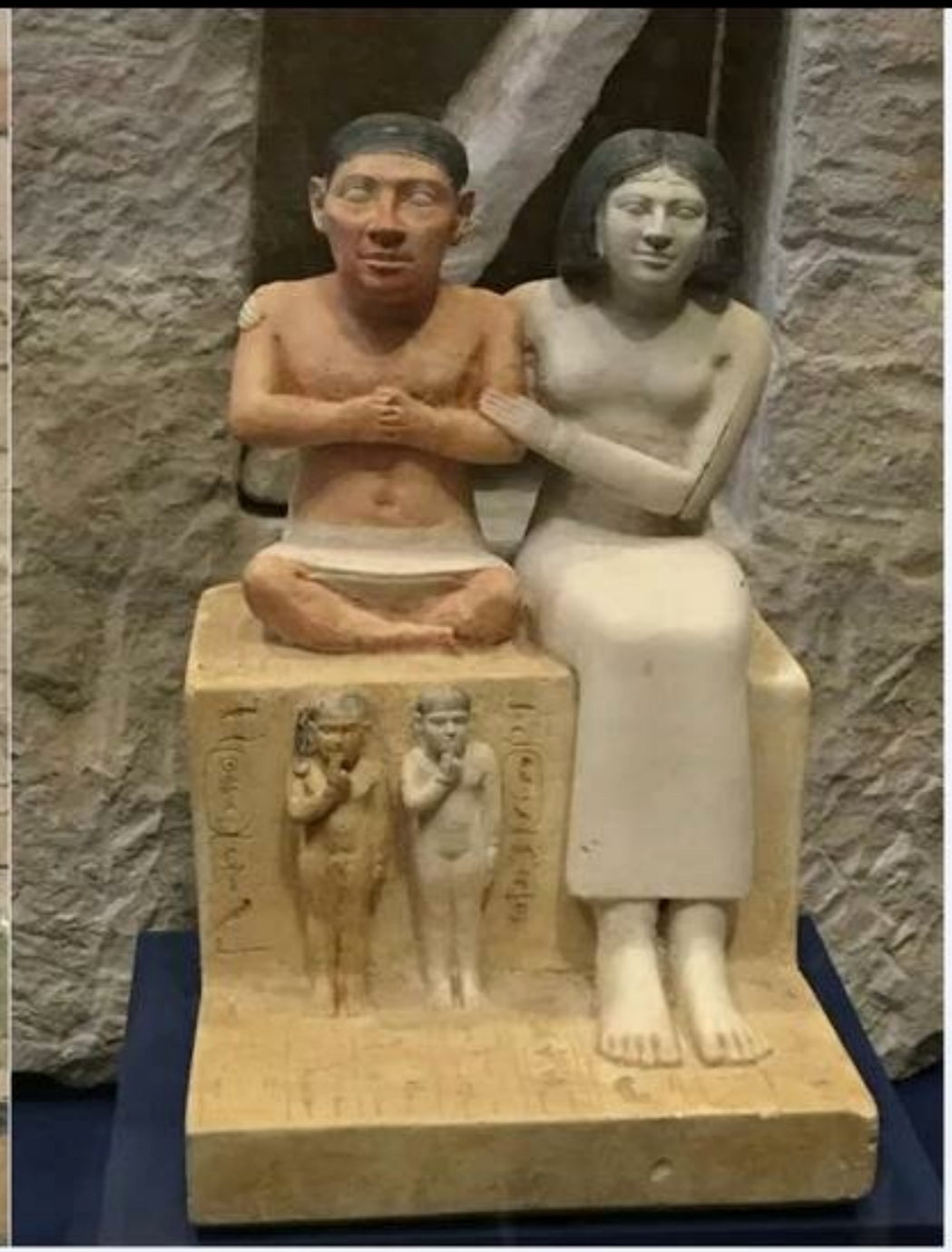
Encoding Data for Rapid Perception

Exercise

Try to count quickly number of time the number 5 appears in the list

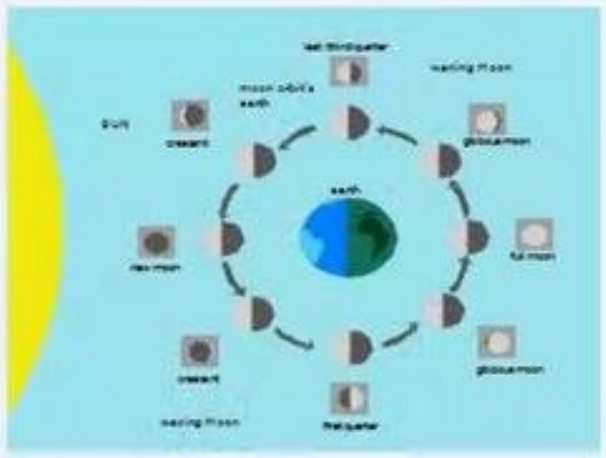
2783715421859880932432320919351173
8997838130446591671126039231573122
7633236615317496459757466312469739
4879477913317994403750258729622143
4439392384969283272229244847967431


Charts



Charts & Graphics

- **Visualize data**
- **Visualize new or abstract concepts**
- **Visualize physical and technical concepts that are invisible to the eye**
- **Communicate a large amount of information efficiently and effectively**

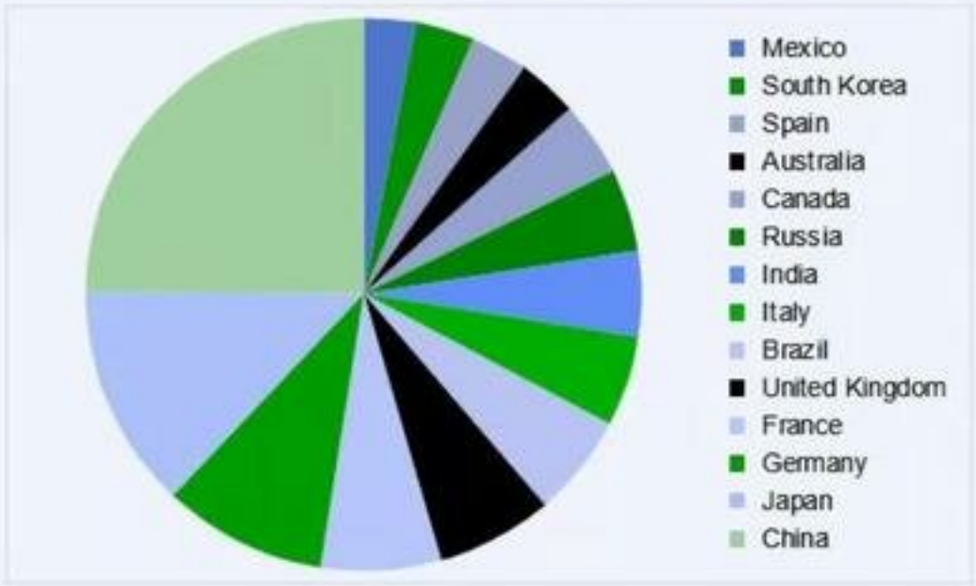


Word Versus Charts

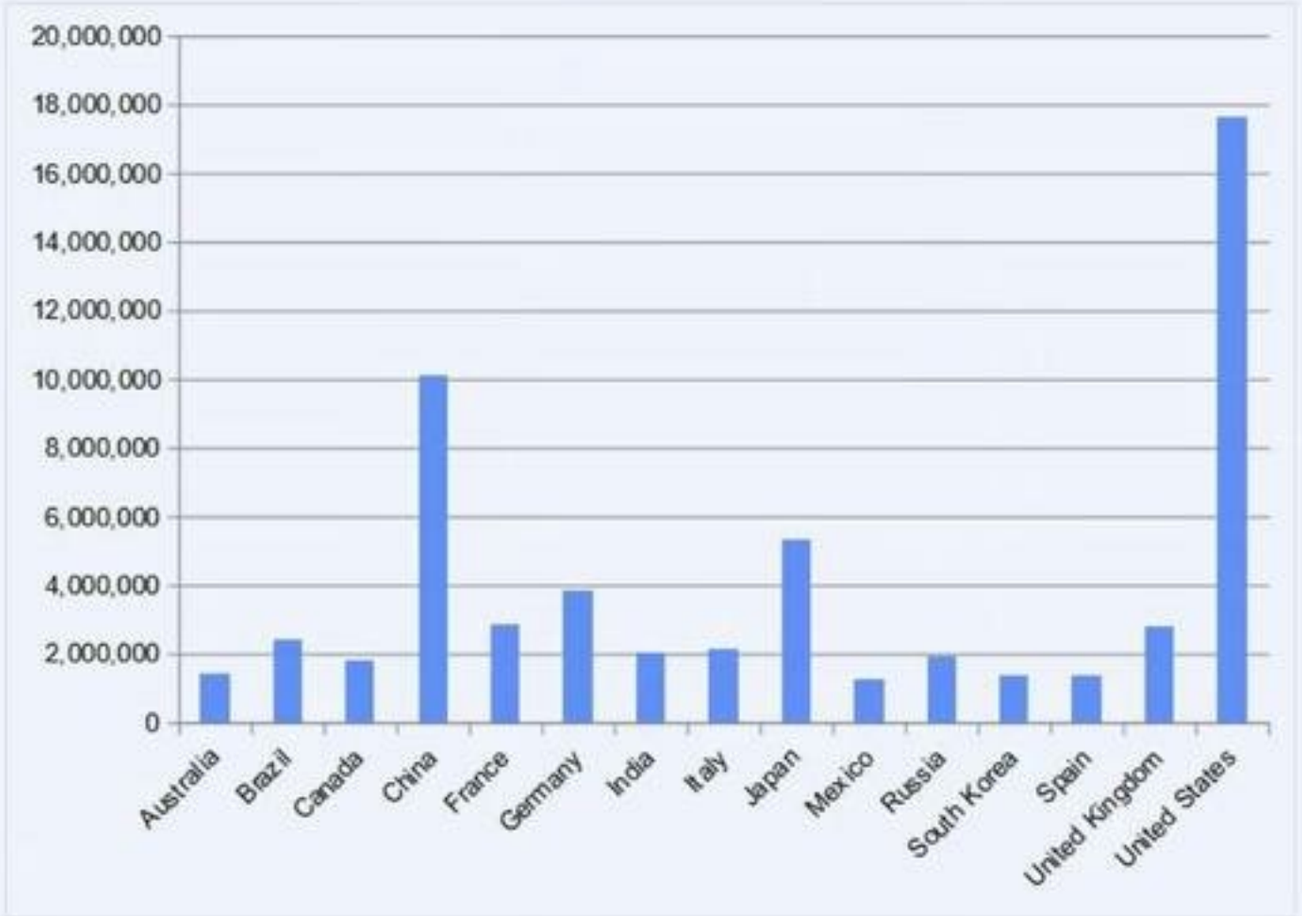
Business Unit 1's sales were $200 million, but business Unit 2's sales were much lower with $100 million.

