



PERE-PAU VÁZQUEZ – VIRVIG GROUP – UPC

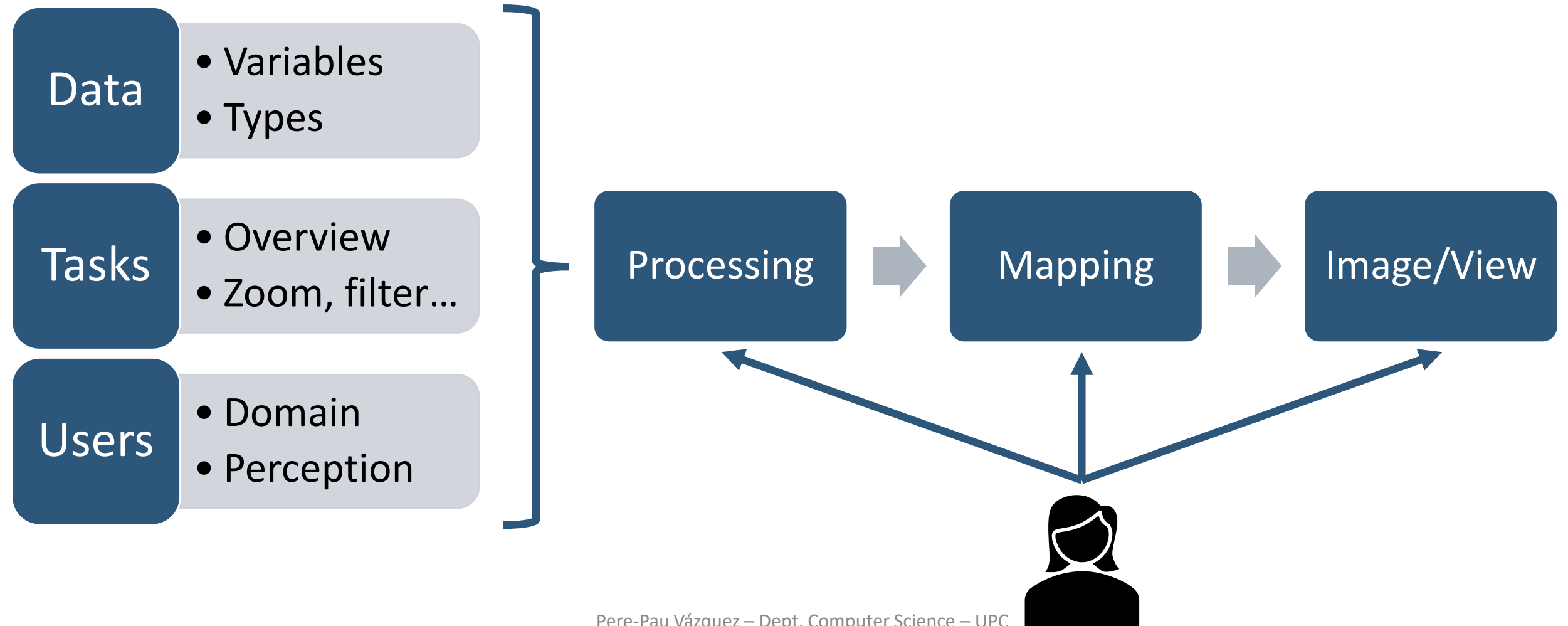
OUTLINE

- Recap
- Introduction
- Preattentive Processing
- Perception Laws
- Applying Perception to Visualization

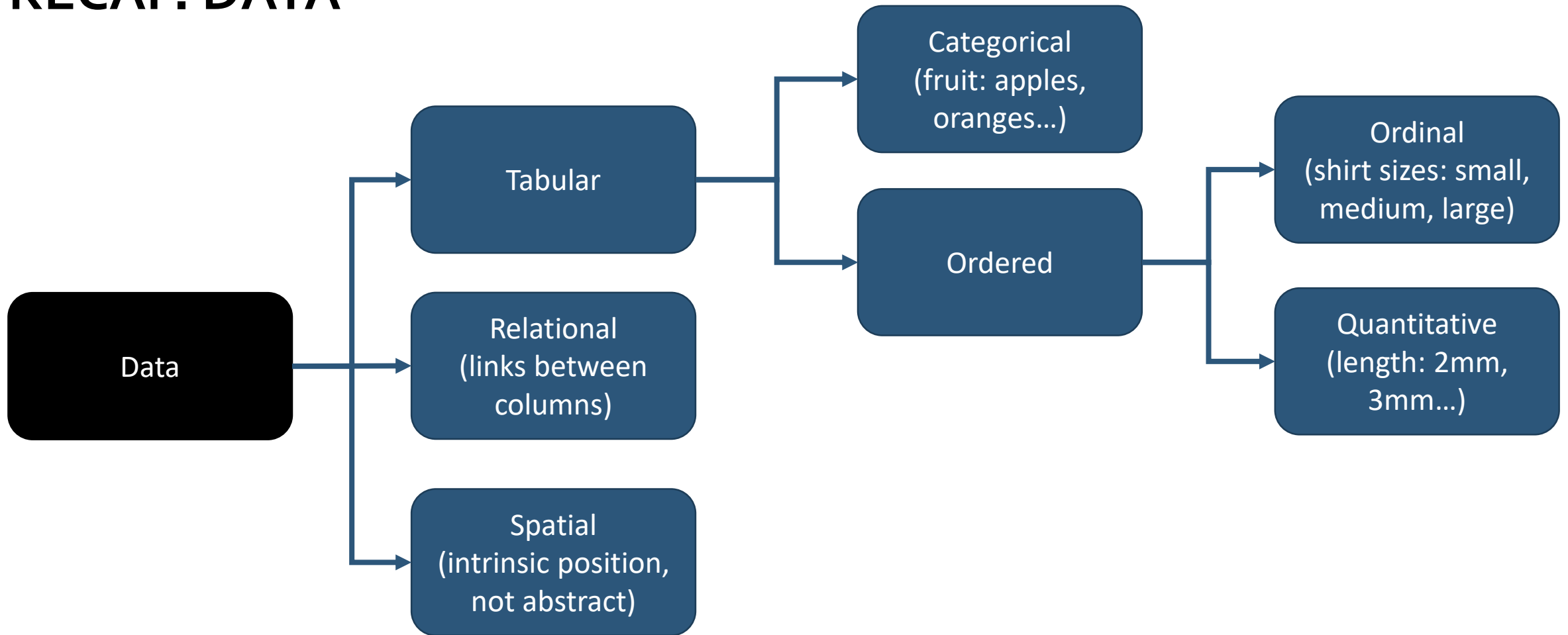
OUTLINE

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RECAP. VISUALIZATION PROCESS



RECAP. DATA



RECAP. MARKS & VISUAL CHANNELS

- Marks:
 - Geometric primitives
- Visual channels: control appearance of marks
 - Control appearance of marks
 - Can redundantly code with multiple channels

RECAP. MARKS & VISUAL CHANNELS

Marks

➔ Points



➔ Lines



➔ Areas



➔ Position

➔ Horizontal



➔ Vertical



➔ Both



➔ Color



Visual channels

➔ Shape



➔ Tilt



➔ Size

➔ Length



➔ Area



➔ Volume



RECAP. TASKS & DATA TYPES

From Shneiderman, 1996

High-level tasks

1	overview	gain an overview of the entire set of data
2	zoom	adjust the size of items of interest
3	filter	remove uninteresting items
4	details-on-demand	select one or more items and get details
5	relate	identify relationships between items
6	history	keep a history of actions to support undo/redo
7	Extract	extract subsets of items for separate analysis

RECAP. TASKS & DATA TYPES

From Shneiderman, 1996

Data types

1	1-dimensional	alphabetic lists, source code, text/documents
2	2-dimensional	planar or map data, photos
3	3-dimensional	molecules, human body, buildings
4	temporal	{start, finish}, e.g., medical records, project management, historical presentations
5	multi-dimensional	n attribute => points in n-dimensional space, e.g., relational DB
6	tree	Hierarchies or tree structured, e.g., file directories, business organizations
7	network	connected as graph(s), e.g., telecommunications network, www

OUTLINE

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- **Introduction**
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INTRODUCTION. MOTIVATION

- Vis creates **Visual** Representations
 - Need to understand how images are processed
- Many aspects will be affected:
 - Distribution of elements: can create groups, clutter...
 - Colors: may highlight, or make things invisible for all/some users
 - Geometric shapes: may communicate/skew/hide data
 - Size: of the screen/of the elements on the screen

We need to understand all of those to infer how users will read our data

INTRODUCTION. MOTIVATION

- Visual design determines:
 - Understanding of information
 - Data
 - Text
 - Affordances: Perceived actionable elements
 - Tasks: e.g., understanding the data overview, relating elements...

INTRODUCTION

- Simple case scenario:
 - Low number of dimensions → “easy”
 - “Any” visualization will work
 - No need for many visual variables
 - Many datapoints
 - Usually a real state problem

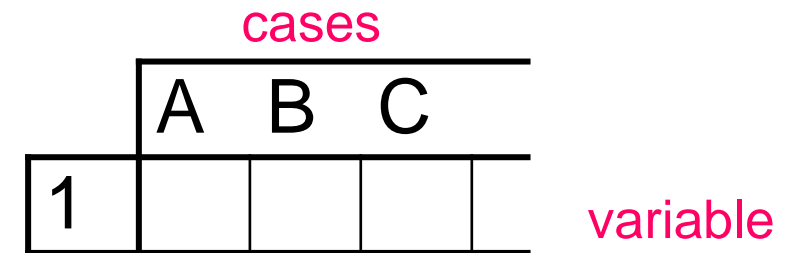
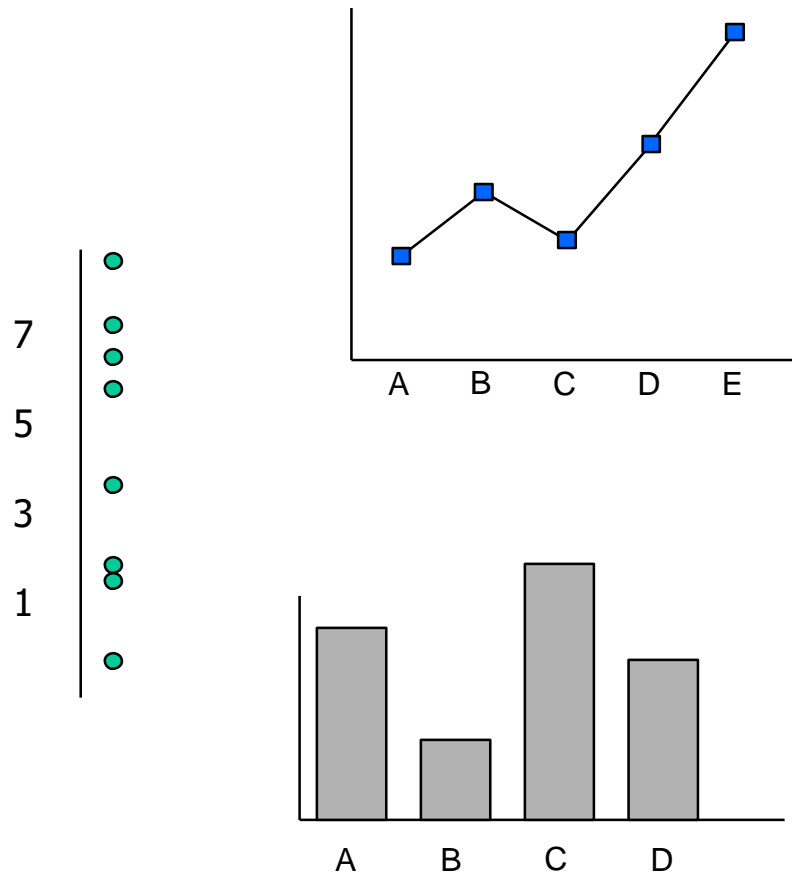
INTRODUCTION

- Worst case scenario:
 - High number of dimensions → hard
 - Many visualization techniques will not work
 - Will fail at communicating data
 - Determining visual variables is difficult
 - They may collide
 - If adding many datapoints:
 - Space organization issues (clutter) on top of the other problems

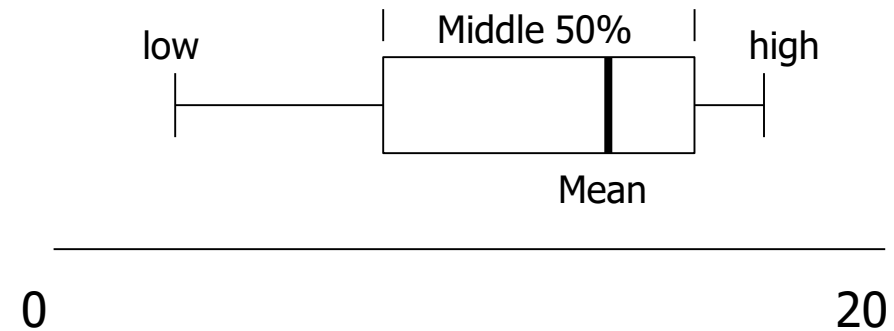
INTRODUCTION

From Mackinlay, 2000

- Univariate data



Tukey box plot

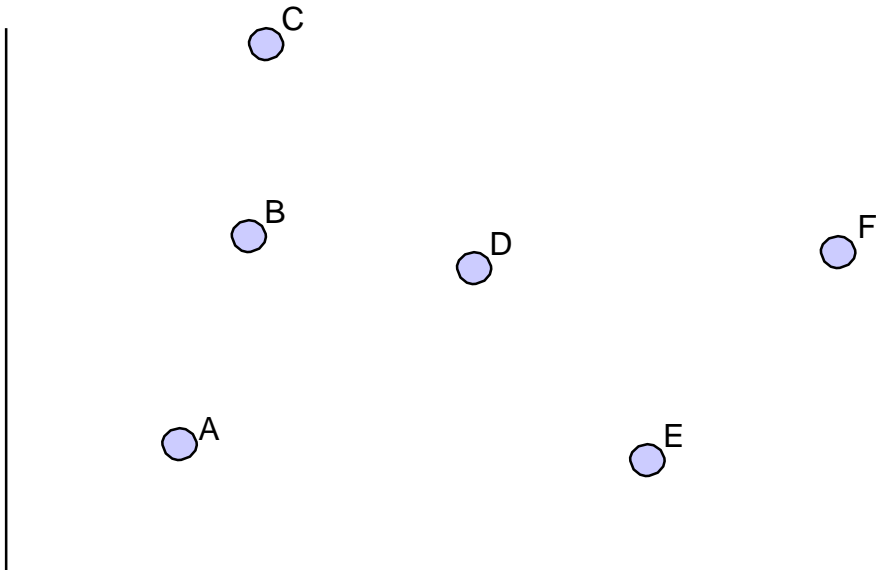


INTRODUCTION

From Mackinlay, 2000

- Bivariate data

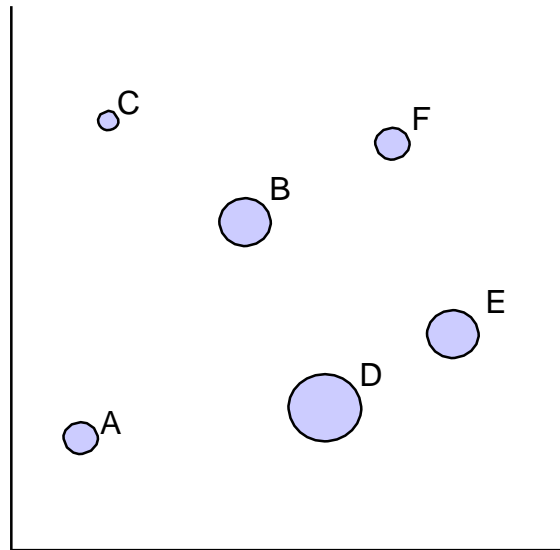
	A	B	C	
1				
2				



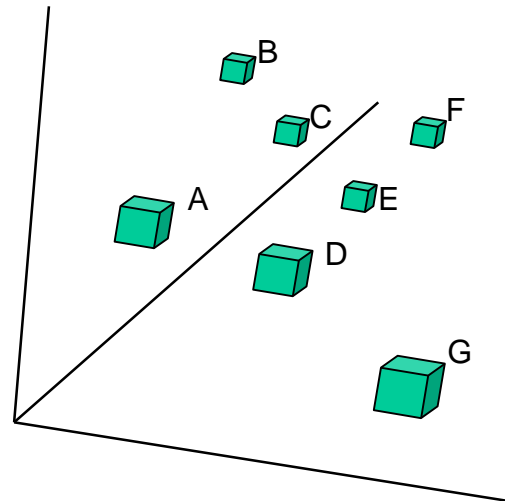
Scatter plot is common

INTRODUCTION

- Trivariate data



3D scatter plot is possible



From Mackinlay, 2000

	A	B	C
1			
2			
3			

INTRODUCTION

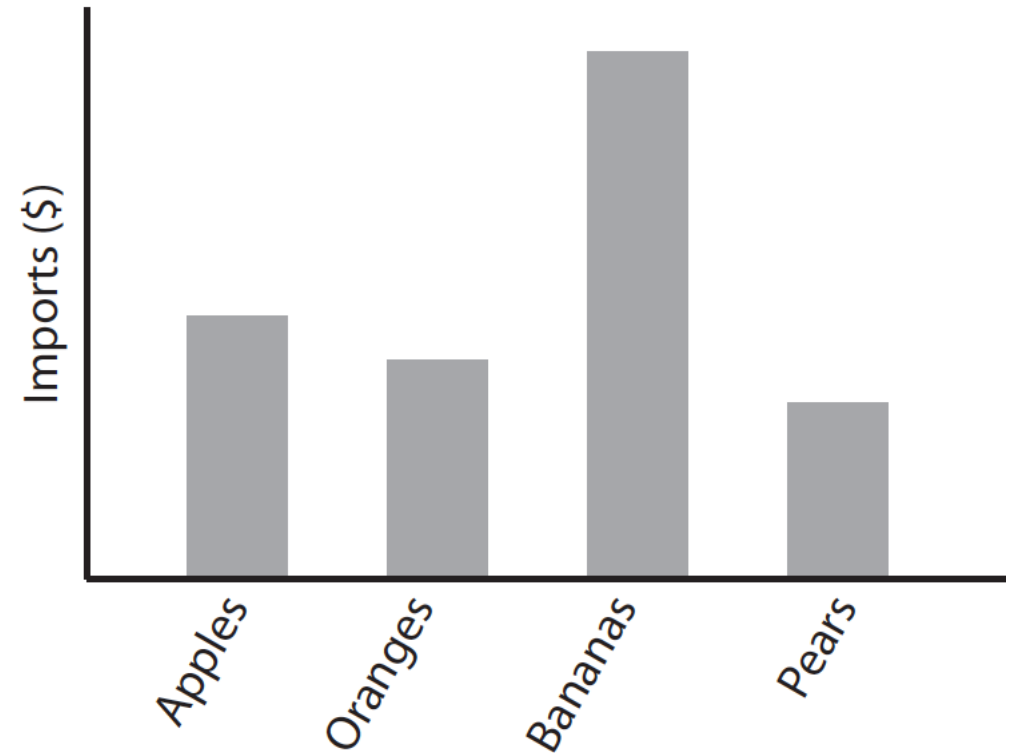
From Mackinlay, 2000

- Multivariate
 - How many dimensions?
 - Which visual encodings?

	A	B	C	
1				
2				
3				
4				
5				
6				
7				
8				

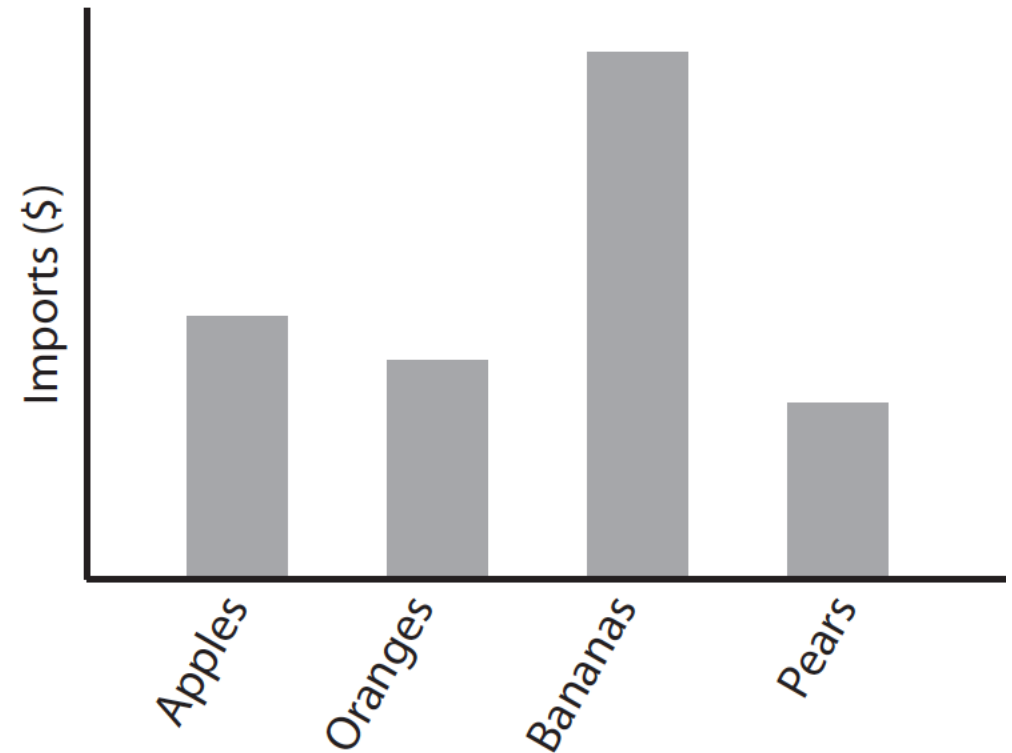
INTRODUCTION. BACKGROUND

- Visual search: Find out which kind of fruit import is the largest by dollar value



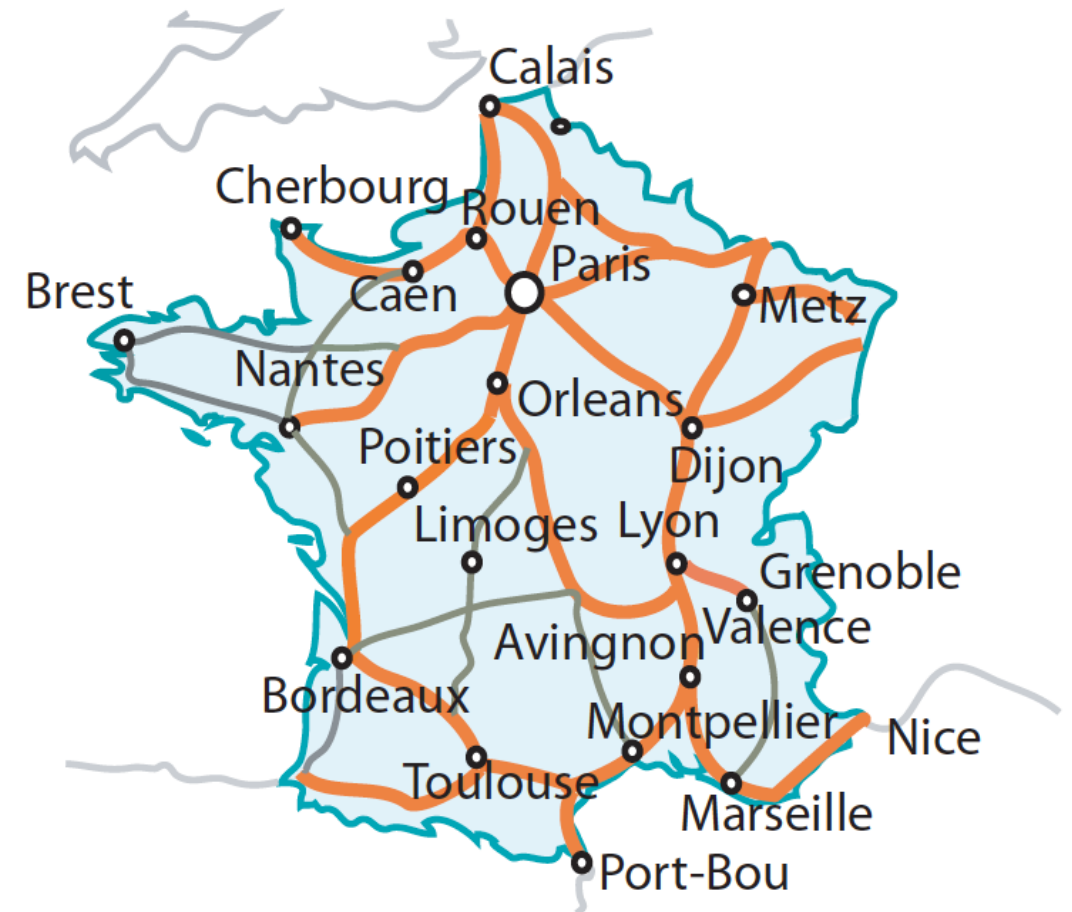
INTRODUCTION. BACKGROUND

- Visual search: Find out which kind of fruit import is the largest by dollar value
 - Visual process:
 - Find the tallest bar
 - Then find and read the label beneath



