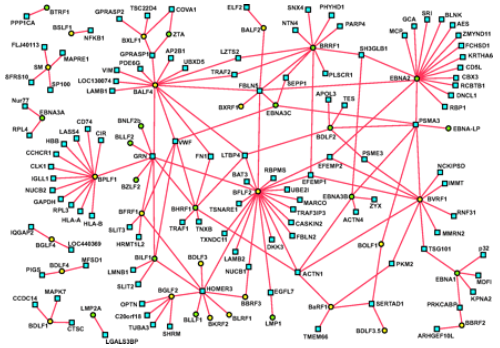
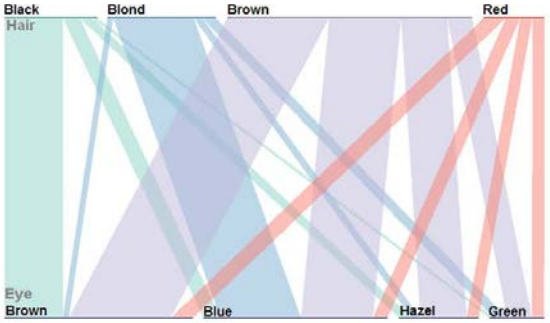
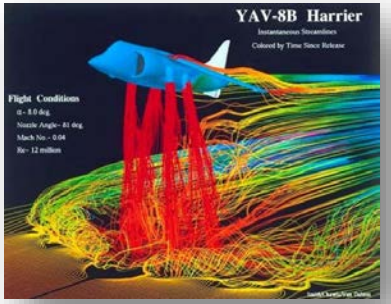






UNIVERSITY OF CALGARY

Data Visualization Tools & Techniques

John Brosz

Research Data & Visualization Coordinator

Renée Reaume

Digital Media & Technical Services Director

http://bit.ly/tfdlvis

Plan for Today

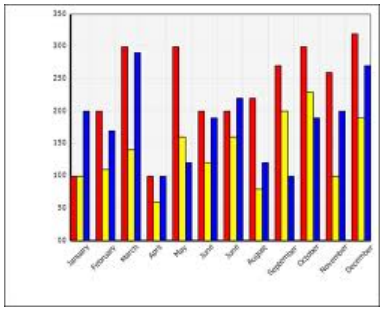
- 9:00 Intro
- 9:30 Visual Variables
- 10:15 Break
- 10:30 Sketching
- 11:30 Vis Software & Tools
- 12:00 Lunch
- 1:00 Tableau
- 2:30 Break
- 3:30 Vis in the Library & Professional Practice
- 4:00 Work with Data

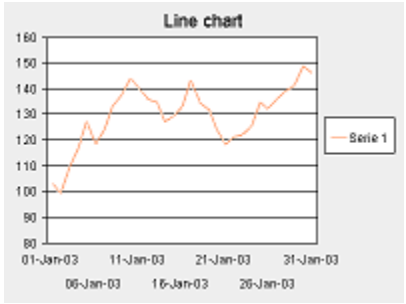
http://bit.ly/tfdlvis

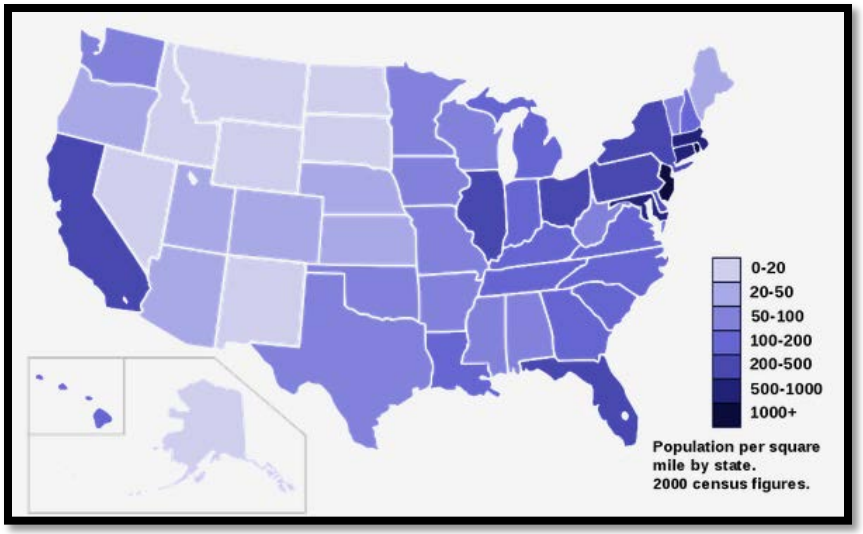
Icebreaker

- Introduce yourself
- Do you have a visualization project?
- What's your goal for the day?

What is Data Visualization?







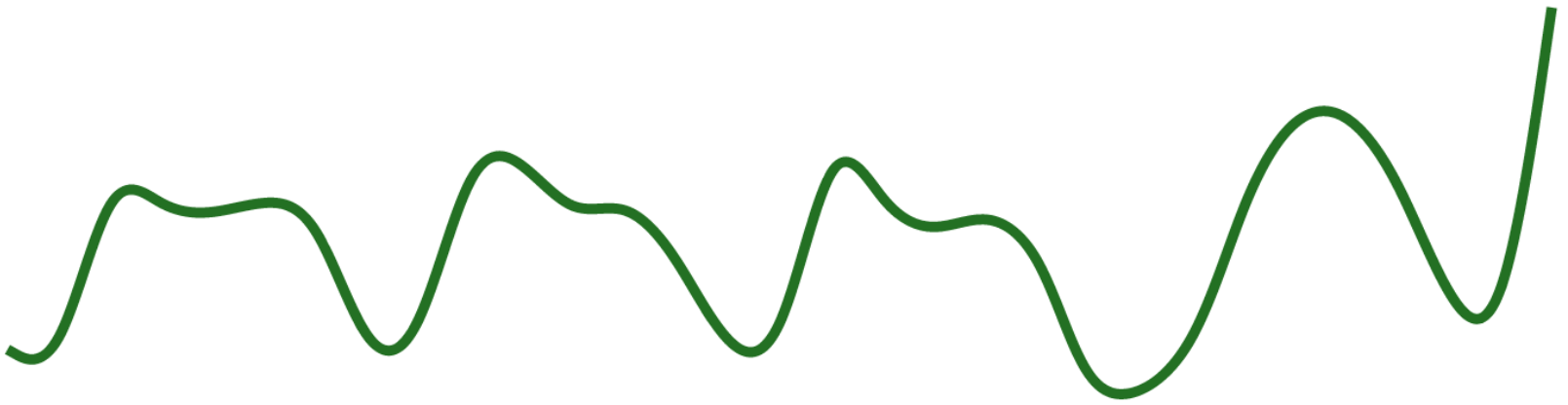
What is Visualization?

- Visual representation of data
- "Transformation of the symbolic into the geometric" [McCormick et al, 1987]
- "… artificial memory that best supports our natural means of perception" [Bertin, 1967]
- "Use of computer-generated, interactive, visual representations of data to amplify cognition" [Card, Mackinlay, & Shneidermann, 1999]

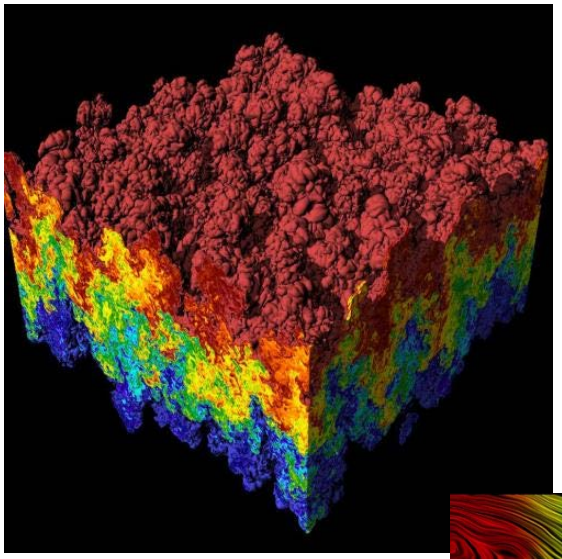
What is Visualization?

1. Based on non-visual data
2. Produce an image
3. Result must be readable and recognizable

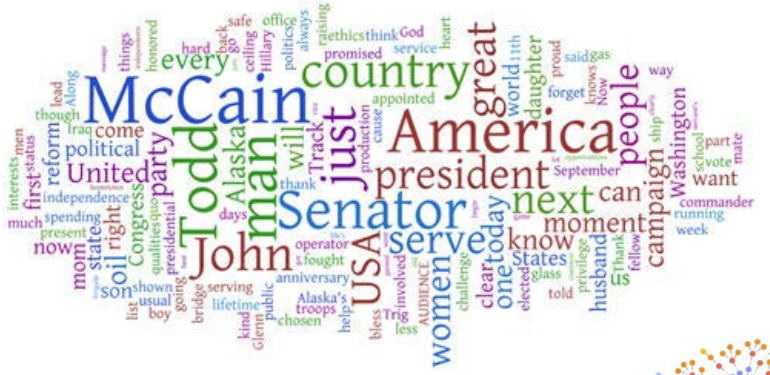
Robert Kosara



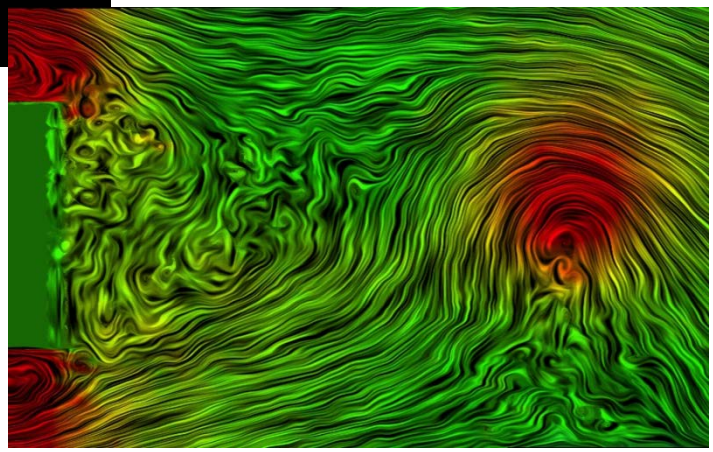
Scientific Visualization & Information Visualization



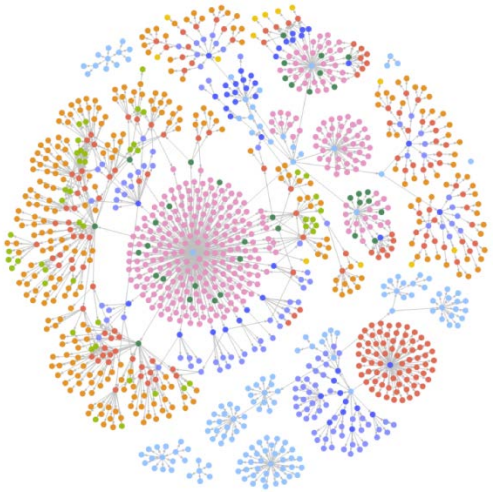
http://wikimedia.org/wikipedia/commons/5/54/Rayleigh-Taylor_instability.jpg



http://rossdawsonblog.com/palin_manyeyes.jpg

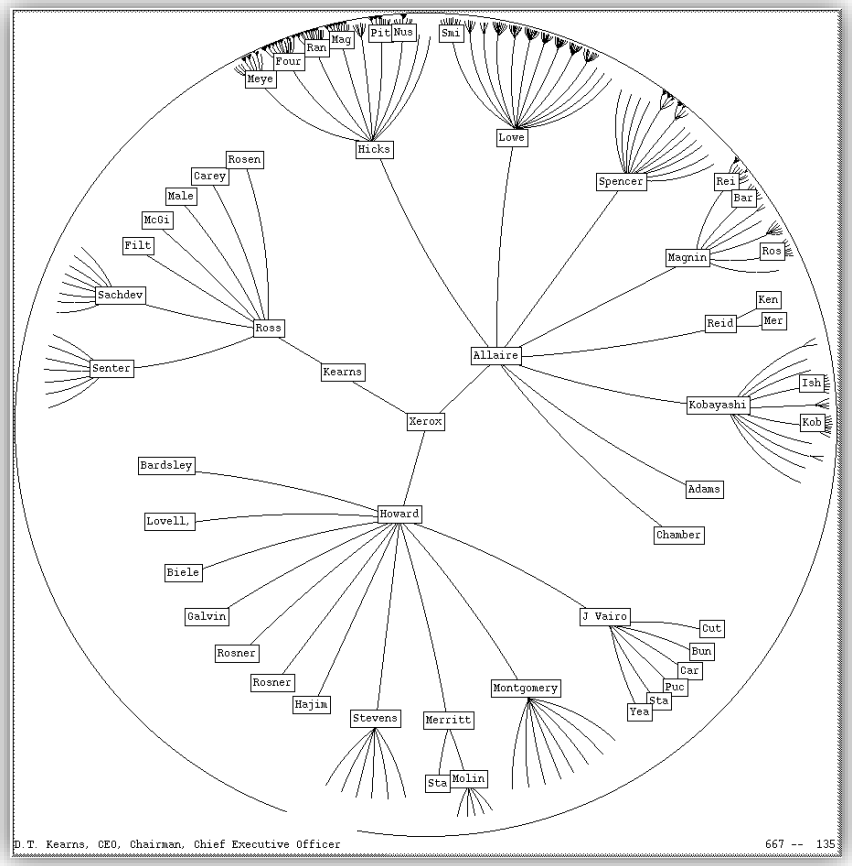


http://tutor.rascal-mpl.org/Rascalopedia/Visualization/flow.png



http://slrohall.files.wordpress.com/2013/08/risk.png

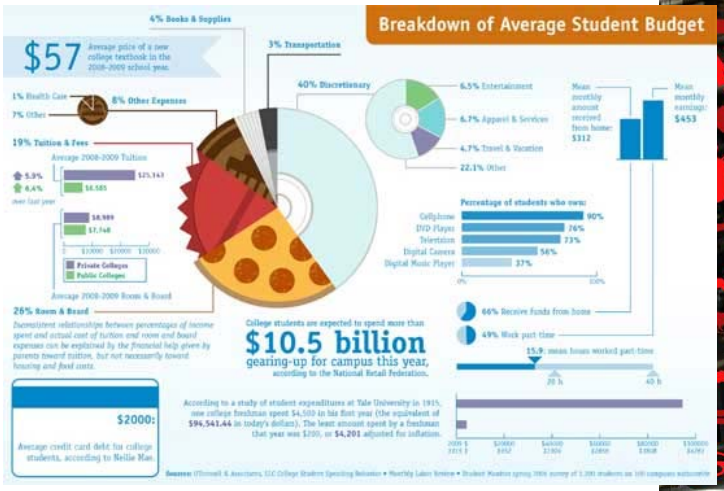
InfoGraphics vs Visualization

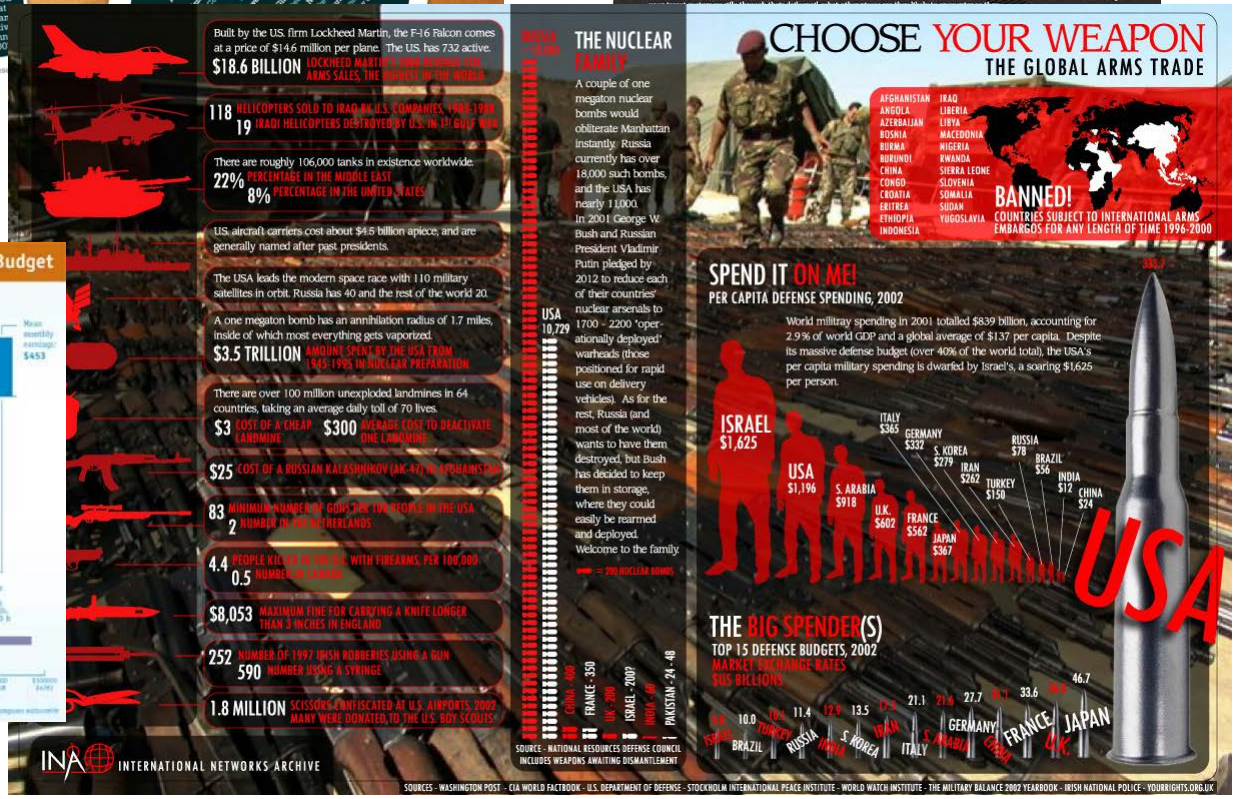


A **visualization** can be applied to many datasets;
an **infographic** is created for a particular dataset.

The Best Beer in America
Top Beers
Top Breweries
Legend
Most
Medals
Least
Data based on Great American Beer Festival medal winners 1987-2007
Map By: Mike Wirth - The Beer Geek © 2008. All Rights Reserved
lyke3drink.blogspot.com

95.9 BILLION First-Class Mail®
103.5 BILLION Standard Mail® & Periodicals
What's in the Customer's Mailstream?
Reporting by Paula Andruss, Illustration by Jude Buffum


Breakdown of Average Student Budget
$57
$10.5 billion
$2000:


$18.6 BILLION LOCKHEED MARTIN'S 2008 GLOBAL ARMS SALES, THE BIGGEST IN THE WORLD
118 HELICOPTERS SOLD TO IRAQ BY U.S. COMPANIES, 1983-1990
19 IRAQI HELICOPTERS DESTROYED BY U.S. IN 1ST GULF WAR
22% PERCENTAGE IN THE MIDDLE EAST
8% PERCENTAGE IN THE UNITED STATES
$3.5 TRILLION AMOUNT SPENT BY THE USA FROM 1945-1995 IN NUCLEAR PREPARATION
$3 COST OF A CHEAP LANDMINE
$300 AVERAGE COST TO DEACTIVATE ONE LANDMINE
$25 COST OF A RUSSIAN KALASHNIKOV (AK-47) IN AFGHANISTAN
83 MINIMUM NUMBER OF GUNS PER 100 PEOPLE IN THE USA
2 NUMBER IN THE NETHERLANDS
4.4 PEOPLE KILLED IN THE U.S. WITH FIREARMS, PER 100,000
0.5 NUMBER IN CANADA
$8,053 MAXIMUM FINE FOR CARRYING A KNIFE LONGER THAN 3 INCHES IN ENGLAND
252 NUMBER OF 1997 IRISH ROBBERIES USING A GUN
590 NUMBER USING A SYRINGE
1.8 MILLION SCISSORS CONFISCATED AT U.S. AIRPORTS 2002
MANY WERE DONATED TO THE U.S. BOY SCOUTS
THE NUCLEAR FAMILY
USA 10,729
CHINA - 400
FRANCE - 350
U.K. - 200
ISRAEL - 200?
INDIA - 60
PAKISTAN - 24-48
SOURCE - NATIONAL RESOURCES DEFENSE COUNCIL
INCLUDES WEAPONS AWAITING DISMANTLEMENT
CHOOSE YOUR WEAPON
THE GLOBAL ARMS TRADE
BANNED!
COUNTRIES SUBJECT TO INTERNATIONAL ARMS EMBARGOS FOR ANY LENGTH OF TIME 1996-2000
SPEND IT ON ME!
PER CAPITA DEFENSE SPENDING, 2002
ISRAEL $1,625
USA $1,196
S. ARABIA $918
U.K. $602
FRANCE $562
JAPAN $367
ITALY $365
GERMANY $332
S. KOREA $279
IRAN $262
TURKEY $150
RUSSIA $78
BRAZIL $56
INDIA $12
CHINA $24
THE BIG SPENDER(S)
TOP 15 DEFENSE BUDGETS, 2002
MARKET EXCHANGE RATES
$US BILLIONS
USA
SOURCES - WASHINGTON POST - CIA WORLD FACTBOOK - U.S. DEPARTMENT OF DEFENSE - STOCKHOLM INTERNATIONAL PEACE INSTITUTE - WORLD WATCH INSTITUTE - THE MILITARY BALANCE 2002 YEARBOOK - IRISH NATIONAL POLICE - YOURRIGHTS.ORG.UK
INA INTERNATIONAL NETWORKS ARCHIVE

Why do we Visualize?

"The ability to take data –

to be able to **understand** it,
to **visualize** it,
to **communicate** it –

that's going to be a hugely important skill in the next decades,

... because now we really do have essentially free and ubiquitous data.

So the complimentary **scarce factor is the ability to understand** the data and extract value from it."

Hal Varian, Google's Chief Economist
The McKinsey Quarterly, Jan 2009

Why do we Visualize?

- **Visual bandwidth** is enormous

Why do we Visualize?

- **Visual bandwidth** is enormous
- **Human perceptual** skills are remarkable
  - Trend, cluster, gap, outlier, pattern …
  - Color, size, shape, proximity…

Perception

How many 3s?

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

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

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

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

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

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

Perception

How many 3s?

