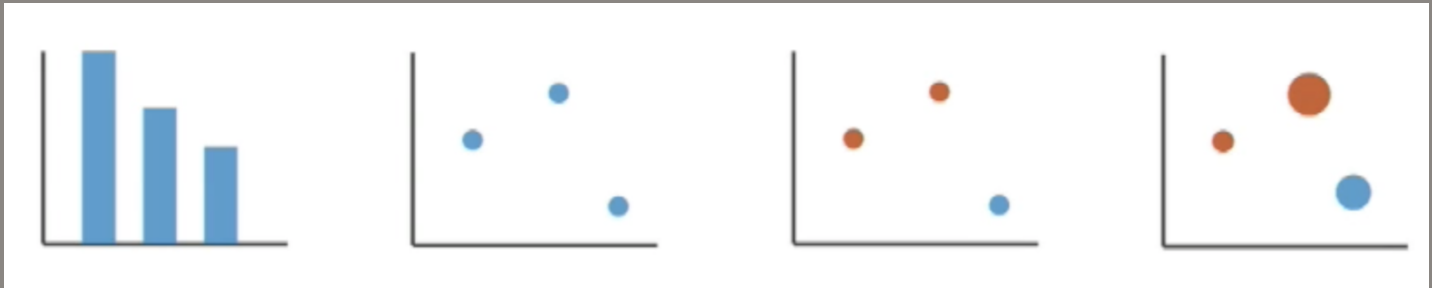
Foundation:
Marks and Channels

S03-01

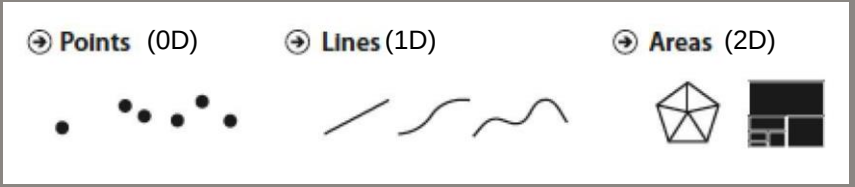
Visual Encoding

- Data/values -> shapes
- Analyze idiom structure



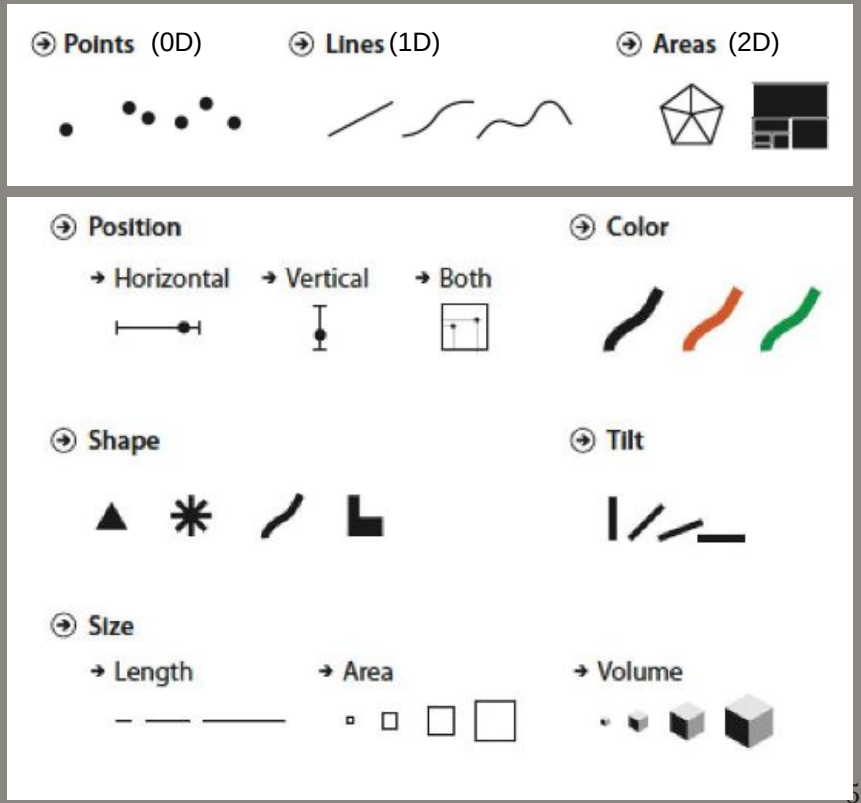
Definition: Marks and Channels

- Marks
  - Geometric primitives
  - Different spatial dimension



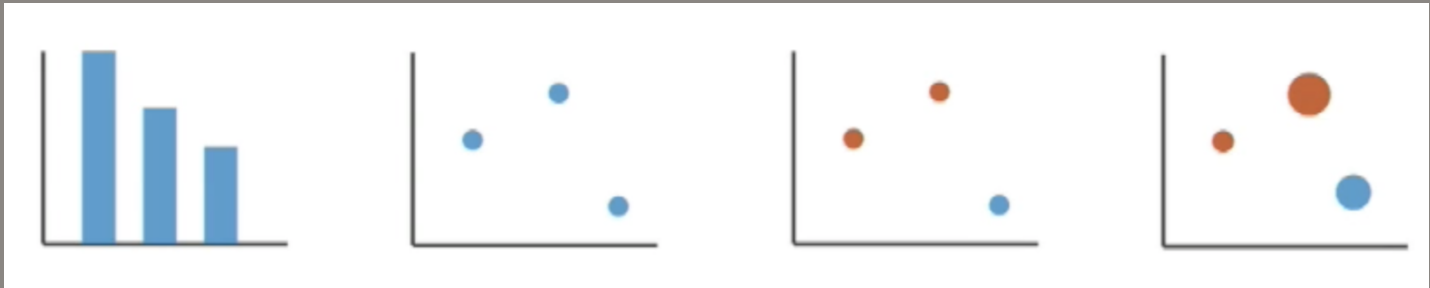
Definition: Marks and Channels

- Marks
  - Geometric primitives
  - Different spatial dimension
- Channels (visual variable)
  - Control appearance of marks
  - Can redundantly code with multiple channels



Visual Encoding

- Data/values -> shapes
- Analyze idiom structure: as combination of marks and channels



Channel: vertical position

Mark: line

Channel: vertical position
horizontal position

Mark: point

Channel: vertical position
horizontal position
color

Mark: point

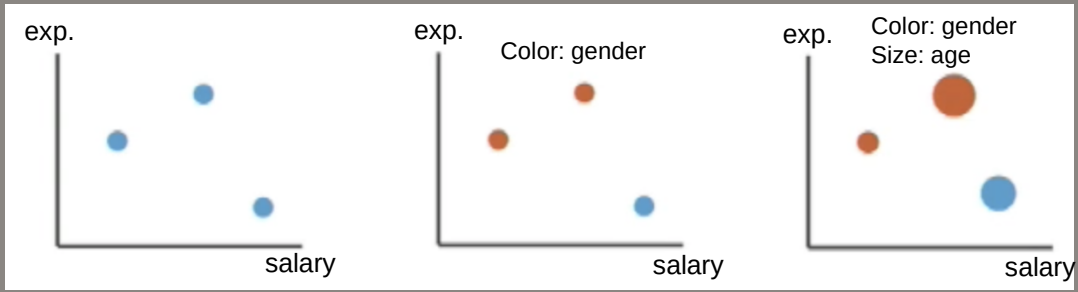
Channel: vertical position
horizontal position
color
size

Mark: point

One Example to Map Data to a Picture

- Relation between data, and mark and channel
  - A mark could represent a data item
  - A channel could represent an attribute
- If this is our data

salary	expenditure	gender	age
100000	80000	female	55
150000	40000	male	40
50000	60000	female	35



Channel: vertical position
horizontal position

Mark: point

Channel: vertical position
horizontal position
color

Mark: point

Channel: vertical position
horizontal position
color
size

Mark: point

One Example to Map Data to a Picture

Mark (each data item): 0D point

- Relation between data, and mark and channel
  - A mark could represent a data item
  - A channel could represent an attribute
- If this is our data

Channels of the 0D point :

horizontal position | Vertical position | Color (hue) | size

salary	expenditure	gender	age
100000	80000	female	55
150000	40000	male	40
50000	60000	female	35

