Visual Variables

SWEN422
Human Computer Interaction
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SWEN 422 – Lecture Schedule

- ~~Week 6 – Information Visualization~~
- Week 7 – Information Visualization
- Week 8 – Information Visualization
- Week 9 – Gestural Interfaces
- Week 10 - AR/VR
- Week 11 - AR/VR
- Week 12 - no lectures (work on project)

https://ecs.wgtn.ac.nz/Courses/SWEN422_2024T1/LectureSchedule

Assignment 2

- Essay
- Review one paper
- Topics:
  - Information Visualization
  - Gestural Interfaces
  - AR/VR
- Length: 3 pages
- Assessment Weighting: **30%** (Updated)
- Due: **2359 Friday 17 May**

https://ecs.wgtn.ac.nz/Courses/SWEN422_2024T1/Assignment2

Assignment 3

- Design (e.g. personas, paper, Figma) and Develop visualizations (e.g. D3 / Unity / Unreal)
- x3 visualizations minimum
- Work in teams 2-4 people
  - Team Signup by **2359 Friday 26 April**
- No individuals
- Data set: COVID-19
- Assessment Weighting: **40%** (Updated)
- Due: **2359 Friday 14 June**

https://ecs.wgtn.ac.nz/Courses/SWEN422_2024T1/Assignment3

Assignment 3 Rubric

- **Team Project Code Grade: 15%**
  - Visualizations (60%)
  - Code Base (20%)
  - Video (20%)
- **Individual Final Report Grade: 25%**
  - Written Communication (25%)
  - Key Design Decisions (25%)
  - Justifications / Alternative Designs (25%)
  - Development Tools Critique (25%)

https://ecs.wgtn.ac.nz/Courses/SWEN422_2024T1/Assignment3

Visual Variables

- What are visual variables?
- Why do they matter?

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

- Based on Bertin's visual variables, 1967.

How Do We Visualize?

- **Know** the Data:
  - Number of attributes
  - Weather: *date/time, temperature, precipitation, humidity, wind, forecast, pressure, cloud cover.*
  - Real Estate: *price, location, square feet, lot size, floors, # bathrooms, # bedrooms, etc.*
- Decide how to **visually encode** the data
  - Requires awareness of:
    - Human perceptual system
    - Display capacity
    - Characteristics of data (size, type)
    - Task

Visual Encoding - Data

Data Types:

- Categorical

- Ordered
  - Ordinal
  - Quantitative

Small Medium Large

1 2 5.29 42 101

Visual Encoding

Visual Channels:

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

Size

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

Colour

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

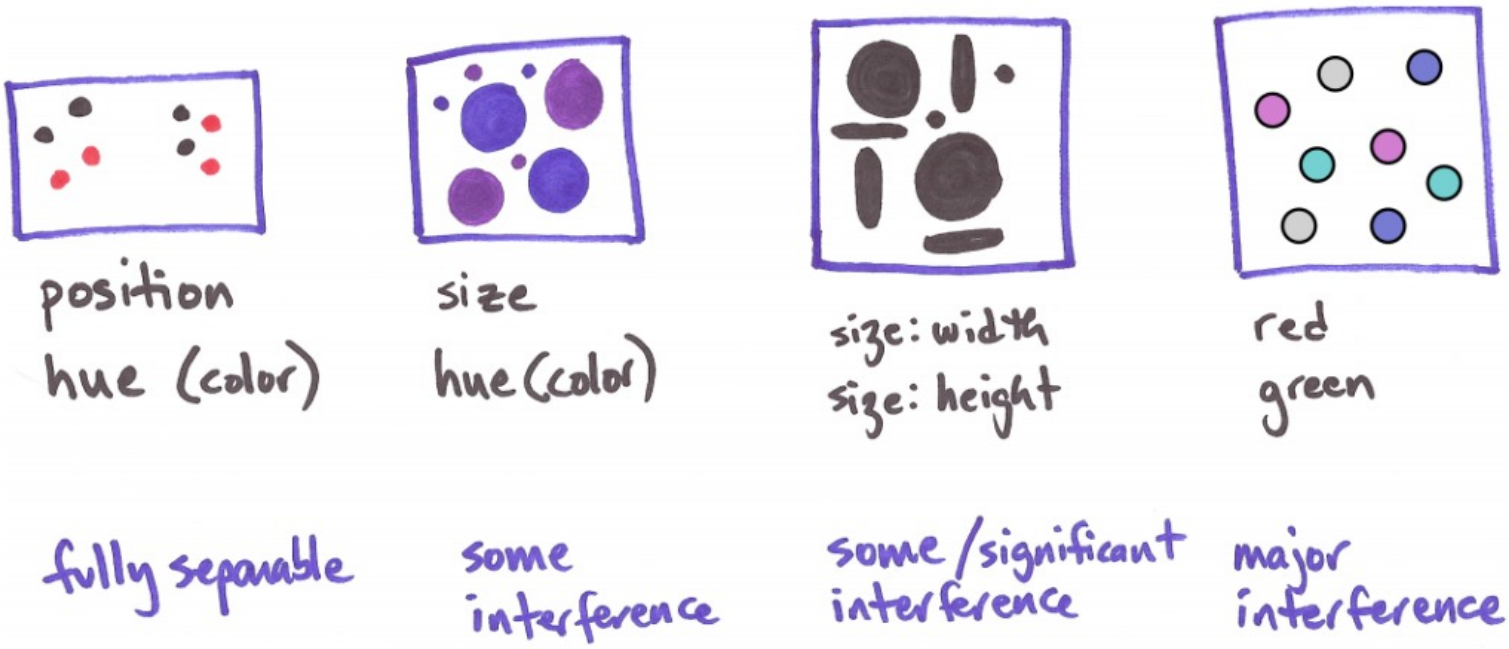
Independent?

?

- *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 **Visual Channel** ***Size*** Selective?

Can you find the big & small Muppets?

Is **Visual Channel** ***Size*** Selective?

Can you find the big & small Muppets?

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 **Visual Channel** ***Size*** Associative?

Can you find the small Muppets?

Is **Visual Channel** ***Size*** Associative?

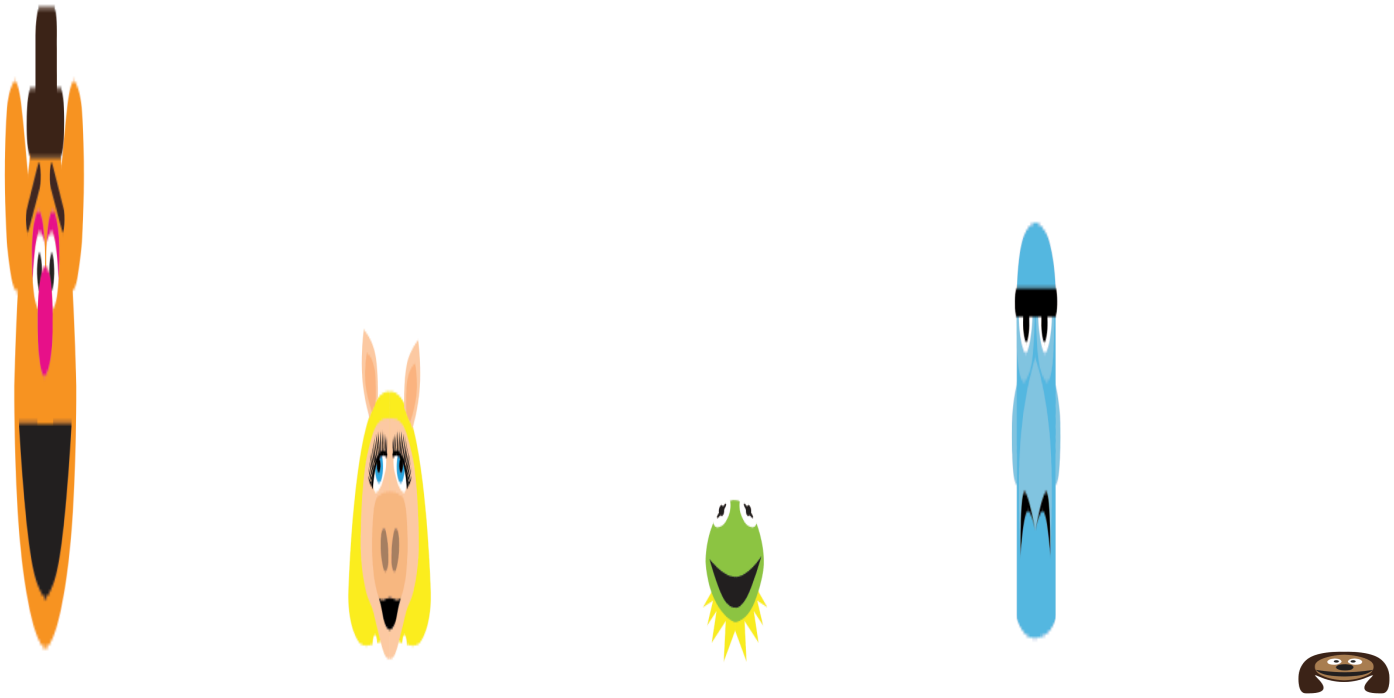
Can you find the small Muppets?

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 **Visual Channel** ***Size*** Quantitative?

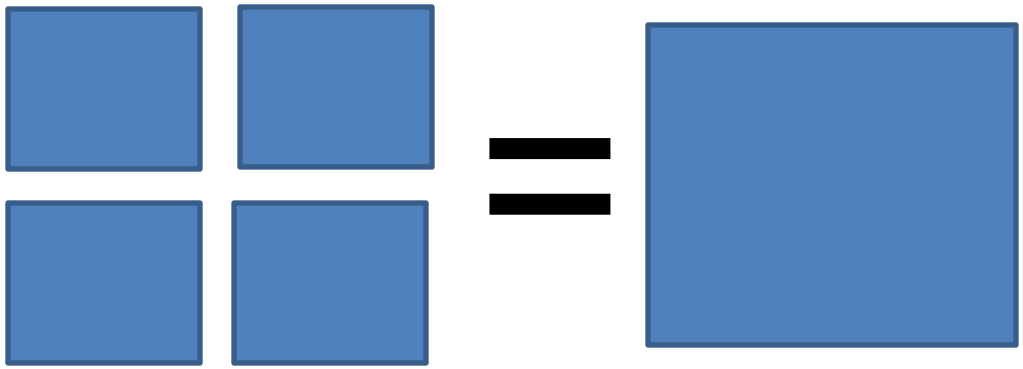
What value is Kermit compared to Fozzie?

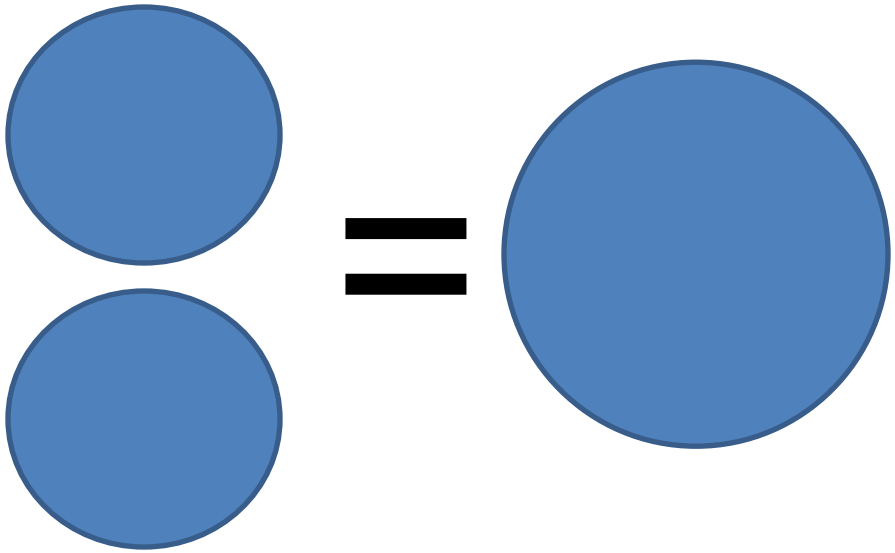


Is **Visual Channel** ***Size*** Quantitative?

What value is Kermit compared to Fozzy?

Is **Visual Channel** ***Size*** Quantitative?