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

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

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

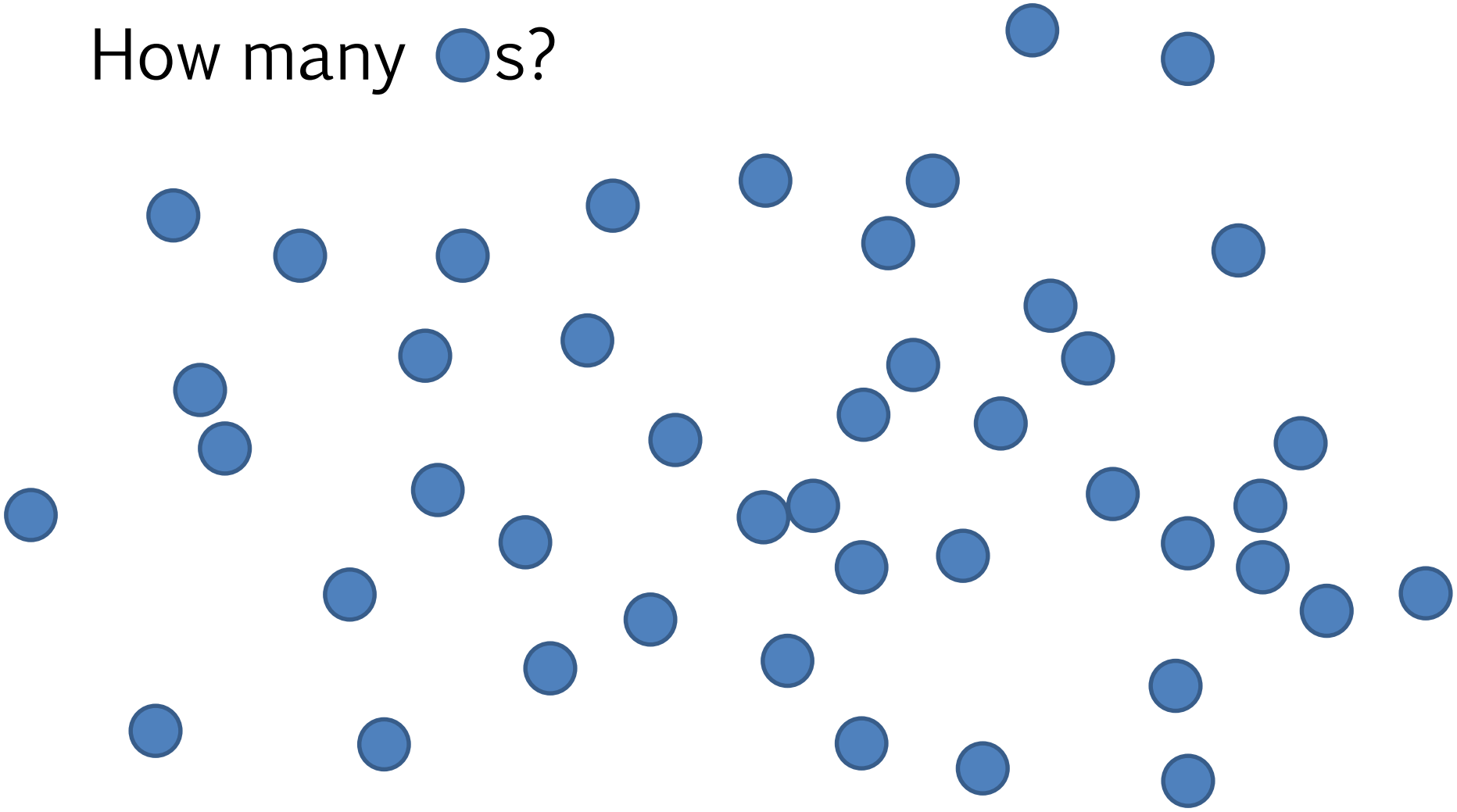
1 5 6 8 7 9 6 5 1 2 3 5 9 9 7 8 9 6 5

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

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

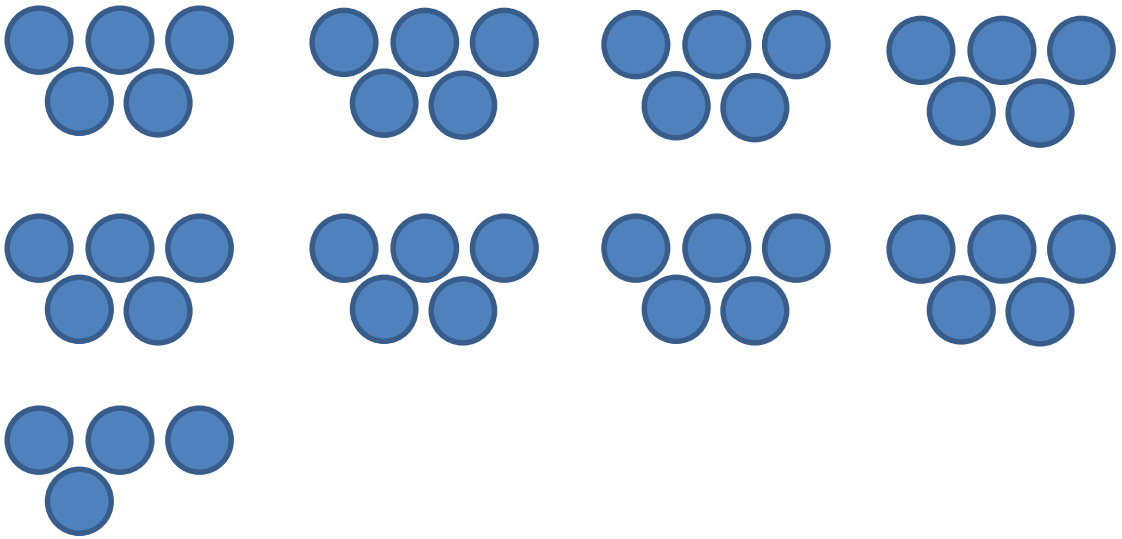
Perception

How many ●s?



Perception

How many ●s?



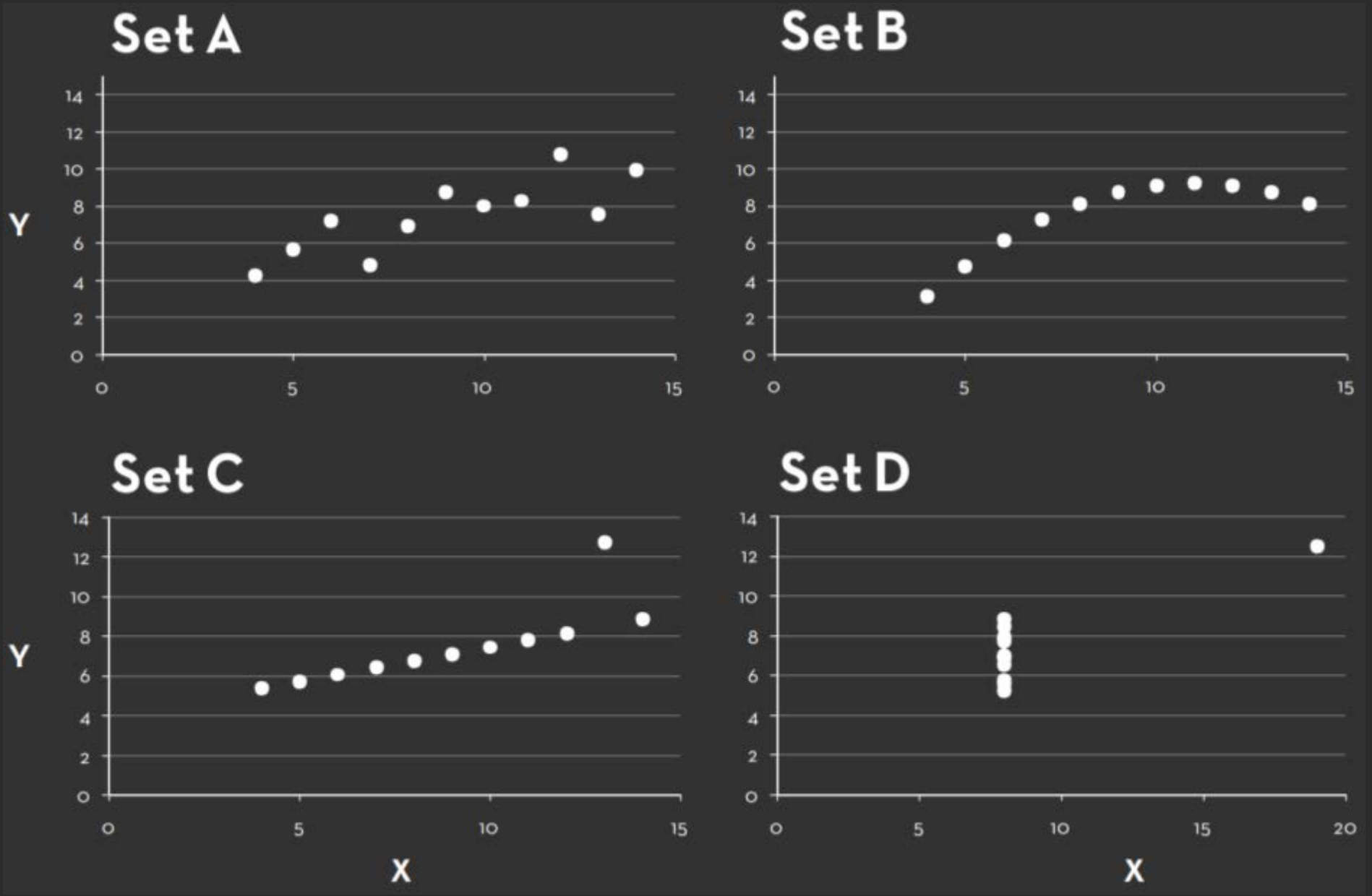
Set A		Set B		Set C		Set D	
X	Y	X	Y	X	Y	X	Y
10	8.08	10	9.14	10	7.47	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.11	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

Summary Statistics

$u_X = 9.0$ $\sigma_X = 3.317$

$u_Y = 7.5$ $\sigma_Y = 2.03$

Anscombe's Quartet (Anscombe, Francis J., 1973)


Set A
Y
14
12
10
8
6
4
2
0
0
5
10
15
Set B
14
12
10
8
6
4
2
0
0
5
10
15
Set C
Y
14
12
10
8
6
4
2
0
0
5
10
15
X
Set D
14
12
10
8
6
4
2
0
0
5
10
15
20
X

Why do we Visualize?

- **Visual bandwidth** is enormous
- **Human perceptual** skills are remarkable
  - Trend, cluster, gap, outlier, pattern…
  - Color, size, shape, proximity…
- External representation
  - **Reduces load** on working memory
  - **Offload** cognition

External Representation

Paper	Mental Buffer
57 X 48	

External Representation

Paper	Mental Buffer
57 X 48	7*8 = 56

External Representation

Paper	Mental Buffer
$\overset{5}{57}$ X 48 6	7*8 = 56

External Representation

Paper	Mental Buffer
$\overset{5}{57}$ X 48 6	

External Representation

Paper	Mental Buffer
$\overset{5}{57}$ X 48 456	5*8 = 40 + 5 = 45

External Representation

Paper	Mental Buffer
5 57 X 48 456	

External Representation

Paper	Mental Buffer
25 57 X 48 456 8	4 * 7 = 28

External Representation

Paper	Mental Buffer
25 57 X 48 456 8	

External Representation

Paper	Mental Buffer
25 57 X 48 456 228	4 * 5 = 20 + 2 = 22

External Representation

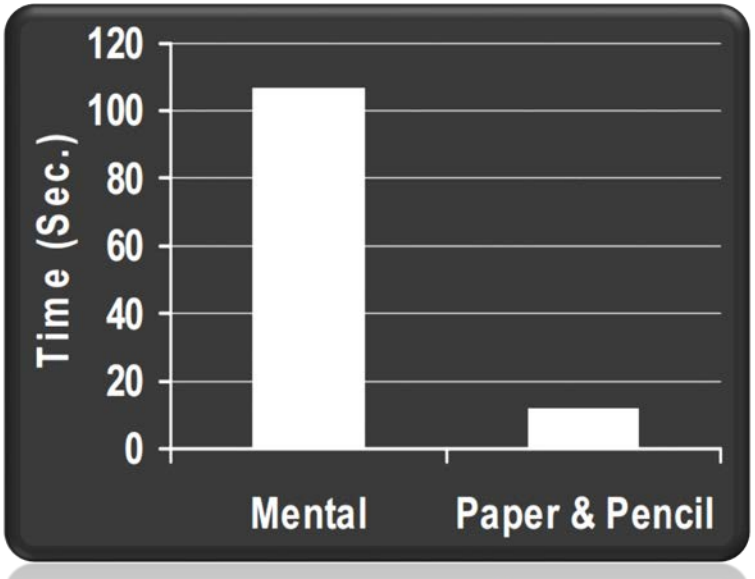
Paper	Mental Buffer
25 57 X 48 456 228	

External Representation

Paper	Mental Buffer
$\overset{2\cancel{5}}{57}$	
X 48	
$\overset{1}{4}56$	6 + 0 = 6
228	5 + 8 = 13
2736	2 + 4 = 6 + 1 = 7
	2 + 0 = 2

External Representation

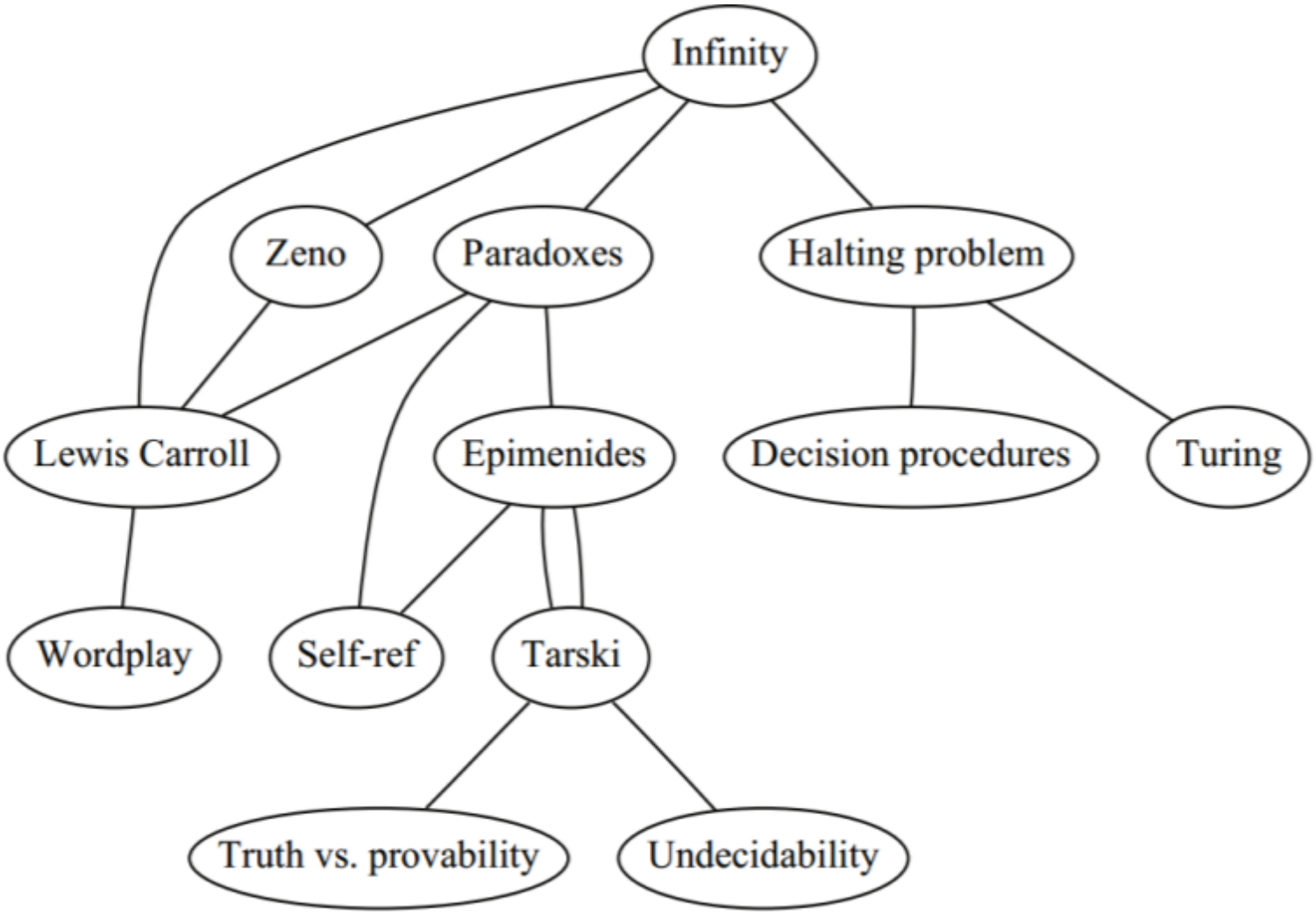
Paper	Mental Buffer
$\begin{array}{r} {}^{2}\cancel{5} \\ 57 \\ \underline{\times\ 48} \\ {}^{1}456 \\ \underline{228} \\ 2736 \end{array}$	$6 + 0 = 6$ $5 + 8 = 13$ $2 + 4 = 6 + 1 = 7$ $2 + 0 = 2$



External Representation: Example

- Paradoxes – Lewis Carroll
- Paradoxes – Epimenides
- Paradoxes – Self-ref
- Paradoxes – Infinity
- Epimenides – Self-ref
- Epimenides – Tarski
- Halting Problem – Decision Procedure
- Halting Problem - Turing
- Infinity – Halting problem
- Infinity – Recursion
- Infinity – Zeno
- Infinity – Lewis Carroll
- Zeno – Lewis Carroll
- Lewis Carroll – Wordplay
- Tarski – Epimenides
- Tarski – Truth vs Provability
- Tarski - Undecidability

External Representation



Why do we Visualize?

- **Visual bandwidth** is enormous
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  - Trend, cluster, gap, outlier, pattern…
  - Color, size, shape, proximity…
- External representation
  - **Reduces load** on working memory
  - **Offload** cognition
- Fewer coded symbols to decode

Decoding

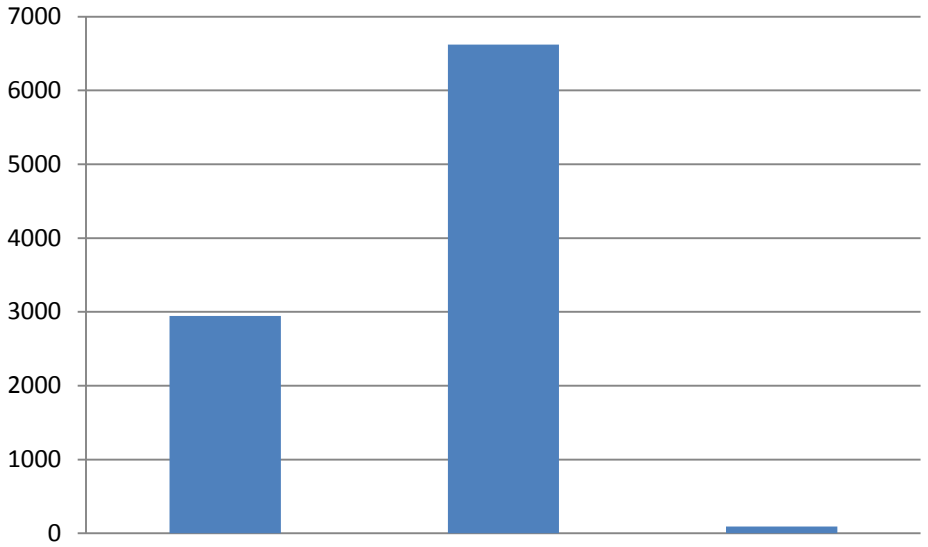
Compare:

2947 vs 6621 vs 95.12

Decoding

Compare:

2947 vs 6621 vs 95.12



Why Don't We Visualize

Myths:

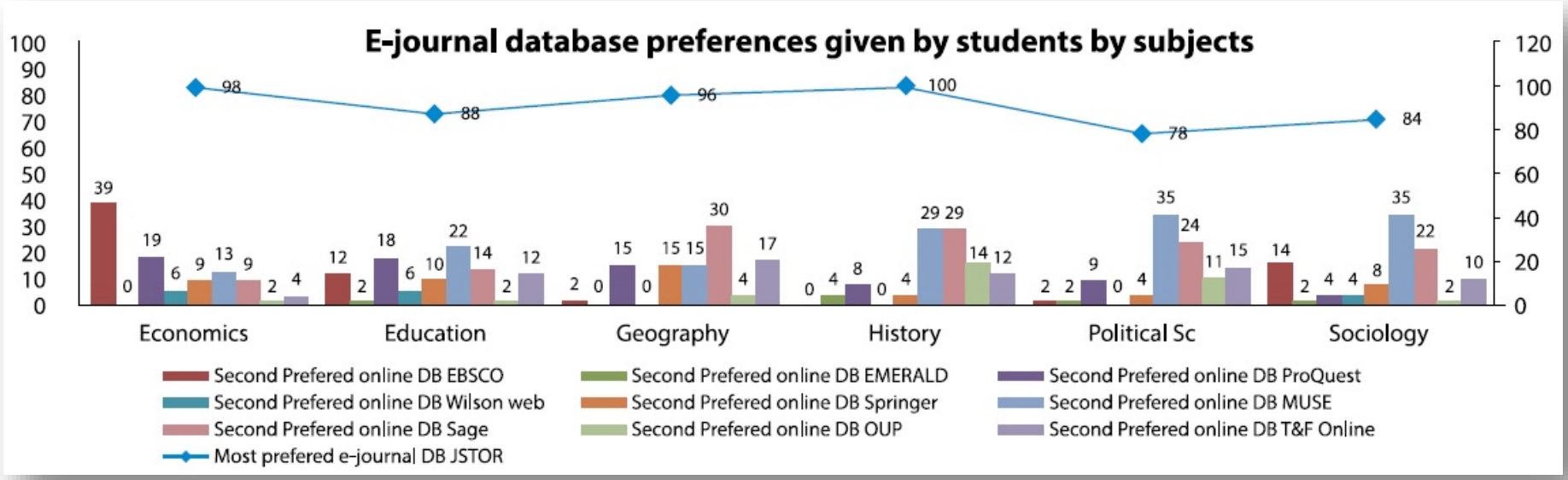
- We visualize data because some people are visual learners.
- We visualize data for people who have difficulty understanding numbers.
- We visualize data to grab people's attention with eye-catching displays.

