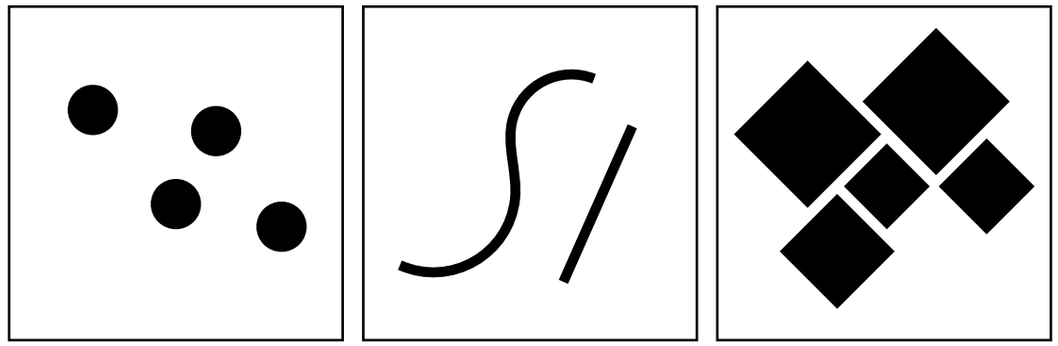
Visual Perception

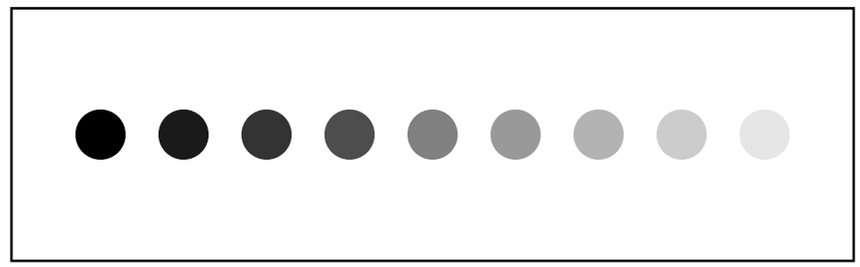
Marks

entities, links, objects



Channels

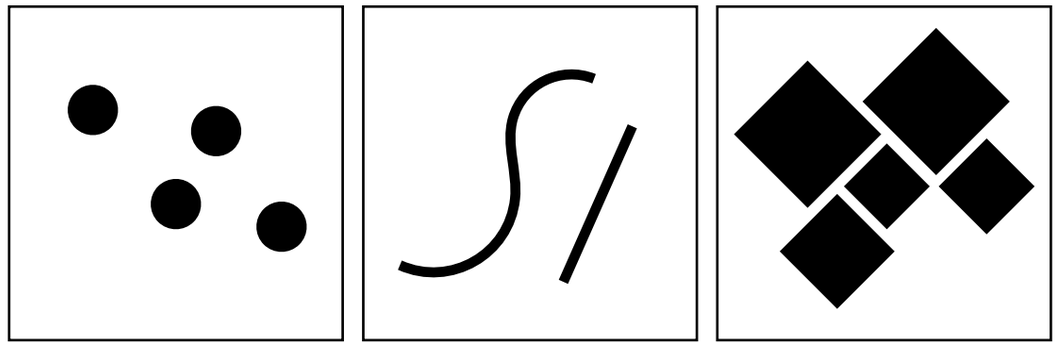
change based on data values



(week 2 lecture)

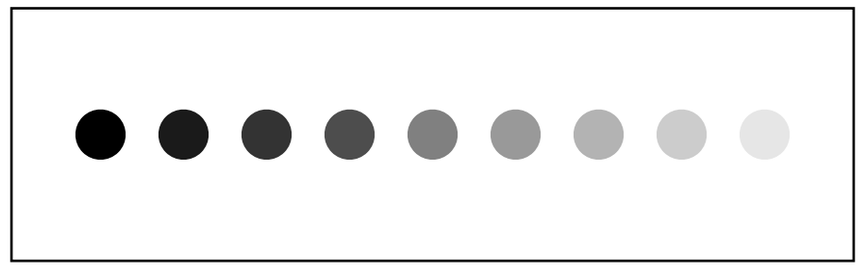
Marks

entities, links, objects



Channels

change based on data values



As designers, how do we best assign visual channels?

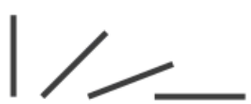
(week 2 lecture)

Position on common scale

Position on unaligned scale

Length (1D size)

Tilt/angle



Area (2D size)

Depth (3D position)

Color luminance

Color saturation

Same

Curvature

Same

Volume (3D size)

Spatial region

Color hue

Motion

Shape

(week 2 lecture)

Visualization Analysis and Design, Tamara Munzner, 2014

Weber's Law of Just Noticeable Differences

$$\Delta S = k \frac{\Delta I}{I}$$

"The minimum amount by which a stimulus must be changed in order to produce a noticeable variation in sensory experience"

(change in sensation equals a proportional change in signal intensity)

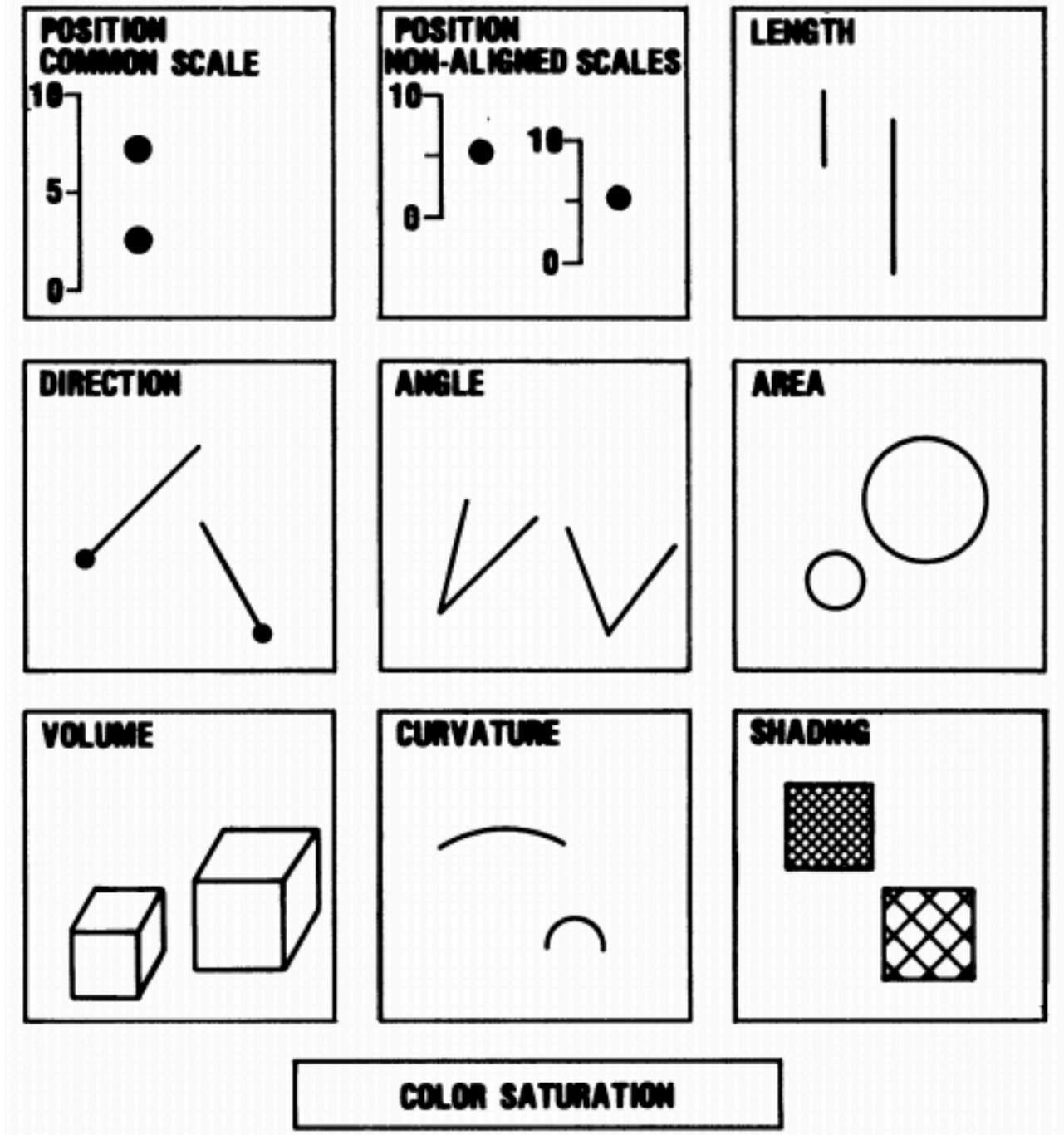


Figure 1. Elementary perceptual tasks.

Cleveland & McGill. 1984. *Graphical perception: Theory, experimentation, and application to the development of graphical methods*.

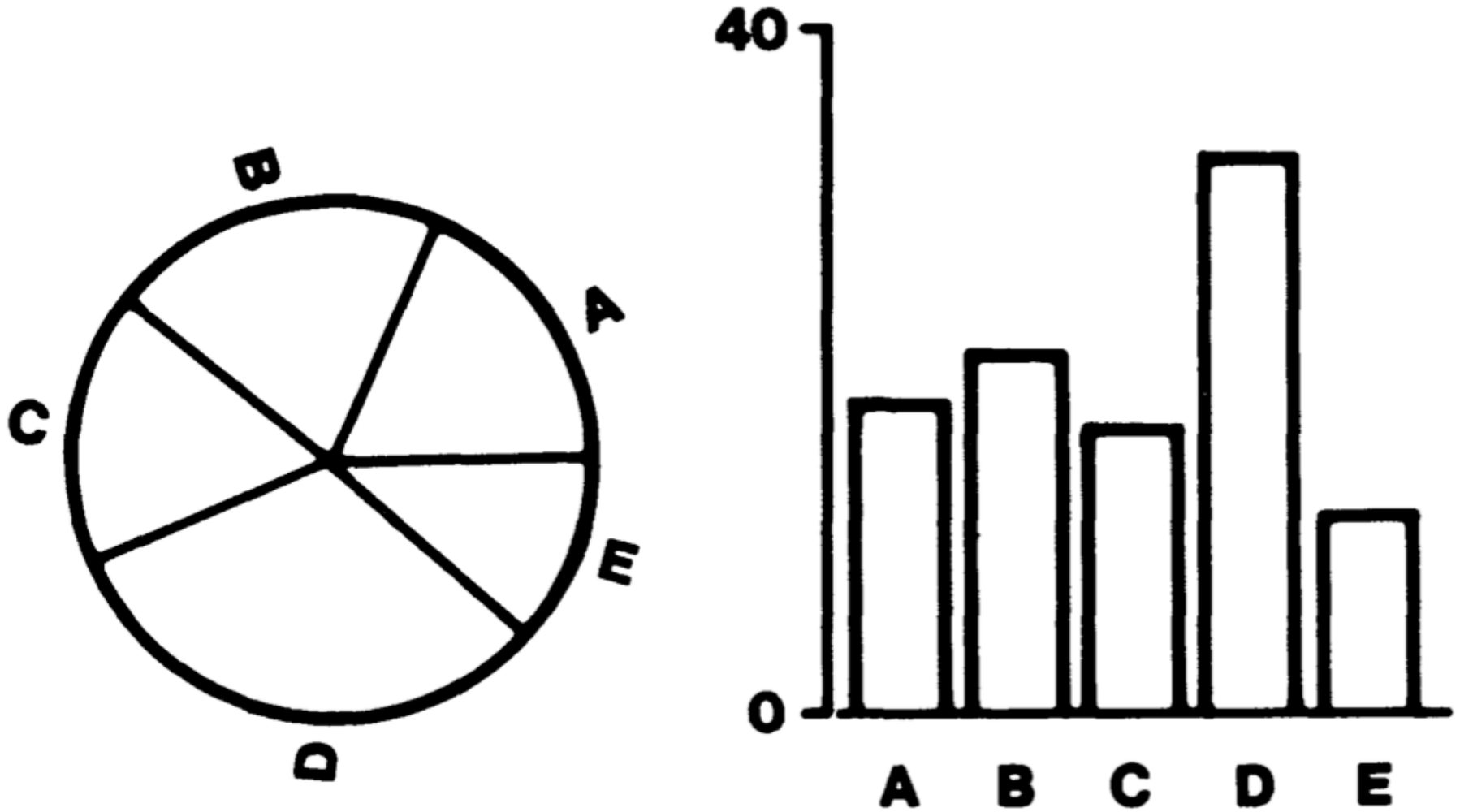


Figure 3. Graphs from position–angle experiment.

