

# **DATA 230 Spring 2023**

## **Week 3**

# **Lecture 3:**

# **Mark and Channel**

Dr. Seungjoon (Joon) Lee

DATA 230: Data Visualization

# **How to Visualize?**

Complex visual encodings can be broken down into two components:

## **Mark and Channel**

Mark: "Basic" geometric/graphical element. (represent (1) item or (2) link)

Channel: Control/change the appearance of marks to convey data

# Mark: Item

Basic graphical element in visualization:

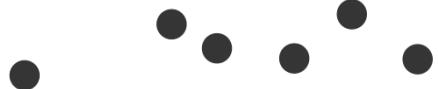
0d : point .

1d : line

2d : area

3d : Volume (Not frequently)

→ Points



→ Lines

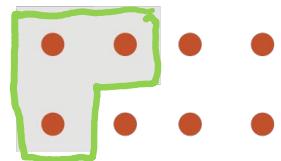


→ Areas

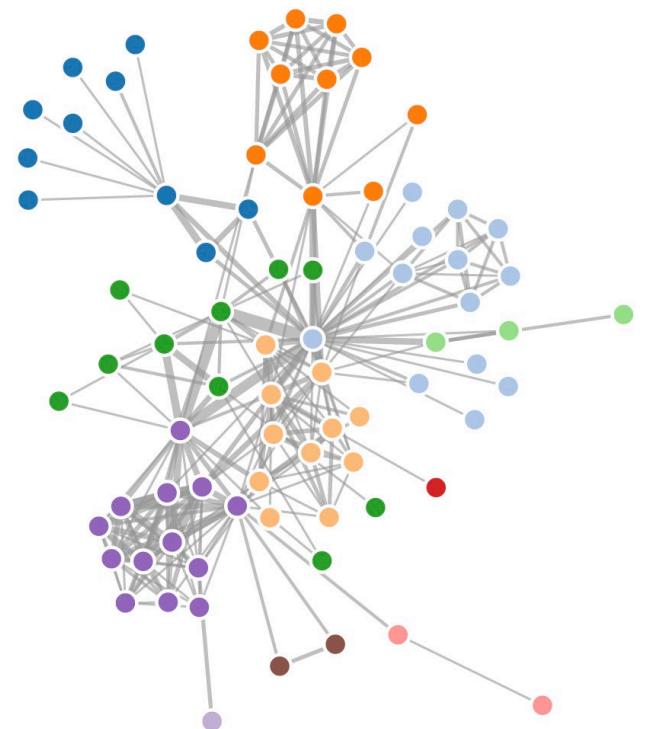
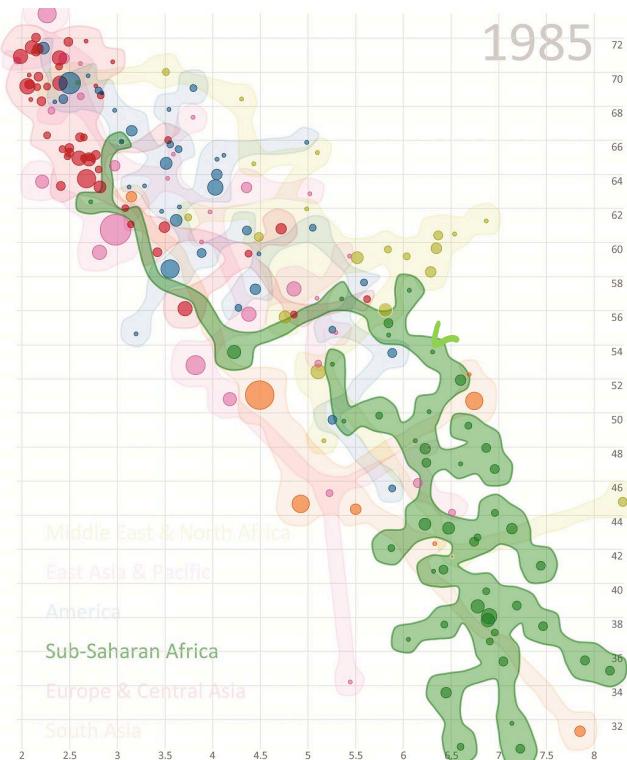
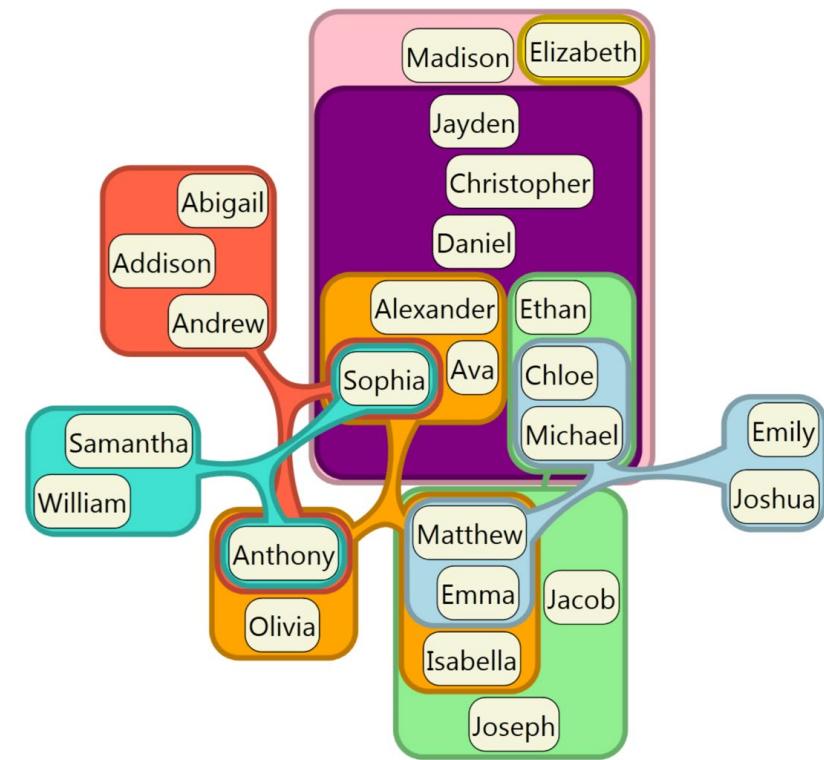
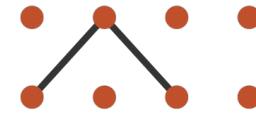


# Mark: Link

## ➔ Containment

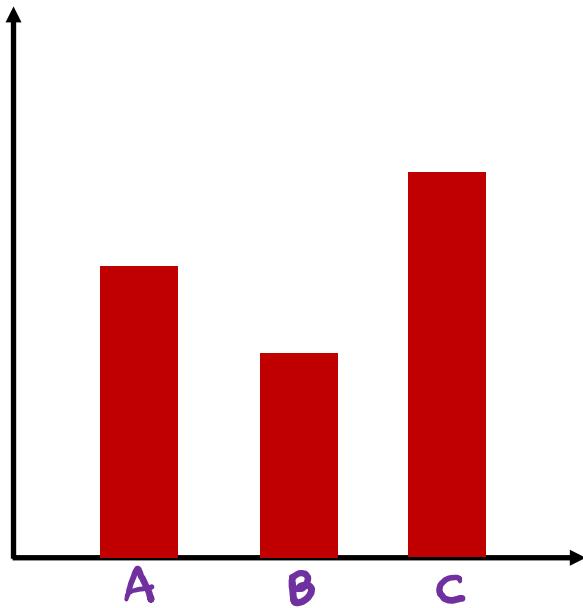


## ➔ Connection

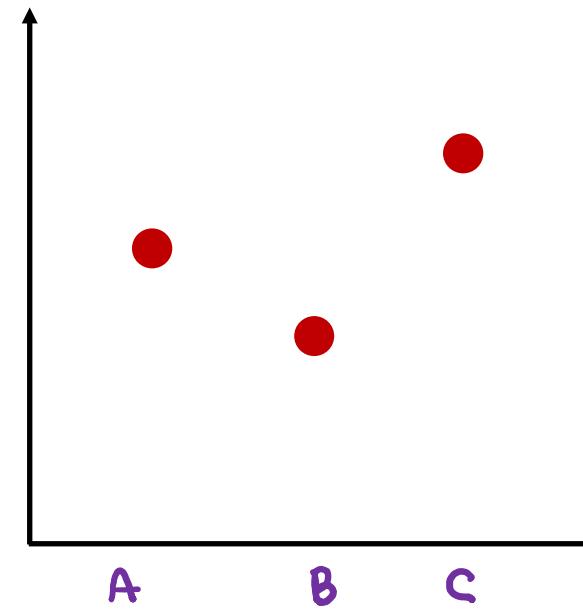


# Mark and Channel

Bar chart vs Scatter plot.



mark : line



mark : point

# Channel

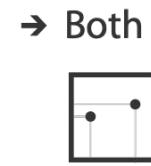
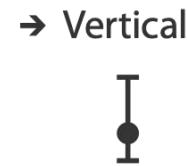
A visual channel is a method to control mark appearance (proportional to or based on features).  
(channels/variables/dimensions)

- Position : horizontal (x-axis), vertical (y-axis) , both
- Color/hue
- Shape : ● ▲ \* ♥
- Tilt : | / —
- Size : length/area/volume

Choose proper number of channels, type of channels for effective visualization.