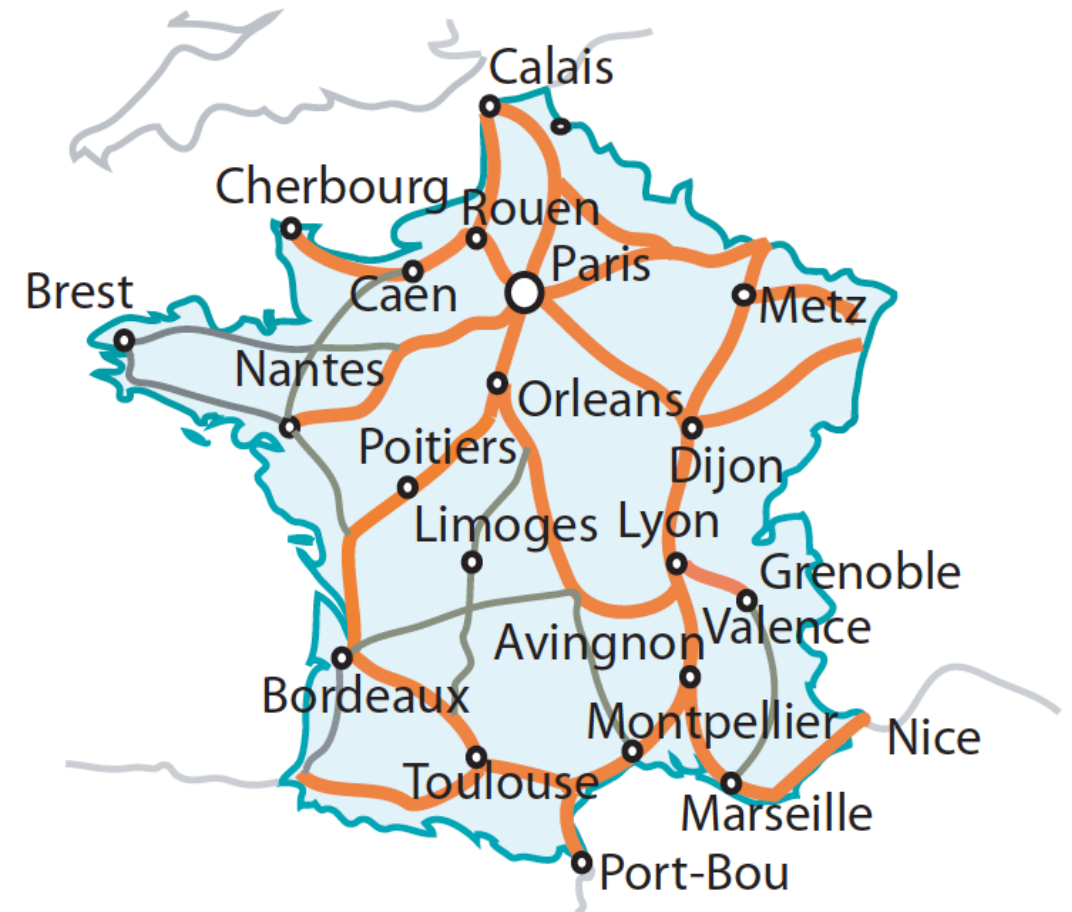
INTRODUCTION. BACKGROUND

- Visual search: Find a fast route



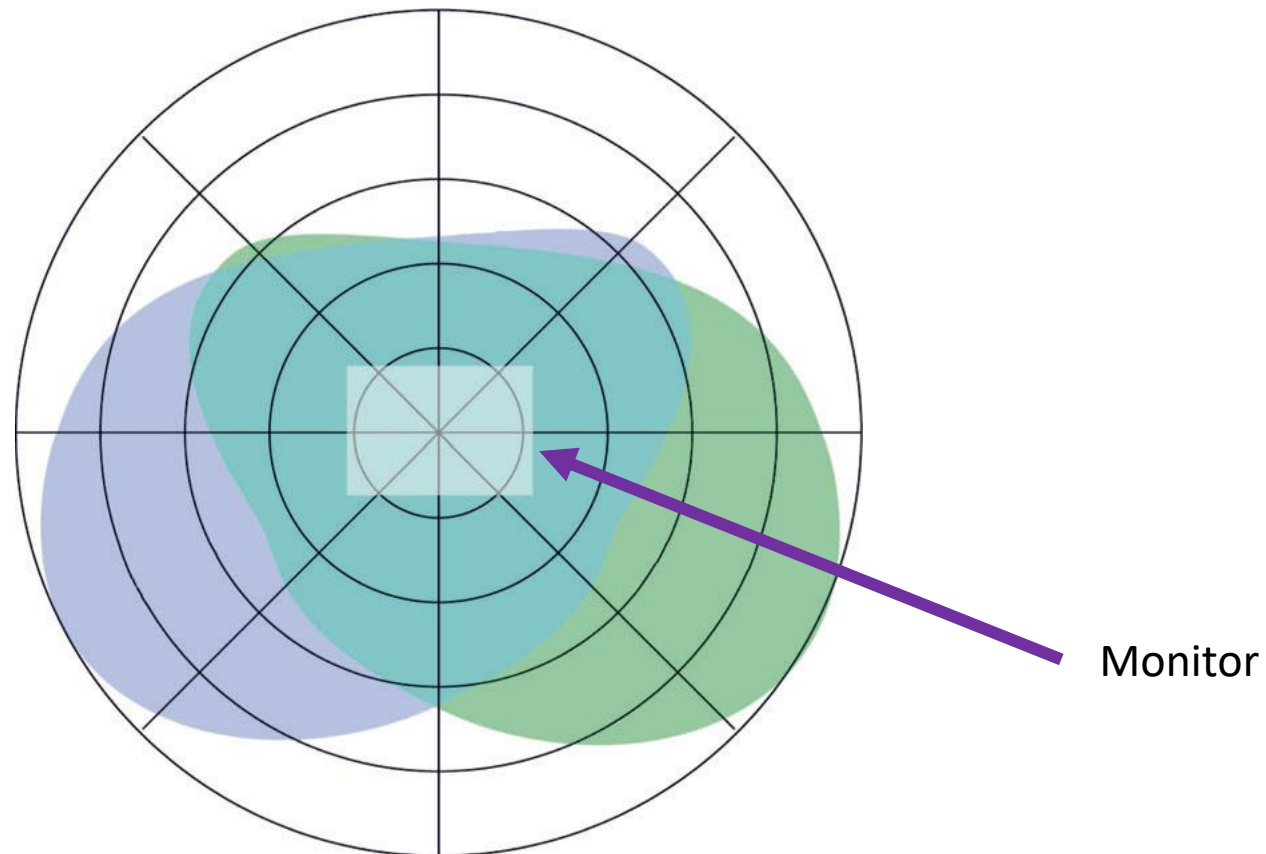
INTRODUCTION. BACKGROUND

- Visual search: Find a fast route
 - Visual process:
 - Make visual queries to find the starting and ending cities
 - Then we make queries to find a connected red line, indicative of fast roads, between those points

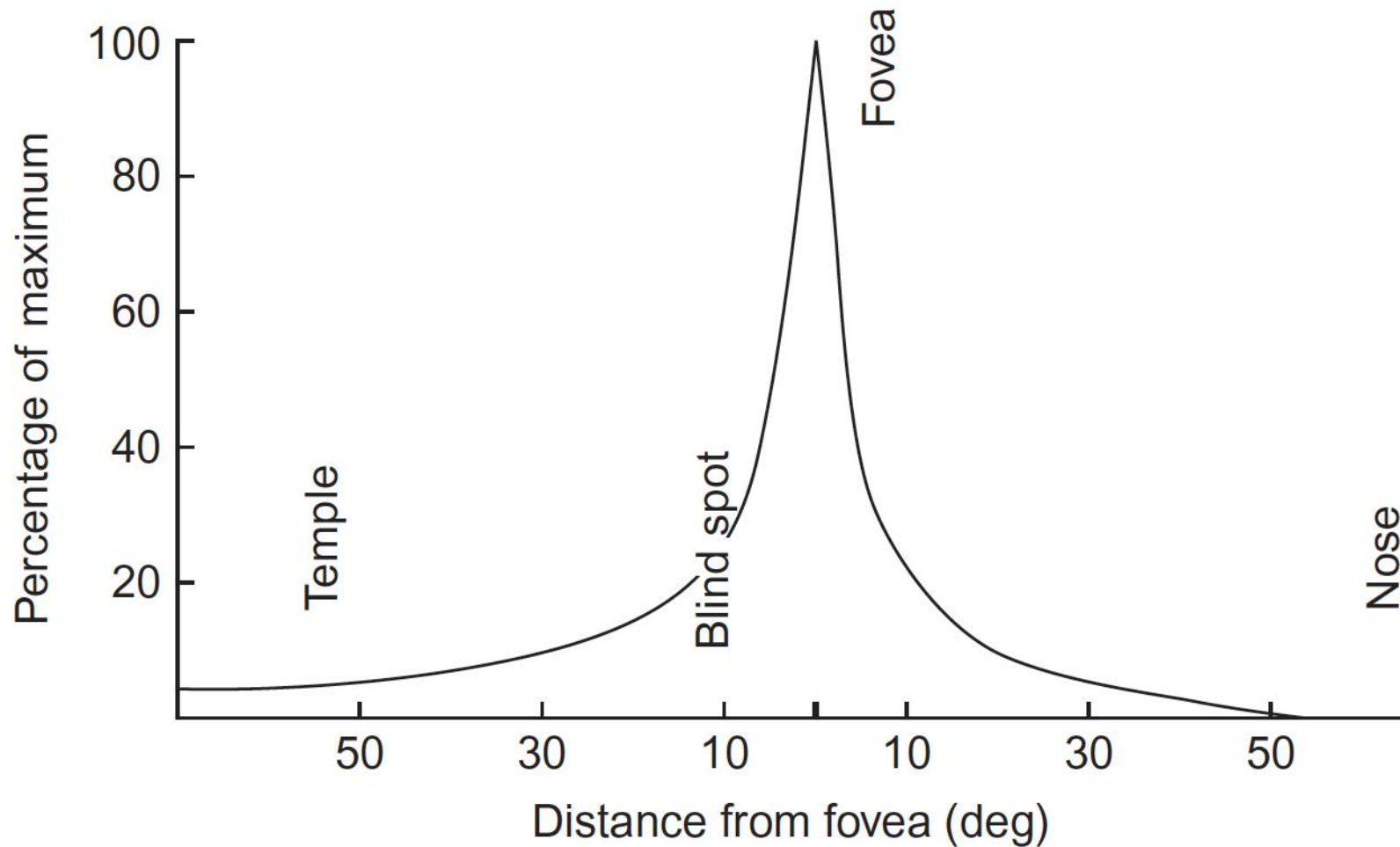


INTRODUCTION. BACKGROUND

The visual field of view for a person gazing straight ahead



INTRODUCTION. BACKGROUND



The acuity of the eye falls off rapidly with distance from the fovea.

INTRODUCTION. BACKGROUND

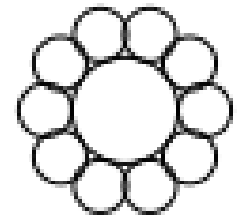
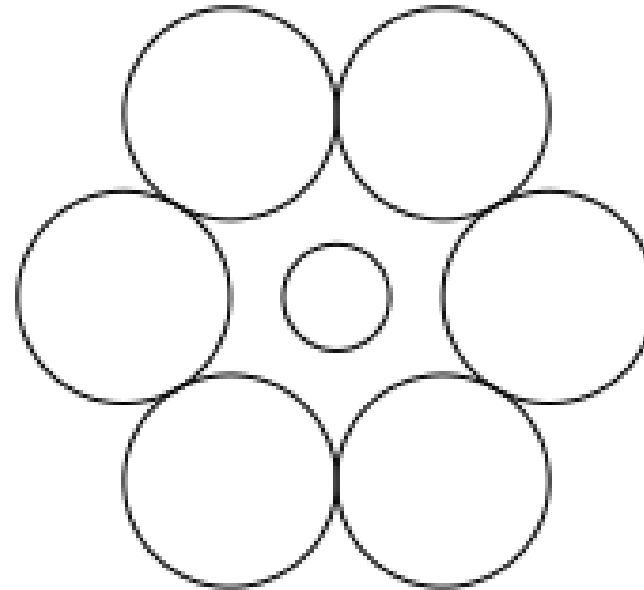
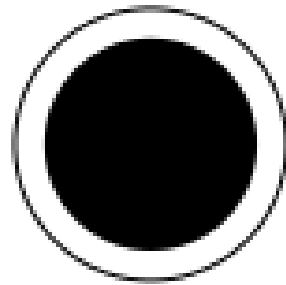
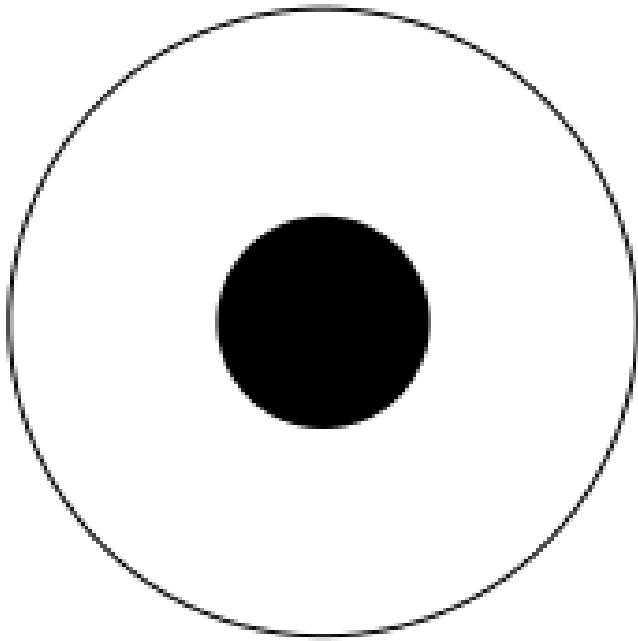
- Differently sized screens with same number of pixels have different areas of visual inefficiency
 - In small screens only a portion of the information hits the fovea, due to the size
 - We waste resolution
 - In large screens a big portion of the information does not project close to the fovea
 - We waste size

INTRODUCTION. BACKGROUND

- Many elements affect our perception, such as the context
 - Shapes
 - Colors
 - Lines

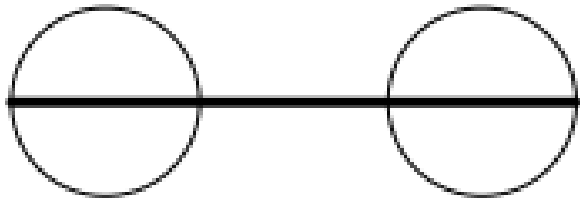
INTRODUCTION. BACKGROUND

- Which of the inner circles is larger, or are they the same size?



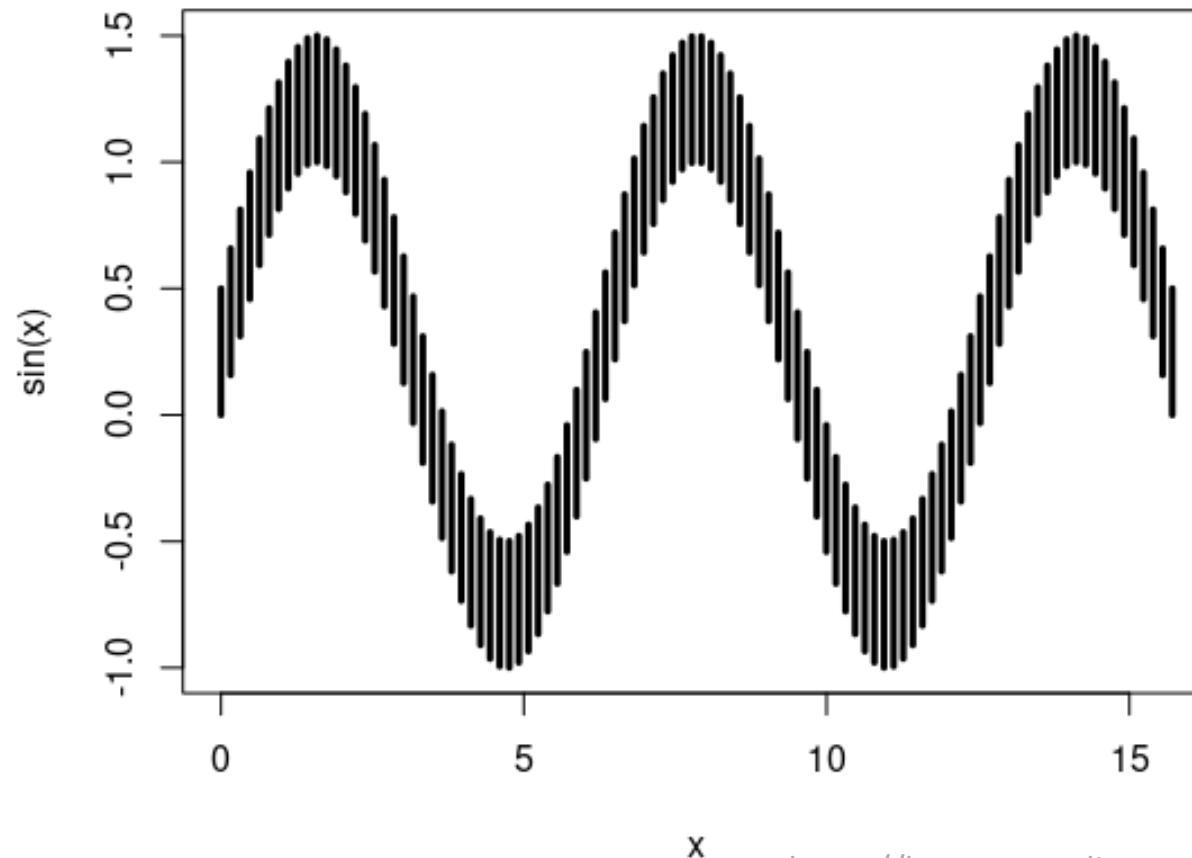
INTRODUCTION. BACKGROUND

- Which of the lines is longer, or are they the same length?



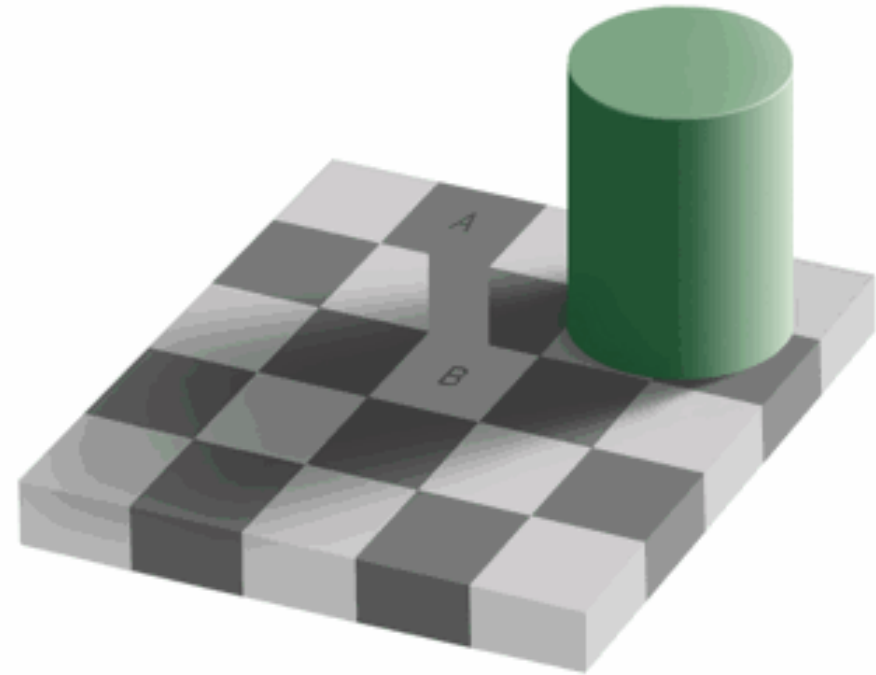
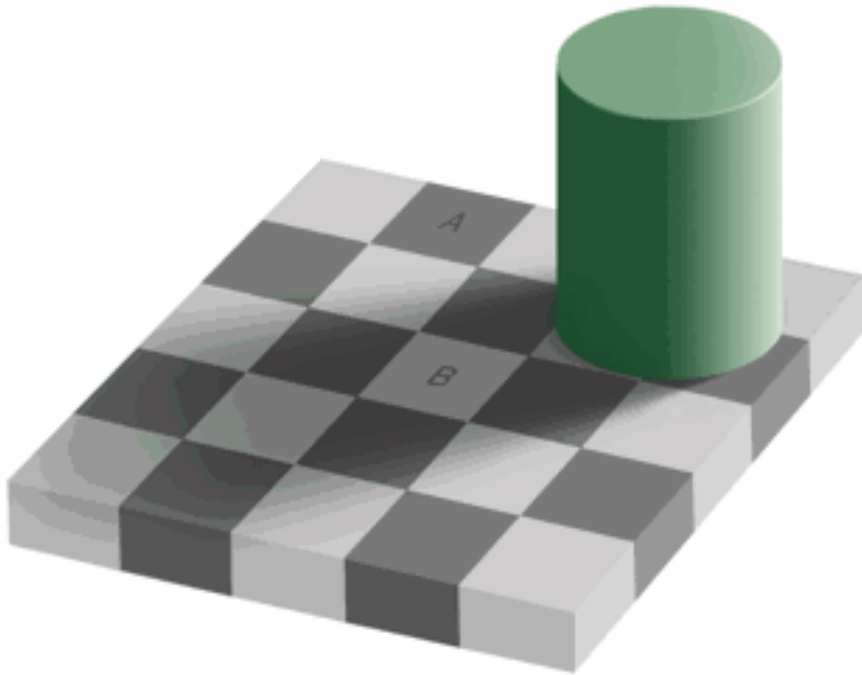
INTRODUCTION. BACKGROUND

- The sine Illusion: which of the bars are longer, or are they the same length?



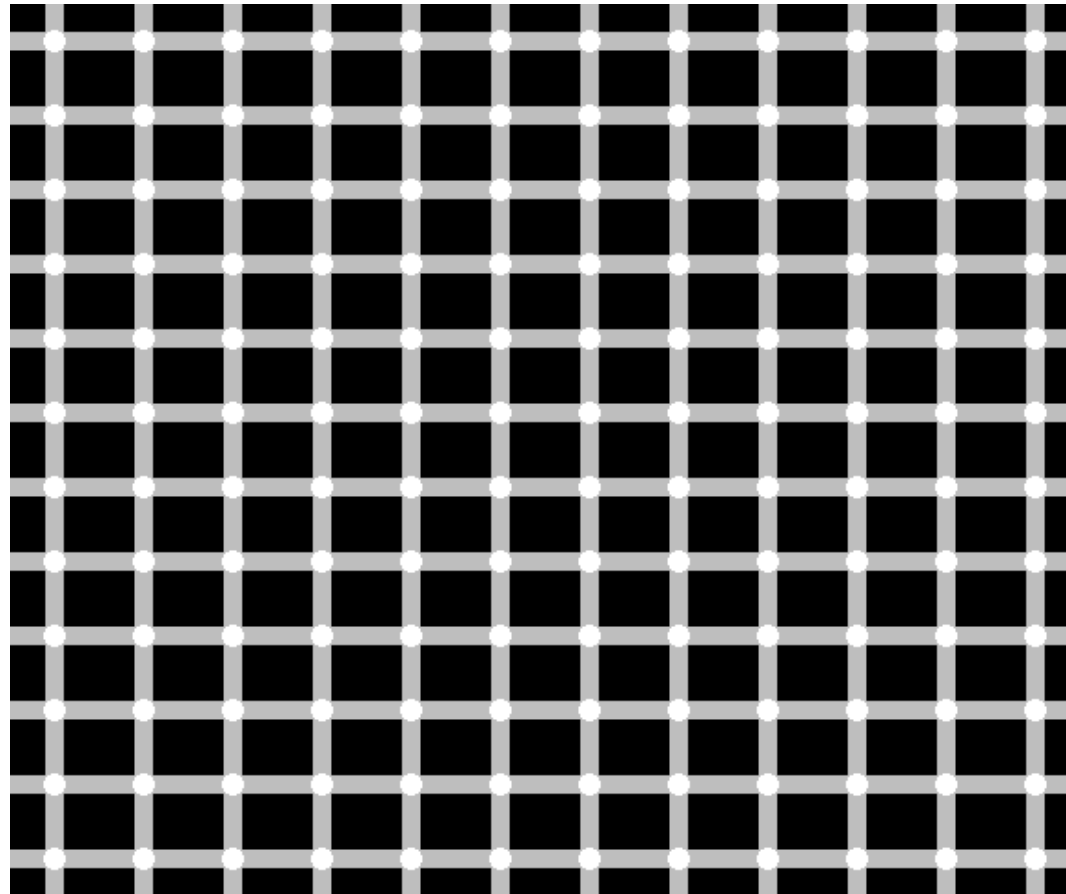
INTRODUCTION. BACKGROUND

- Which of the squares A and B is darker, or are they the same shade?



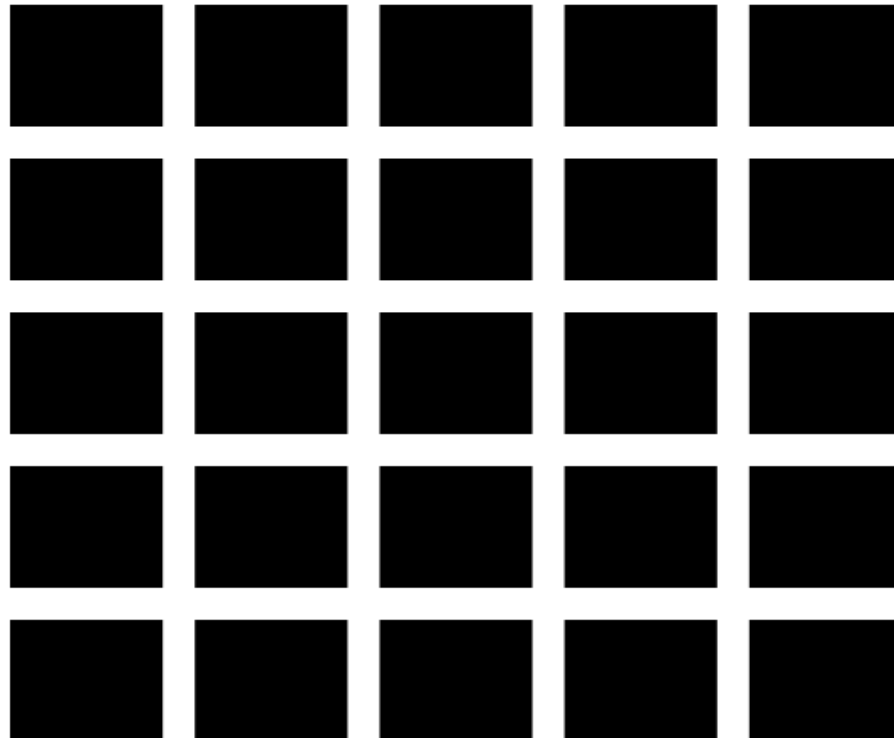
INTRODUCTION. BACKGROUND

- Black dots at the intersections appear and disappear; are they real?