Cleveland & McGill. 1984. *Graphical perception: Theory, experimentation, and application to the development of graphical methods*.

Experiment

- Open up a web browser and visit:

  bit.ly/3uq1LdL

- Also open up a text editor or a notebook so that you can record your observations for each set of 5.

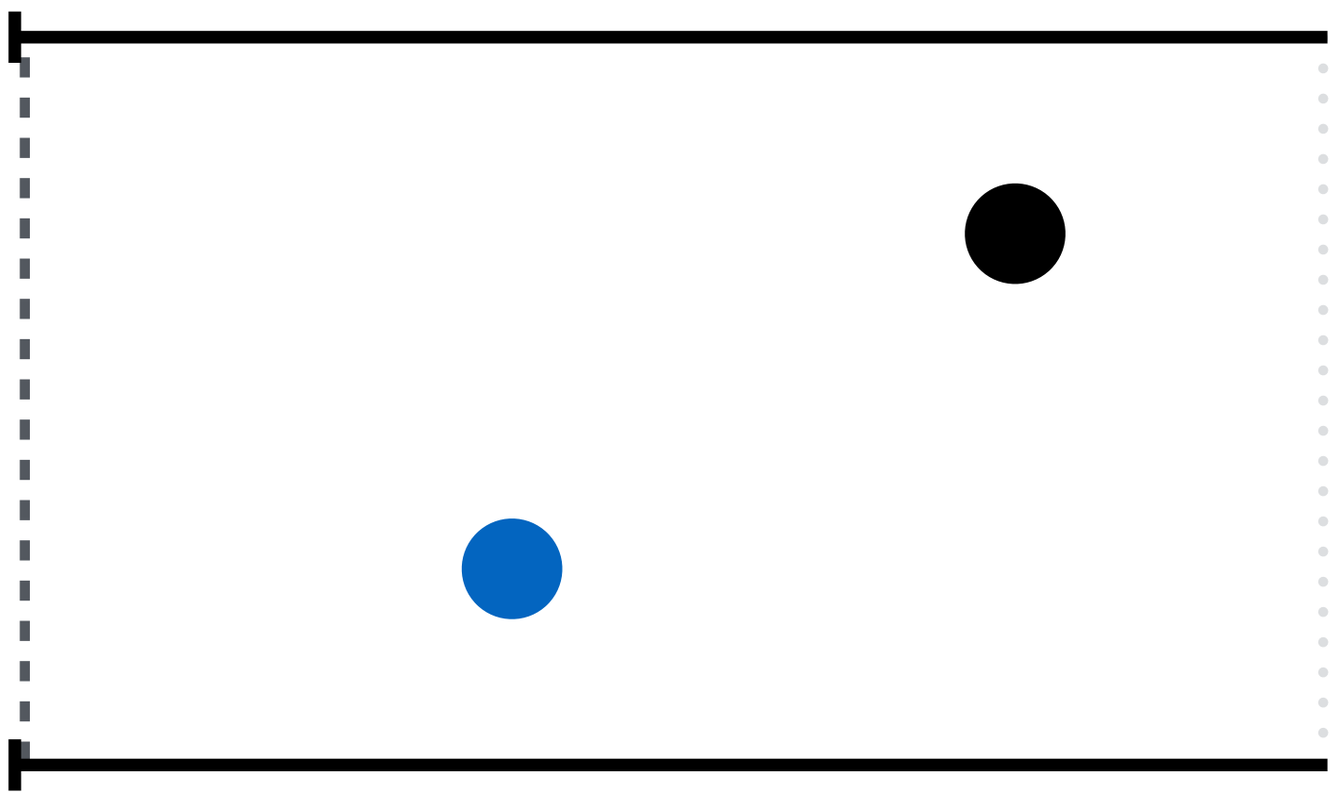
- We'll make 5 observations, then enter them online. Make sure your observations are in order of appearance. I'll tell you when to record your answers and move on.

- Results will be shown next week in class.

Position

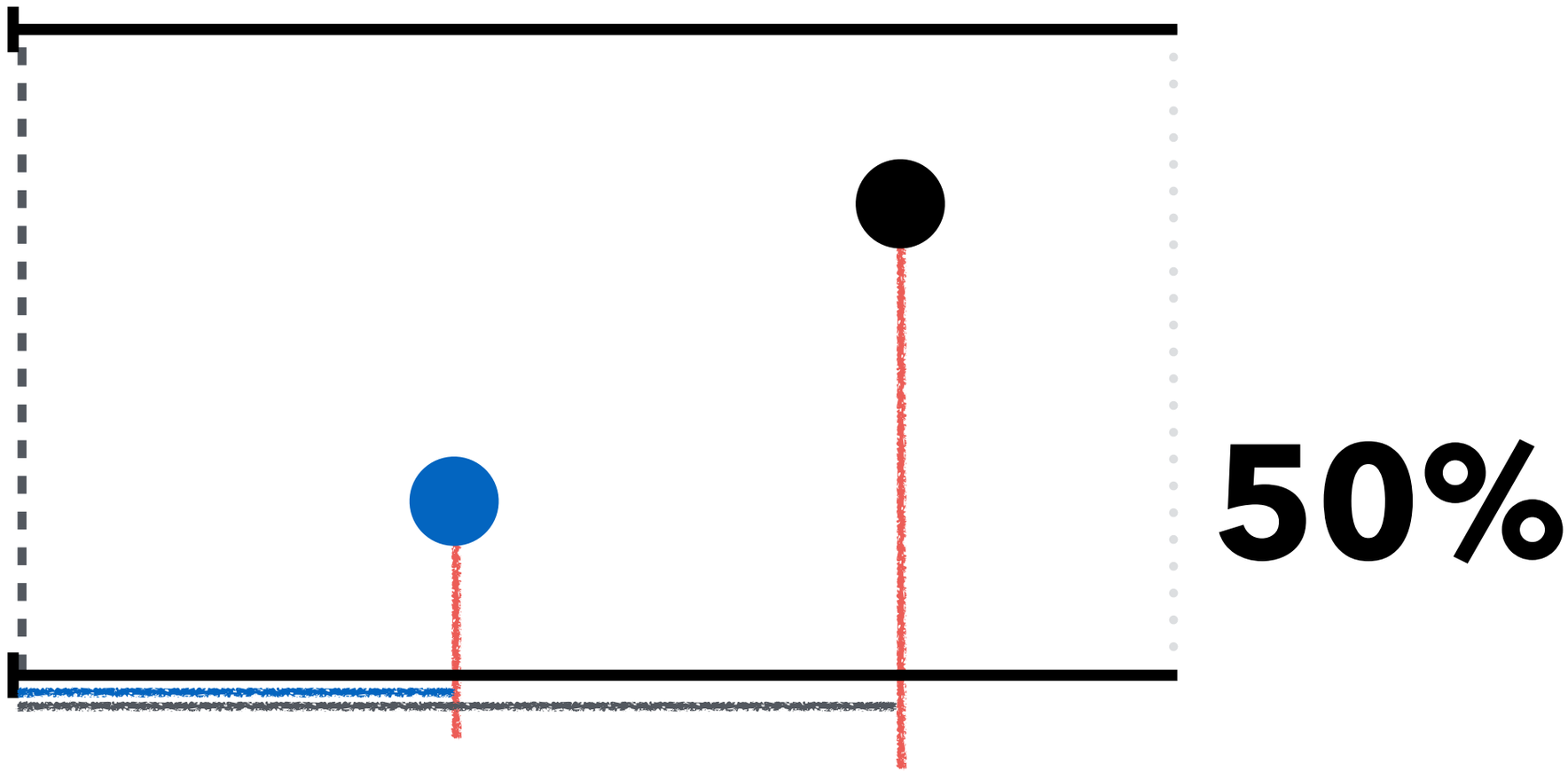
(on an aligned axis)

EXAMPLE



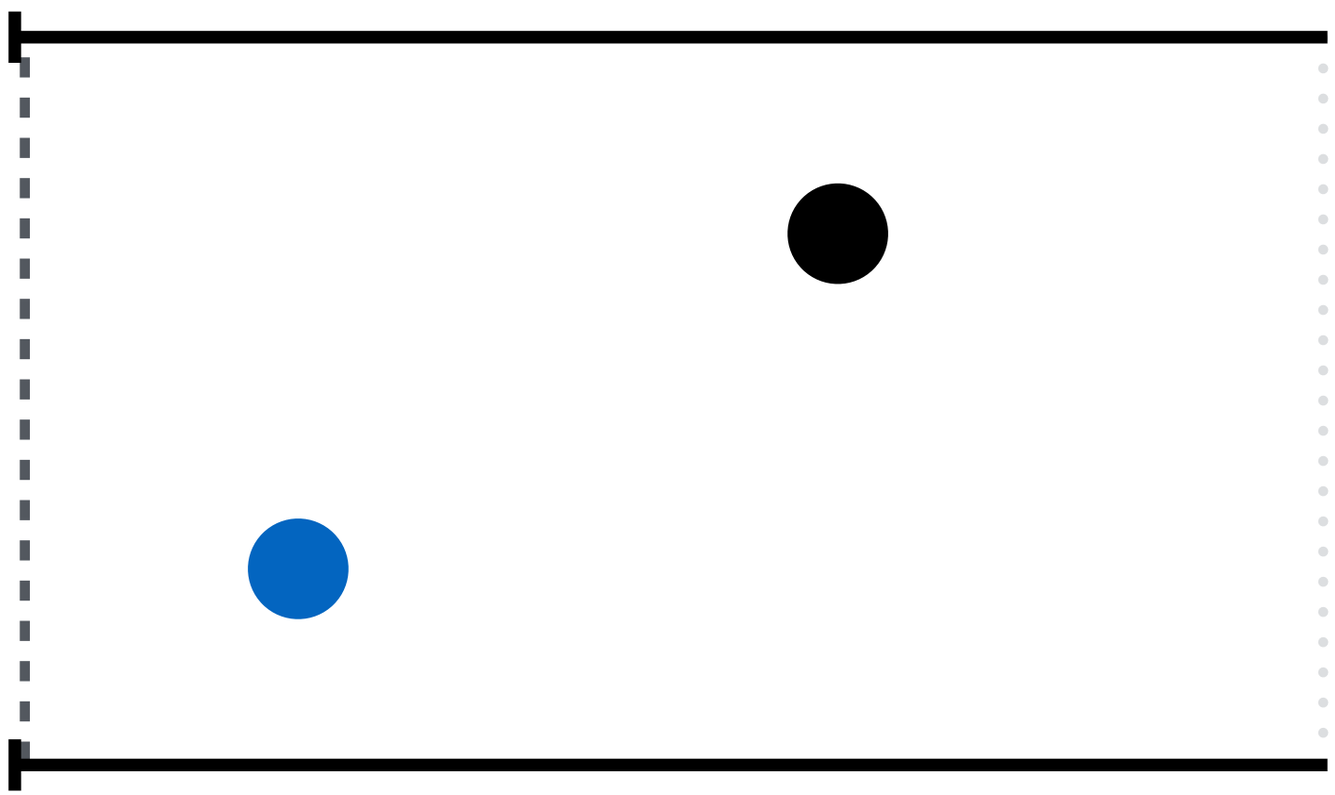
(black dot is the reference, blue dot is the target)