Channel: vertical position
horizontal position

Mark: point

Channel: vertical position
horizontal position
color

Mark: point

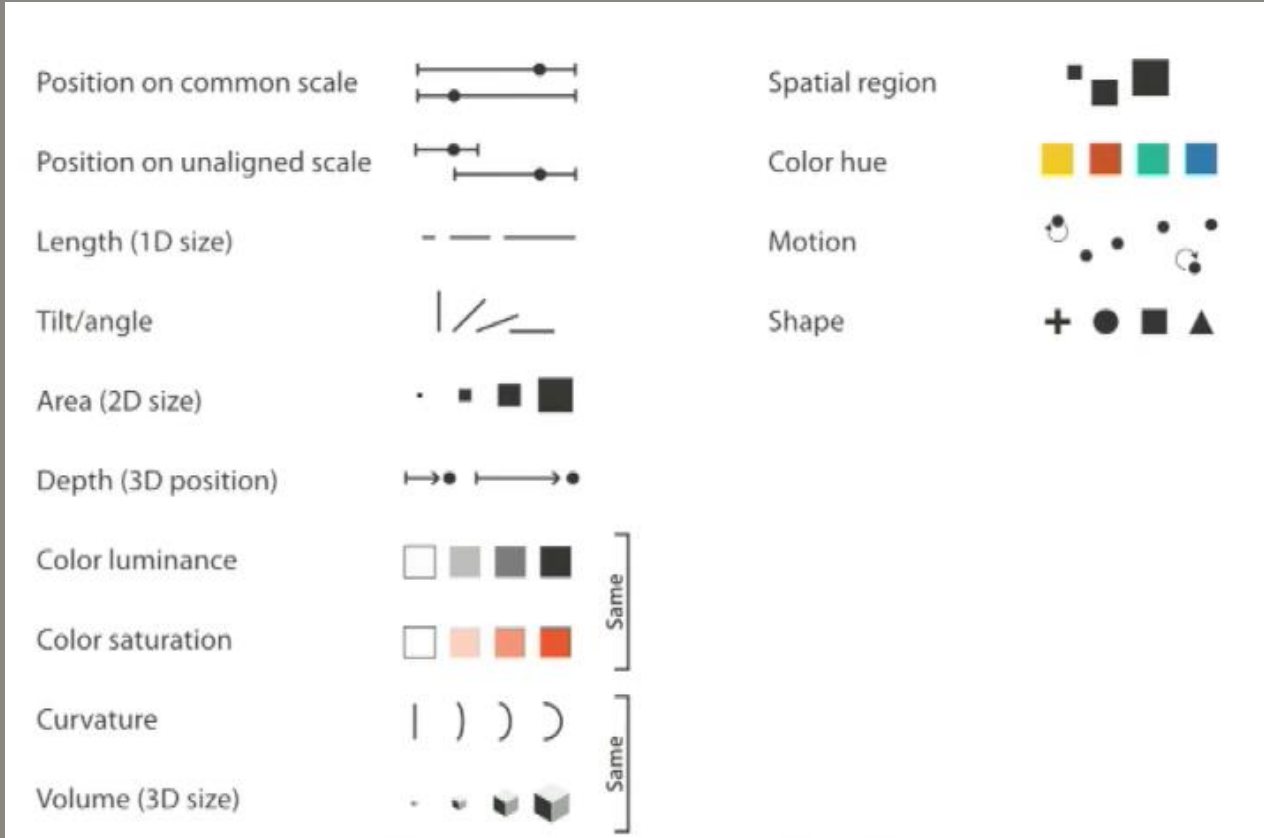
Channel: vertical position
horizontal position
color
size

Mark: point

Channels

- We have a lot of choice about channel
  - How to determine which channel is proper to represent an attribute

Why not: color -> age
size-> gender



S03-02

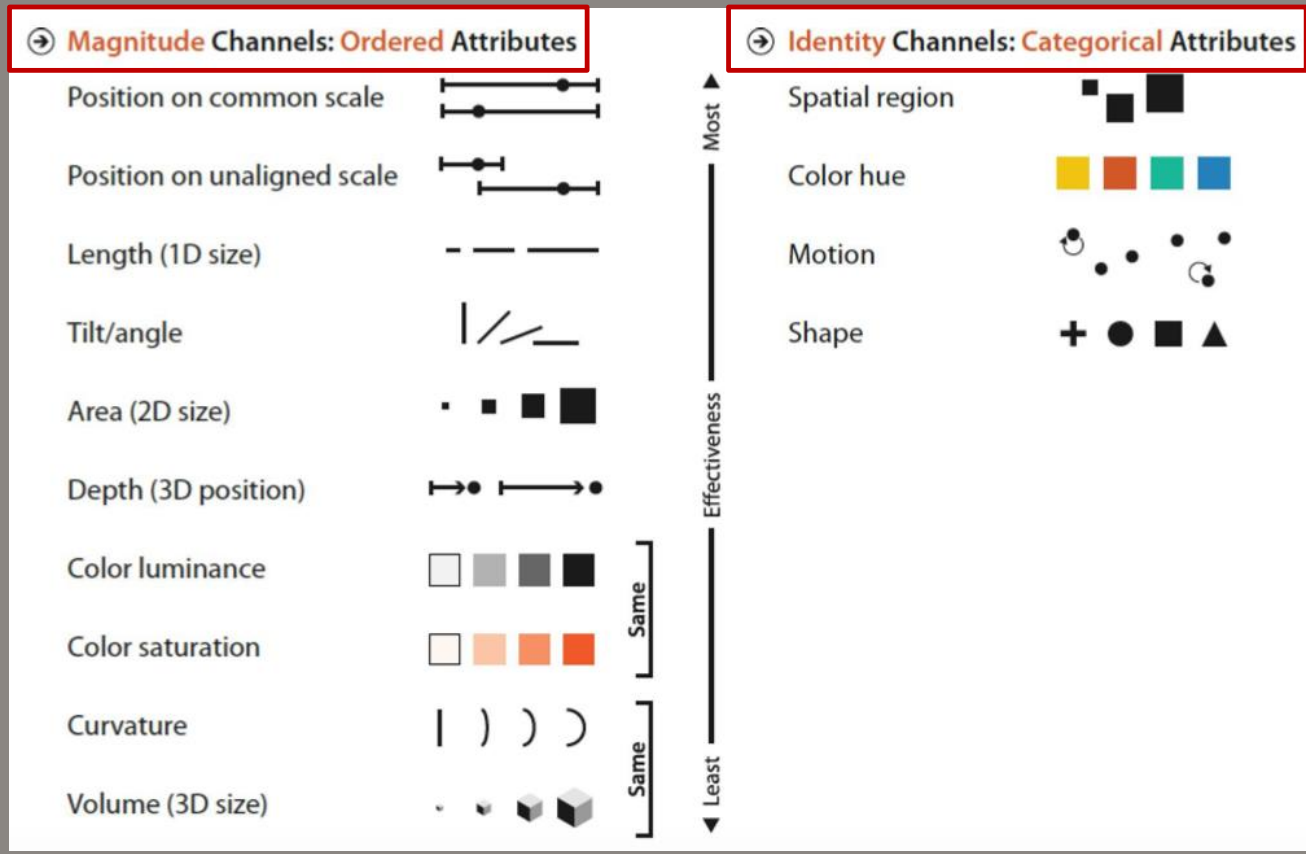
Choice of Mark and Channels

- Expressiveness
  - Match channel and data characteristic
    - For example, ordered data are seen as orders (and vice versa)

Why not: color -> age
size-> gender

Expressiveness

- Magnitude channel
  - human naturally percepts the order
  - good to represent “ordered” attribute
- Identity channel
  - human can easily separate the channel with different value
  - good to represent “categorical” attribute



S03-03

Choice of Mark and Channels

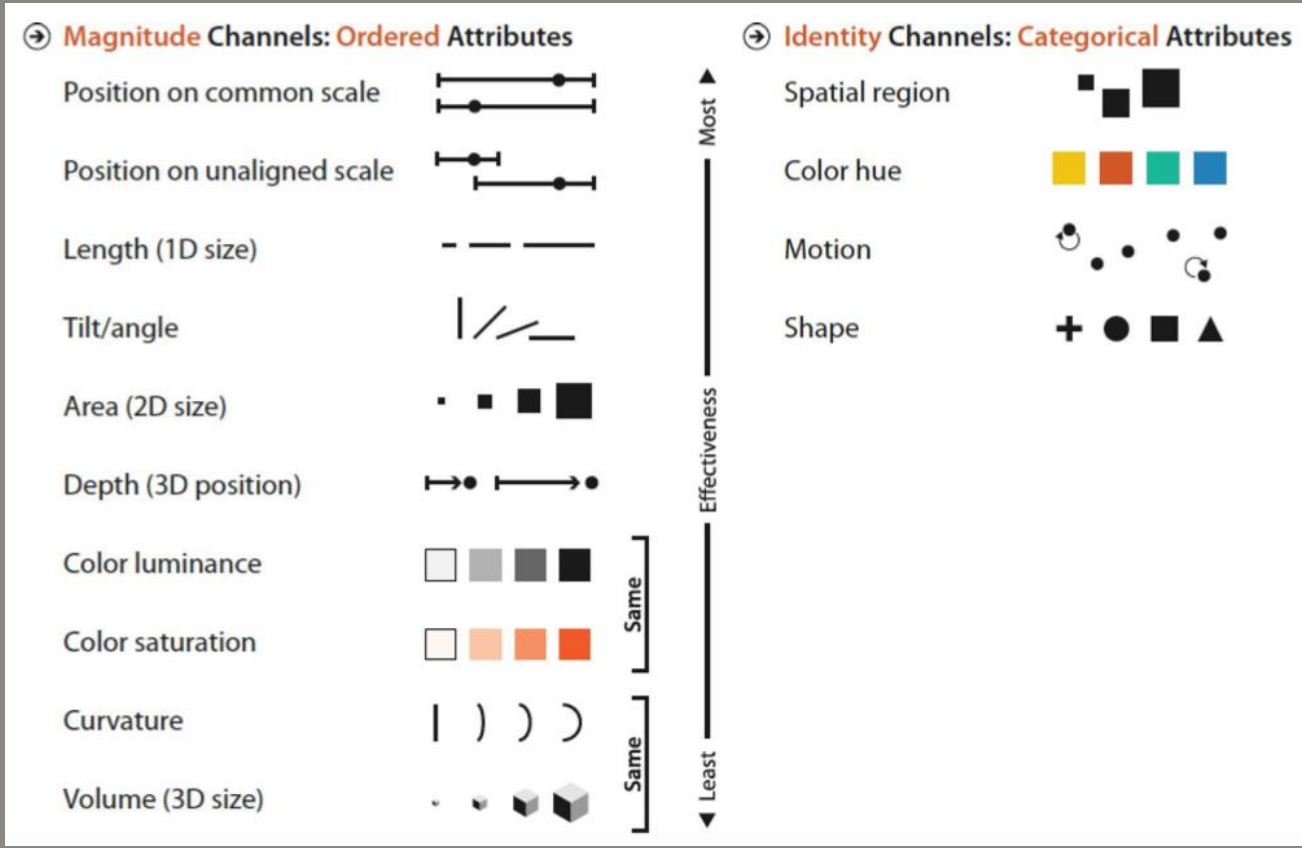
- Expressiveness
  - Match channel and data characteristic
    - For example, ordered data are seen as orders (and vice versa)
- Effectiveness
  - The importance of the attribute should match the **salience** channel
    - For example, important items are made the most noticeable