INTRODUCTION. BACKGROUND

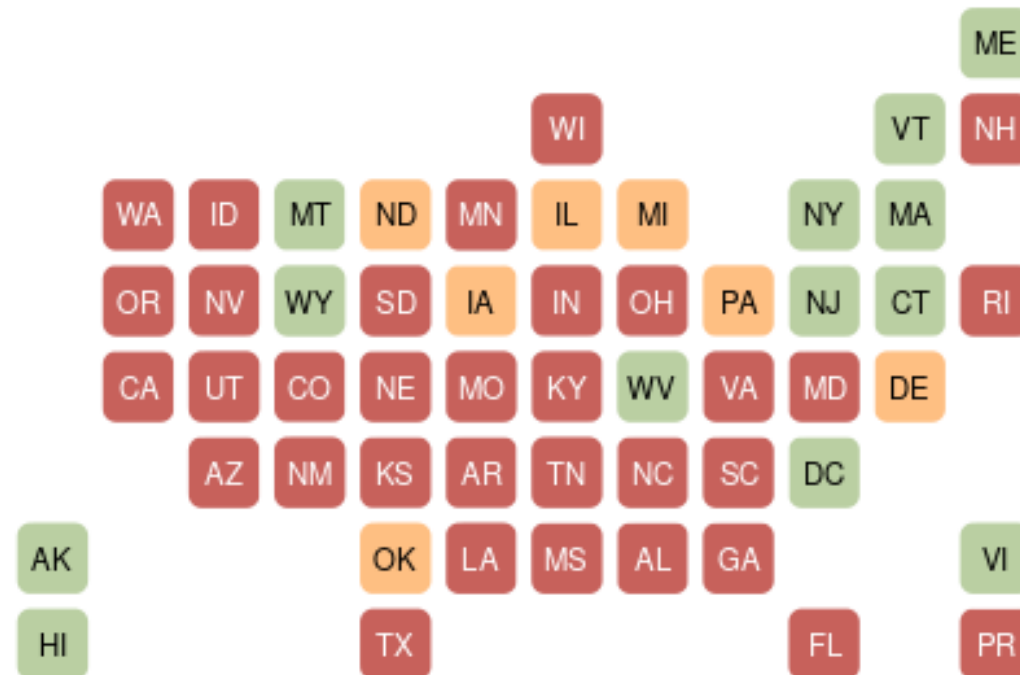
- Black dots at the intersections appear and disappear; are they real?



INTRODUCTION. BACKGROUND

Is Your State Doing Enough Coronavirus Testing?

12 states meet the testing target;
5 are near the target; **34** are below the target;



Data source: NYTimes <www.nytimes.com/interactive/2020/us/coronavirus-testing.html>

Pere-Pau Vázquez – Dept. Computer Science – UPC

<https://homepage.divms.uiowa.edu/~luke/classes/STAT4580/percep.html>

INTRODUCTION. BACKGROUND

- Red, from black and white

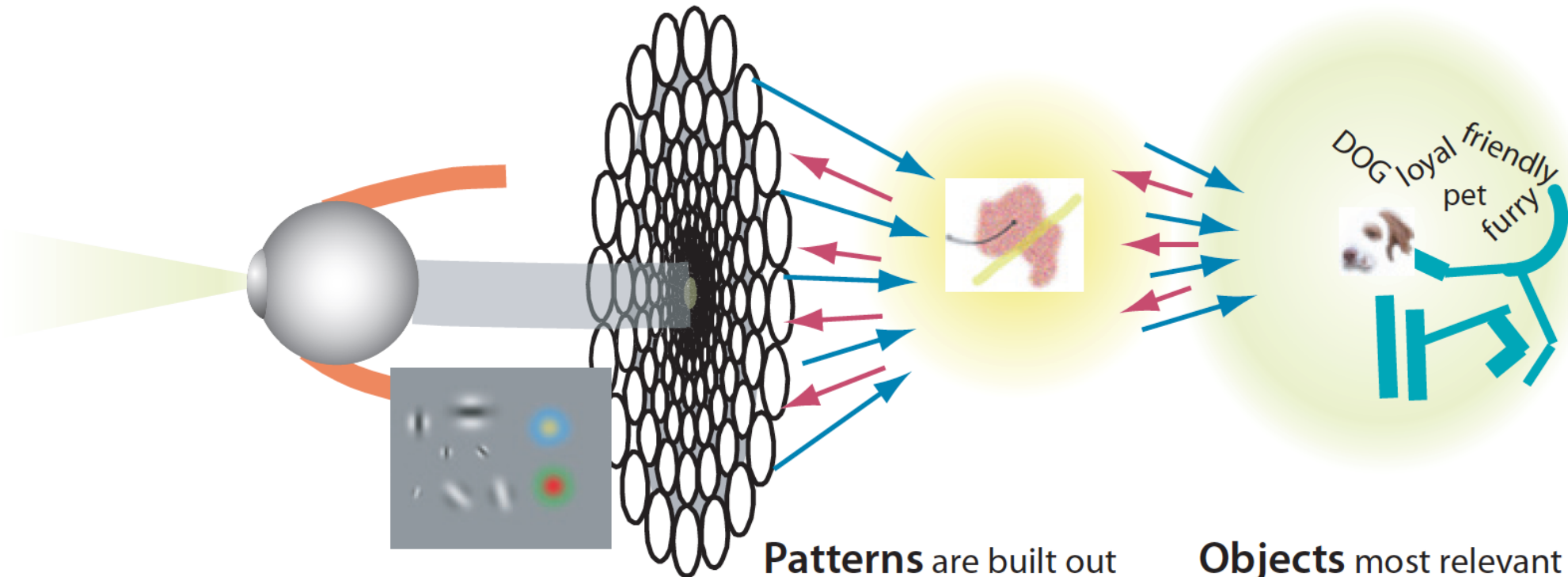


OUTLINE

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- **Preattentive Processing**
- Perception Laws
- Applying Perception in Visualization

PREATTENTIVE PROCESSING

- Design visual information to be efficiently perceivable – quick, unambiguous
- Need to understand how human visual perception and information processing works
- Perception science related to:
 - Physiology: study the physical, biochemical and information processing functions of living organisms
 - Cognitive psychology: studying internal mental processes
 - how do people learn, understand, solve problems with regard to sensory information?



Features are processed in parallel from every part of the visual field. Millions of features are processed simultaneously.

Patterns are built out of features depending on attentional demands. Attentional tuning reinforces those most relevant.

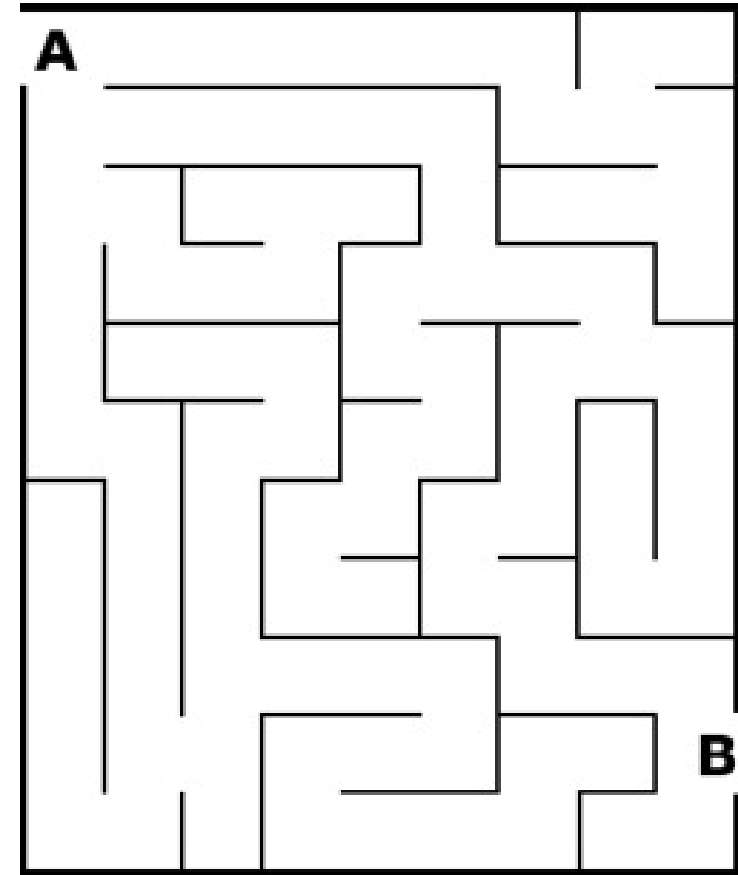
Objects most relevant to the task at hand are held in Visual Working Memory. Only between one and three are held at any instant. Objects have both non-visual and visual attributes.

Bottom-up information drives pattern building

Top-down attentional processes reinforce relevant information

PREATTENTIVE PROCESSING. 3-STAGE MODEL

- Example. Route between the two letters?
 - Stage 1: automatic parallel extraction of colors, shapes, position, etc.
 - Stage 2: Pattern finding of black contours (lines) between two symbols (letters)
 - Stage 3:
 - Few objects are held in working memory at a time
 - Identify path sequentially (formulate new visual query)



PREATTENTIVE PROCESSING

- Many perceptual processing models exist
- Simplified 3-stage model:
 - Iconic memory
 - Working memory (short-term)
 - Long-term memory

PREATTENTIVE PROCESSING. ICONIC MEMORY

- Images remain in iconic memory for less than a second
- Processing in iconic memory is massively parallel and automatic
- This is called *preattentive processing*

PREATTENTIVE PROCESSING. SHORT-TERM MEMORY

- Meaningful visual chunks moved from iconic memory to short term memory
 - Used by conscious, or attentive, processing
 - Attentive processing often involves conscious comparisons or search
- Short term memory is limited:
 - Information is retained for only a few seconds
 - Only three or four chunks can be held at a time
 - Chunks can be of varying size
 - A coherent pattern can form a single chunk even if it is quite large
- If more chunks are needed or needed longer they need to be reacquired (or retrieved from long term memory)

PREATTENTIVE PROCESSING. LONG-TERM MEMORY

- Built up over a lifetime
 - Though infrequently used visual chunks may become lost
- Chunks processed repeatedly in working memory may be transferred to long term memory
- Common patterns and contextual information can be retrieved from long term memory for attentive processing in working memory

PREATTENTIVE PROCESSING

- Visual Design Implications
 - Try to make as much use of preattentive features as possible
 - Recognize when preattentive features might mislead
 - For features that require attentive processing, keep in mind that working memory is limited

PREATTENTIVE PROCESSING

- A limited set of basic visual properties are processed ***preattentively***
 - Information that “pops out”
 - Parallel processing by the low-level visual system (Stage 1 in the model)
 - Occurs prior to conscious attention
 - Important for designing effective visualizations
 - What features can be perceived rapidly?
 - Which properties are good discriminators?
 - What can mislead viewers?
 - How to design information such that it pops out?

PREATTENTIVE PROCESSING

- Example: Find the 3s

142416496357598475921765968474891728482
285958819829450968504850695847612124044
074674898985171495969124567659608020860
608365416496457590643980479248576960781
285960799918712845268101495969124567781
874241649645757659608149596912456701285
960799164964575127879918712845298496912
223591649645759588198250963576596080596

PREATTENTIVE PROCESSING

- Example: Find the 3s

142416496**3**57598475921765968474891728482
285958819829450968504850695847612124044
074674898985171495969124567659608020860
608**3**6541649645759064**3**980479248576960781
285960799918712845268101495969124567781
874241649645757659608149596912456701285
960799164964575127879918712845298496912
22**3**59164964575958819825096**3**576596080596

PREATTENTIVE PROCESSING

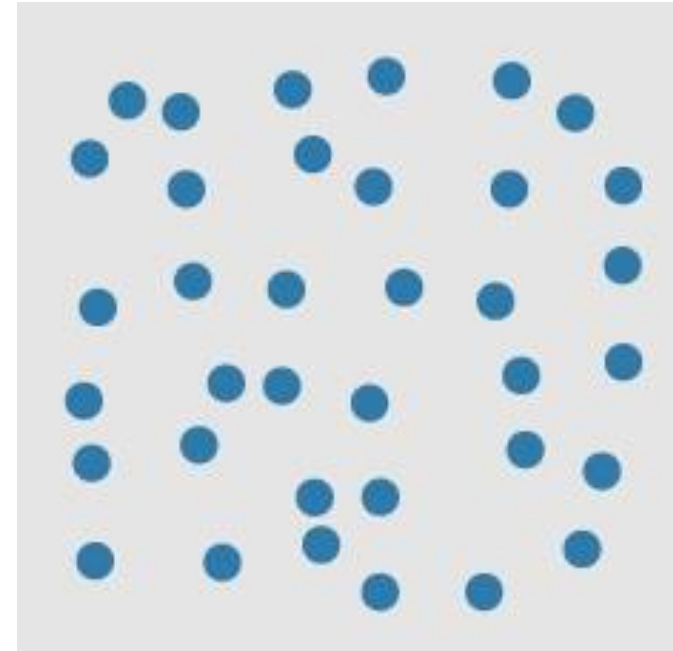
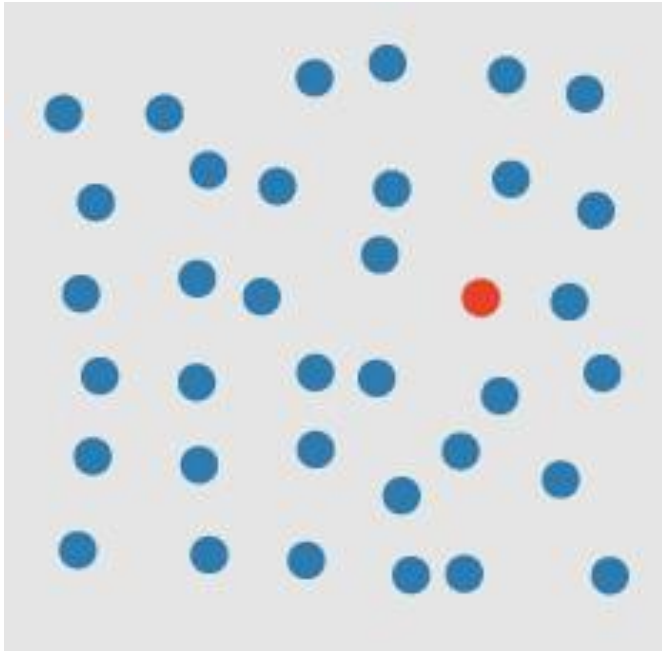
- How to find out if a visual attribute is preattentive?
 1. Measure response time for tasks
 2. Check whether time is smaller than a certain threshold (see next slide)
- Different **tasks** are possible
 - Detection of a target among distractors – Is the target present?
 - Boundary detection – Do items form two groups?
 - Counting – How many targets are there?

PREATTENTIVE PROCESSING

- **Time** threshold:
 - Detection of targets on a large multi-element display
 - Times < 200 to 250 ms are considered preattentive
 - Eye movement takes at least 200 ms to initiate
- Example: is there a red target present in the images?

PREATTENTIVE PROCESSING

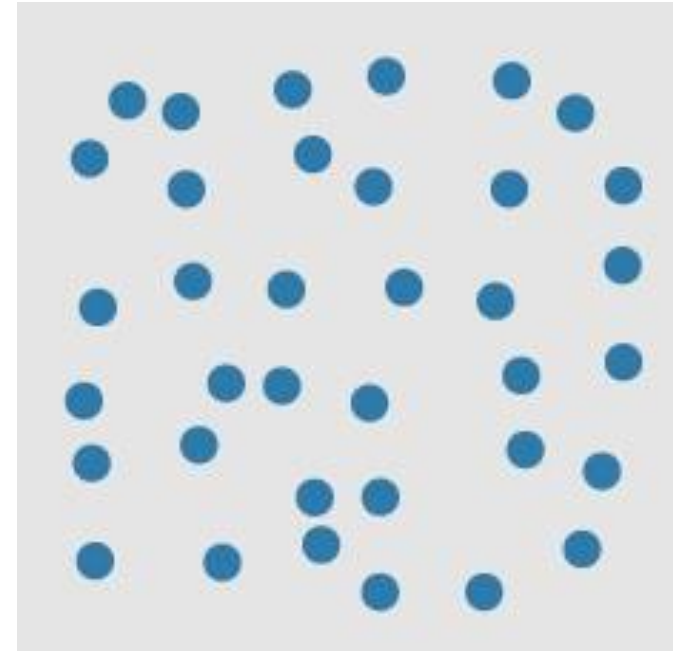
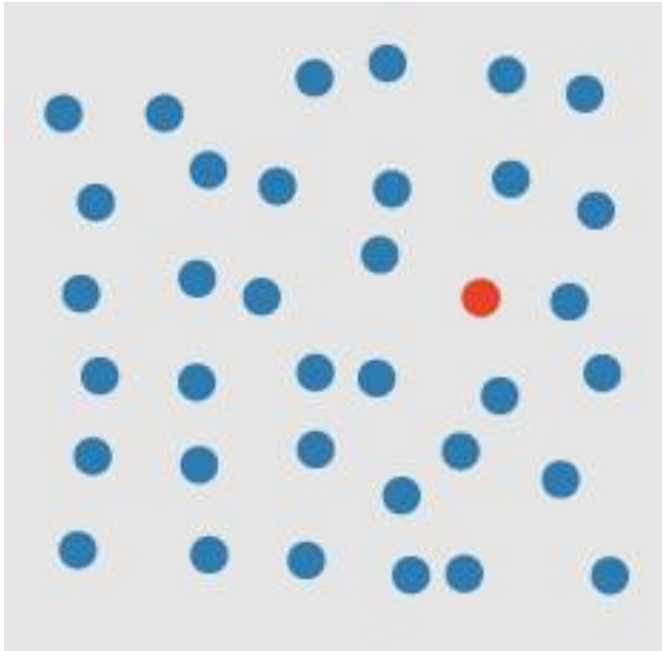
- Is there a red circle present in the image?



<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

- Is there a red circle present in the image?

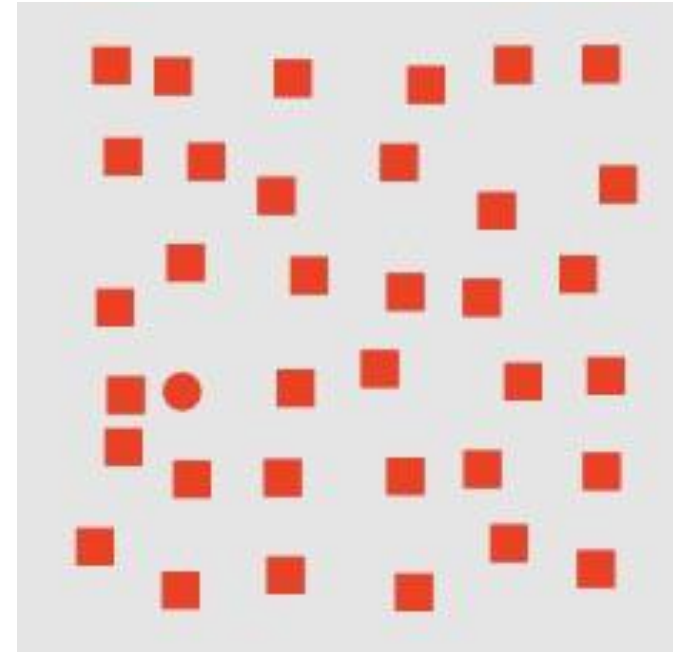
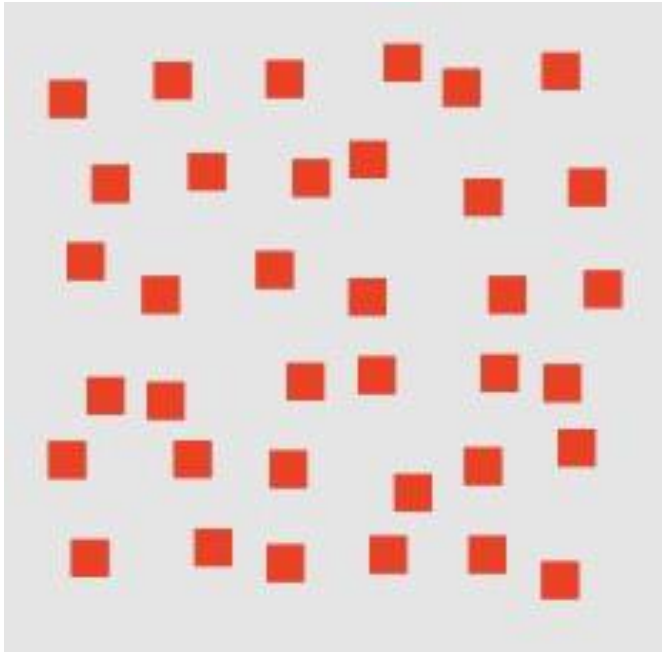


Color is preattentively processed!

<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

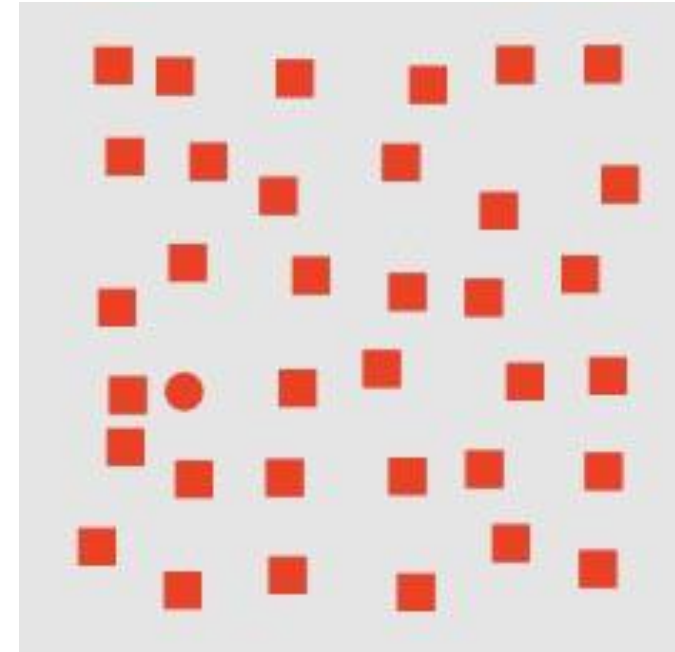
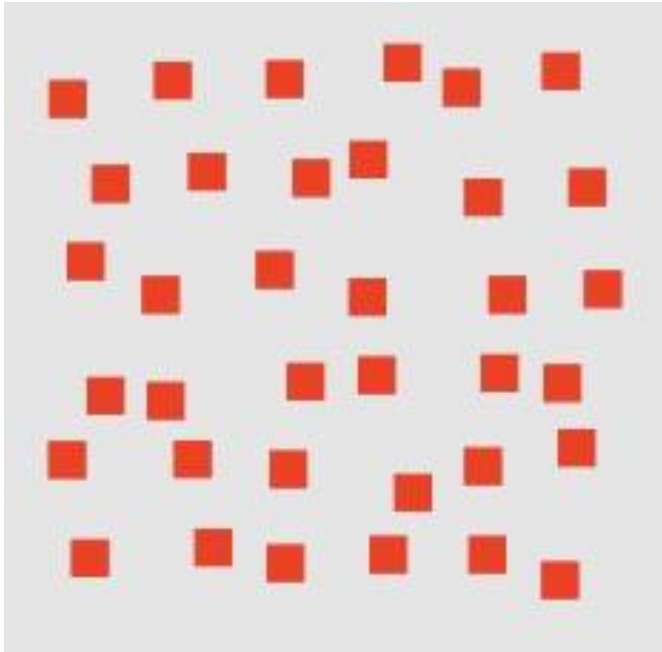
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<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

- Is there a red circle present in the image?

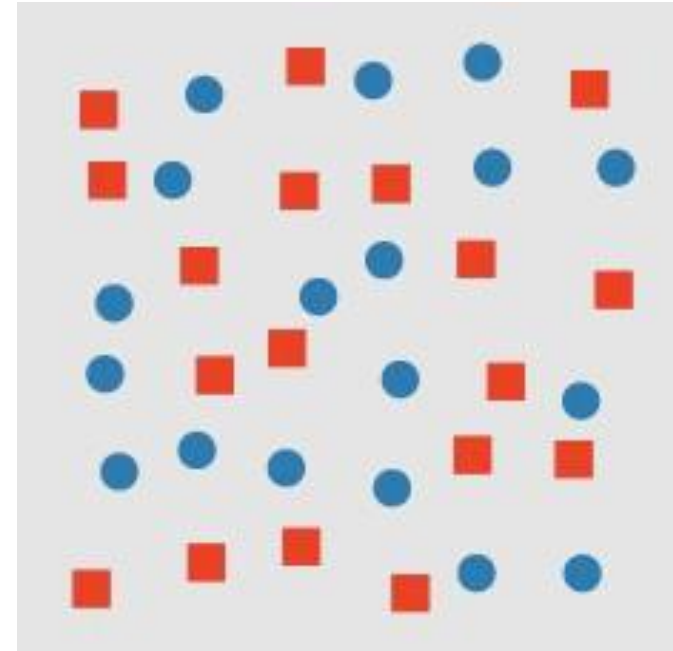
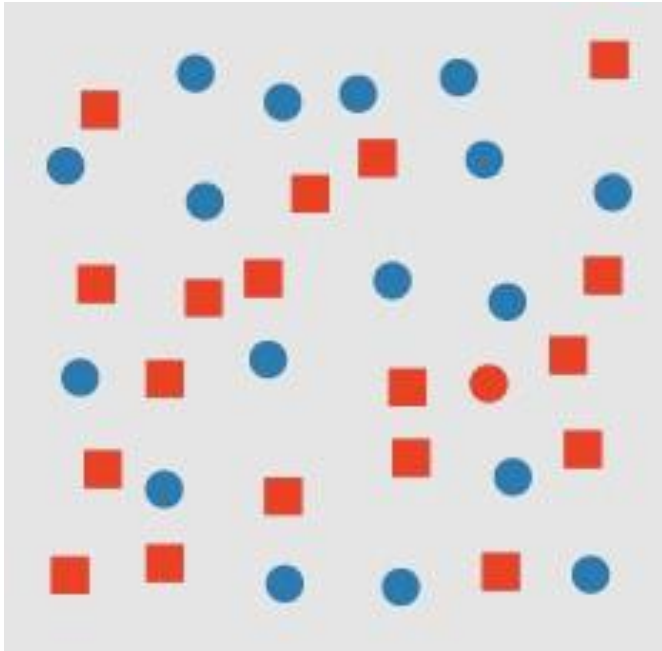


Shape is preattentively processed!