EXAMPLE



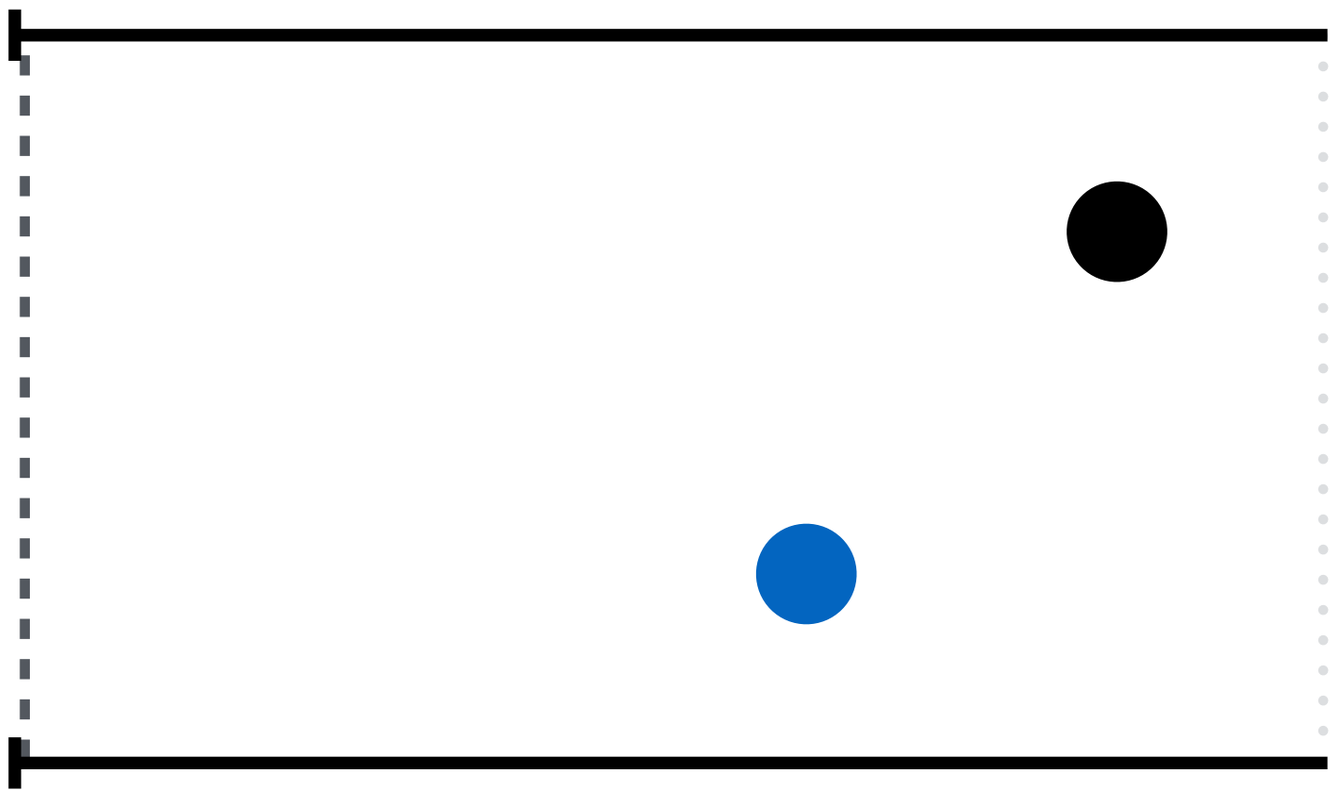
(black dot is the reference, blue dot is the target)

Trial 1



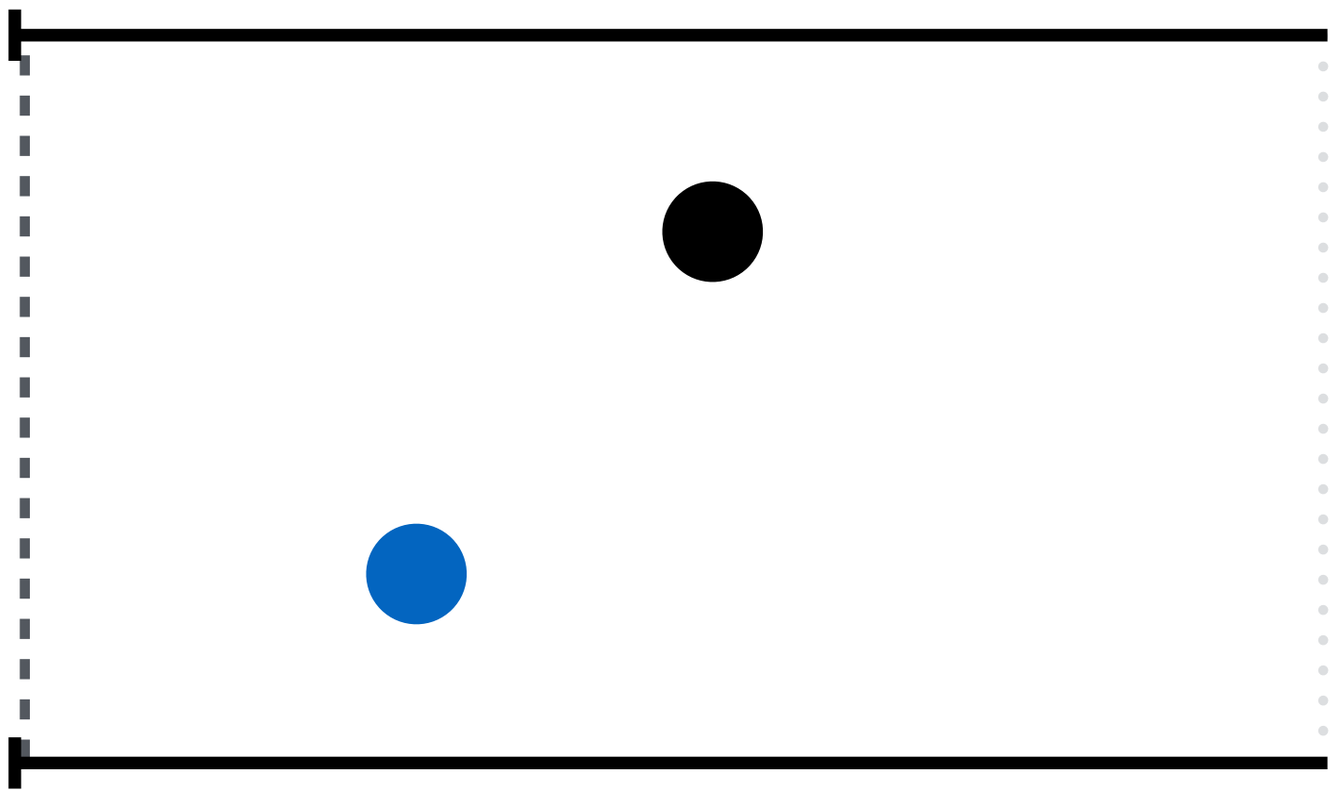
(black dot is the reference, blue dot is the target)

Trial 2



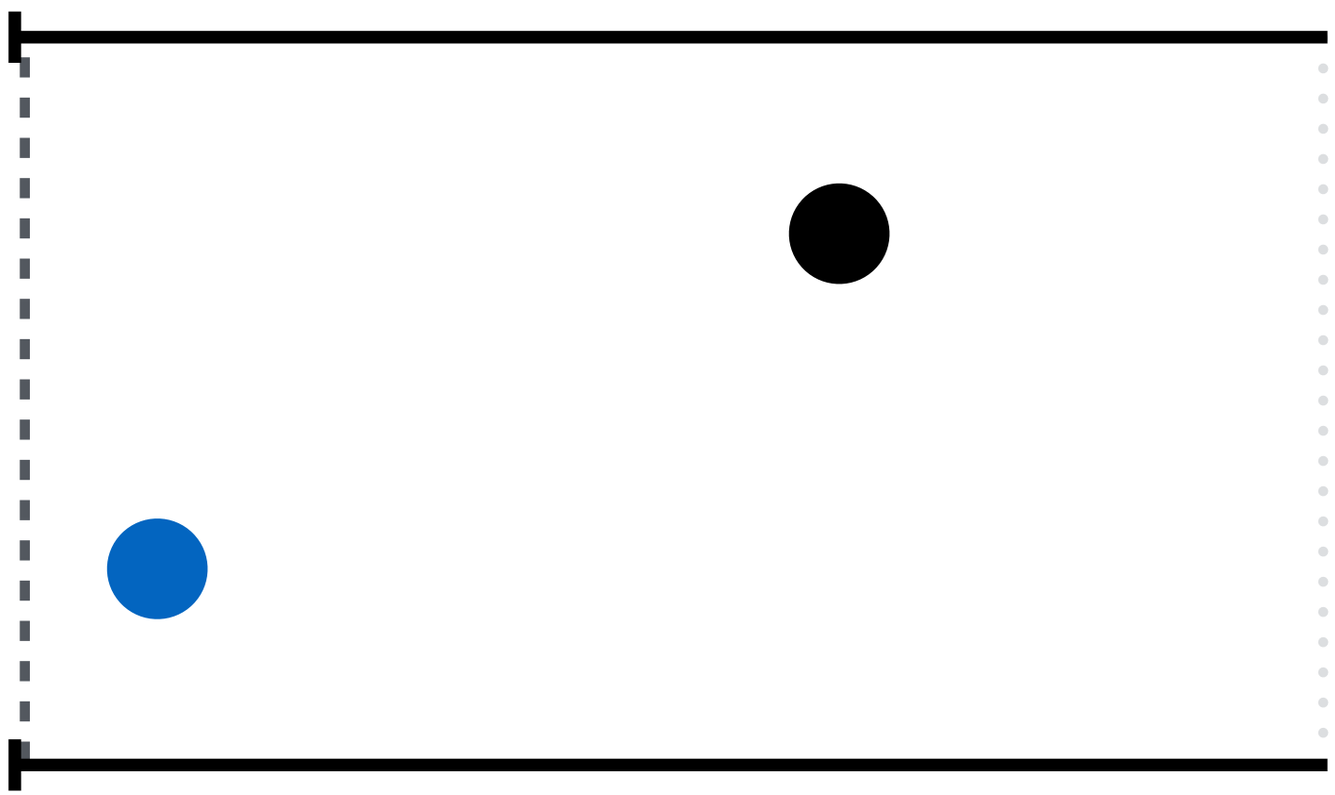
(black dot is the reference, blue dot is the target)

Trial 3



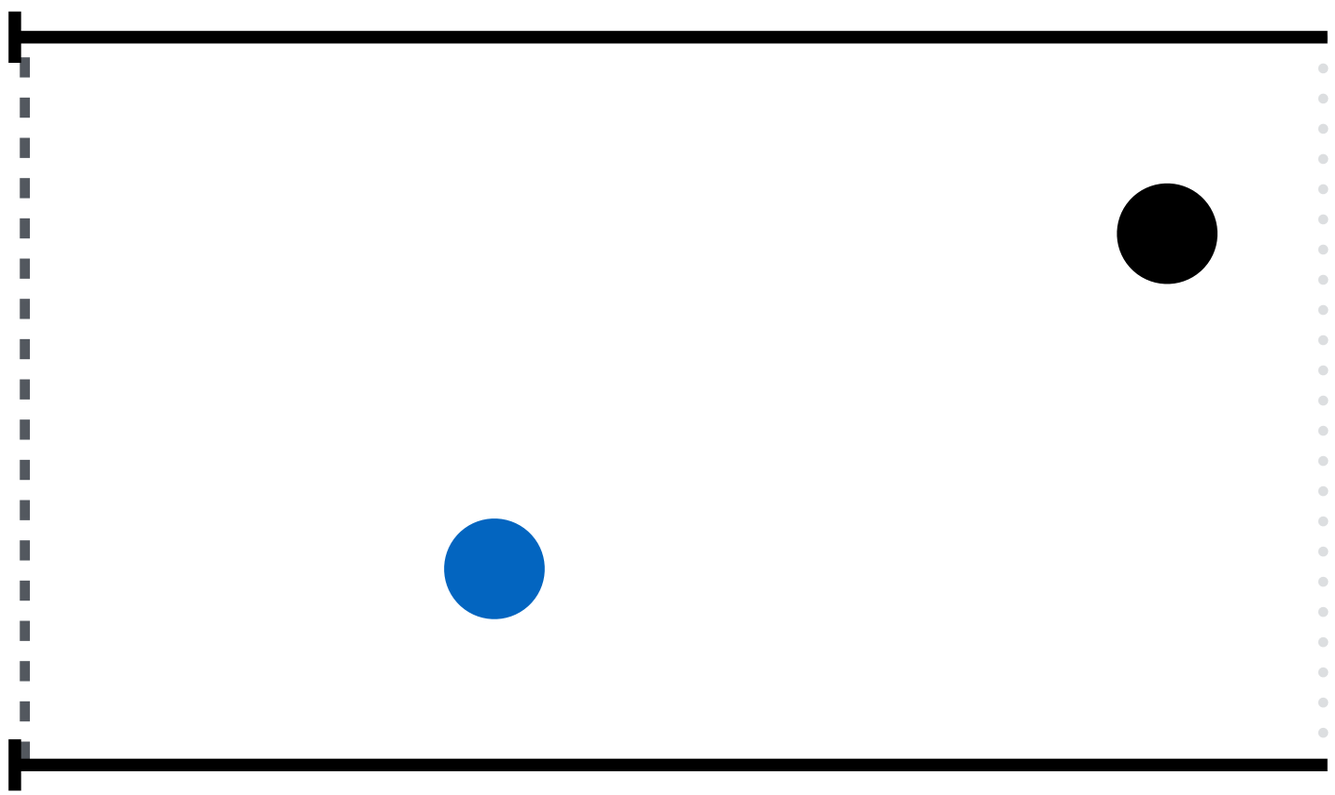
(black dot is the reference, blue dot is the target)