Stephen Few http://www.perceptualedge.com/blog/?p=1897

Why Visualize in the Library?

Your Practice

- Explore our data



http://central.oak.go.kr/search/detailarticle.jsp?article_seq=12786&tabname=abst&resource_seq=null&keywords=null

Why Visualize in the Library?

Your Practice

- Explore our data
- Communicate our data

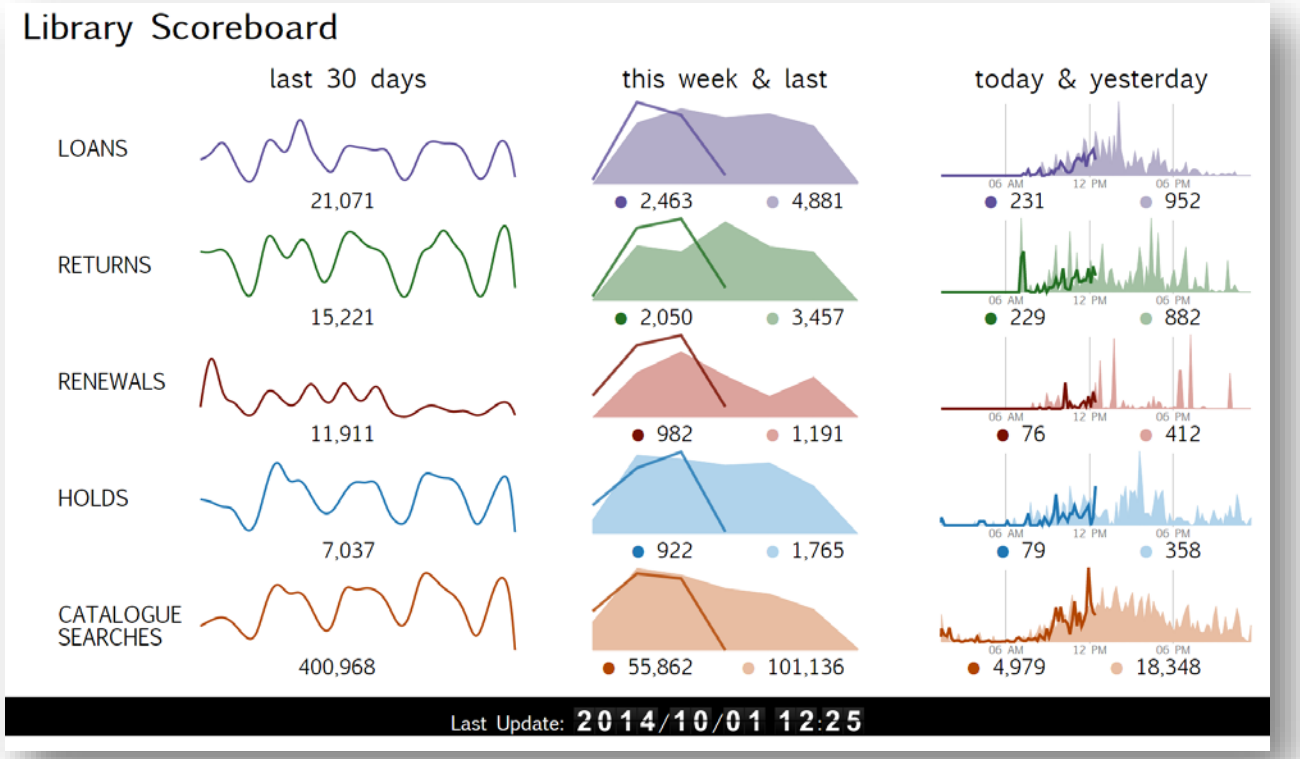
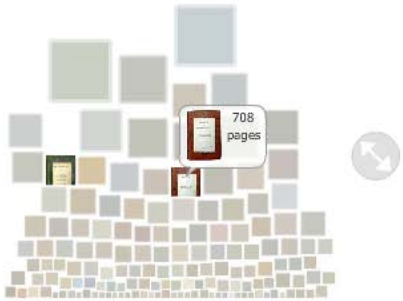


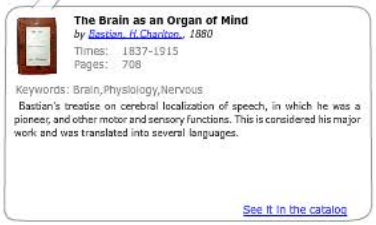
	Image:	Title:	Author:	Description:
1.		Acromegaly	Sternberg, Maximilian, b. 1863	An early monograph on acromegaly including photos.
2.		Appendix to The anatomy of the brain : containing a paper read before the Royal Society on the 14th of May, 1829, and some remarks on Mr. Charles Bell's animadversions on phrenology	Spurzheim, J. G. (Johann Gaspar), 1776-1832	Remark regarding Mackie Family History of Neuroscience Collection copy: Laid in a typed letter signed by Barbara Rootenberg, bookseller regarding her knowledge of the significance of this book.
3.		Autonomic nervous system, The. Part I	Langley, J. N. (John Newport), 1852-1925	Langley succeeded Gaskell as head of the Department of Psysiology at Cambridge. He coined the term, "autonomic nervous system," (adapting it from Gaskell's Involuntary nervous system). He also introduced the terms, "preanglionic" and "postanglionic." His orientation was more physiological and pharmacological...
4.		Basis of sensati… the sense organ…		
5.		Beiträge zur Ke… normalen mens… : Festschrift zu… Jubiläum des är… Frankfurt a. M.,… 1895		

NUMBER OF PAGES
Browse Books by Page Count



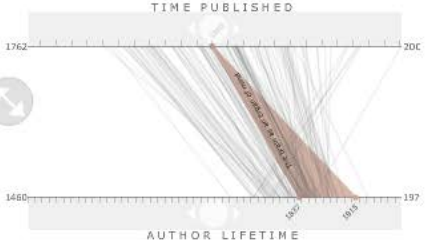
AUTHORS
Browse Books by Author Name

COVER COLOUR
Browse Books by Colour



KEYWORDS
Follow Keyword Chains to New Books

TIME PUBLISHED



AUTHOR LIFETIME

TIMELINES
Compare Publication Year and Content Time

Why Visualize in the Library?

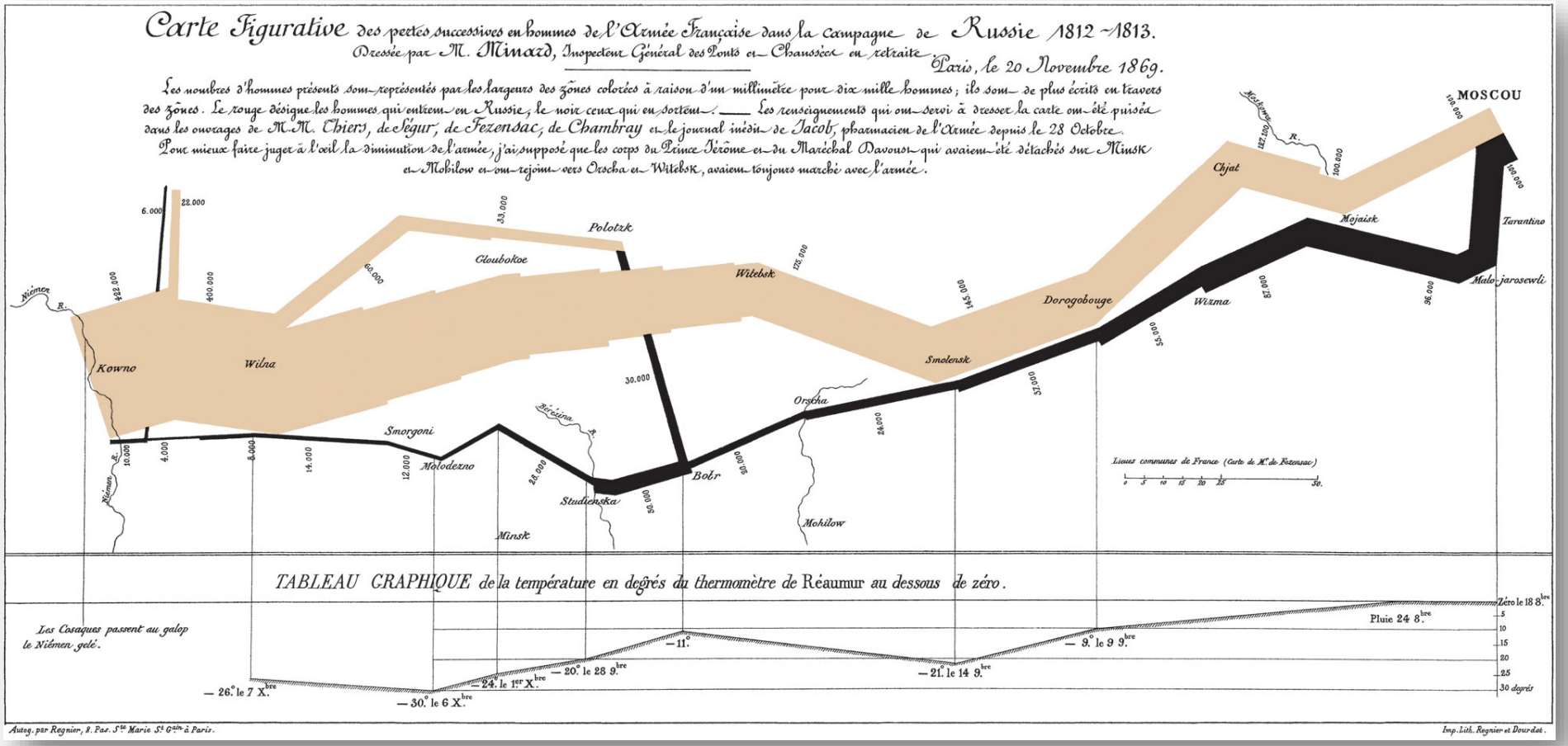
Your Practice

- Explore our data
- Communicate our data
- 21st Century Competency

External Practice

- Support data resources
- Tool across entire academy

Visualization Examples



Map of the successive losses in men of the French Army in the Russian campaign 1812-1813. Charles Minard, 1869.

http://upload.wikimedia.org/wikipedia/commons/2/29/Minard.png

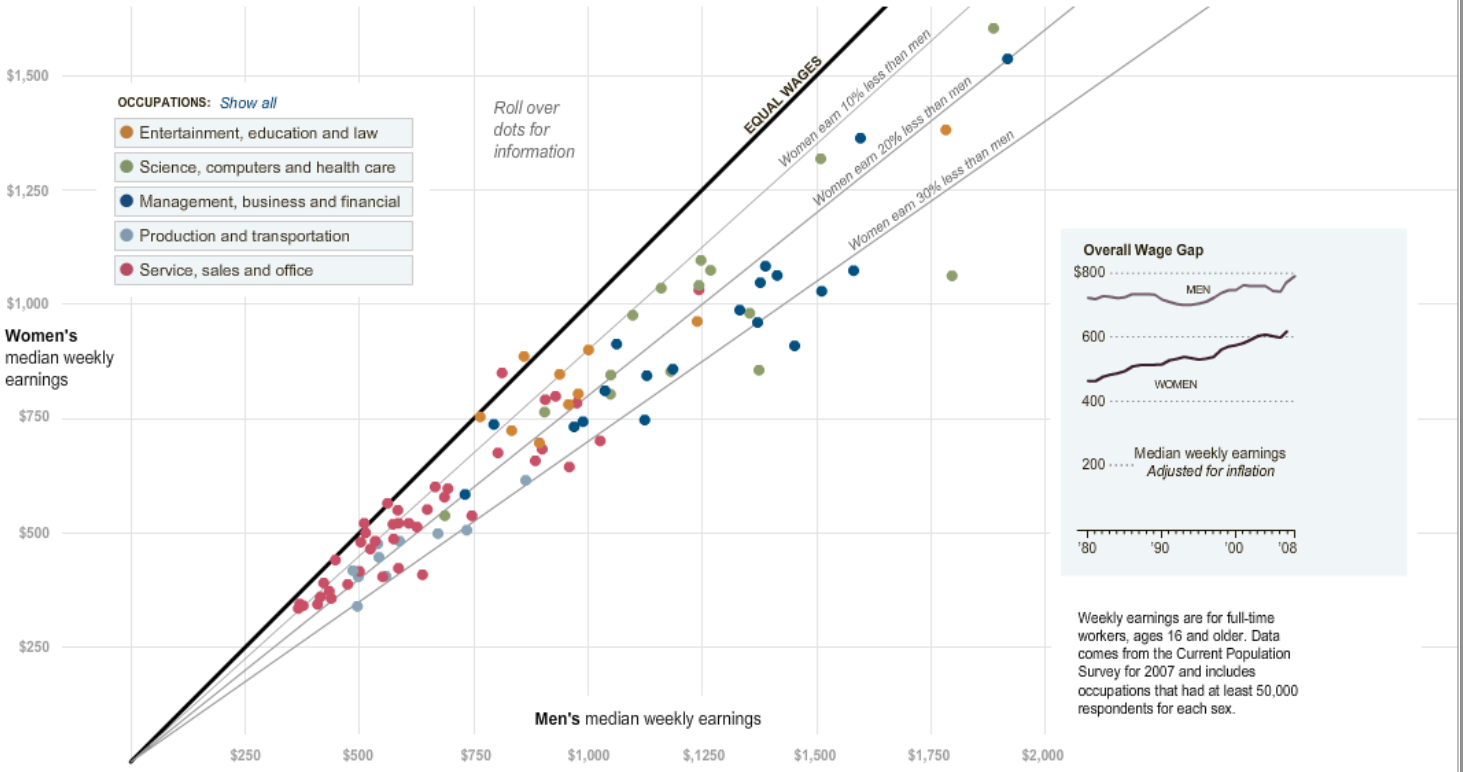
John Snow's Cholera Map, London 1854

http://en.wikipedia.org/wiki/John_Snow_(physician)#mediaviewer/File:Snow-cholera-map-1.jpg

Published: May 18, 2010

Why Is Her Paycheck Smaller?

Nearly every occupation has the gap — the seemingly unbridgeable chasm between the size of the paycheck brought home by a woman and the larger one earned by a man doing the same job. Economists cite a few reasons: discrimination as well as personal choices within occupations are two major factors, and part of the gap can be attributed to men having more years of experience and logging more hours.



Hannah Fairfield and Graham Roberts/The New York Times

| Send Feedback

Sources: Bureau of Labor Statistics; Census Bureau

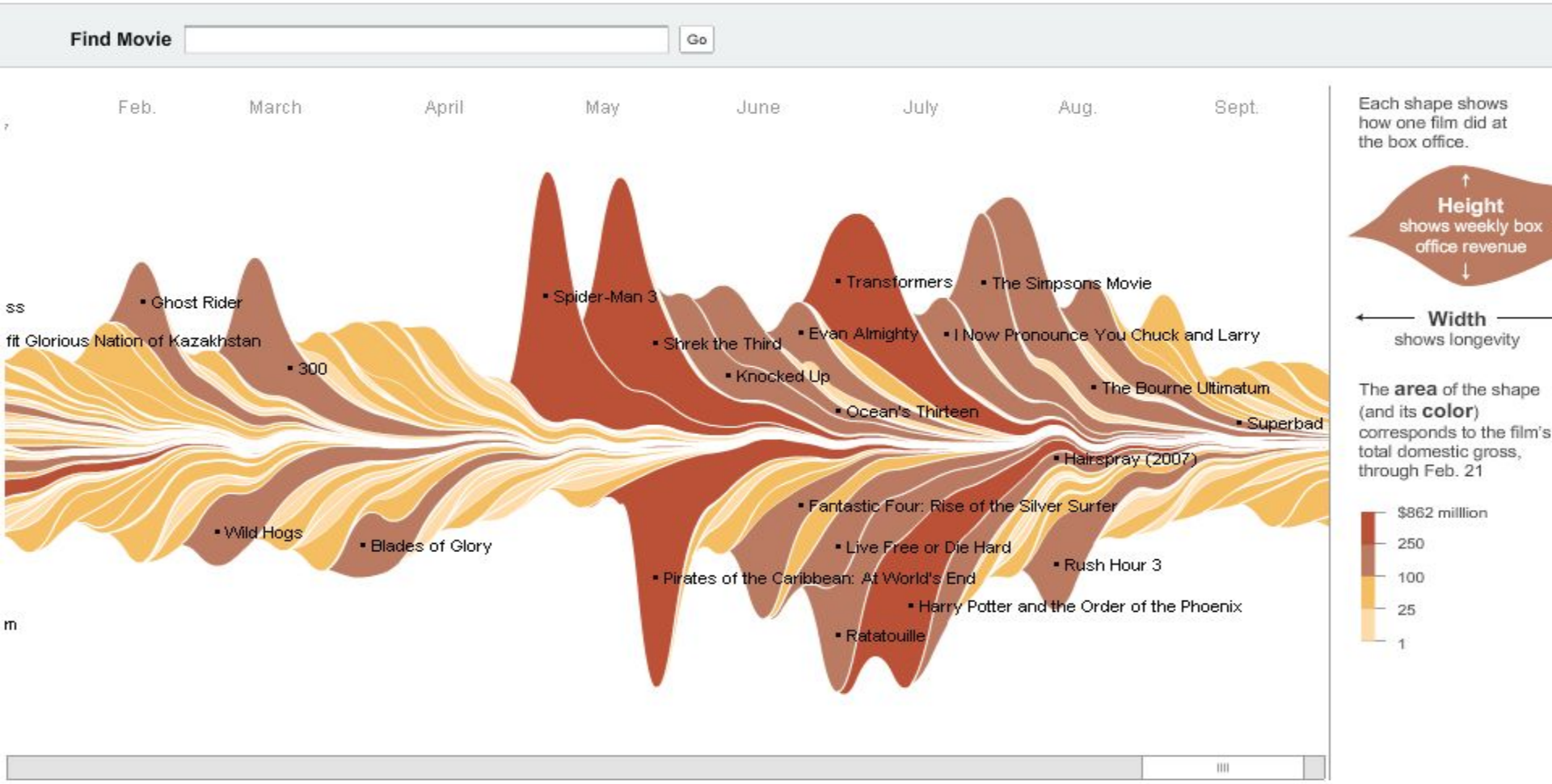
http://www.nytimes.com/interactive/2009/03/01/business/20090301_WageGap.html?_r=0

February 23, 2008

SIGN IN TO E-MAIL OR SAVE THIS | FEEDBACK

The Ebb and Flow of Movies: Box Office Receipts 1986 — 2008

Summer blockbusters and holiday hits make up the bulk of box office revenue each year, while contenders for the Oscars tend to attract smaller audiences that build over time. Here's a look at how movies have fared at the box office, after adjusting for inflation.

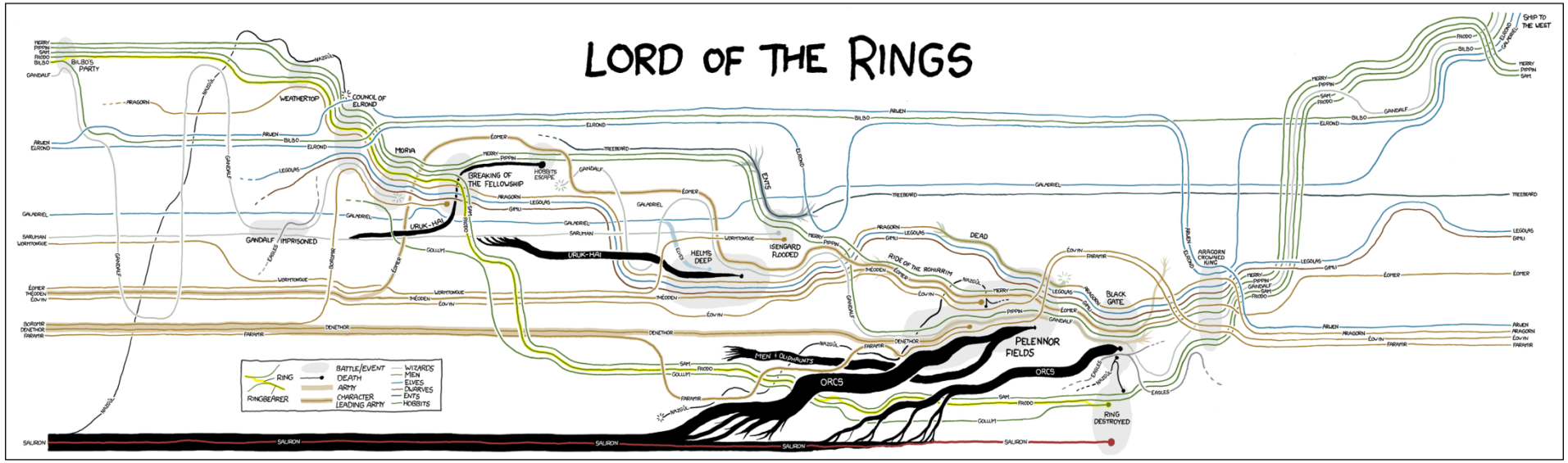


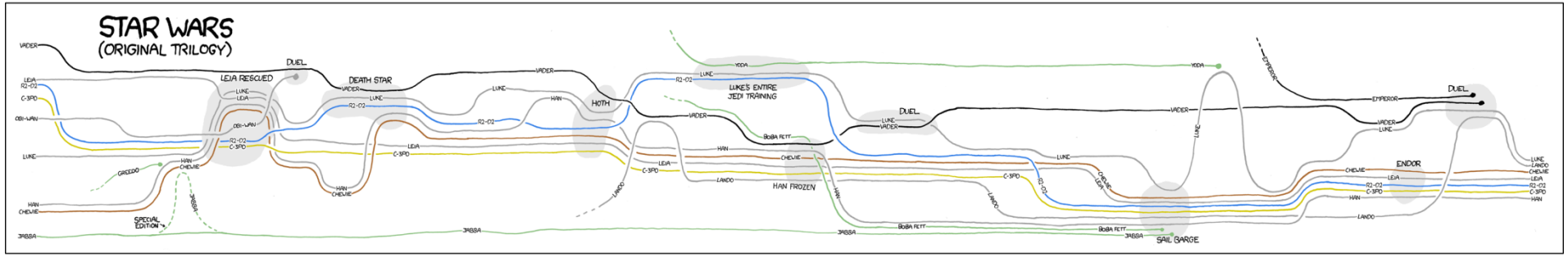
Sources: Baseline StudioSystems; Box Office Mojo

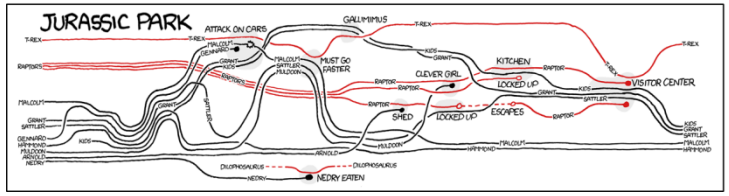
Mathew Bloch, Lee Byron, Shan Carter and Amanda Cox

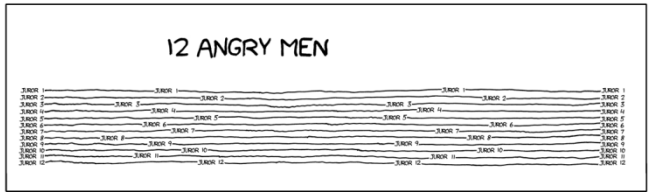
http://www.nytimes.com/interactive/2008/02/23/movies/20080223_REVENUE_GRAPHIC.html

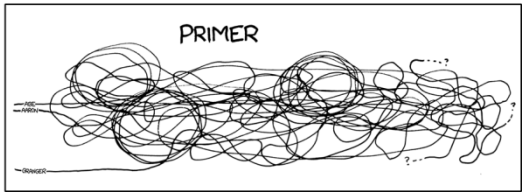
THESE CHARTS SHOW MOVIE CHARACTER INTERACTIONS.
THE HORIZONTAL AXIS IS TIME. THE VERTICAL GROUPING OF THE
LINES INDICATES WHICH CHARACTERS ARE TOGETHER AT A GIVEN TIME.