Effectiveness

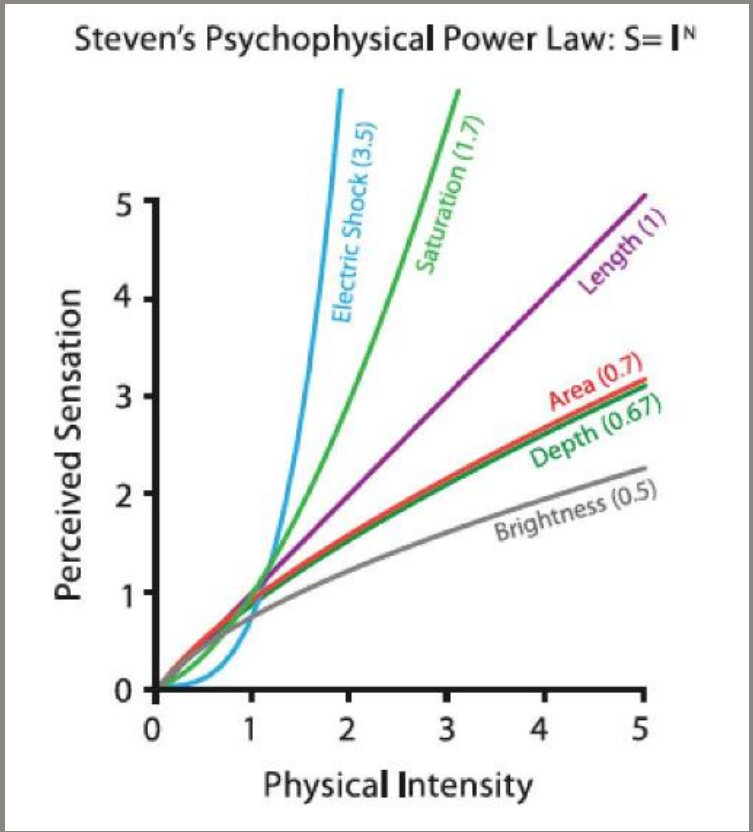
- Sensitivity of our visual system

Their length is the same?

Their angle is the same?



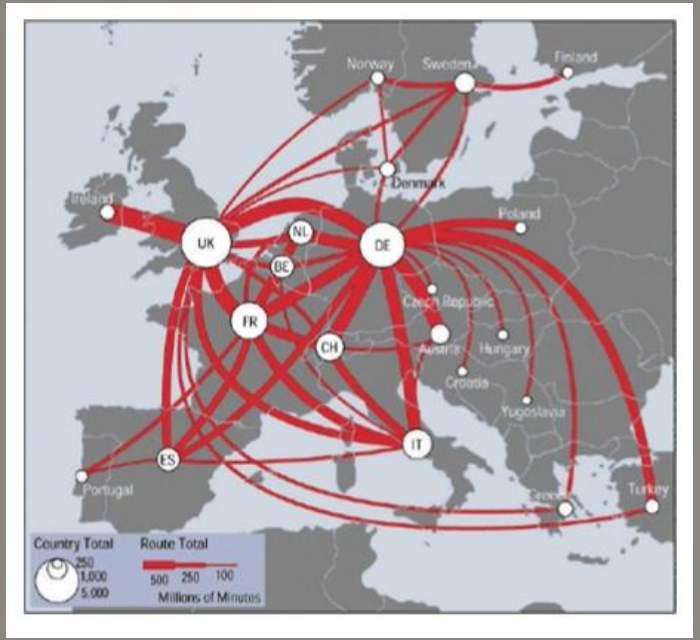
Accuracy: Fundamental Theory



S03-04

Discriminability

- When we use a channel to represent the values of an attribute, we should consider the discriminability of the channel
  - How many “usable” steps
- Must be sufficient for number of attribute level to show
  - Linewidth: 3 or 4 bins
  - Even if you draw lines with 10 different width, human cannot separate them



Example: Separability

- Sometimes, we want users can query and compare arbitrary groups
  - compare high vs low literacy (red and gray)
  - Compare high vs low urban (circle and cross)

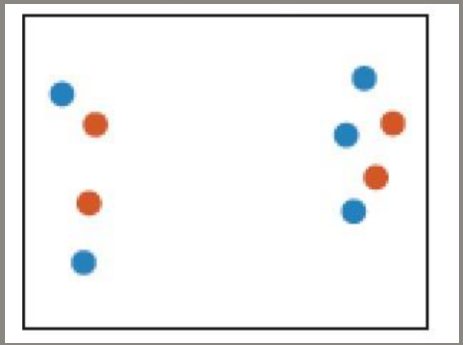
This visual design is ok to meet above tasks

Encode the data by other channels? might not be as easy as this design to complete above tasks

S03-05

Separability

Separate red and blue group
Separate left and right group



Separability

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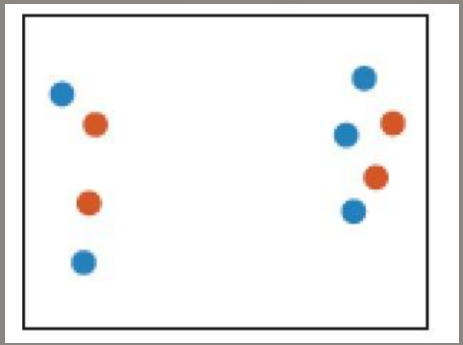
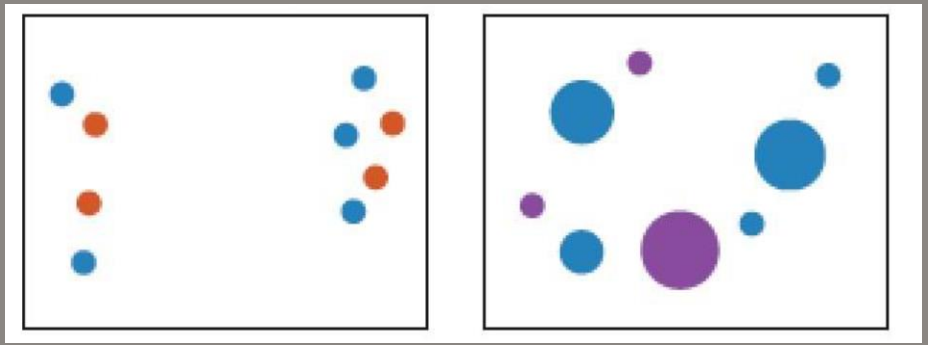


These two channel (position, hue color) is fully separable

Separability

Separate large and small size
Separate blue and purple



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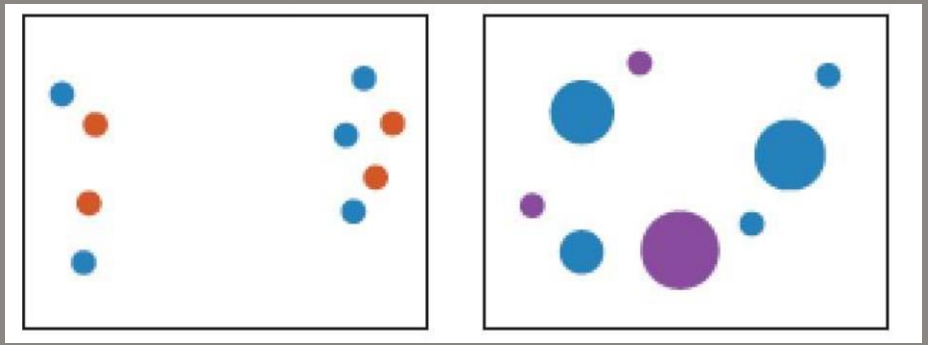
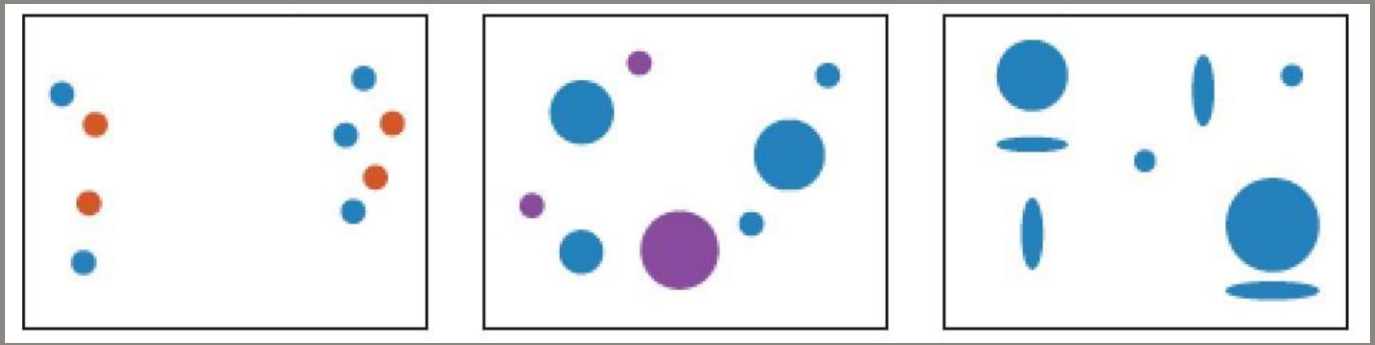