Trial 4



(black dot is the reference, blue dot is the target)

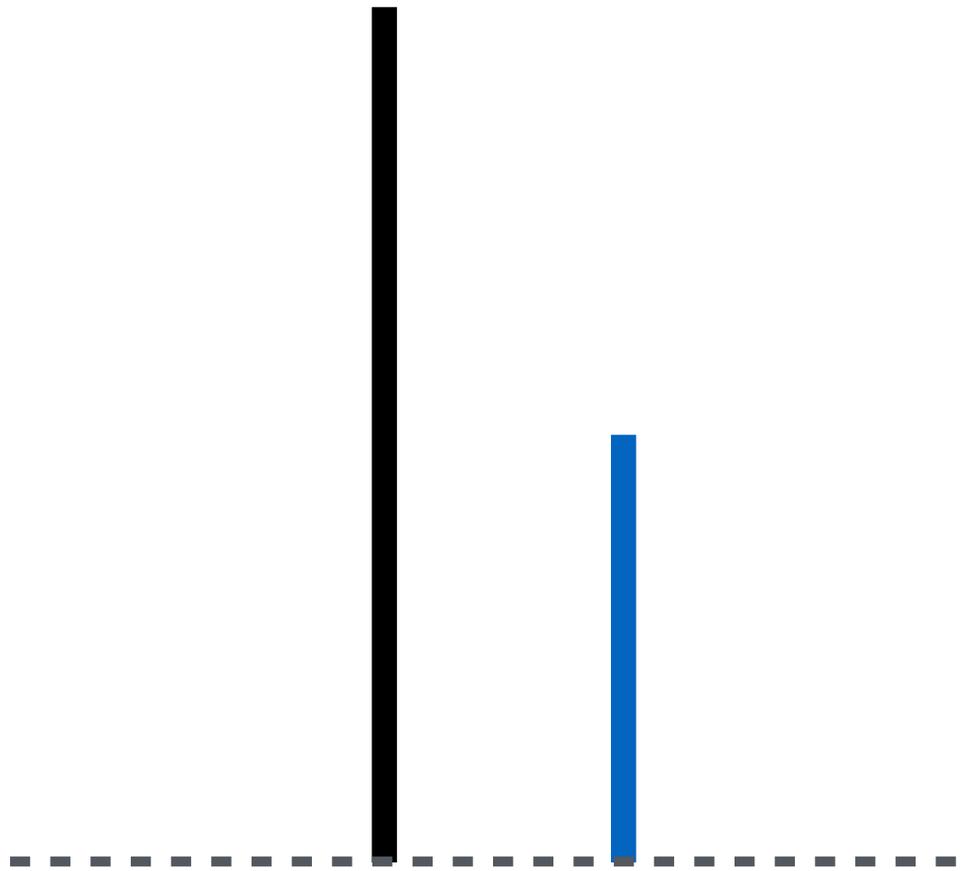
Trial 5



(black dot is the reference, blue dot is the target)

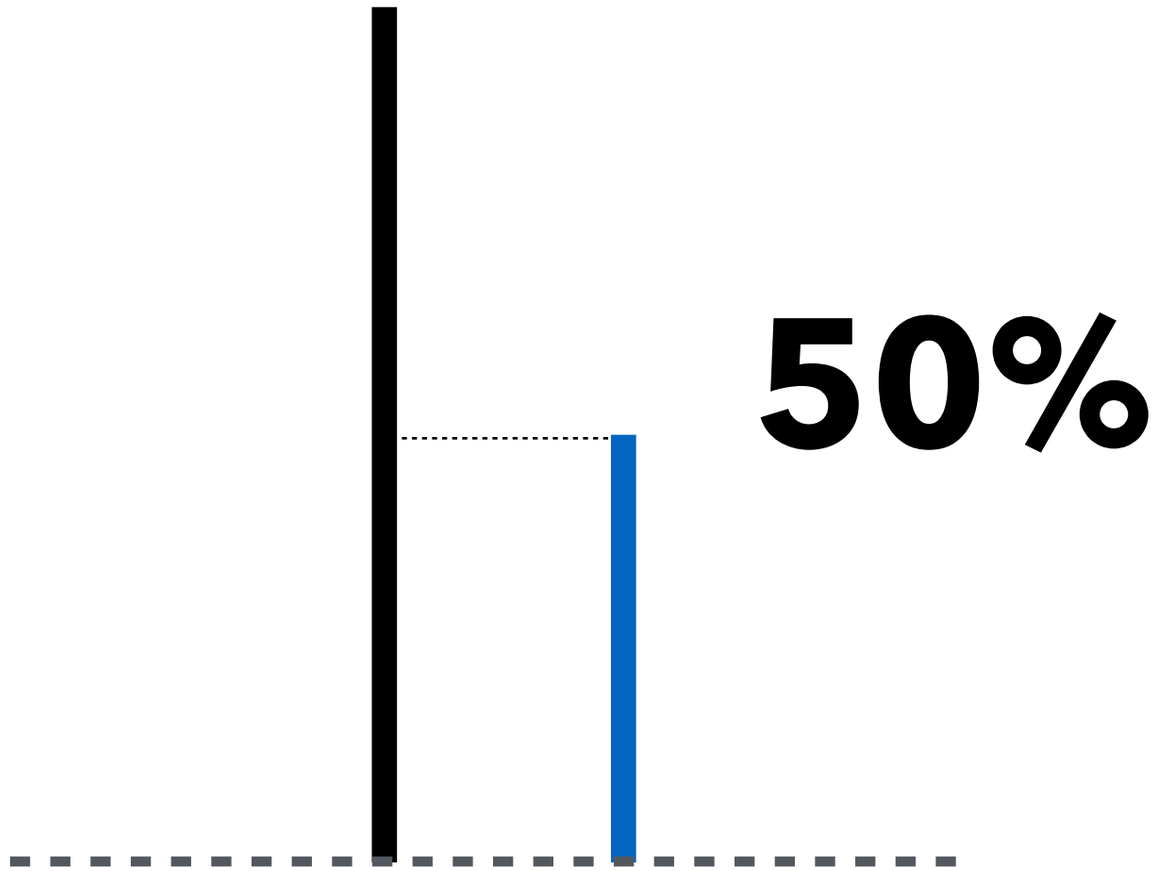
Length

EXAMPLE



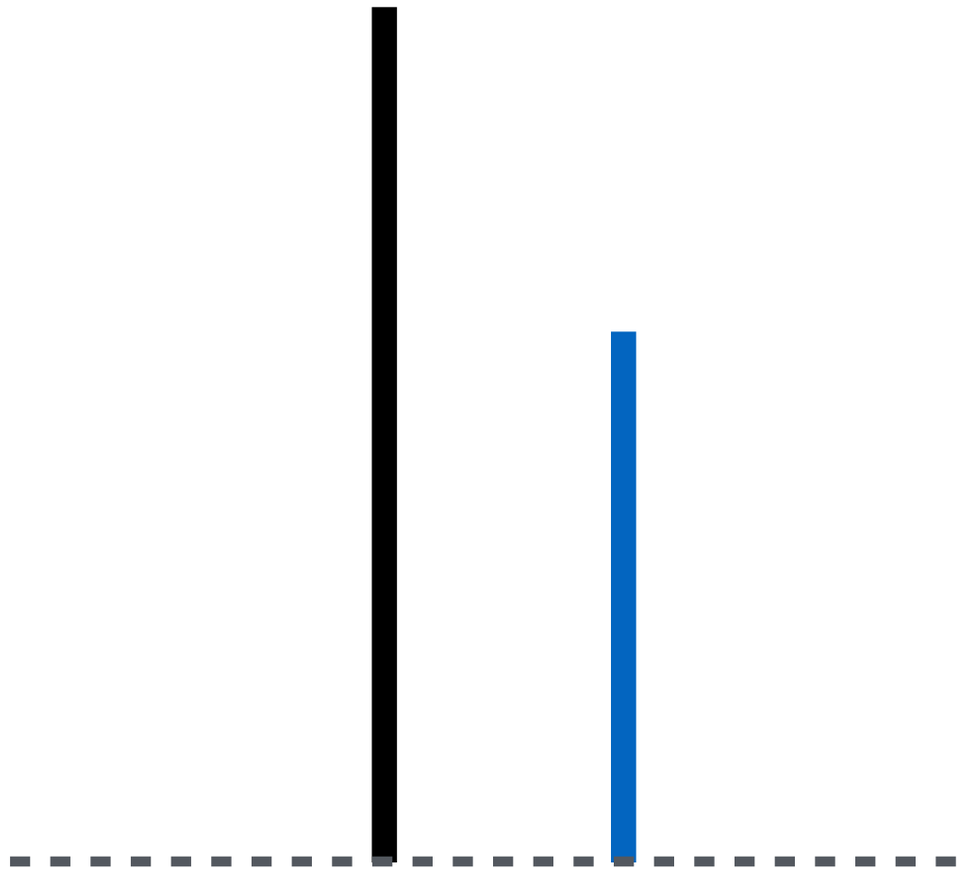
(black line is the reference, blue line is the target)

EXAMPLE



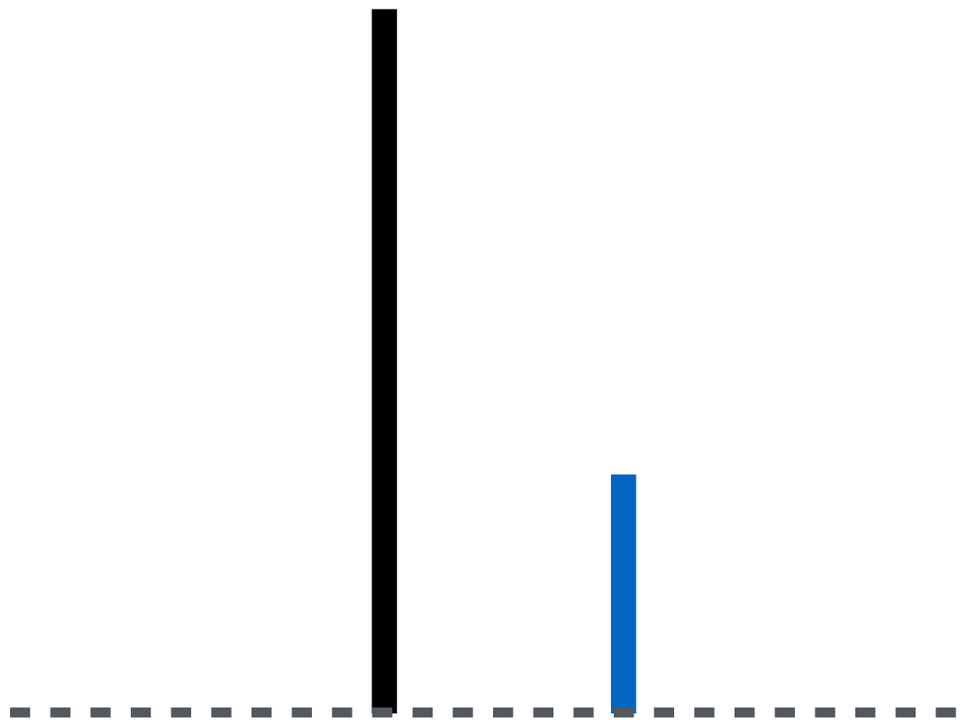
(black line is the reference, blue line is the target)