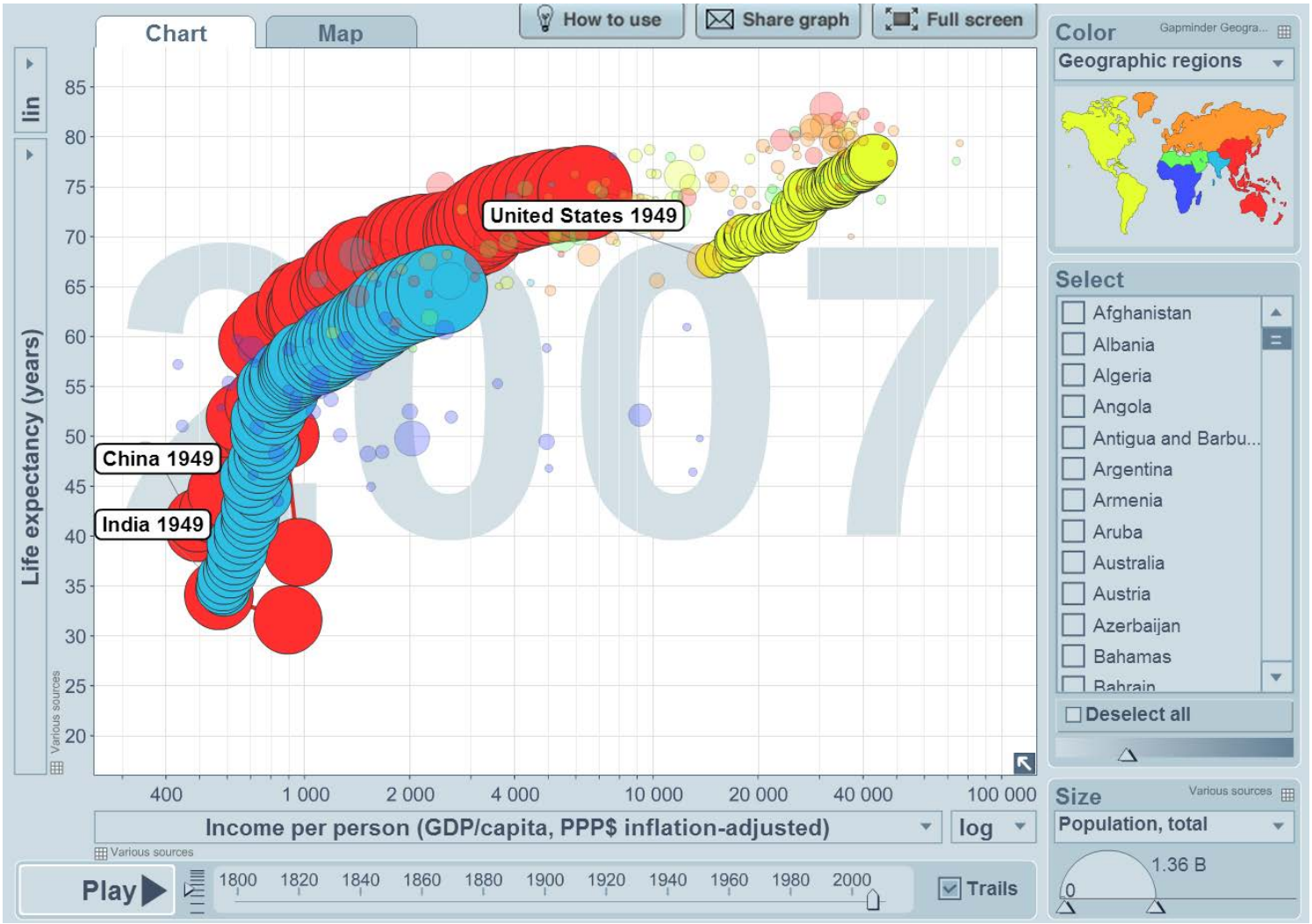






http://xkcd.com/657/large/

Gapminder



http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen?language=en

http://www.gapminder.org/

Exercise:

How many ways can you communicate two quantities?

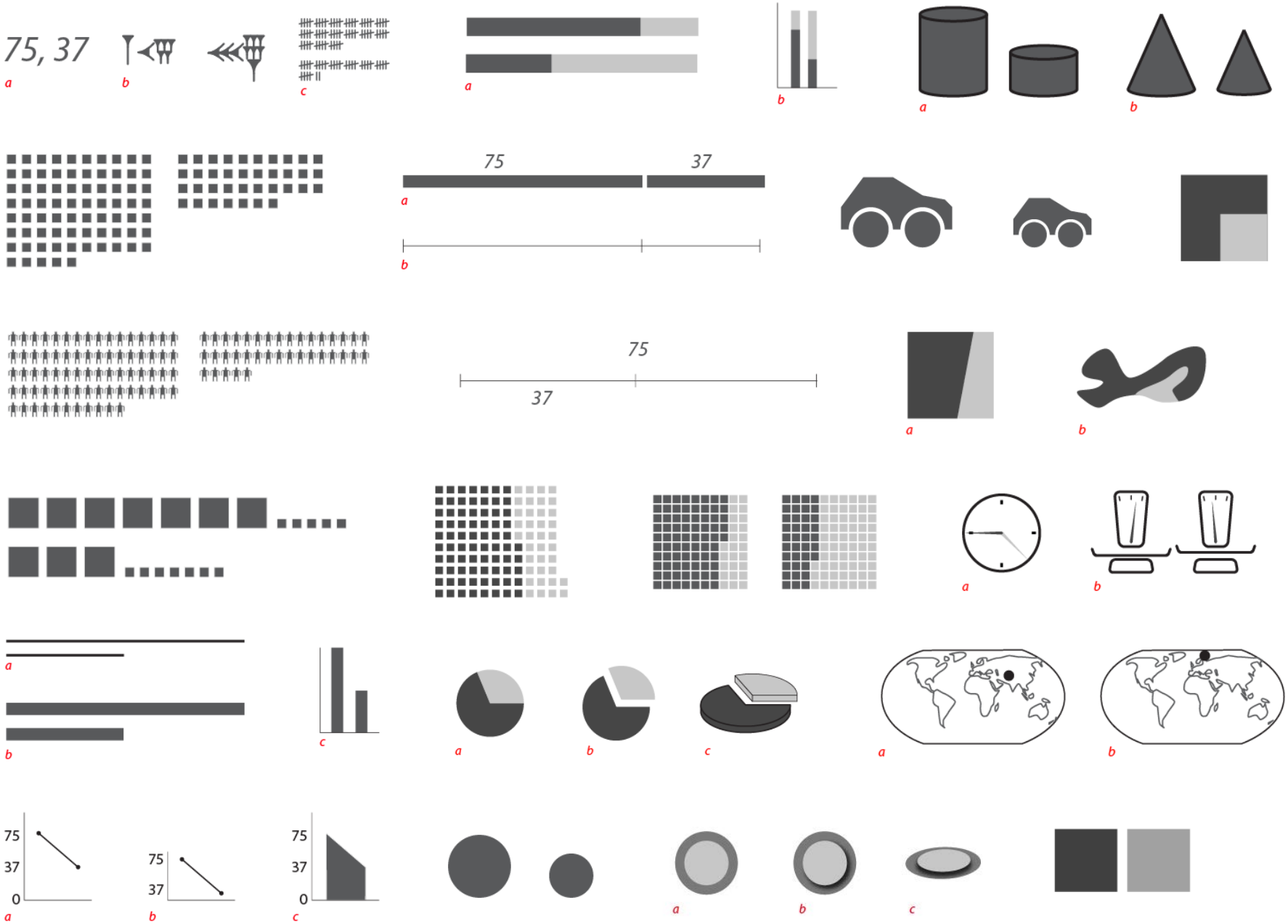
75 and 37

Exercise:

How many ways can you communicate two quantities?

75 and 37

http://blog.visual.ly/45-ways-to-communicate-two-quantities/


75, 37
a
b
c
a
b
a
b
75
37
a
b
75
37
a
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a
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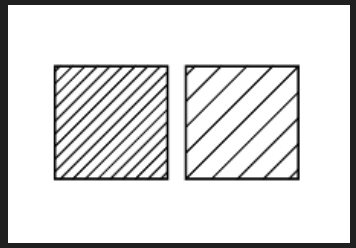
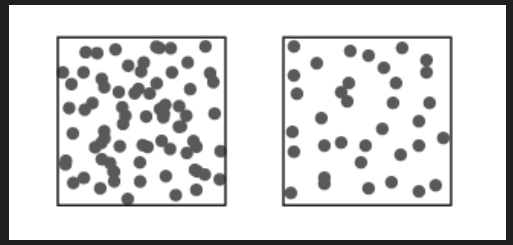
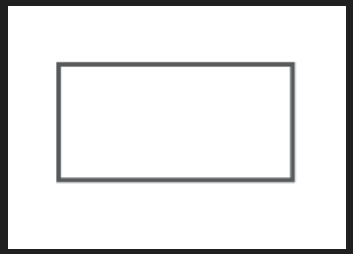
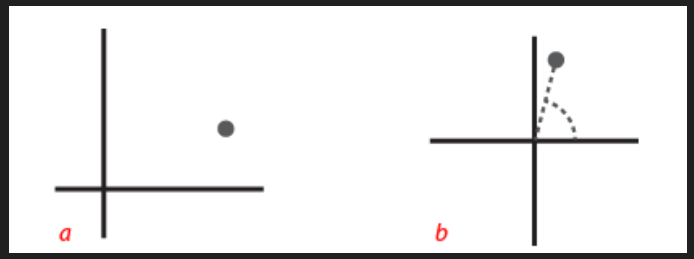
c









http://blog.visual.ly/45-ways-to-communicate-two-quantities/

Visualization Resources

Books

- *Semiology of Graphics* by Jacques Bertin
  - *The book on visual variables*
- *Visual Display of Quantitative Information, Beautiful Evidence, Visual Explanations,* or *Envisioning Information* by Edward Tufte
  - *Beautiful examples of historic visualizations*
- *Visualizing Data* by Ben Fry
  - *Current overarching text book*
- *Visual Thinking for Design* by Colin Ware
  - Ties perception theory and design processes to visualization practices.
- Beautiful Visualization by Steele & Iliinsky
  - Combines techniques from artists, designers, scientists, and others.

Visualization Resources

Web Sites

- New York Times
  - Dedicated team producing exceptional work.
- Information aesthetics
  - Creative design applied to visualization. Gorgeous.
- Eagereyes
  - Vis Researcher with criticism as well as overview from assorted research conferences.
- Gapminder
  - Hans Rosling's stat software & data.
- Visual Business Intelligence
  - Analytics blog, frequently discussing big data and dashboard design.
- Tableau Viz of the Day
  - Daily example of a visualization created with Tableau software.

Plan for Today

- 9:00 Intro
- 9:30 Visual Variables
- 10:15 Break
- 10:30 Sketching
- 11:30 Vis Software & Tools
- 12:00 Lunch
- 1:00 Tableau
- 2:30 Break
- 3:30 Vis in the Library & Professional Practice
- 4:00 Work with Data

http://bit.ly/tfdlvis

Creating a Visualization

1. Know the Data

2. Know the Audience/Purpose/Venue

3. Visually Encode the Data

1 - Know the Data

- Number of attributes
  Examples,
  - Weather: *date/time, temperature, precipitation, humidity, wind, forecast, pressure, cloud cover.*
  - Real Estate: *price, location, square feet, lot size, floors, # bathrooms, # bedrooms, etc.*
- Quality of the data
  - Missing, uncertain, bad values
- Amount of data
- Data Types

Data Types

- Categorical
- Ordered
  - Ordinal Small Medium Large
  - Quantitative 1 2 5.29 42 101
- Spatial

2 - Know the Audience

- Who is the for?
- What is your goal?
- What is interesting?
- Story?
- Interactive?
- Display capacity?

3 - Visually Encode

- Requires awareness of:
  - Human perceptual system
  - Display capacity
  - Characteristics of data (size, type)
  - Task

3 - Visually Encode

- Marks

3 - Visually Encode

- Marks

- What can we change about a mark?

Visual Encoding

Visual Channels:

- *Position*
- *Angle*
- *Slope*
- *Length*
- *Area*
- *Volume*
- *Shape*

Size

- *Lightness*
- *Saturation*
- *Hue*

Colour

- *Texture*
- *Connection*
- *Containment*

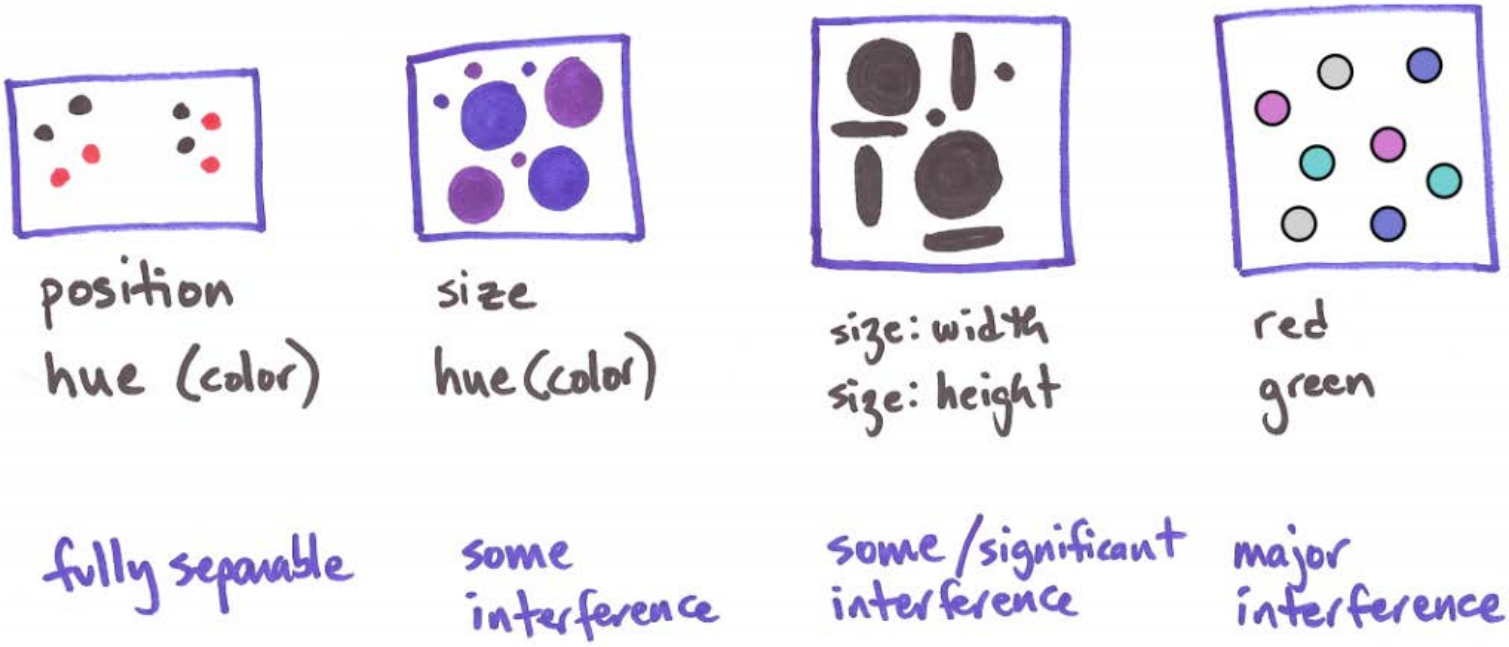
Independent?

?

- *Opacity*
- *"Sketchiness"*

Visual Encoding

- How well can we judge a channel's magnitude
- Are differences perceivable?
- How many bins?
- Ideally all channels would be independent (not so)
  - Interactions between channels



Visual Variable Properties

1. Selective
2. Associative
3. Quantitative
4. Order
5. Length

Visual Variable Properties

1. Selective
   - Is a change of a mark in this variable alone enough to allow us to select it from other marks?
2. Associative
3. Quantitative
4. Order
5. Length

Is Size Selective?

Can you find the big & small Muppets?

Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

Is Size Selective?

Can you find the big & small Muppets?

Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

Visual Variable Properties

1. Selective
   - Is a change of a mark in this variable alone enough to allow us to select it from other marks?
2. Associative
   - Can we identify a group of marks by this variable?
3. Quantitative

4. Order

5. Length

Is Size Associative?

Can you find the small Muppets?

Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

Is Size Associative?

Can you find the small Muppets?

Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

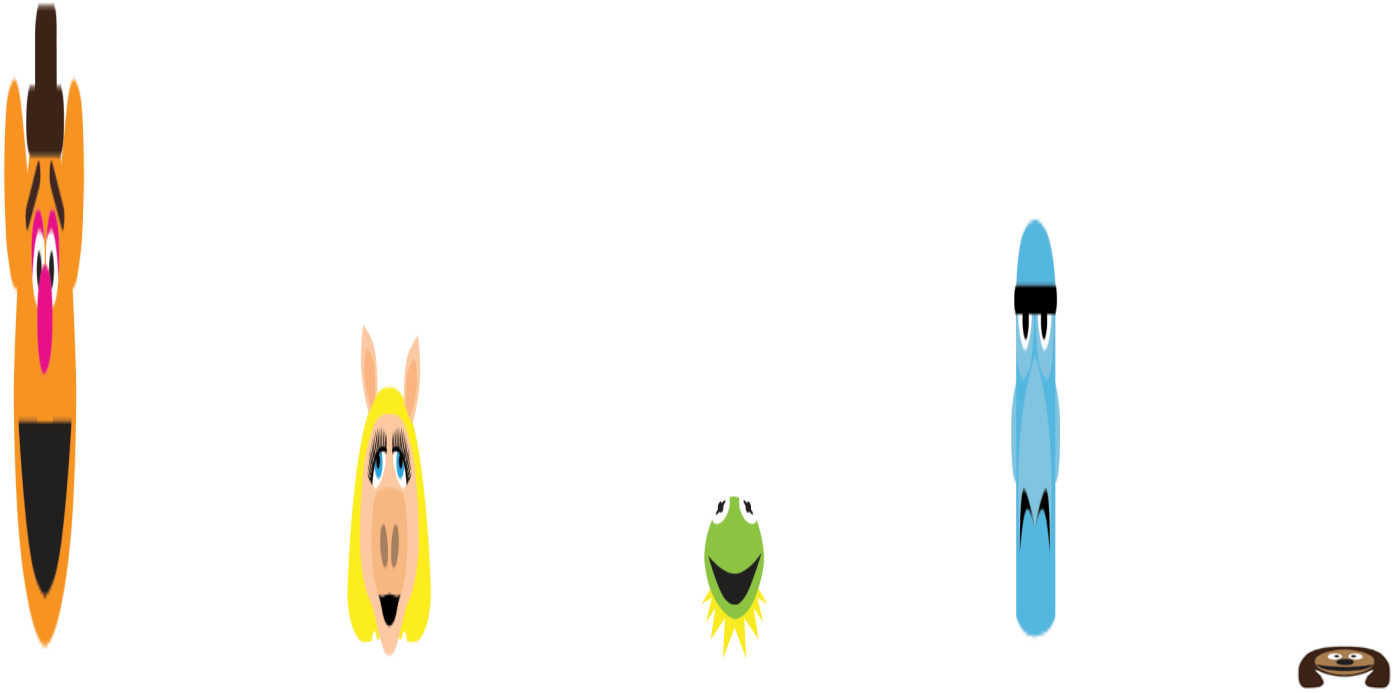
Visual Variable Properties

1. Selective
   - Is a change of a mark in this variable alone enough to allow us to select it from other marks?
2. Associative
   - Can we identify a group of marks in this variable?
3. Quantitative
   - Can the relation between two of these marks be seen as numeric? Can we tell if one is 3X another?
4. Order

5. Length

Is Size Quantitative?

What value is Kermit compared to Fozzie?