Chart Types

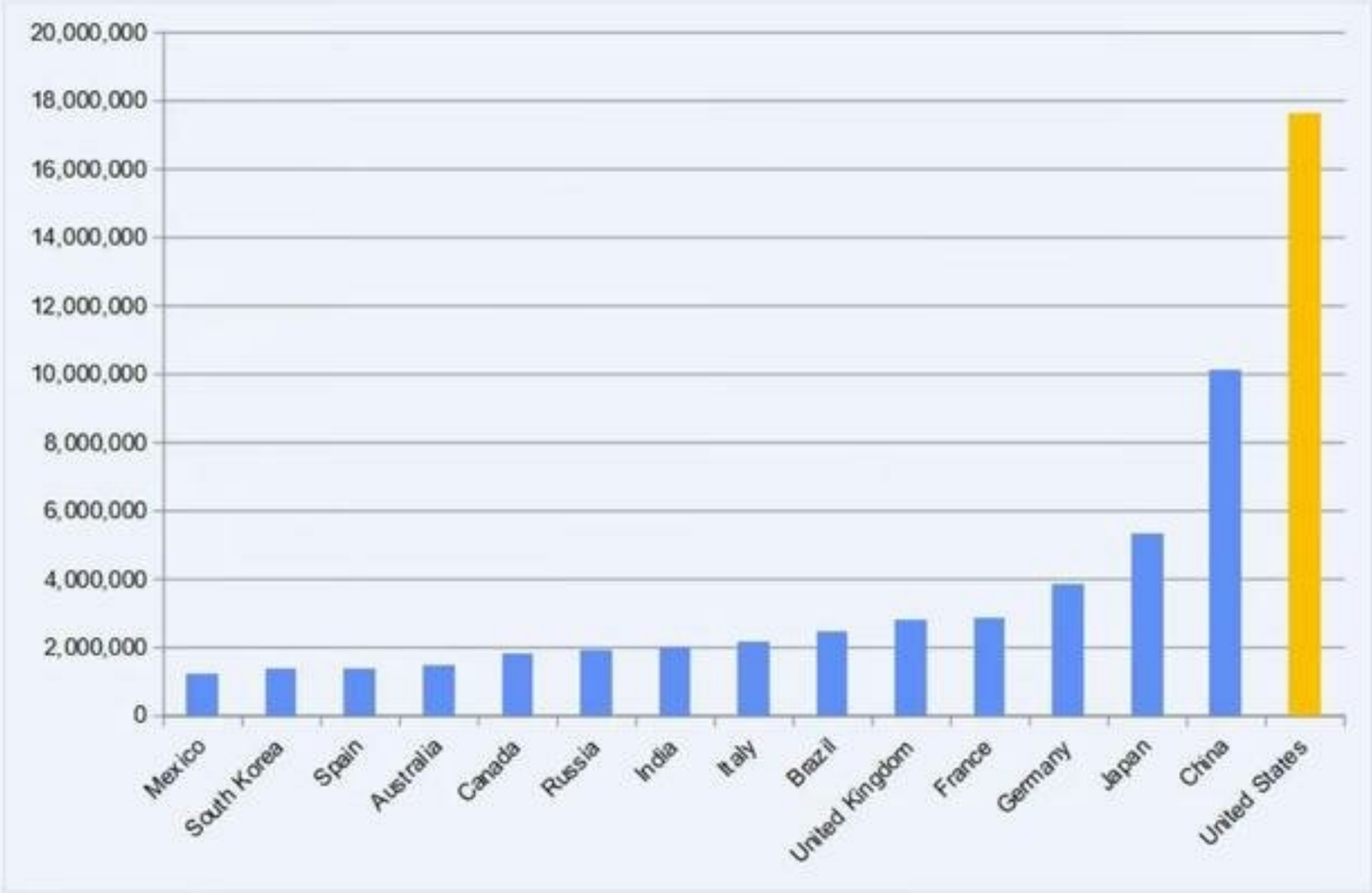
Gross National Income



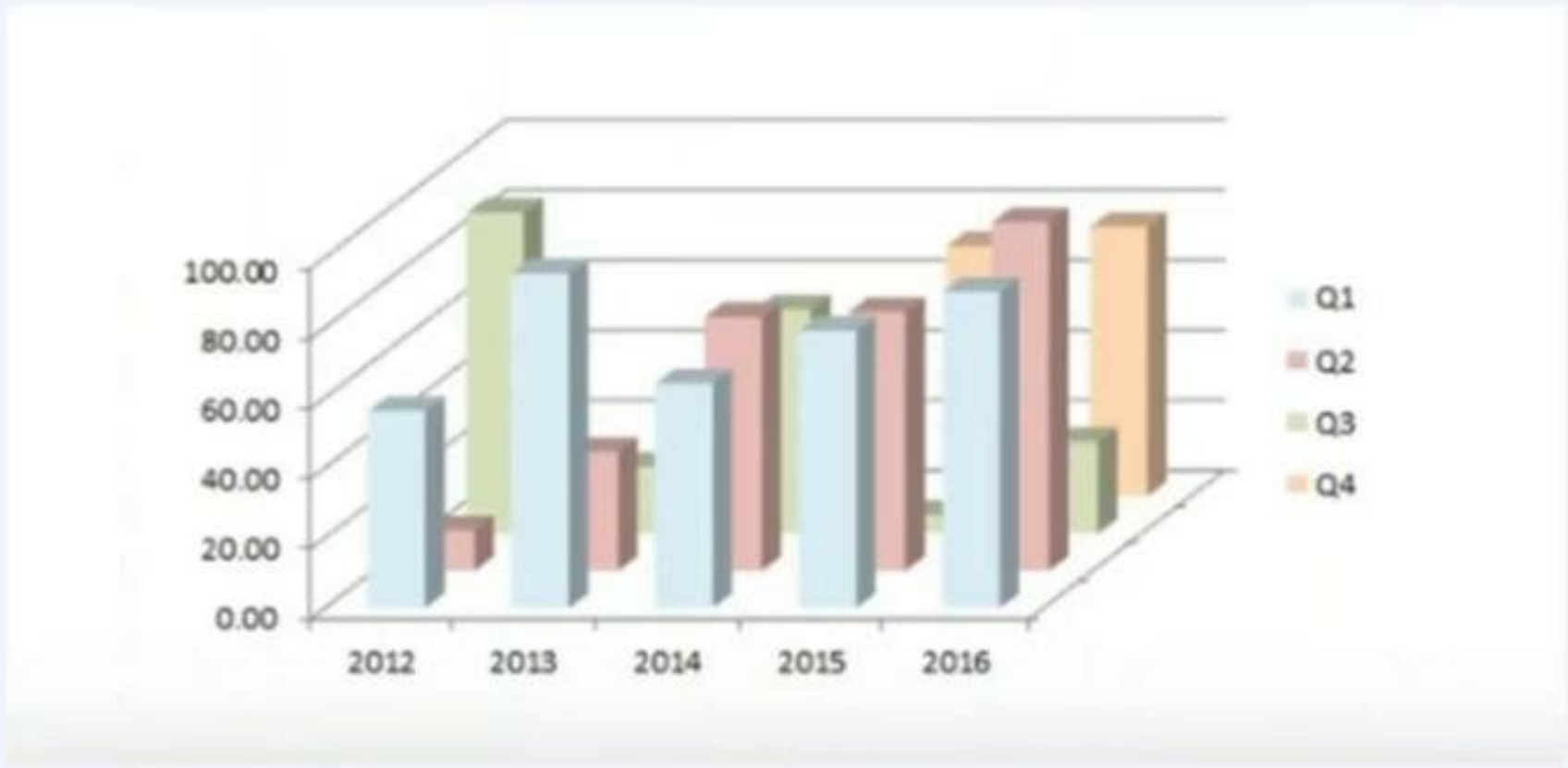
Gross National Income



Gross National Income



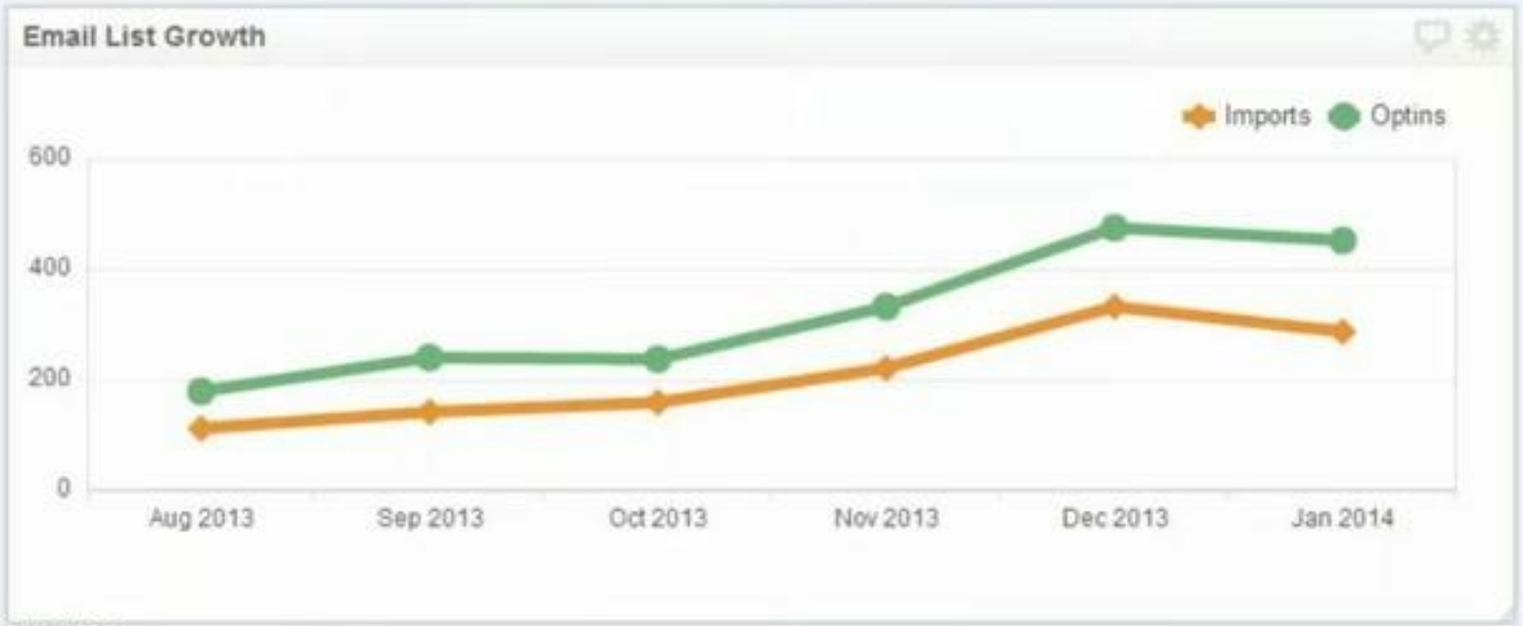
3 Dimensional Charts



Line Chart

Effective

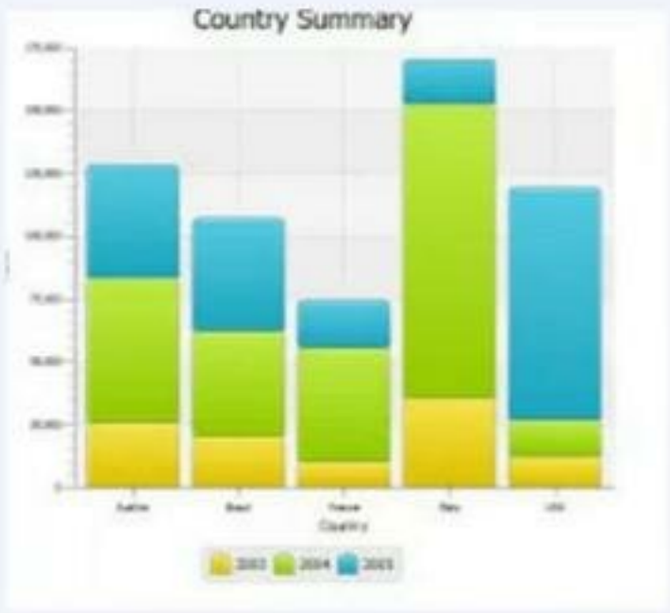
- **To spot trends and patterns in the data.**
- **To understand the general trends,**
- **To show fluctuations, and patterns associated with a data set.**
- **Good to compare two or more related data sets.**



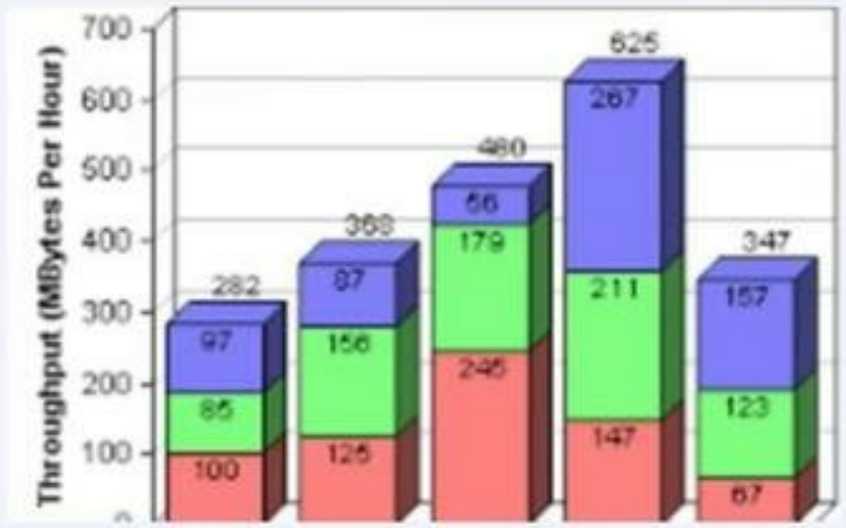
Bar Charts

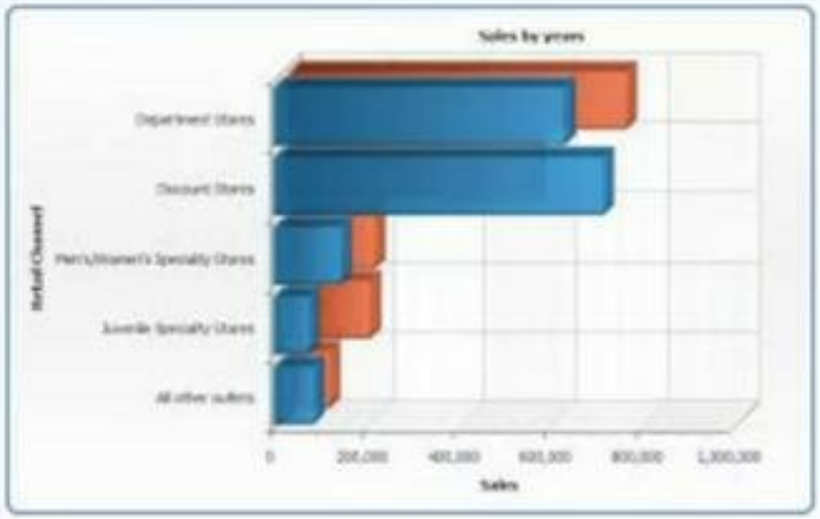
Effective

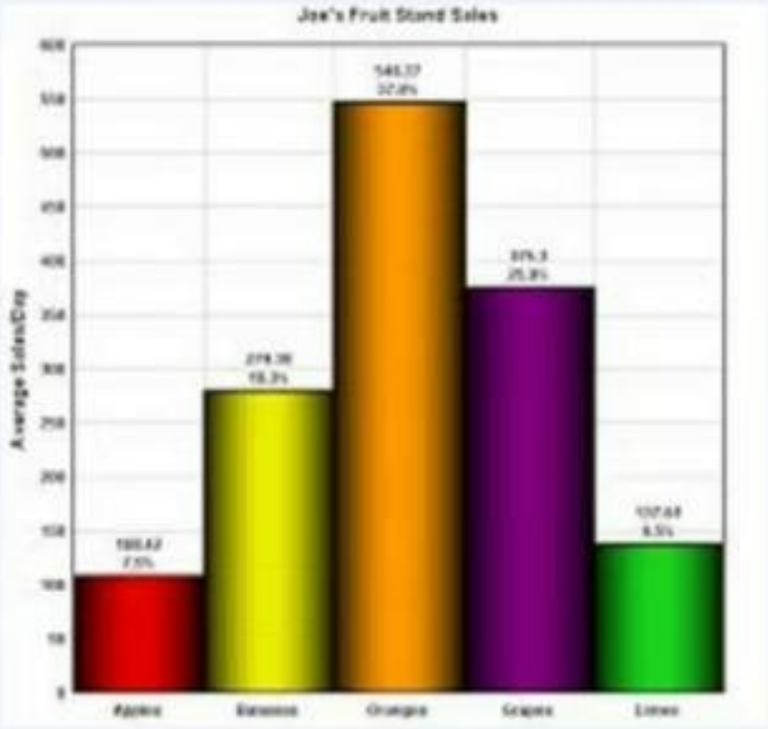
- **To compare two or more values that fall within the same category,**
- **To show multiple, similar data sets relate to each other.**



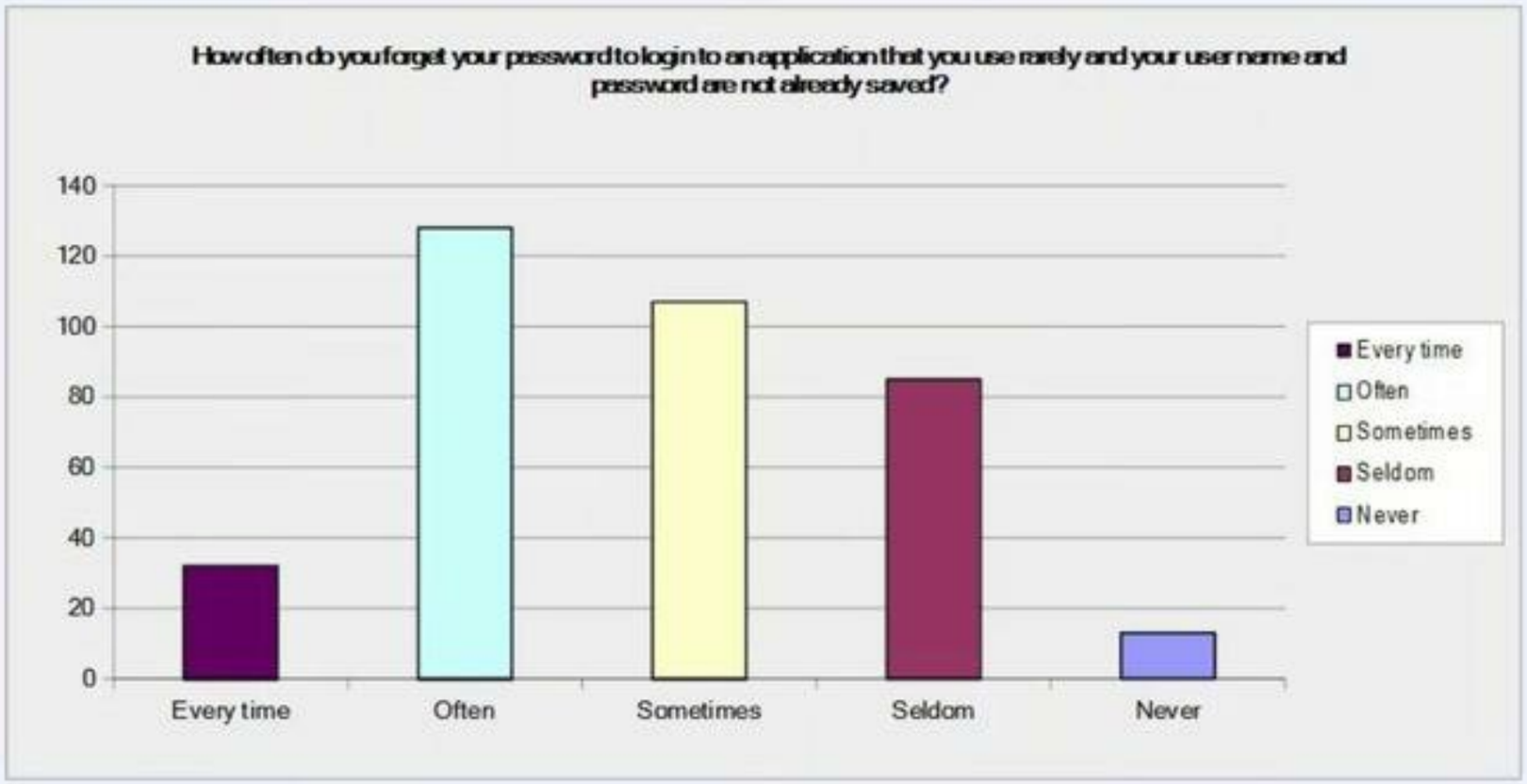
How about these charts?