Trial 1



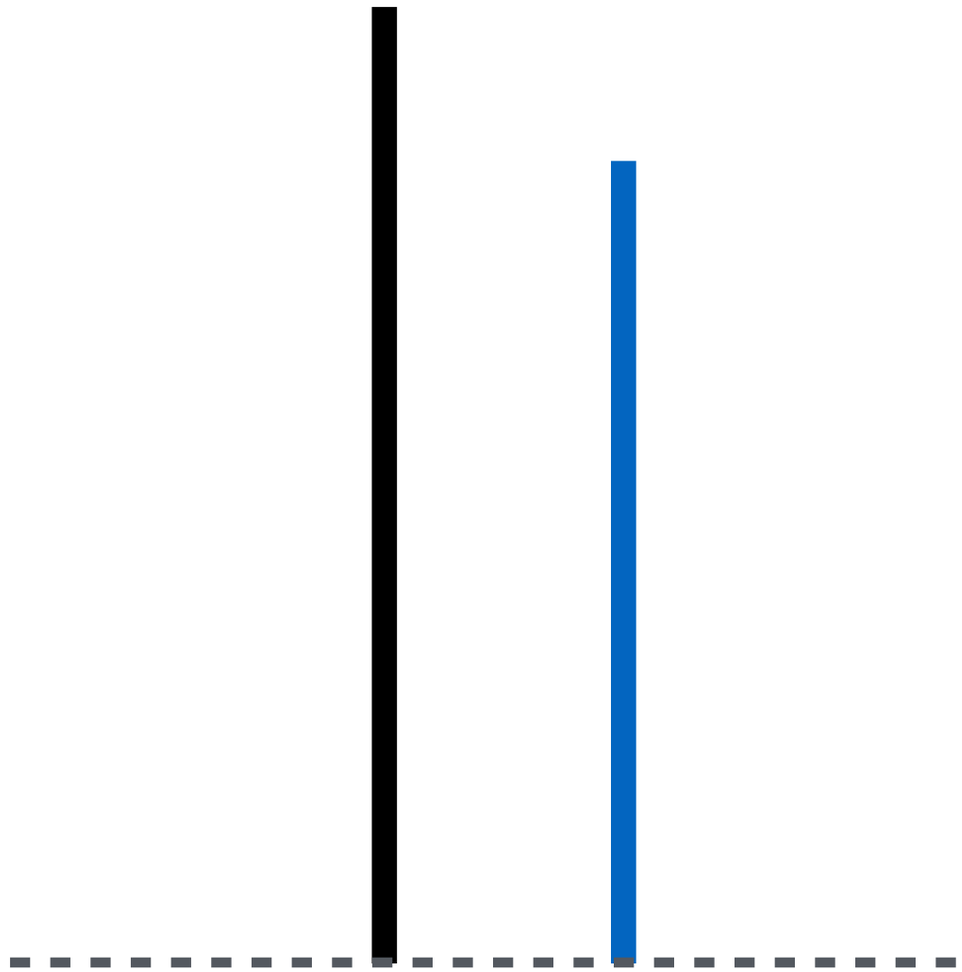
(black line is the reference, blue line is the target)

Trial 2



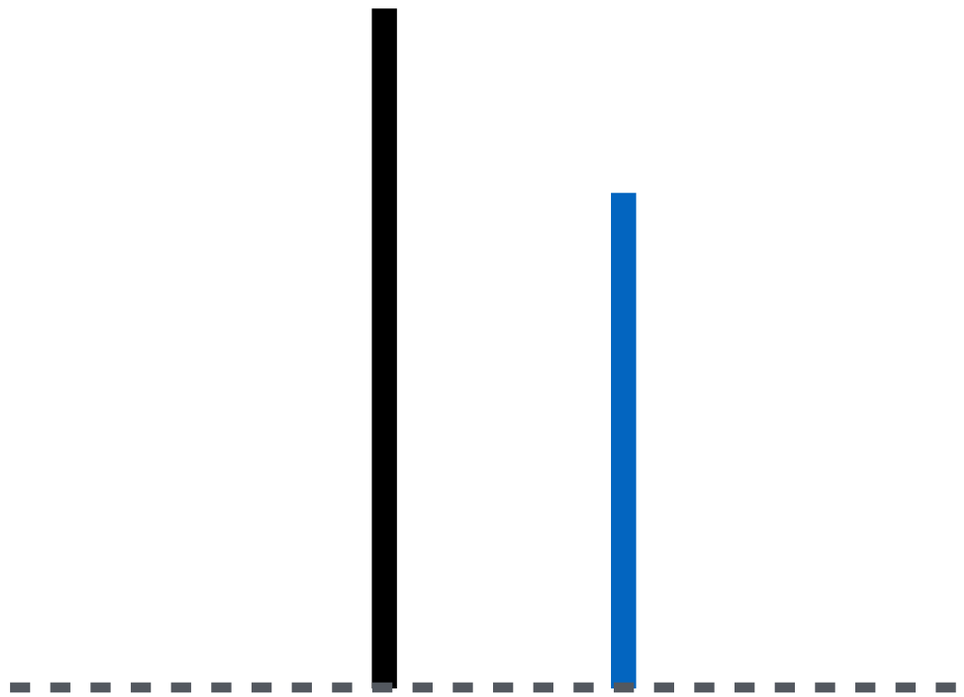
(black line is the reference, blue line is the target)

Trial 3



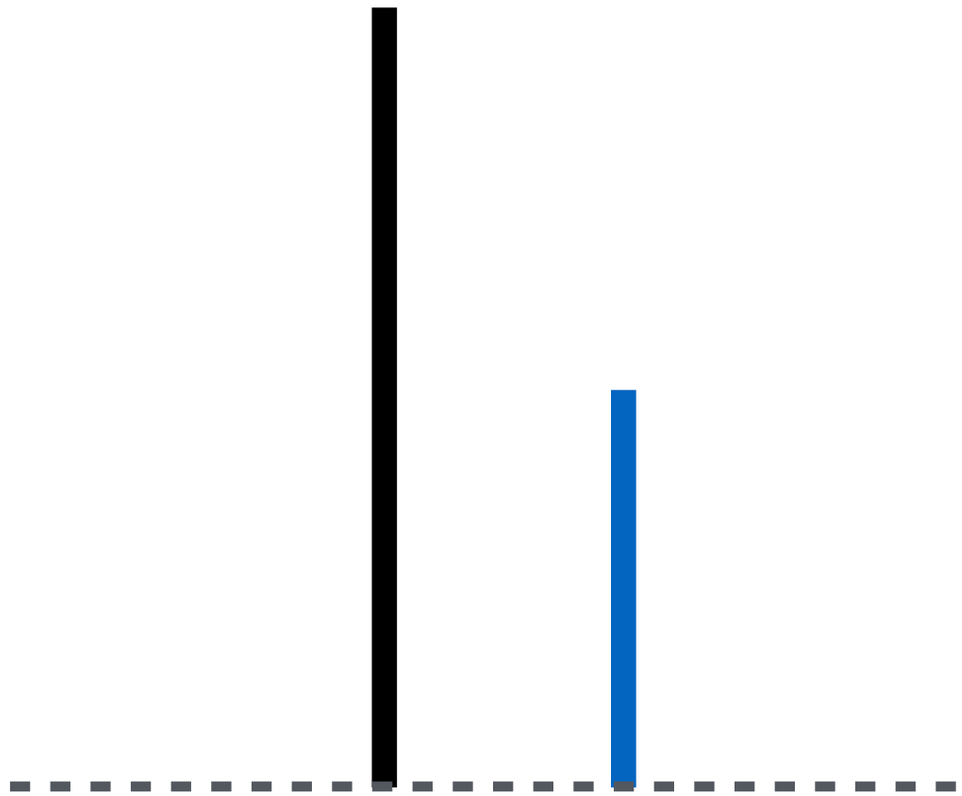
(black line is the reference, blue line is the target)

Trial 4



(black line is the reference, blue line is the target)

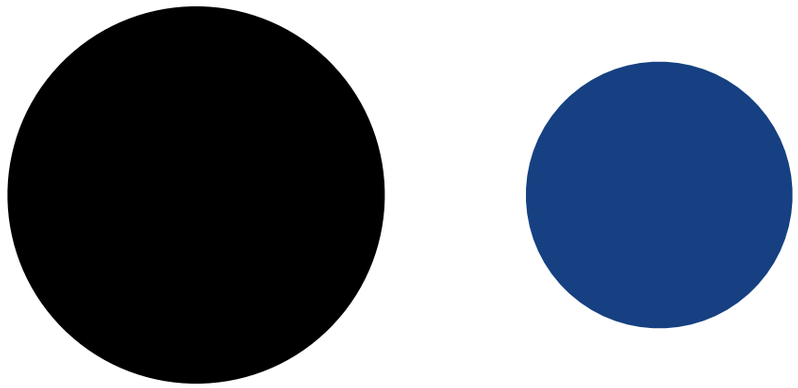
Trial 5



(black line is the reference, blue line is the target)

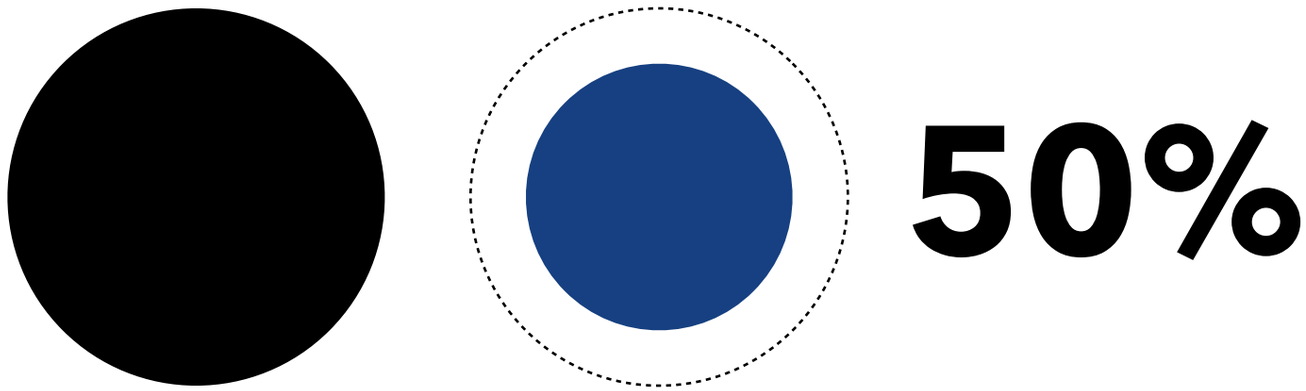
Area

EXAMPLE



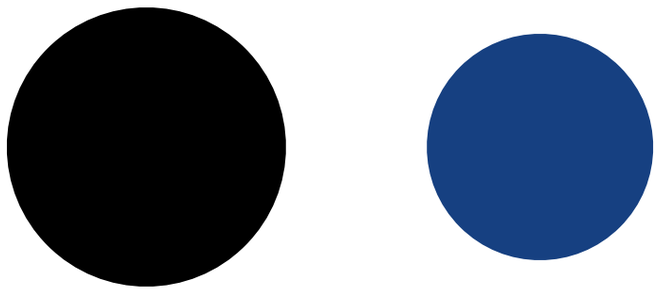
(black circle is the reference, blue circle is the target)

EXAMPLE



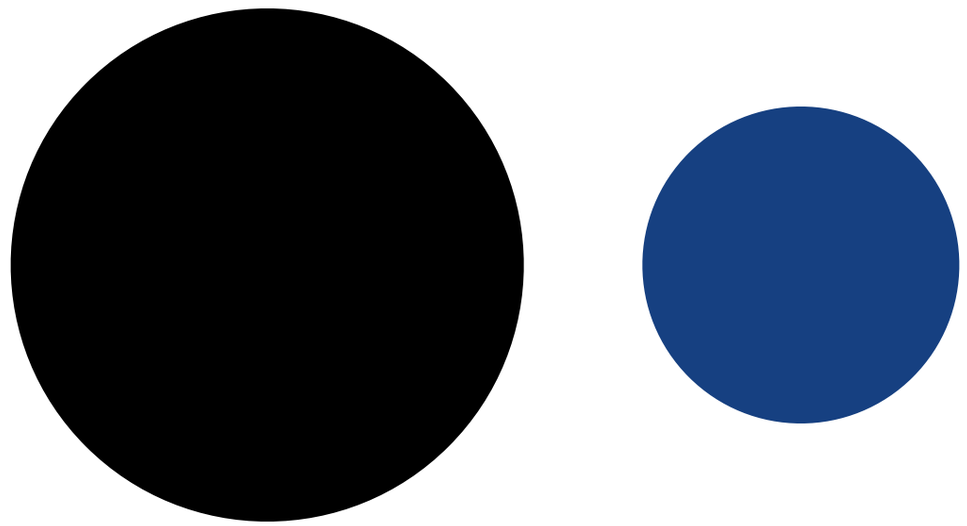
(black circle is the reference, blue circle is the target)