# Channel

## ④ Position



## ④ Color



## ④ Shape



## ④ Tilt



## ④ Size

→ Length



→ Area

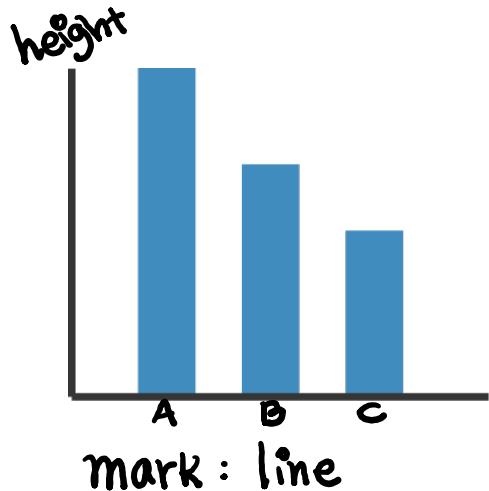


→ Volume

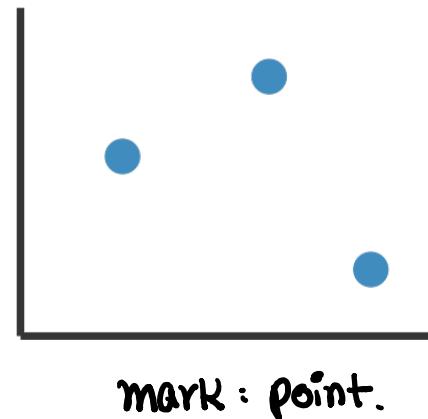


# Visual Encoding

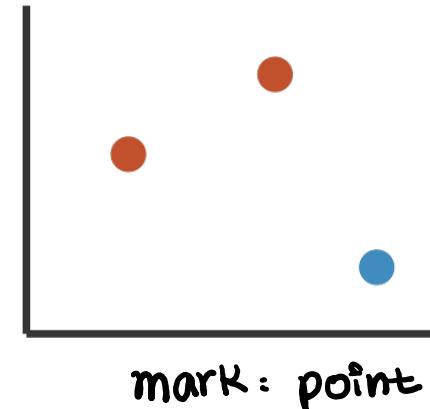
Analyze idiom structure as combination of marks and channels



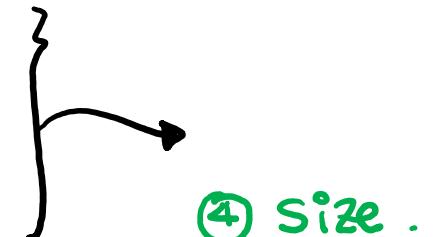
- Channel :
- ① x-position (Cat. ord.)
  - ② length .



- Channel :
- ① x-position
  - ② y-position



③ Color/hue



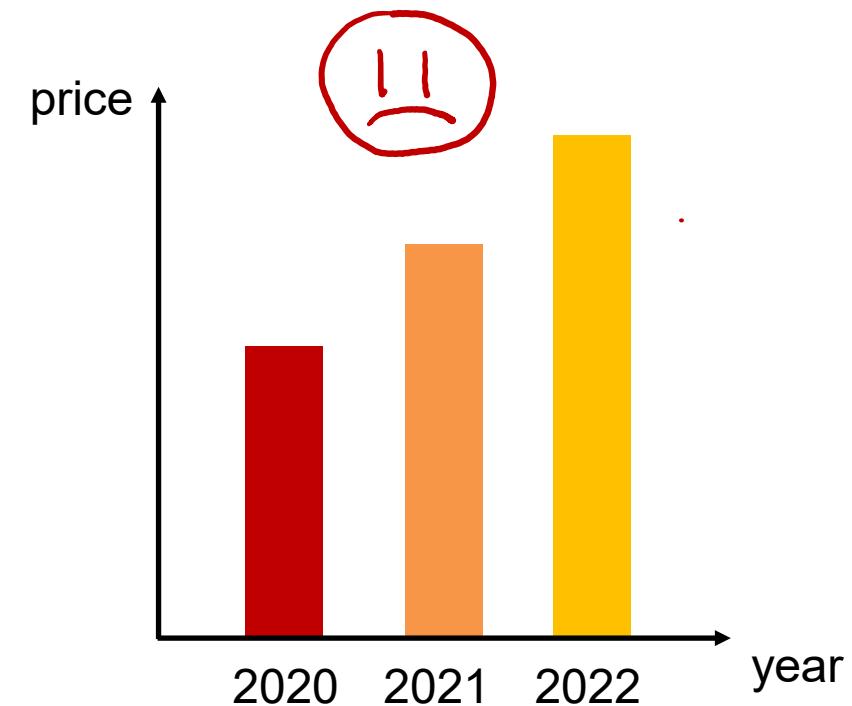
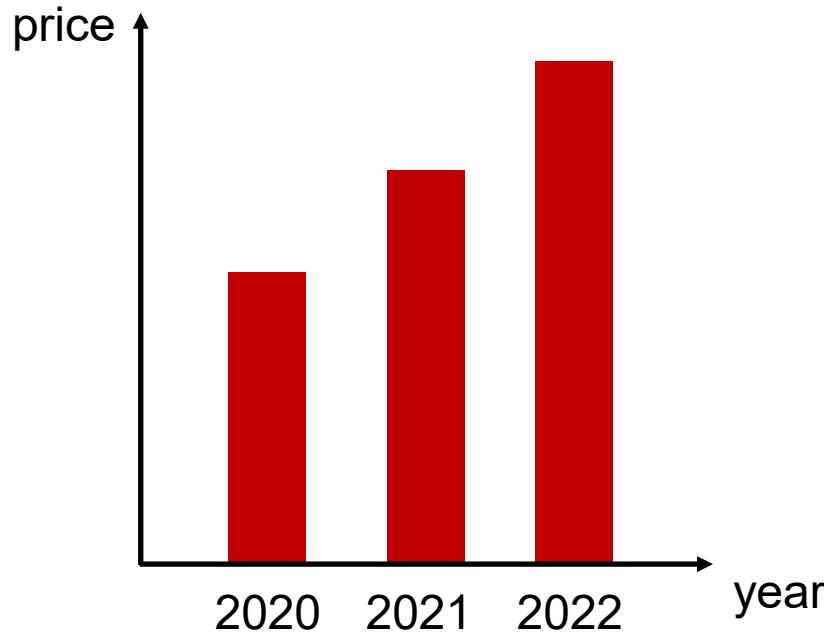
# Marks and Channels

You can use ***multiple*** visual channels to encode more data.

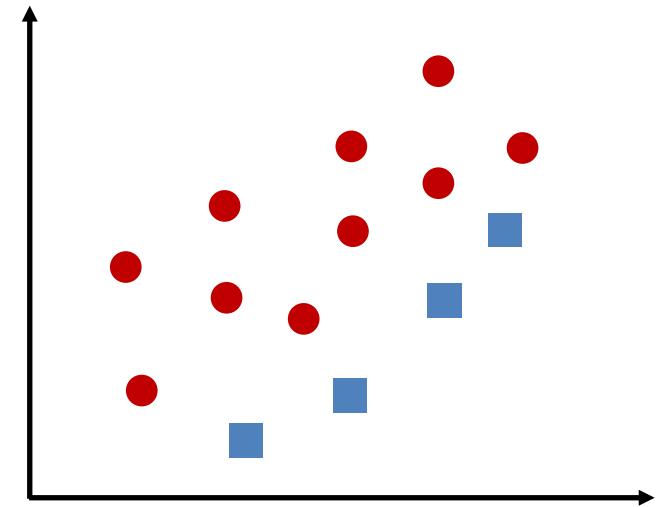
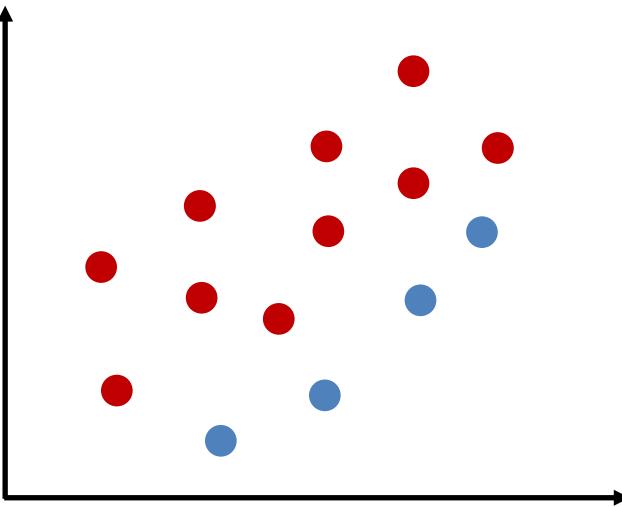
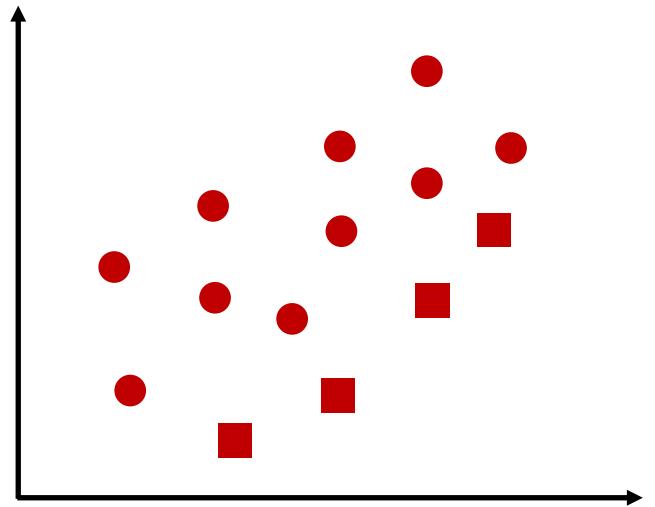
The more you encode, the harder to interpret. (*less effective*)