<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

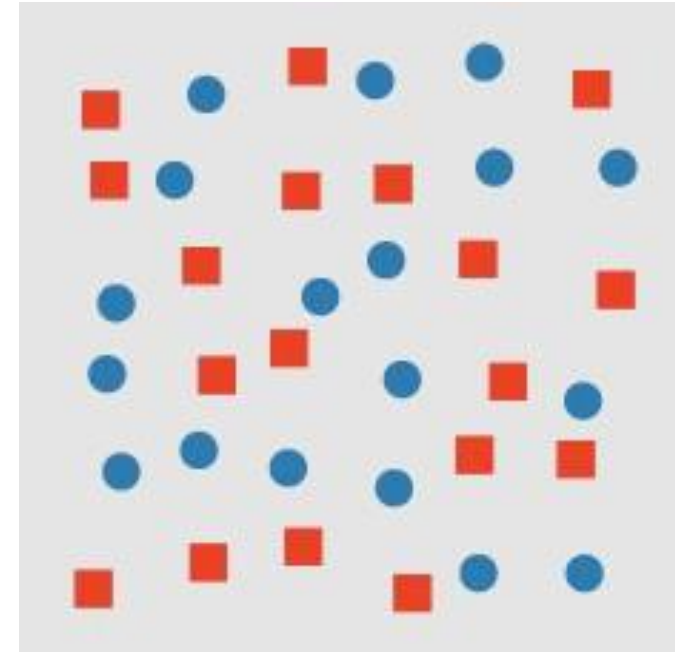
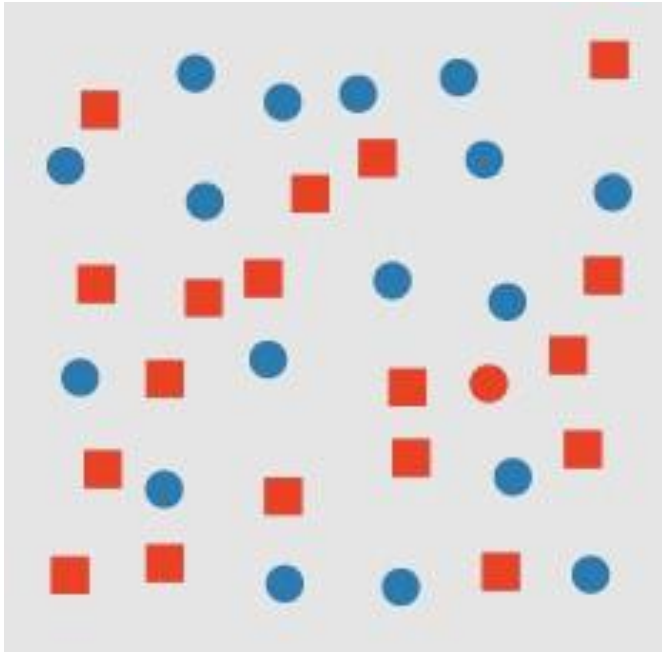
- Is there a red circle present in the image?



<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

- Is there a red circle present in the image?

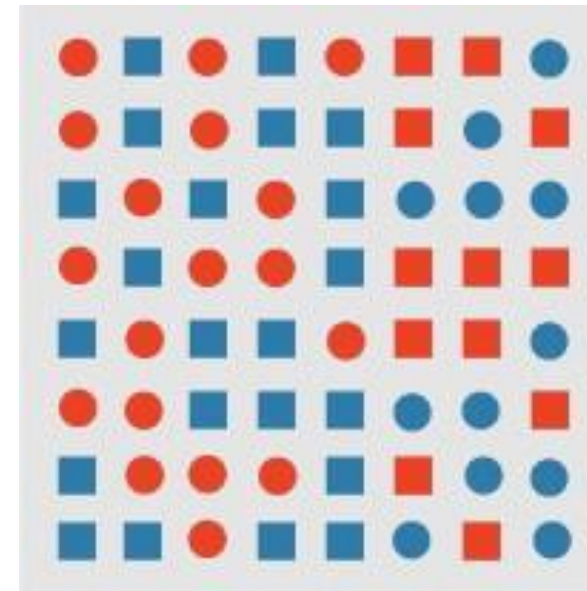
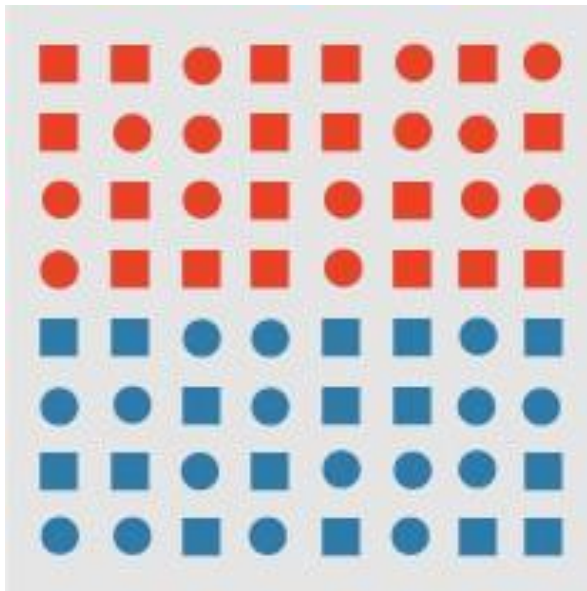


Conjunction of 2 properties is usually not preattentive

<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

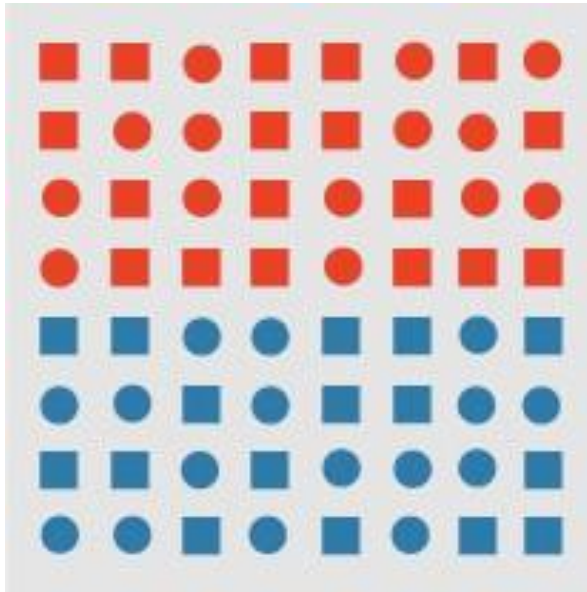
- Do items form a boundary? If yes, based on which attribute(s)?



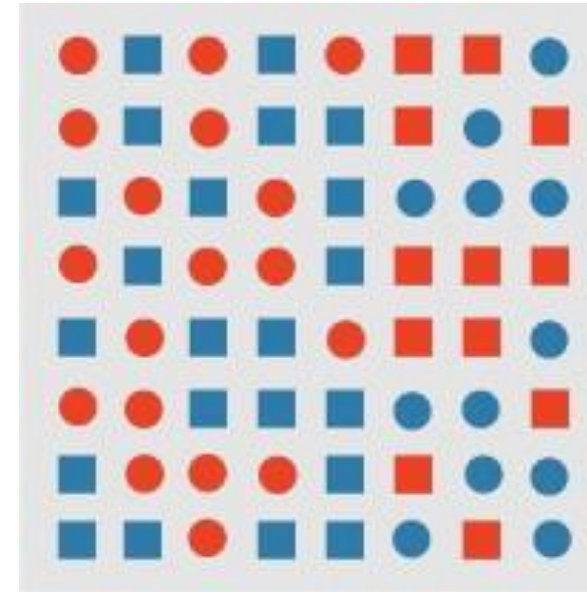
<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

- Do items form a boundary? If yes, based on which attribute(s)?



Preattentive: grouping by hue



Conjunction search: grouping
by hue and shape

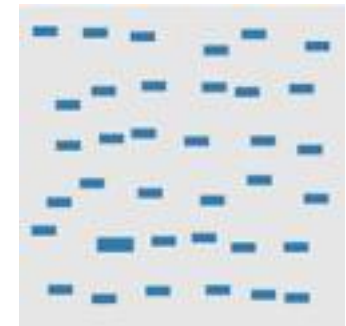
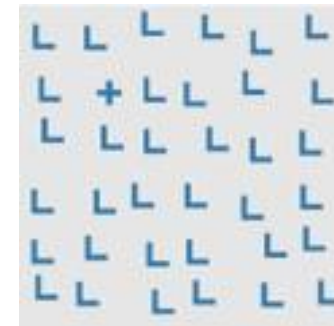
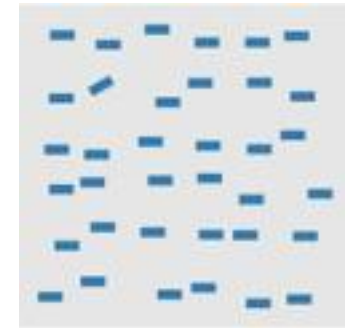
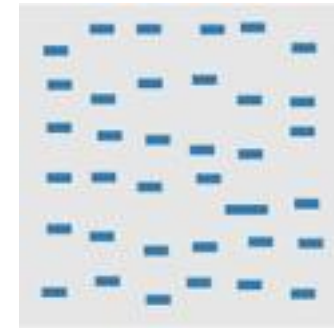
<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

- Common Preattentive Properties

- Form

- Line orientation
 - Line length
 - Line width
 - Size
 - Curvature
 - Shape
 - Spatial grouping



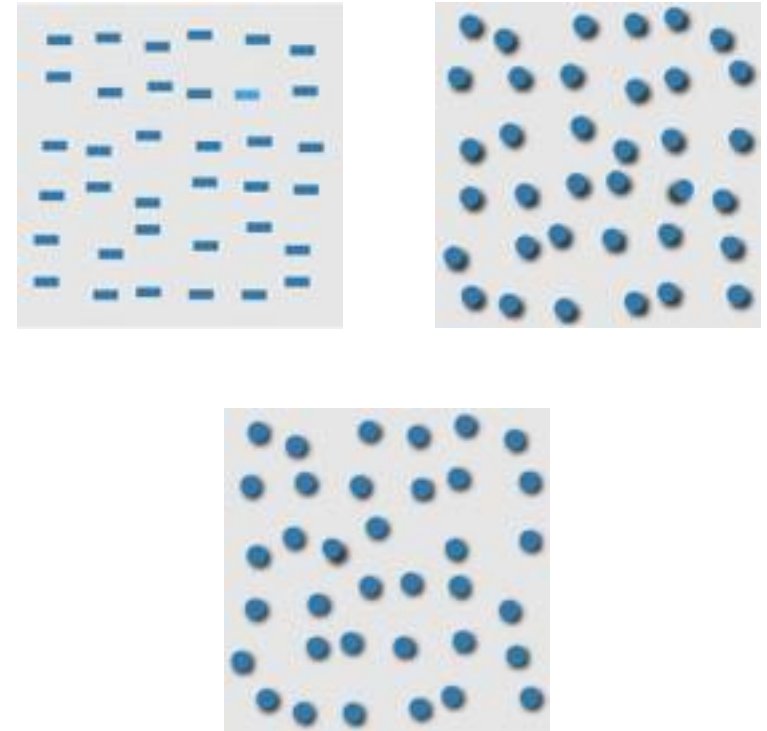
<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

- Common Preattentive Properties

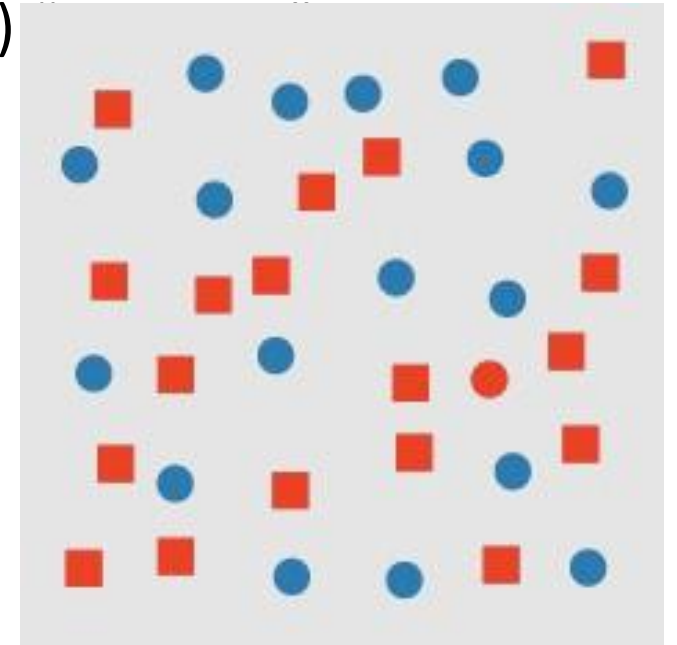
- Color

- Hue
 - Intensity
 - Motion
 - Flicker
 - Direction of motion
 - Spatial Position
 - 2D position
 - Stereoscopic depth
 - Convexity / Concavity



PREATTENTIVE PROCESSING

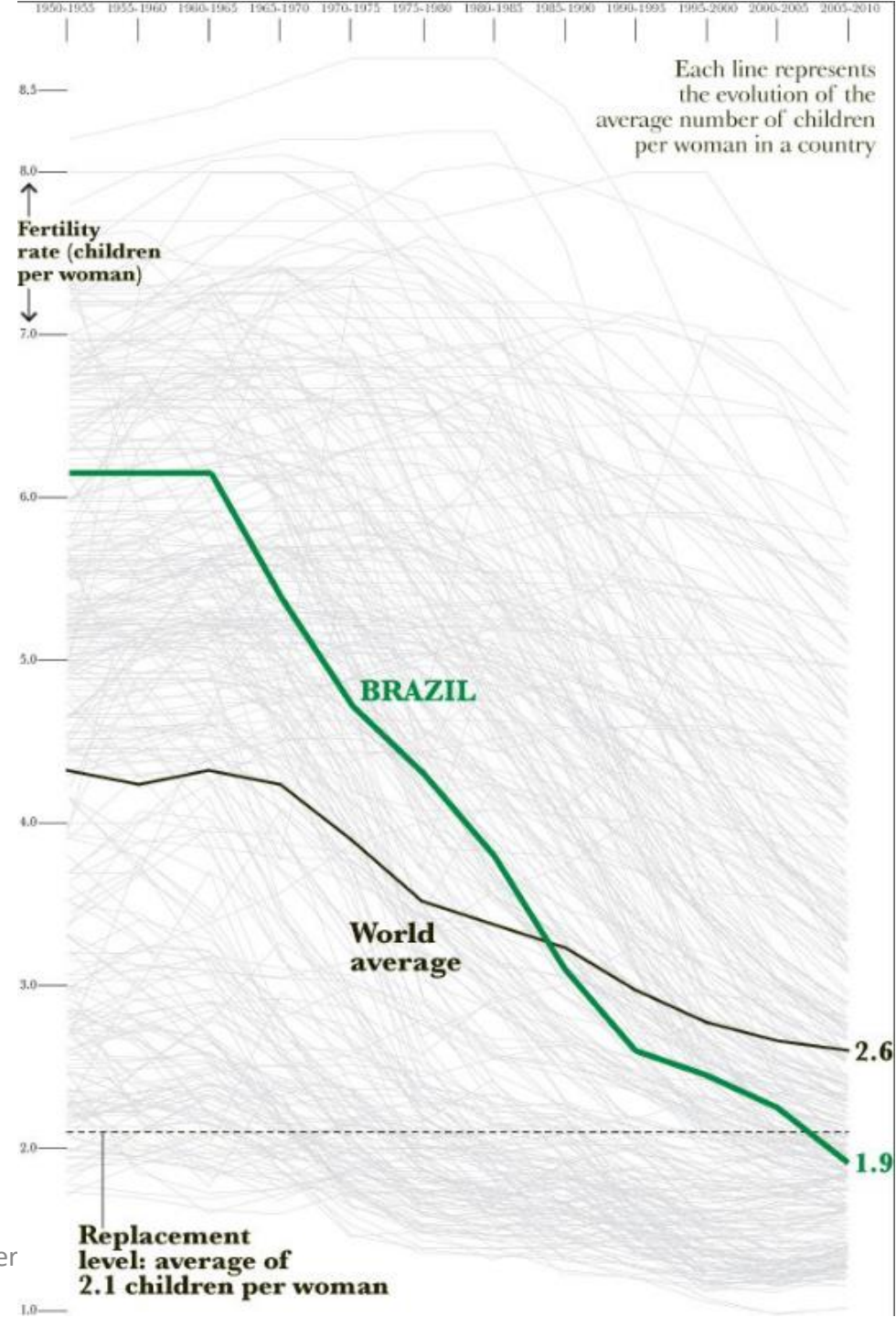
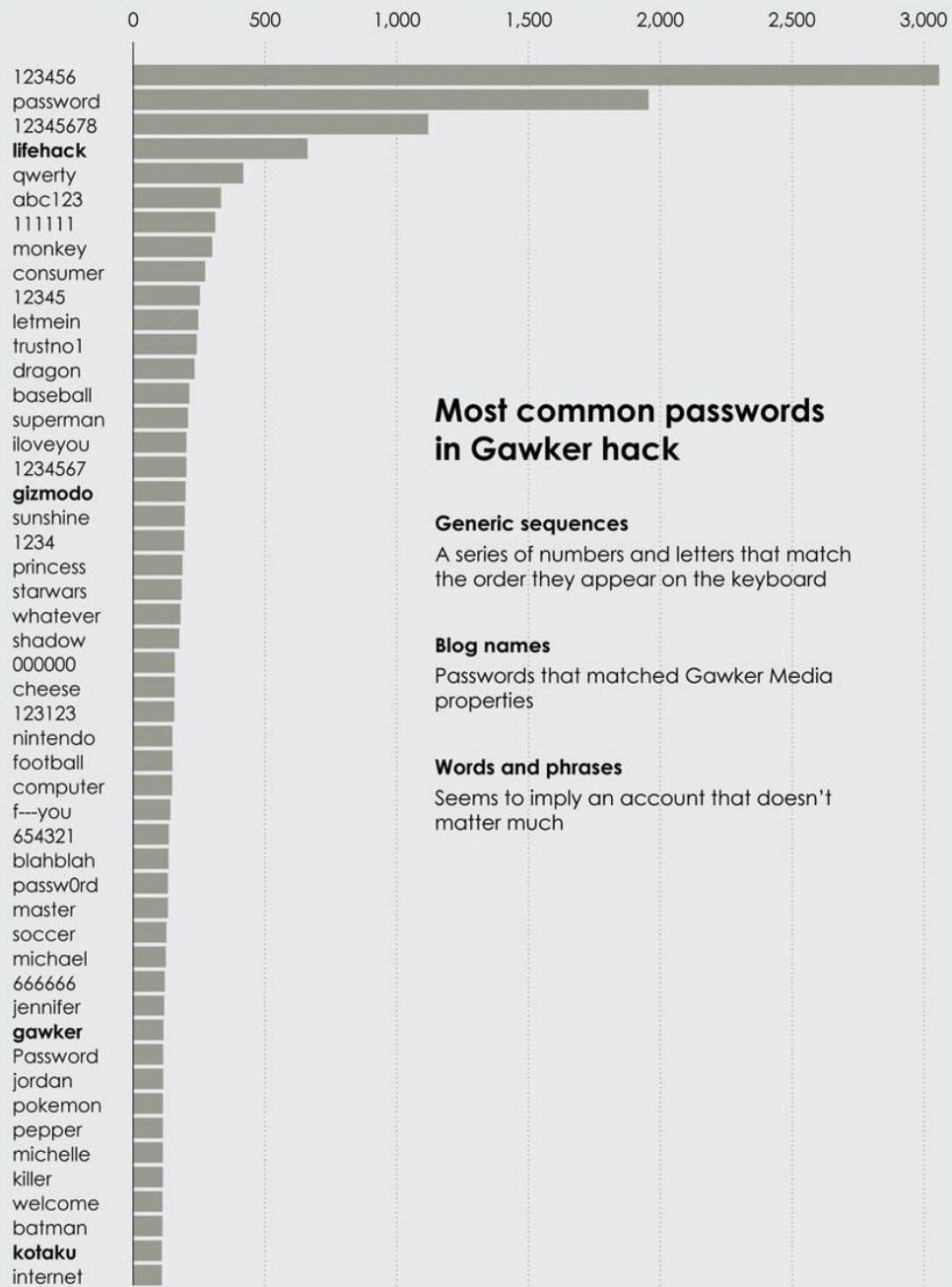
- Conjunction Search
 - A target with a unique visual property (e.g., shape OR color)
- Conjunction target is made up of non-unique features
 - Requires a time-consuming serial search, e.g.
 - For every red colored item: is it a circle?
 - For every circular item: is it red?

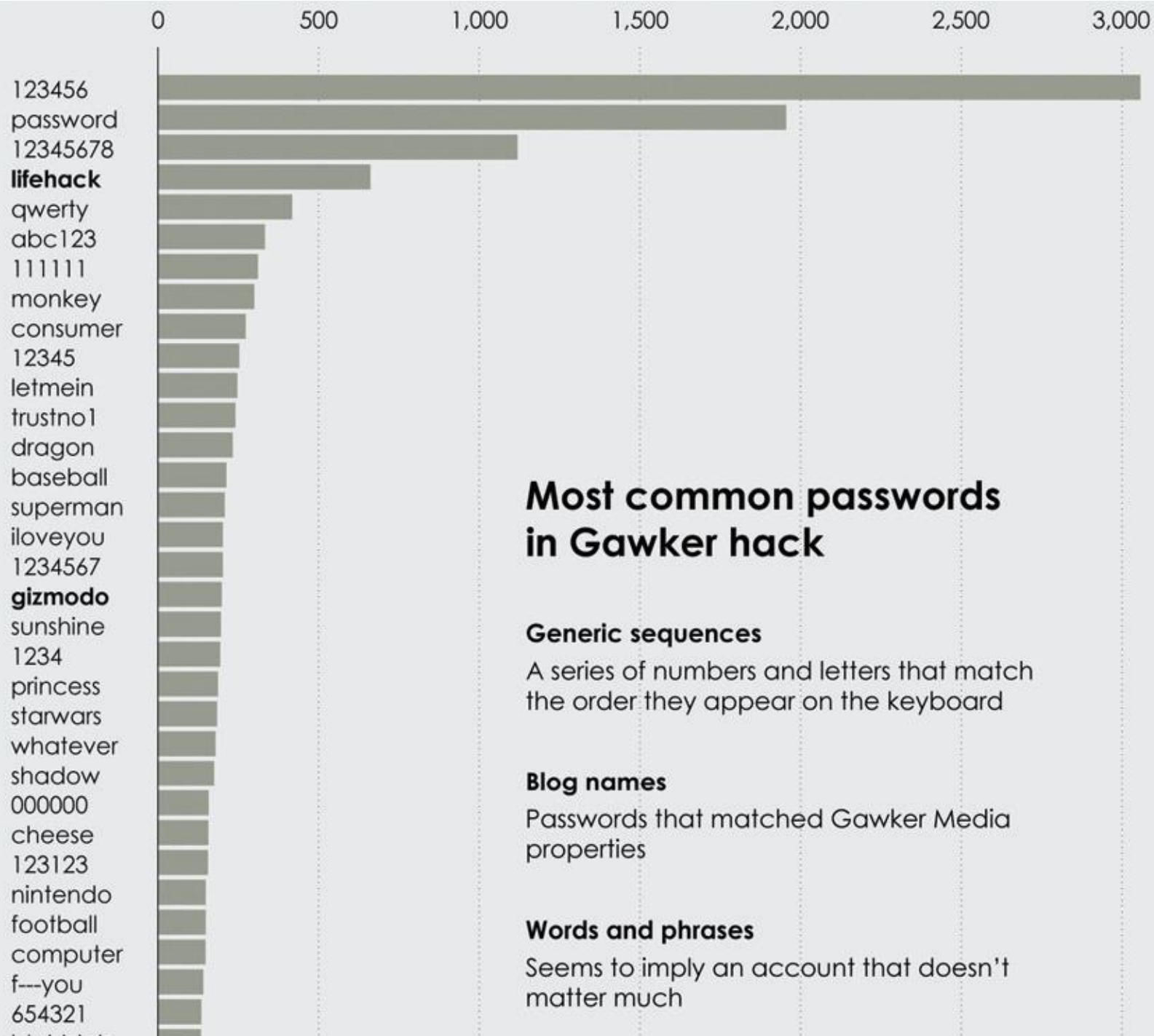


<https://www.csc2.ncsu.edu/faculty/healey/PP/>

PREATTENTIVE PROCESSING

- Use of preattentive features in visualization. Some tips:
 - Remember preattentive features are asymmetric
 - E.g., a sloped line in a sea of vertical lines can be detected preattentively, but the opposite is not true
 - Consider the effect of background distractors with the target feature
 - Avoid use of conjunction targets