These two channel (position, hue color) is fully separable

Size and color (hue) have some interference

Separability

Separate wide and narrow width
Separate short and tall height



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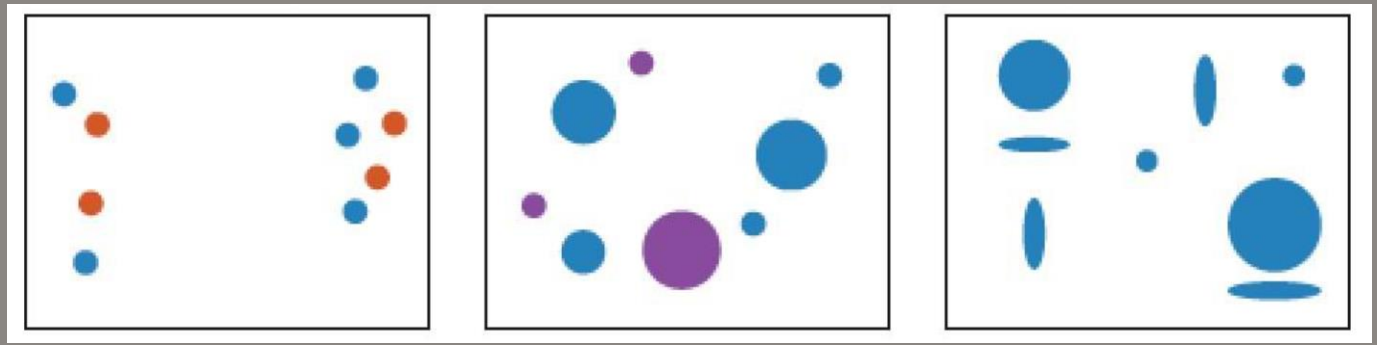


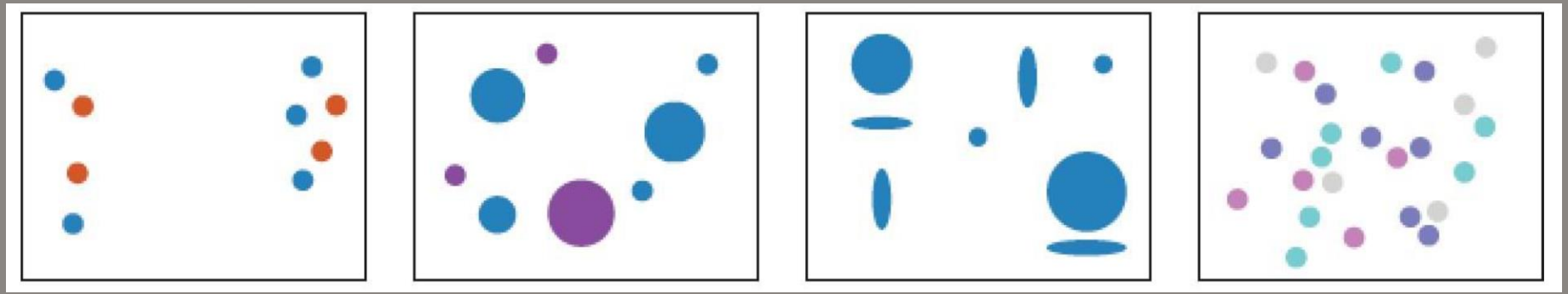
Position and hue color channels are fully separable

Size and color (hue) channels have some interference

Width and height channels have significant interference (our visual system naturally focus to size channel)

Separability

Consider RGB color
Separate high/low value in red channel
Separate high/low value in green channel



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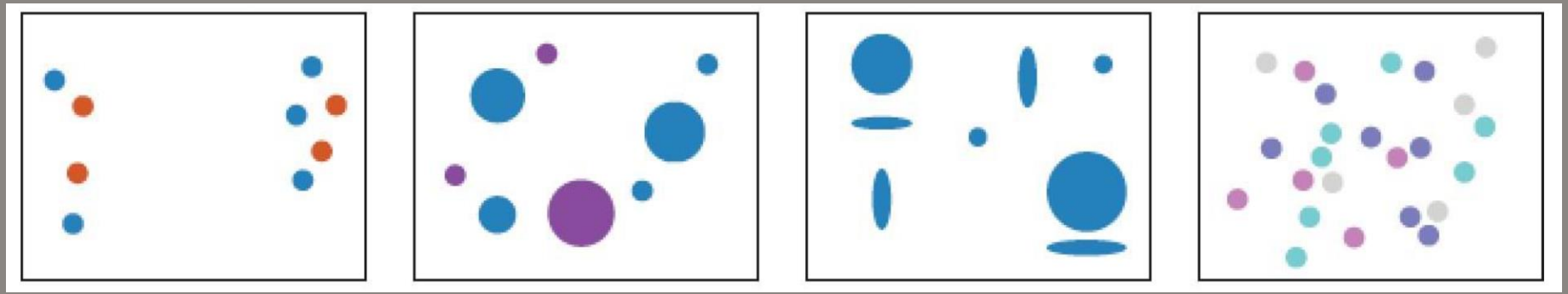

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Size and color (hue) channels have some interference

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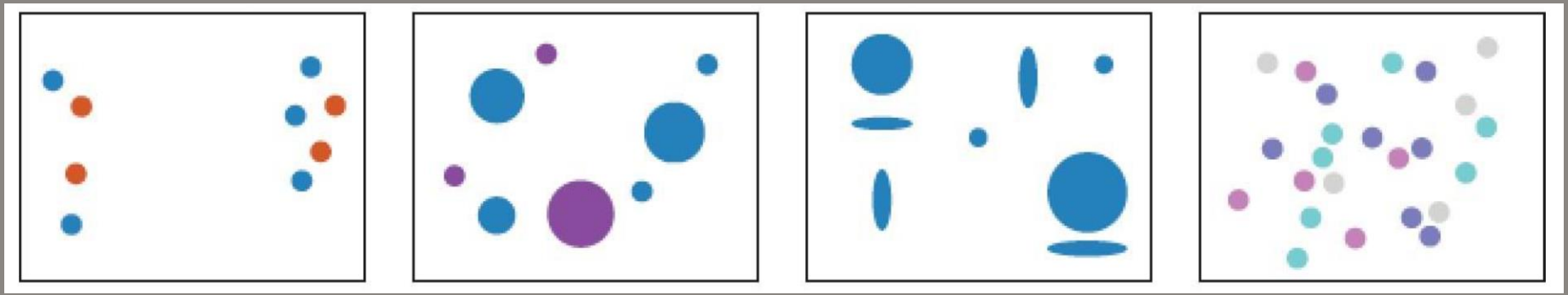
Major interference
Use RGB system to understand color does not fit out visual system

Separability

- Integrality vs separability is not good or bad
  - Key: match the characteristics of the channels to the information that to encode
    - Do you want users visually group data by one channel only and sometimes by another channel only?
  - They are not binary



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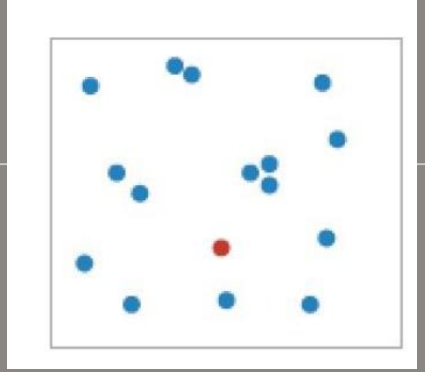
Popout

- Find the “red circle”
  - How long does it take?