\* You may use two or more channels to encode the same thing. (*redundant*)

# Redundant Encoding



# Redundant Encoding



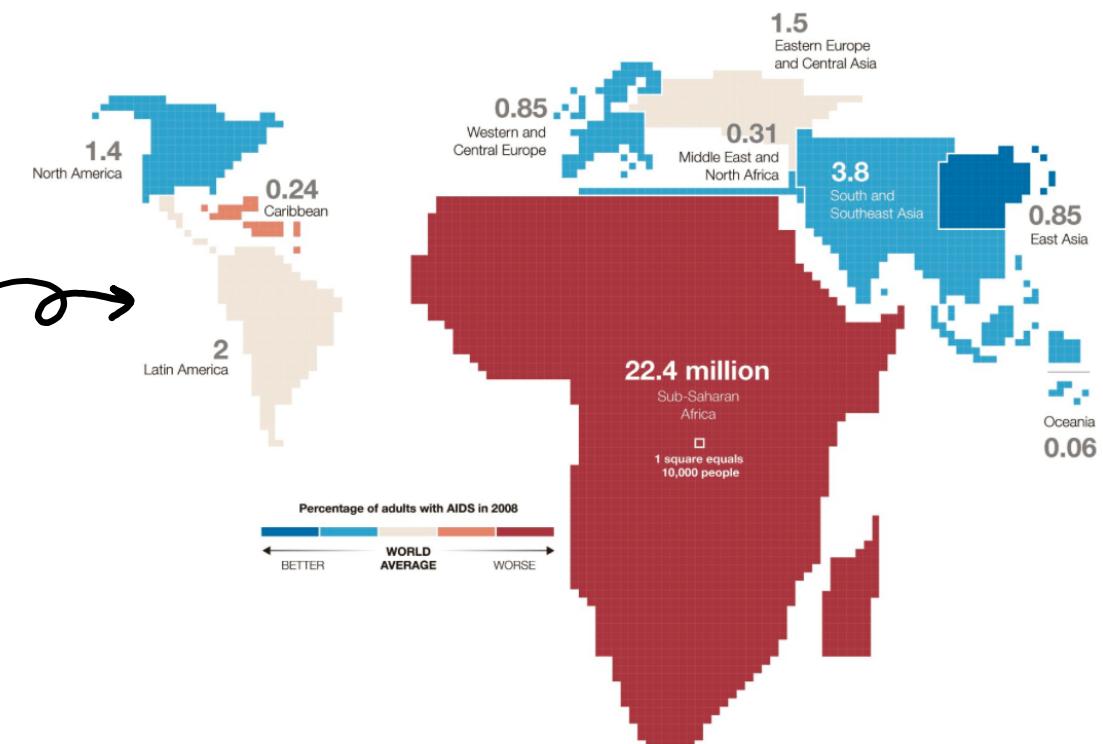
# Interaction between Mark and Channel

Point (mark) includes position → can encode it with the size and color.

Line (mark) includes position and length → can encode it with thickness and color.

Area (mark) includes position, length, width (fully constrained) → only color.

“Cartogram”  
⇒ Intentionally  
distort



# Channel Type

Magnitude: How much of something there is. (quant. ordinal)

Identity: What something it is. (Categorical, "Sometimes" ordinal)

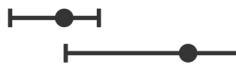
# Channel Type

## → Magnitude Channels: Ordered Attributes

Position on common scale



Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



Color saturation



Curvature



Volume (3D size)



## → Identity Channels: Categorical Attributes

Spatial region



Color hue



Motion



Shape



▲ Best  
Effectiveness  
▼ Least

Same

Same

# Expressiveness and Effectiveness

Too many pairs for (mark, channel) → **Which one is the best?**

Expressiveness:

Should express all of, and only, the information in the dataset variables.

 **No less, no more.**

Match channel type to data type.

Effectiveness:

Important variable should match the important (salient) channel – noticeability.

# Example

Expressiveness

Show more (length)



# Effectiveness

- Accuracy: How accurately can humans read the true value?
- Discriminability: How many different values can be encoded effectively?
- Separability: with what other channels can a channel be used together?
- Visual pop-out. ←→ *redundancy* .
- Perceptual groupings.

# **Effectiveness - Accuracy**

The obvious/primary way to quantify effectiveness is accuracy.

How close is human perceptual judgement to some object measurement of the stimulus.

Different visual channels → different level of accuracy .

# Effectiveness - Accuracy

## Stevens' Power Law

Large exponent: we feel more sensitive.

Small exponent: we feel less sensitive.

Exponent = 1: exact judgement.



Continuum	Exponent	Stimulus condition
Electric shock	3.5	Current through fingers
Taste	1.4	<a href="#">Salt</a>
Finger span	1.3	Thickness of blocks
Warmth	1.3	Irradiation of skin, small area
Lightness	1.2	Reflectance of gray papers
Duration	1.1	White-noise stimuli
Pressure on palm	1.1	Static force on skin
<a href="#">Vocal effort</a>	1.1	Vocal sound pressure
Brightness	1	Point source briefly flashed
Thermal pain	1	Radiant heat on skin
Visual length	1	Projected line
Taste	0.8	<a href="#">Saccharin</a>
Visual area	0.7	Projected square
Warmth	0.7	Irradiation of skin, large area
Loudness	0.67	Sound pressure of 3000 Hz tone
Smell	0.6	<a href="#">Heptane</a>
Brightness	0.5	<a href="#">Point source</a>
Brightness	0.5	Brief flash

# Channel Type

## ④ Magnitude Channels: Ordered Attributes

Position on common scale



Position on unaligned scale



Length (1D size)



Tilt/angle



Area (2D size)



Depth (3D position)



Color luminance



Color saturation



Curvature



Volume (3D size)