Most common passwords in Gawker hack

Generic sequences

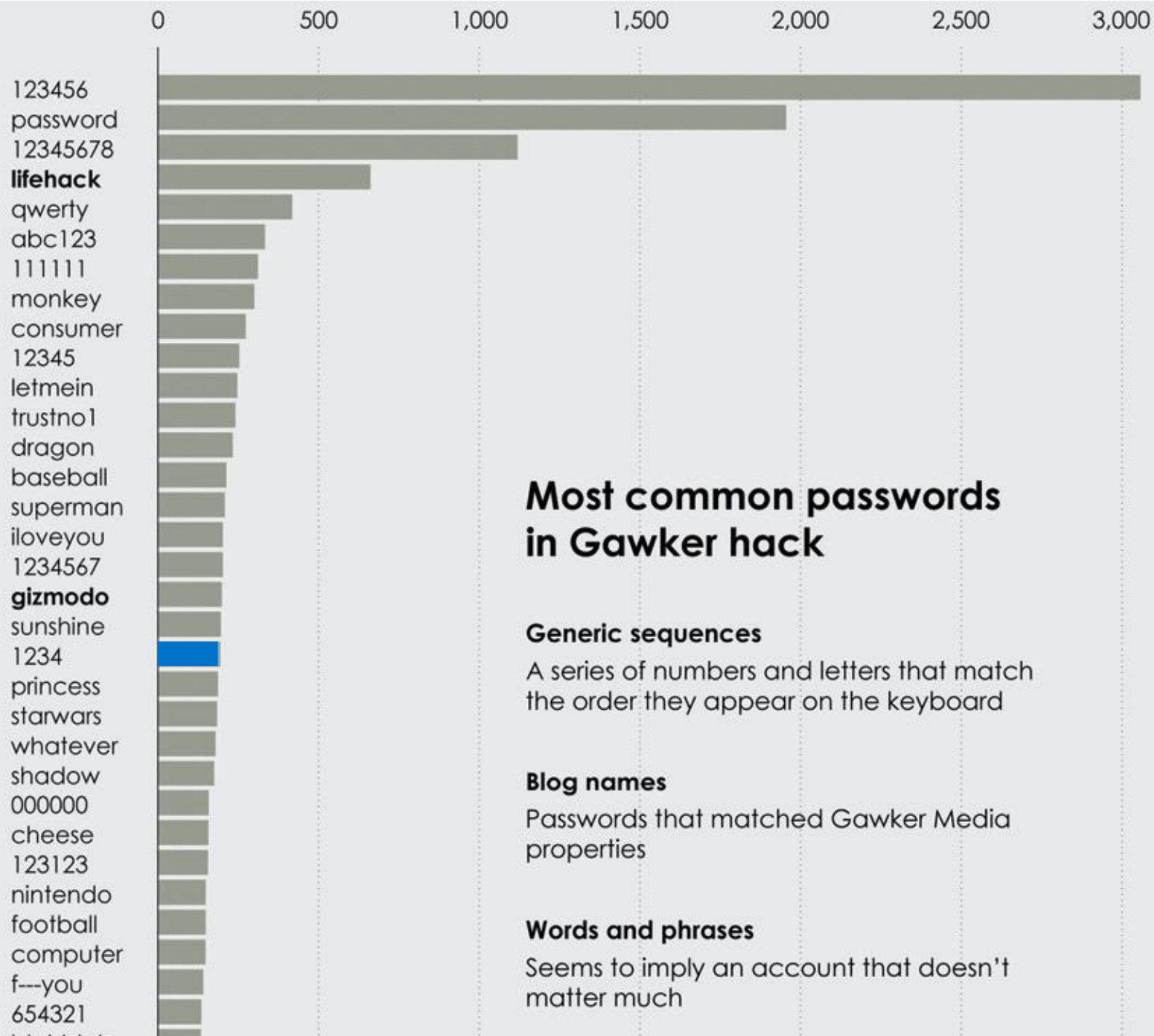
A series of numbers and letters that match the order they appear on the keyboard

Blog names

Passwords that matched Gawker Media properties

Words and phrases

Seems to imply an account that doesn't matter much



Most common passwords in Gawker hack

Generic sequences

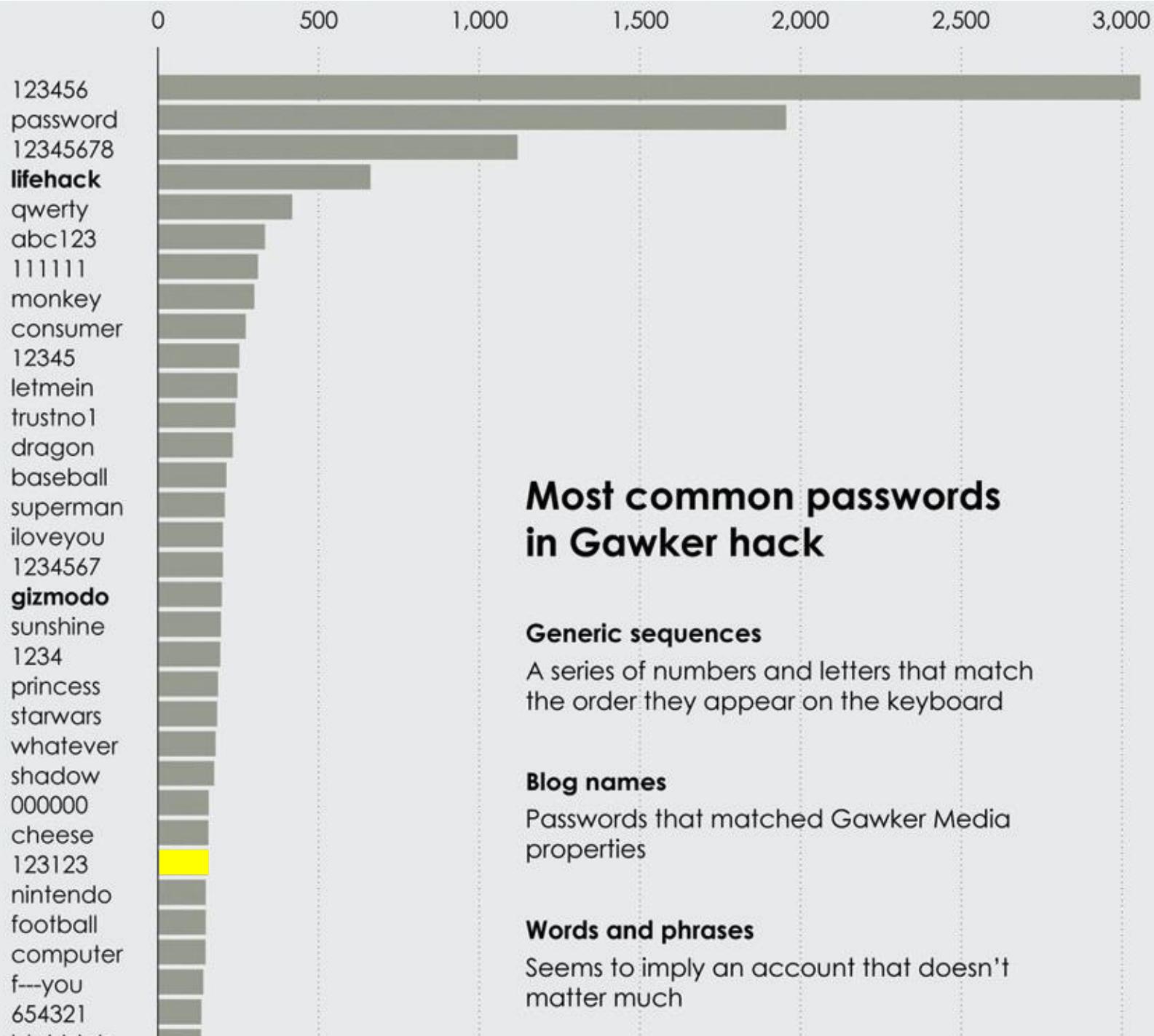
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Most common passwords in Gawker hack

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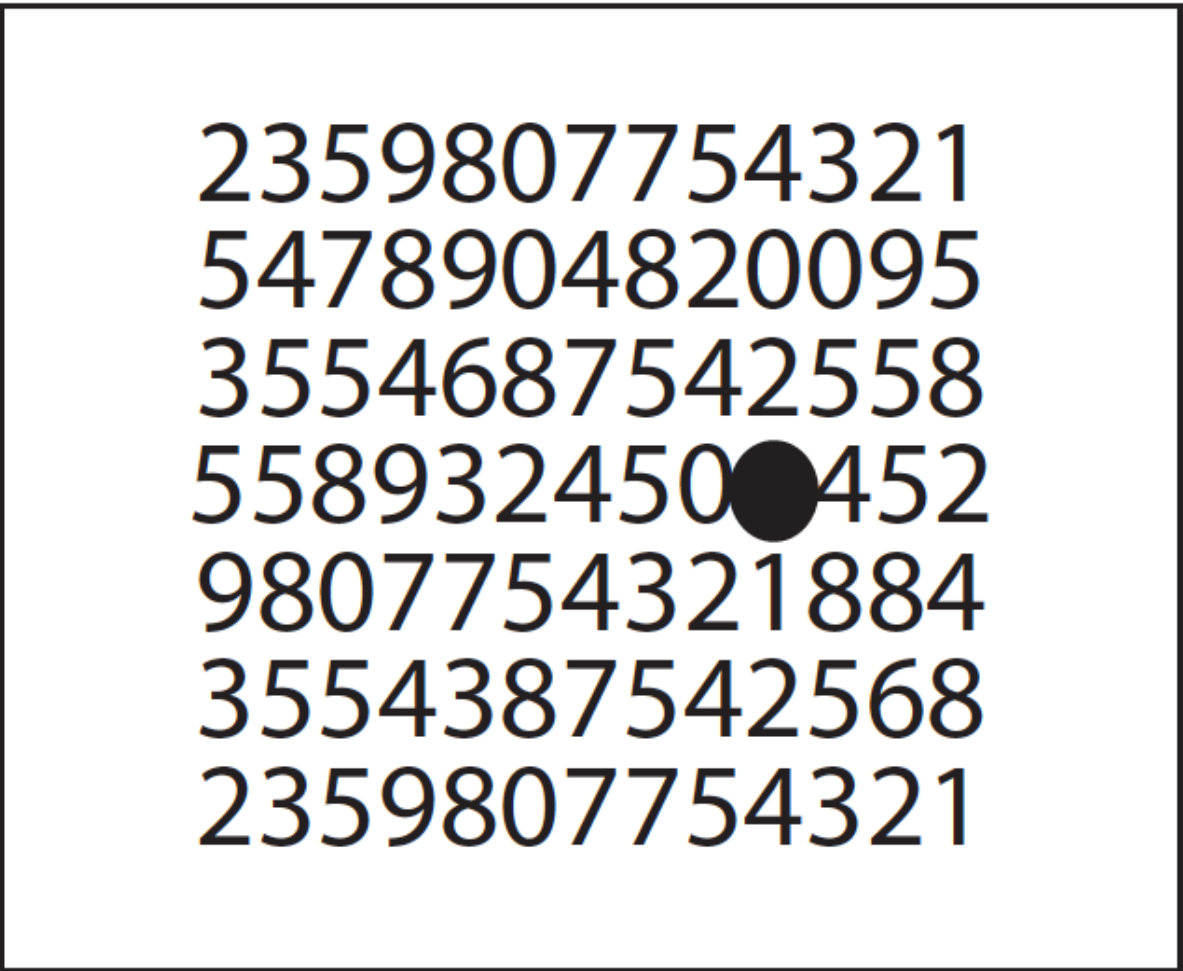
PREATTENTIVE PROCESSING. CONCLUSIONS

- Preattentive processing **works when we know what we are looking for**
 - **Otherwise, most stimuli pass undetected**
 - The brain lets the cells sensitive to the element searched for to have more relevant paper
 - While the other are partially silenced
 - Very sensitive to the distractors
 - Training does not have any influence
- **Movement ALWAYS attracts our attention**
 - Moving elements in webpages, flickering text or banners, are highly distracting!

PREATTENTIVE PROCESSING. CONCLUSIONS

6
difficult

●
easy



2359807754321
5478904820095
3554687542558
558932450●452
9807754321884
3554387542568
2359807754321

From Ware, 2013

PREATTENTIVE PROCESSING. CONCLUSIONS



difficult



easy

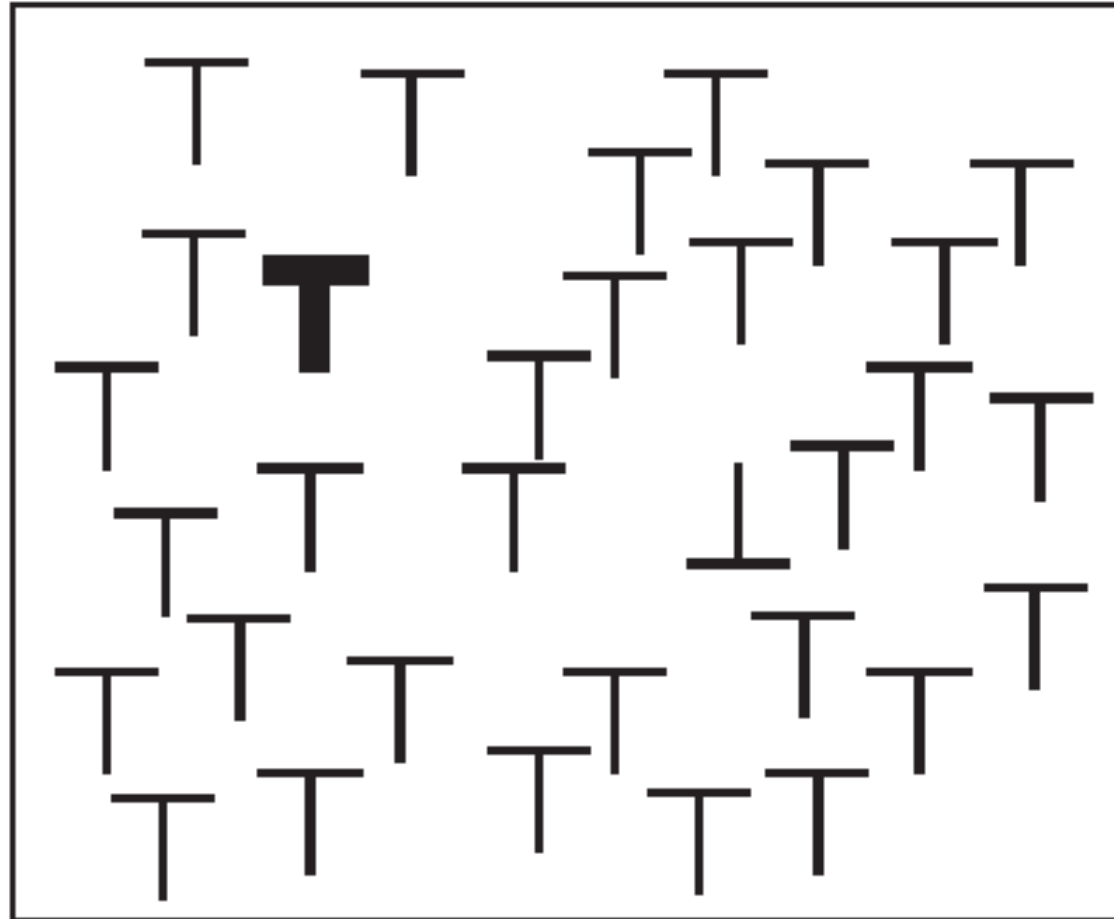
From Ware, 2013



PREATTENTIVE PROCESSING. CONCLUSIONS

┐
difficult

└
easy



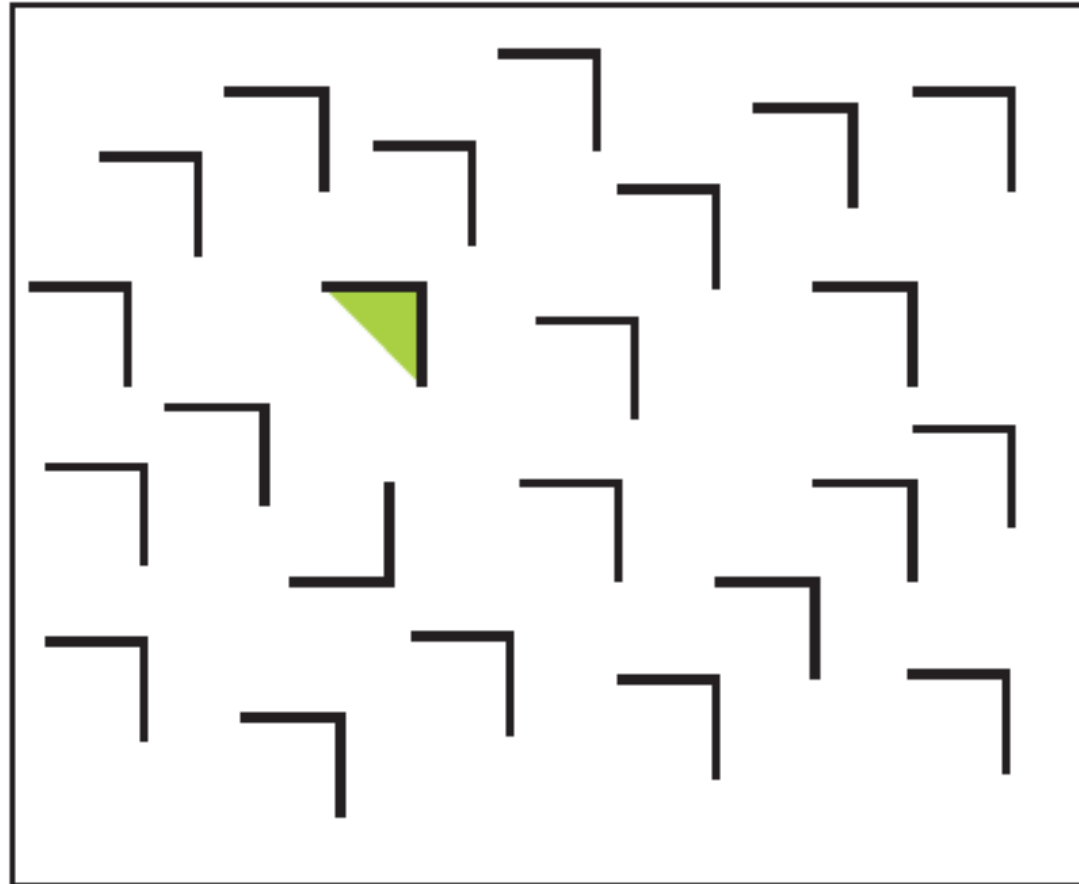
From Ware, 2013

PREATTENTIVE PROCESSING. CONCLUSIONS


difficult


easy

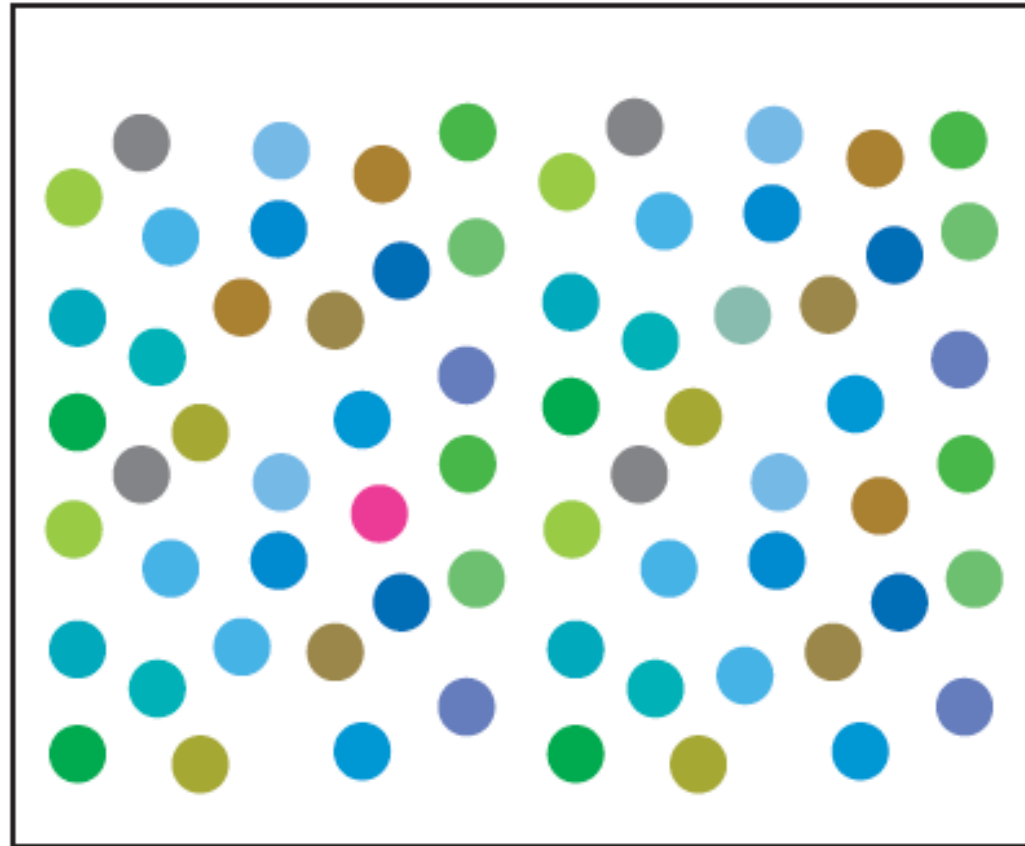
From Ware, 2013



PREATTENTIVE PROCESSING. CONCLUSIONS

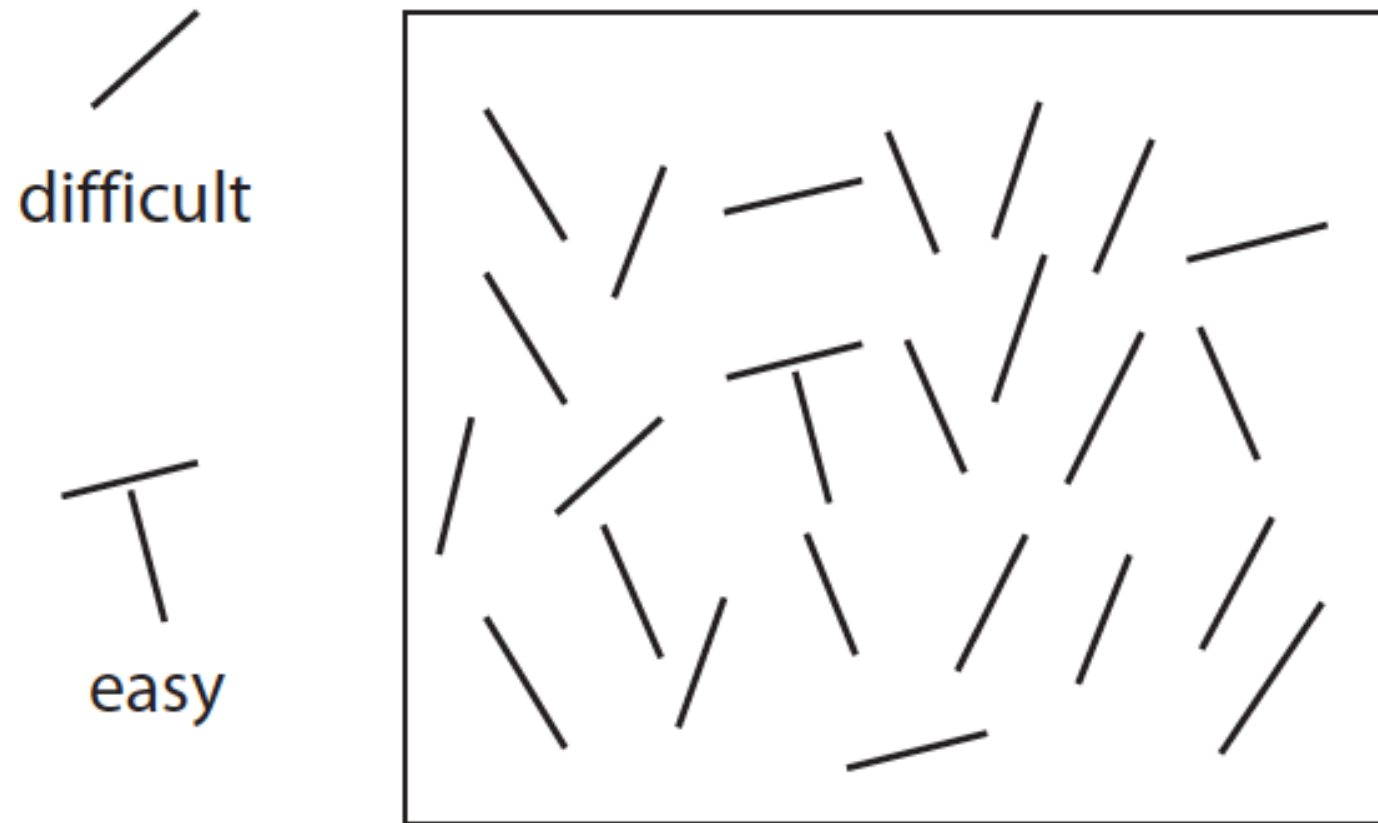

difficult


easy



From Ware, 2013

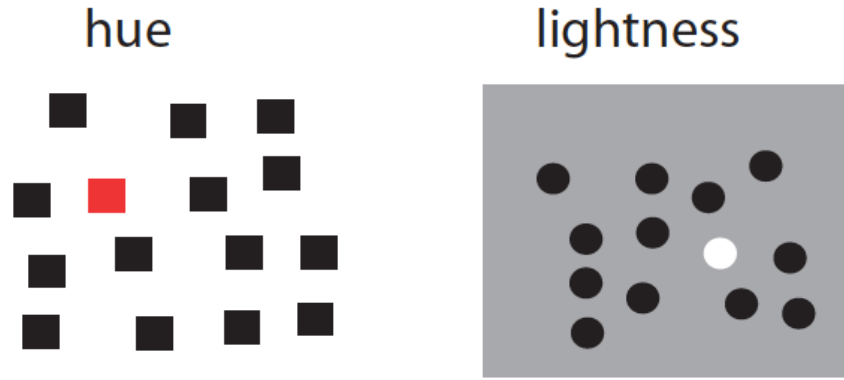
PREATTENTIVE PROCESSING. CONCLUSIONS



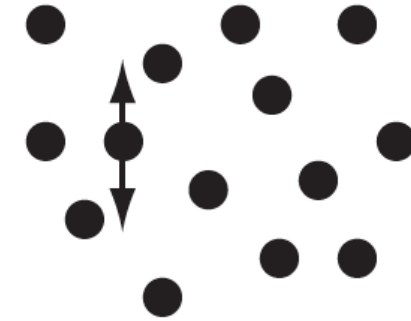
From Ware, 2013

PREATTENTIVE PROCESSING. BASIC POP-OUT CHANNELS

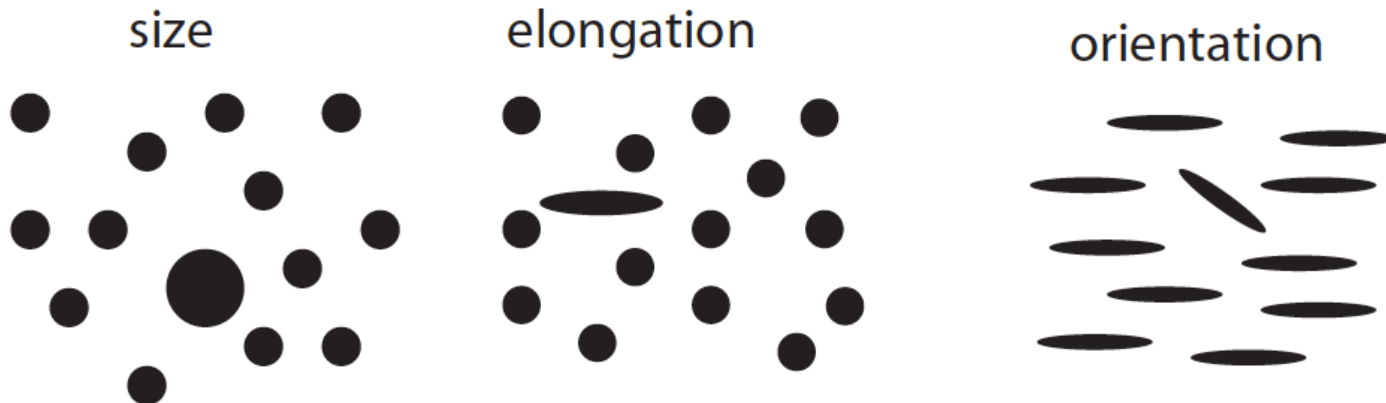
Color



Motion



Elementary shape



Spatial grouping



OUTLINE

- *Recap*
- *Introduction*
- *Preattentive Processing*
- **Perception Laws**
- Applying Perception in Visualization