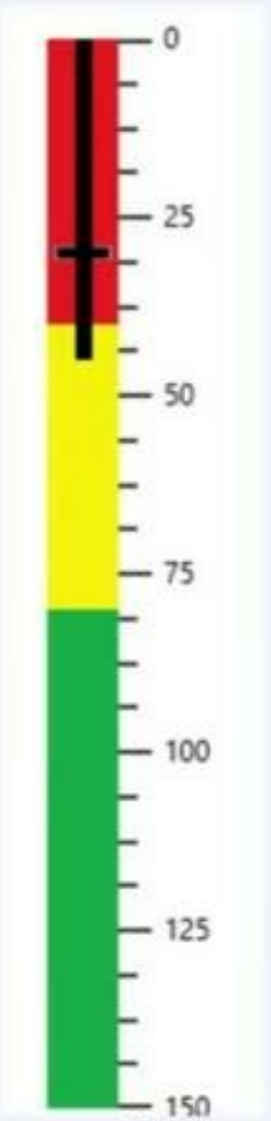


What is wrong in this chart?



Bullet Graph

- **Effective on a dashboard**
- **Requires less real state**
- **Provides several indicators**



Sparkline

Effective to

- **Display patterns**
- **Trend of change through time**
- **Use in dashboards**

Can be

- **Stand alone or part of a series**
- **Display a particular range of values**

Sparkline

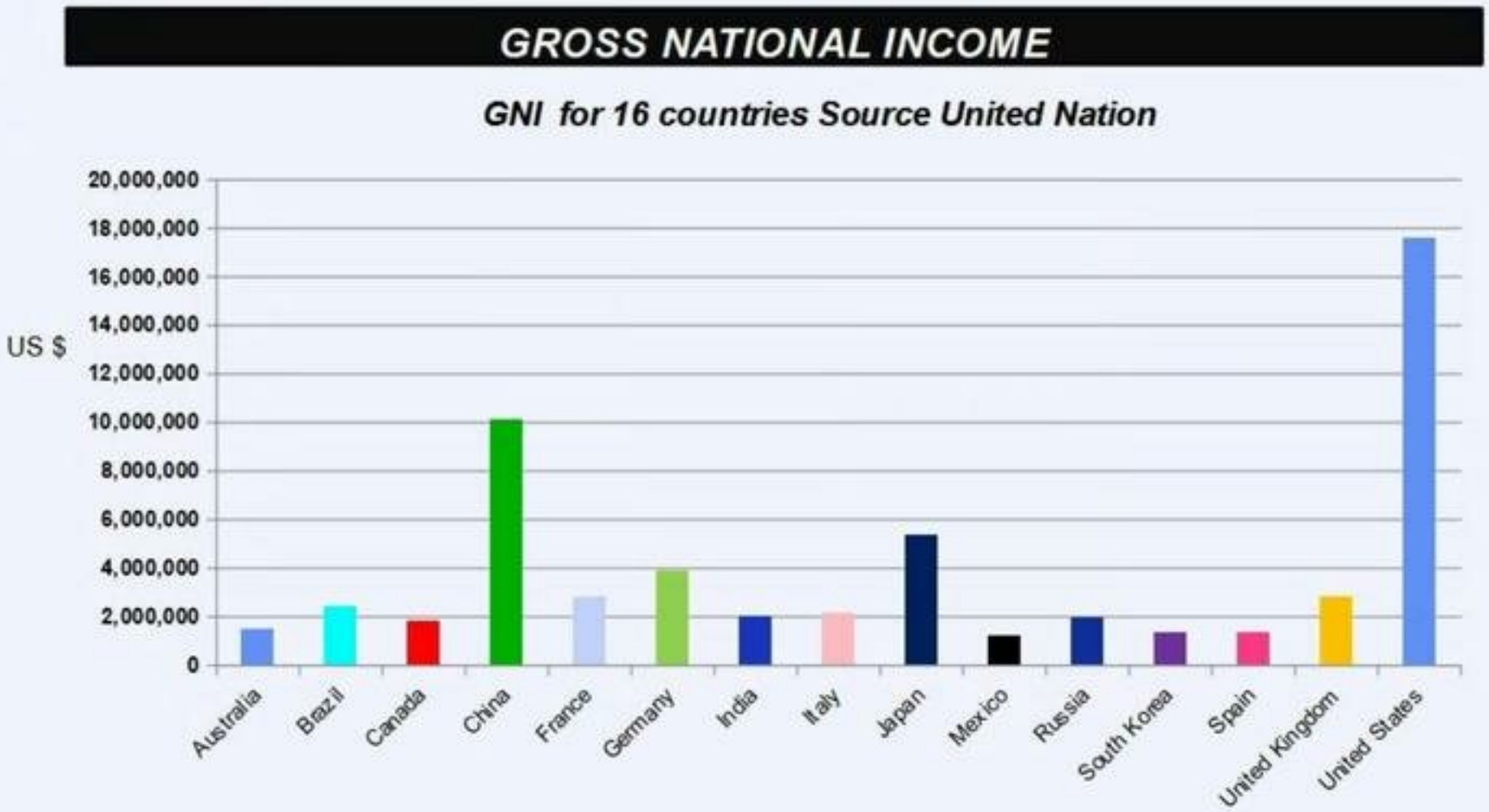
Market Movers

Most Actives | % Gainers | % Losers

Symbol	Company Name	Price	Change	% Change	Volume	Chart
CLF	Cliffs Natural Resourc...	11.15	-0.22	-1.93%	116,059,464	
BAC	Bank of America Corp...	23.08	-0.04	-0.17%	90,547,654	
TWTR	Twitter, Inc.	15.58	-0.83	-5.06%	73,061,193	
AMD	Advanced Micro Devic...	13.58	+0.16	+1.19%	54,575,518	
IMMU	Immunomedics, Inc.	5.23	+0.93	+21.63%	54,348,196	

More

Typography in Charts

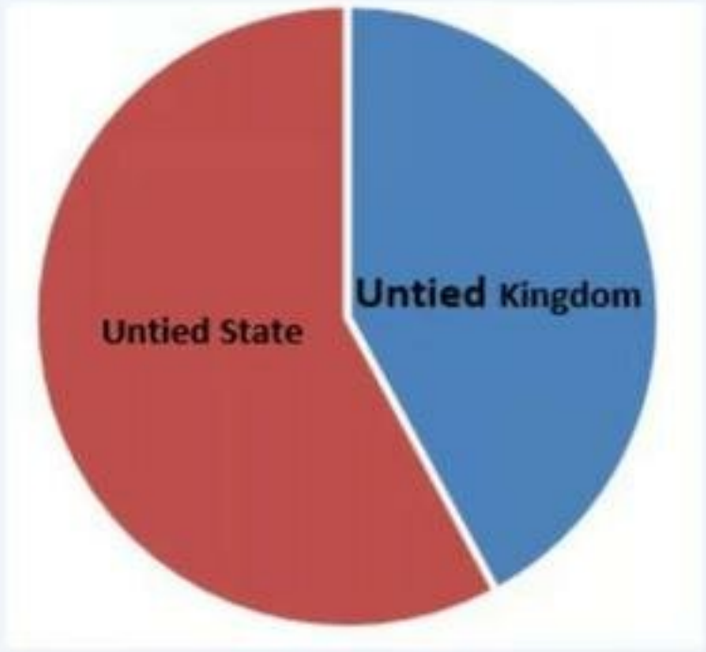


Typography in Charts

- **Don’t use all uppercase letters and white letter on black background**
- **Don’t use bold italic text**
- **Don’t use bold text for numbers on the scale**
- **Don’t set type at an angle**

Typography in Charts

- **Provide a headline for the chart**
- **Provide a short description of the chart**
- **Use bold to increase legibility on a shaded background**



Change all these labels in the HTML template
View list by:
Select
Nav Link 1 | Nav Link 2 | Nav Link 3 | Nav Link 4 | Nav Link 5 | Nav Link 6
ID
Name
Amount
Type
Last Activity

Tables

Text and Sparkline

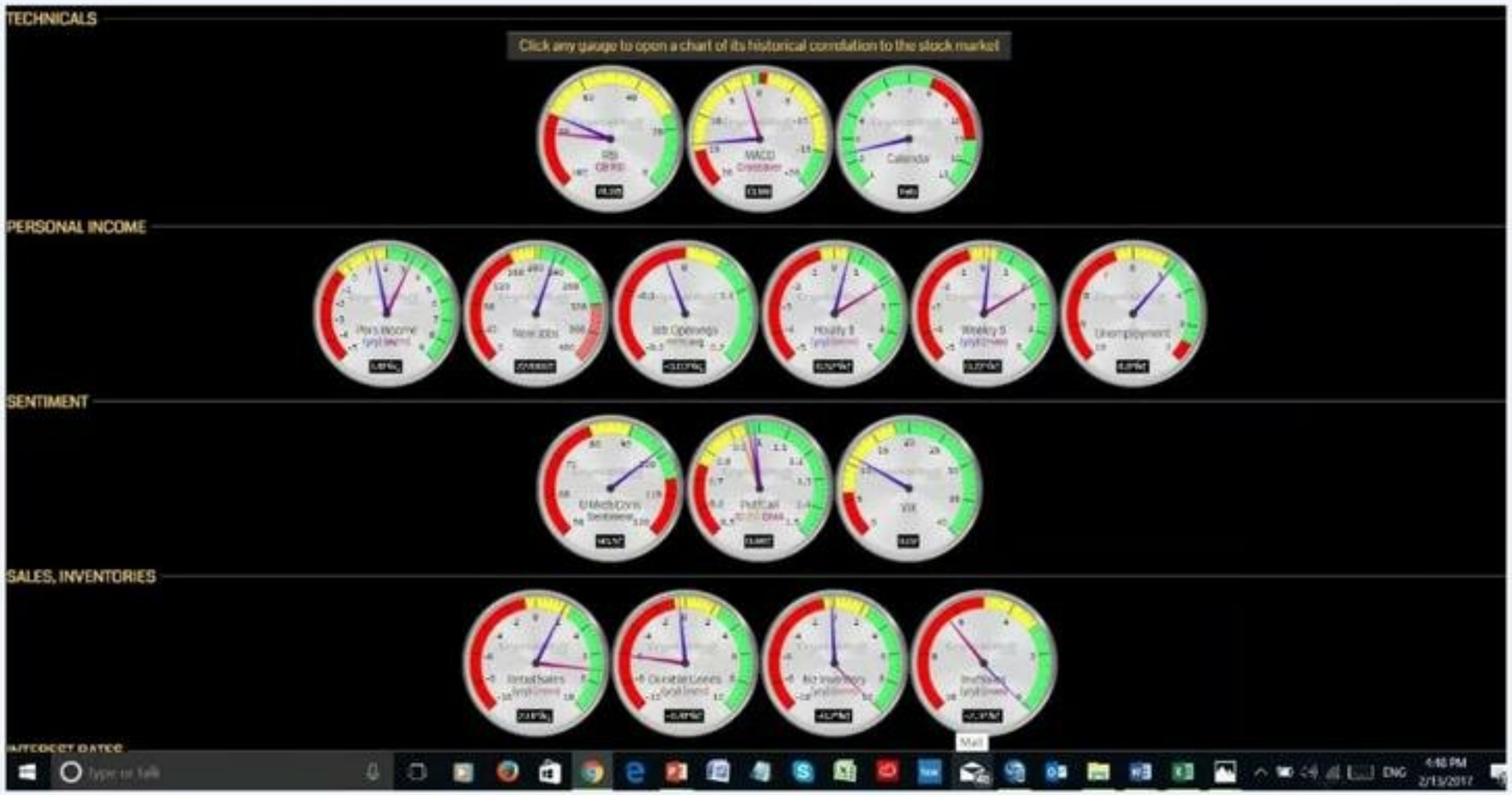
Gauges

Gauges

Effective

- **To demonstrate when values are either hitting their target or missing the mark**
- **To track single metrics that have a clear, immediate objective**
- **Not always useful for a computer dashboard**

What do you think about this design?



https://www.crystalbull.com/?gclid=CjwKEAiAz4XFBRCW87vj6-28uFMSJAAHeGZb9fZkzmIkSzcQzxU7aXMoNV4NxWJVVMpDWYB_qengzhoCRtDw_wcB

New Design

NETGEAR® Smart Network
Apps Store
David Henry
My Devices
My Apps
Broadband Traffic Meter
Today: Tuesday January 10, 2011 10:31 AM
Broadband Traffic Meter on : WNDR4500
Your Current Data Usage
Show Usage Chart: Gauge Meter
0 GB
Limit 150 GB
21 days left in this billing cycle
Next cycle starts Feb 1, 2012
At this rate you reach the usage limit in 15 days.
Traffic Meter Settings

Visual Elements

- Text: Typography
- Color
- Icons
- Visualization & Communications Forms

Text

Readability and Legibility

Readability is the ease with which a reader can understand a text.