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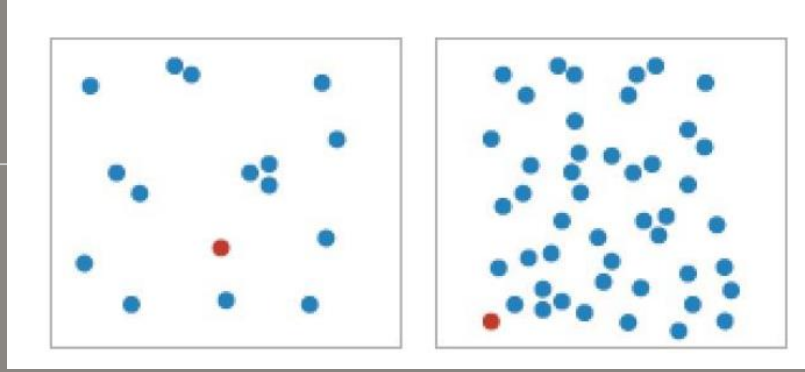

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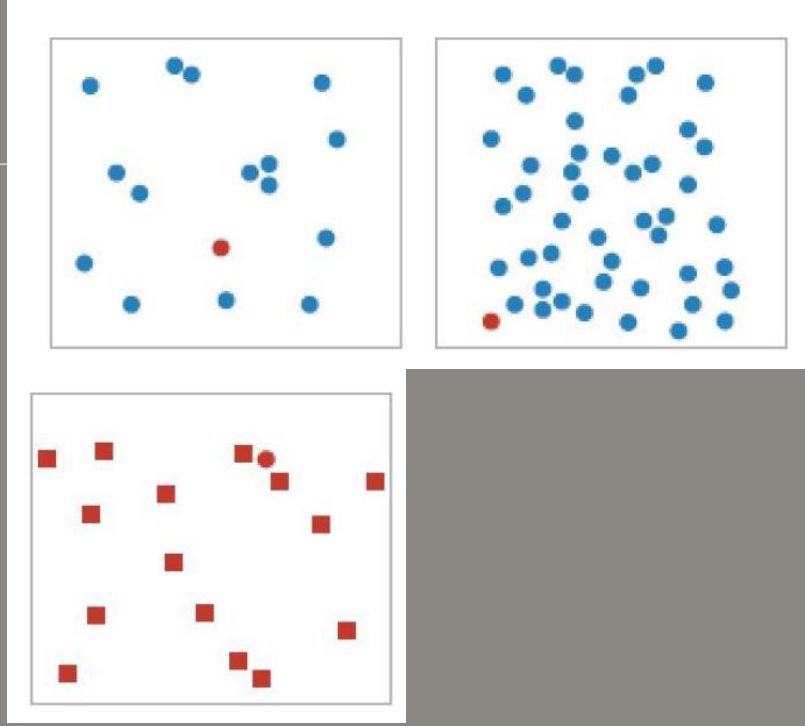

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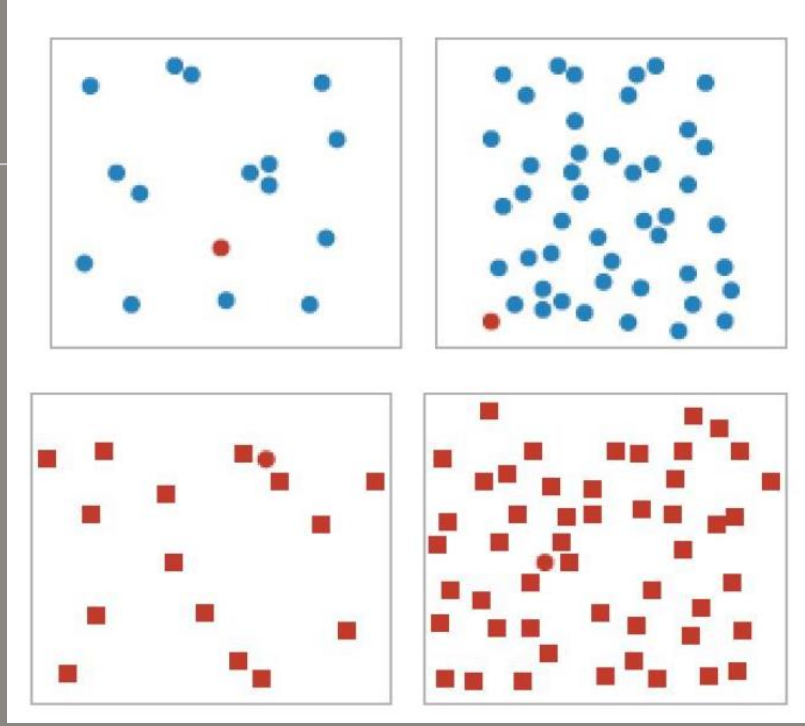

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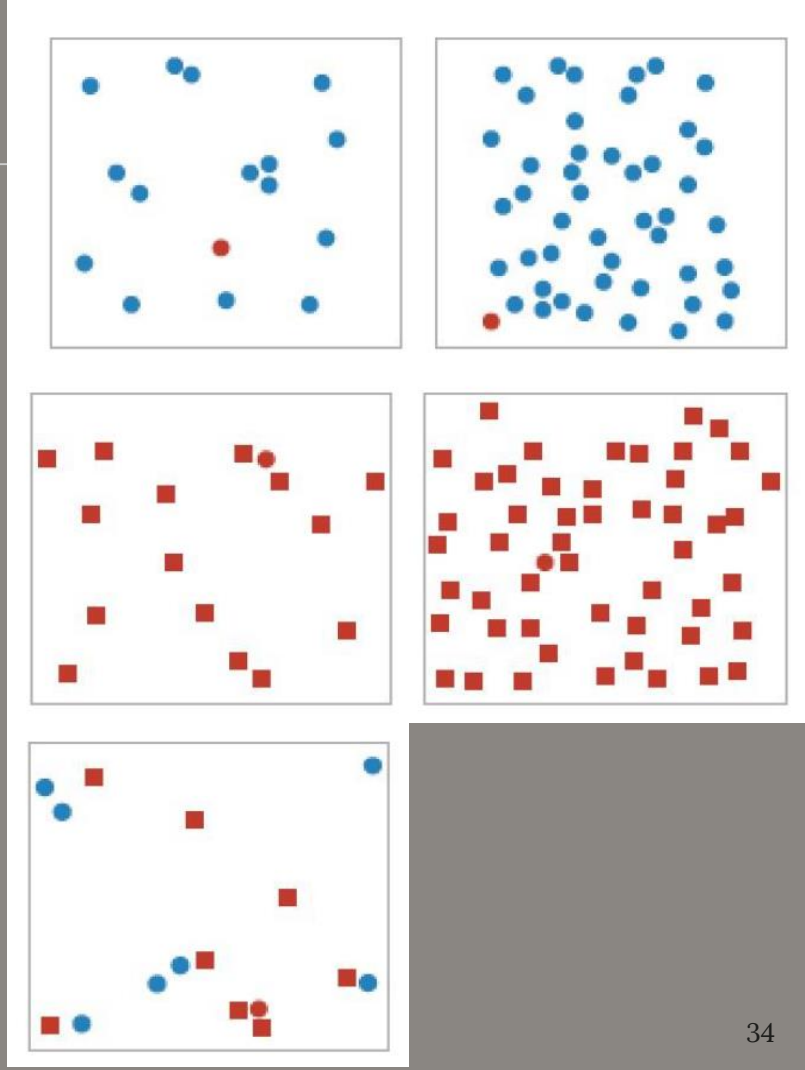