Trial 1



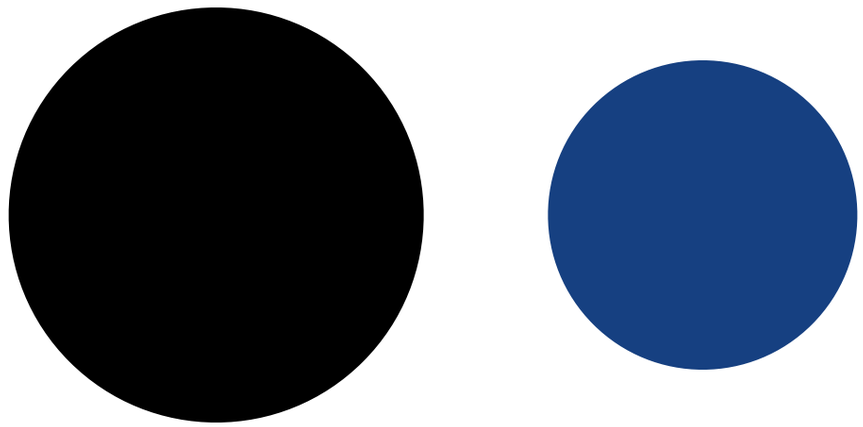
(black circle is the reference, blue circle is the target)

Trial 2



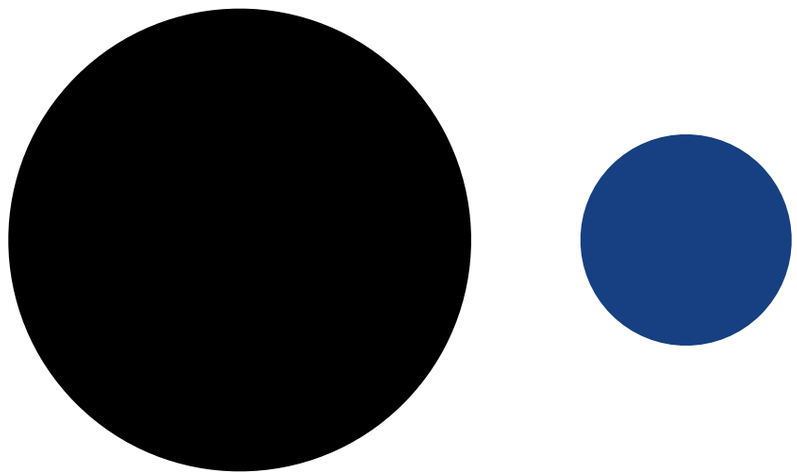
(black circle is the reference, blue circle is the target)

Trial 3



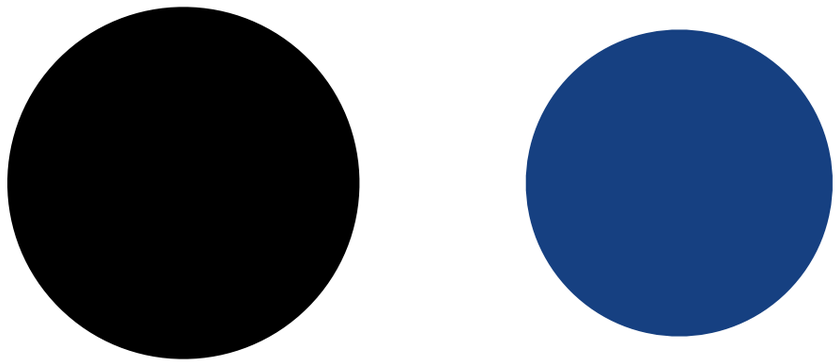
(black circle is the reference, blue circle is the target)

Trial 4



(black circle is the reference, blue circle is the target)

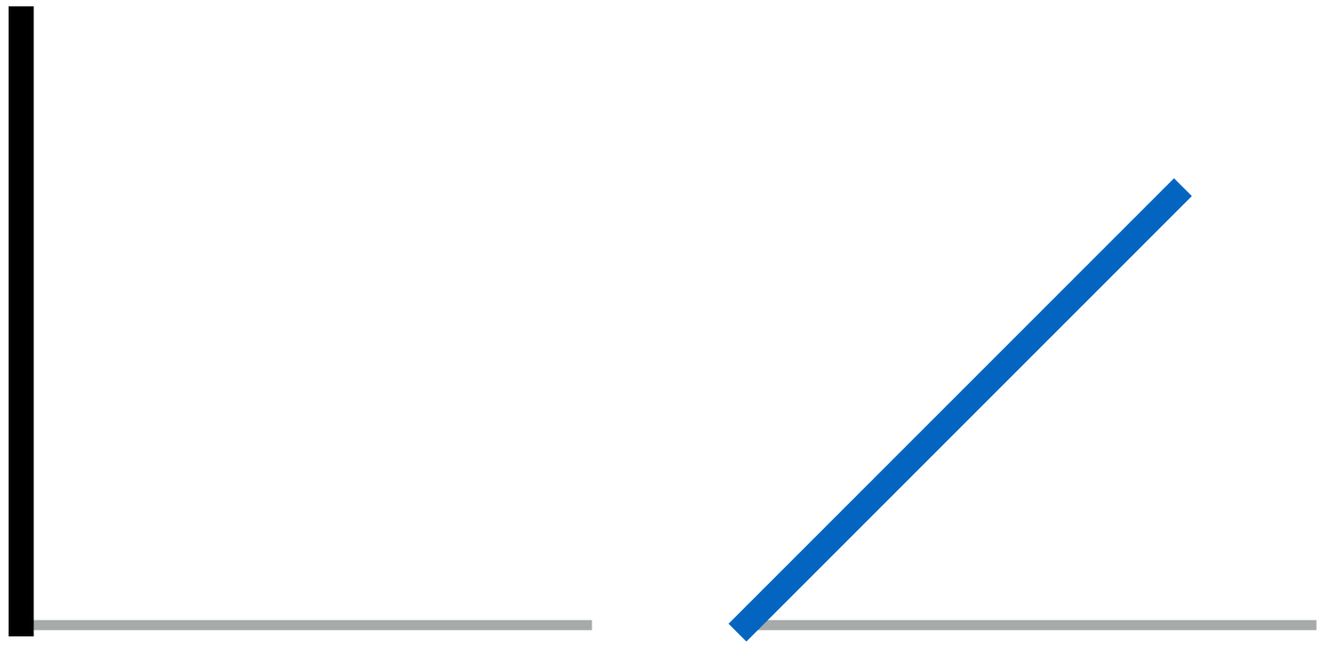
Trial 5



(black circle is the reference, blue circle is the target)

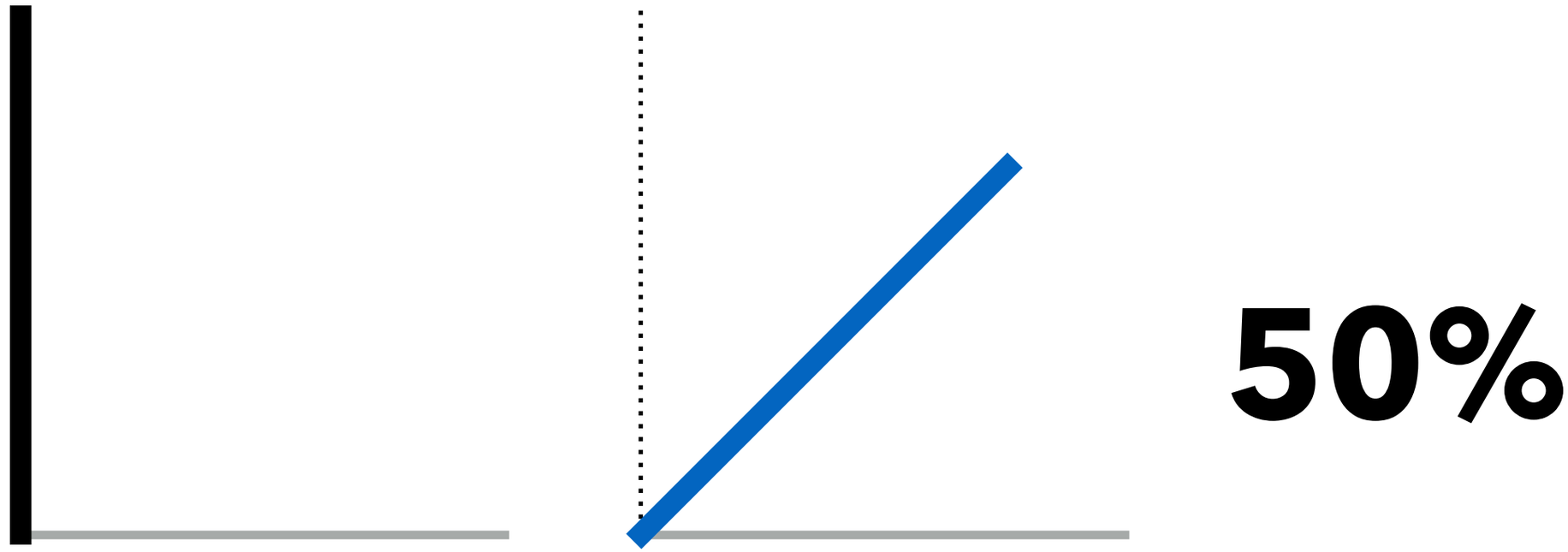
Rotation

EXAMPLE



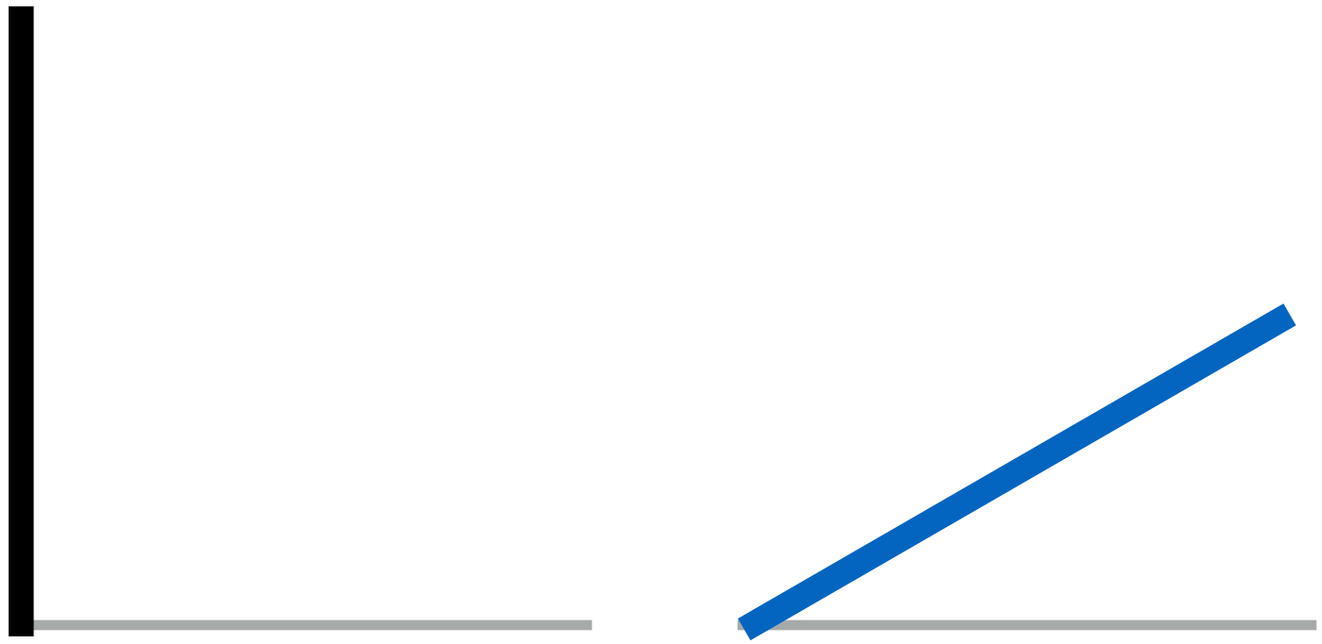
(black circle is the reference, blue circle is the target)