- **It depends on**
  - **Content (the complexity of its vocabulary and syntax)**
  - **Presentation (such as typographic aspects like font size, line height, and line length).**

Legibility is he quality of being clear enough to read

- Typeface
- Output/viewing device, resolution
- Line length/column width
- Letter spacing, word spacing, line spacing
- Justified versus ragged columns
- Movement
- Color
- Viewing environment

Typographic Guidelines

- **Letter Spacing:**
  - Too tight word spacing makes words difficult to distinguish from the next.
  - Too wide word spacing, gaps between word don't allow the eye to forms word group easily.
  - Line Spacing/Leading
    - Spaces between lines of test, or leading, should increase in relation to type size.
  - Line Length/Column Width
- **Justified Versus Ragged Right**
  - Unless the type is manually set or justified, it is better to use a ragged right column.

Typographic Guidelines

- **Serif and Sans Serif**
  - Serif is the stroke that projects from the top or bottom of the main stroke of the letter.
  - Sans Serif have no serifs at all; these letterforms are called sans serif.
- **Sans Serif is often easier to read online, depending on:**
  - Type size and monitor resolution
- **Sans Serif or Serif can be effective for contrast when combined with size or weight changes.**

Serif and Sans Serif Example

Futura In The Past, or A Triumph of Geometry: developed by Paul Renner in 1928, this font may be called the starting point of sans serif history in our century

Typographic Guidelines

- **Combining Typefaces**
  - It is important to decide whether the goal is harmony or contrast
  - General rule is not to use more than two different typeface on one page
  - Contrast in weight (boldness)
    - Combination of faces: Bold regular
  - Output device and viewing environment
    - Monitor resolution, Print quality, Poor lighting

Typography

- **X-Height**
  - **Height of the main element of a lowercase letter and is equivalent to the height of a lowercase x.**
- **Ascenders and Descanters**
  - **Ascenders is part of lowercase letter that rises above the body (x-Height) of the letter.**
  - **Descanter refers to the part of the lowercase letter that falls below the body (x-Height) of the letter.**

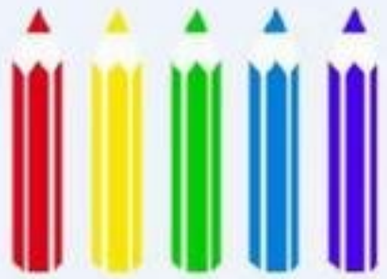
Color

Advantages of Using of Color

- **Aesthetic value**
- **Supports a theme or brand**
- **Provides grouping**
- **Shows relationships**
- **Draws attention**

Color Vision

- **Cone cells are called "red, green, or blue" based on the photo pigment they contain.**
- **Photo pigments are sensitive to different wavelengths of light,**
  - **Long-wavelength sensitive ("red"),**
  - **Middle-wavelength sensitive ("green"), and**
  - **Short-wavelength sensitive ("blue").**
- **L, M, and S are common abbreviations for "red", "green", and "blue" when referring to photo pigments.**

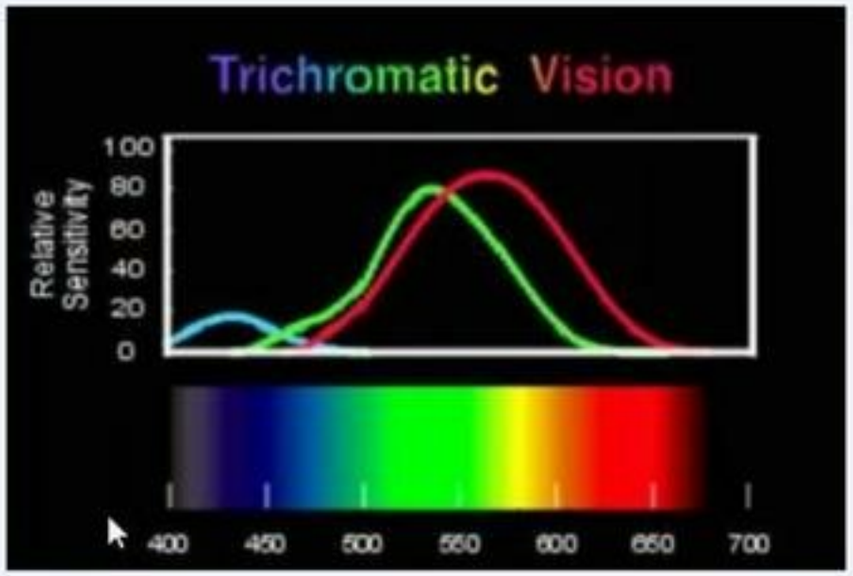


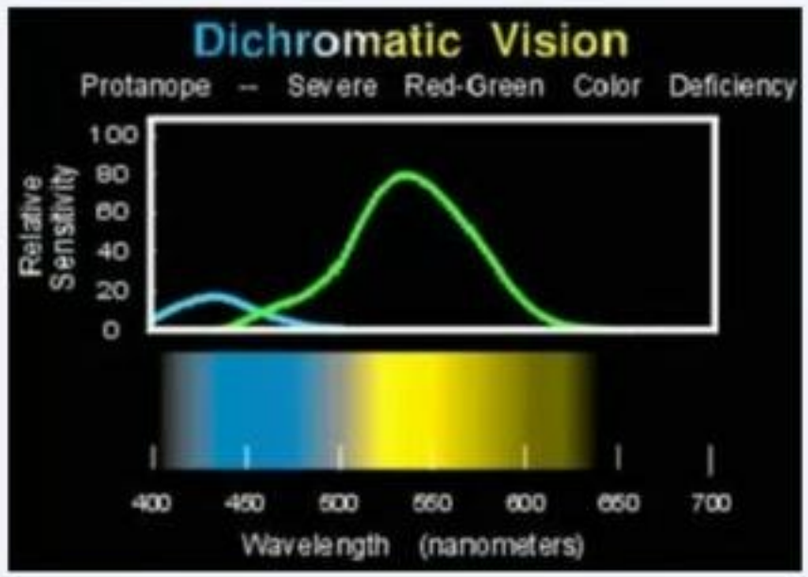
Visual Disabilities Color Blindness

- **"Red-green" color blindness is common — about 4-5% of the population.**
- **8-10% of the male population is "red-green" colorblind.**
- **Many people with low vision are also unable to distinguish among some or any colors.**
- **A significant portion of any population is "color blind".**

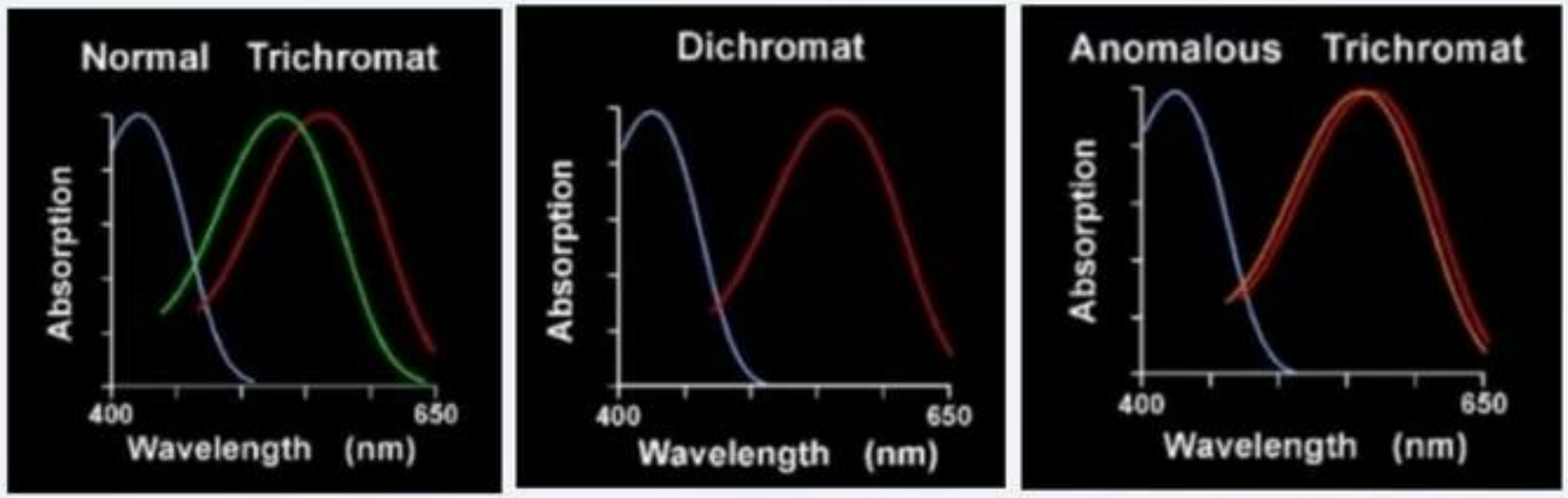
Colorblindness

The spectral sensitivities of the cone pigments and spectrum in color normal trichromats are compared with those of a color blind person:





Examples of Colorblindness



Simulated Color-Blind Vision

Normal Vision	Simulated Color Blind Vision

Simulated Color Blind Vision

Original Image

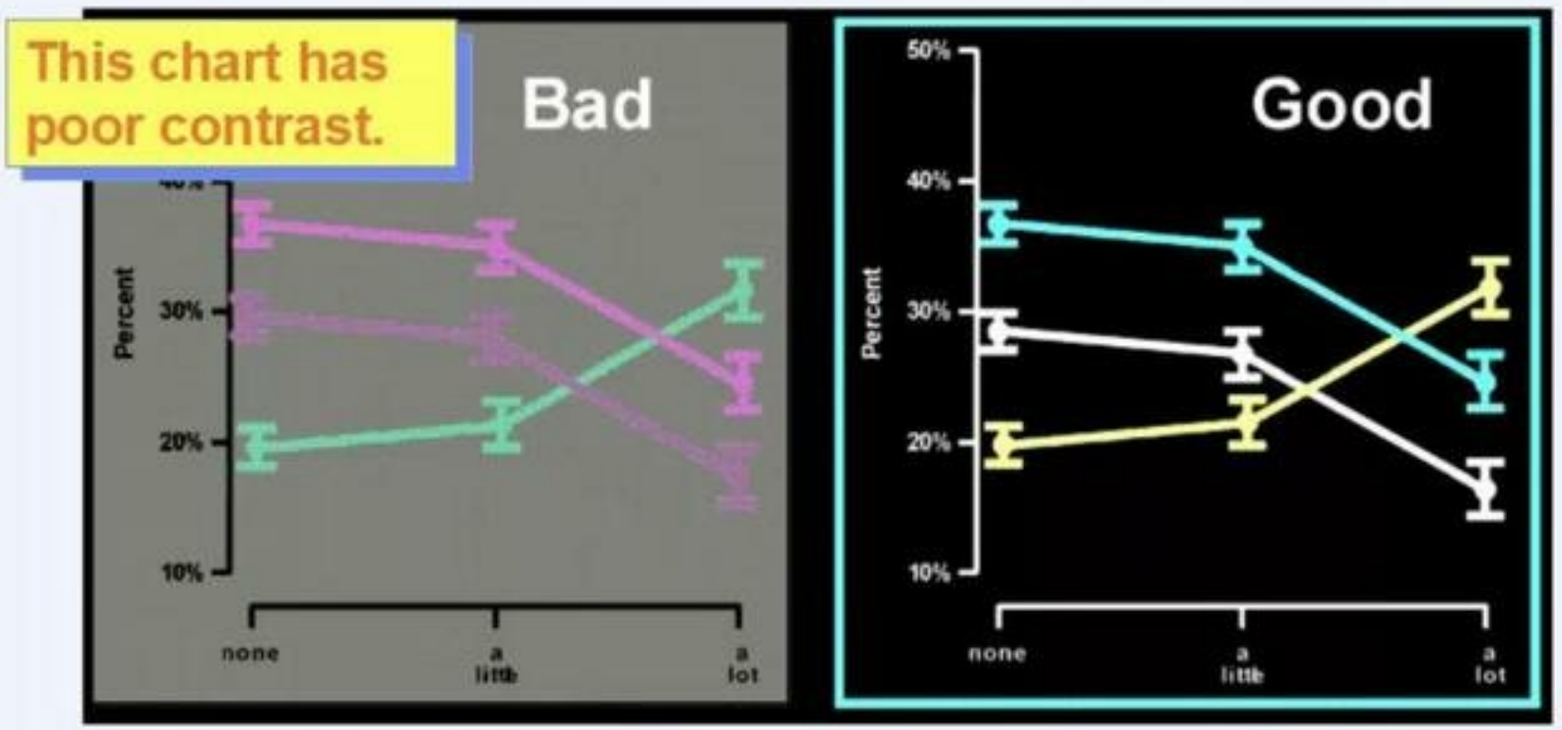
Protanope Simulation

Use of Color for People with Colorblindness

- **Color should be used with care to ensure that color-blind people can view the information.**
- **Color should not be used as the only way to convey information.**
- **Pages that are printed on black and white printers can also become unintelligible if color is the only way information is being conveyed.**

Graphics

Clear graphics are very important because graphics are often the source of the most difficulty. Here are two examples showing the difference between good and bad use of color:



Example-Deuteranope

Example

Use icons of different shapes and colors to denote status:

Color Coding

- **One color dramatically speeds up search time.**
- **More than six colors can eliminate the benefits of color and slow down performance.**
- **Messages must also be clear without color (color blindness).**
- **Cultural value**

How to use color

- Make text/background ratio high in contrast.
- Keep background low contrast and simple to reduce visual noise.
- Do not create pure or blue text on white background- chromatic aberration.
- Do not use highly saturated colors together.
  - Red and blue- chromostereopsis.

How to use color

- Never use more than six colors on one display (page or screen).
- Be sure that there is adequate contrast among the colors and between background and foreground objectives.
- Do not pair spectrally distant pure colors, and surround colors with complementary colors.
- Red and navy create an alternating stereoscopic effect. Avoid this color combination.
- Black and white is the most legible combination.
- Other acceptable combinations are red or blue on white, never use yellow on white

How to use color

- **Black and white is the most legible combination.**
- **Other acceptable combinations are red or blue on white, never use yellow on white**
- **White on black is the second most legible color combination.**
- **Other acceptable combination are yellow or green on black, never use blue, red, or magenta on black.**
- **Always assign meaningfully.**
- **Never assign a color without understanding its emotional social and cultural associations**

How to use color

- Be sure objects are large enough to carry color. An object should be at least this big to carry color.
- O O O O O O
- These are 39 point letters.
- Do not use color for tight patterns.
- If you must color code text, color code the entire word, not selected letters.
- Always test color under actual viewing conditions. Color on screen appears much lighter than the same color appear on printed page.