Visual Variable Properties

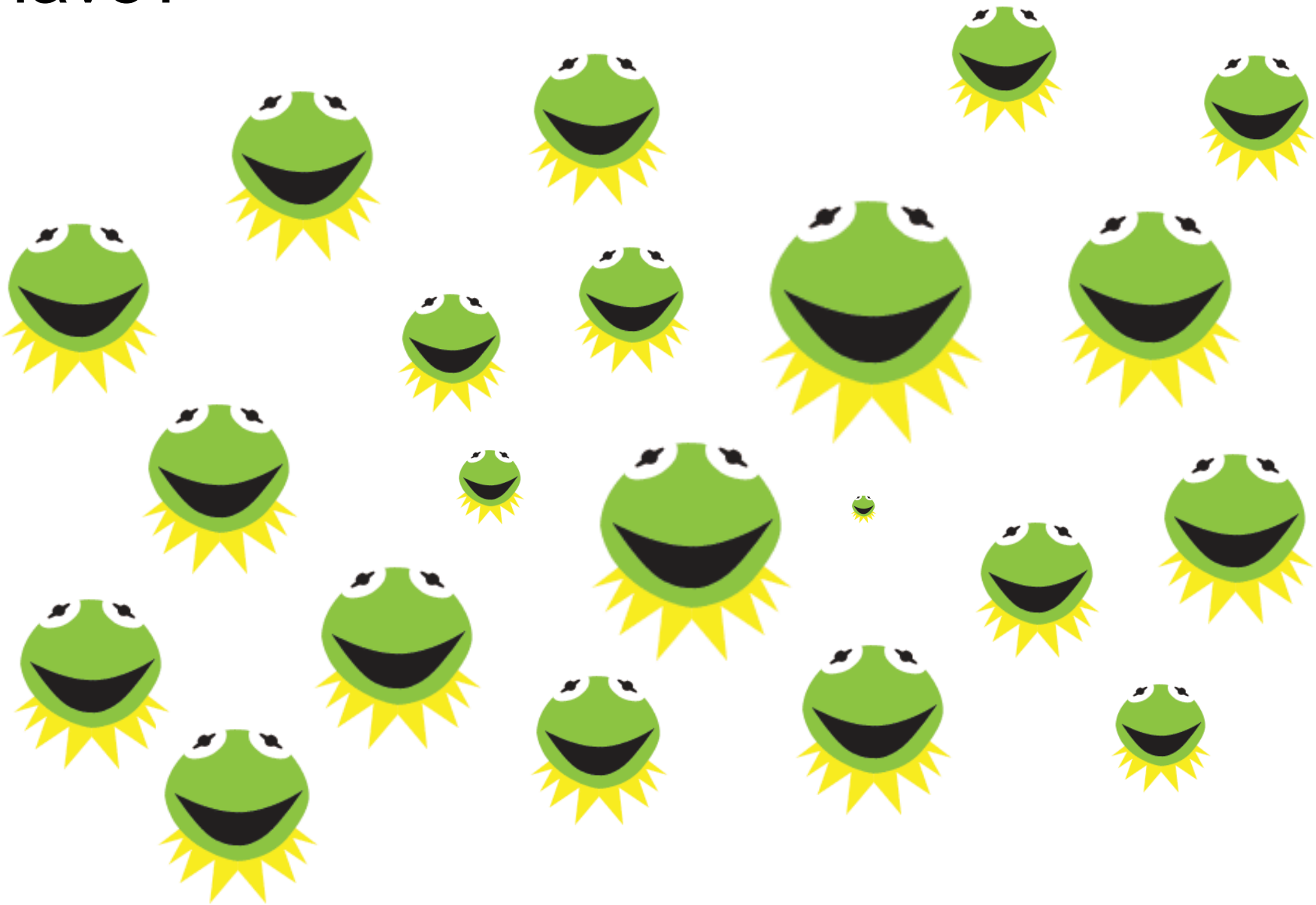
1. **Selective**
   - Is a change of a mark in this variable alone enough to allow us to select it from other marks?
2. **Associative**
   - Can we identify a group of marks in this variable?
3. **Quantitative**
   - Can the relation between two of these marks be seen as numeric? Can we tell if one is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

Is **Visual Chanel** ***Size*** Ordered?

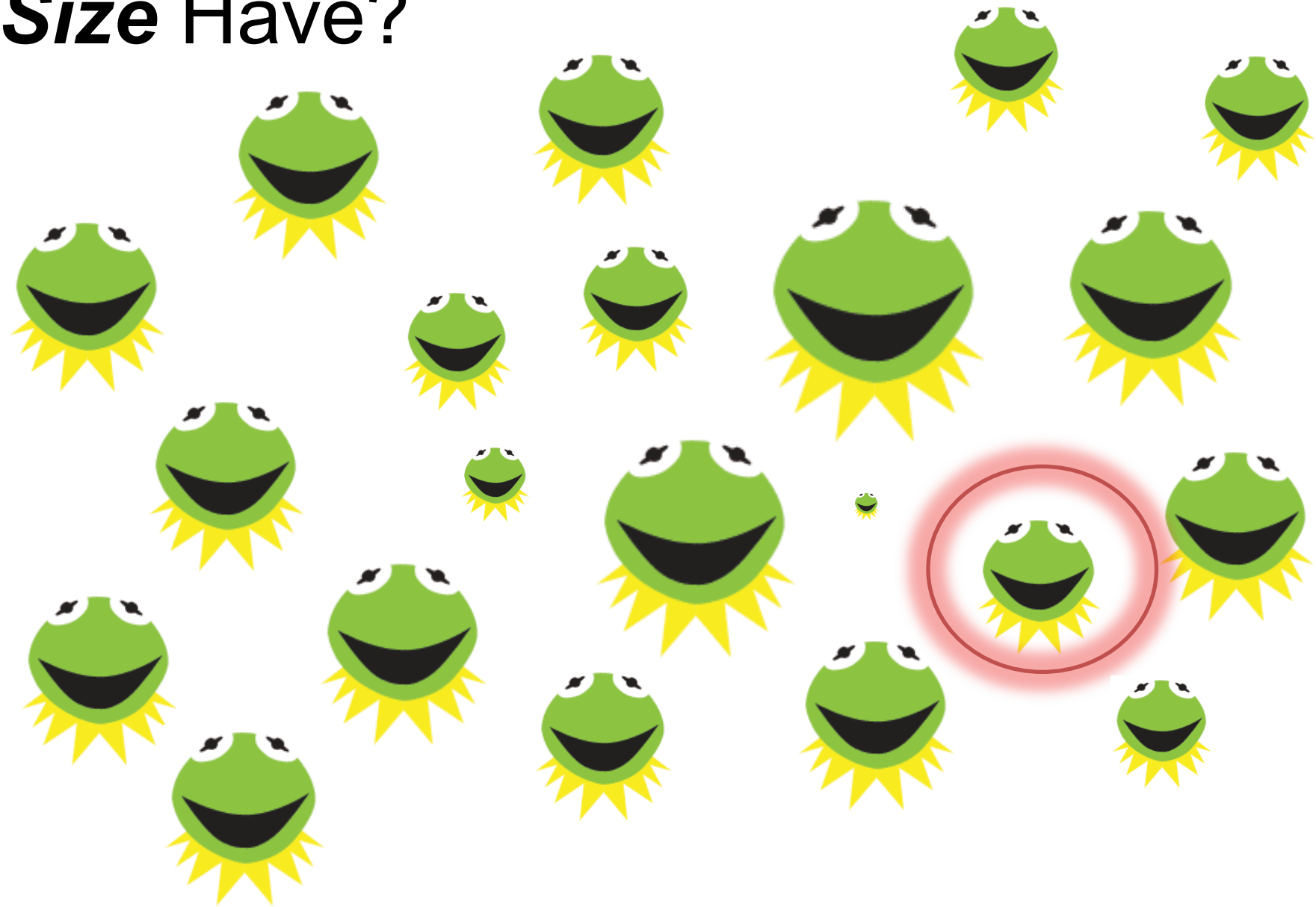
Visual Variable Properties

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 **Visual Chanel** ***Size*** Have?

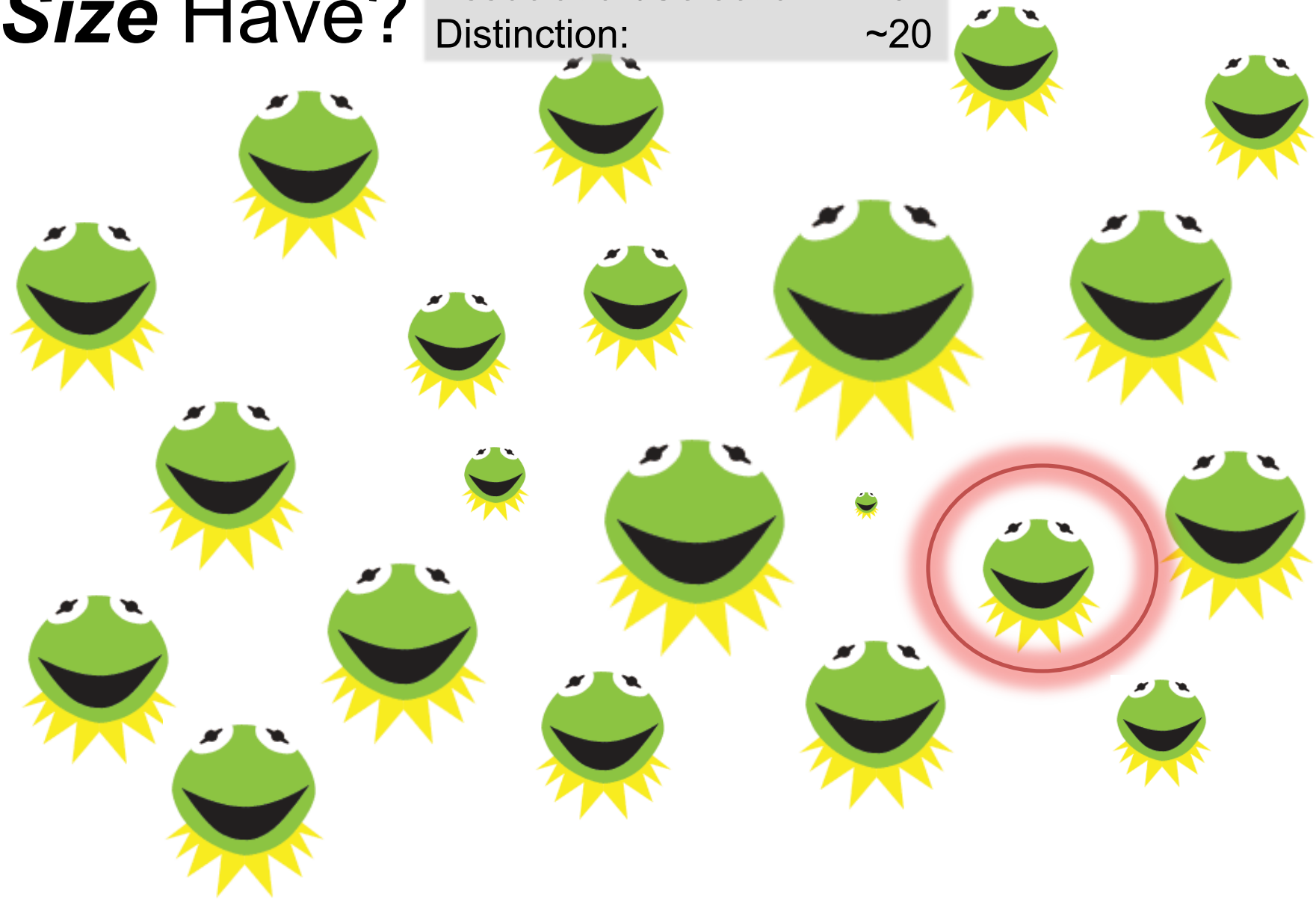


What Length Does **Visual Chanel** ***Size*** Have?



What Length Does **Visual Chanel** ***Size*** Have?

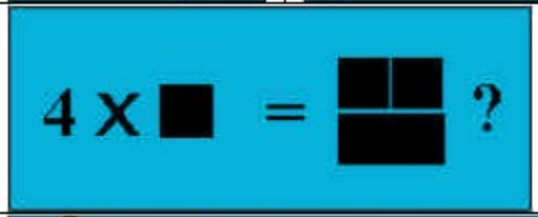
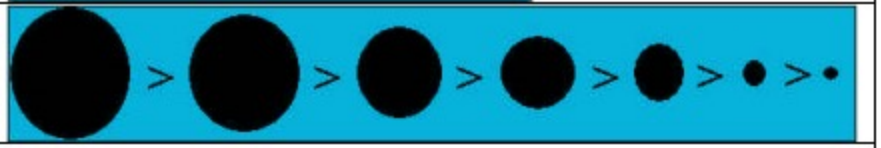
Association/Selection: ~5
Distinction: ~20