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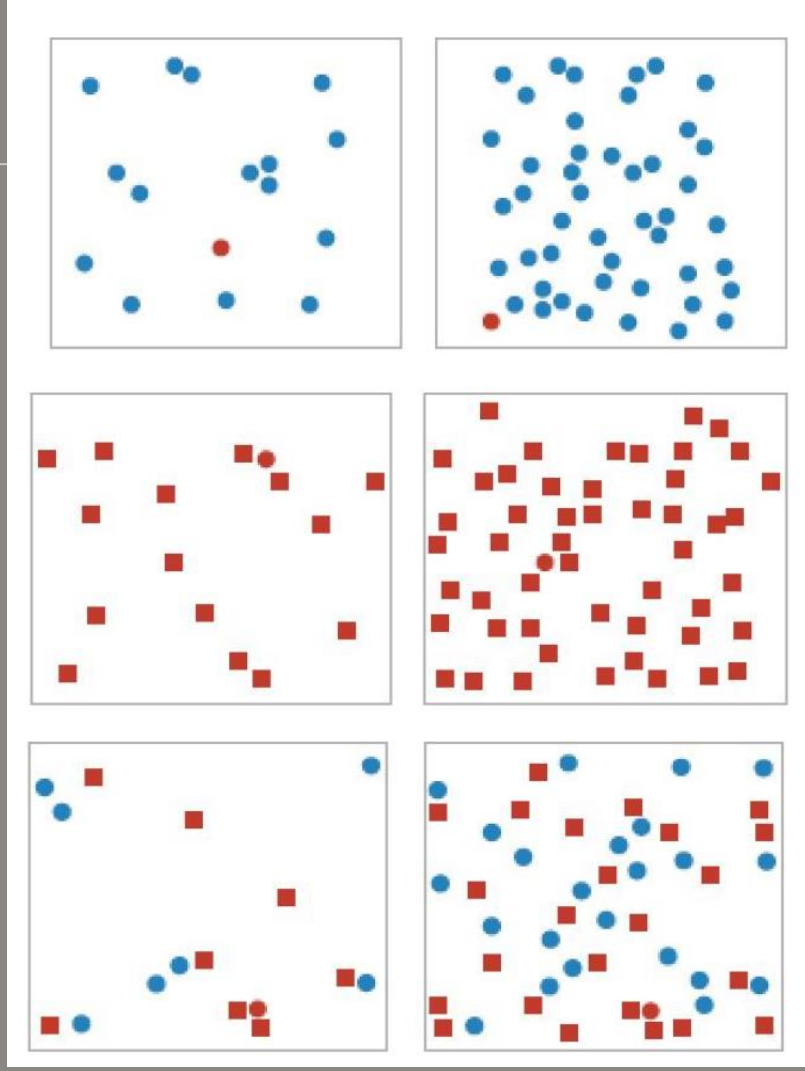
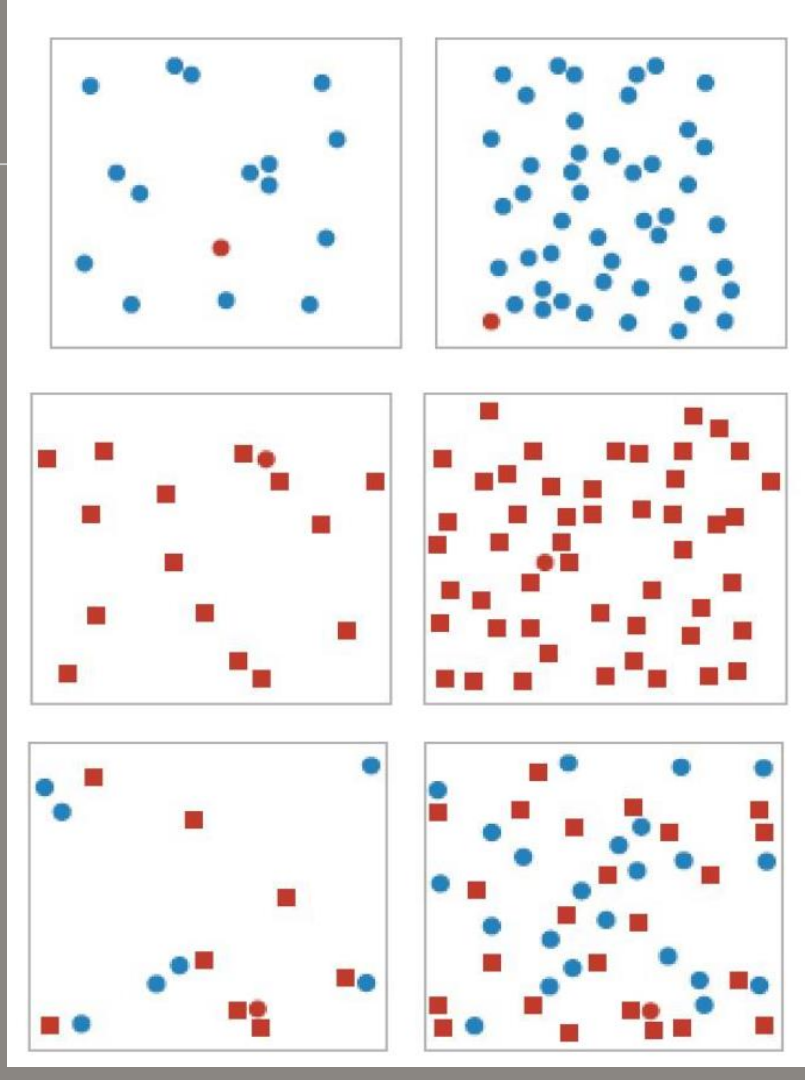


Popout

- Find the “red circle”
  - How long does it take?
- Parallel processing on many individual channels
  - Speed independent of distractor count
  - Speed depends on channel and amount of difference
- Serial search for (almost all) combinations
  - Speed depends on number of distractors



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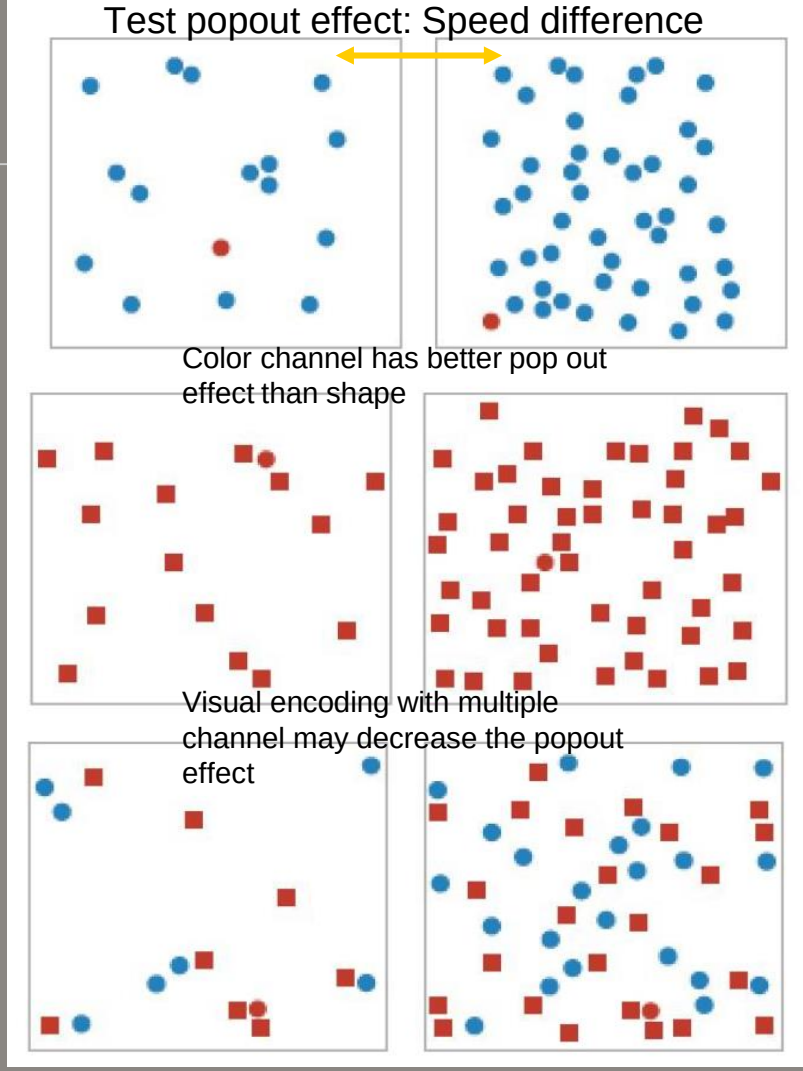
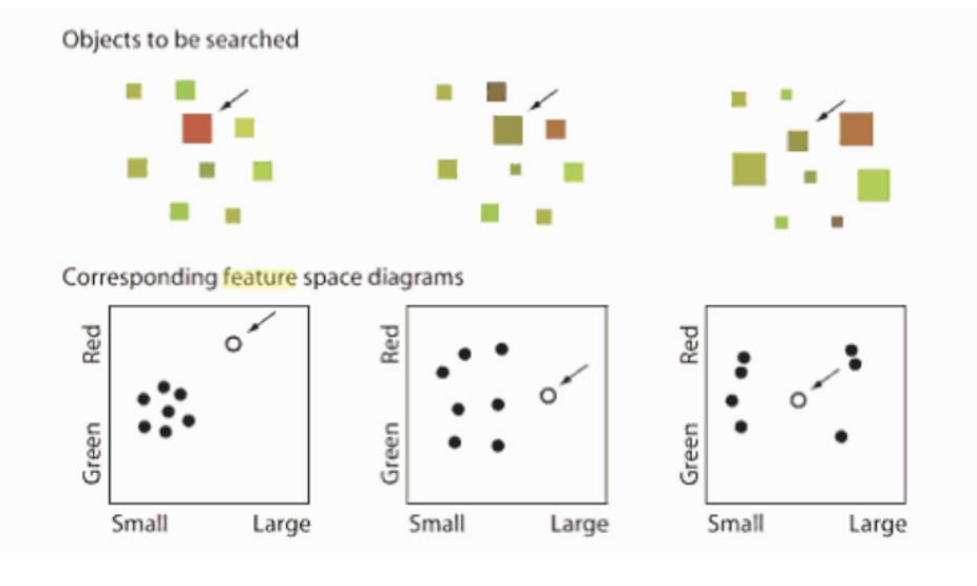


Popout: Channel Space

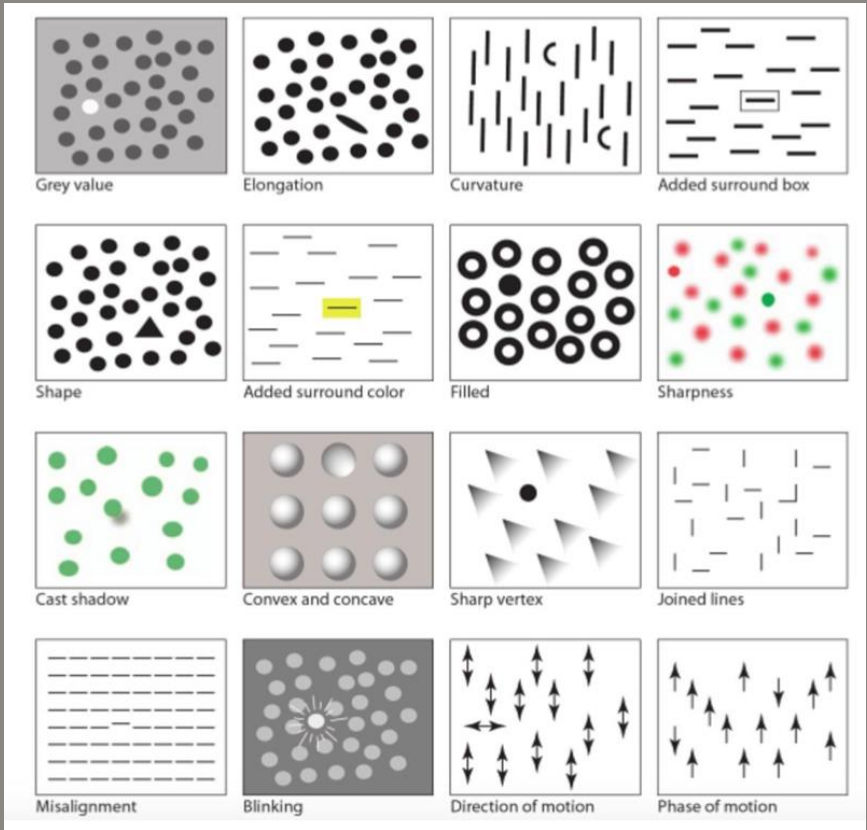
- Evaluate your visual encoding in the low level channel space
- Learning does not help popout effect