EXAMPLE



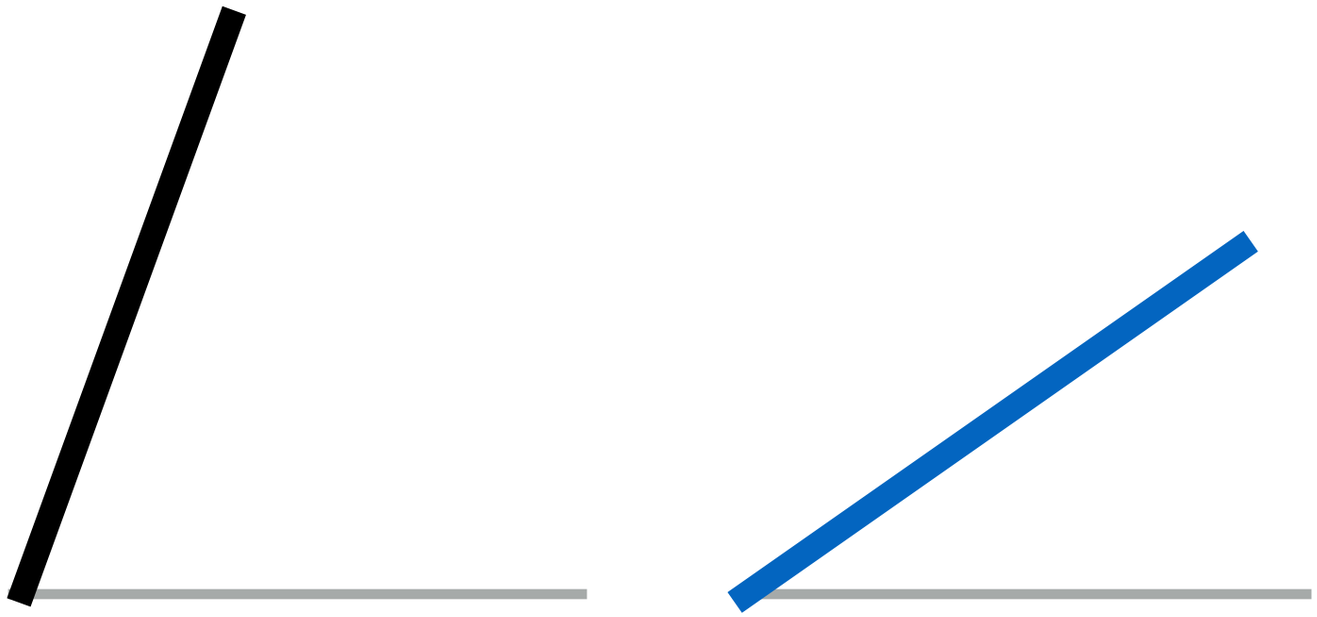
(black circle is the reference, blue circle is the target)

Trial 1



(black circle is the reference, blue circle is the target)

Trial 2



(black circle is the reference, blue circle is the target)

Trial 3

(black circle is the reference, blue circle is the target)

Trial 4

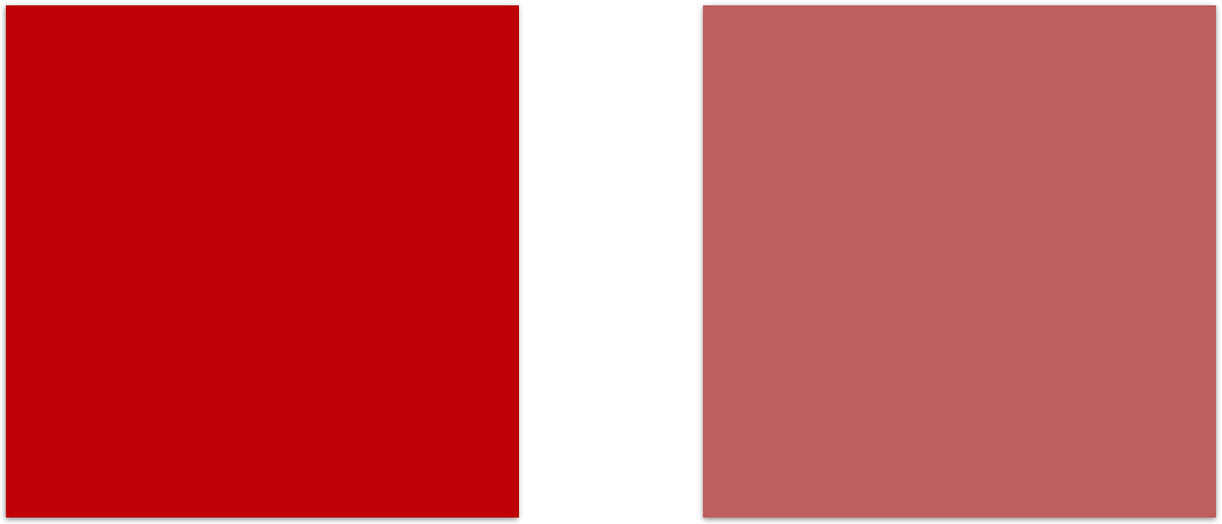
(black circle is the reference, blue circle is the target)

Trial 5

(black circle is the reference, blue circle is the target)

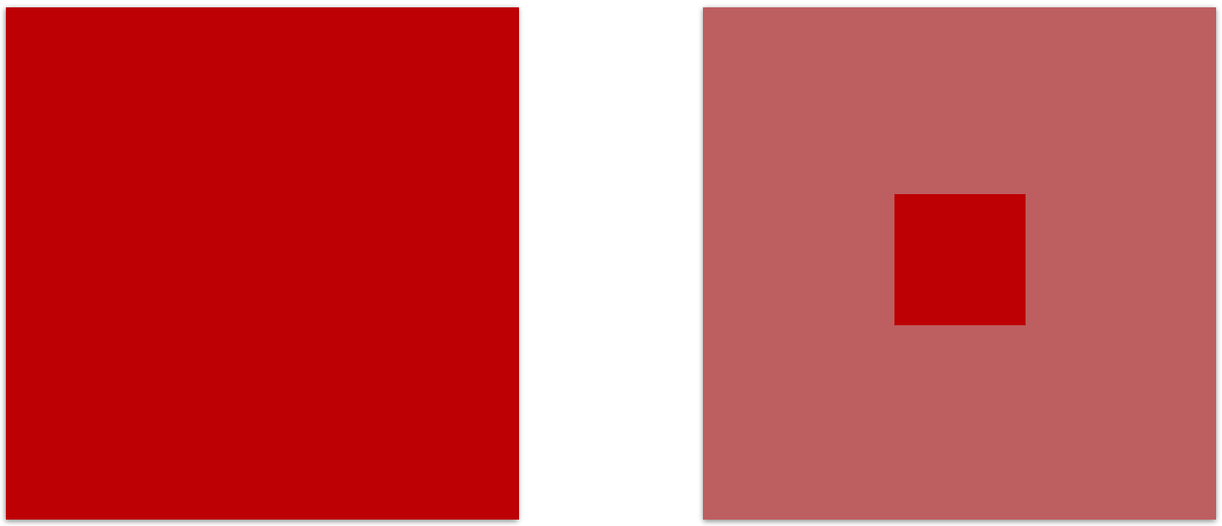
Saturation

EXAMPLE



(black arrow is the reference, blue arrow is the target)

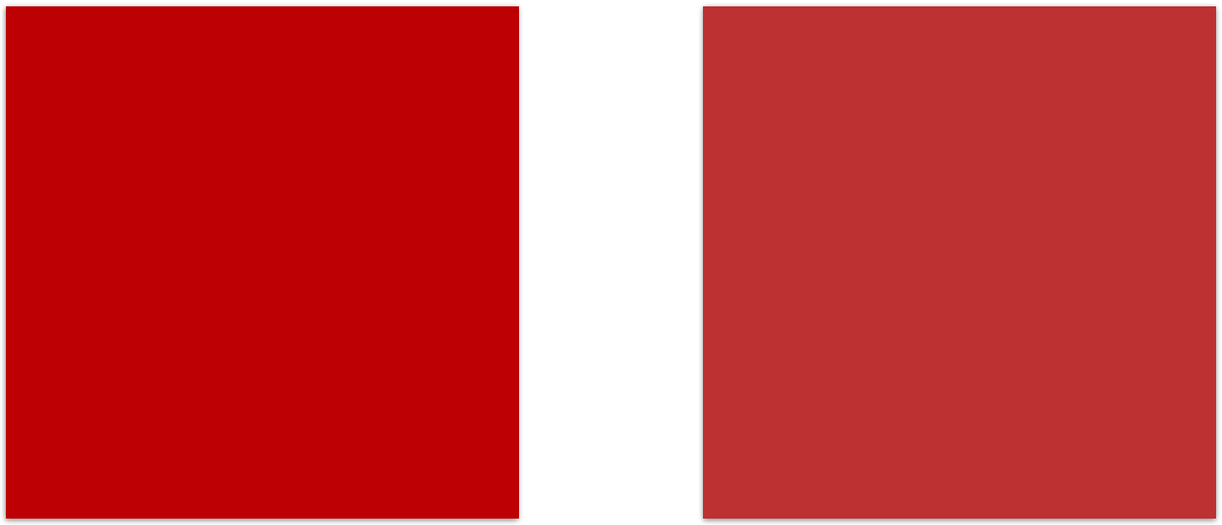
EXAMPLE



50%

(black arrow is the reference, blue arrow is the target)

Trial 1

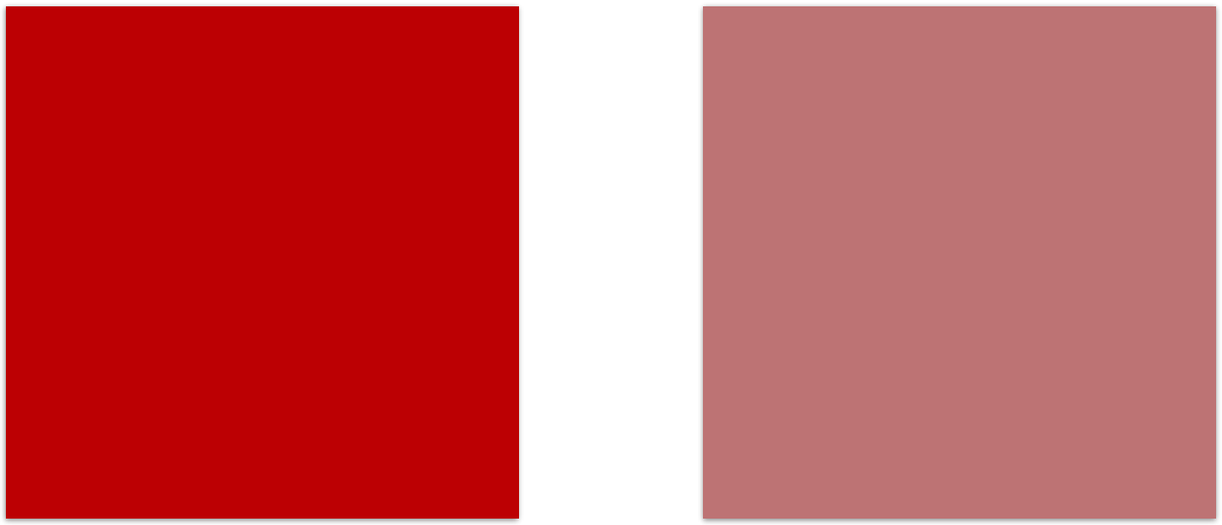


(black arrow is the reference, blue arrow is the target)

Trial 2

(black arrow is the reference, blue arrow is the target)

Trial 3



(black arrow is the reference, blue arrow is the target)

Trial 4

(black arrow is the reference, blue arrow is the target)

Trial 5

(black arrow is the reference, blue arrow is the target)

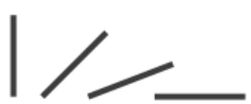
Stay tuned for results

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)