## ⑤ Identity Channels: Categorical Attributes

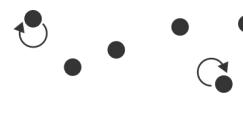
Spatial region



Color hue



Motion

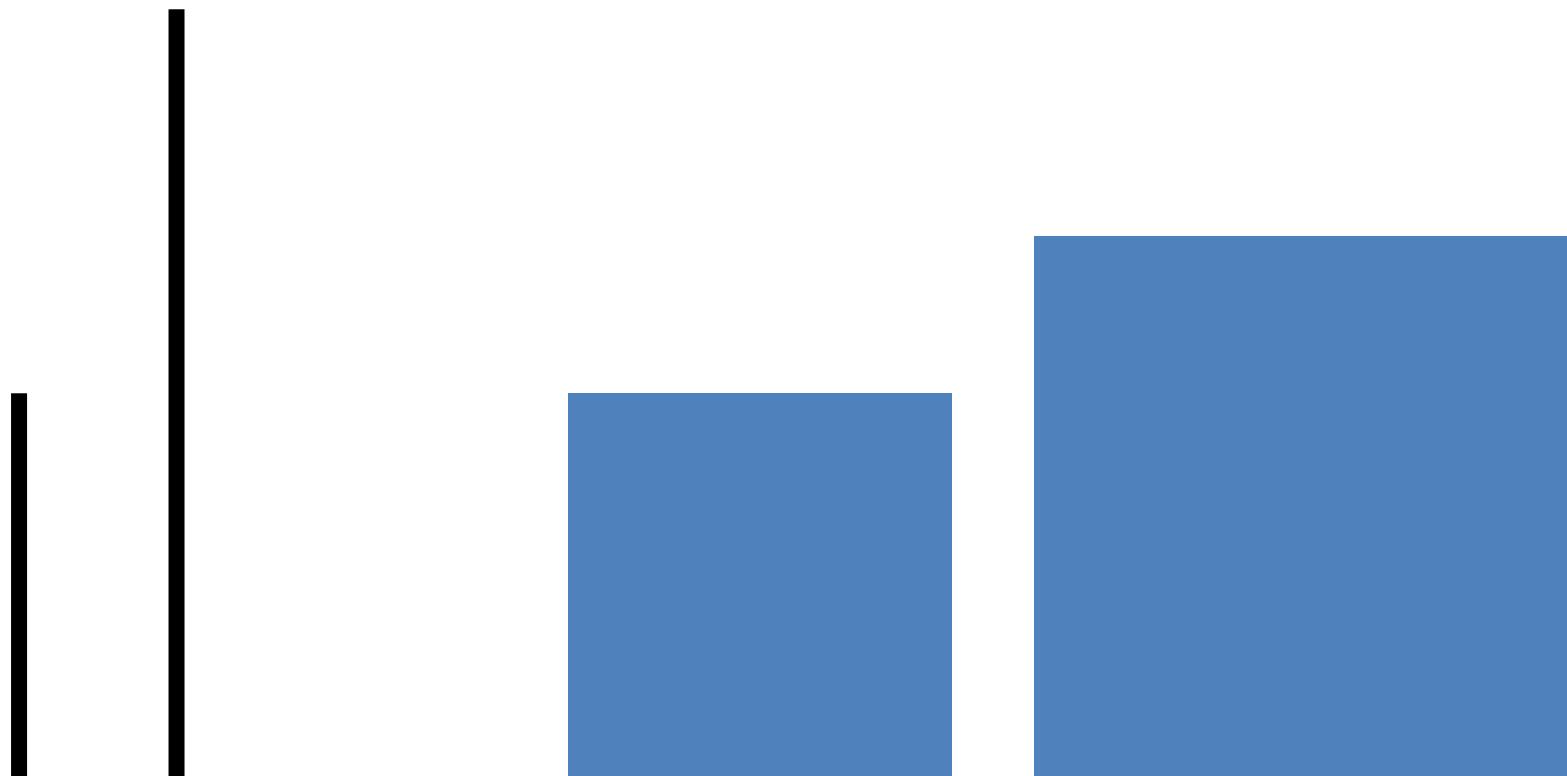


Shape

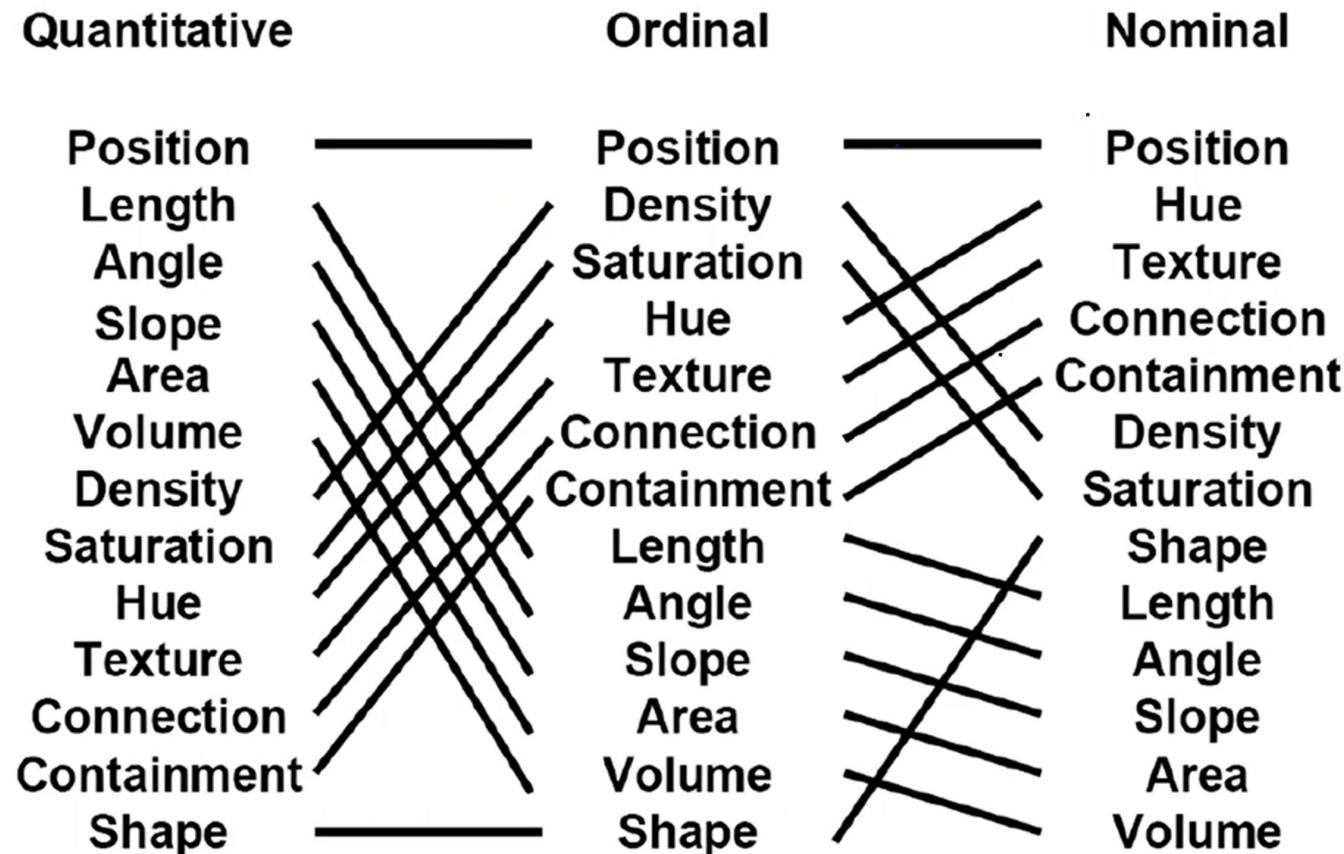


▲ Best  
Effectiveness  
Same  
Least ▼

# **Effectiveness - Accuracy**

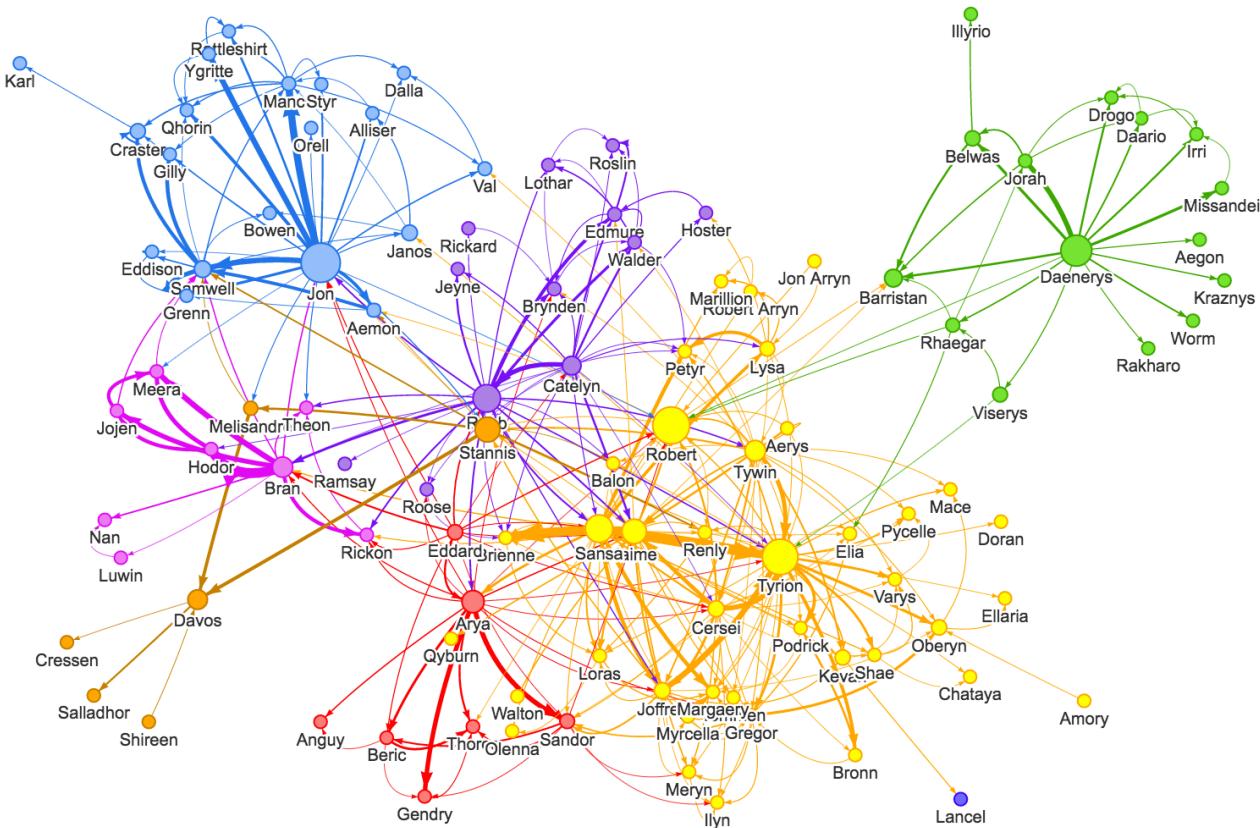


# Effectiveness Ranks by Data (Variable) Type



# Effectiveness - Discriminability

Quantify the number of **bins** that are available for a visual channel.



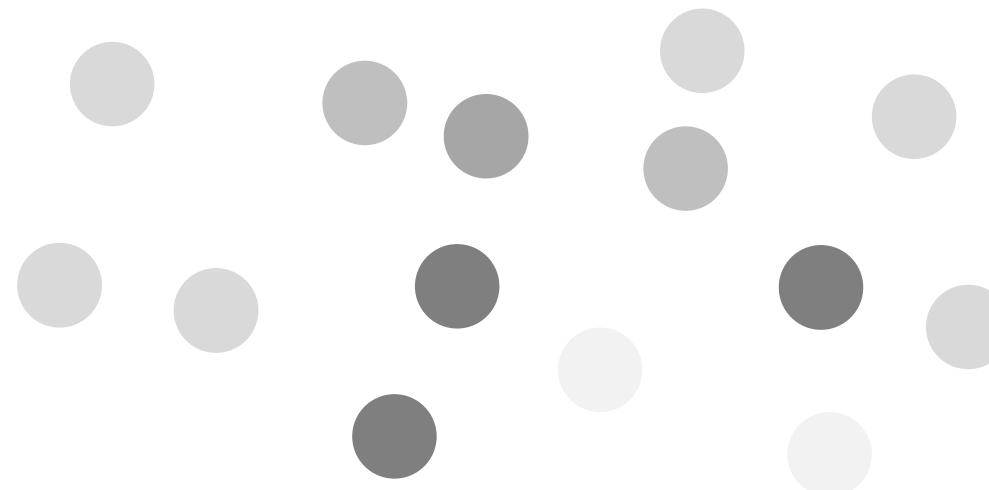
# Effectiveness - Discriminability

How many levels of lightness?