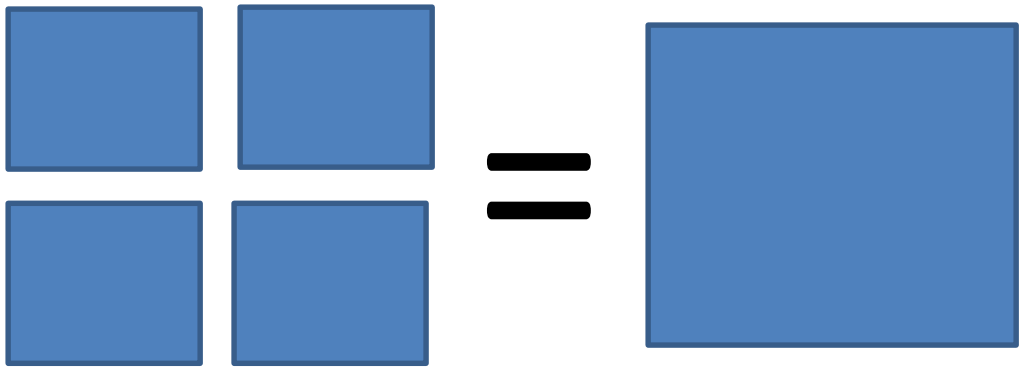
Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

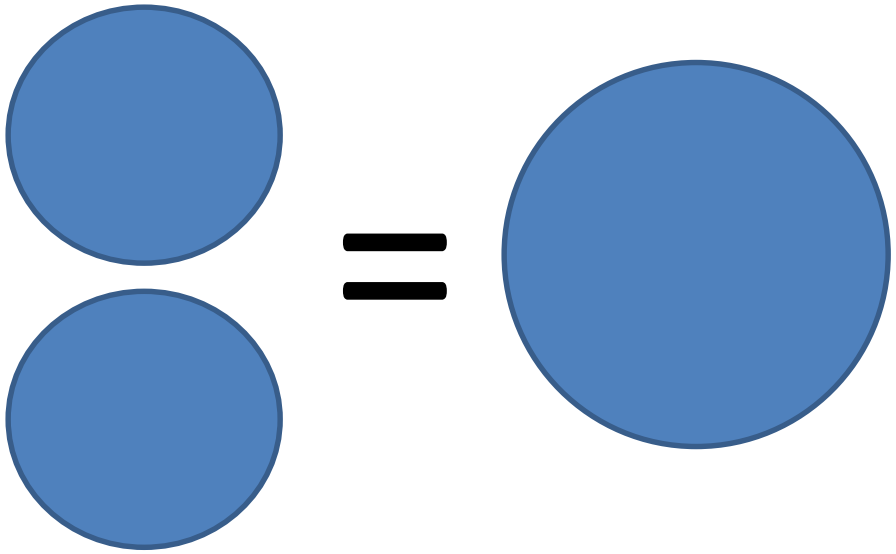
Is Size Quantitative?

What value is Kermit compared to Fozzy?

Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

Is Size Quantitative?





Visual Variable Properties

1. Selective
   - Is a change of a mark in this variable alone enough to allow us to select it from other marks?
2. Associative
   - Can we identify a group of marks in this variable?
3. Quantitative
   - Can the relation between two of these marks be seen as numeric? Can we tell if one is 3X another?
4. Order
   - Does this variable support ordered reading (more/less)?
5. Length

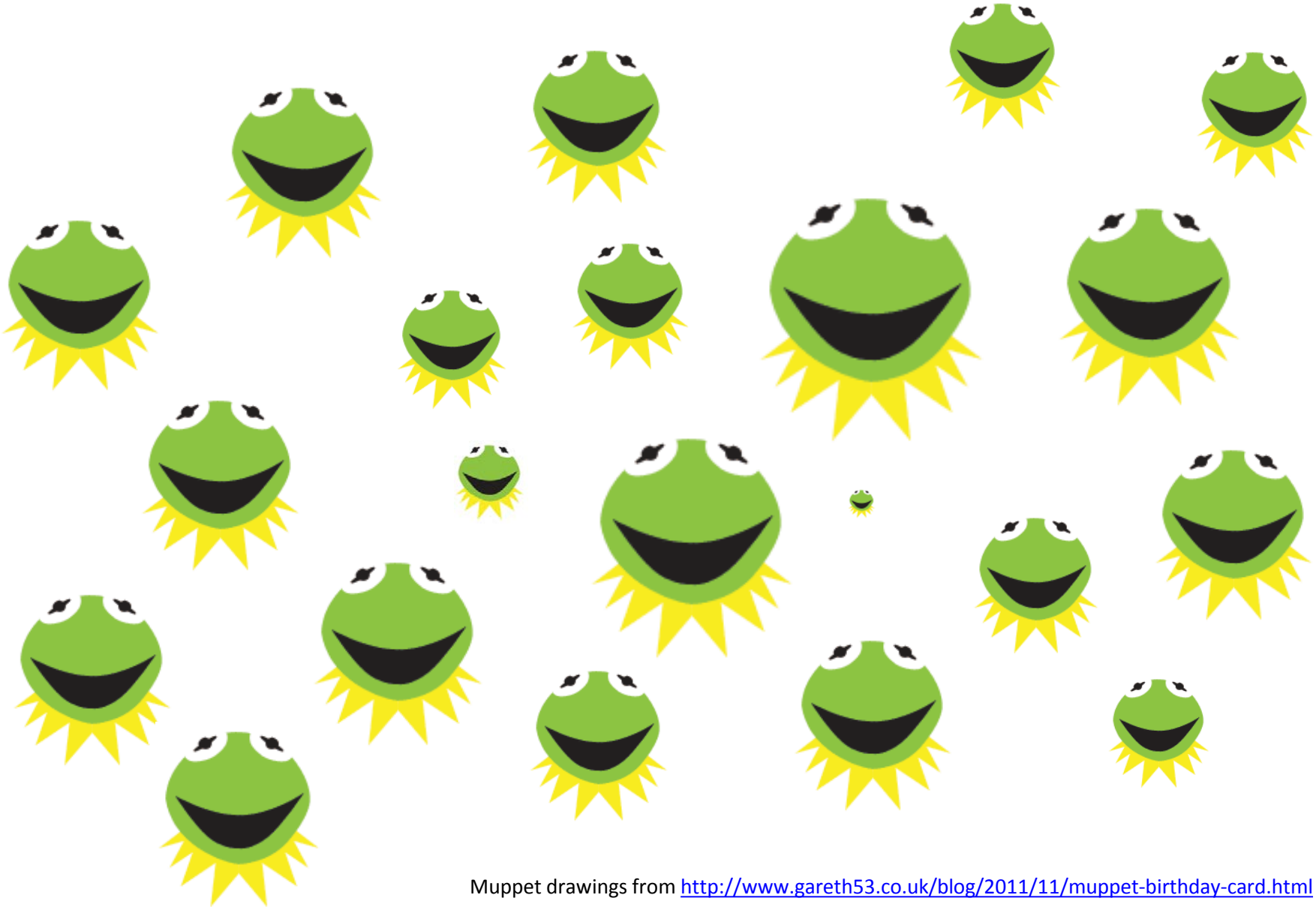
Is Size Ordered?

Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

Visual Variable Properties

1. Selective
   - Is a change of a mark in this variable alone enough to allow us to select it from other marks?
2. Associative
   - Can we identify a group of marks in this variable?
3. Quantitative
   - Can the relation between two of these marks be seen as numeric? Can we tell if one is 3X another?
4. Order
   - Does this variable support ordered reading (more/less)?
5. Length
   - How many differences in this variable can be discerned?

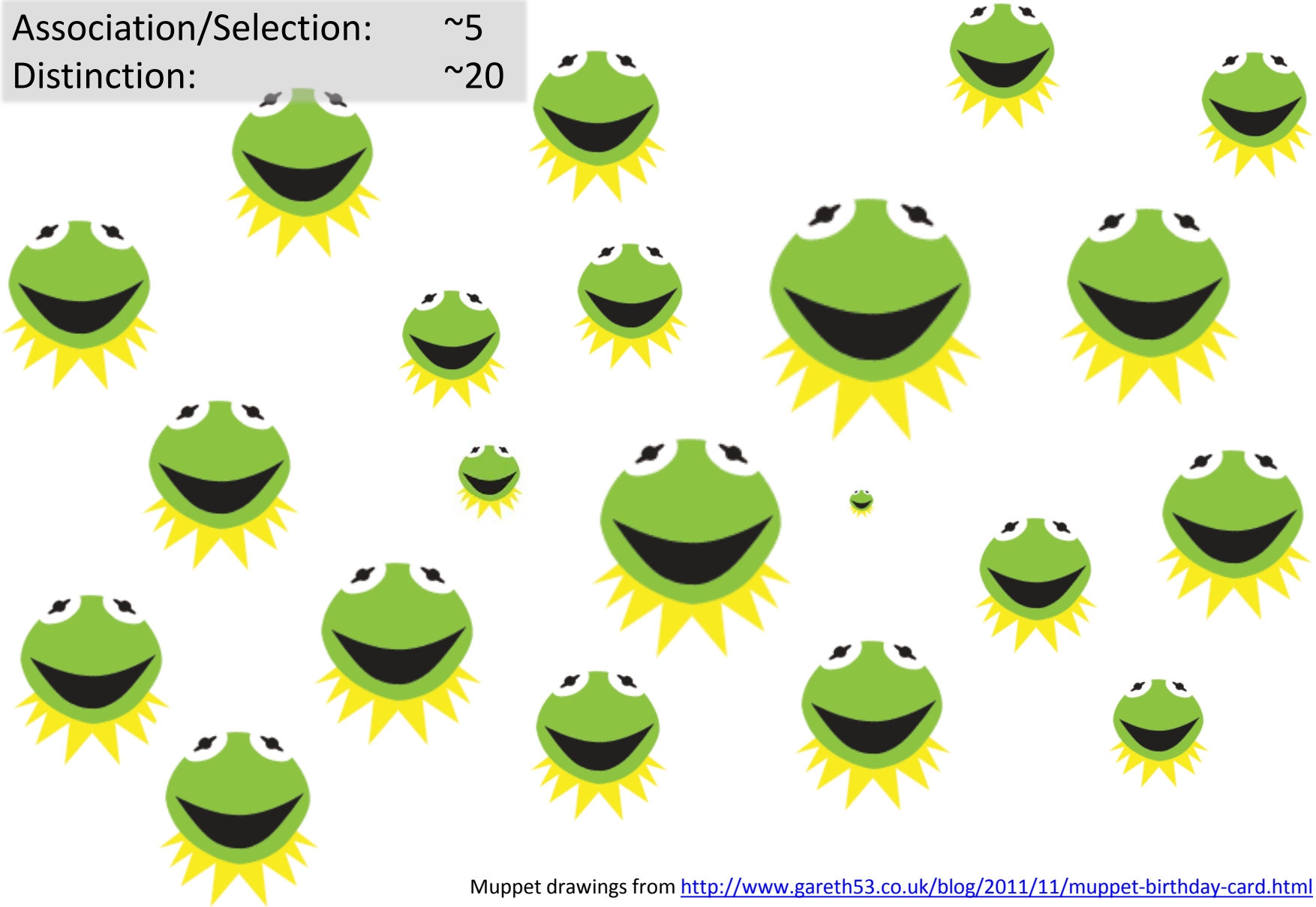
What Length Does Size Have?



Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

What Length Does Size Have?

Association/Selection:	~5
Distinction:	~20



Muppet drawings from http://www.gareth53.co.uk/blog/2011/11/muppet-birthday-card.html

Visual Encoding Channel Properties

- Selective
  - Is a change in this variable alone enough to allow us to select it from a group?
- Associative
  - Can we identify a group of these marks?
- Quantitative
  - Can the relation between two of these marks be seen as numeric? Can we tell if one is 3X as much as another?
- Order
  - Does this variable support ordered reading (more/less)?
- Length
  - How many differences in this variable can be discerned?

Size

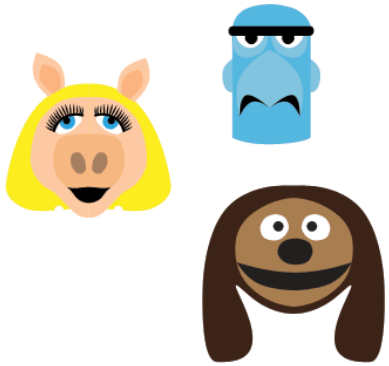
Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position					
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

Position

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position					
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

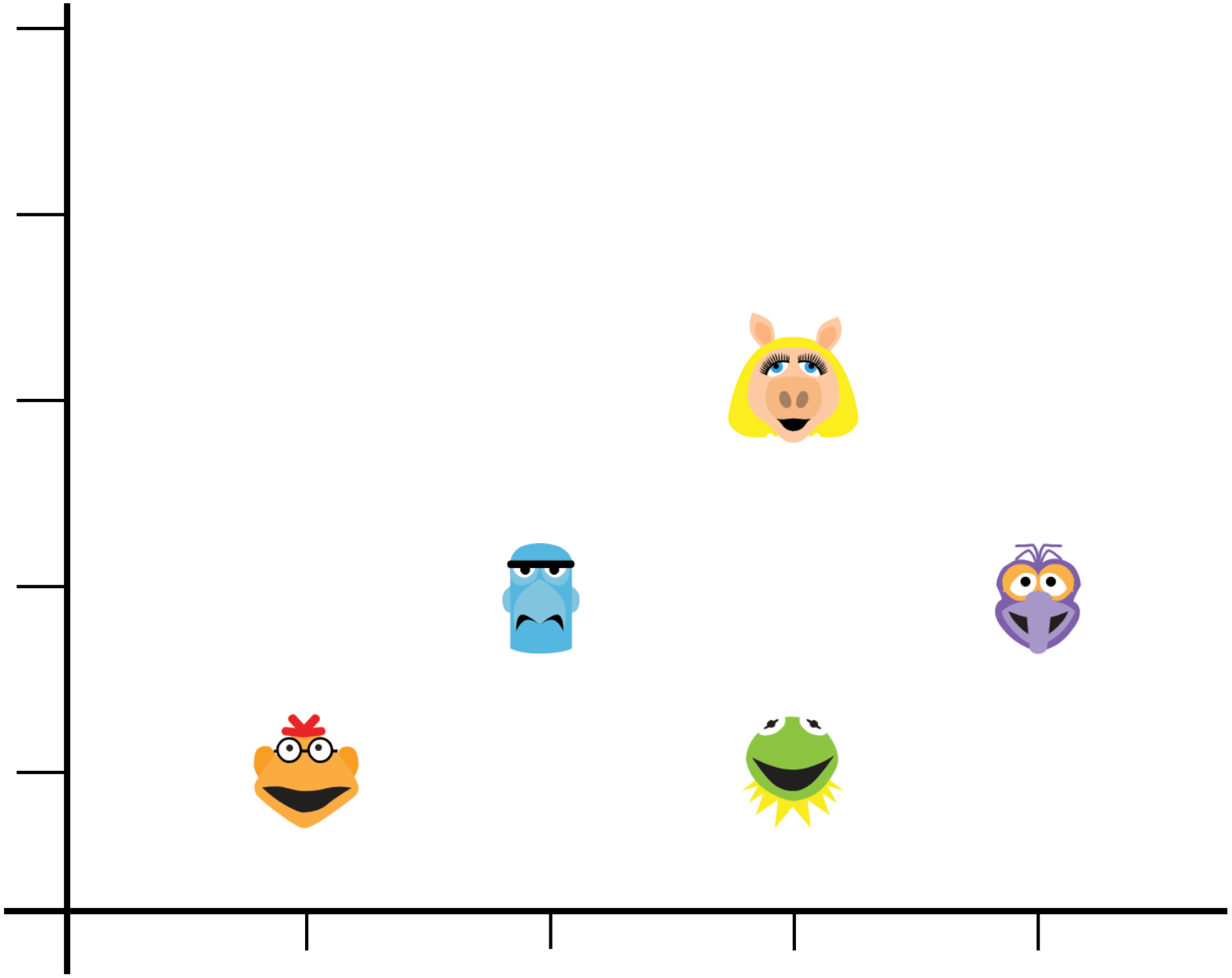
Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes				
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes				
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					



Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes			
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes			
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					



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Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes		
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

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Position	Yes	Yes	Yes		
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

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Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

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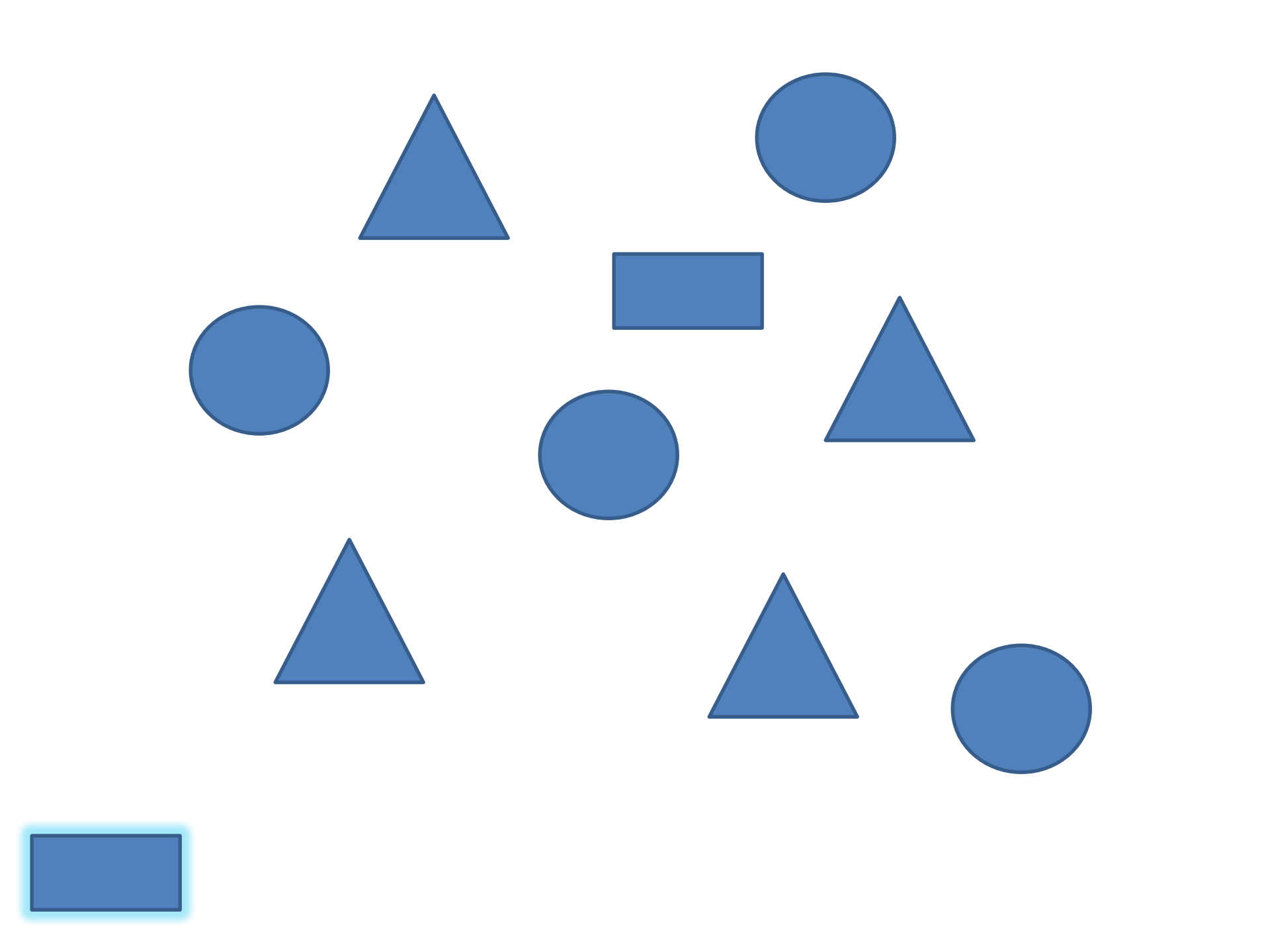
Position	Yes	Yes	Yes	Yes	
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					

Theoretically infinite but dependent on display size

Shape

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape					
Lightness					
Saturation					
Hue					
Angle					
Texture					



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Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	Yes				
Lightness					
Saturation					
Hue					
Angle					
Texture					

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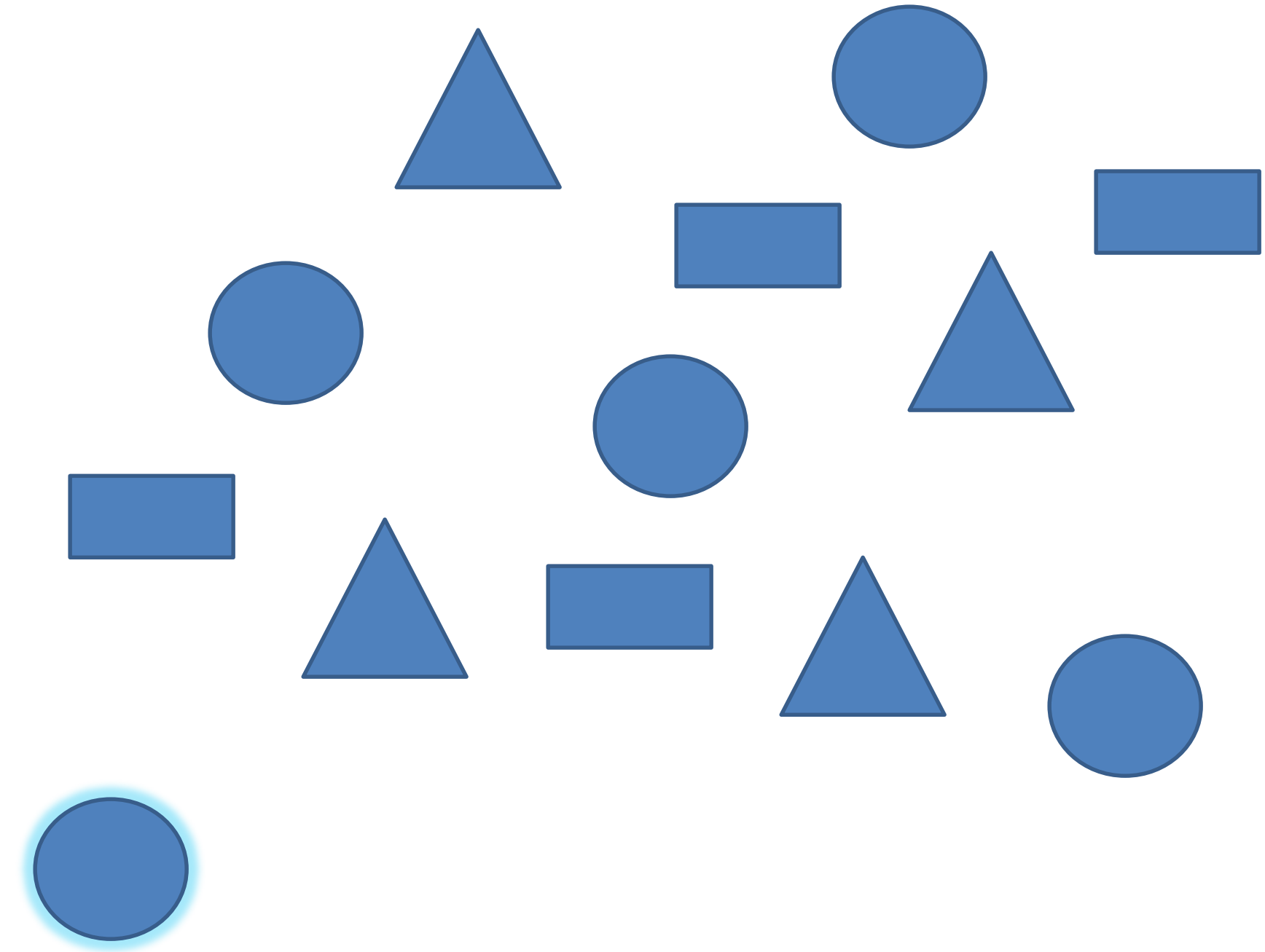
Position	Yes	Yes	Yes	Yes	Infinite
Shape	Yes				
Lightness					
Saturation					
Hue					
Angle					
Texture					