How We Perceive Color

- **Subjective**
  - Black and white stimuli produce pastel afterimages.
- **Purkinje Shift**
  - Our sensitivity to various wavelengths shifts toward the shorter wavelengths in poorly lit condition.
- **Memory Color**
  - Our perception of an object's color depends on that object's typical color.
- **Color Categorization**
  - We name and remember blue, yellow, green, and red better and faster than other colors

Most Distinctive Colors

Black

White

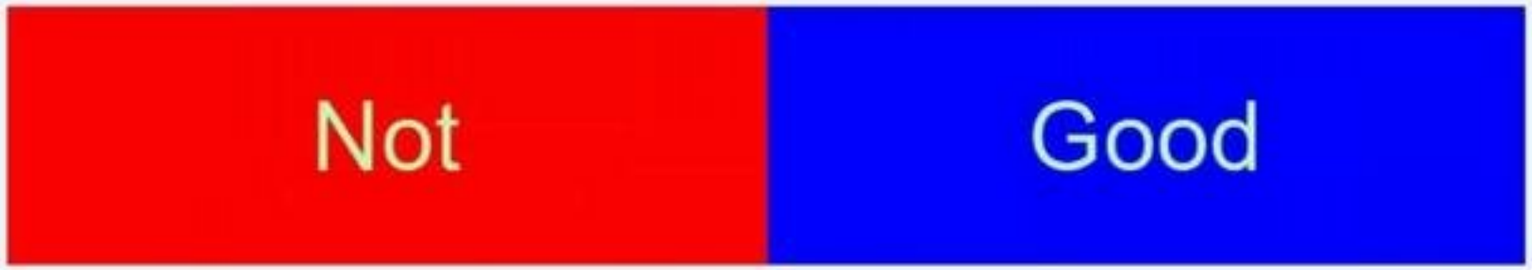
Red

Green

Yellow

Blue

Separate Strong Opponent Colors



Placing opponent colors right next to or on top of each other causes a disturbing shimmering sensation, and so it should be avoided

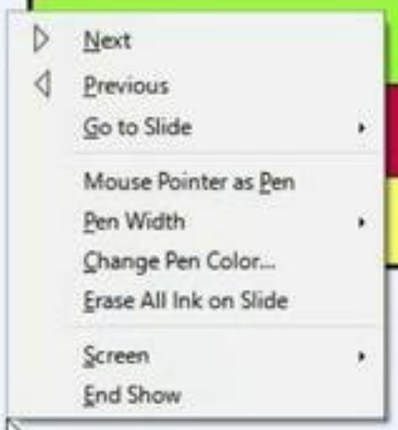
Use Color With Other Cues

Color and Cultures

Country	Red	Yellow	Green	
China	Happiness	Birth Wealth Power	Heaven Claude	
Egypt	Death	Happiness Prosperity	Fertility Strength	
France	Aristocracy	Temporary	Criminality	Neutrality Peace
India	Life Creativity	Success	Prosperity Fertility	Death Purity
Japan	Stop Danger	Grace Nobility	Future Youth Energy	
United States	Stop Danger	Cowardice Caution	Safety Go Purity	

Color and Mapping

Color	Mapping
Bleu	Water
Brown	Dead Vegetation
	New Vegetation
	Blood, Fire
	Sun

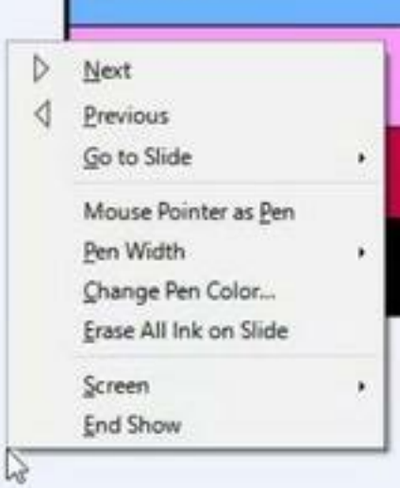


Color and Cultures

Color	Culture	Association
Red	Western	Danger
Red	Japanese	Anger
Red	Chinese	Joy
Yellow	Western	Caution, Cowardice
Yellow	Japanese	Honor Royalty
Yellow	Chinese	Happiness, Prosperity

Western Cultures Social Associations

Color	Social Association
	Evil
Bleu	Male, Authority
	Female, Helplessness
	Stop
	Good



Color and Mapping

Color	Mapping
Bleu	Water
Brown	Dead Vegetation
Green	New Vegetation
Red	Blood, Fire
Yellow	Sun

Western Cultures Emotional Associations

Color	Emotional Association
Bleu	Cold, Calm, Innocence
Gold	Richness, Wisdom, Honor
Orange	Friendliness, Pride, Gregariousness
Red	Aggression, Impulsiveness, Shame
Yellow	Caution, Cowardice, Betrayal

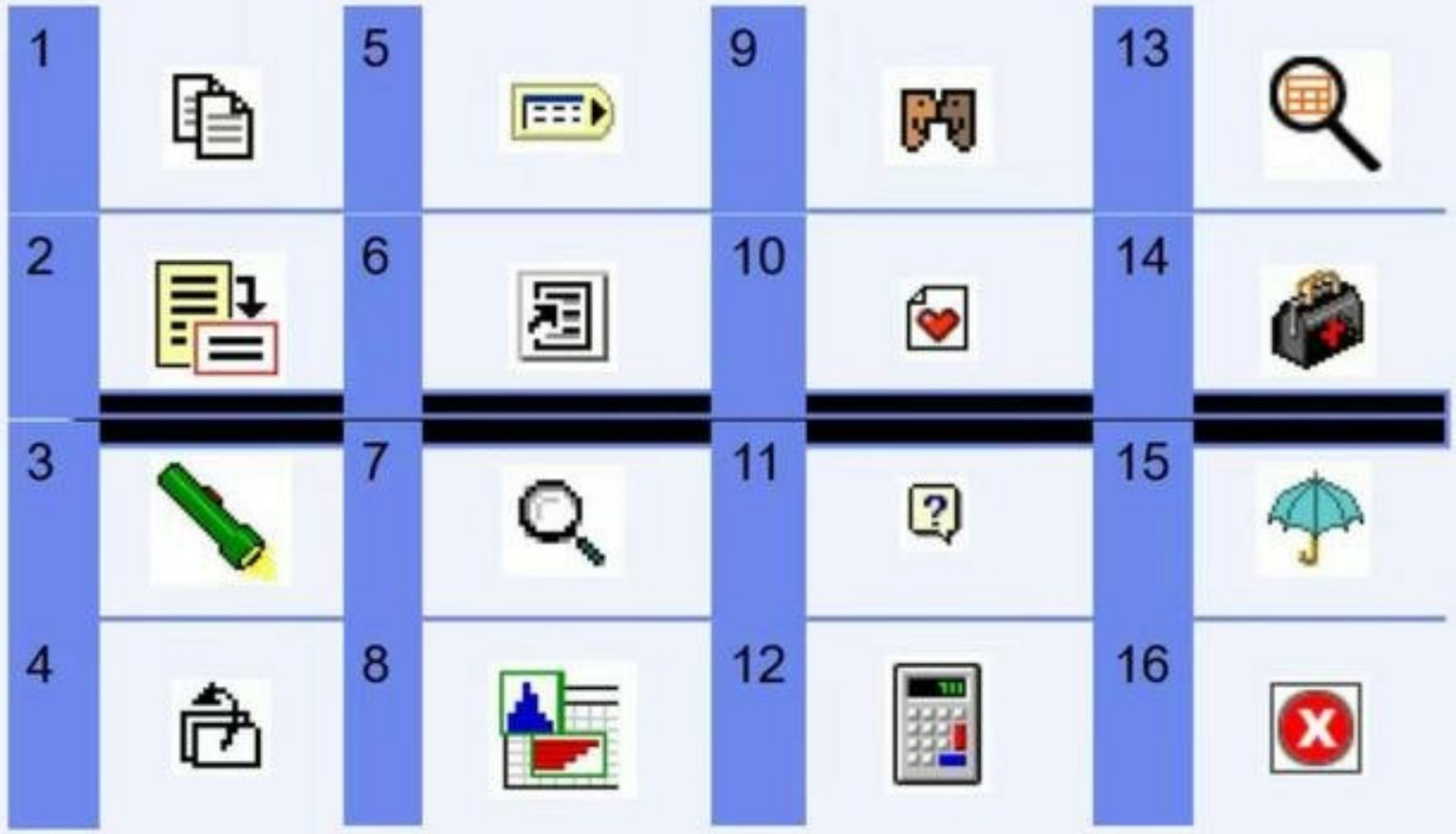
Weste

Icon

- **Icons are assumed to be easier to learn and remember than commands**
- **Can be designed to be compact and variably positioned on a screen**

Icons

Which one of these icons are the easiest to understand? Why?



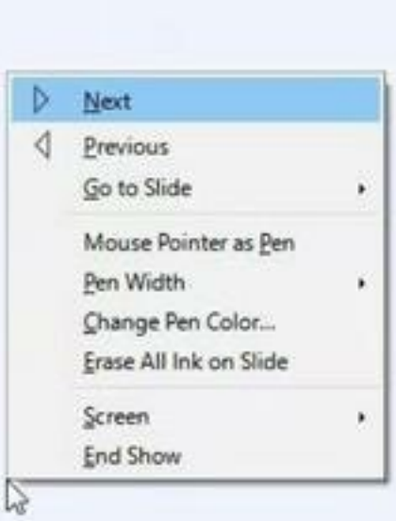
Simple Icons Plus Labels

Other Page Design Techniques

- **White Space**
  - Extremely effective to visually open up a page, focus attention, help group like kinds of information.
- **Grid**
  - Distribution of visual elements in a clearly intelligible order.
- **Field of Vision**
  - What a user can see on a page with little or no eye movement.
  - Main area where the eye rests to view most of the page.
- **Proximity**
  - Placement of visual elements physically close.
- **Illusion of Depth**
  - Layering, overlapping perspective, size contrast and color reinforce

Digital Forms

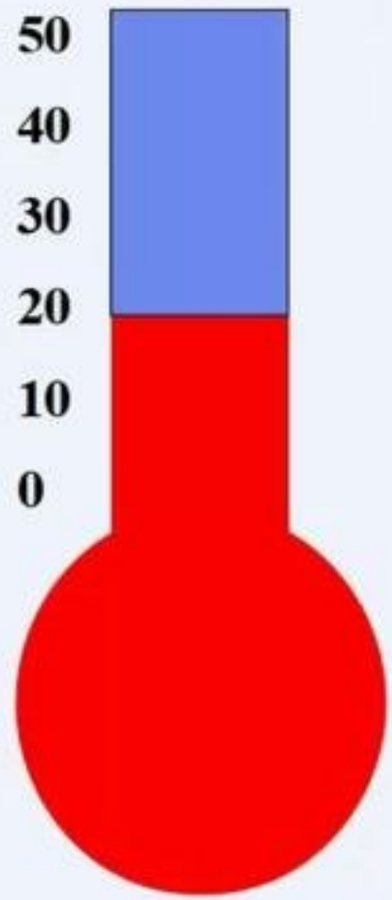
- **Alphanumeric representation of data**
- **Effective where precision is required**
- **Tells user an exact measured value at the point in time**



Analog Form

- Are graphical representation of data
- Are effective for showing context and changes over time
- Require the establishment of a frame of reference