PERCEPTION LAWS IN DESIGN



PERCEPTION LAWS IN DESIGN

- Can you find the dog?
 - Dalmatian exploring a leaf covered forest floor
 - Once you have found it, try to think of the picture as a simple pattern of black and white again

PERCEPTION LAWS IN DESIGN

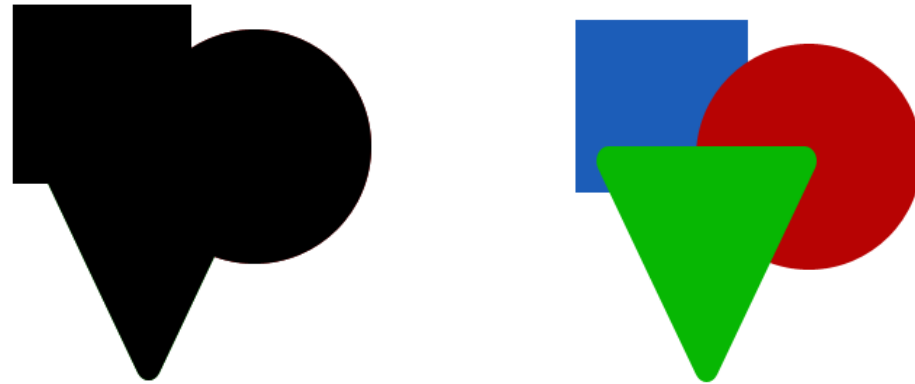


PERCEPTION LAWS IN DESIGN

- Can you find the dog?
 - Dalmatian exploring a leaf covered forest floor
 - Once you have found it, try to think of the picture as a simple pattern of black and white again
 - Does it work?
 - Mind tries to detect anything meaningful by identifying patterns
 - Different tools are tried sequentially
- Perceptual organization is a powerful mechanism

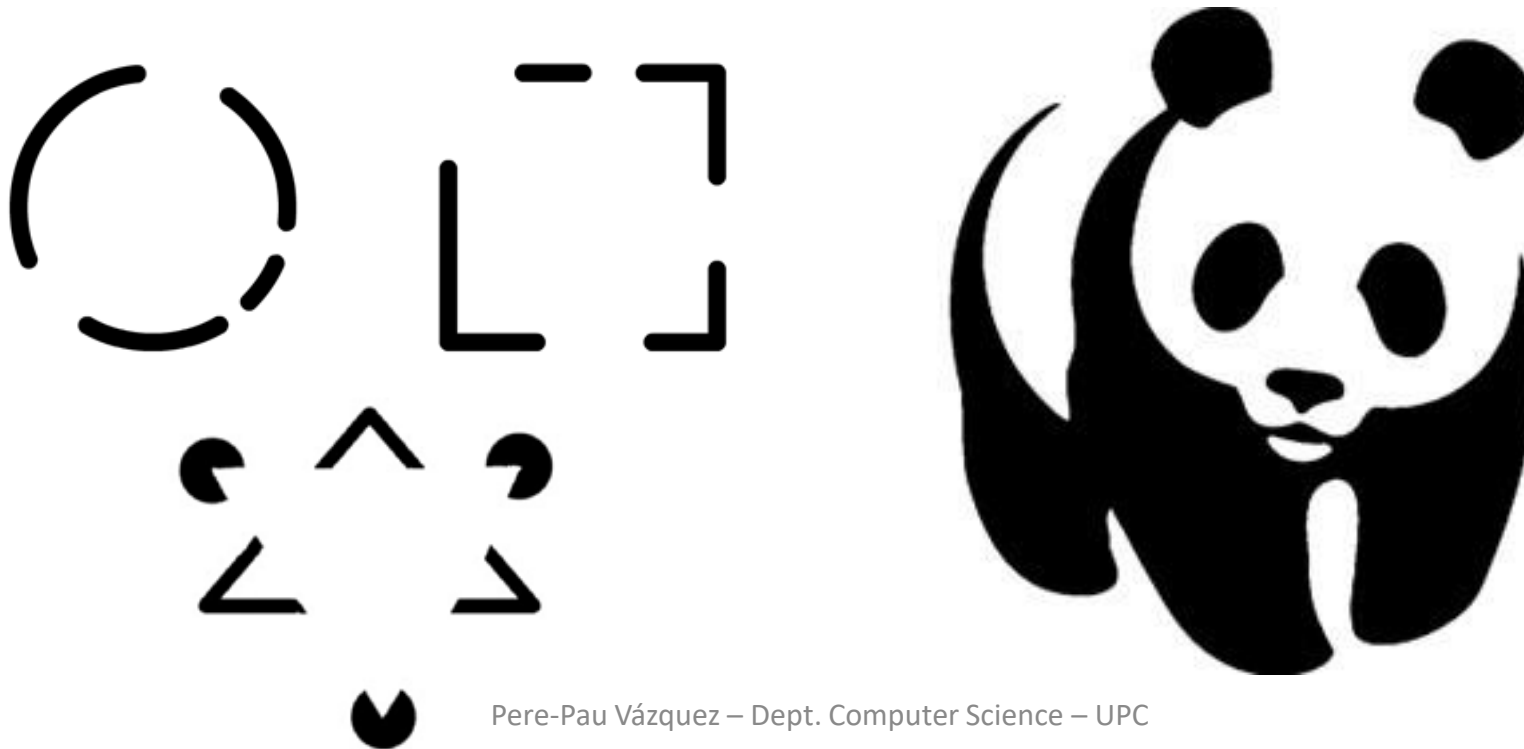
PERCEPTION LAWS IN DESIGN

- Pragnänz Law: Law of good figure, simplicity: We tend to perceive simpler shapes



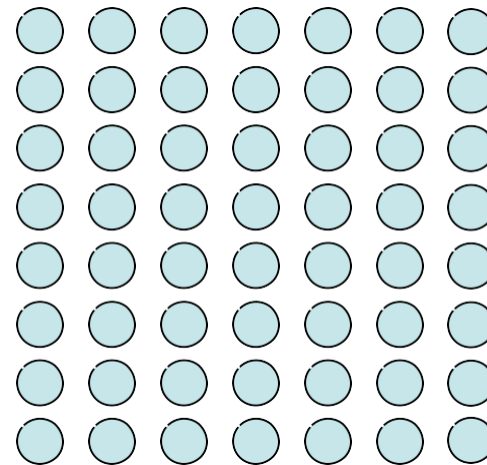
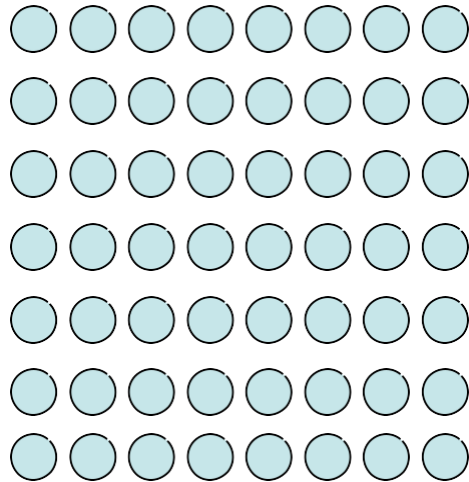
PERCEPTION LAWS IN DESIGN

- The law of closure: The mind may experience elements it does not perceive through sensation, in order to complete a regular figure



PERCEPTION LAWS IN DESIGN

- Grouping by spatial proximity
 - Columns or rows?

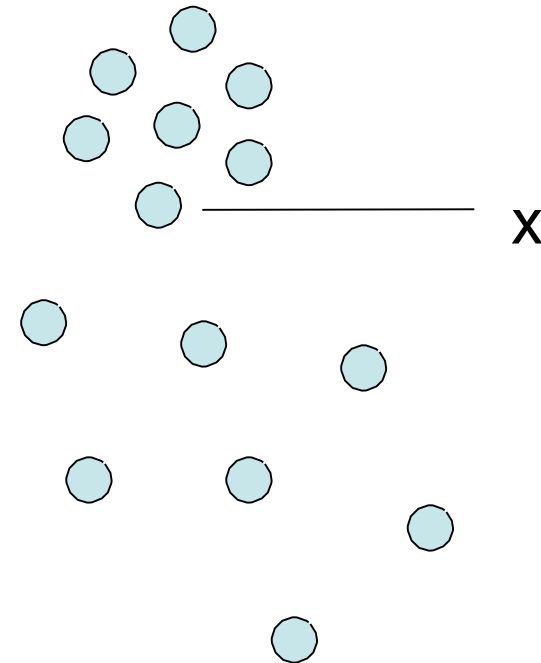


PERCEPTION LAWS IN DESIGN

- Grouping by spatial proximity. Columns or rows?
 - Small difference in spacing causes change in perception
 - Use proximity to emphasize between display items
 - To which group (top / bottom) does the x dot belong? Spacing is equal for both groups!

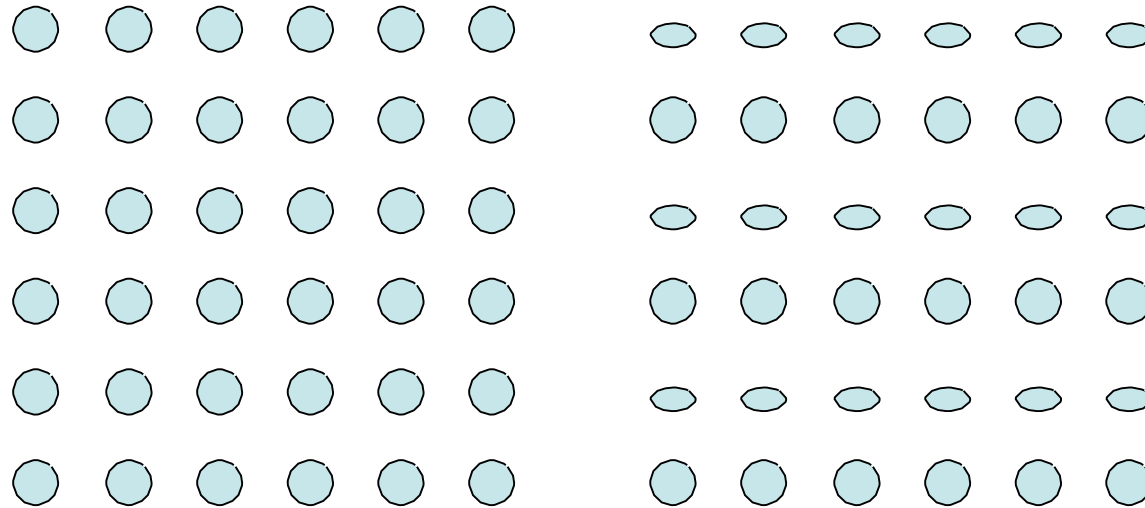
PERCEPTION LAWS IN DESIGN

- Grouping by spatial proximity
 - Spatial concentration principle: we group regions of similar element density (Slocum1983)



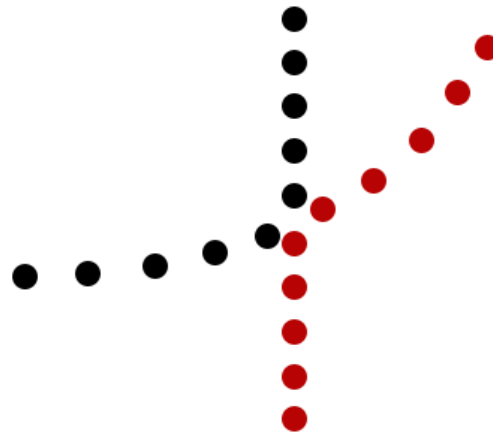
PERCEPTION LAWS IN DESIGN

- Similarity
 - Rows or columns?
 - Similar elements tend to be grouped together



PERCEPTION LAWS IN DESIGN

- The law of continuity: The mind continues visual, auditory, and kinetic patterns.
 - Elements on a line/curve may be perceived as more related than elements not on the line/curve.



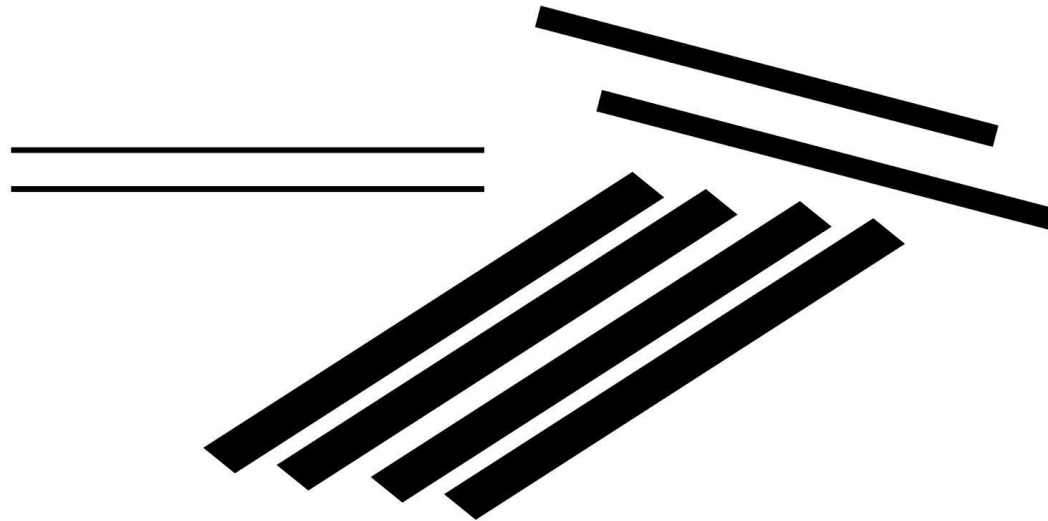
PERCEPTION LAWS IN DESIGN

- The law of common fate: Elements with the same moving direction are perceived as a collective or unit.



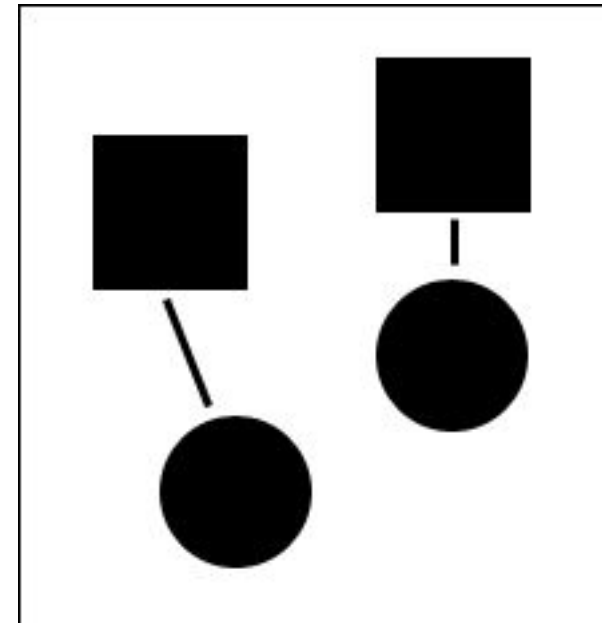
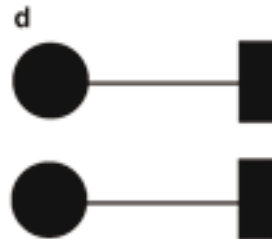
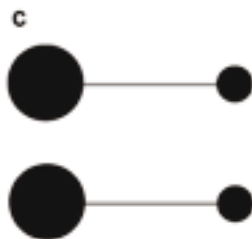
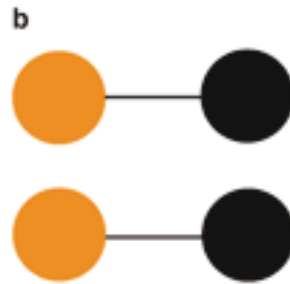
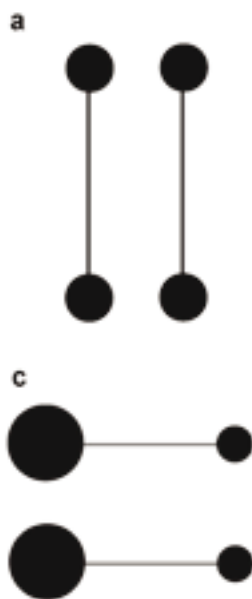
PERCEPTION LAWS IN DESIGN

- Principle of parallelism: Parallel elements tend to be perceived as a group
 - Similar to principle of common fate since elements are seen as pointing in the same direction



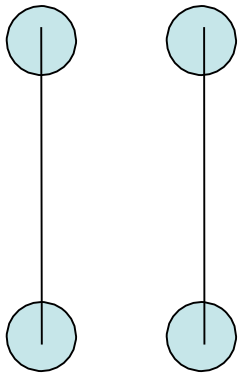
PERCEPTION LAWS IN DESIGN

- Principle of connectedness
 - Elements being visually connected are perceived as more related than unconnected elements

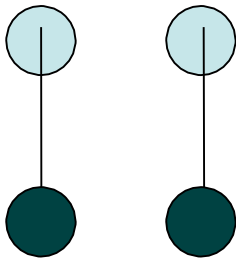


PERCEPTION LAWS IN DESIGN

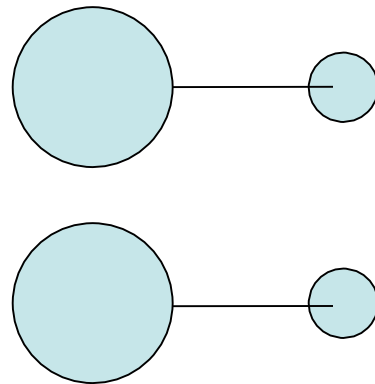
- Connectedness
 - Palmer & Rock 1994
 - Potentially more powerful organizing principle than proximity, color, size, shape



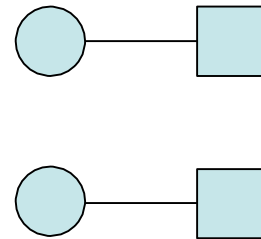
proximity



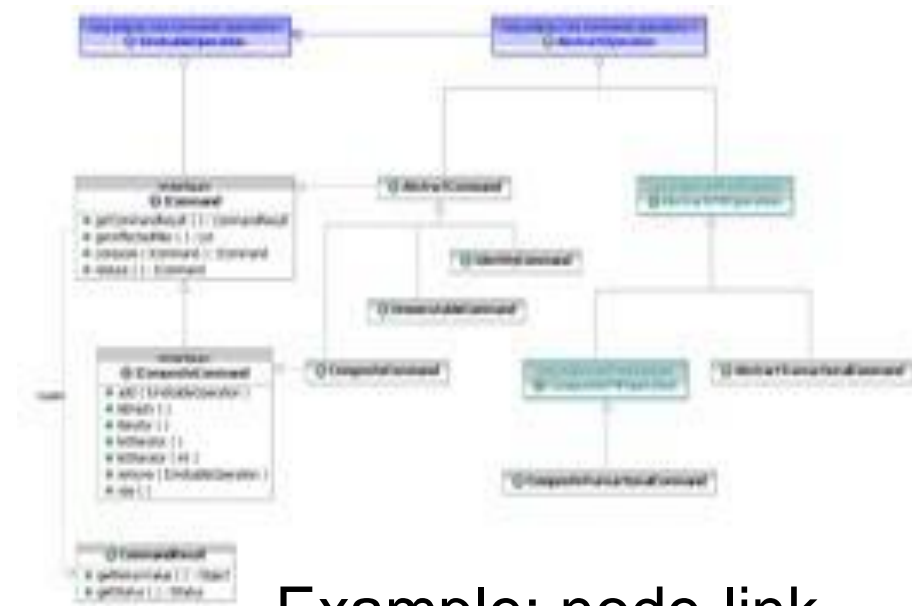
color



size



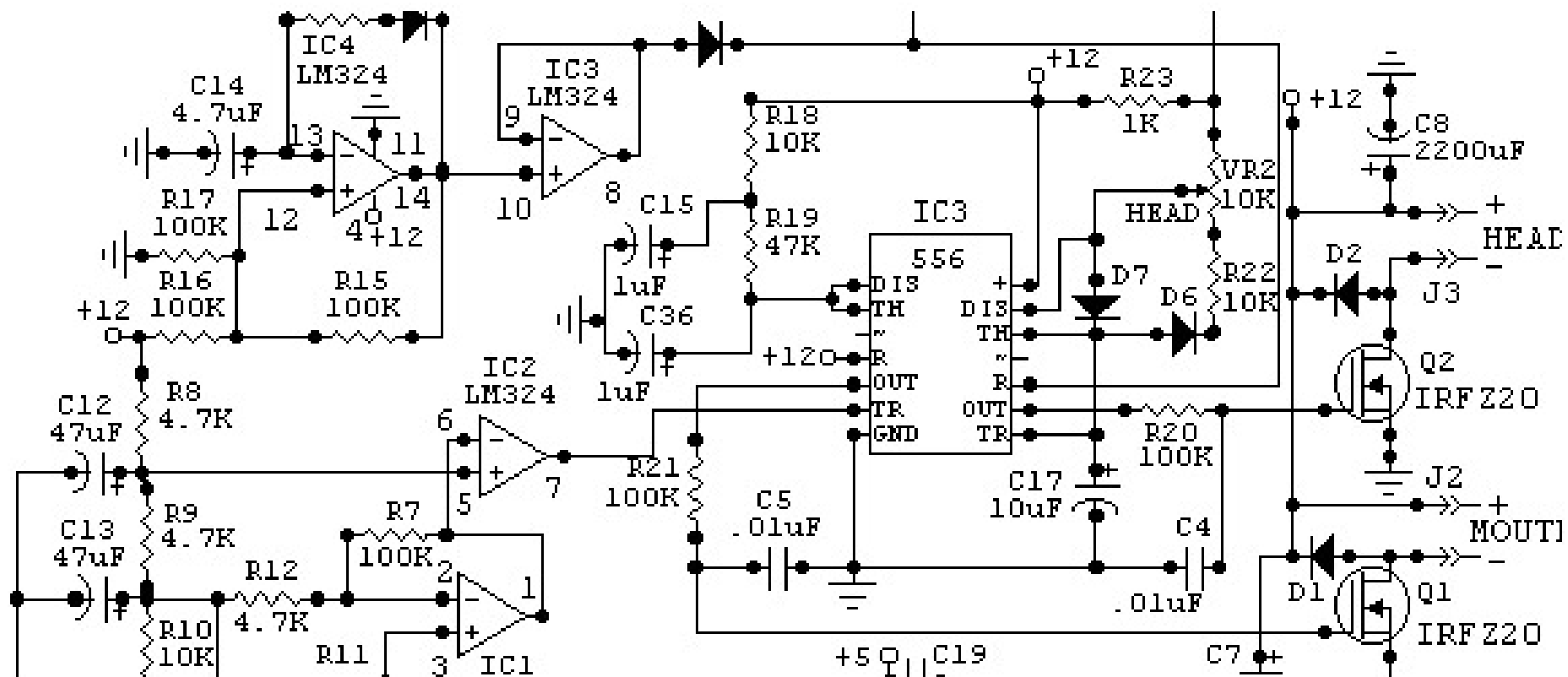
shape



Example: node-link
diagram

PERCEPTION LAWS IN DESIGN

- Connectedness & continuity, example:
 - Circuit design – understanding how components are connected



PERCEPTION LAWS IN DESIGN

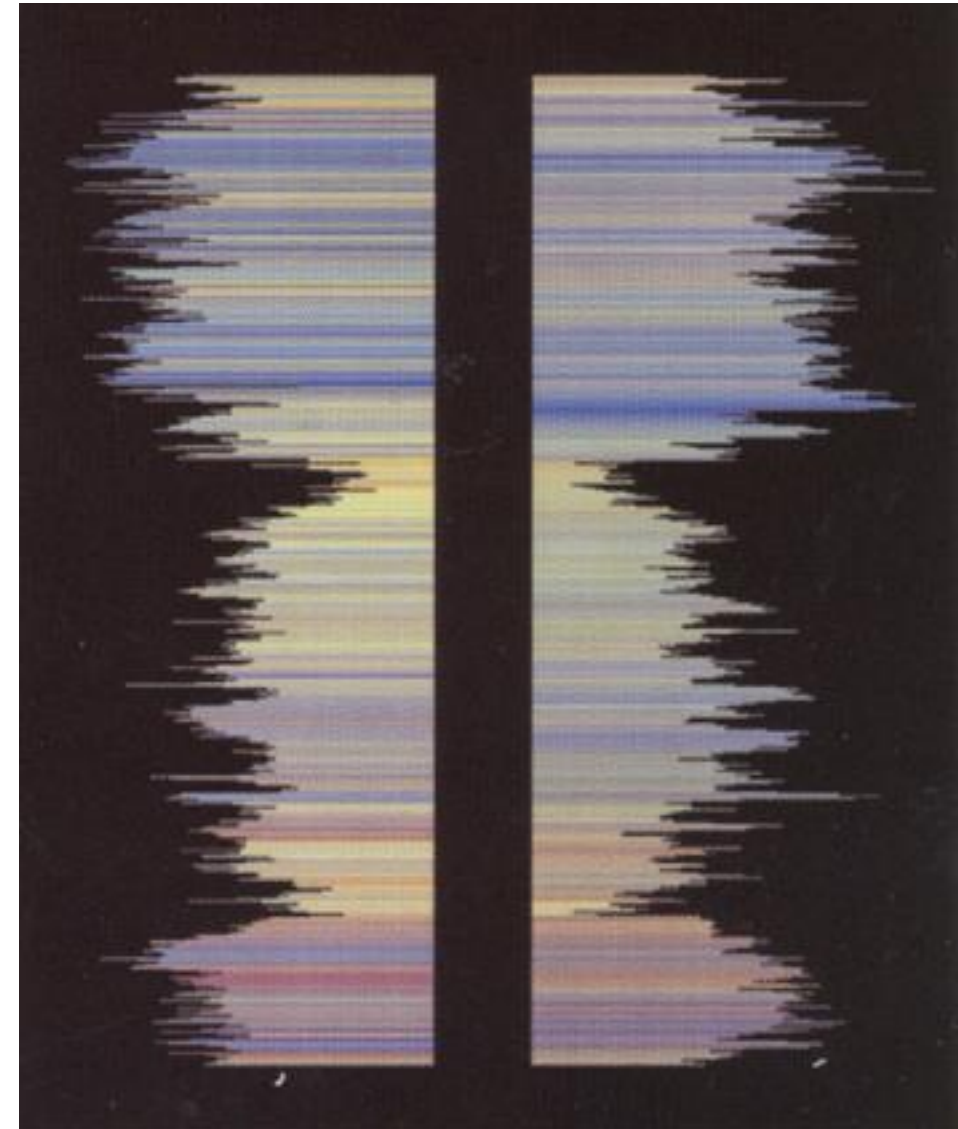
- The law of symmetry: Symmetrical images are perceived collectively, even in spite of distance.