# Effectiveness - Discriminability

How many levels of lightness?



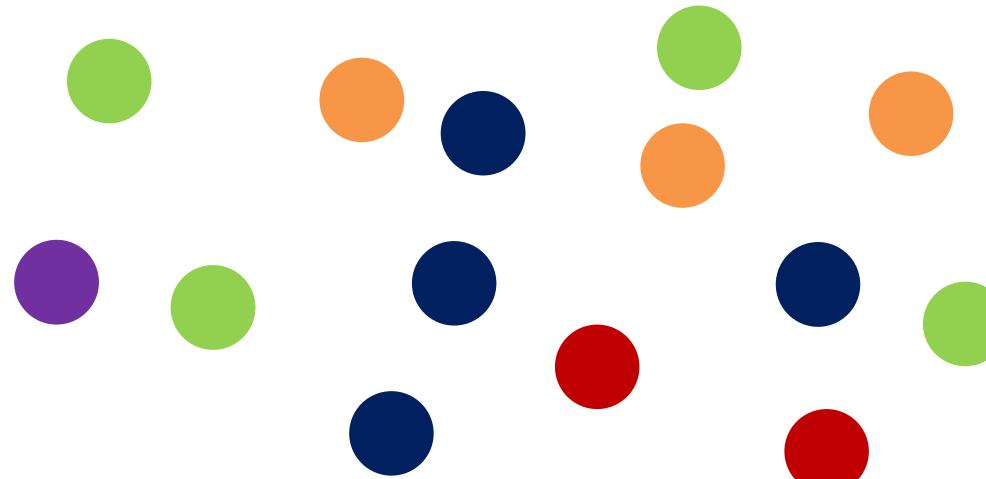
# Effectiveness - Discriminability

How many levels of lightness?



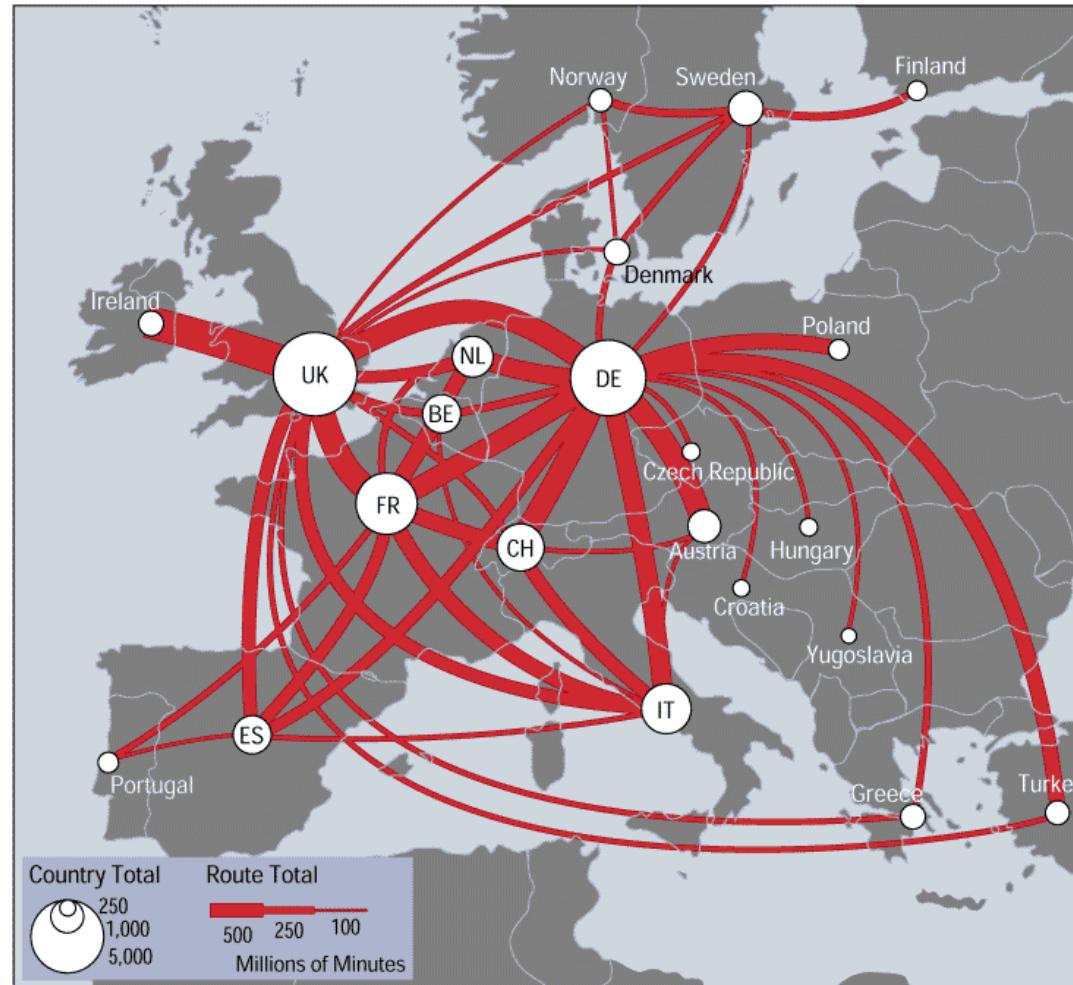
# Effectiveness - Discriminability

How about Hue?



# Effectiveness - Discriminability

How about width?

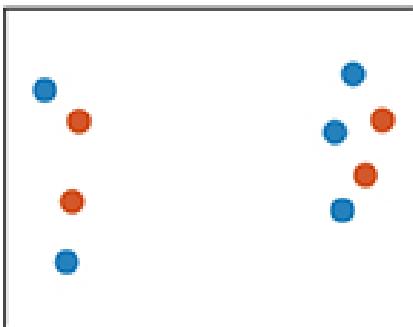


# Effectiveness - Separability

Some channels have interactions with other channels.

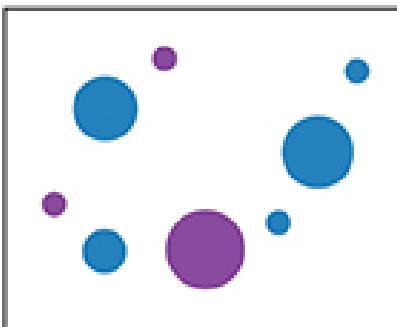
How accurately can people access information encoded by each channel?

Position  
+ Hue (Color)



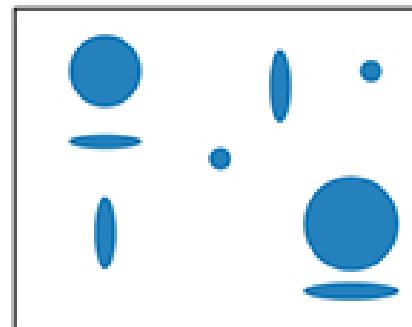
Fully separable

Size  
+ Hue (Color)