Popout: Other Conditions

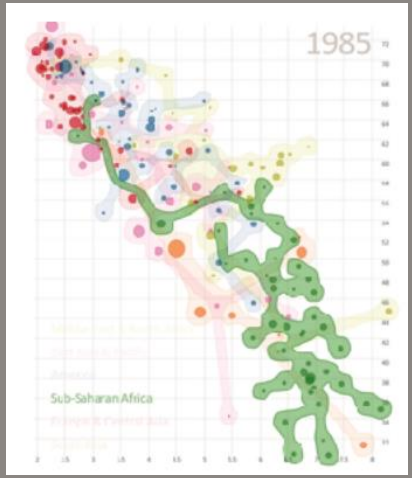
- For things to pop out, the low level feature differences need to be sufficiently large
  - E.g. 30 degree difference or more
- The extend of variation in the background is also important
  - Extremely homogeneous vs busy background

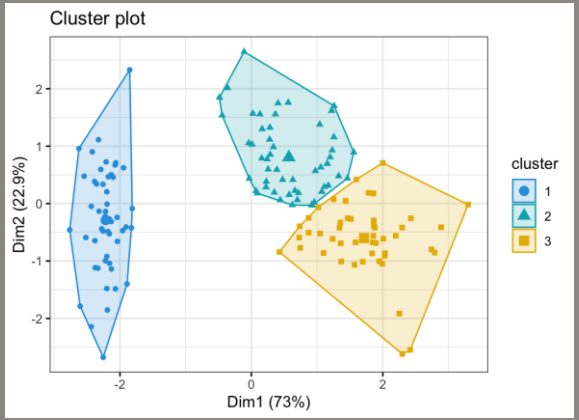
Popout: More Examples

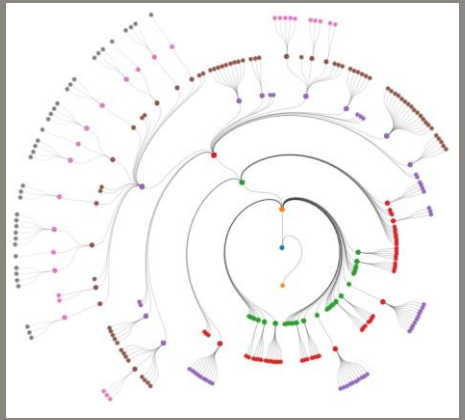


Grouping

- Directly visualize the group or link
  - e.g. data with labels, network data







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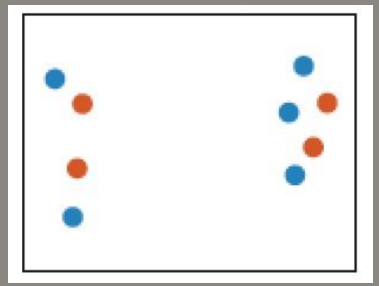
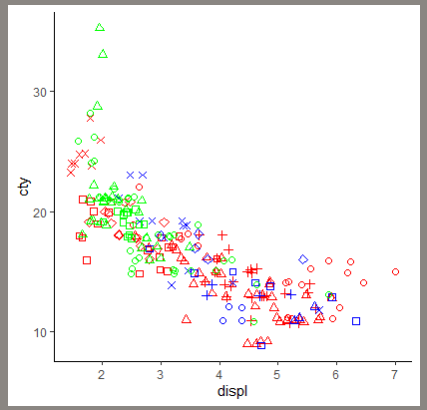
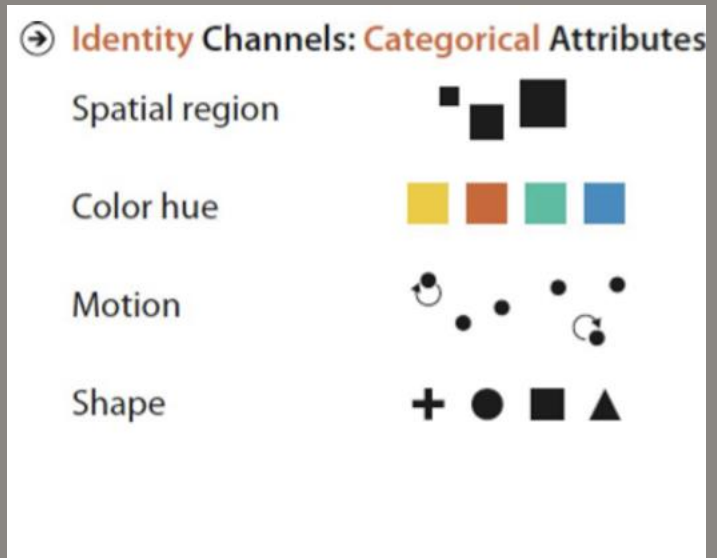
- Same or similar values in the **categorical** channel

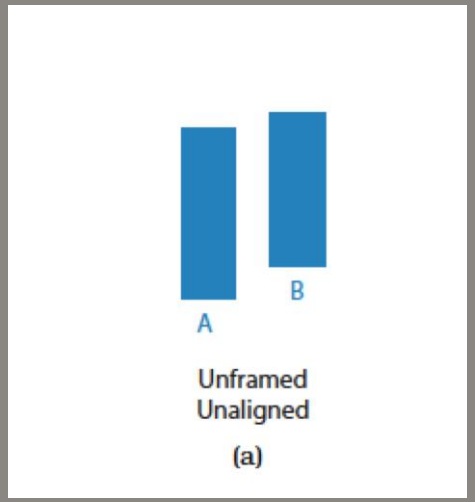






Relative vs. Absolute Judgements

- Human's perceptual system mostly operates with relative judgements, not absolute
  - That is why accuracy increases with common frame/scale and alignment



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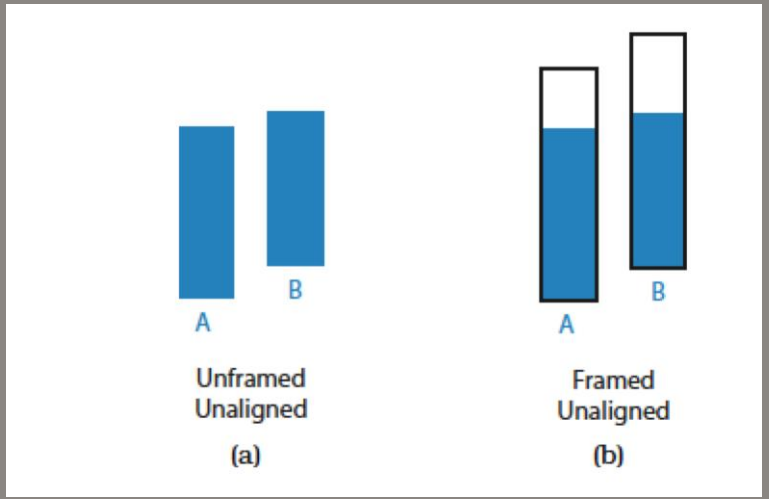