PERCEPTION LAWS IN DESIGN

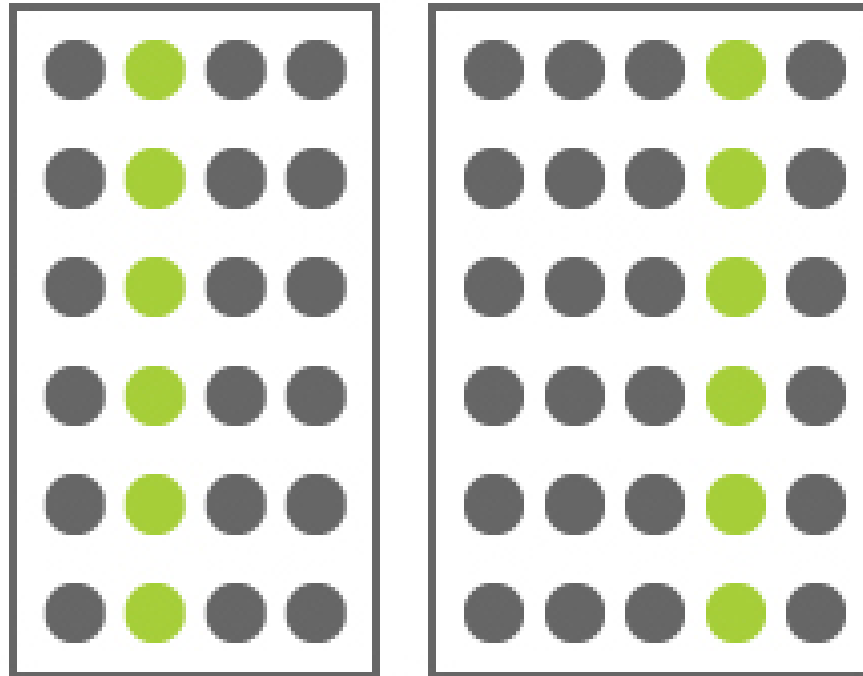
- Symmetry
 - Example of how symmetry detection may be exploited for visual data mining
 - Support the search for similar patterns in time-series plots (measurements of deep ocean drilling cores)

From Ware, 2001



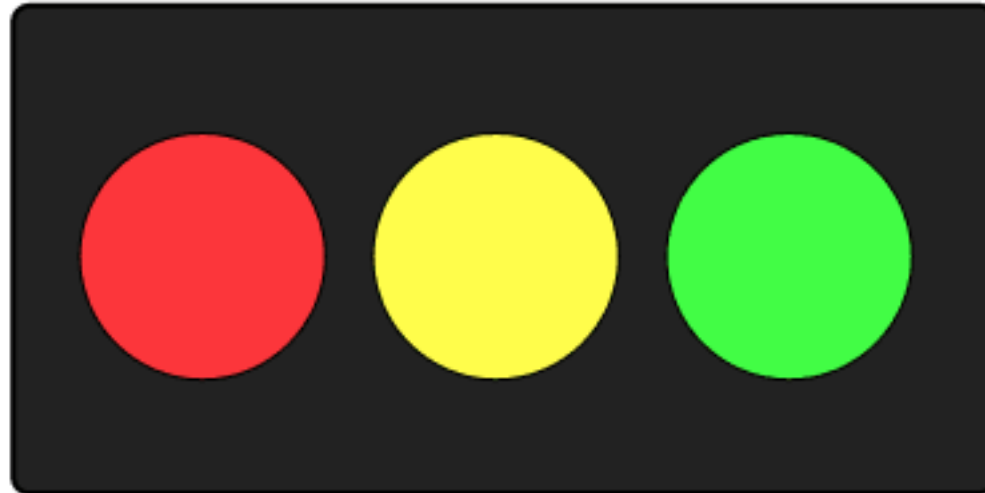
PERCEPTION LAWS IN DESIGN

- Principle of common region: Elements located in the same closed region are perceived as a group (*containment*)



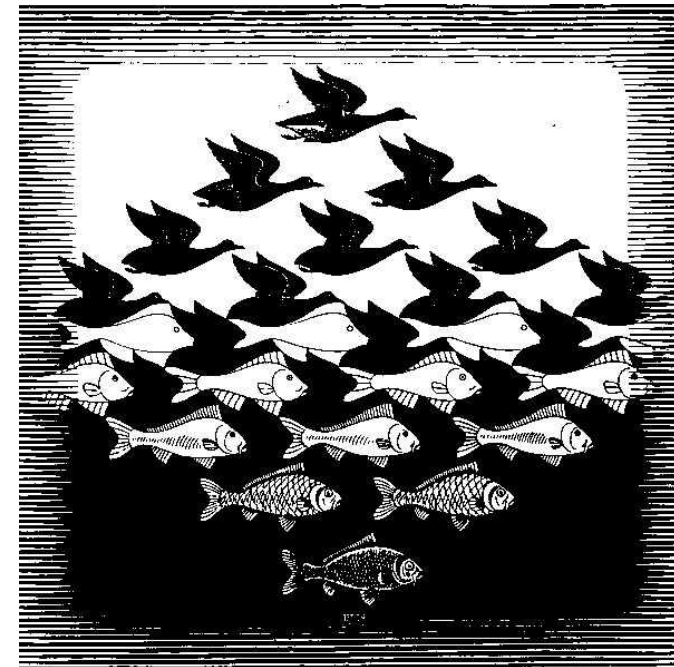
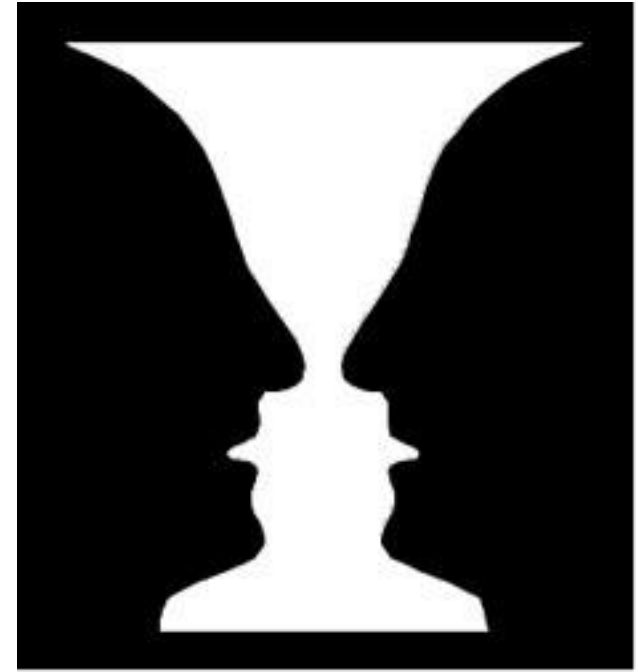
PERCEPTION LAWS IN DESIGN

- Principle of past experience: People's experience influences their perception
 - Experience is unique to the individual but some experiences are shared, e.g., in a cultural circle



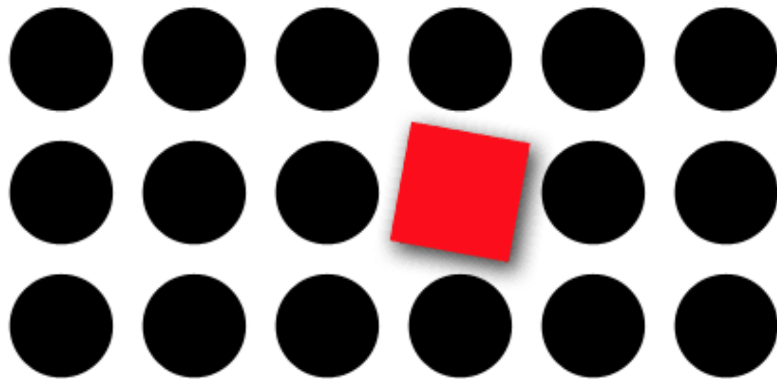
PERCEPTION LAWS IN DESIGN

- We tend to divide scenes in figure & ground
 - Figure: something object-like that is perceived being in the foreground
 - Ground: whatever lies behind the figure
- Fundamental perceptual act of identifying objects
- All Gestalt laws contribute, e.g., closed contour, symmetry, area (e.g., larger elements -> background)
- Equally balanced cues for figure and ground can result in bistable perception



PERCEPTION LAWS IN DESIGN

- Principle of focal point: Among elements, a point of interest, emphasis, or difference will capture the viewer's attention
 - Serve as an entry point into visualization





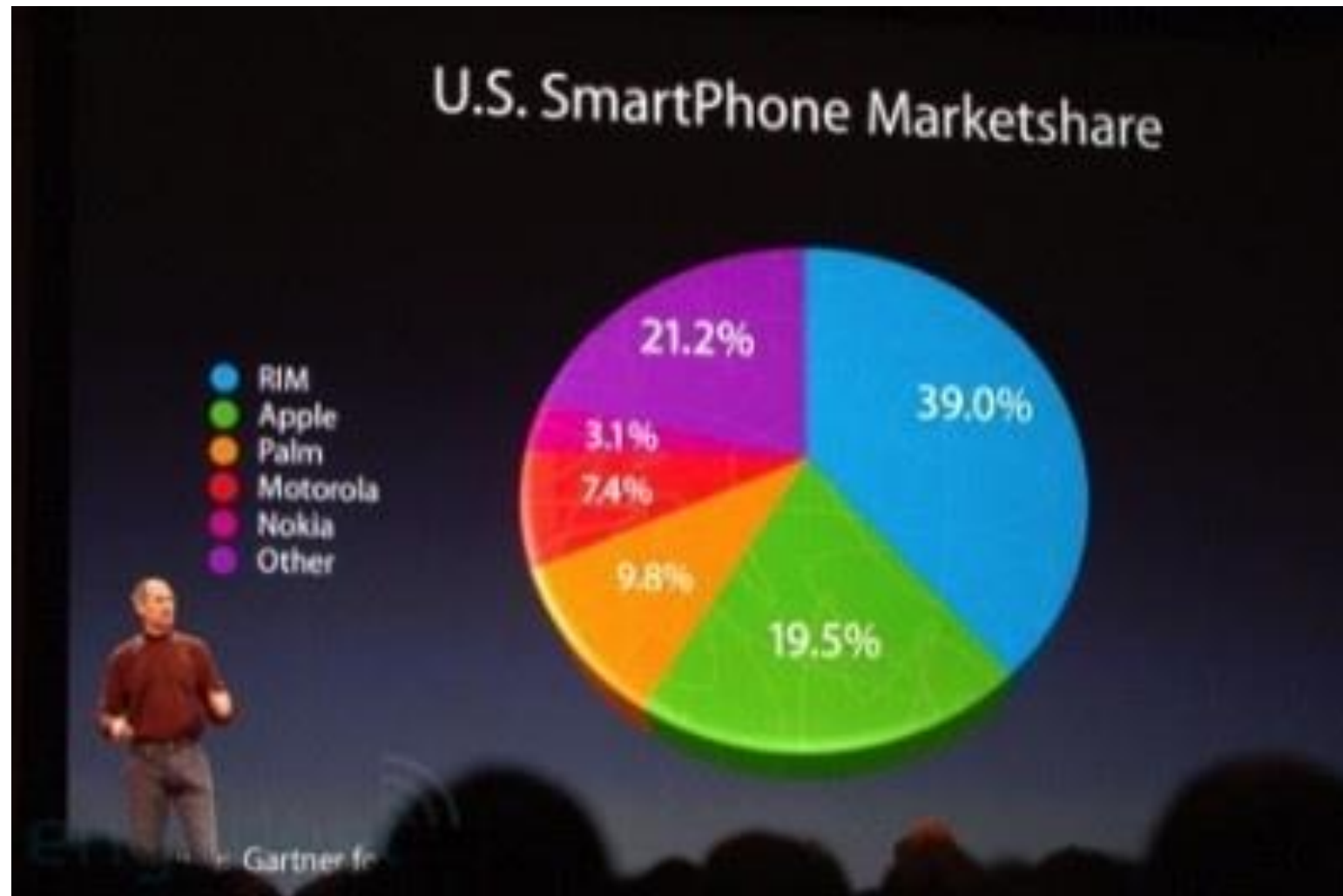
EXERCISES

PERE-PAU VÁZQUEZ – VIRVIG GROUP – UPC

EXERCISES

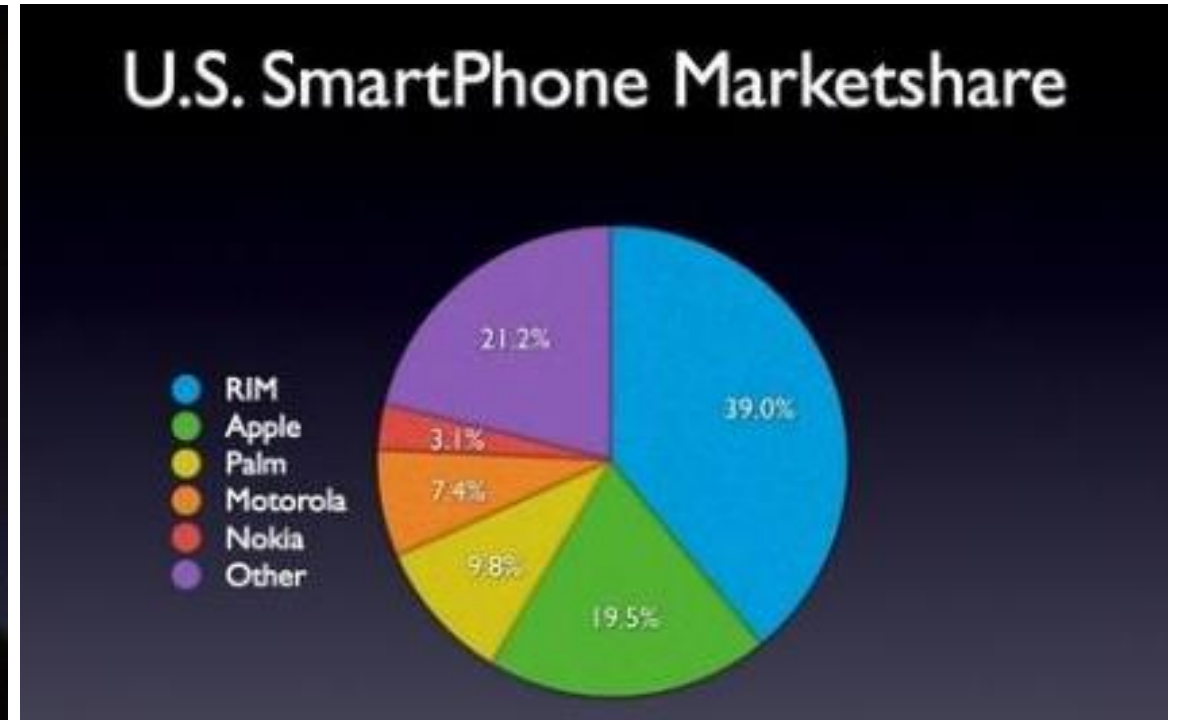
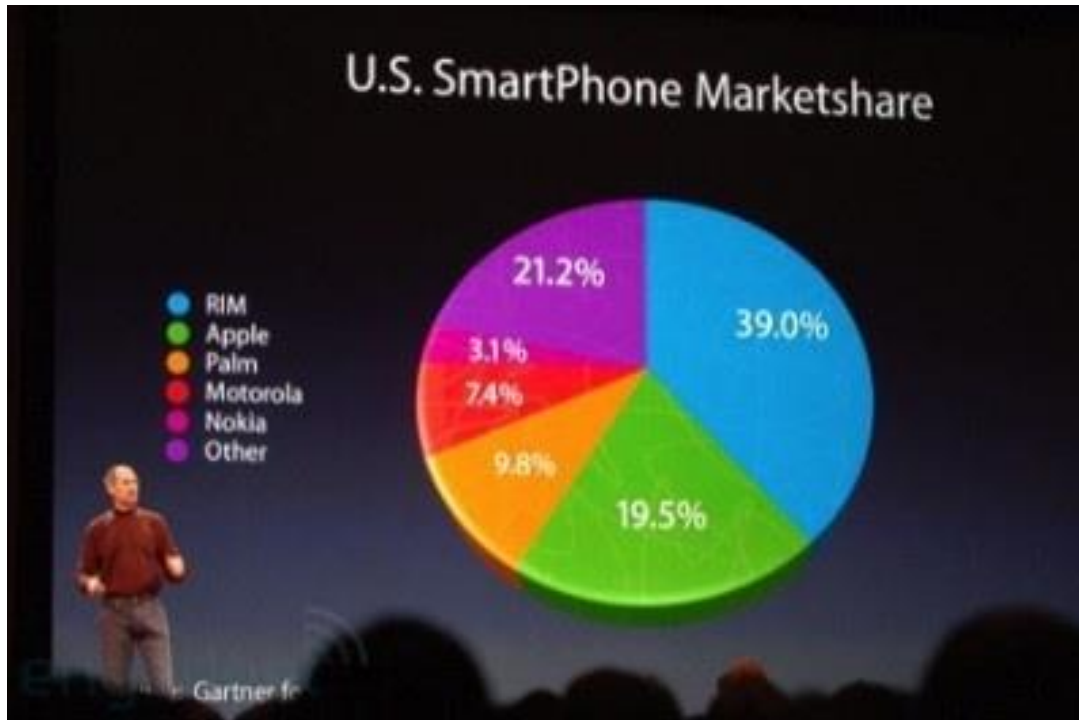
- How to approach the following exercises
 - What do you think is the main point or piece of information this visualization is trying to convey?
 - What elements of the visualization are used to communicate the information that is being conveyed?
 - Are they effective?
 - Are there distractors?
 - Would you change elements to make the meaning clearer?
 - Which ones?
 - How?

EXERCISES



EXERCISES

- Data distortion

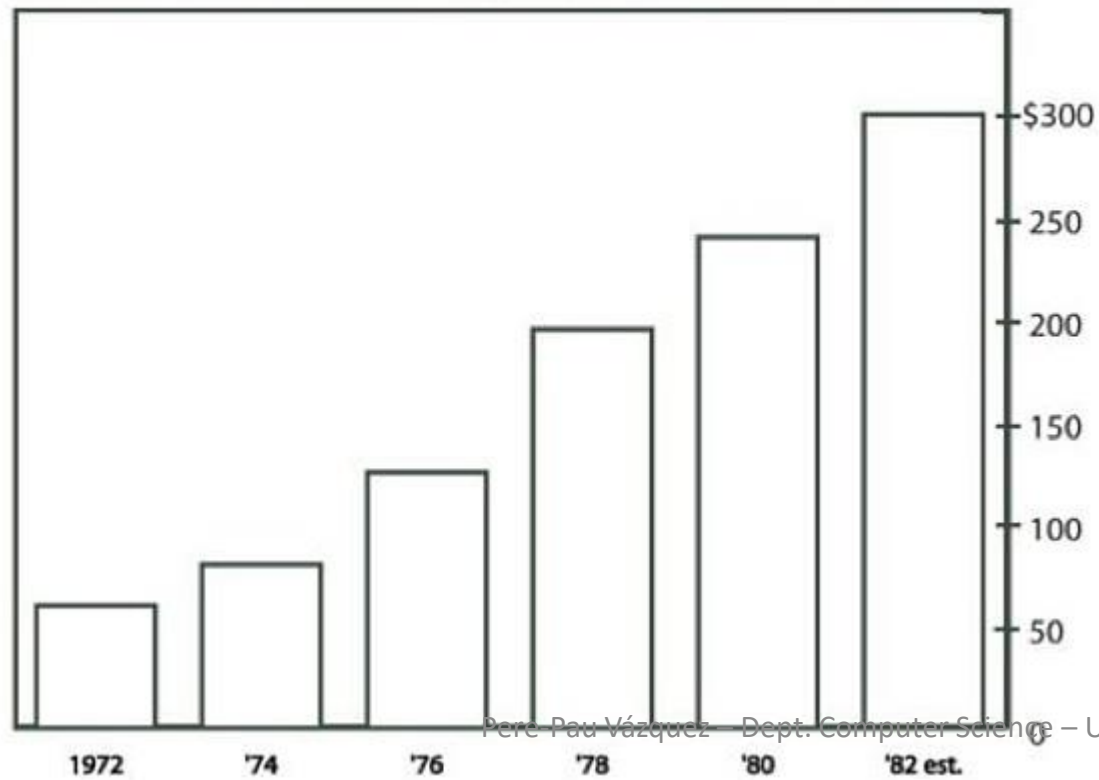


EXERCISES



EXERCISES

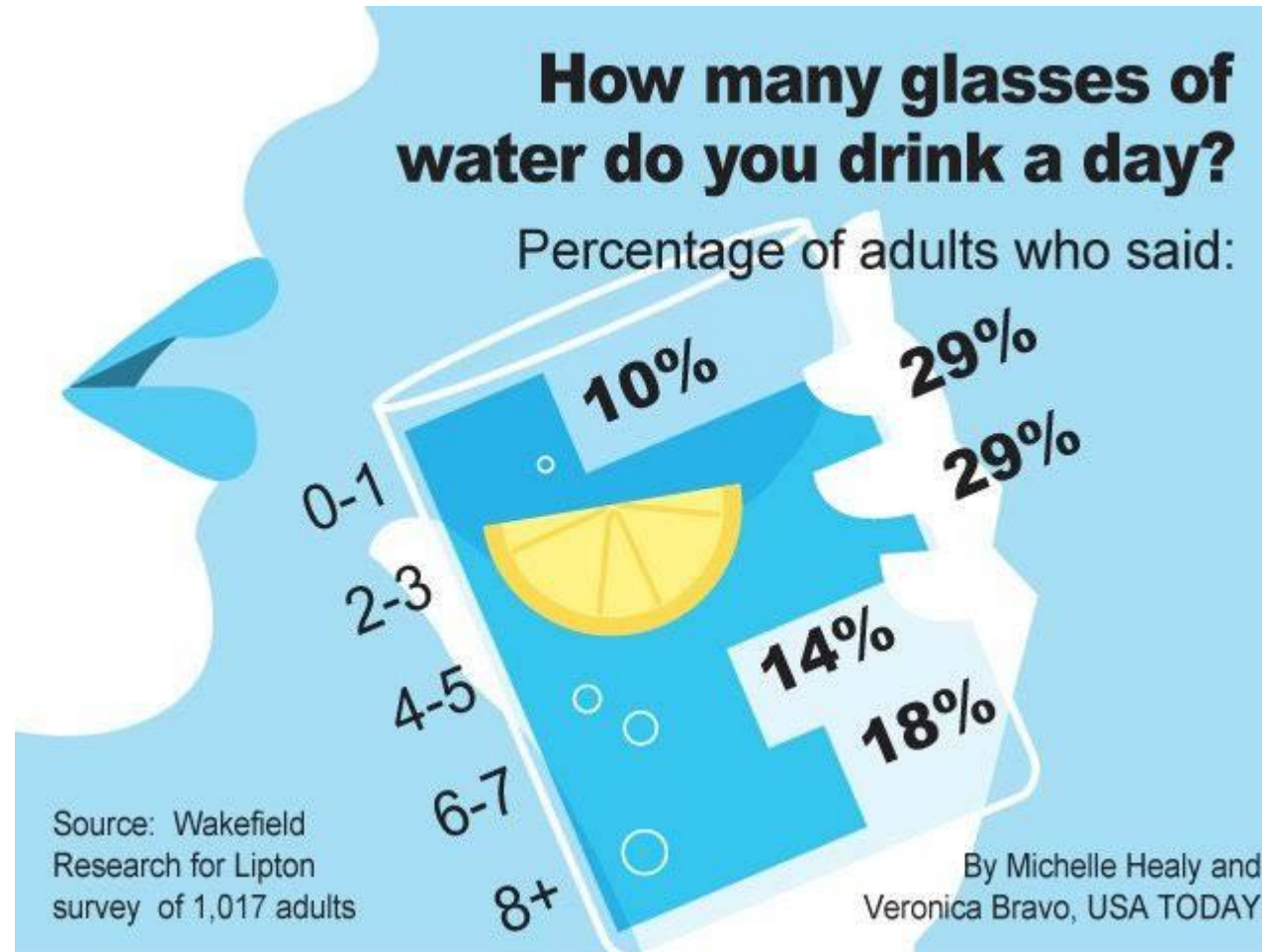
MONSTROUS COSTS
Total House and Senate campaign expenditures, in millions