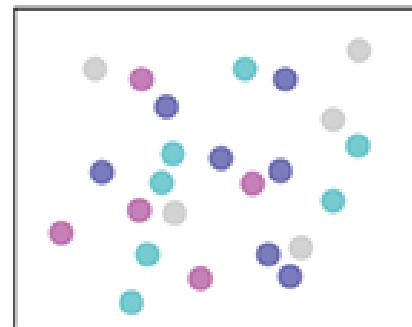
Some interference

Width  
+ Height



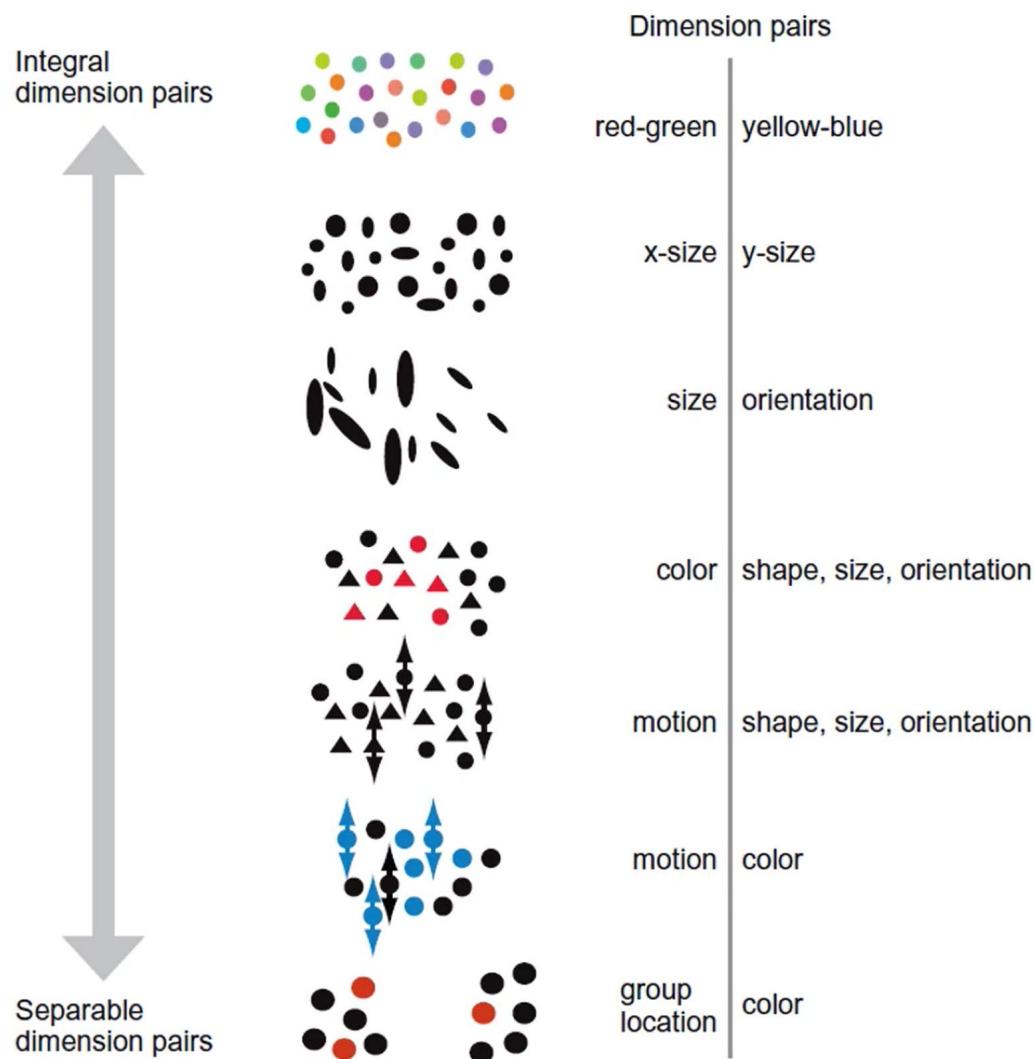
Some/significant  
interference

Red  
+ Green



Major interference

# Effectiveness - Separability



# **Effectiveness - Separability**

If the goal is to show two different data features independently, you need to use well separable channels.

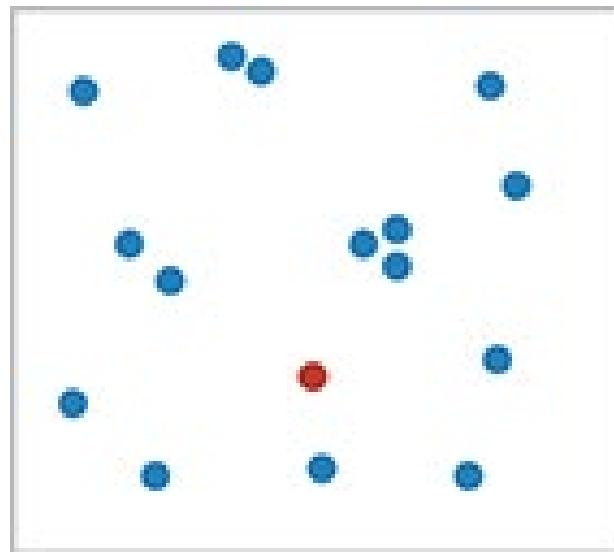
# Visual Popout

Without the need for the viewer to consciously directly attention to items one by one.

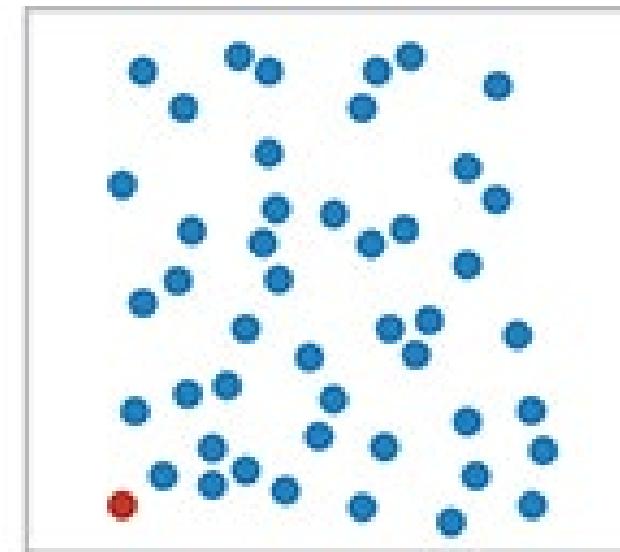
51**3**5141**3**210**3**1**3**8486**3**5156874**353**84515611122546  
6546846548444844555546879846542**3**54984846548  
14448454878966254846518752265**33**549844254864  
66541824897885526254899611546484667115**33**546

# Visual Popout

Without the need for the viewer to consciously directly attention to items one by one.



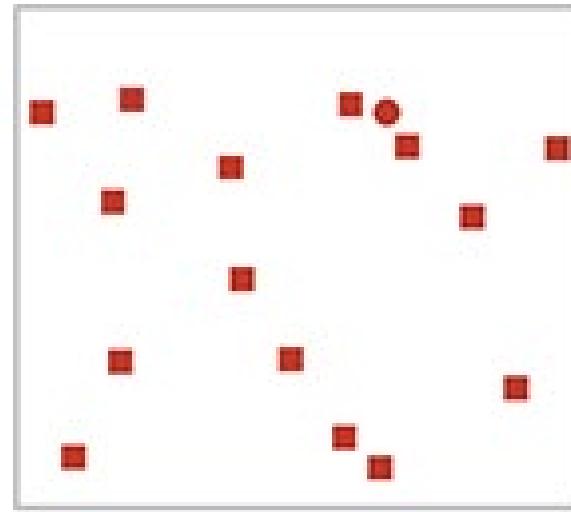
(a)



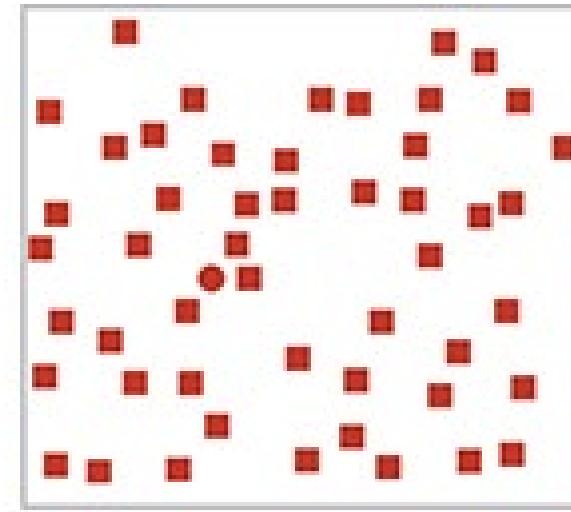
(b)

# Visual Popout

Without the need for the viewer to consciously directly attention to items one by one.



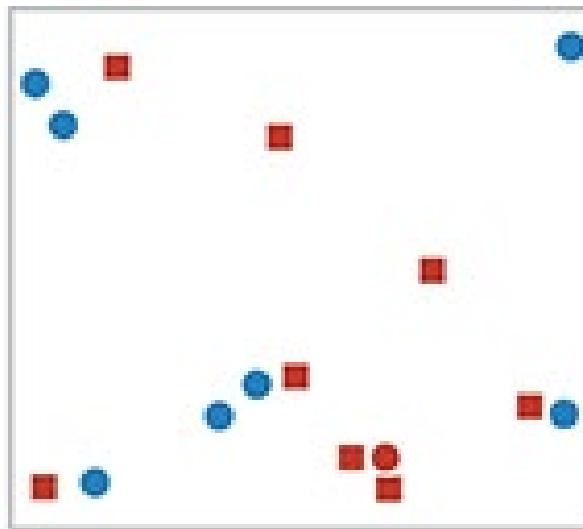
(c)



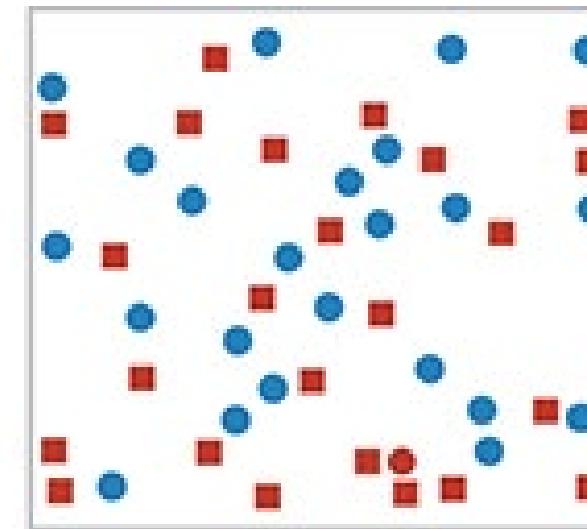
(d)

# Visual Popout

Without the need for the viewer to consciously directly attention to items one by one.



(e)



(f)

# Visual Popout

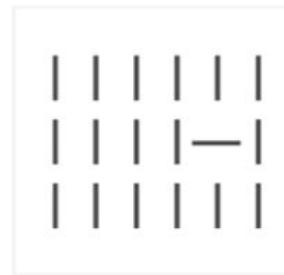
Without the need for the viewer to consciously directly attention to items one by one.