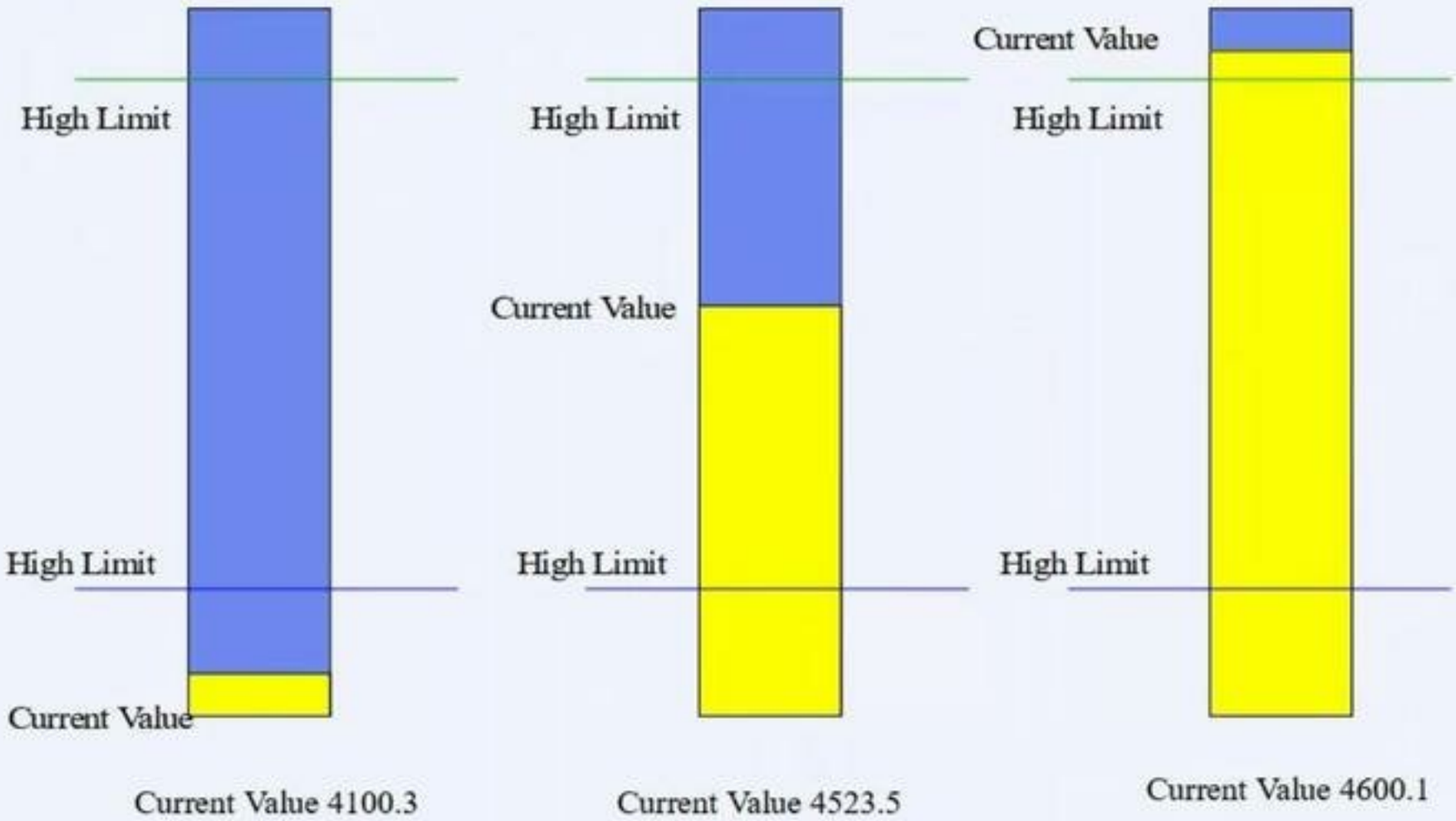
Analogue Display



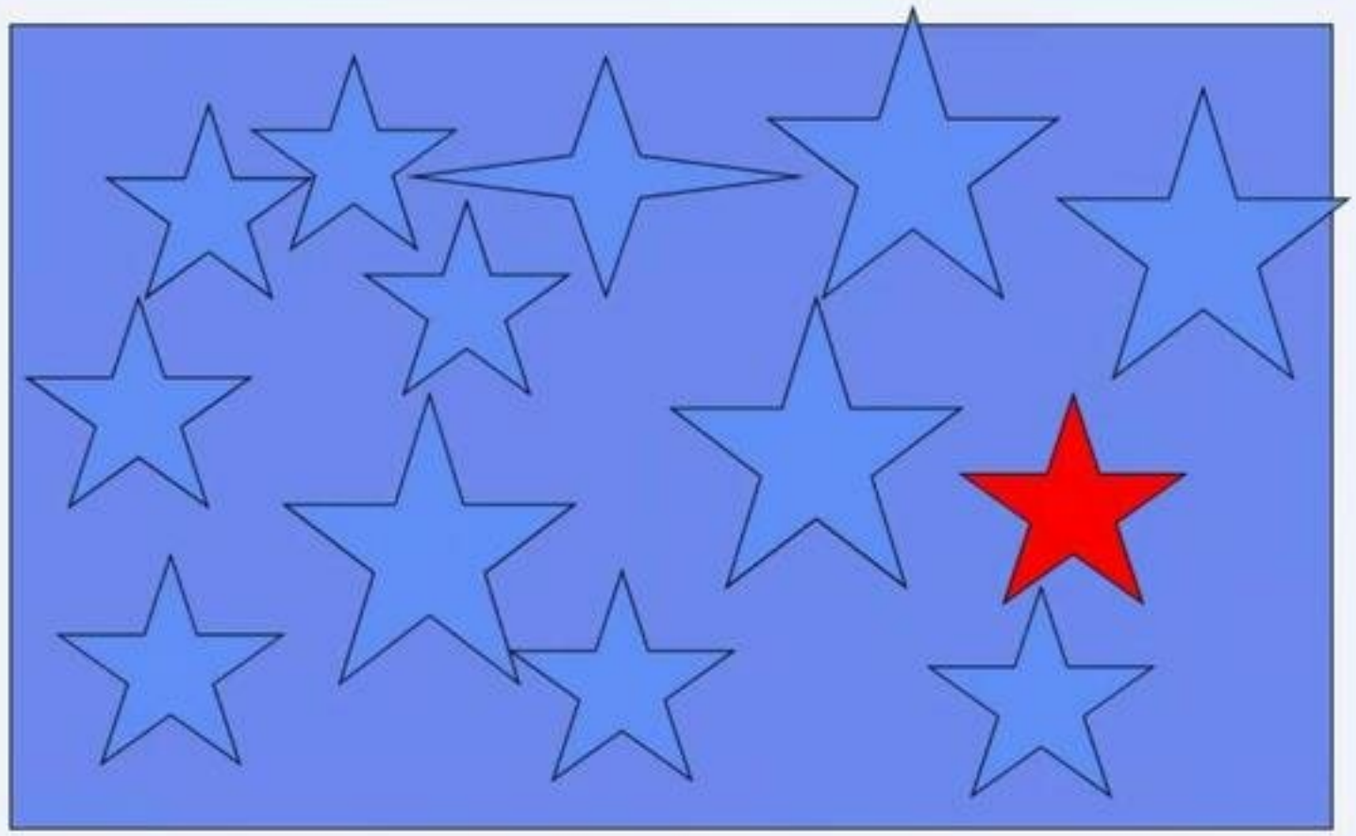
Digital Forms

- Alphanumeric representation of data
- Effective where precision is required
- Tells user an exact measured value at the point in time

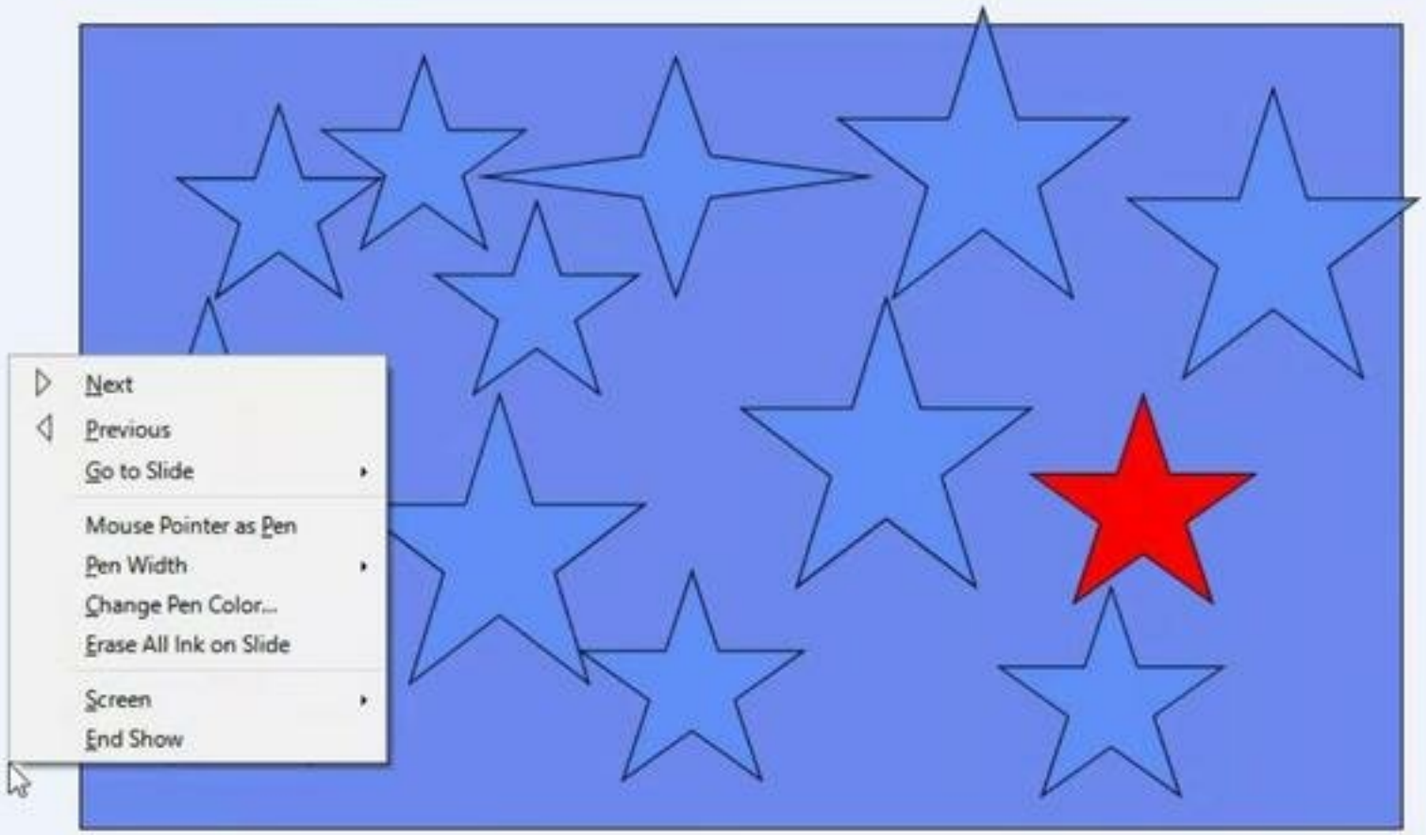
Combination of Analog and Digital



Example



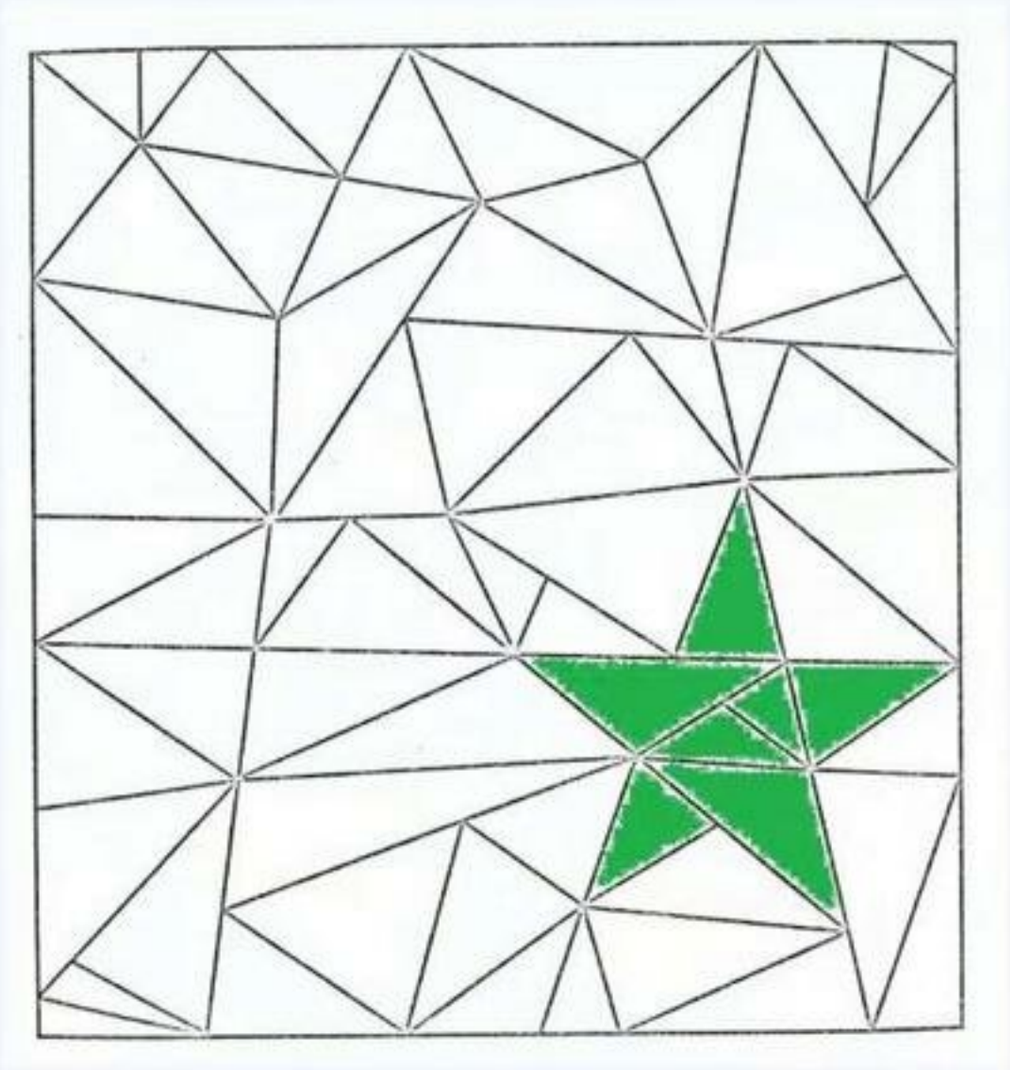
Example


Next
Previous
Go to Slide
Mouse Pointer as Pen
Pen Width
Change Pen Color...
Erase All Ink on Slide
Screen
End Show