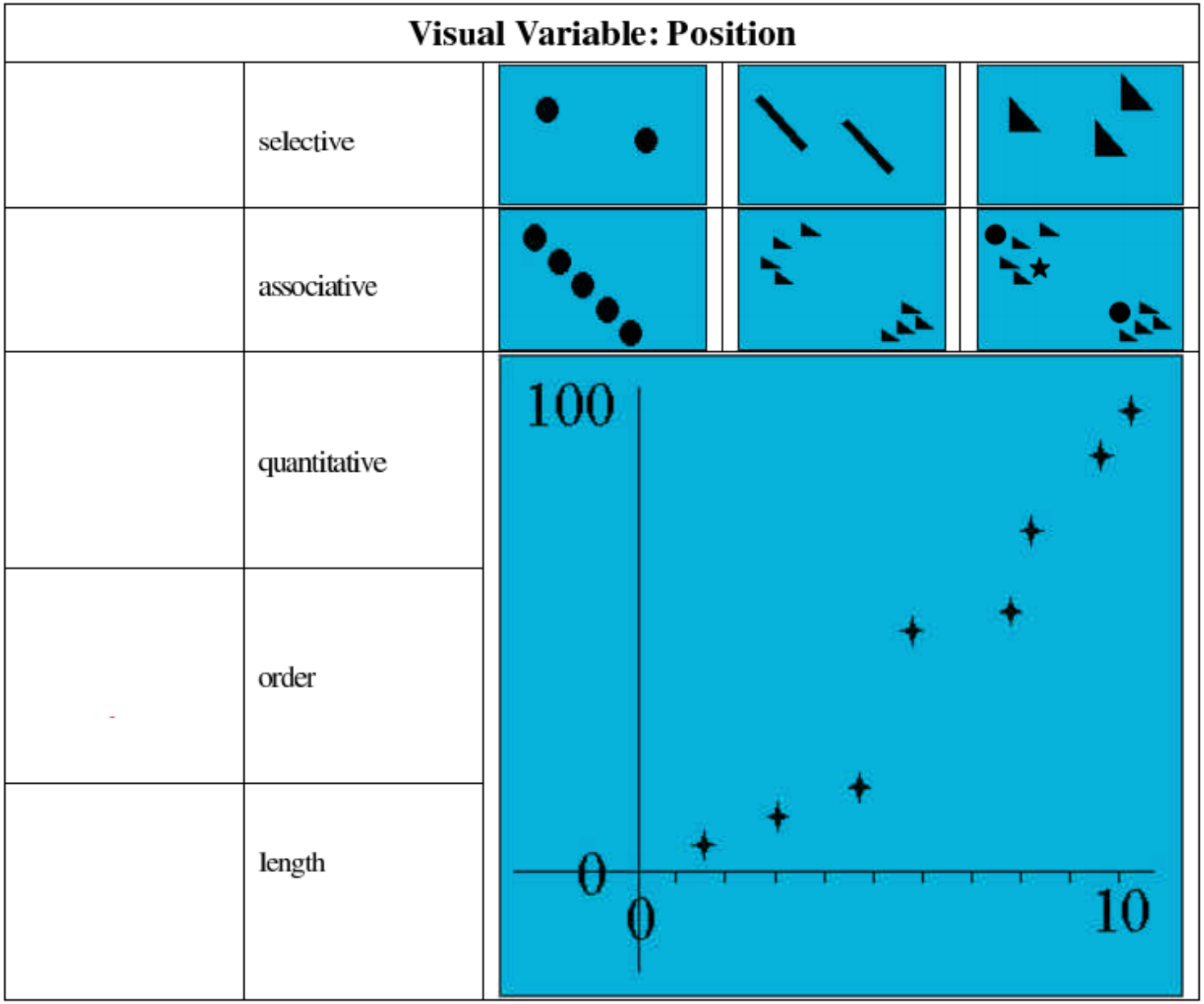
Visual Variable Properties

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

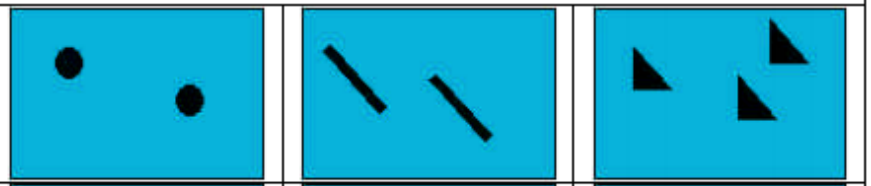
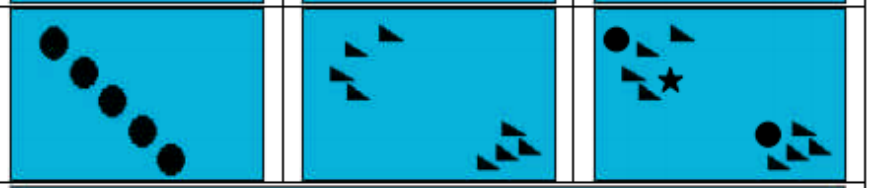
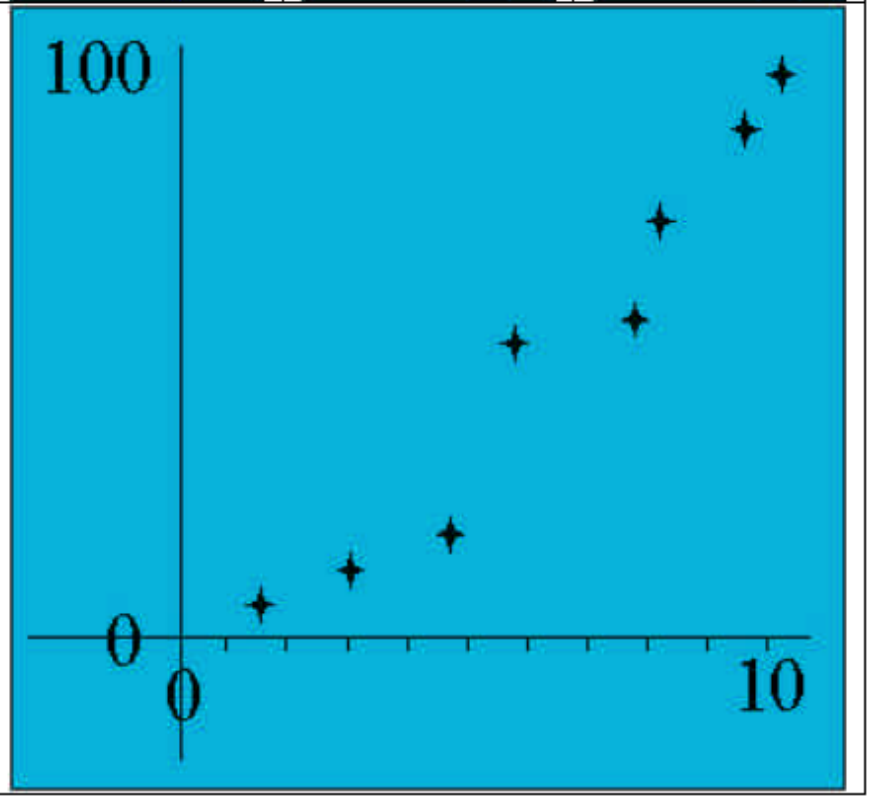
Channel Properties: Size

Visual Variable: Size		
✓	selective	
✓	associative	
≃	quantitative	
✓	order	
✓	Length	• theoretically infinite but practically limited • association and selection ~ 5 and distinction ~ 20

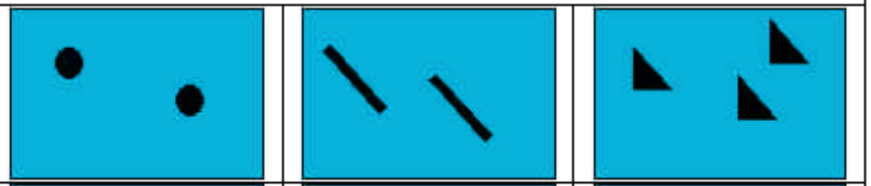
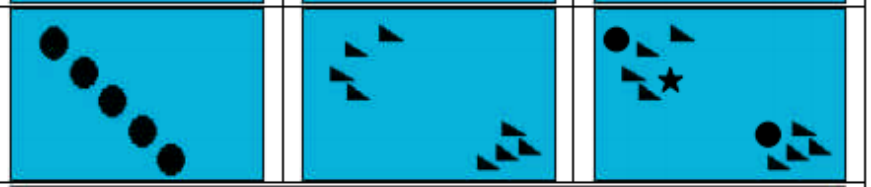
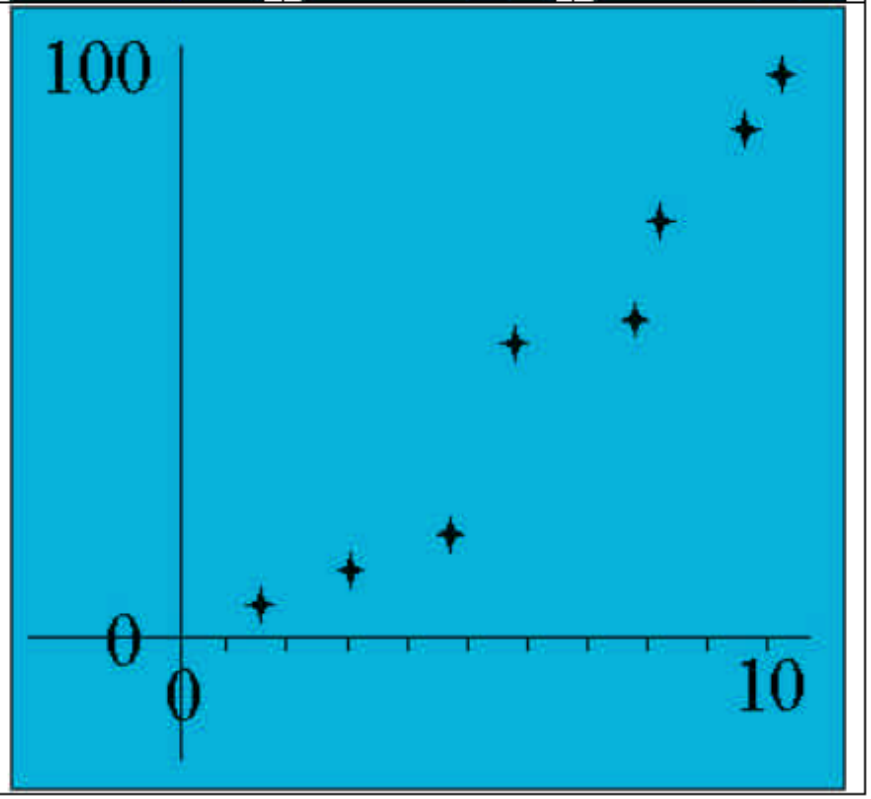
Channel Properties: Position



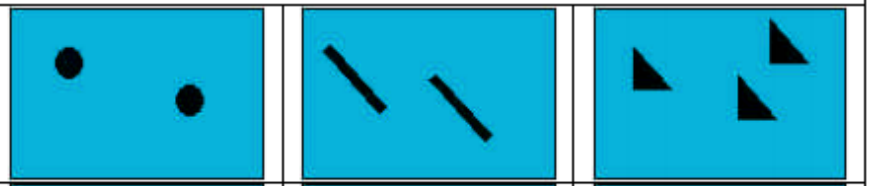
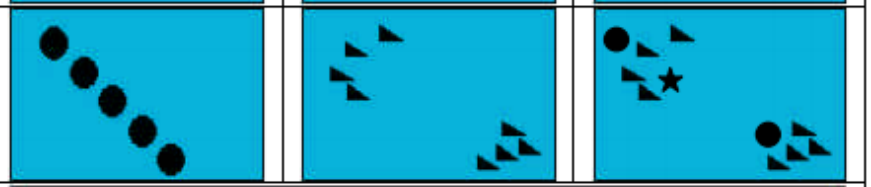
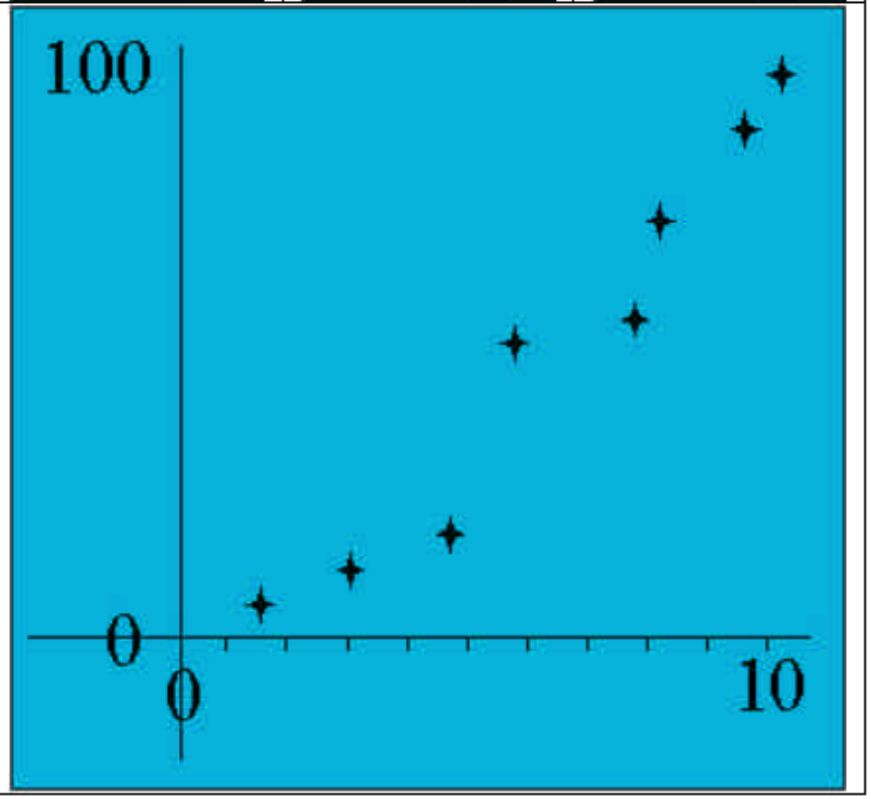
Channel Properties: Position

Visual Variable: Position		
✓	selective	
	associative	
	quantitative	
	order	
	length	

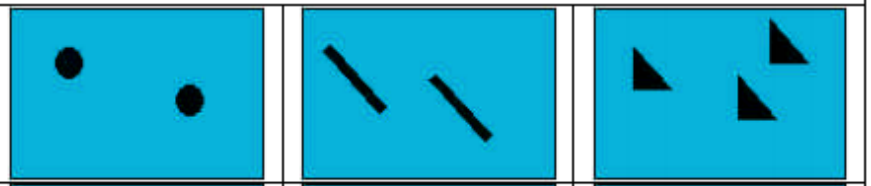
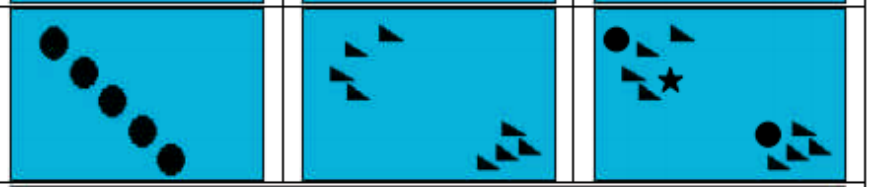
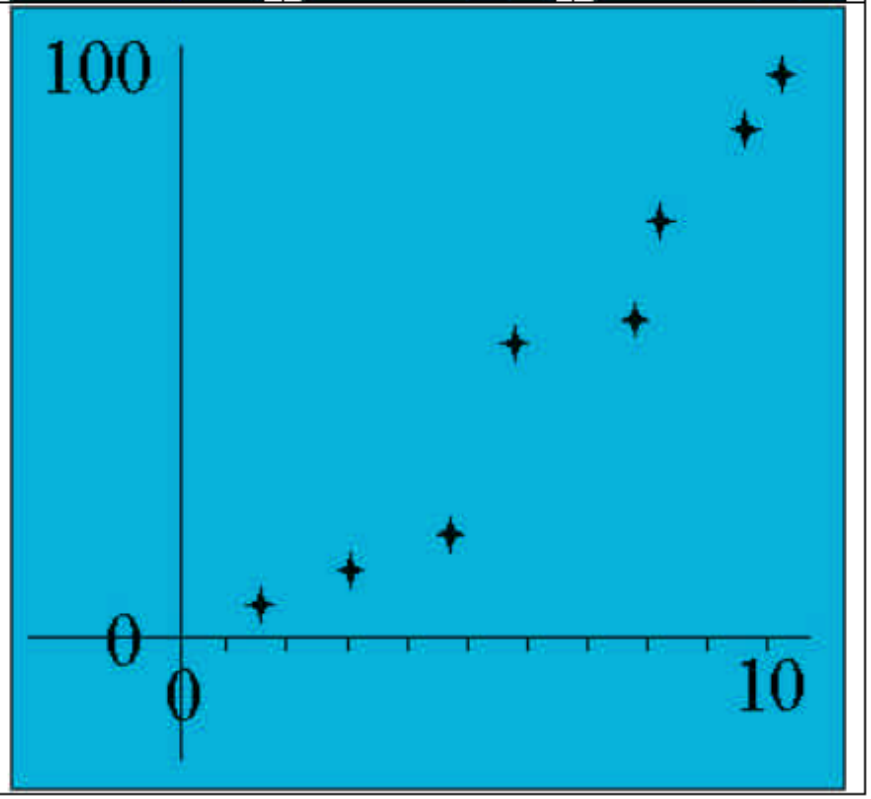
Channel Properties: Position