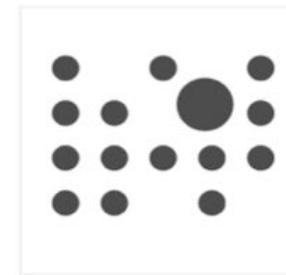
Length



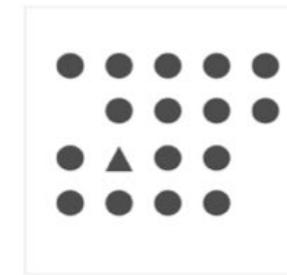
Width



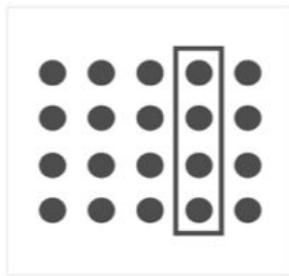
Orientation



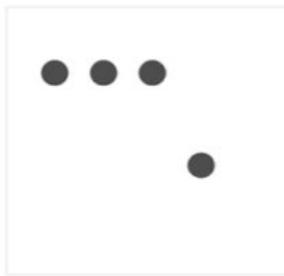
Size



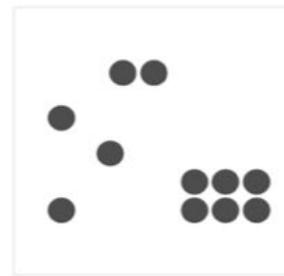
Shape



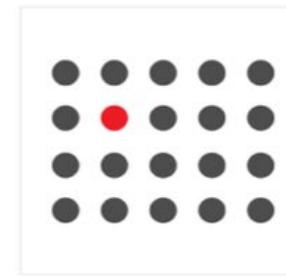
Enclosure



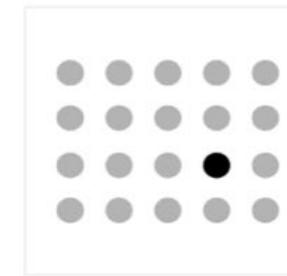
Position



Grouping



Color Hue



Color  
Intensity

# Visual Popout

Popout happens for a single visual channel.

Most pairs of channels do not support popout, but

- ✓ Shape + Color
- ✓ Motion + Shape

Impossible for three or more channels.

5135141321031384863515687435384515611122546  
6546846548444844555546879846542354984846548  
1444845487896625484651875226533549844254864  
6654182489788552625489961154648466711533546

# Grouping

Easiest way to show visual elements as groups is just to connect the elements

Gestalt Law:

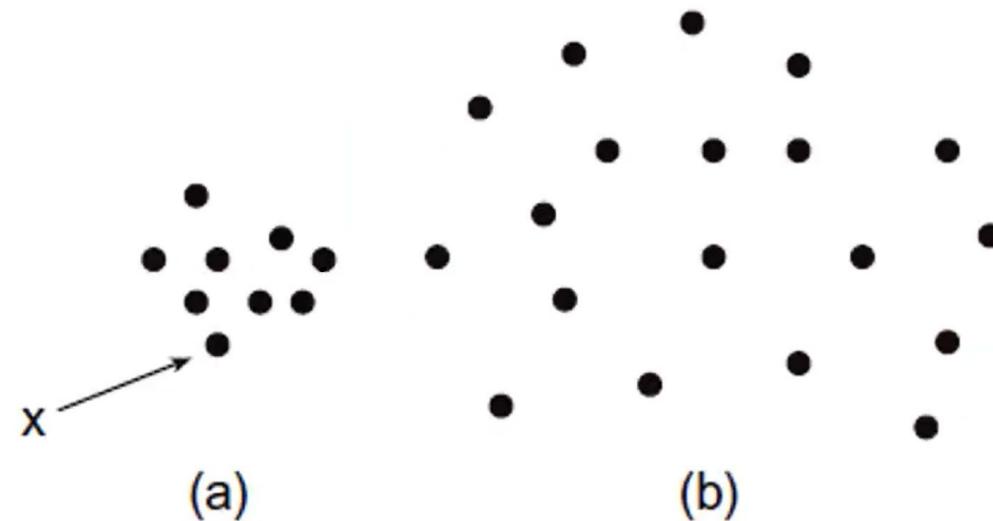
Proximity: close together

Similarity: similar object (mark)

Connectedness:

Continuity

# Proximity

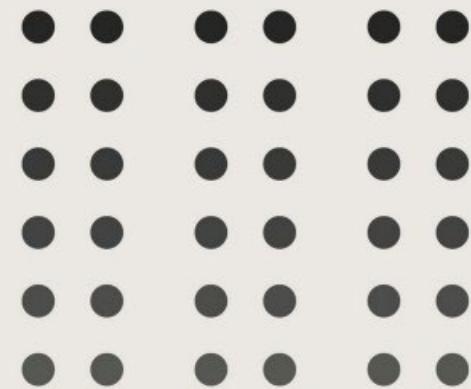


# Proximity

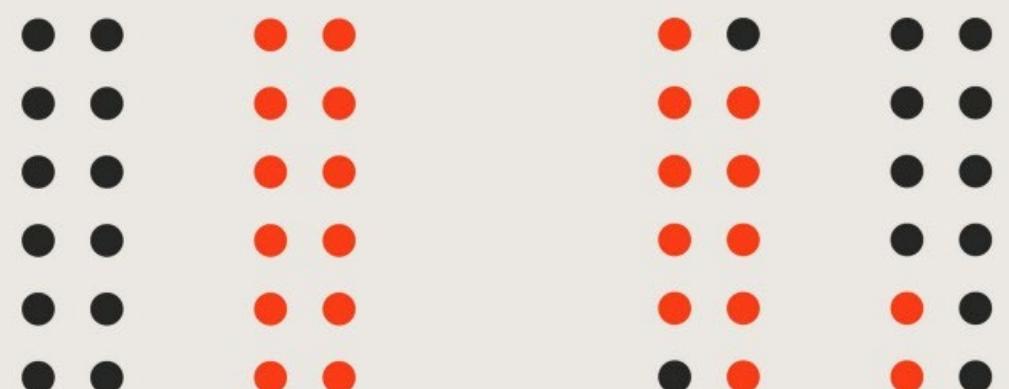
Proximity  
Grouping  
**Abstract**



ex. 01



Proximity  
**Overpowers**  
Color

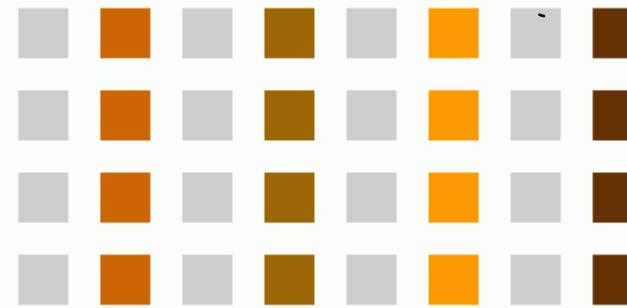
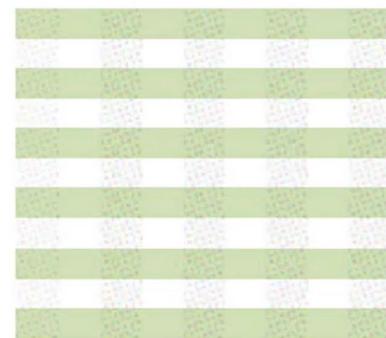
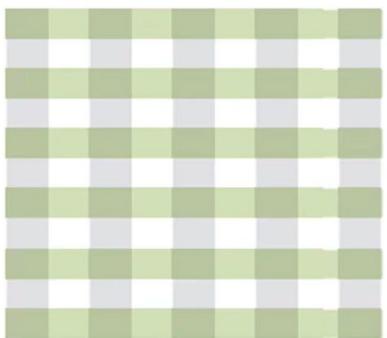
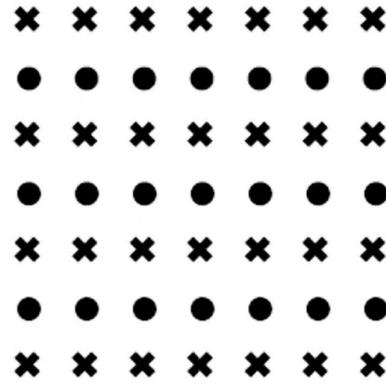
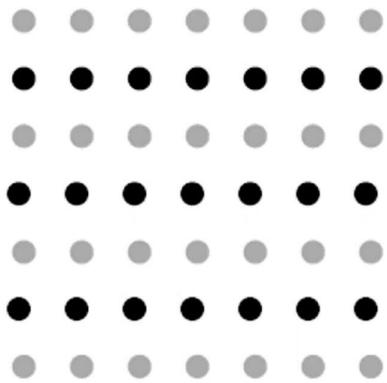


ex. 02

# Proximity



# Similarity



# Similarity

Color > Shape .