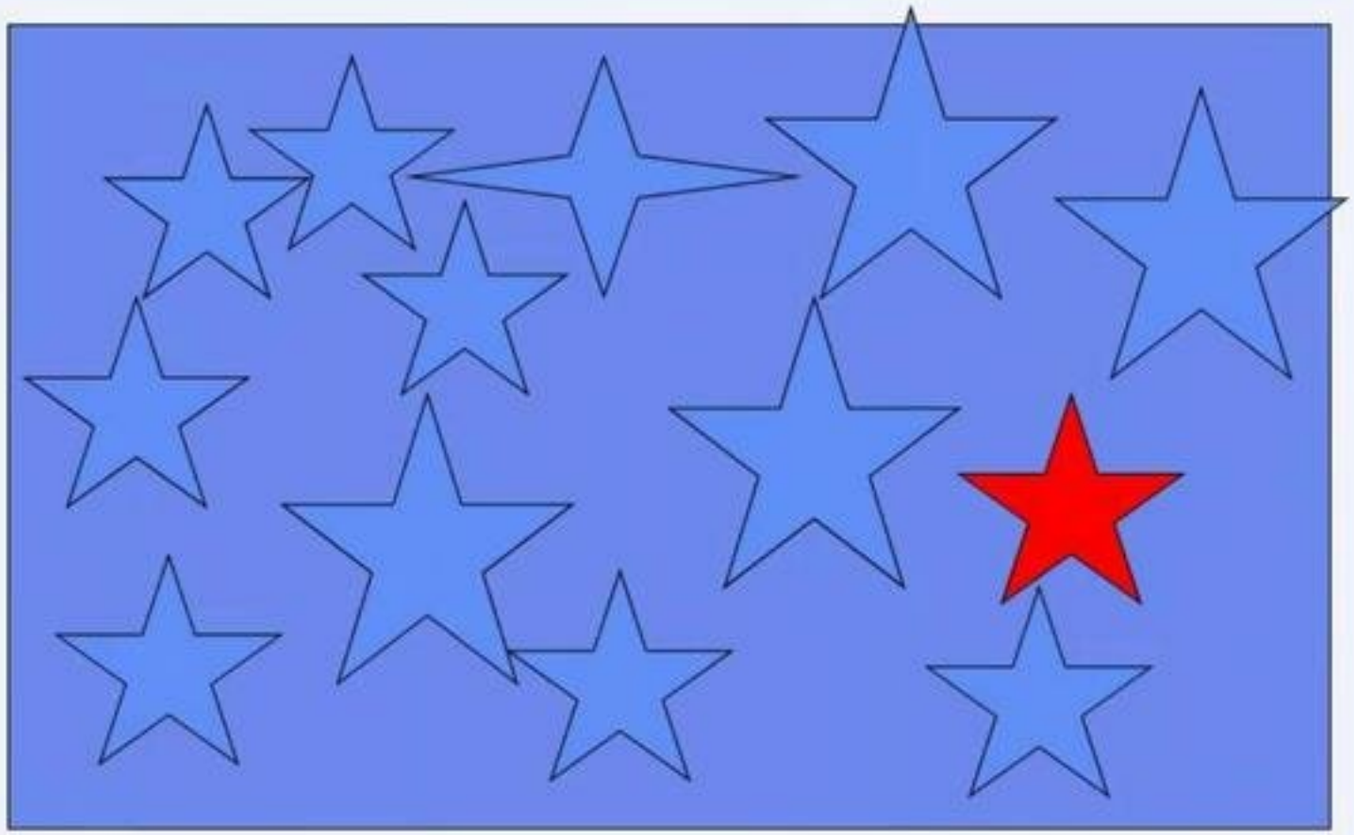
Salience

- **Large**
- **Moving**
- **Flashing**
- **High contrast with the background**

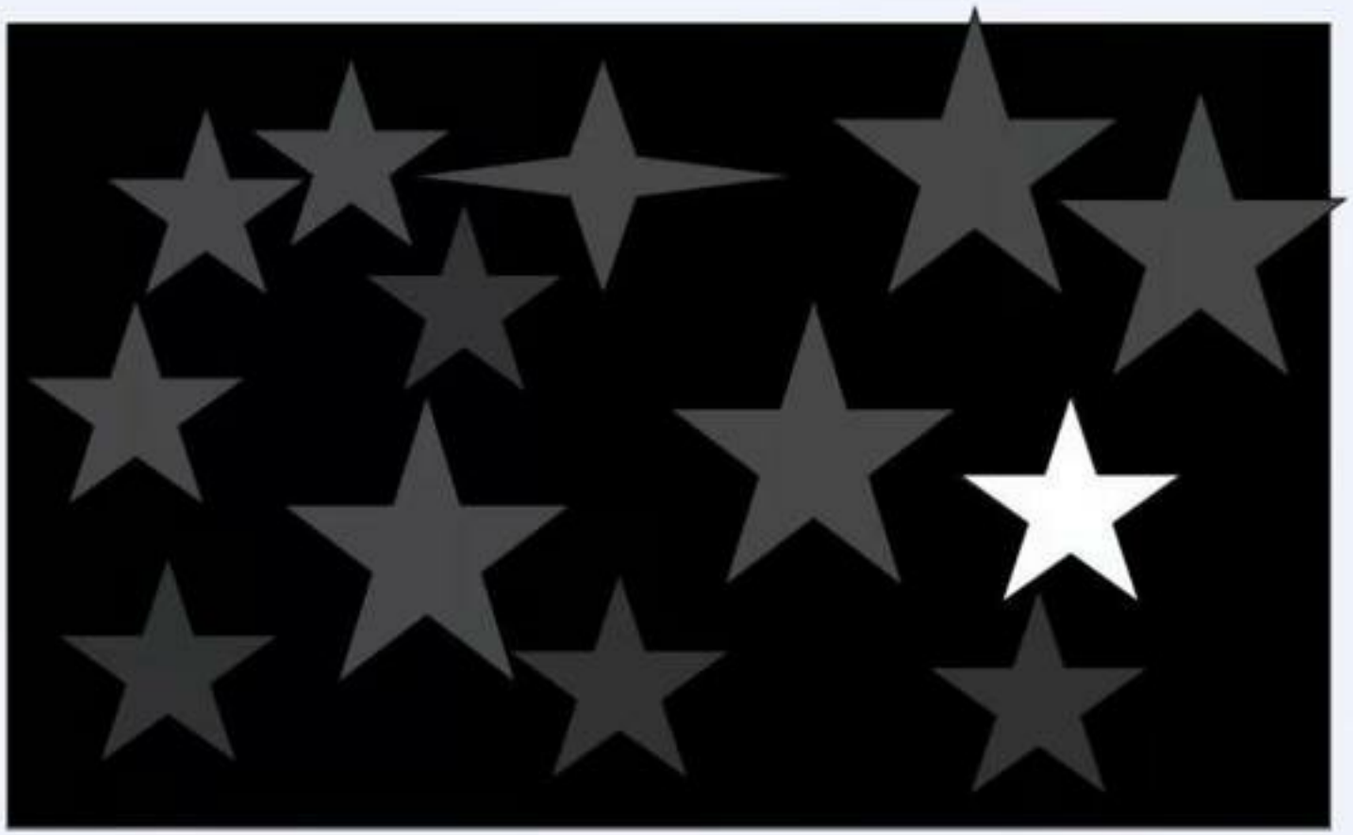
Focus



Salmple



Example



Data-Ink Ratio

- **Tufte refers to data-ink as the non-erasable ink used for the presentation of data. If data-ink would be removed from the image, the graphic would lose the content. Non-data-ink is accordingly the ink that does not transport the information but it is used for scales, labels and edges. The data-ink ratio is the proportion of ink that is used to present actual data compared to the total amount of ink (or pixels) used in the entire display (ratio of data-ink to non-data-ink).**

According to Tufte, 1983

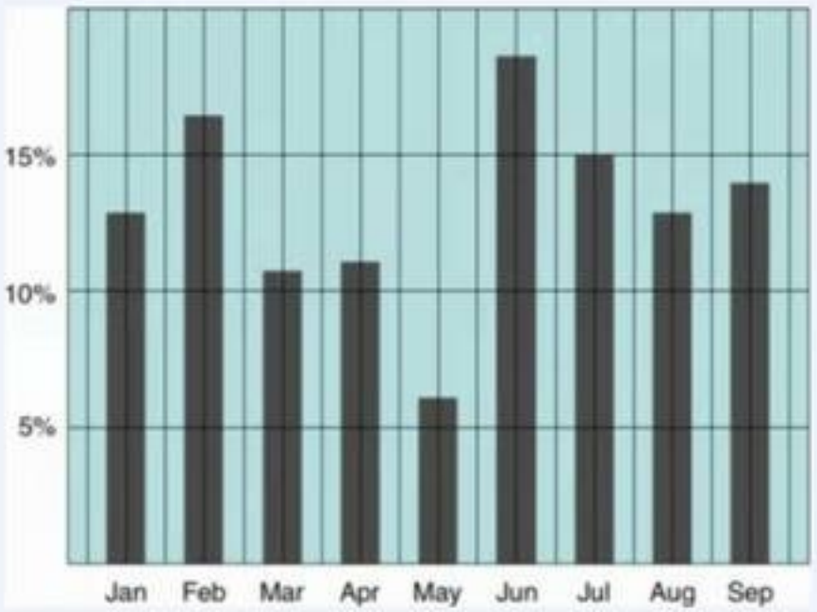
Data Ink

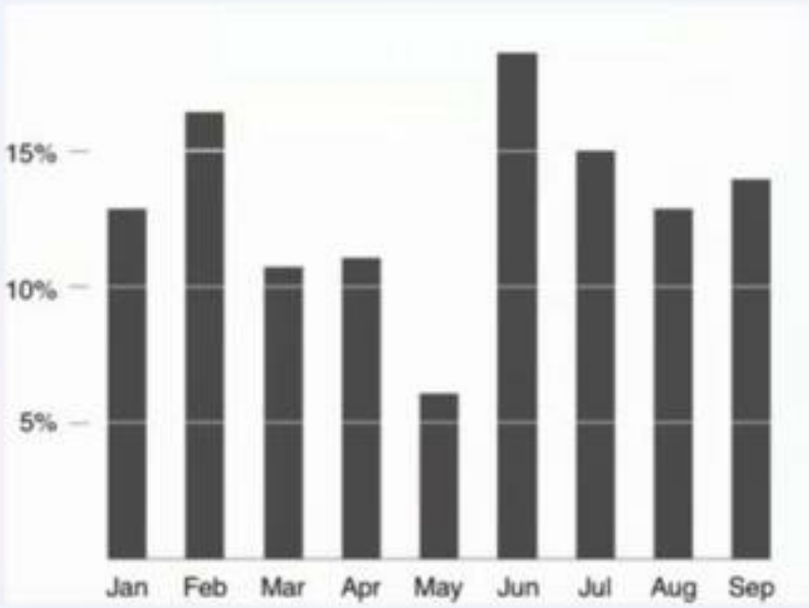
$$\text{Data-ink ratio} = \frac{\text{Data-ink}}{\text{Total ink used to print the graphic}}$$

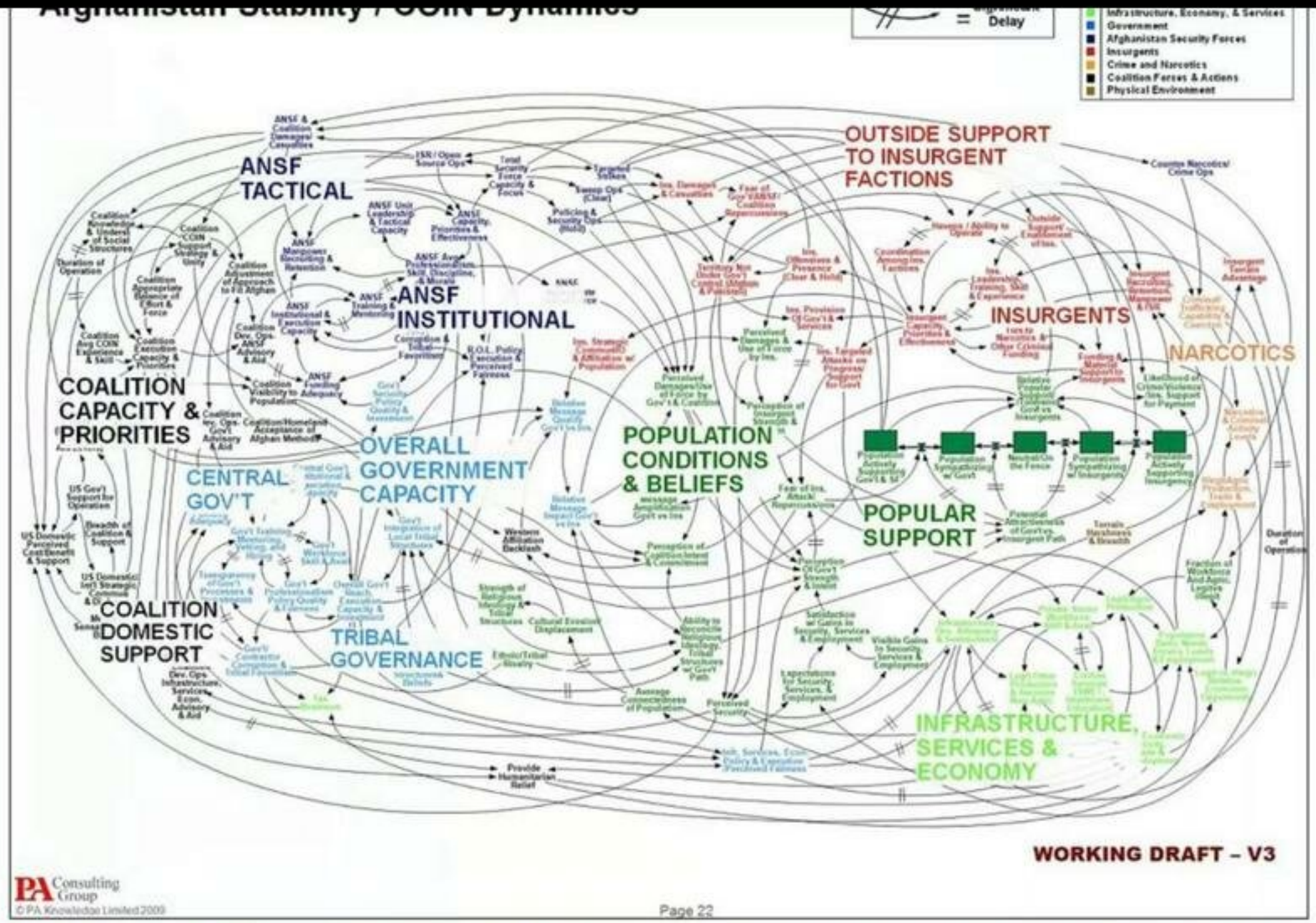
$$= \text{proportion of a graphic's ink devoted to the non-redundant display of data-information}$$

$$= 1.0 - \text{proportion of a graphic that can be erased}$$

Data Ink- Example



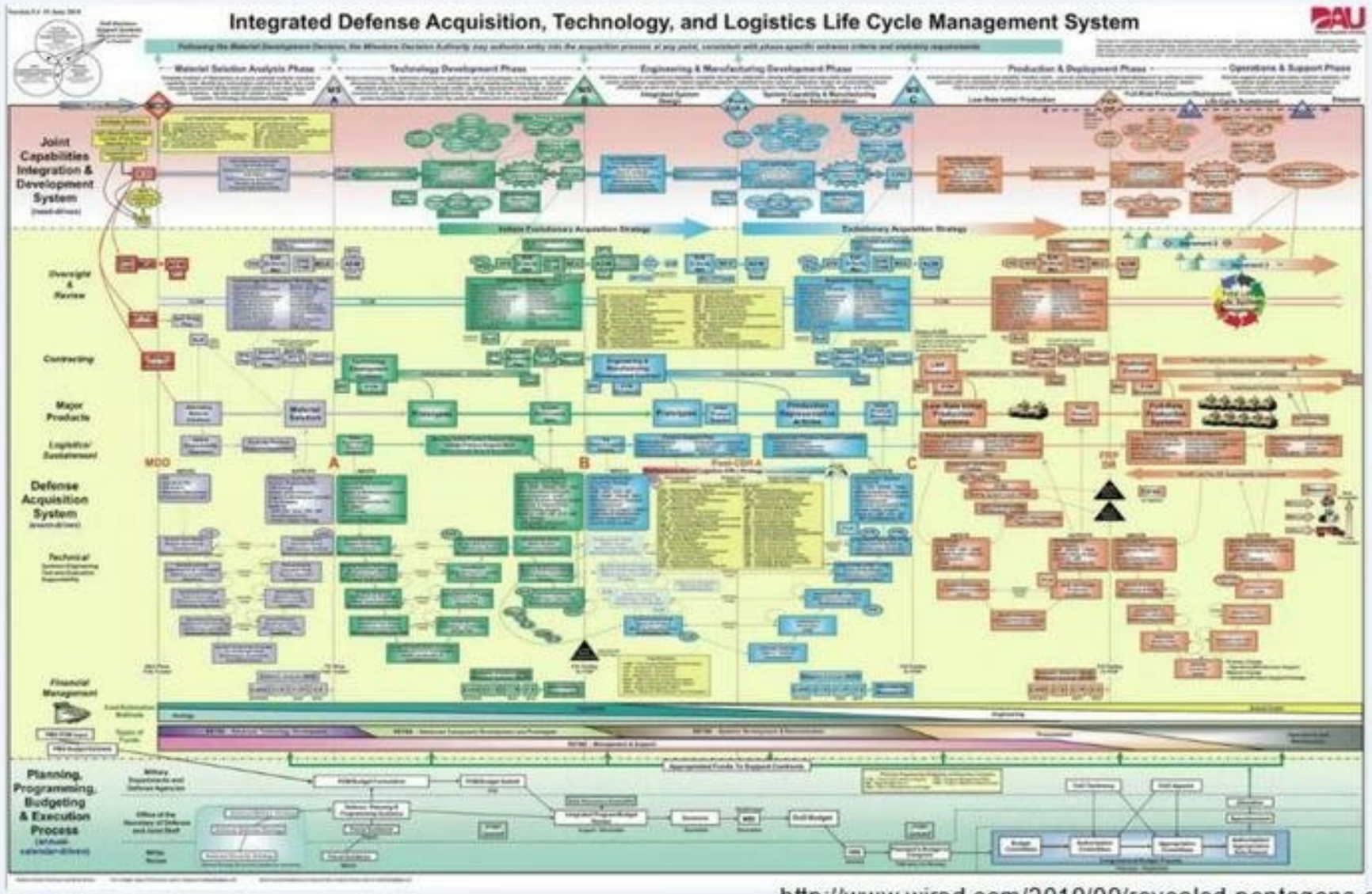




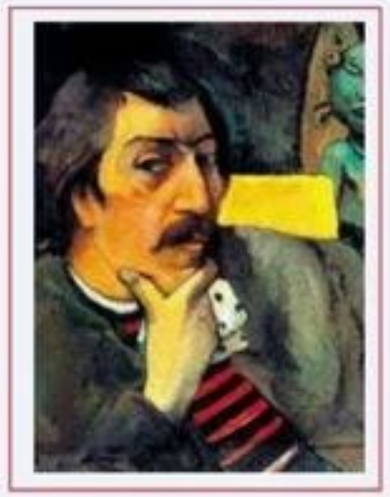
Abbas Moali

Baffling: The PowerPoint slide shown to US commanders shows security, economic and political conditions in Afghanistan. The dark blue arrows represent Afghan National Security Forces with the enemy in red. Other arrows highlight corruption, tribal favouritism and drug

Example



http://www.wired.com/2010/09/revealed-pentagons-craziest-powerpoint-slide-ever/



Interactivity

AFFORDANCES, DIRECT MANIPULATION & CONSTRAINTS

Affordances of the Objects

Manipulation & Affordances

Affordances

Questions/Answers

Direct Manipulation

Direct manipulation systems have icons representing objects, which can be moved around the screen and manipulated by controlling a cursor with a mouse.