Visual Variable: Position		
✓	selective	
✓	associative	
	quantitative	
	order	
	length	

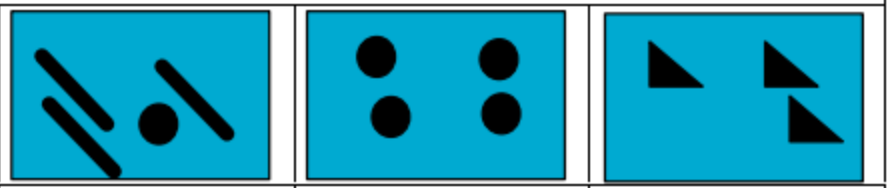
Channel Properties: Position

Visual Variable: Position		
✓	selective	
✓	associative	
✓	quantitative	
	order	
	length	

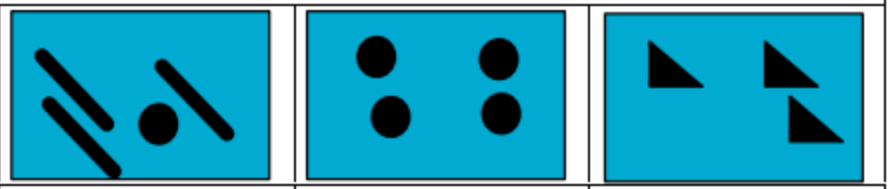
Channel Properties: Position

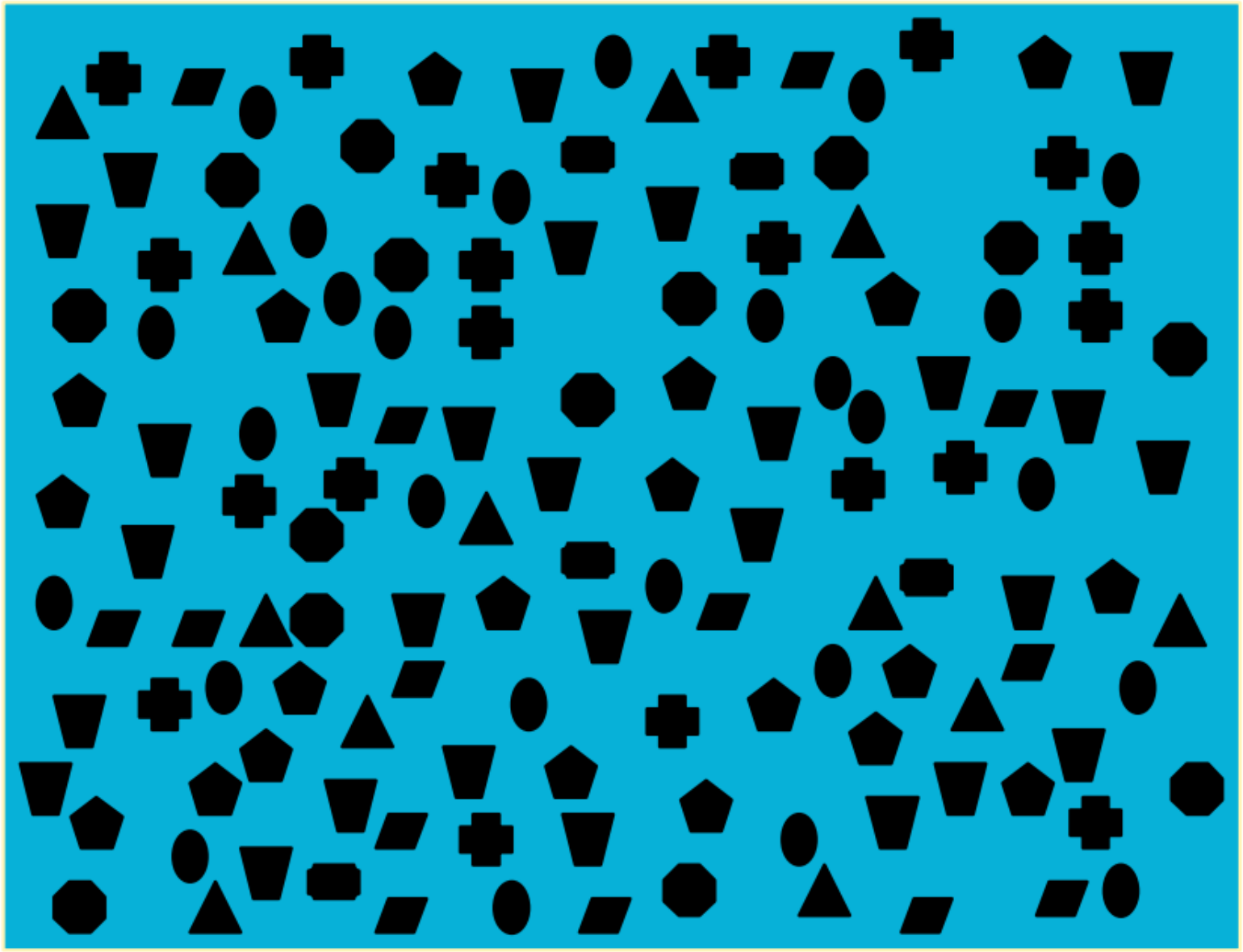
Visual Variable: Position		
✓	selective	
✓	associative	
✓	quantitative	
✓	order	
✓	length	

Channel Properties: Shape

Visual Variable: Shape		
	selective	
	associative	
	quantitative	
	order	
	length	

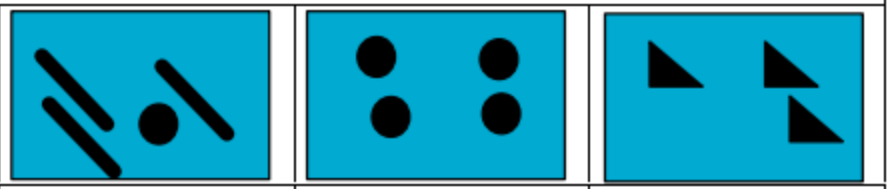
Channel Properties: Shape

Visual Variable: Shape		
≈	selective	
≈	associative	
	quantitative	
	order	
	length	

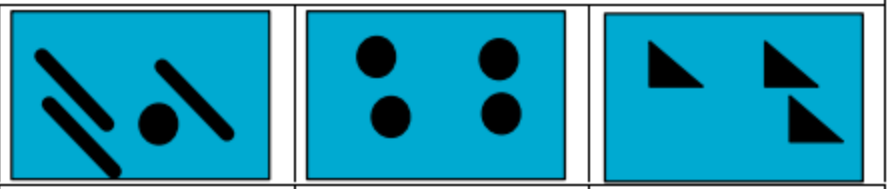


Associative – group this shape

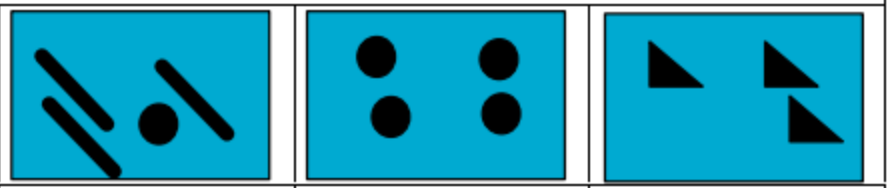
Channel Properties: Shape

Visual Variable: Shape		
≈	selective	
≈	associative	
	quantitative	
	order	
	length	

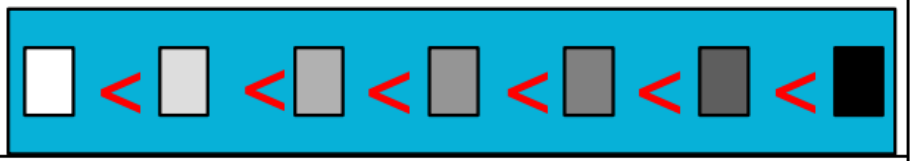
Channel Properties: Shape

Visual Variable: Shape		
≠ ≃	selective	
≠ ≃	associative	
≠	quantitative	
≠	order	
	length	

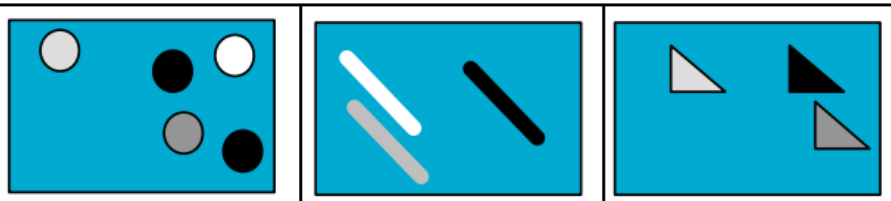
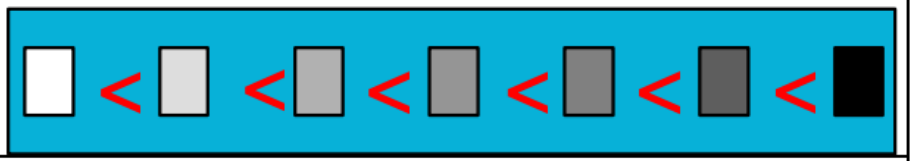
Channel Properties: Shape

Visual Variable: Shape		
≁	selective	
≁	associative	
≠	quantitative	
≮	order	
✓	length	theoretically infinite

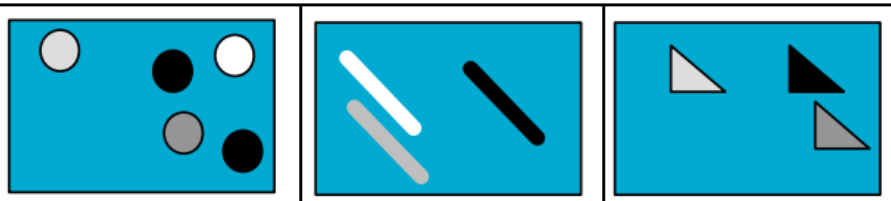
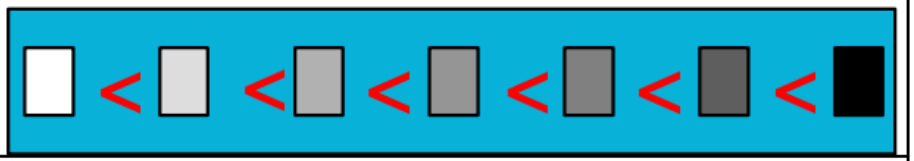
Channel Properties: Lightness

Visual Variable: Lightness		
	selective	
	associative	
	quantitative	
	order	
	length	

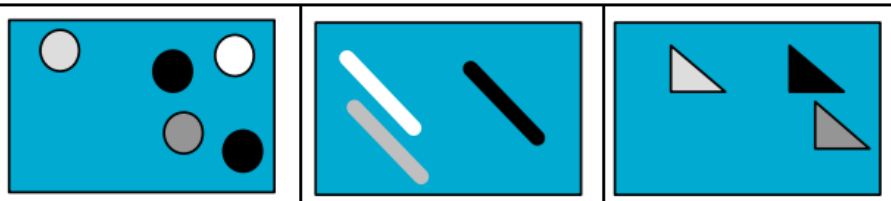
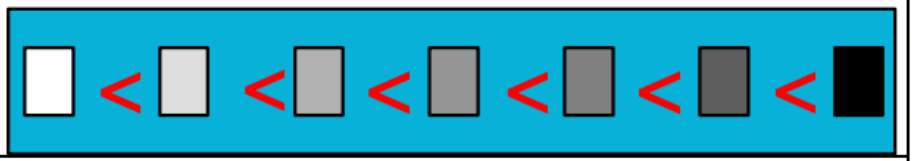
Channel Properties: Lightness

Visual Variable: Lightness		
✓	selective	
✓	associative	
	quantitative	
	order	
	length	