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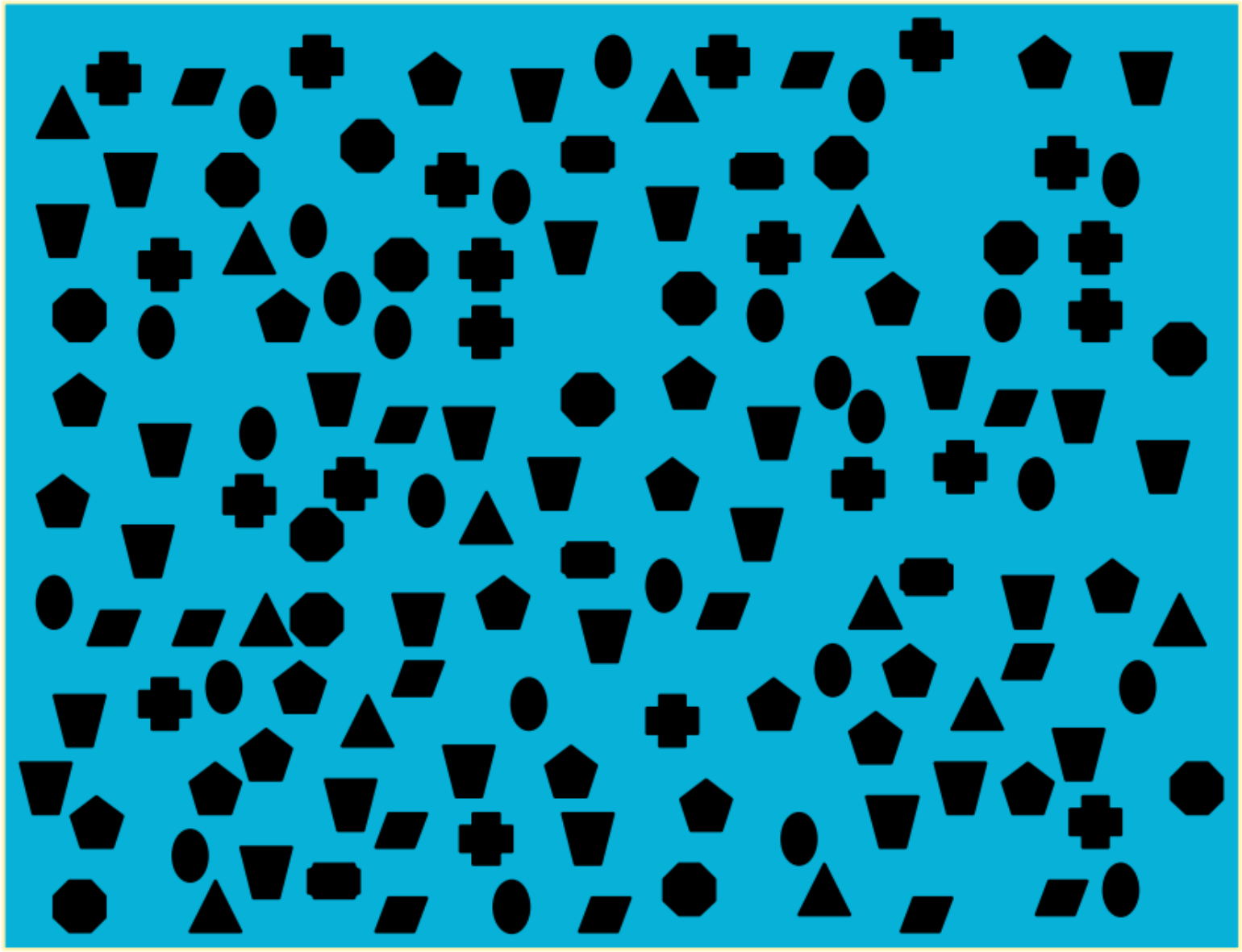
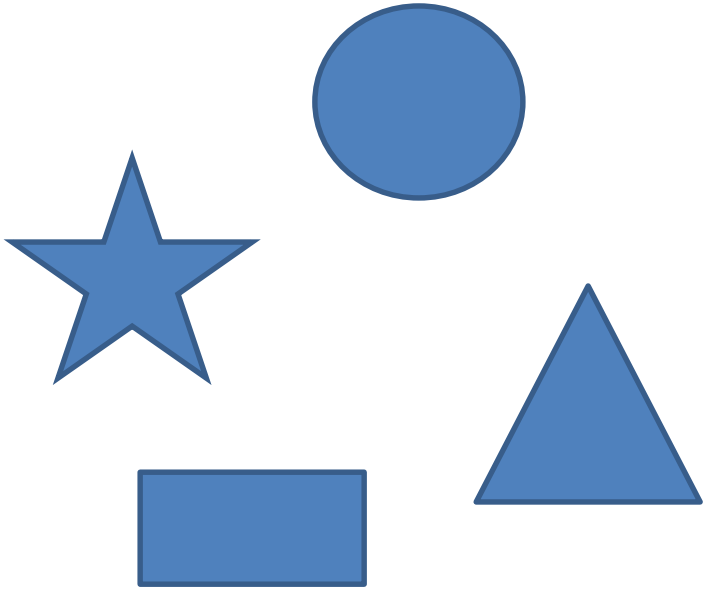
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	Yes	Yes			
Lightness					
Saturation					
Hue					
Angle					
Texture					



Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5			
Lightness					
Saturation					
Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5			
Lightness					
Saturation					
Hue					
Angle					
Texture					



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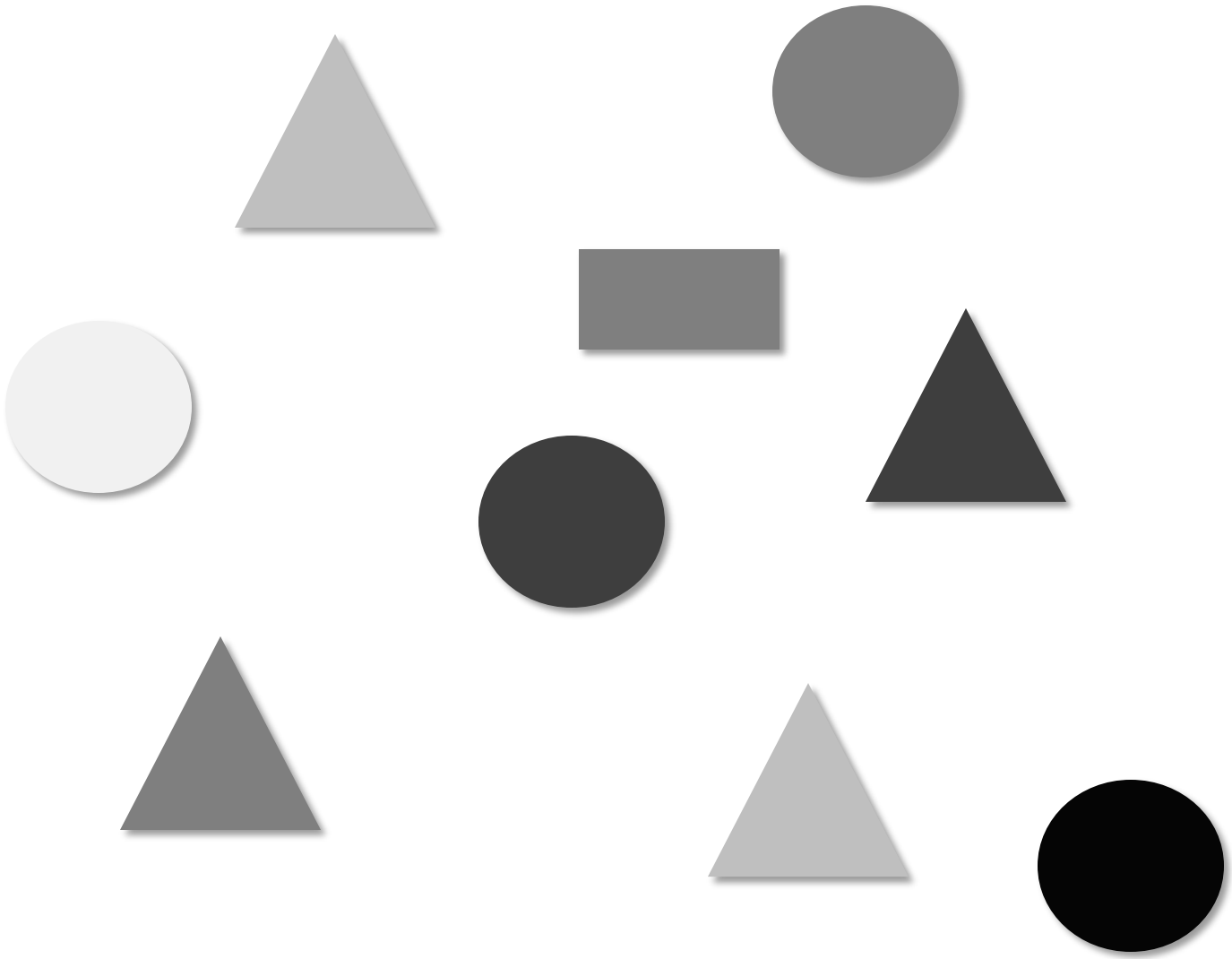
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	
Lightness					
Saturation					
Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	~~5/20~~
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness					
Saturation					
Hue					
Angle					
Texture					

Theoretically infinite

Lightness

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness					
Saturation					
Hue					
Angle					
Texture					



Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes				
Saturation					
Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
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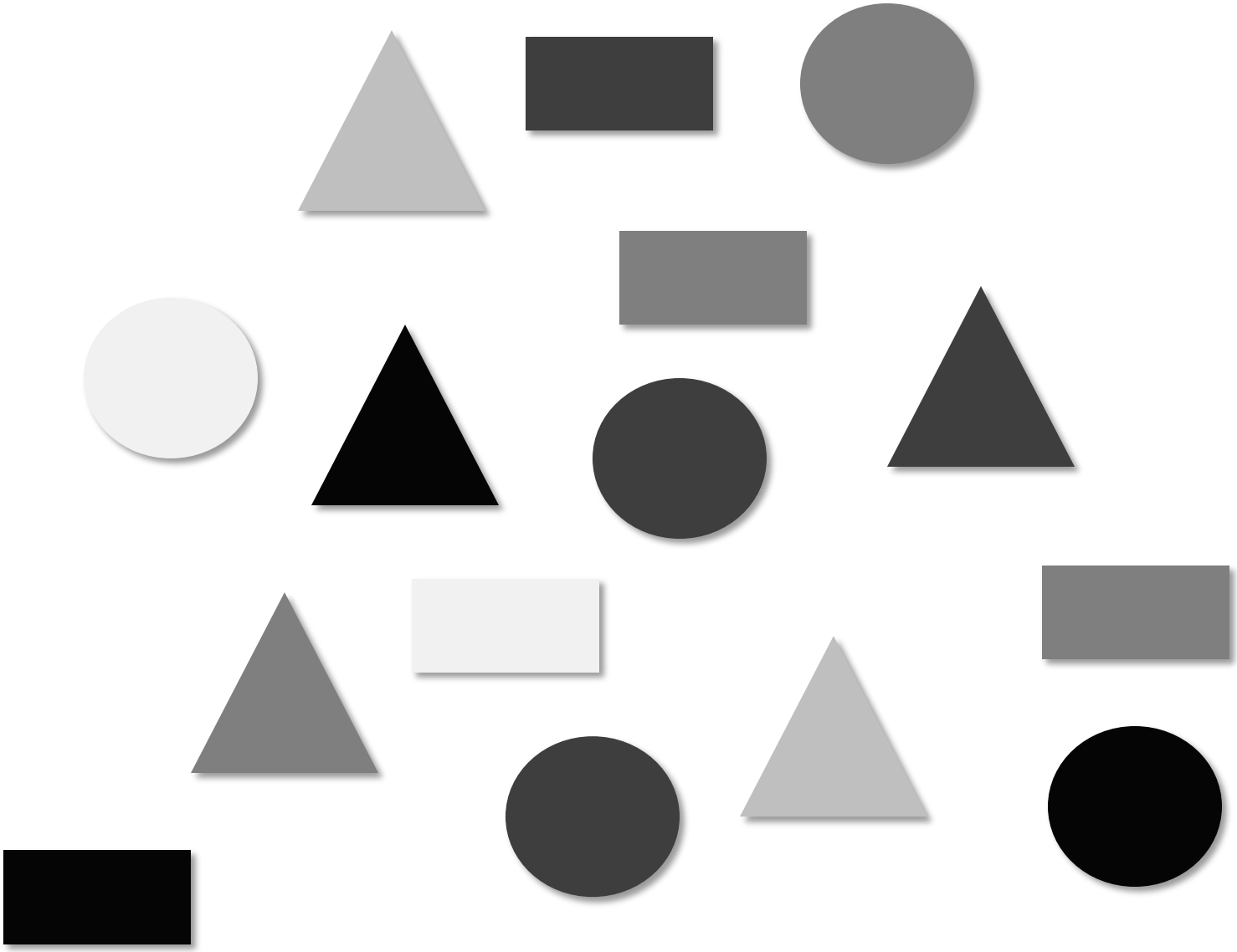
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes				
Saturation					
Hue					
Angle					
Texture					



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Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes			
Saturation					
Hue					
Angle					
Texture					

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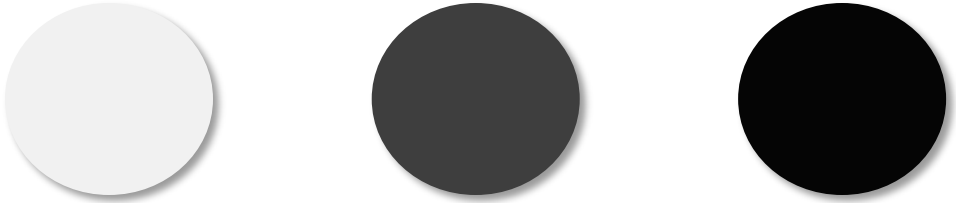
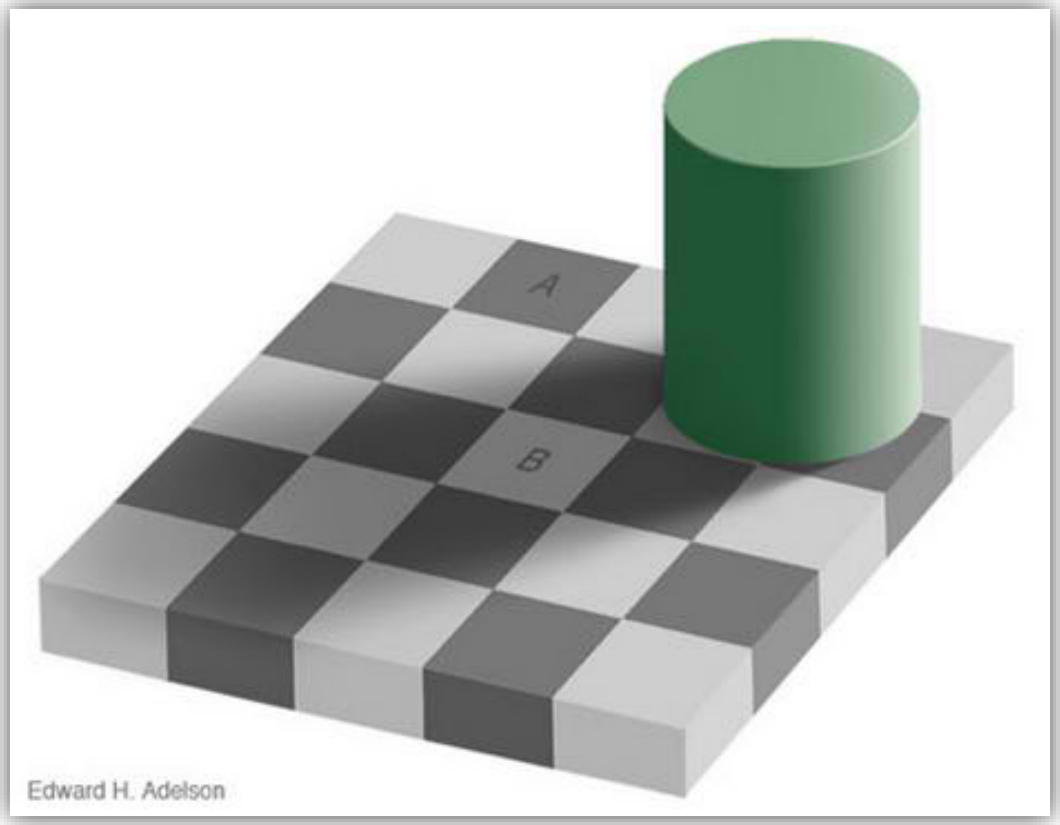
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes			
Saturation					
Hue					
Angle					
Texture					

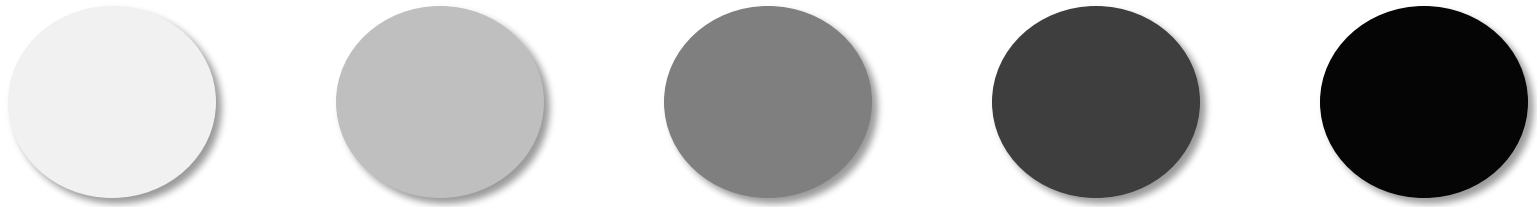




Weber's Law: human perception is fundamentally based on relative judgments, not absolute values.

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No		
Saturation					
Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No		
Saturation					
Hue					
Angle					
Texture					



Variable	Selective	Associative	Quantitative	Order	Length
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Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No	Yes	
Saturation					
Hue					
Angle					
Texture					

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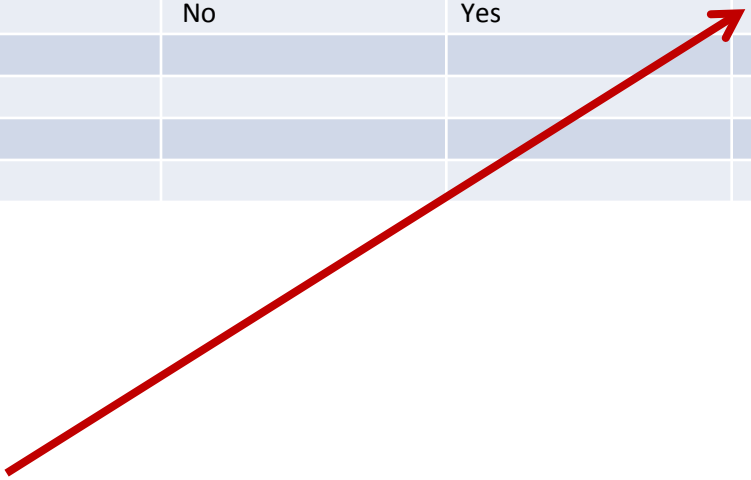
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No	Yes	7 / 10
Saturation					
Hue					
Angle					
Texture					



Theoretically infinite

Saturation (same as Lightness)

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No	Yes	7 / 10
Saturation	Yes	Yes	No	Yes	7 / 10
Hue					
Angle					
Texture					

Hue

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No	Yes	7 / 10
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Hue					
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
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Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes				
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
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Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes				
Angle					
Texture					

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Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes	Yes			
Angle					
Texture					

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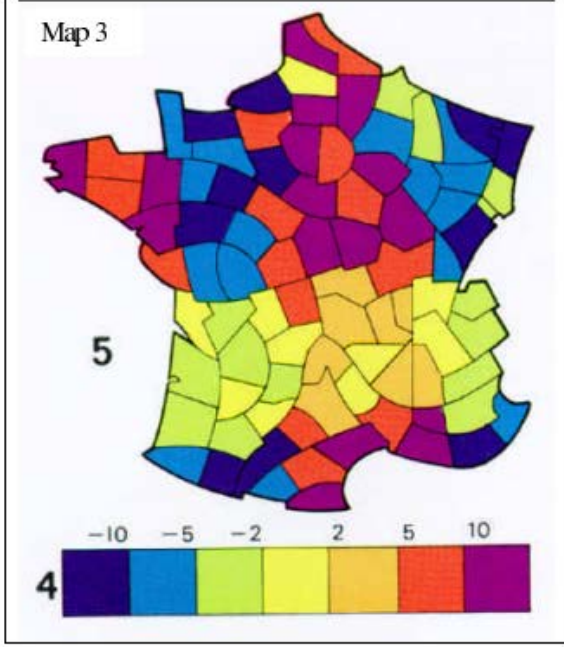
Lightness	Yes	Yes	No	Yes	7 / 10
Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes	Yes			
Angle					
Texture					