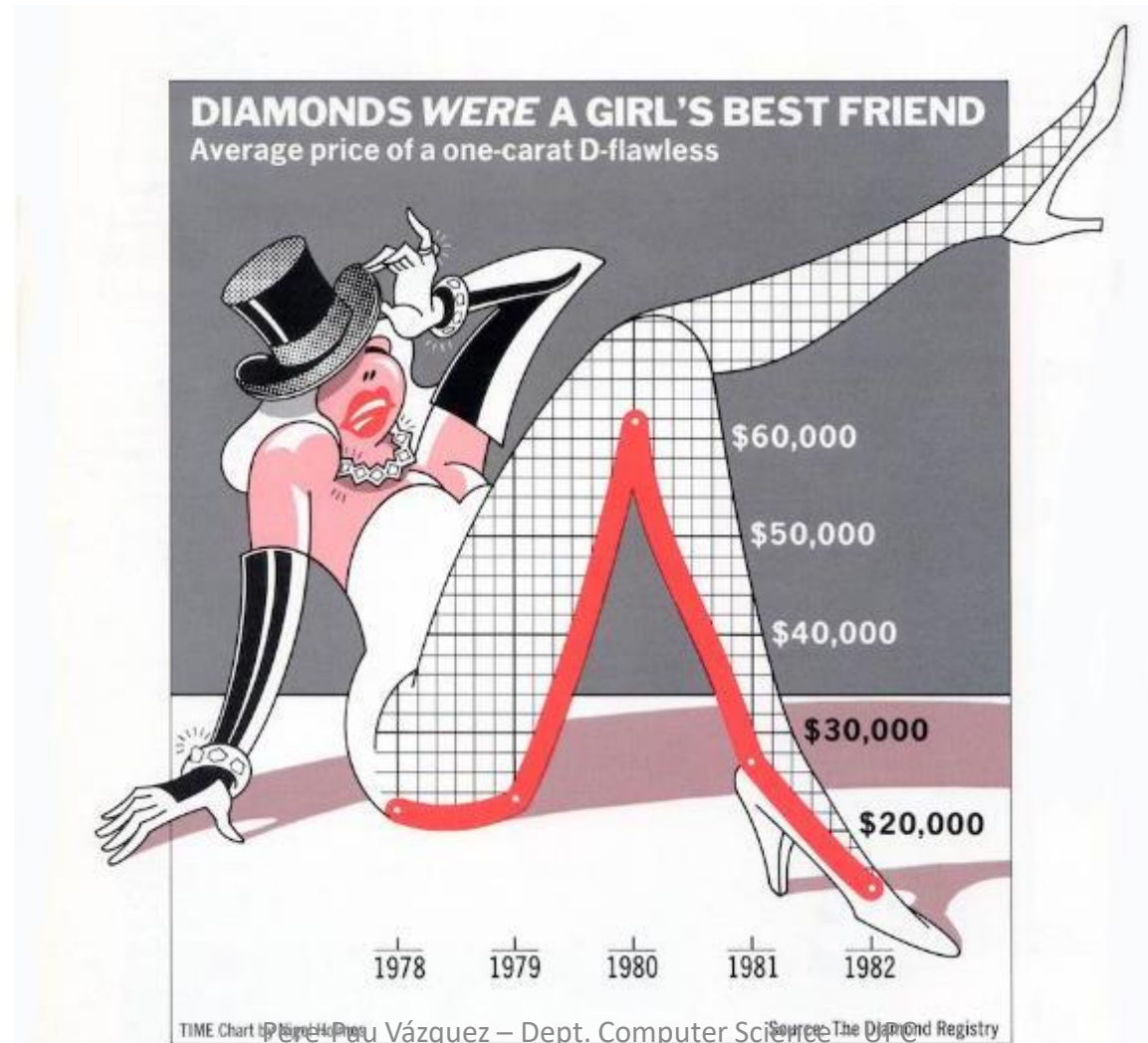
Pere Pau Vázquez Dept. Computer Science – UPC



EXERCISES



EXERCISES



EXERCISES

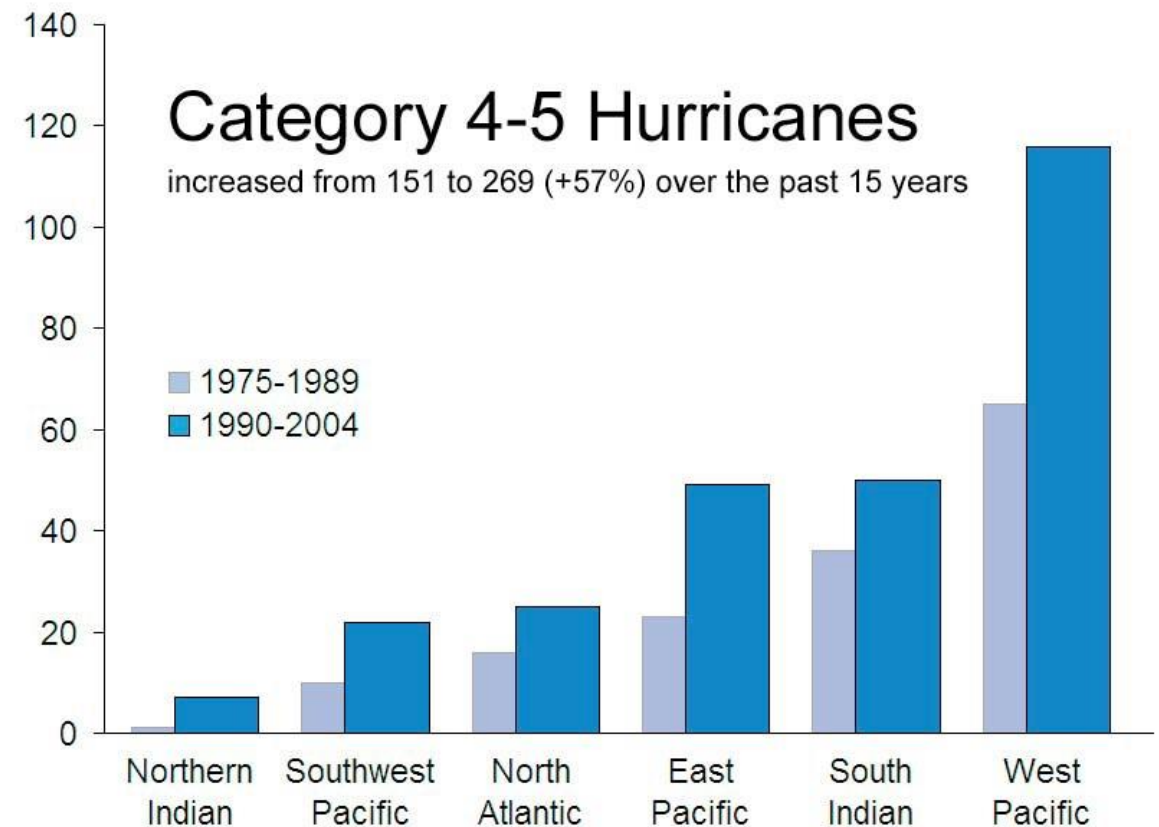
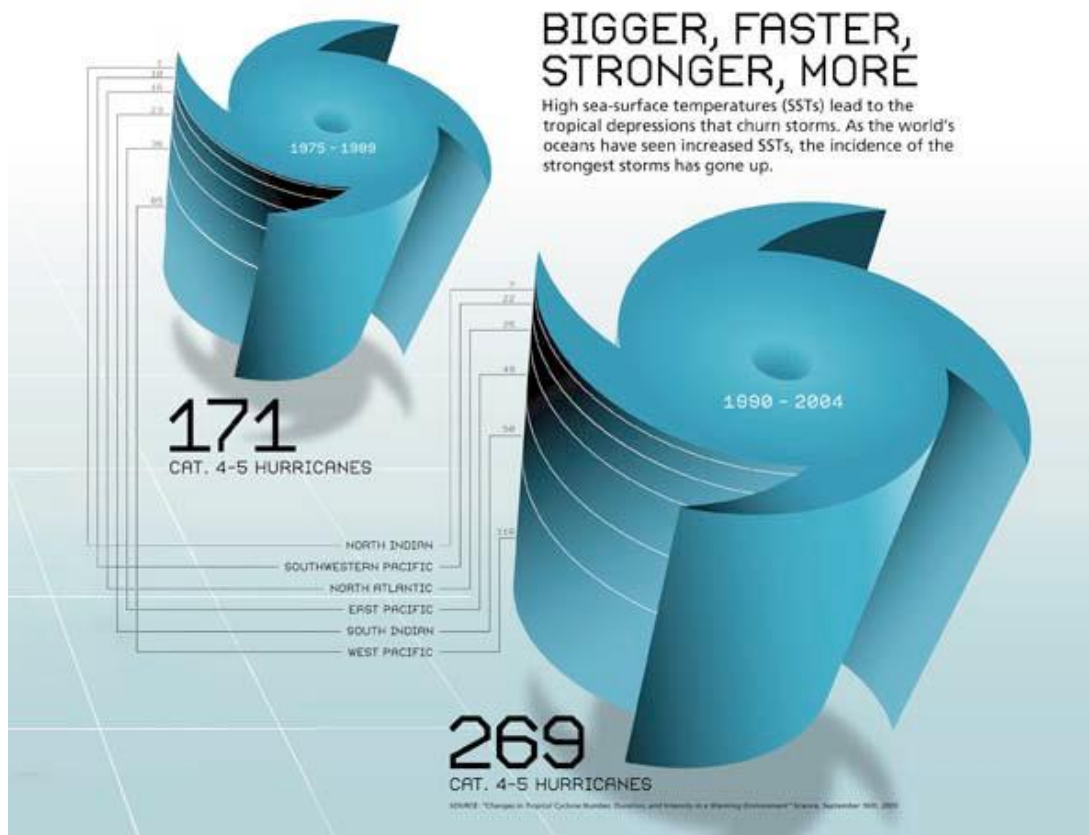


EXERCISES



EXERCISES

- Example:



EXERCISES

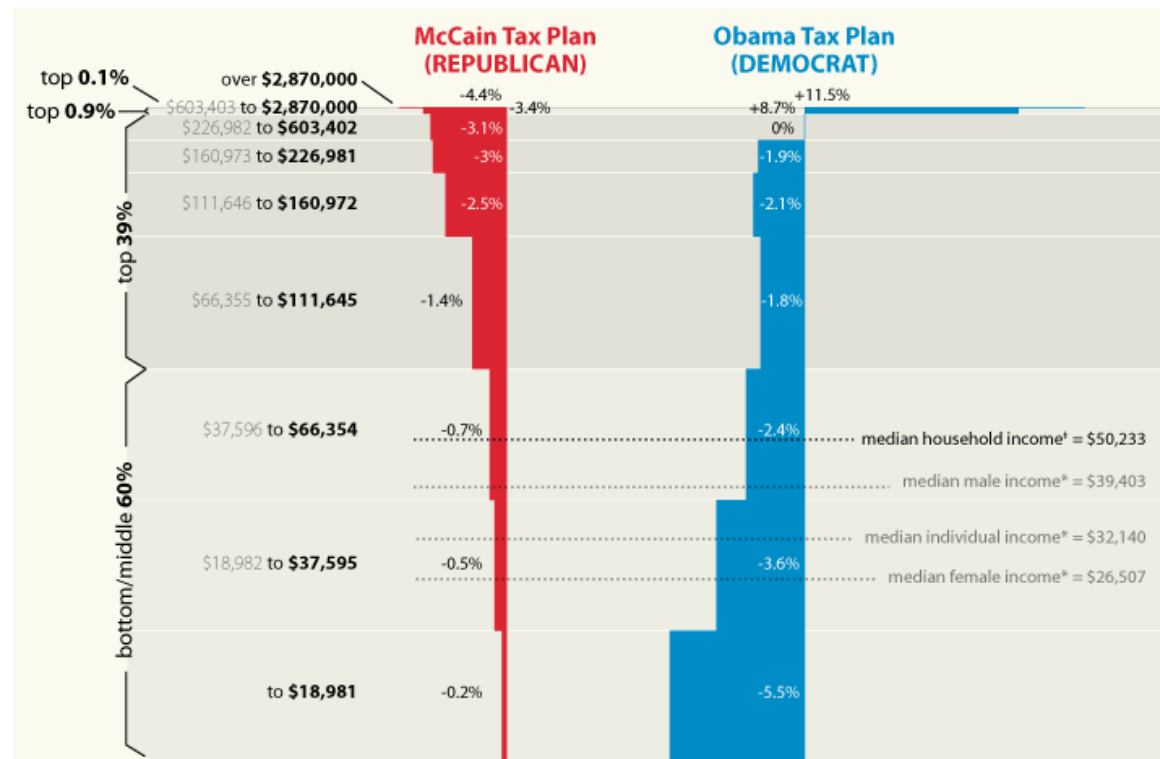
Average percentage change in after-tax income in 2009					
FAMILY INCOME In 2008 dollars	McCAIN		OBAMA		AVERAGE CHANGE IN TAXES
	TAX DECREASE	AVERAGE CHANGE IN TAXES	TAX DECREASE	TAX INCREASE	
Above \$2.87 million (Top 0.1%)	-4.4%	-\$269,364		+11.5%	+\$701,885
\$603,403 to \$2.87 million (Top 1%)	-3.4	-\$45,361		+8.7	+\$115,974
\$226,982 to \$603,402	-3.1	-\$7,871	0		-\$12
\$160,973 to \$226,981	-3	-\$4,380	-1.9		-\$2,789
\$111,646 to \$160,972	-2.5	-\$2,614	-2.1		-\$2,204
\$66,355 to \$111,645	-1.4	-\$1,009	-1.8		-\$1,290
\$37,596 to \$66,354	-0.7	-\$319	-2.4		-\$1,042
\$18,982 to \$37,595	-0.5	-\$113	-3.6		-\$892
Up to \$18,981	-0.2	-\$19	-5.5		-\$567
Average cut:	-2%	-\$1,195	-0.3%		-\$160

Bottom three
groups amount
to 60% of
taxpayers

EXERCISES

- Corrected version

FAMILY INCOME In 2008 dollars	McCAIN		OBAMA	
	AVERAGE CHANGE IN TAXES	AVERAGE CHANGE IN TAXES	AVERAGE CHANGE IN TAXES	AVERAGE CHANGE IN TAXES
Above \$2.87 million (Top 0.1%)	-4.4%	-\$269,364	+11.5%	+\$701,885
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\$18,982 to \$37,595	-0.5%	-\$113	-3.6%	-\$892
Up to \$18,981	-0.2%	-\$19	-5.5%	-\$567
Average cut:	-2%	-\$1,195	-0.3%	-\$160



Tax Plan data from Washington Post reporting of Tax Policy Center analysis.
 Redrawn to scale with height of bars corresponding to population of each group,
 as given in original TPC data.

*Income for individuals age 25 or older with earnings.
 2005 FY Data from US Census Bureau, 2006 via
http://en.wikipedia.org/wiki/Demographics_of_the_United_States

† US Census Bureau, Aug. 2008 press release

http://www.census.gov/Press-Release/www/releases/archives/income_wealth/012528.html



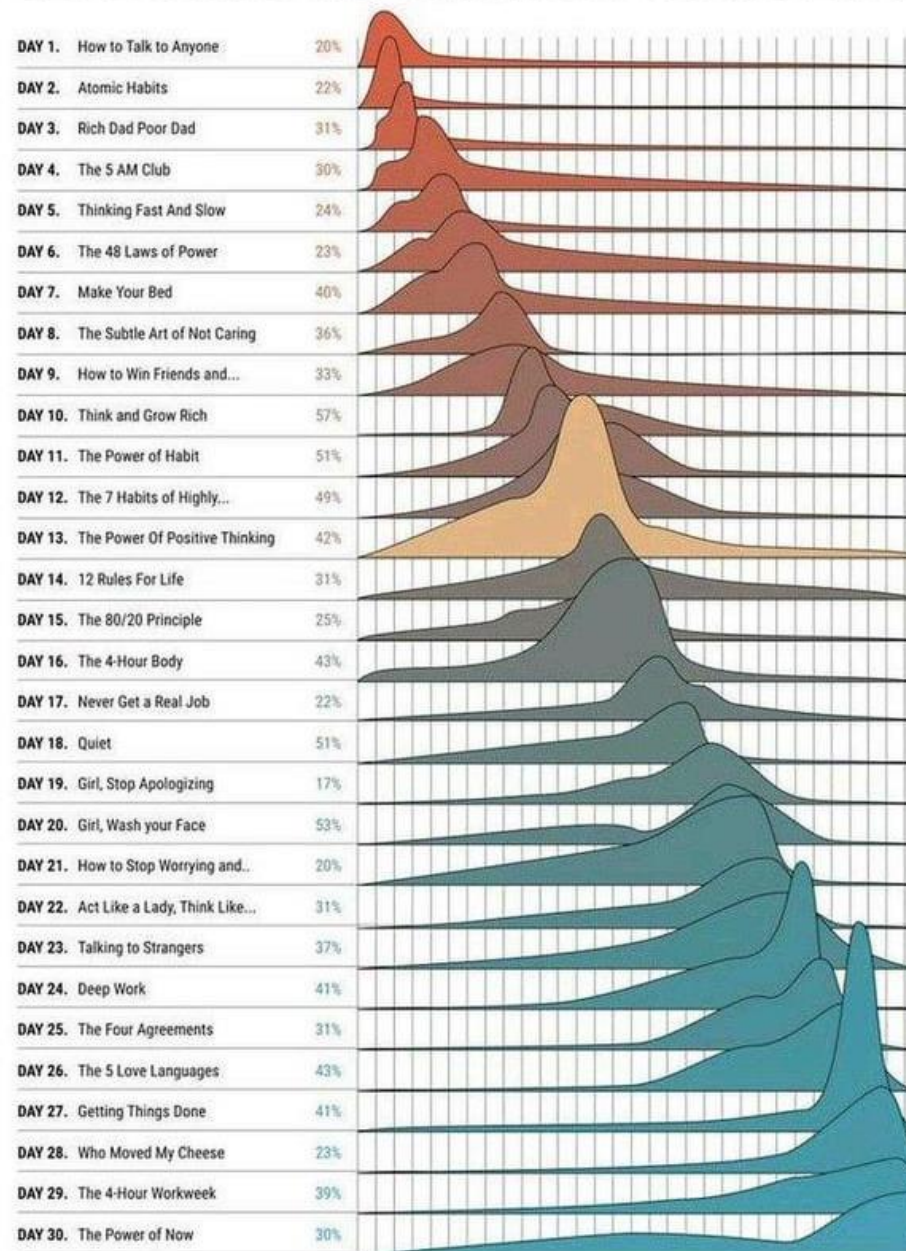
US Presidential Candidates tax plans, redrawn from Washington Post data by Viveka Weiley - <http://chartjunk.karmanaut.com>
Some Rights Reserved: Creative Commons Attribution ShareAlike license: see <http://creativecommons.org/licenses/by-sa/2.5/au/>
 Briefly: you may use and redistribute this image, but must credit me and may not prevent others from sharing it.

EXERCISES



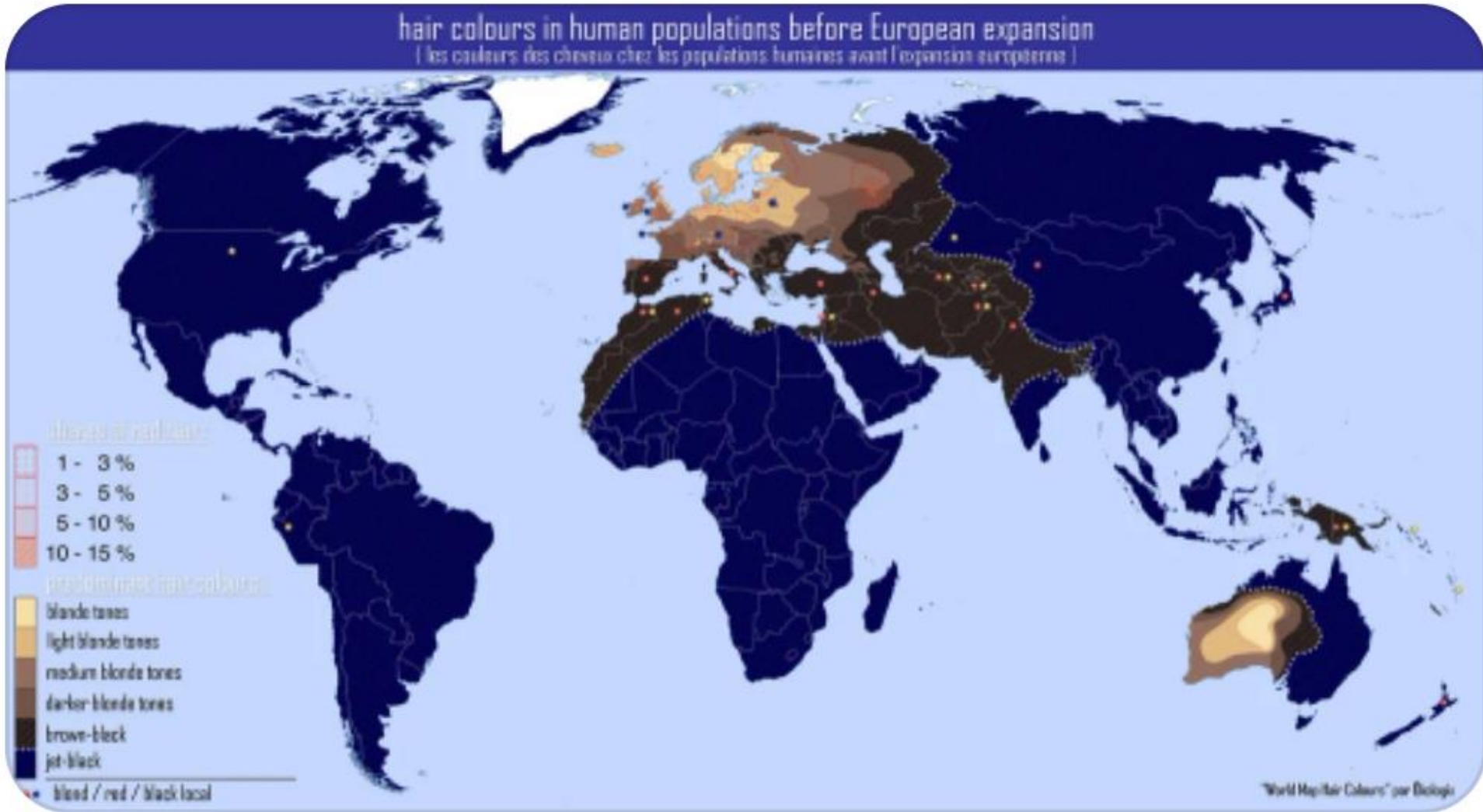
EXERCISES

30 BOOKS TO CHANGE YOUR LIFE



EXE

Hair colours in human populations before European expansion

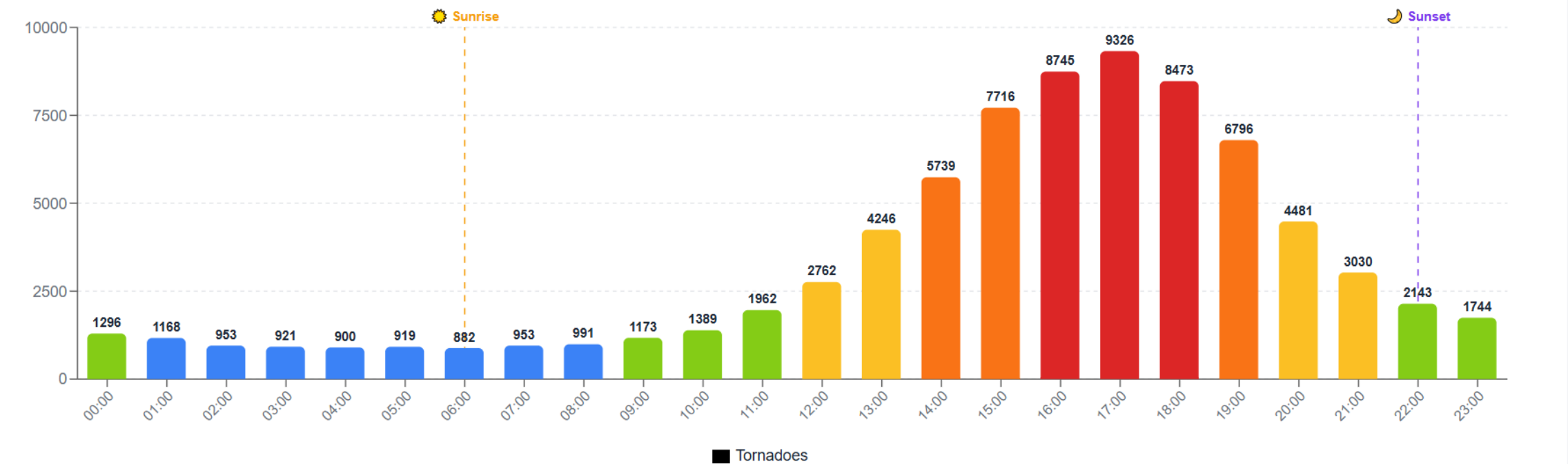


EXERCISES

Time of Day Analysis

Reveals the hourly pattern of tornado occurrence, showing when tornadoes are most likely to strike. Late afternoon and early evening (3-7 PM) are peak tornado hours, while nighttime tornadoes are rare but especially dangerous.

 Times shown as recorded in each tornado's local timezone (mix of ET, CT, MT, PT, etc.).





EXERCISES

PERE-PAU VÁZQUEZ – VIRVIG GROUP – UPC



PERCEPTION IN VIS

PERE-PAU VÁZQUEZ – VIRVIG GROUP – UPC