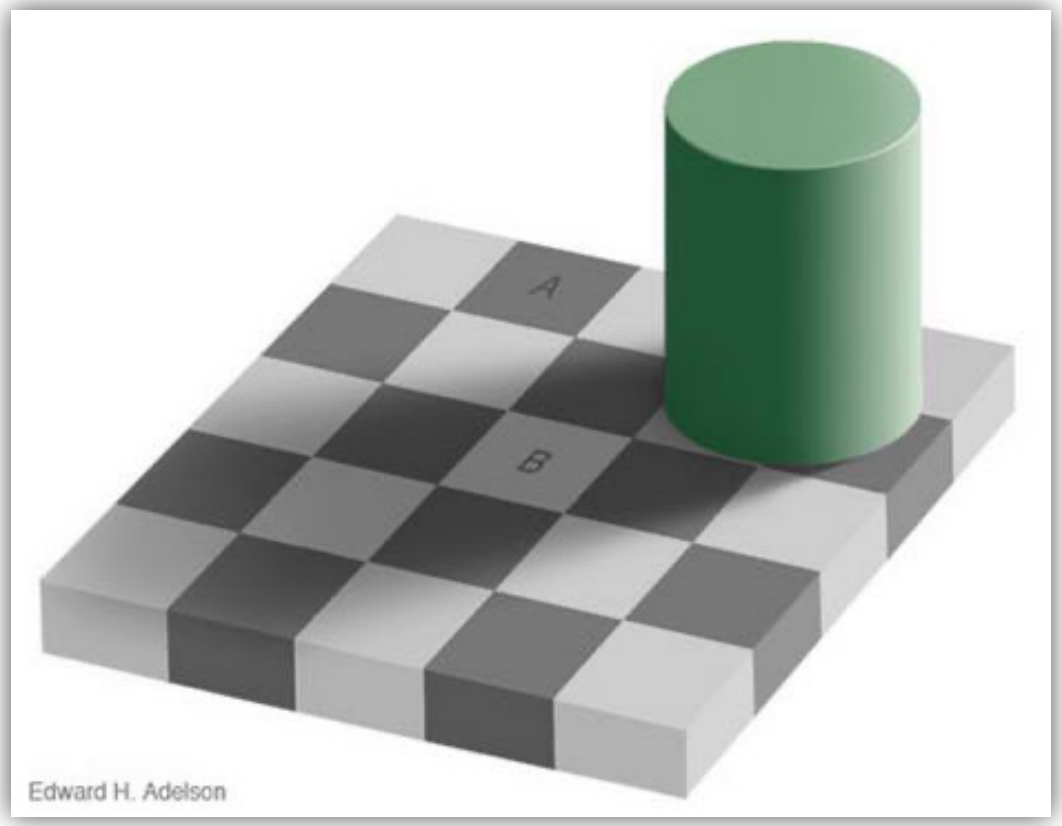
Channel Properties: Lightness

Visual Variable: Lightness		
✓	selective	
✓	associative	
≠	quantitative	
	order	
	length	

Channel Properties: Lightness

	Visual Variable: Lightness	
✓	selective	
✓	associative	
≠	quantitative	
✓	order	
	length	

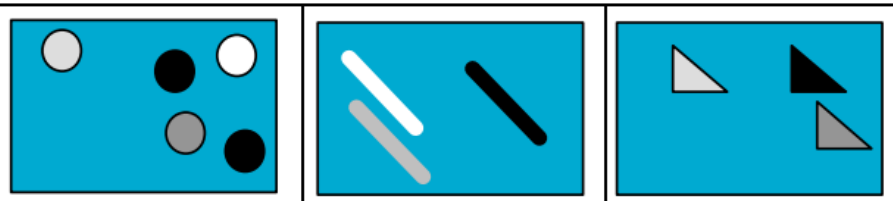
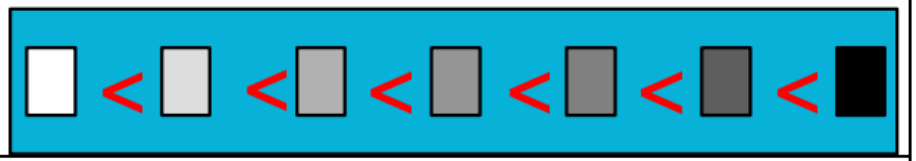
Adelson's Checker-Shadow Illusion



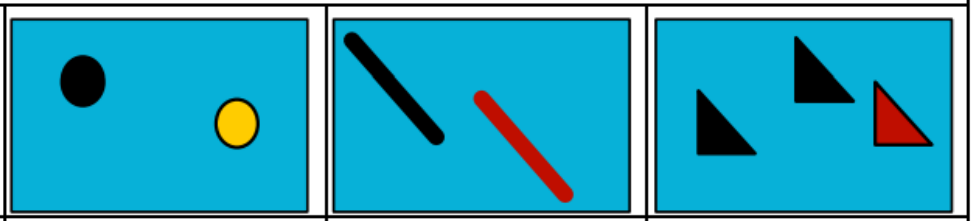
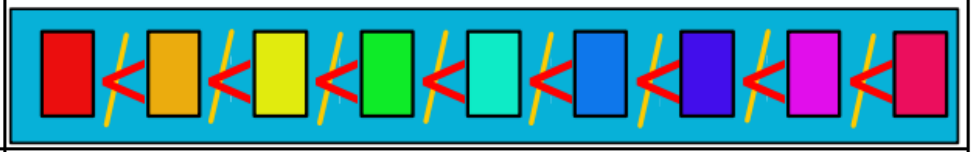
Weber's Law: human perception is fundamentally based on relative judgments, not absolute values.

https://www.illusionsindex.org/ir/20-checkershadow
https://www.youtube.com/watch?v=GALLMJxLvgA

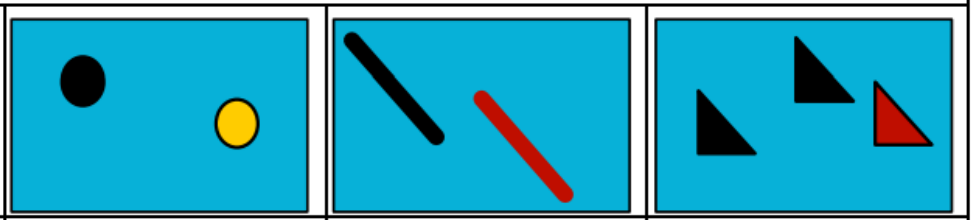
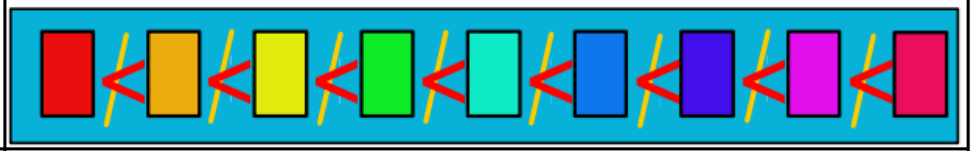
Channel Properties: Lightness

Visual Variable: Lightness		
✓	selective	
✓	associative	
≠	quantitative	
✓	order	
✓	length	• theoretically infinite but practically limited • association and selection ~ < 7 and distinction ~ 10

Channel Properties: Colour

Visual Variable: Colour		
	selective	
	associative	
	quantitative	
	order	
	length	

Channel Properties: Colour

Visual Variable: Colour		
✓	selective	
✓	associative	
	quantitative	
	order	
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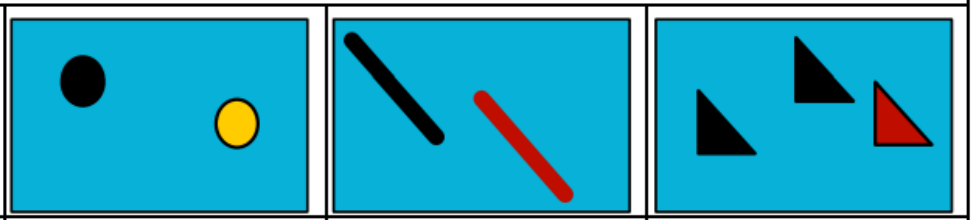
Channel Properties: Colour

Visual Variable: Colour		
✓	selective	
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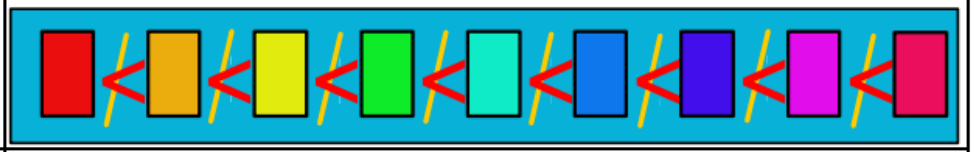
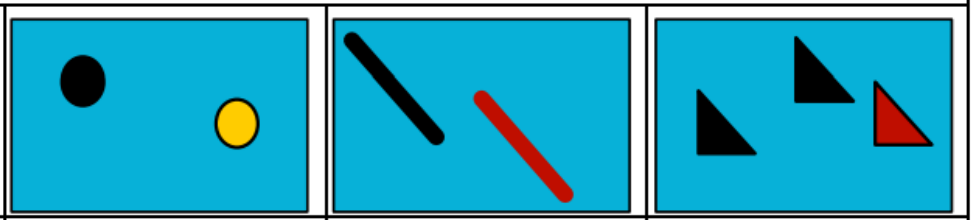
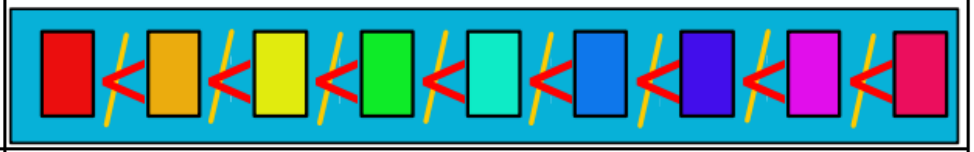
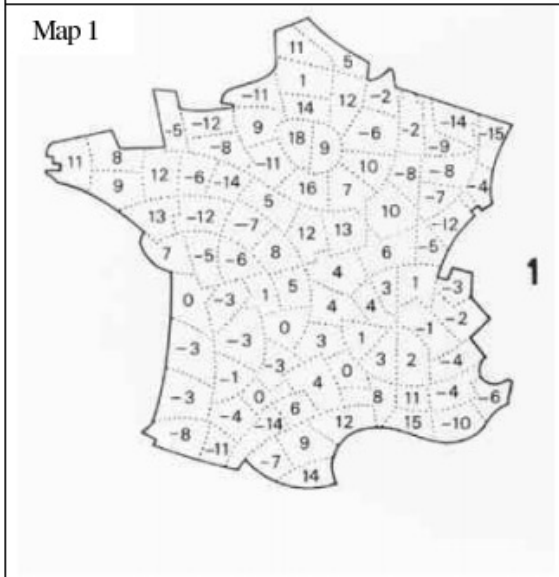
≠	quantitative	
	order	
	length	

Channel Properties: Colour

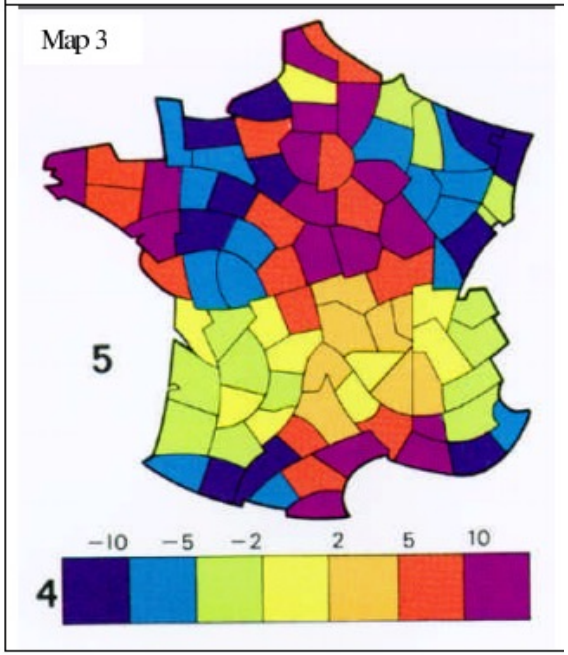
Visual Variable: Colour		
✓	selective	
✓	associative	
≠	quantitative	
≠	order	
	length	