Rainbow Scale Considerations

Map 1

Map 3

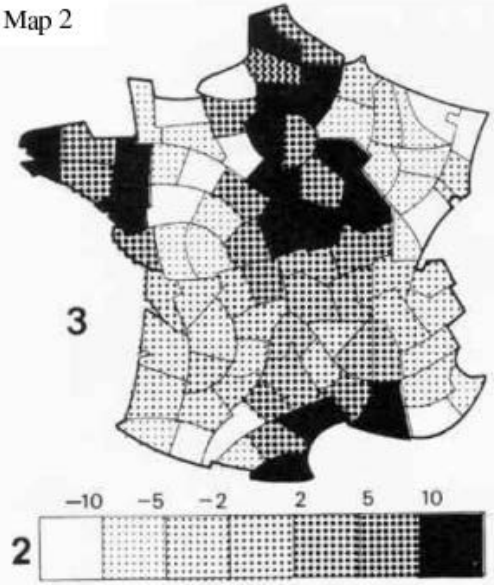


Rainbow Scale Considerations

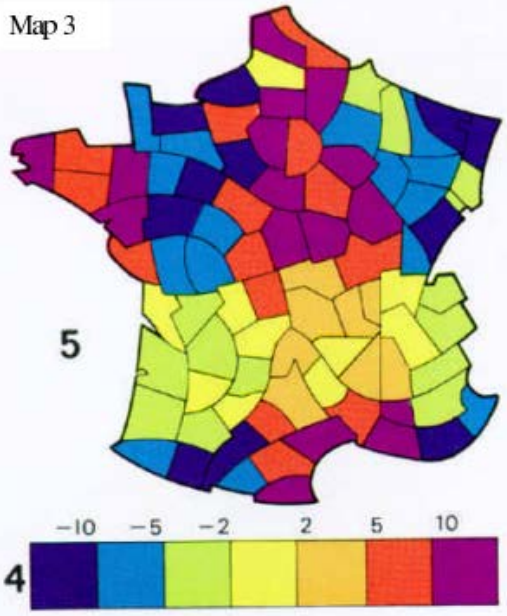
Map 1

1

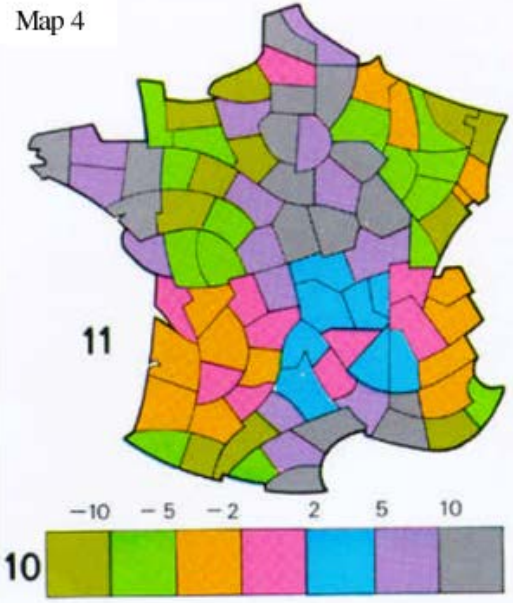
Map 2

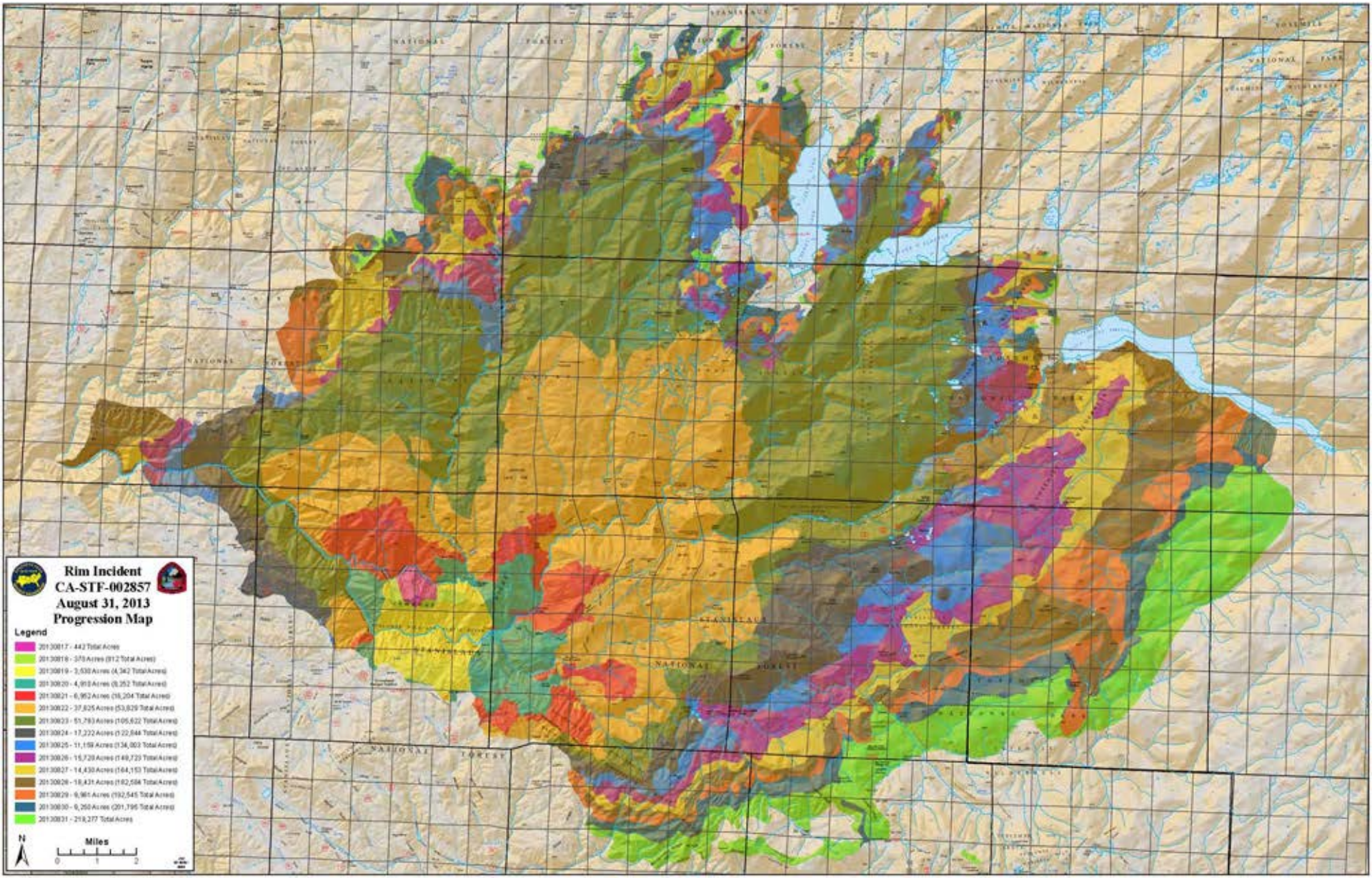


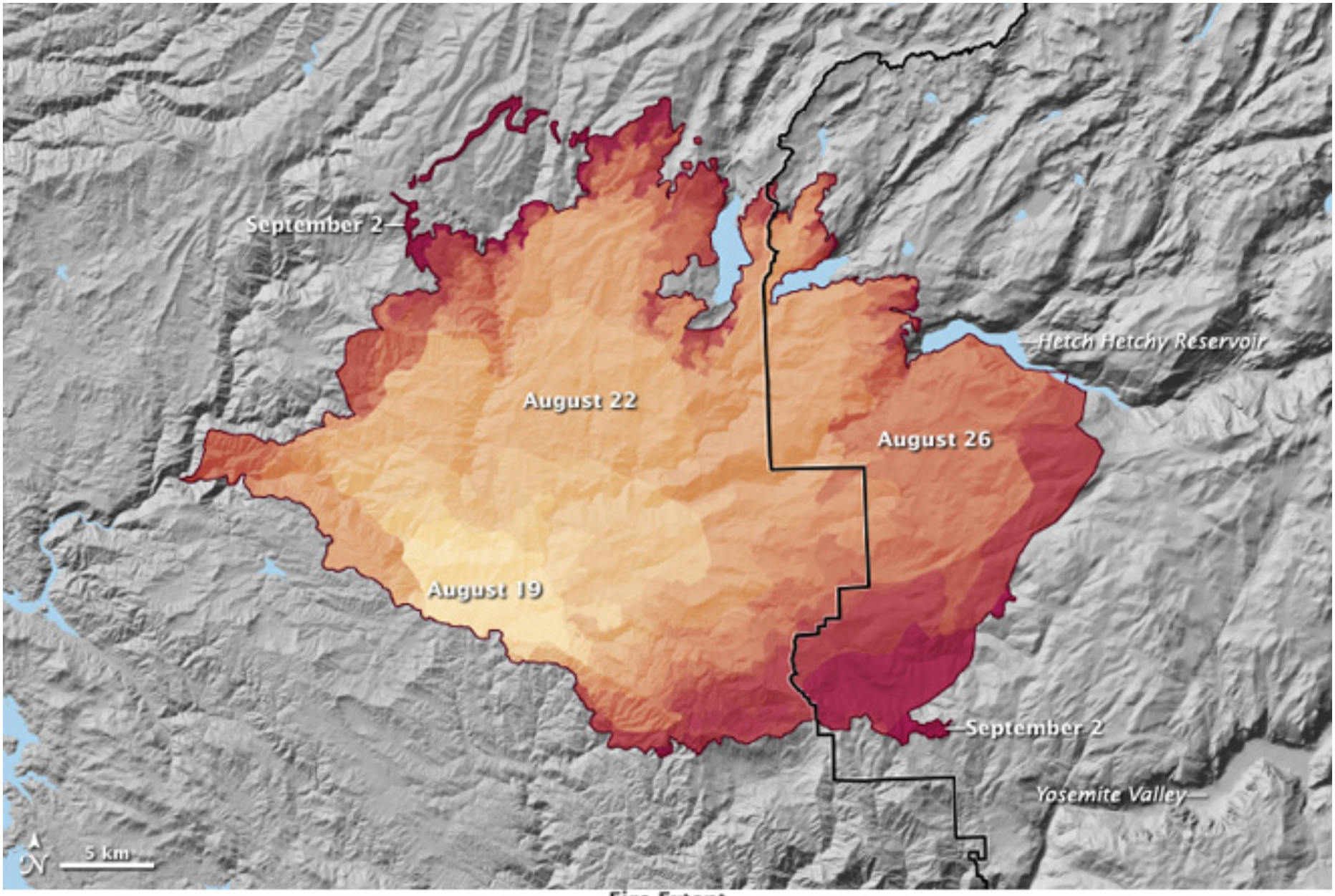
Map 3



Map 4




Rim Incident
CA-STF-002857
August 31, 2013
Progression Map
Legend
20130817 - 442 Total Acres
20130818 - 370 Acres (812 Total Acres)
20130819 - 3,530 Acres (4,342 Total Acres)
20130820 - 4,910 Acres (9,252 Total Acres)
20130821 - 6,952 Acres (16,204 Total Acres)
20130822 - 37,625 Acres (53,829 Total Acres)
20130823 - 51,793 Acres (105,622 Total Acres)
20130824 - 17,222 Acres (122,844 Total Acres)
20130825 - 11,159 Acres (134,003 Total Acres)
20130826 - 15,720 Acres (149,723 Total Acres)
20130827 - 14,430 Acres (164,153 Total Acres)
20130828 - 18,431 Acres (182,584 Total Acres)
20130829 - 9,961 Acres (192,545 Total Acres)
20130830 - 9,250 Acres (201,795 Total Acres)
20130831 - 219,277 Total Acres
N
Miles
0
1
2


September 2
August 22
August 26
August 19
Hetch Hetchy Reservoir
September 2
Yosemite Valley
N
5 km
Fire Extent
August 19
August 26
September 2

Destroys Detail

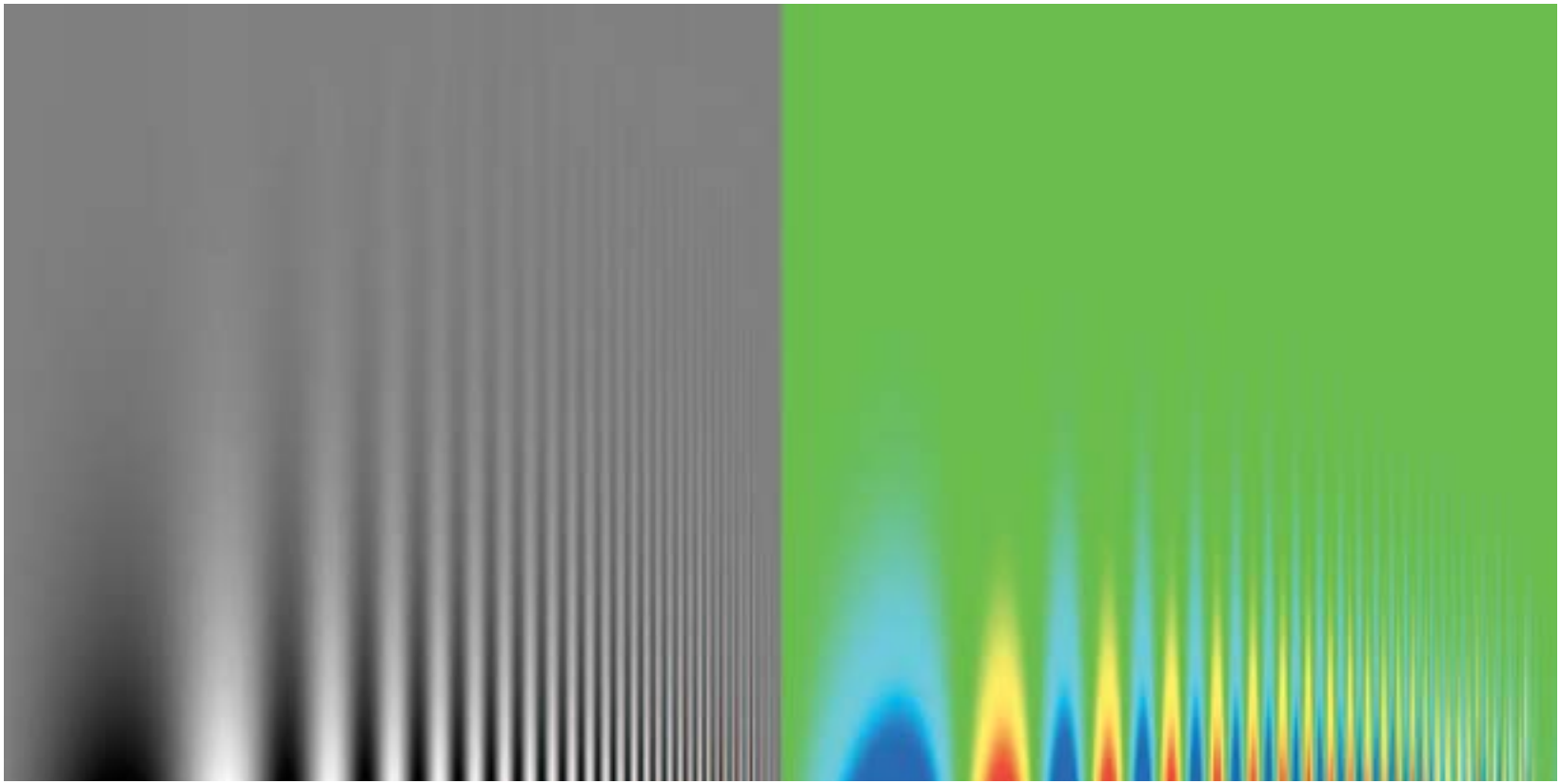


Image from *Borland & Taylor II (2007), Rainbow Color Map (Still) Considered Harmful. IEEE Visualization Viewpoints, pp 14-17.*

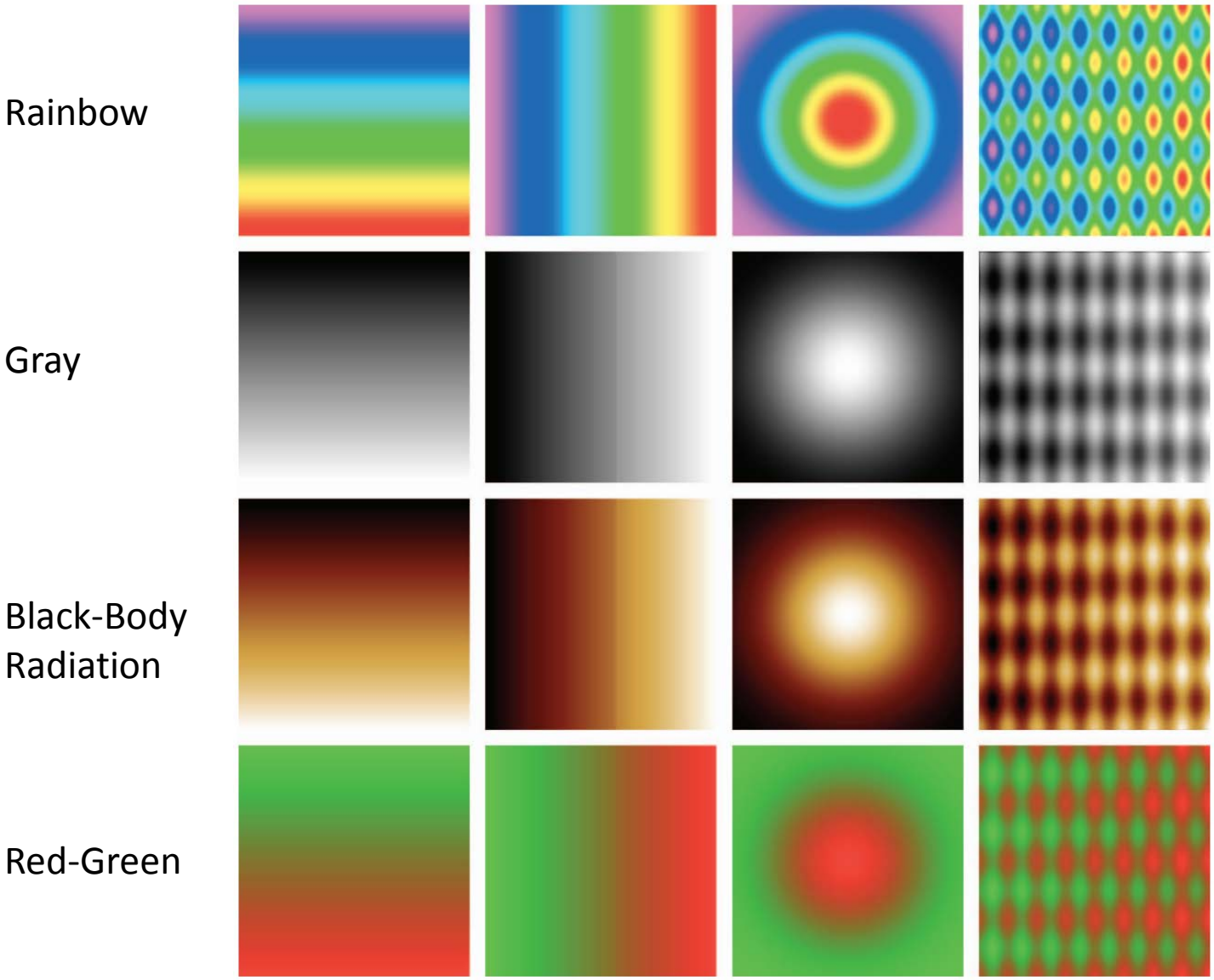


Image from *Borland & Taylor II (2007), Rainbow Color Map (Still) Considered Harmful. IEEE Visualization Viewpoints, pp 14-17.*

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No	Yes	7 / 10
Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes	Yes	Not advisable	Not advisable	
Angle					
Texture					

Variable	Selective	Associative	Quantitative	Order	Length
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Angle

Variable	Selective	Associative	Quantitative	Order	Length
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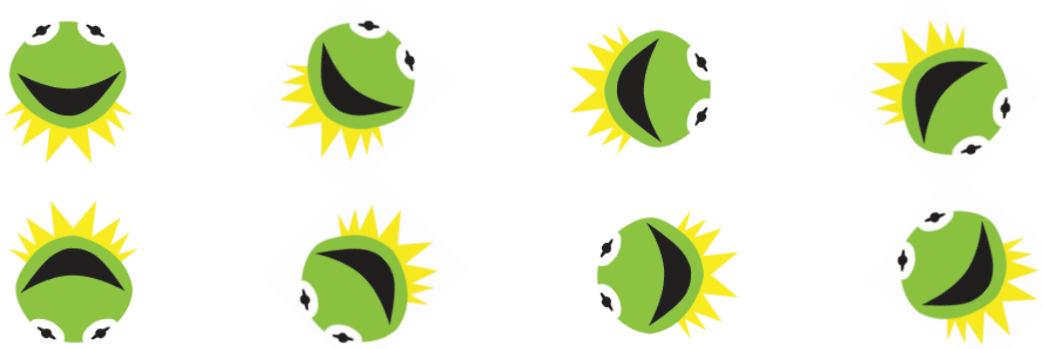
Angle					
Texture					



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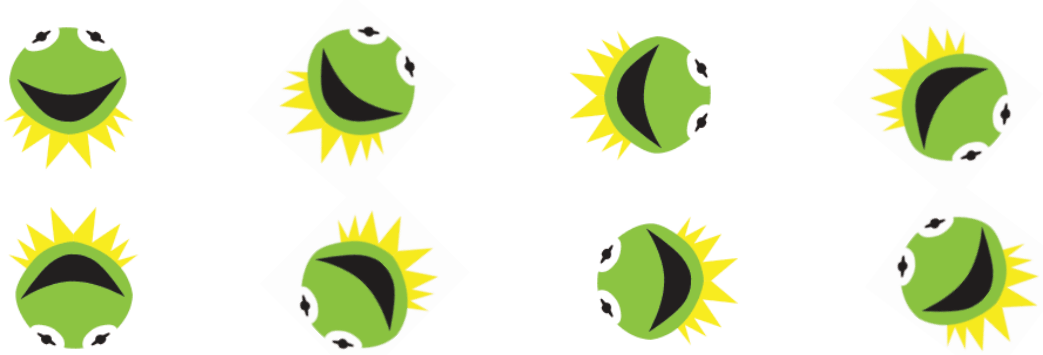
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No	Yes	7 / 10
Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes	Yes	Not advisable	Not advisable	7 / 10
Angle	Yes	Yes	No	No	4 / 8
Texture					



Texture (mostly same as Hue)

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
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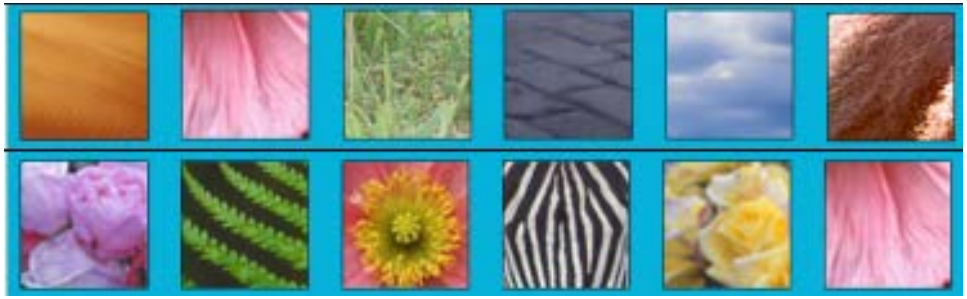
Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes	Yes	Not advisable	Not advisable	7 / 10
Angle	Yes	Yes	No	No	4 / 8
Texture					



Angle (mostly same as Hue)

Variable	Selective	Associative	Quantitative	Order	Length
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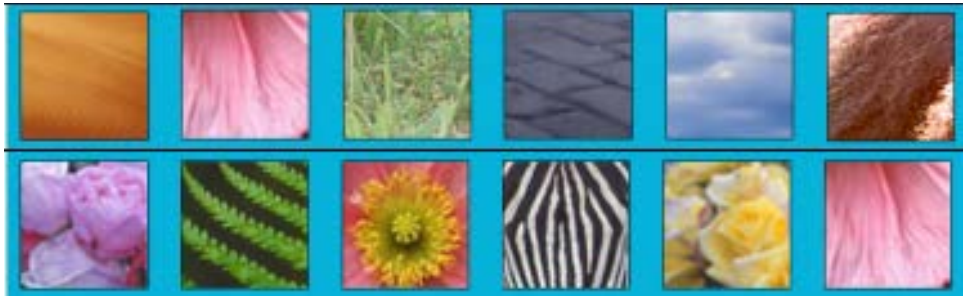
Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes	Yes	Not advisable	Not advisable	7 / 10
Angle	Yes	Yes	No	No	4 / 8
Texture	Yes	Yes	No	No	Infinite



M.S.T. Carpendale. **Considering Visual Variables as a Basis for Information Visualisation**. Research report 2001-693-16, Department of Computer science, University of Calgary, 2003.