These systems have the following features:

- **Visibility of the objects of interest**
- **Rapid, reversible, incremental actions**
- **Replacement of complex command language by direct manipulation of the object of interest**

Welcome

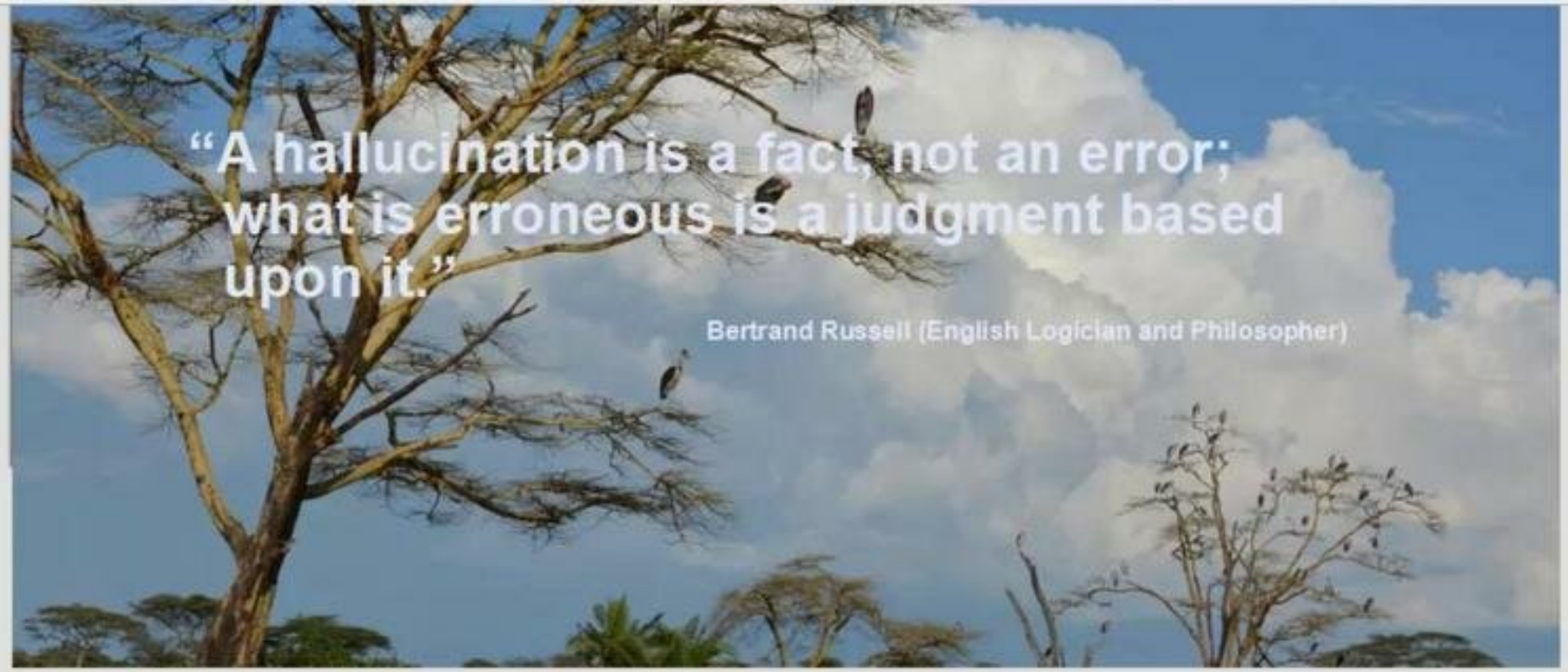
"A hallucination is a fact, not an error; what is erroneous is a judgment based upon it."

Bertrand Russell (English Logician and Philosopher)

22_DataVis_Tutorial.pptx - LibreOffice Impress

File Edit View Insert Format Slide Slide Show Tools Window Help

Slides



Slide 1 of 288 (287) | Title and Content | -1.07 / 8.77 | 0.00 x 0.00 | English (USA) | 76%

Type here to search

77°F Clear

12:18 PM
7/24/2022

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Slides

- L, M, and S are common abbreviations for "red", "green", and "blue" when referring to photo pigments.

131 132 133 134 135 136 137

Color Vision

Slide 136 of 288 (287) | Title and Content | -1.07 / 8.77 | 0.00 x 0.00 | English (USA) | 76%

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Slides

209 210 211 212 213 214 215

Abbas Moallem, P

212

Slide 212 of 288 (287) | Sub page | -0.74 / 9.54 | 0.00 x 0.00 | English (USA) | 76%

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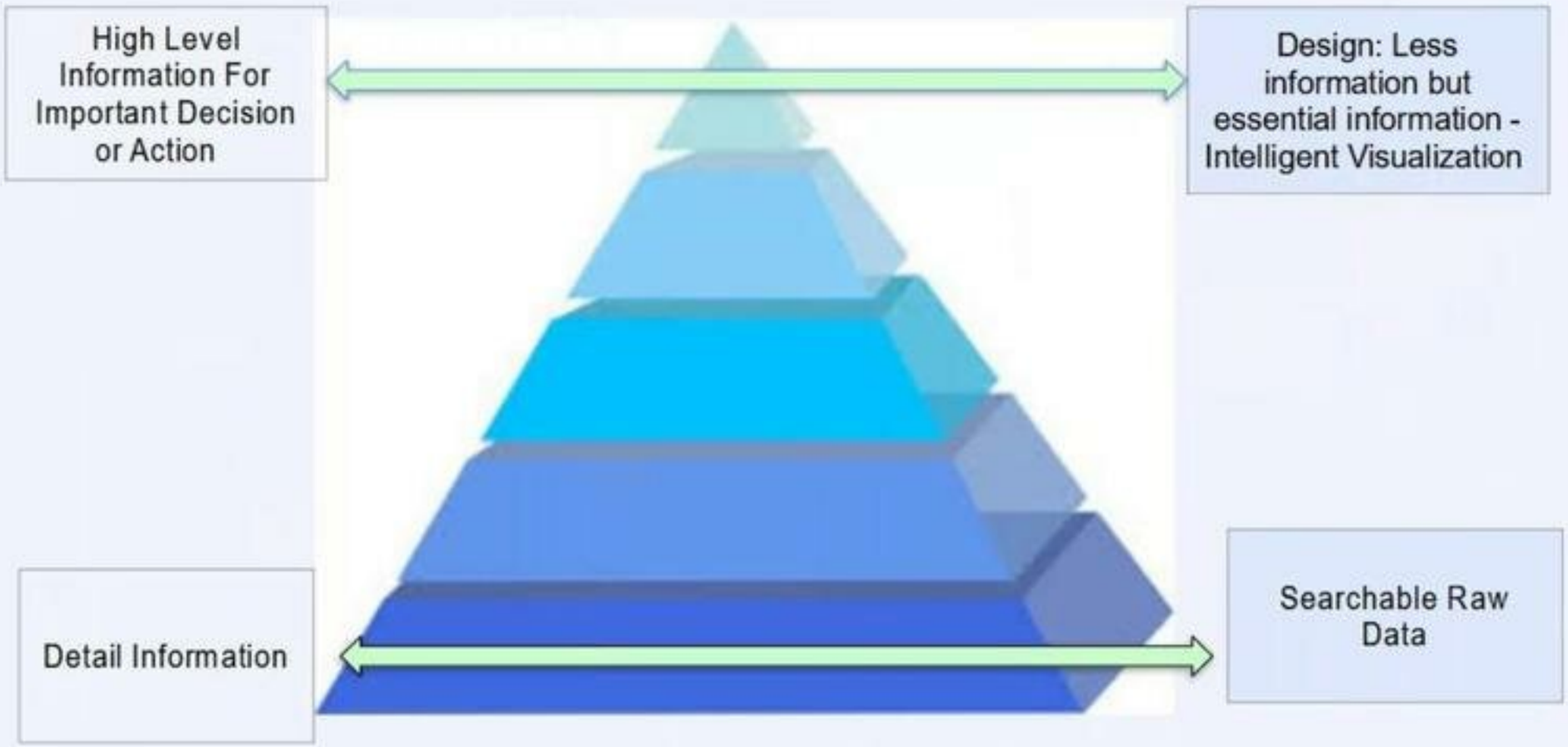
7/24/2022

Dashboard Design Architecture



Principles

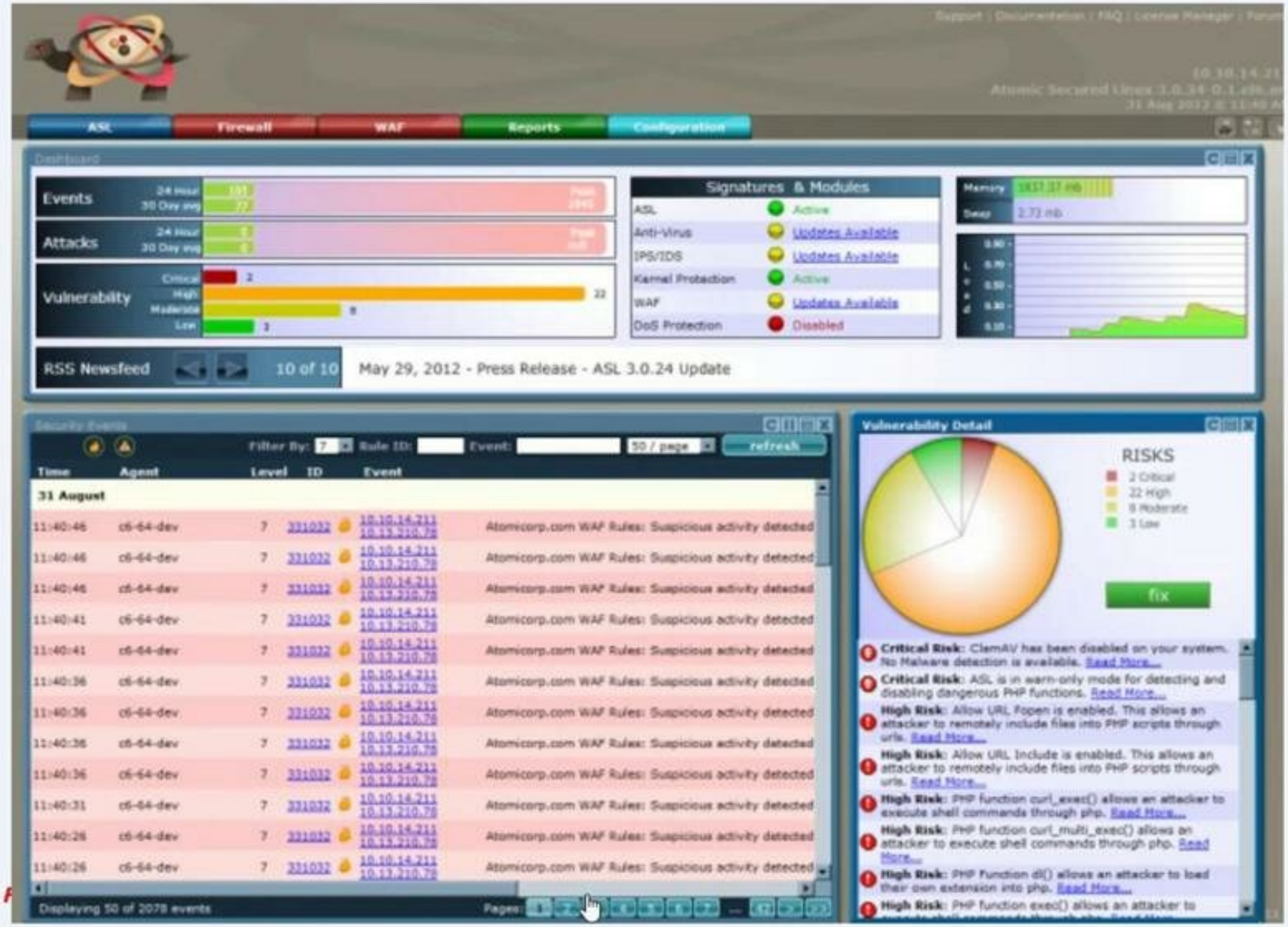
One Screen

Important Data

Highlighted Information for Decision Making

Visual Appeal

F%


ASL
Firewall
WAF
Reports
Configuration
Dashboard
Events
Attacks
Vulnerability
Critical
High
Moderate
Low
Signatures & Modules
ASL
Anti-Virus
IPS/IDS
Kernel Protection
WAF
DoS Protection
Active
Updates Available
Disabled
RSS Newsfeed
10 of 10
May 29, 2012 - Press Release - ASL 3.0.24 Update
Security Events
Filter By:
Rule ID:
Event:
refresh
Time
Agent
Level
ID
Event
31 August
Displaying 50 of 2078 events
Vulnerability Detail
RISKS
2 Critical
22 High
8 Moderate
1 Low
fix
Critical Risk: ClamAV has been disabled on your system. No Malware detection is available. Read More...
Critical Risk: ASL is in warn-only mode for detecting and disabling dangerous PHP functions. Read More...
High Risk: Allow URL Fopen is enabled. This allows an attacker to remotely include files into PHP scripts through urls. Read More...
High Risk: Allow URL Include is enabled. This allows an attacker to remotely include files into PHP scripts through urls. Read More...
High Risk: PHP function curl_exec() allows an attacker to execute shell commands through php. Read More...
High Risk: PHP function curl_multi_exec() allows an attacker to execute shell commands through php. Read More...
High Risk: PHP Function dl() allows an attacker to load their own extension into php. Read More...
High Risk: PHP function exec() allows an attacker to