Rainbow Scale Considerations

Map 1



Map 3

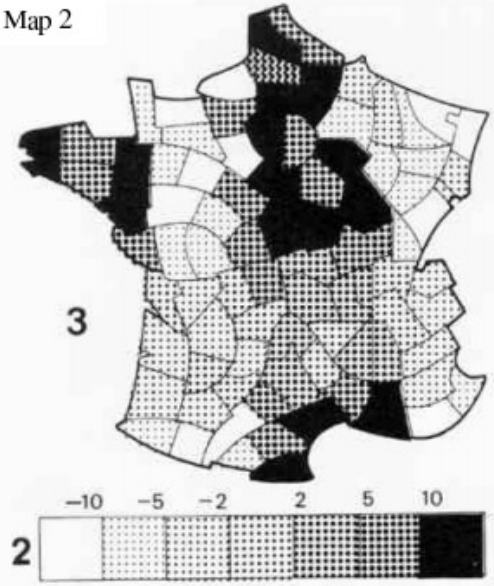


Rainbow Scale Considerations

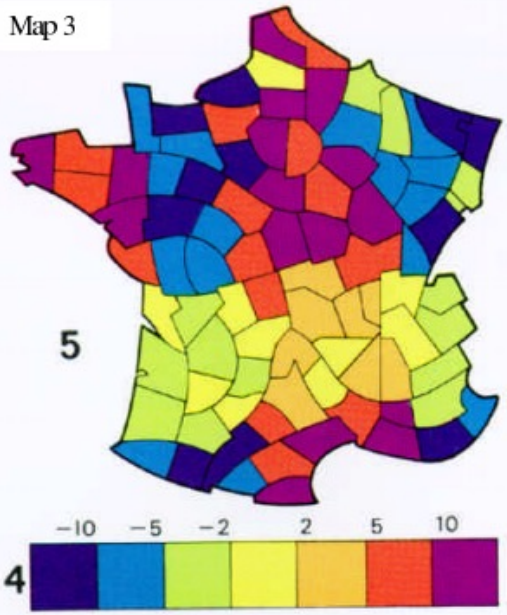
Map 1

1

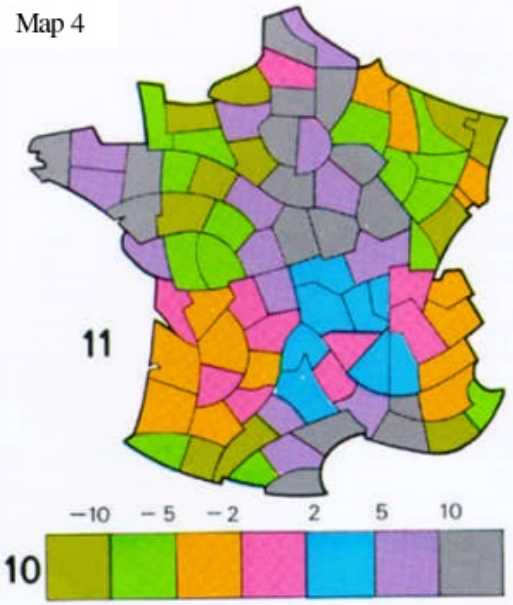
Map 2

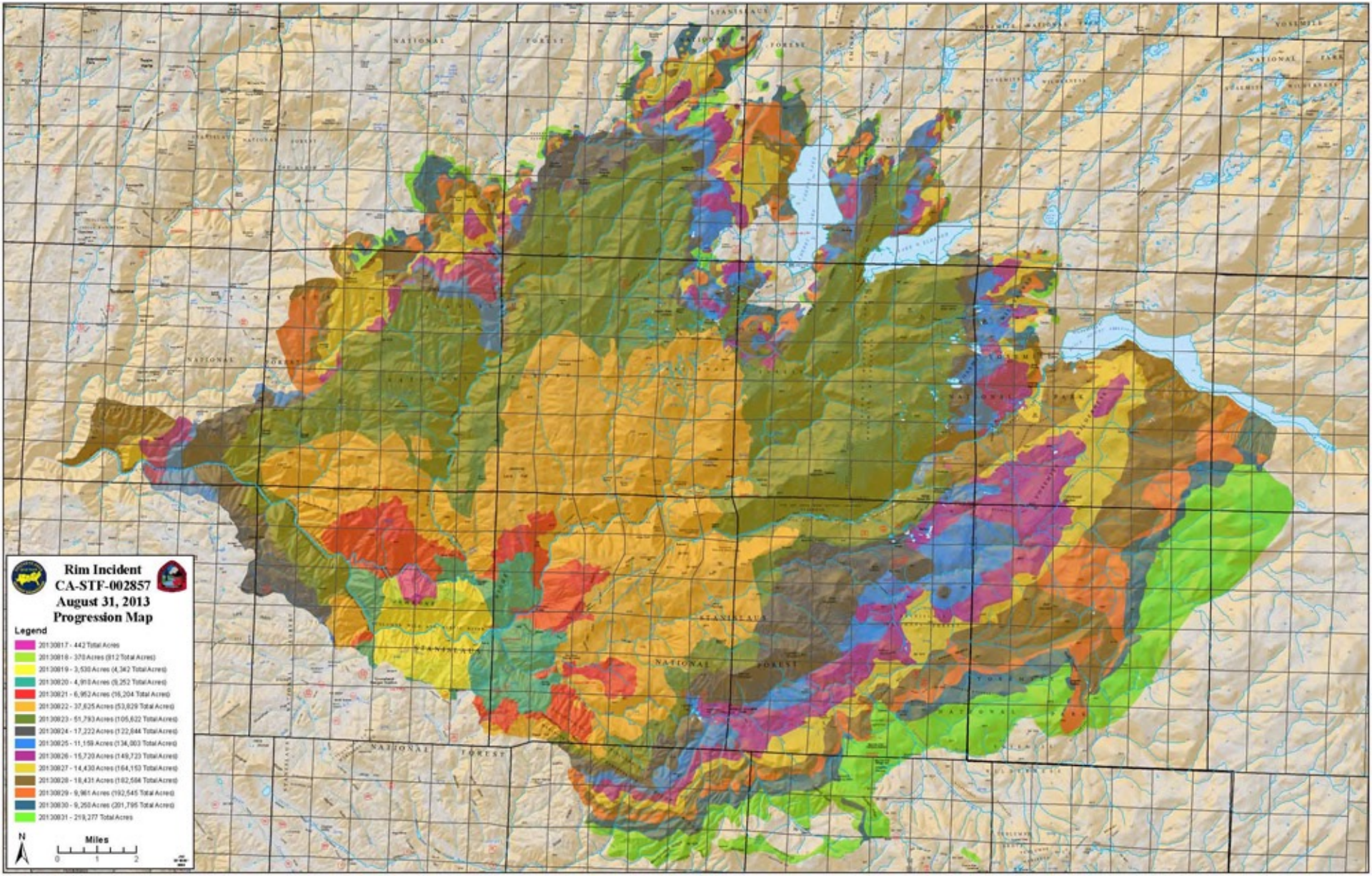


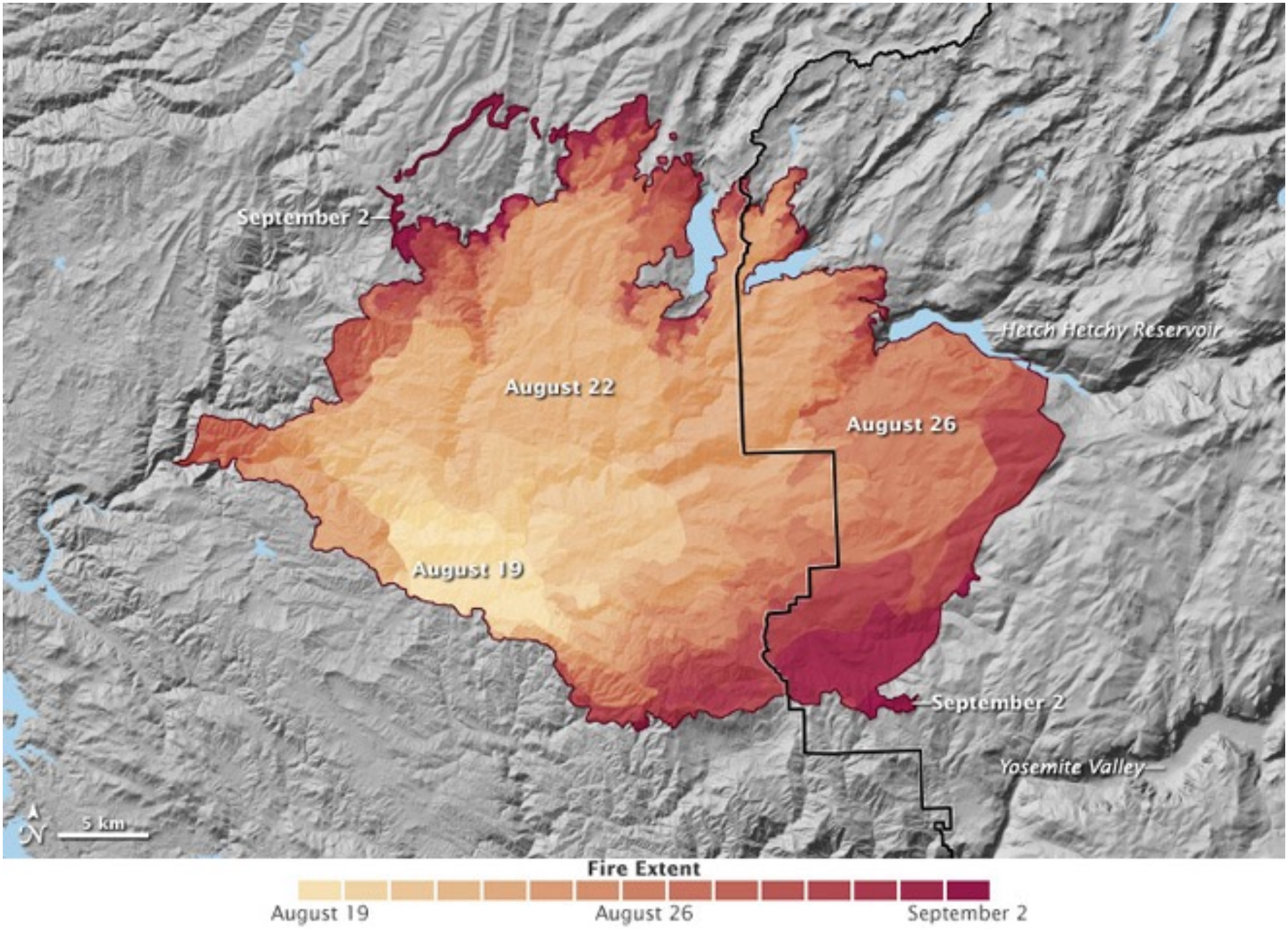
Map 3



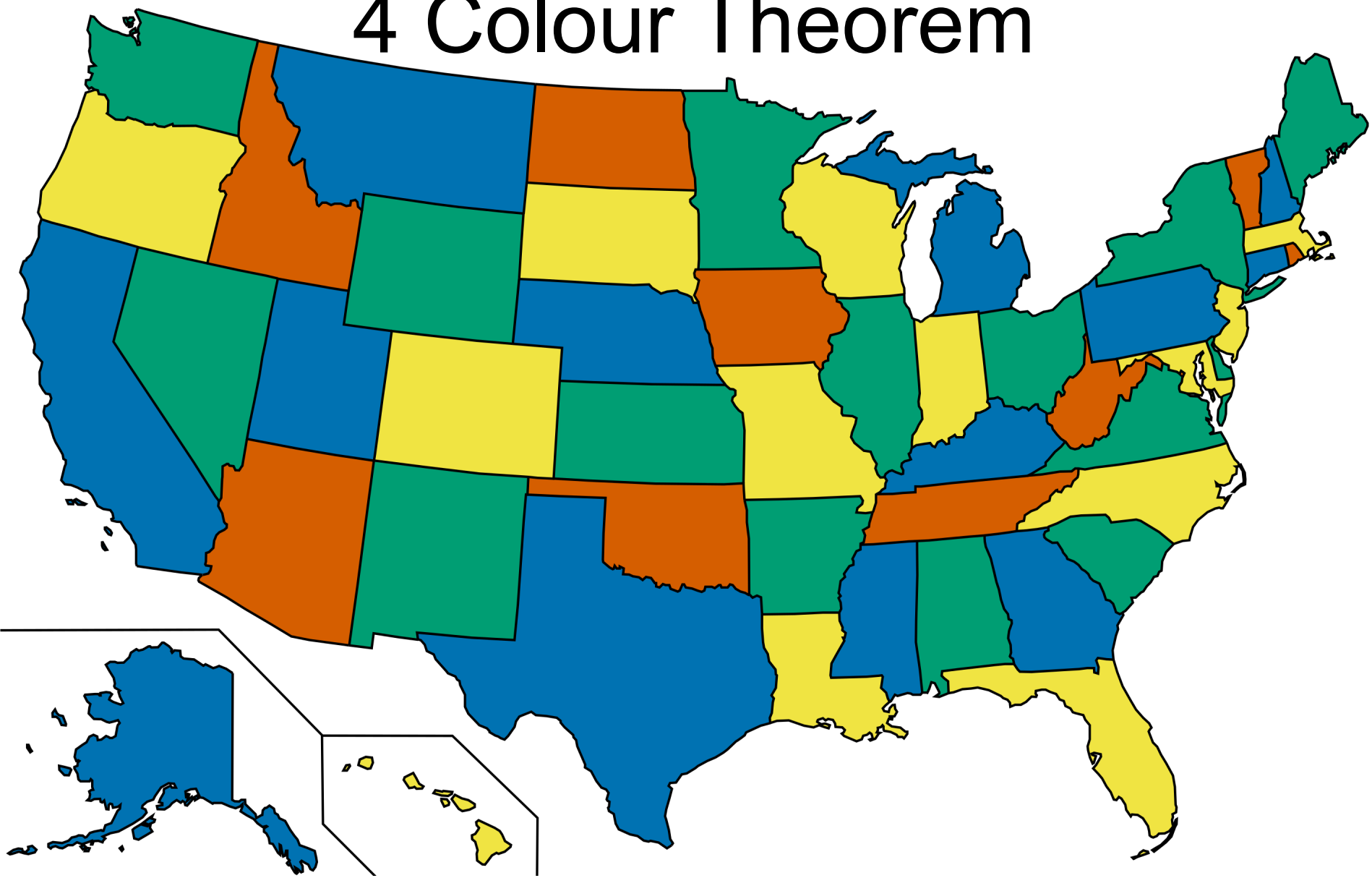
Map 4




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

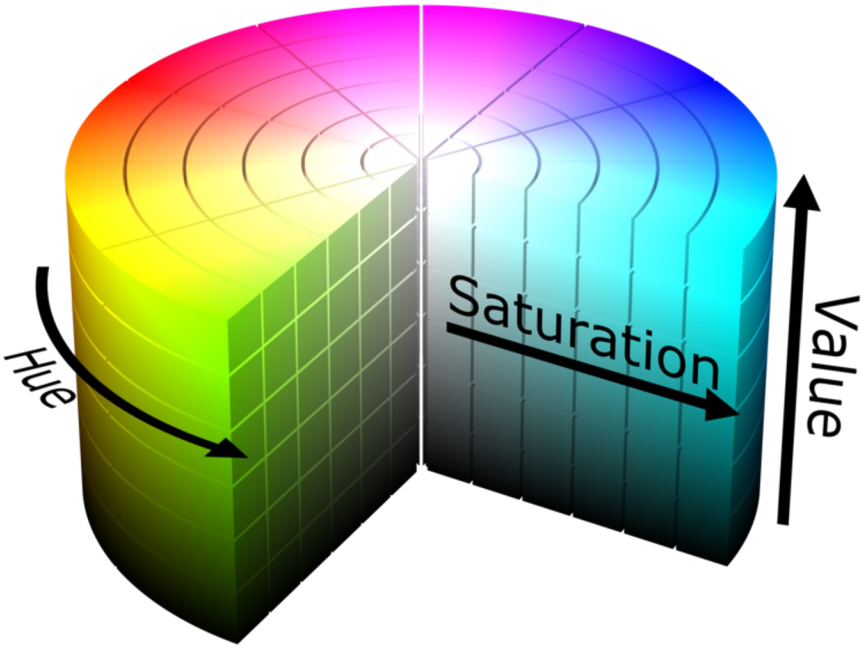

September 2
August 22
August 26
Hetch Hetchy Reservoir
August 19
September 2
Yosemite Valley
5 km
Fire Extent
August 19
August 26
September 2