Plan for Today

- 9:00 Intro
- 9:30 Visual Variables
- 10:15 Break
- 10:30 Sketching
- 11:30 Vis Software & Tools
- 12:00 Lunch
- 1:00 Tableau
- 2:30 Break
- 3:30 Vis in the Library & Professional Practice
- 4:00 Work with Data

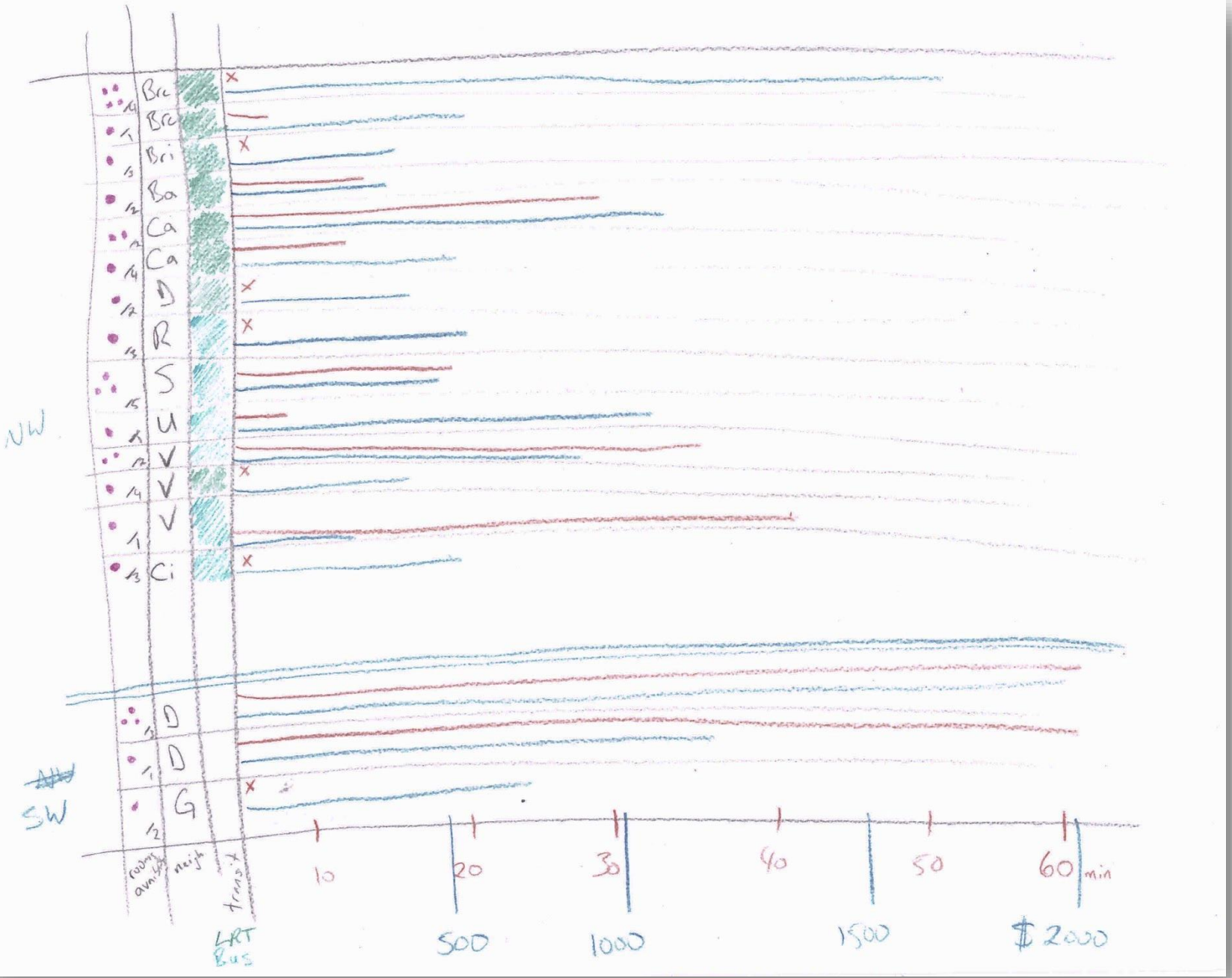
http://bit.ly/tfdlvis

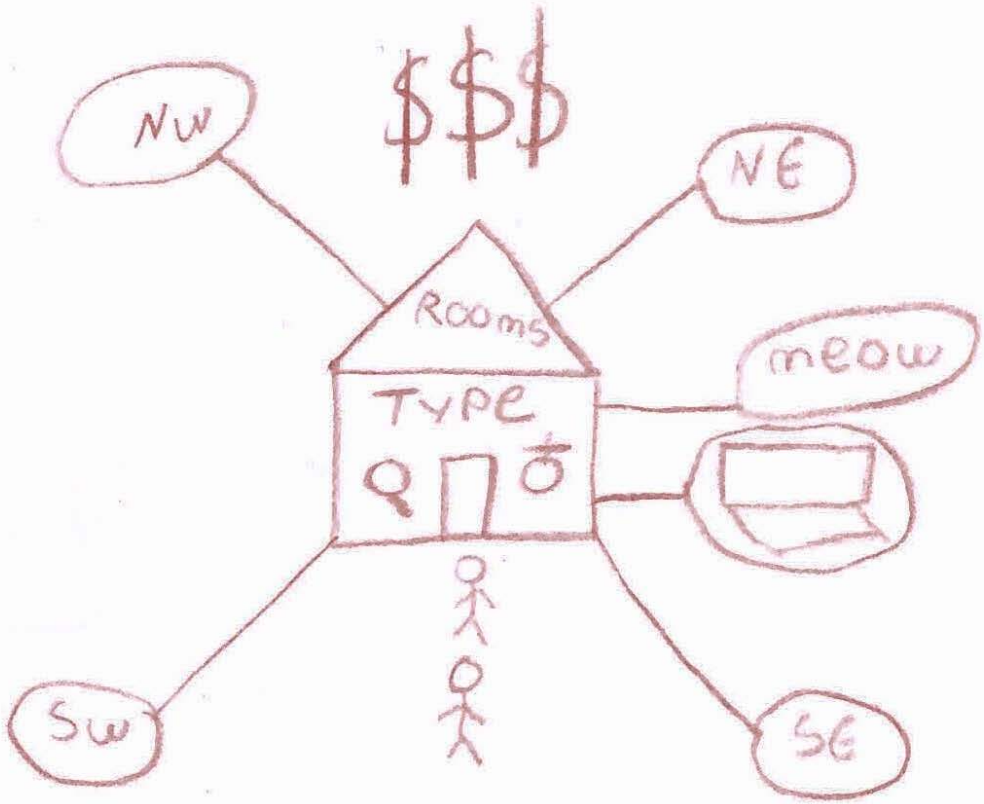
Sketching Exercise

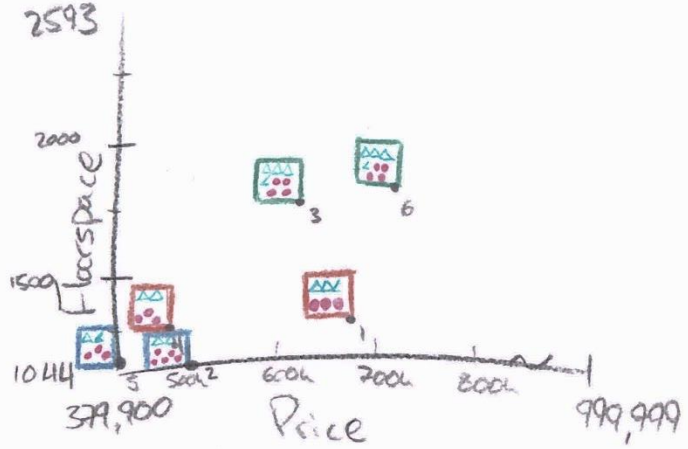
- Create a visualization

- Anything you want
  - What interests you in the data?
  - What questions do you have?

- *Challenge*: Try to encode as many properties as possible in your visualization.


NW
SW
Brc
Brc
Bri
Ba
Ca
Ca
D
R
S
U
V
V
V
Ci
D
D
G
rooms available
neighbourhood
transit
LRT Bus
10
20
30
40
50
60 min
500
1000
1500
$2000

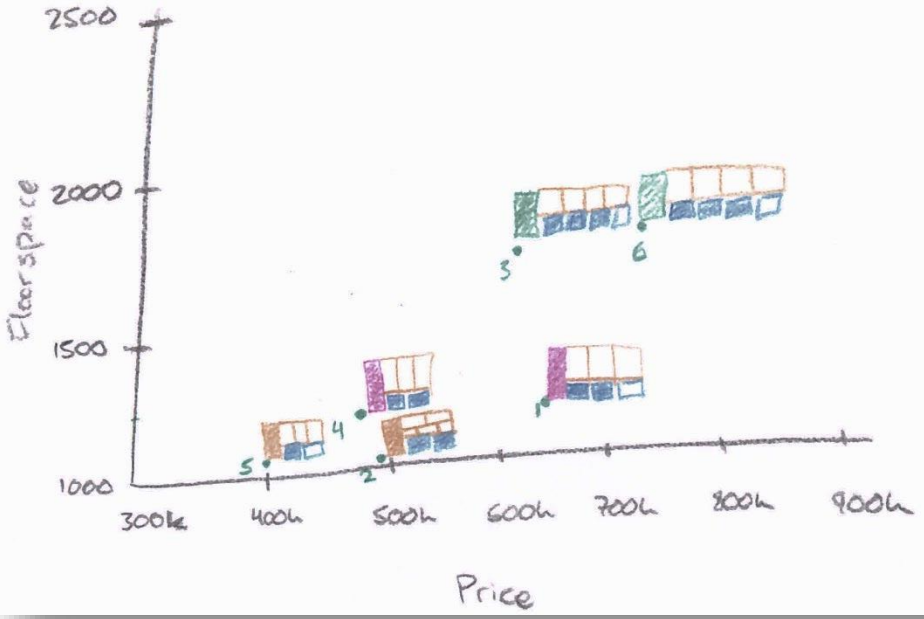

$$$
NW
NE
Rooms
meow
TYPE
SW
SE

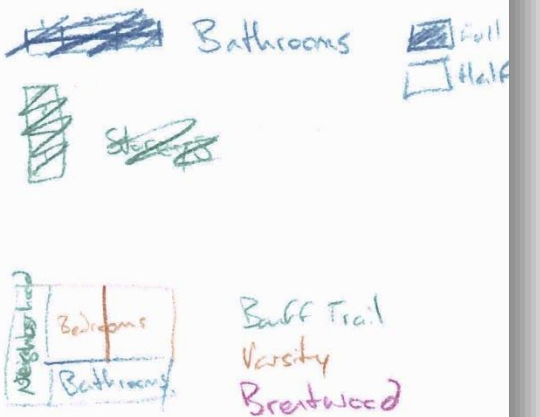


Banff Trail
Varsity
Brentwood

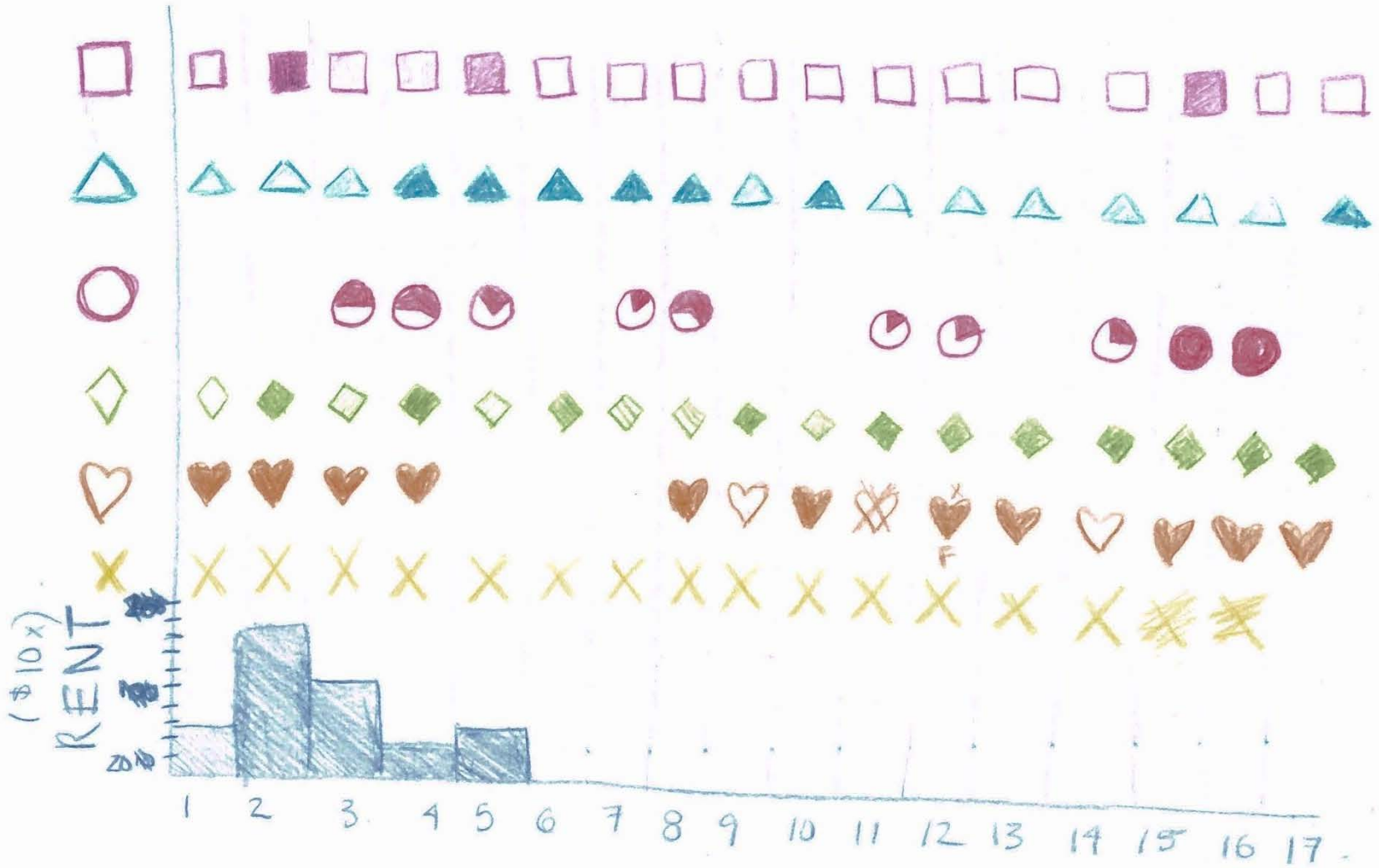
△ Bath ∠ Half Bath

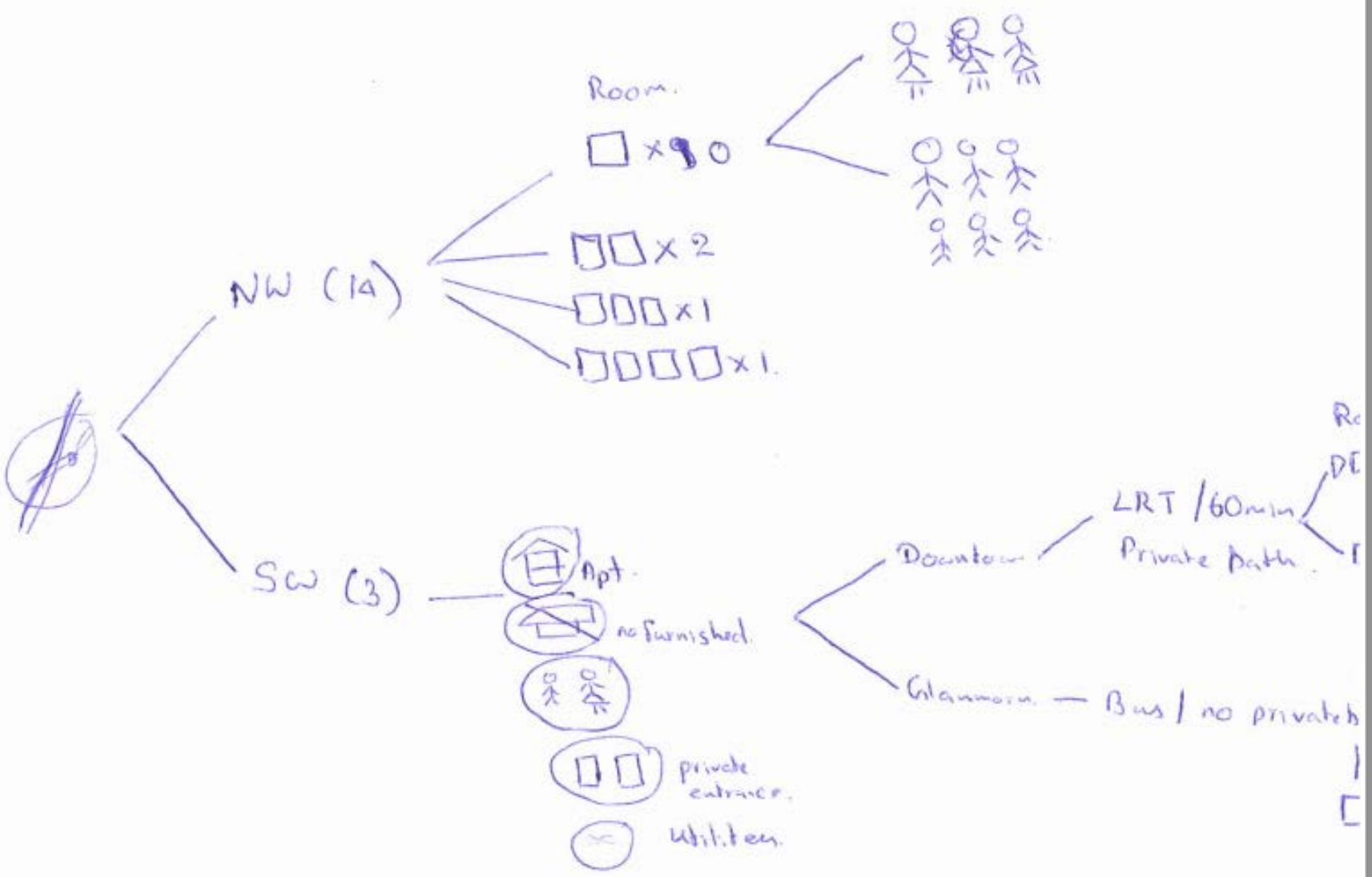
● Bedroom



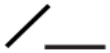


Banff Trail
Varsity
Brentwood


RENT
($10x)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17


Room.
NW (14)
SW (3)
Apt.
no furnished.
private entrance.
Utilities.
Downtown
LRT / 60min
Private bath.
Glammorn.
Bus / no private

Variable	Selective	Associative	Quantitative	Order	Length
Size	Yes	Yes	Yes (1D), Mostly (2D), Not likely (3D)	Yes	5/20
Position	Yes	Yes	Yes	Yes	Infinite
Shape	< 5	< 5	No	No	5 / Infinite
Lightness	Yes	Yes	No	Yes	7 / 10
Saturation	Yes	Yes	No	Yes	7 / 10
Hue	Yes	Yes	Not advisable	Not advisable	7 / 10
Angle	Yes	Yes	No	No	4 / 8
Texture	Yes	Yes	No	No	Infinite

Example	Encoding	Ordered	Useful Values	Quantitative	Ordinal	Categorical
	Position, Placement	Yes	Infinite	Good	Good	Good
1, 2, 3; A, B, C	Text Labels	Optional (alphabetic/ numbered)	Infinite	Good	Good	Good
	Length	Yes	Many	Good	Good	
	Size, Area	Yes	Many	Good	Good	
	Angle	Yes	Medium/ Few	Good	Good	
	Pattern Density	Yes	Few	Good	Good	
	Weight, Boldness	Yes	Few		Good	
	Saturation, Brightness	Yes	Few		Good	
	Color	No	Few (<20)			Good
	Shape, Icon	No	Medium			Good
	Pattern, Texture	No	Medium			Good
	Enclosure, Connection	No	Infinite			Good

Closing Thought on Visual Variables

- Why is this useful?
  - Any software tool will use these variables
- Exercise useful even if design not implemented
  - Understanding
  - Quality Checking/Assurance

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