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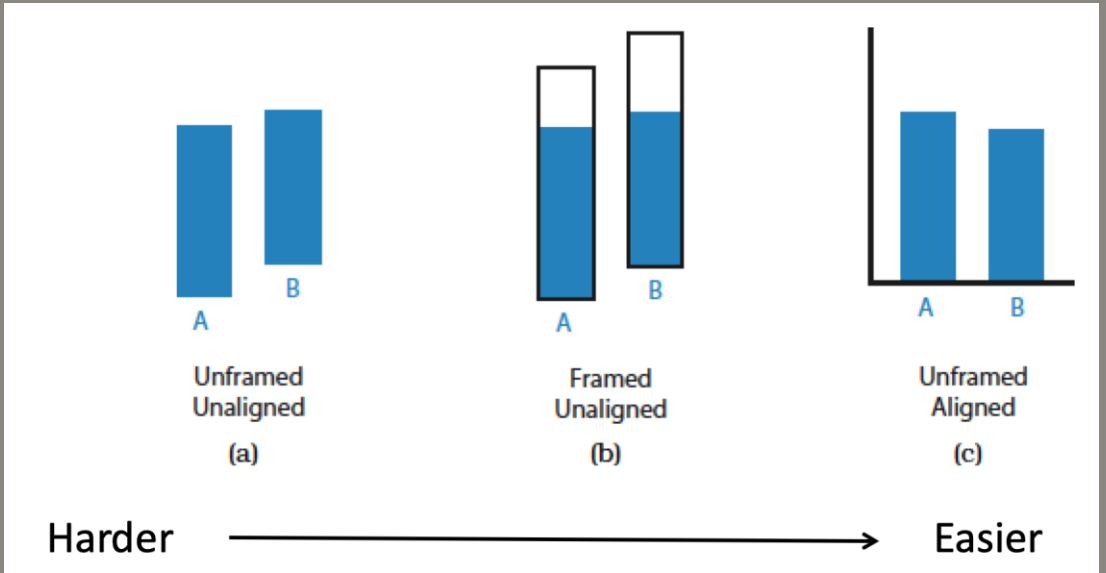
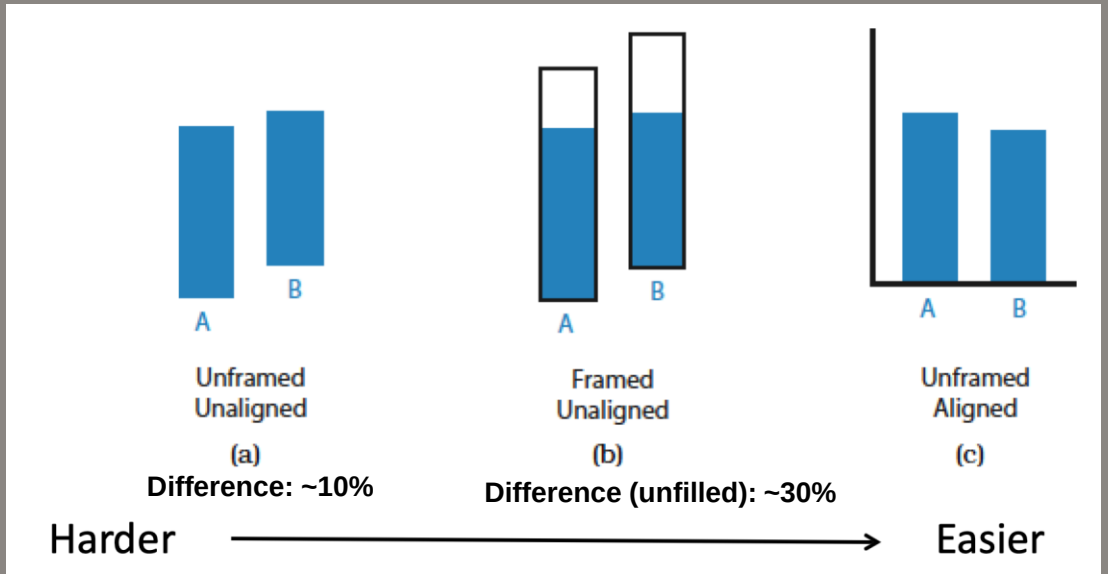


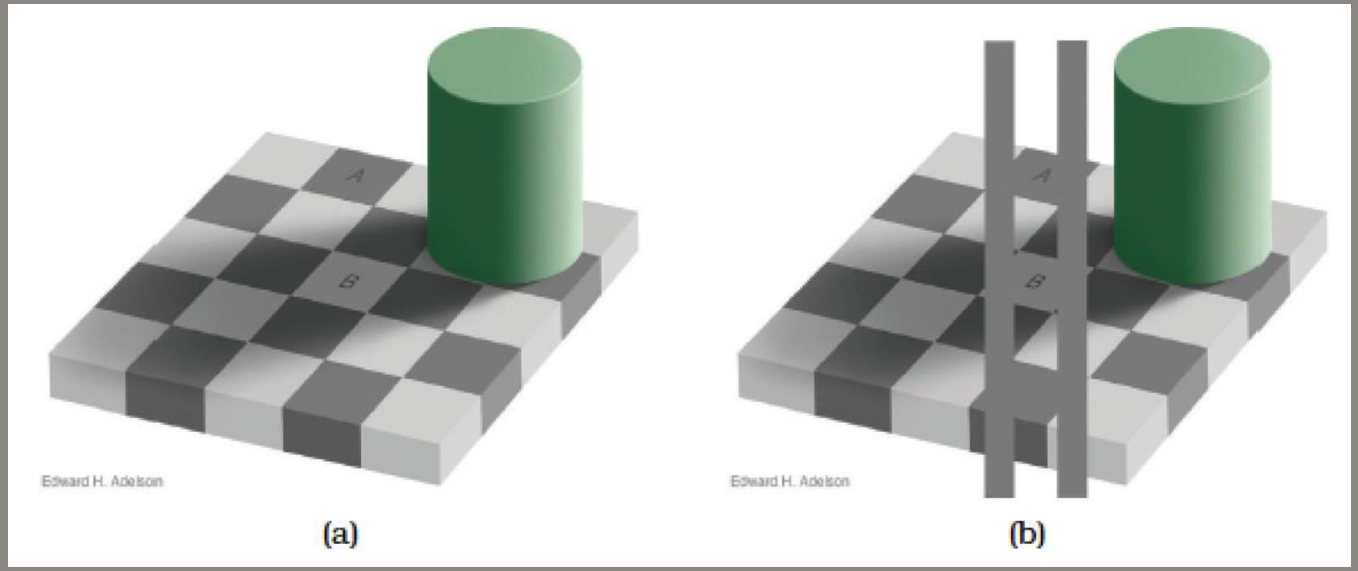
Relative vs. Absolute Judgements

- Human's perceptual system mostly operates with relative judgements, not absolute
  - That is why accuracy increases with common frame/scale and alignment
  - Weber's Law: ratio of increment to background is constant



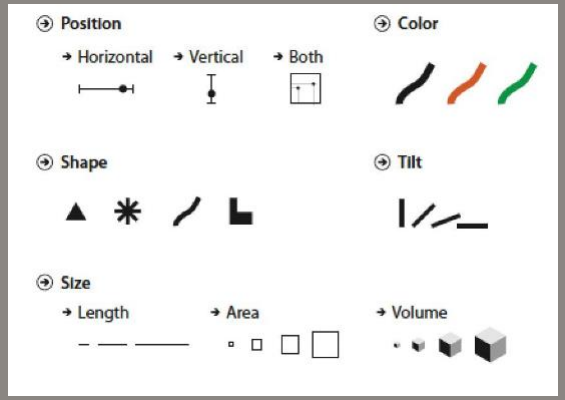
Relative Luminance Judgements

- Perception of luminance is contextual based on contrast with surroundings

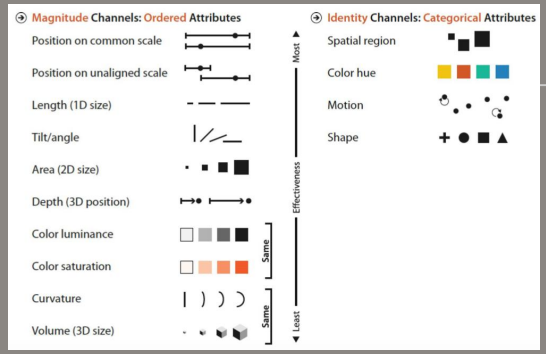


Summary

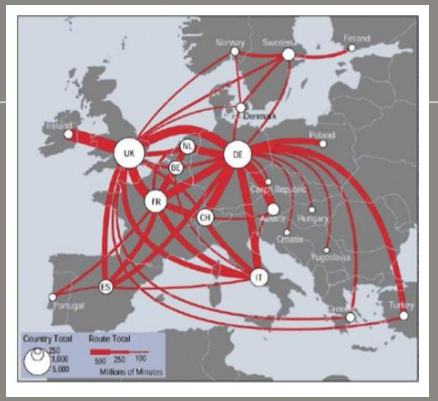
Visual encoding: attribute -> visual channel



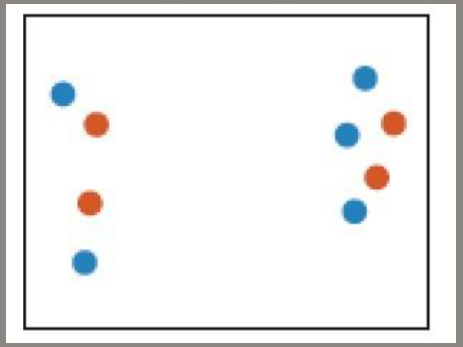
Expressiveness and effectiveness



Discriminability

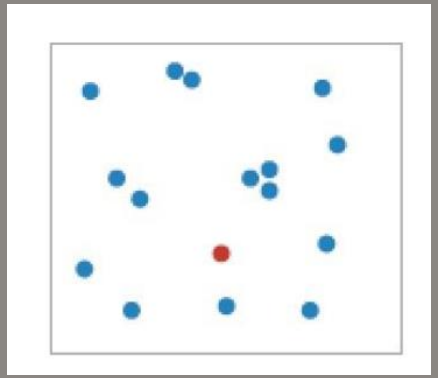


Separability

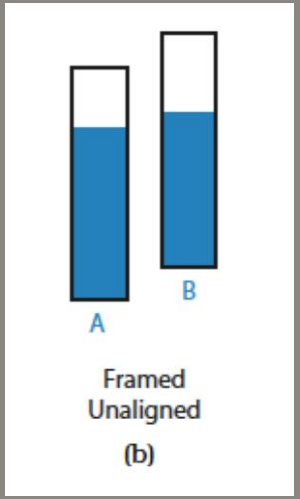


Grouping

Popout effect



Relative vs. Absolute Judgements



S03-06

Exercise

- Name the visual channels