4 Colour Theorem



https://en.wikipedia.org/wiki/Four_color_theorem

Hue, Saturation & Value



Hue: the degree to which a stimulus can be described as similar to or different from stimuli that are described as red, orange, yellow, green, blue, violet

Destroys Detail

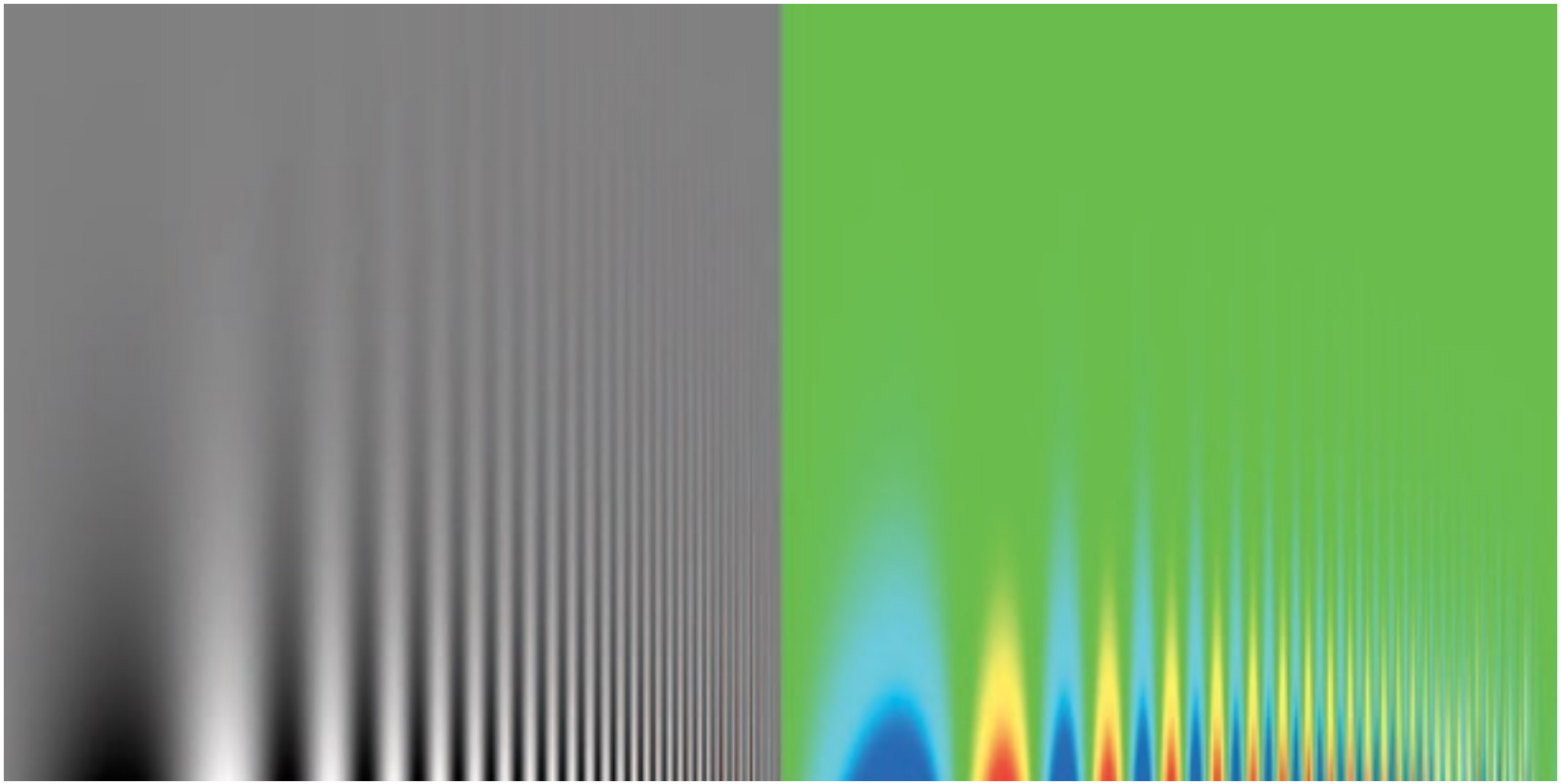


Image from *Borland & Taylor II (2007), Rainbow Color Map (Still) Considered Harmful. IEEE Visualization Viewpoints, pp 14-17.*

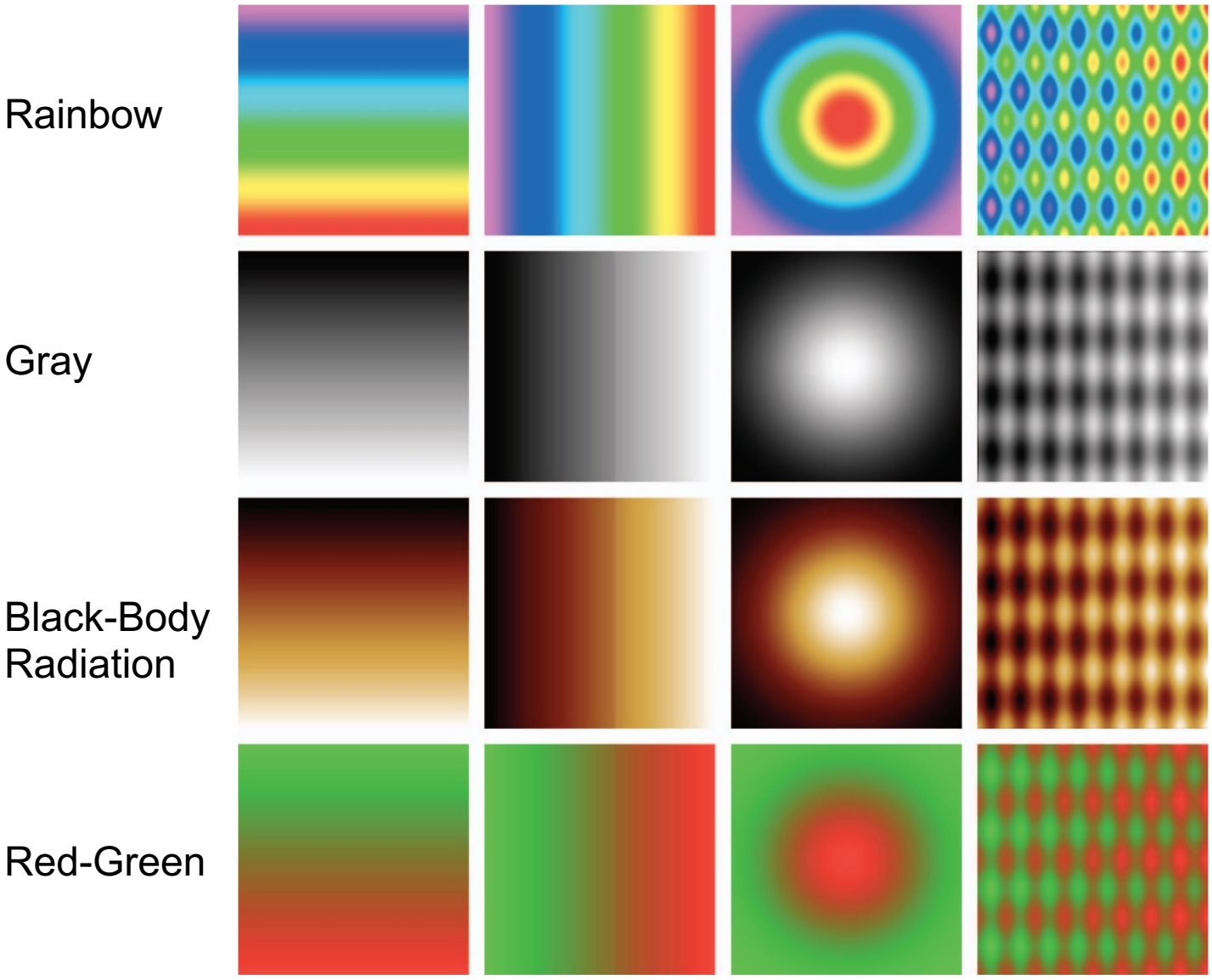
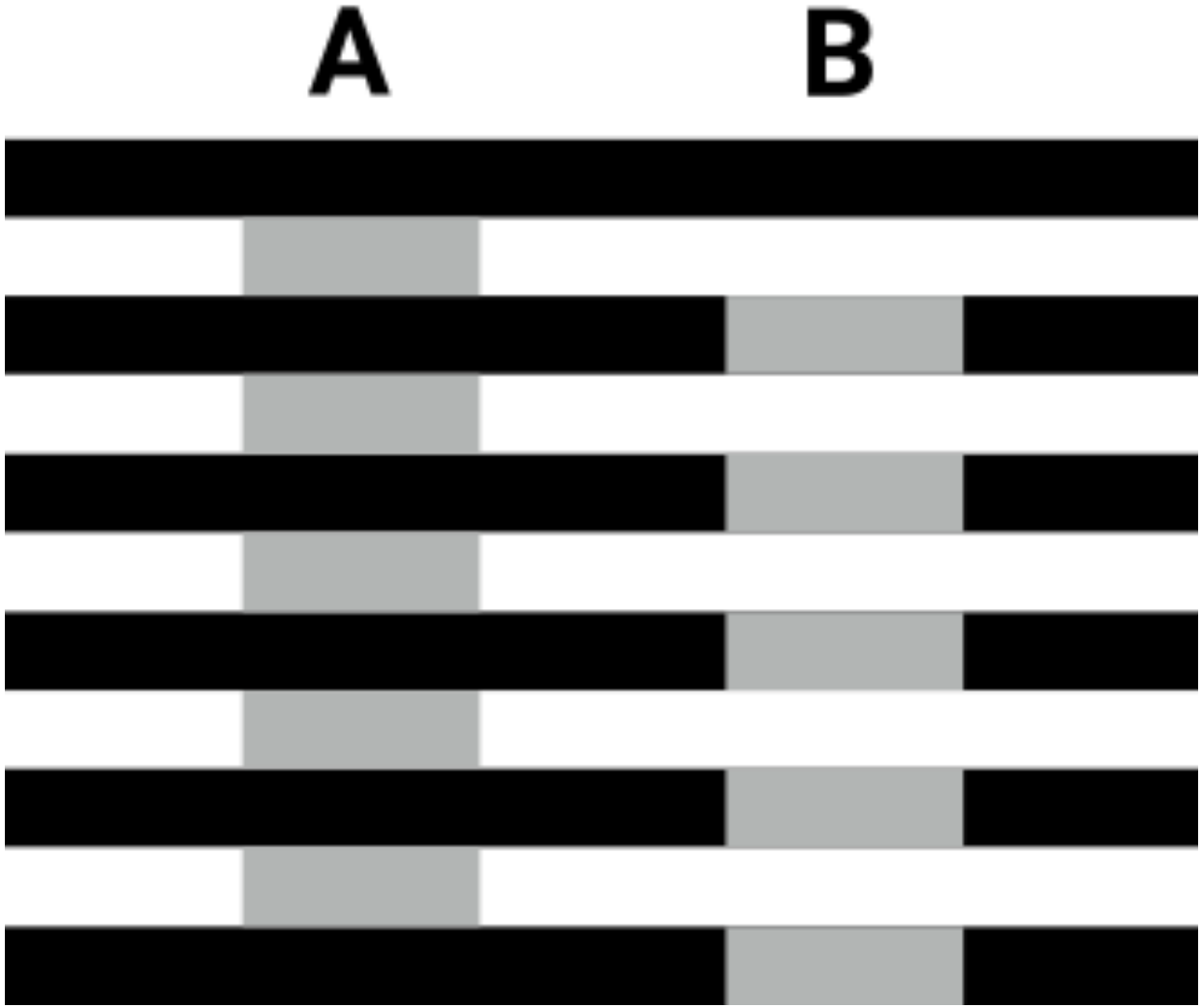


Image from *Borland & Taylor II (2007), Rainbow Color Map (Still) Considered Harmful. IEEE Visualization Viewpoints, pp 14-17.*