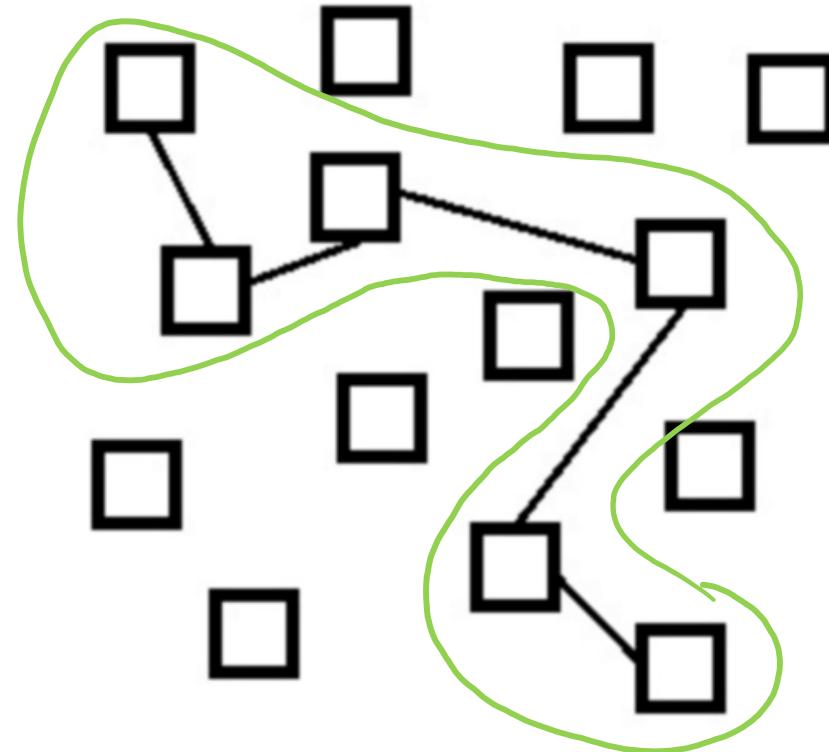
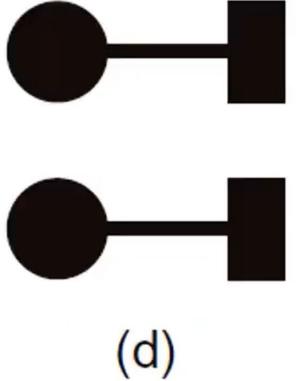
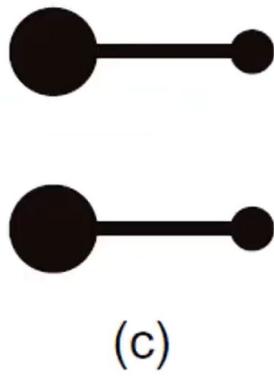
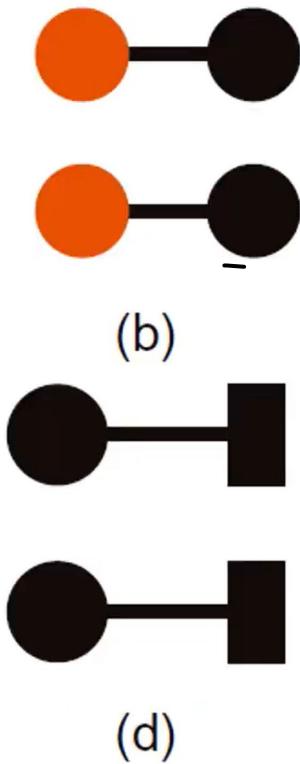
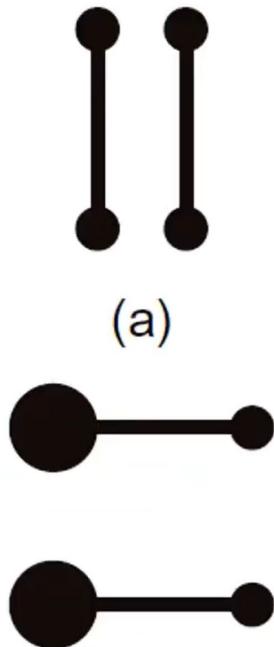


NNGROUP.COM NN/g

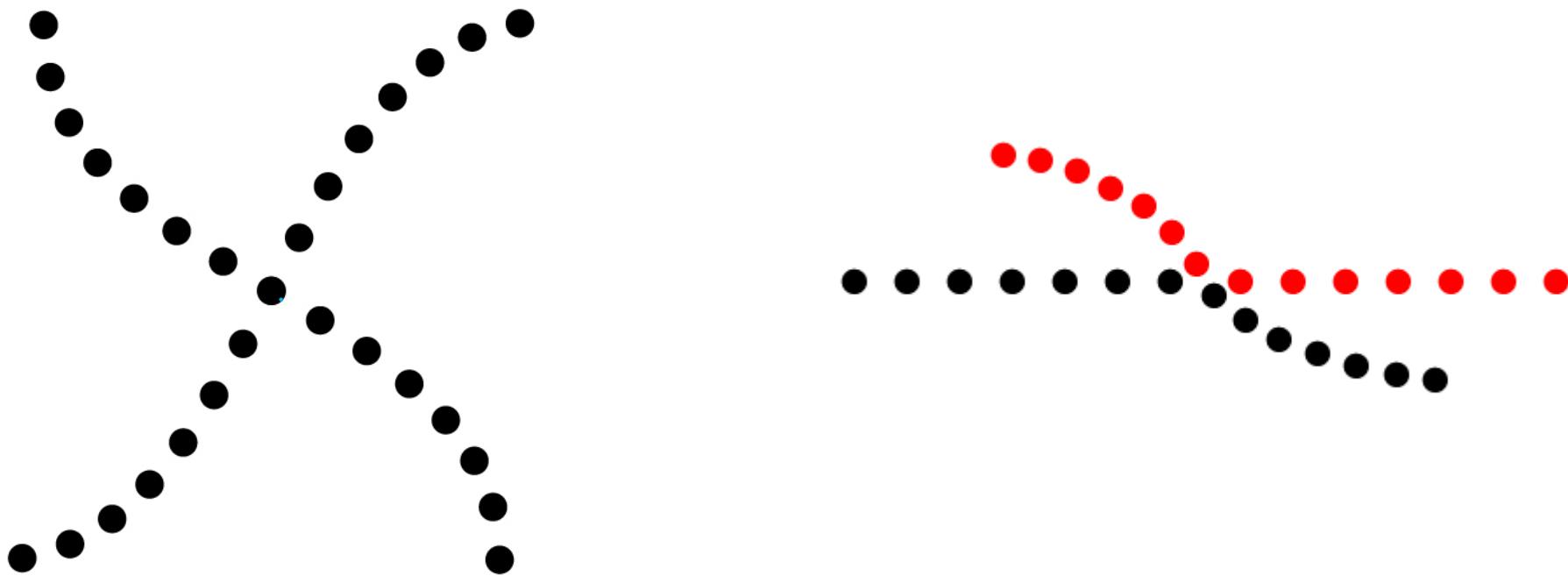
NNGROUP.COM NN/g

**Connectedness >> proximity , similarity**

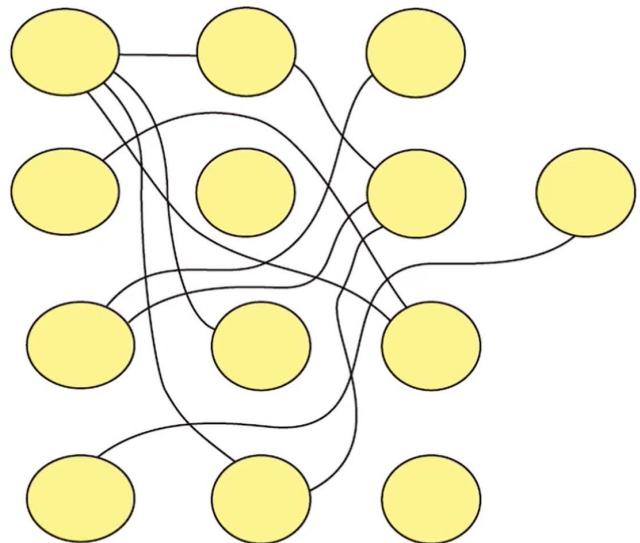
Very Strong



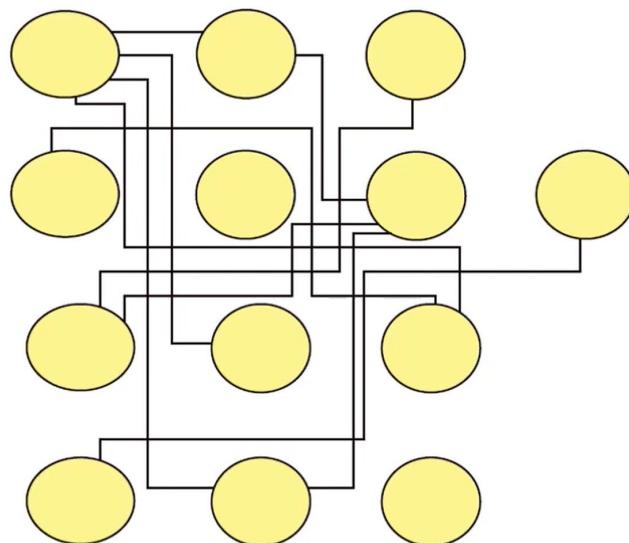
# Continuity



# Continuity



(a)



(b)

# Summary

1. Mark and Channel.
2. Expressiveness and Effectiveness.
  - Accuracy.
  - Discriminability.
  - Separability.
  - Visual pop-out.
  - Perceptual groupings.