White's illusion

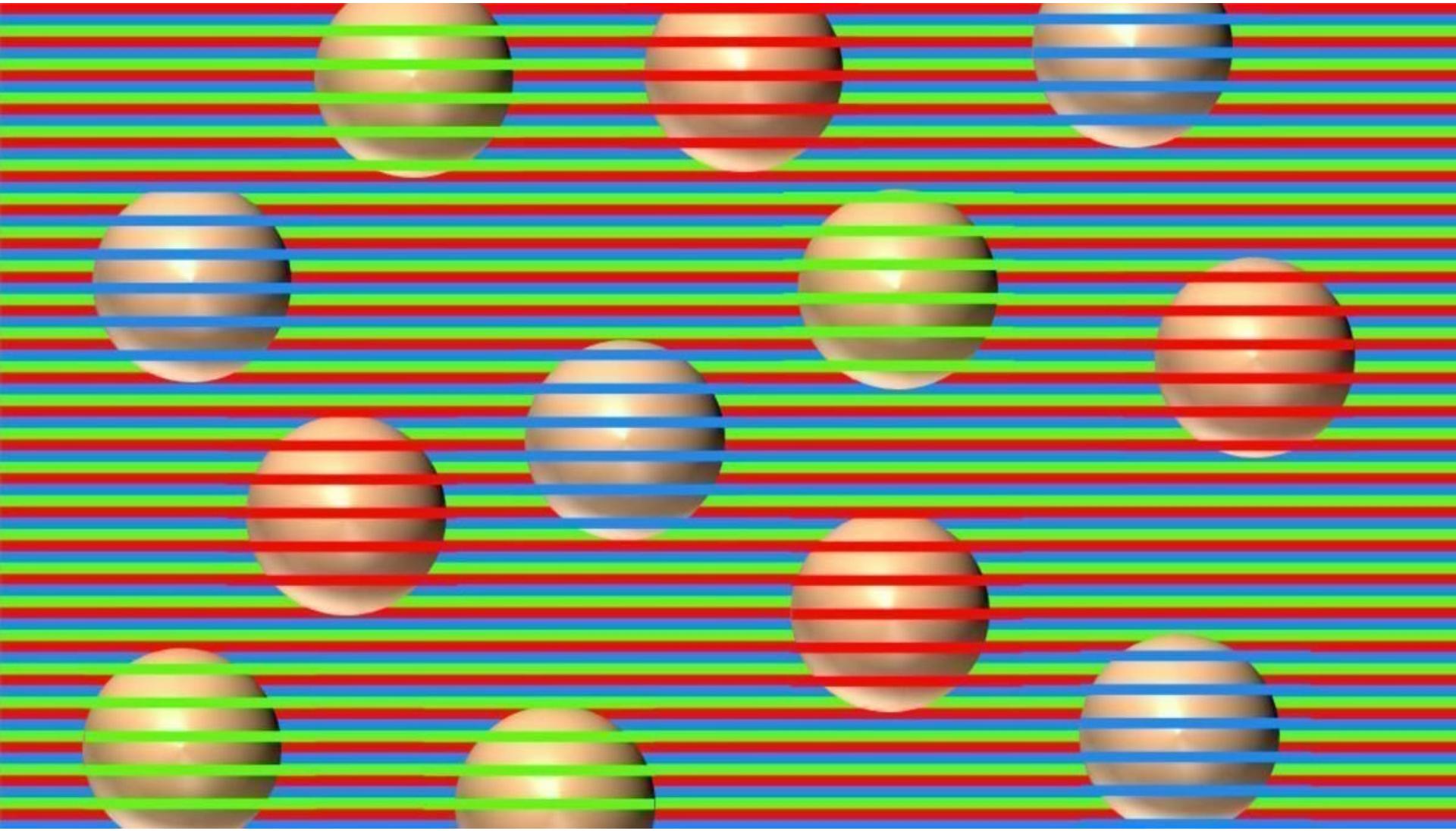


https://en.wikipedia.org/wiki/White%27s_illusion

The Dress 2015

https://en.wikipedia.org/wiki/The_dress
https://www.youtube.com/watch?v=I0OPNOpU6SY

David Novick's three color confetti illusion



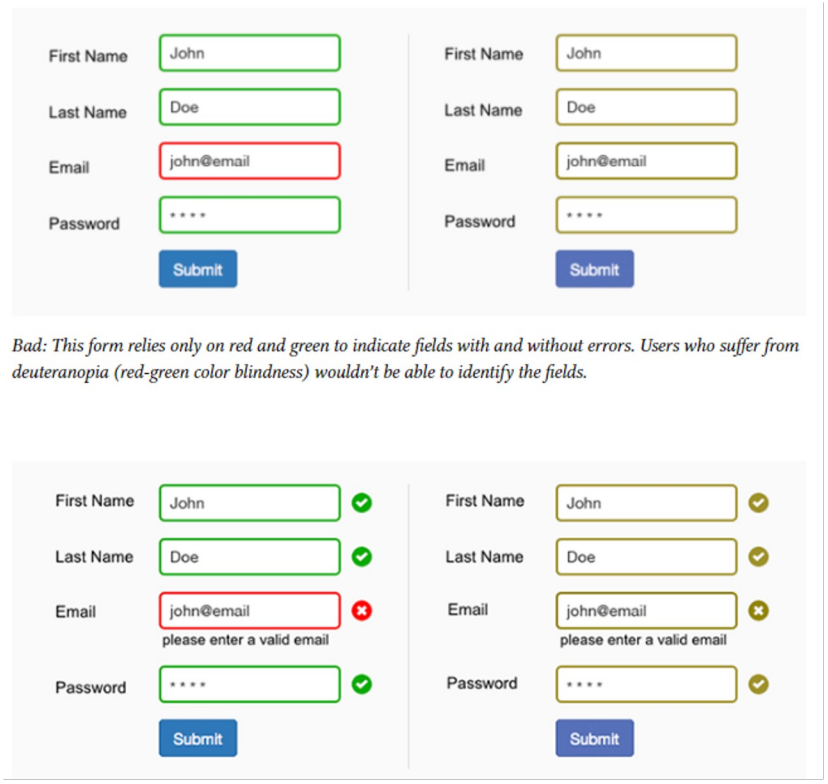
https://journalofillusion.net/index.php/joi/article/view/6152/13749
https://www.youtube.com/watch?v=SvEiEi8O7QE

Colours

- Humans are mostly the same
- Some have different ability to see colour - even gender differences
- Some rules are about humans some about culture.

Colour Blind

Always 2 cues



https://www.cs.umd.edu/users/ben/goldenrules.html

Color in culture

Different colours mean different things

Blue - calm

Green - growth: Indonesia forbidden

Red - energy/danger: Asia luck

Yellow - happiness - Germany envy

Purple - royalty: Brazil mourning

White - purity: China death

Tino Rangatiratanga

https://commons.wikimedia.org/wiki/File:Tino_Rangatiratanga_Maori_sovereignty_movement_flag.svg

Māori colour signifiers

- **RED represents**
  - Te Whei Ao (coming into being). It symbolises Papatuanuku, the earth-mother, the sustainer of all living things, both the land and active forces.
- **BLACK represents**
  - Te Korekore (the realm of potential being). Symbolising the long darkness from which the earth emerged, as well as signifying Ranginui, the sky father floating above the earth.
- **WHITE represents**
  - Te Ao Marama (the realm of being and light) was created when Rangi and Papa were separated by their children. It symbolises the physical world, purity, harmony, enlightenment and balance.

Colours link to Emotions

Green: Sparks creativity

Red: Reduces analytical thinking

Blue: is most accepted

Yellow: isn't usually a hit

Orange: is associated with good value

Pink: Calms people down

White: May lead to boredom

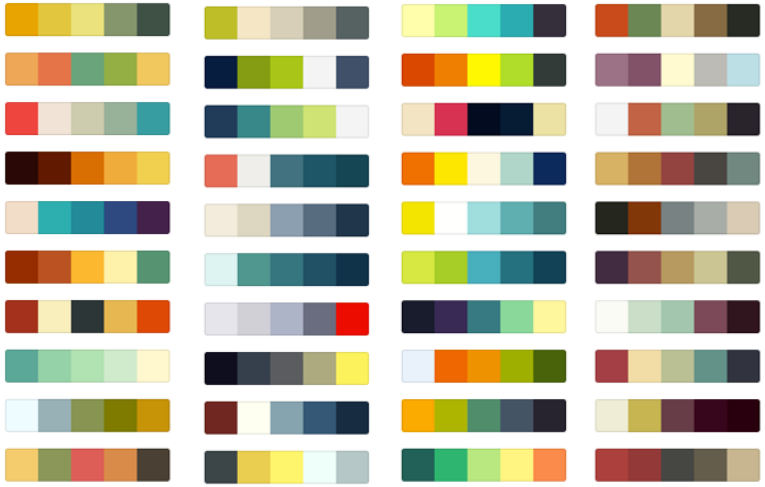
https://www.forbes.com/sites/amymorin/2014/02/04/how-to-use-color-psychology-to-give-your-business-an-edge/#55ae55c3170a

Harmony and contrast

- Colours are similar to sound
- Music has Harmony and discord
- Music links to emotions - often by memories

Colour palettes

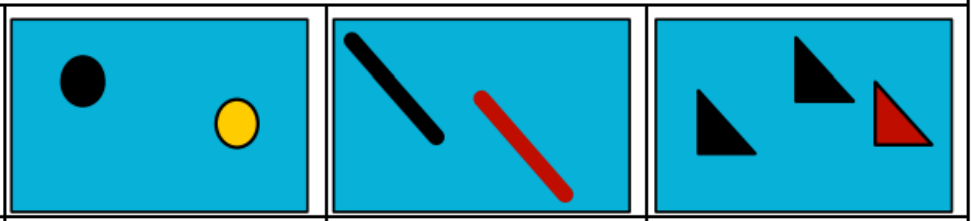
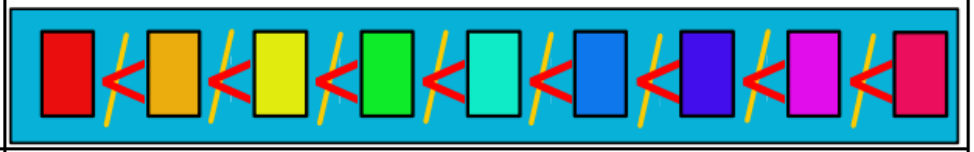
- Finding a set of colours for your product
- Continuity - keeping your site consistent
- Color Brewer
  - https://colorbrewer2.org/



Generators

- From a Photo
  - https://www.adobe.com/nz/products/capture.html
- From a start colour
  - https://coolors.co/
- From examples
  - https://www.canva.com/learn/100-color-combinations

Channel Properties: Colour

Visual Variable: Colour		
✓	selective	
✓	associative	
≠	quantitative	
≠	order	
✓	length	• theoretically infinite but practically limited • association and selection ~ < 7 and distinction ~ 10

Channel Properties: Orientation

Visual Variable: Orientation		
✓	Selective	
✓	associative	
≠	Quantitative	
≠	Order	
✓	Length	

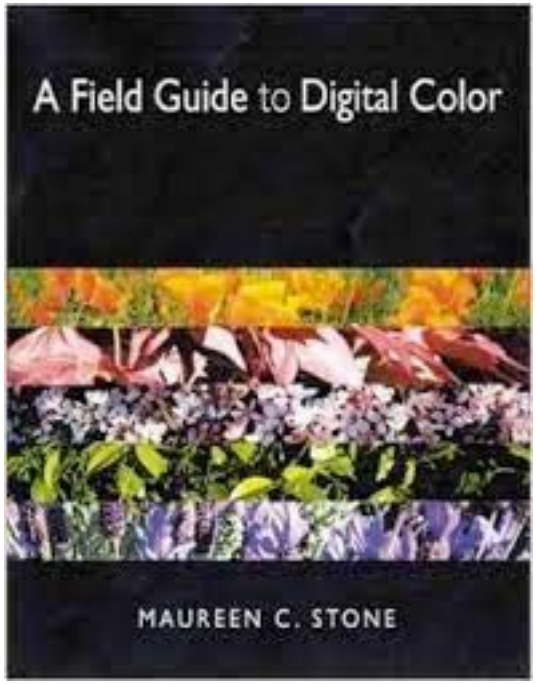
Channel Properties: Texture

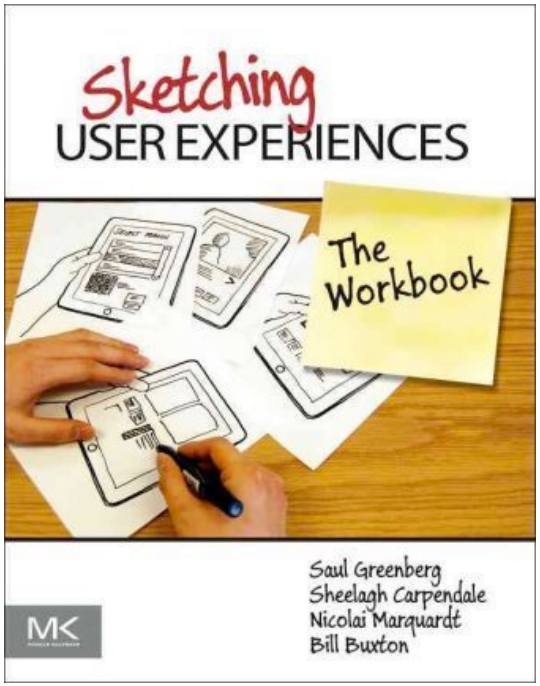
Visual Variable: Texture		
✓	selective	
✓	associative	
≠	quantitative	
≠	order	
✓	Length	• theoretically infinite

Recommended Reading

Sheelagh Carpendale, Considering Visual Variables as a Basis for Information Visualisation. Research report 2001-693-16, Department of Computer science, University of Calgary, Calgary, AB, Canada, 2003.

Ben Shneiderman, The eyes have it: a task by data type taxonomy for information visualizations, VL 1996





Summary - How Do We Visualize?

- **Know the Data**
  - Number of attributes
  - Date types: ordinal vs ordered (ordinal or quantitative)
  - Trustworthiness: bad fields, inaccuracies, missing values
- **Know your purpose (& audience)**
  - What do you/they want to see?
  - What might you/they want to focus on?
- **Decide how to use the visual variables to encode the data**
  - Requires awareness of:
    - Human perceptual system
    - Display capacity
    - Characteristics of data (size, type)
    - Task