Same

Same

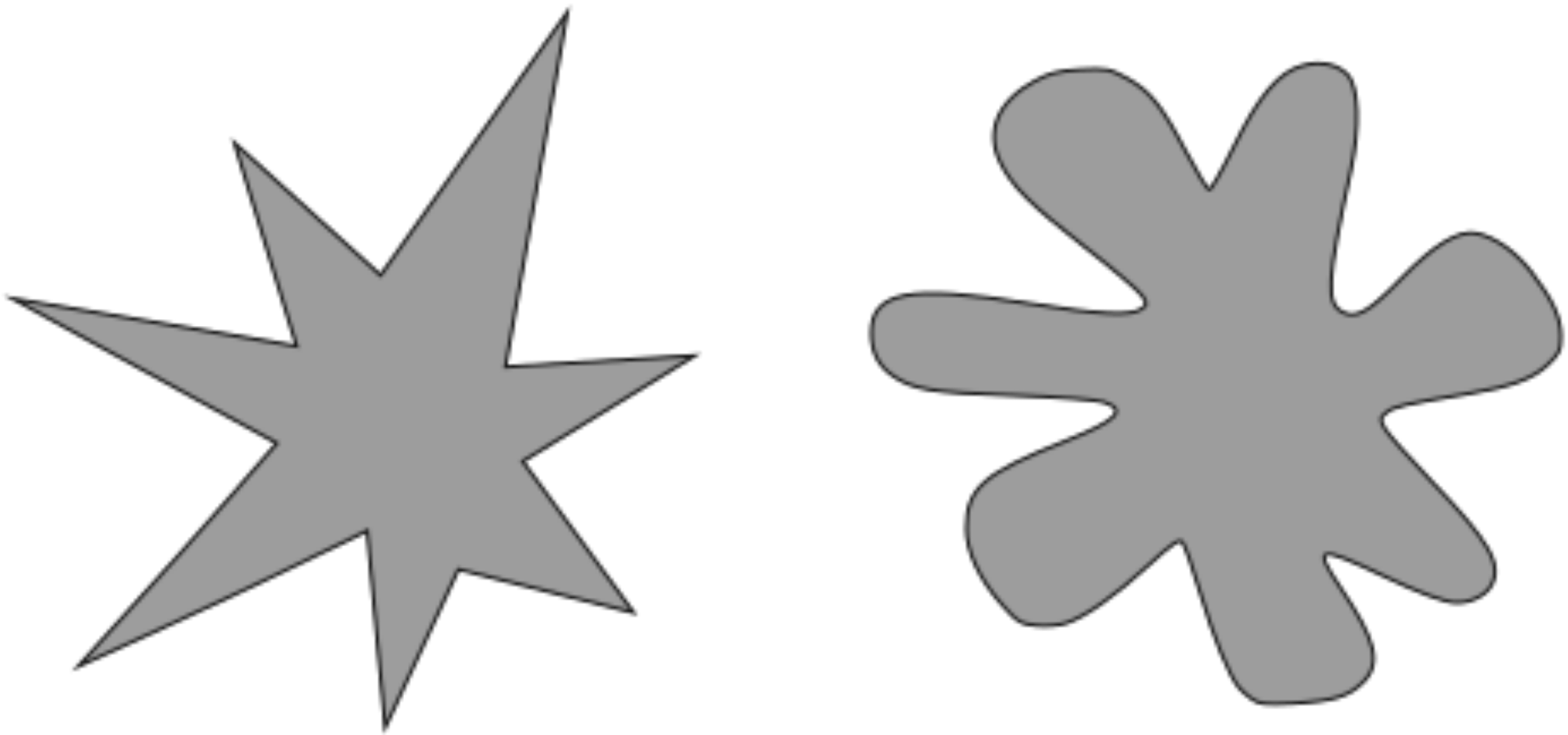
Spatial region

Color hue

Motion

Shape

Visualization Analysis and Design, Tamara Munzner, 2014



Köhler, Wolfgang (1929). Gestalt Psychology.

Gestalt Principles

PROXIMITY

When objects placed together, the eye perceives them as a group.

SIMILARITY

When objects look similar to one another, the eye perceives them as a group or pattern.

CONTINUANCE

The eye is compelled to move from one object through another.

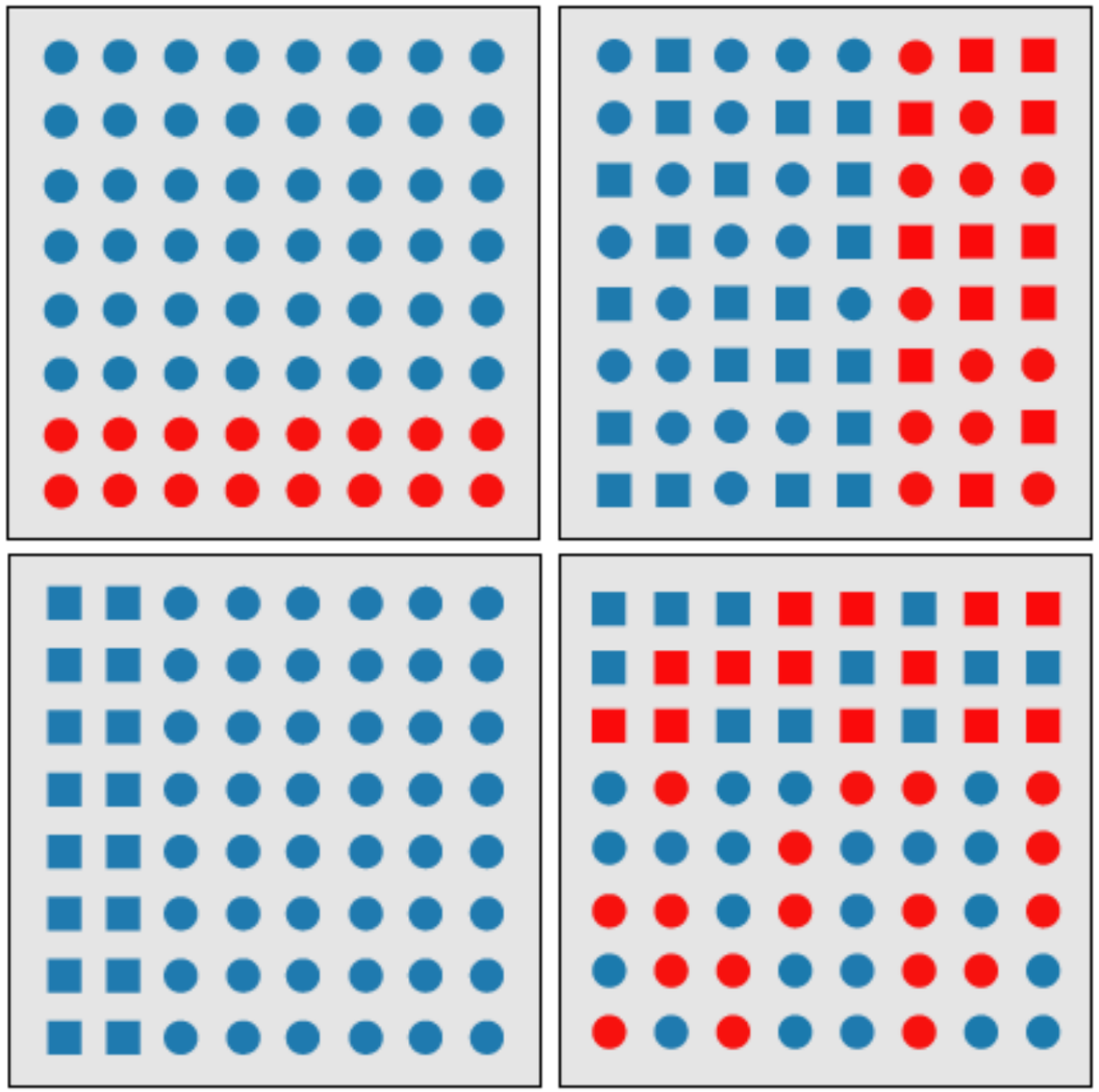
CLOSURE

When an object is incomplete or not completely enclosed.

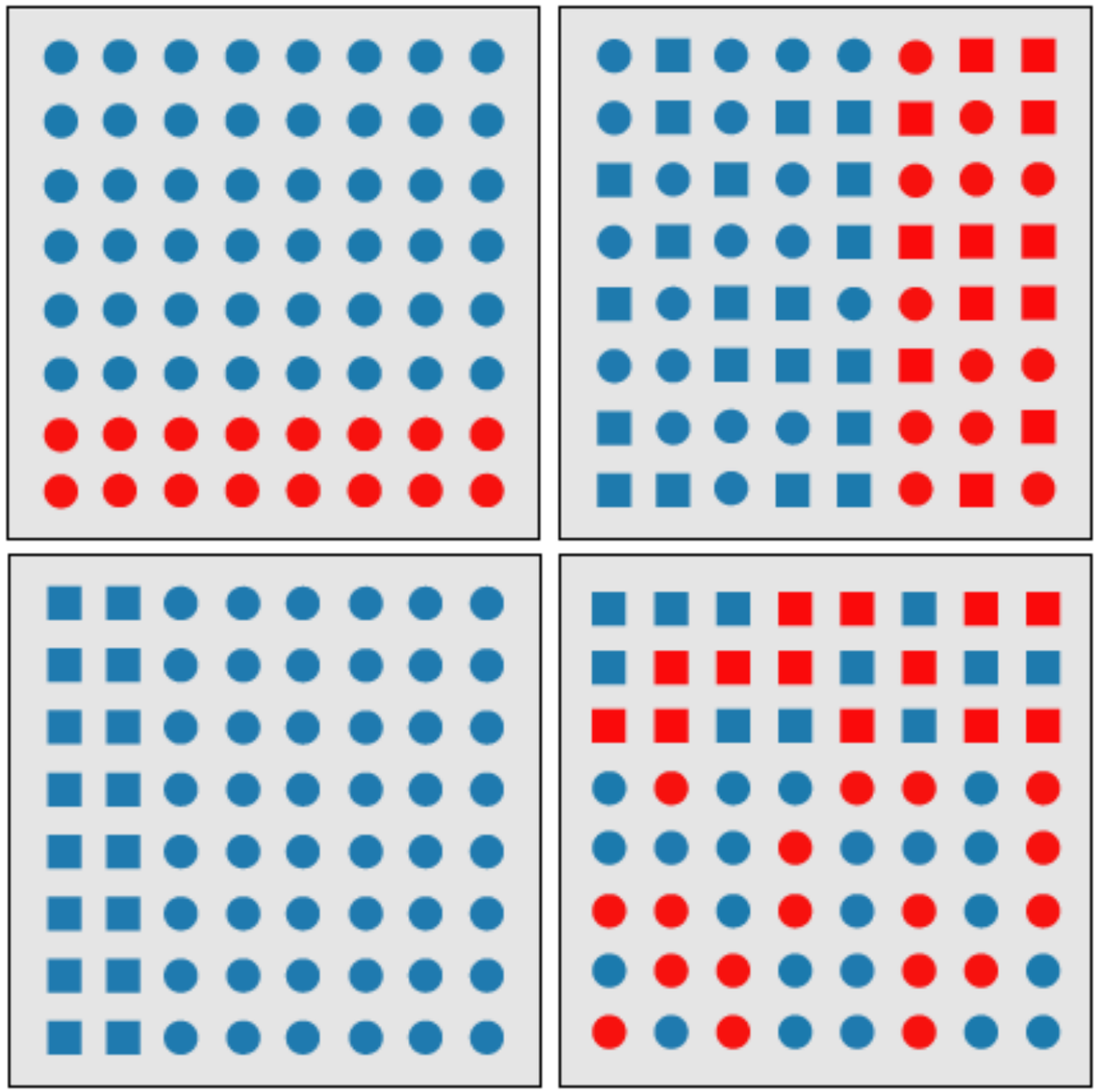
FIGURE & GROUND

When the eye differentiates an object from its surrounding area.

Tubik Studio, Gestalt Theory for Efficient UX



Credit:
Christopher Healey, https://www.csc2.ncsu.edu/faculty/healey/PP/



What other factors should we consider when designing visualizations?

Credit:
Christopher Healey, https://www.csc2.ncsu.edu/faculty/healey/PP/

Graphical Perception

Visual Stimulus

Light enters the eye, then transduced and transmitted

Pre-attentive Processing

Cells identify and select features (line, angle, etc.)

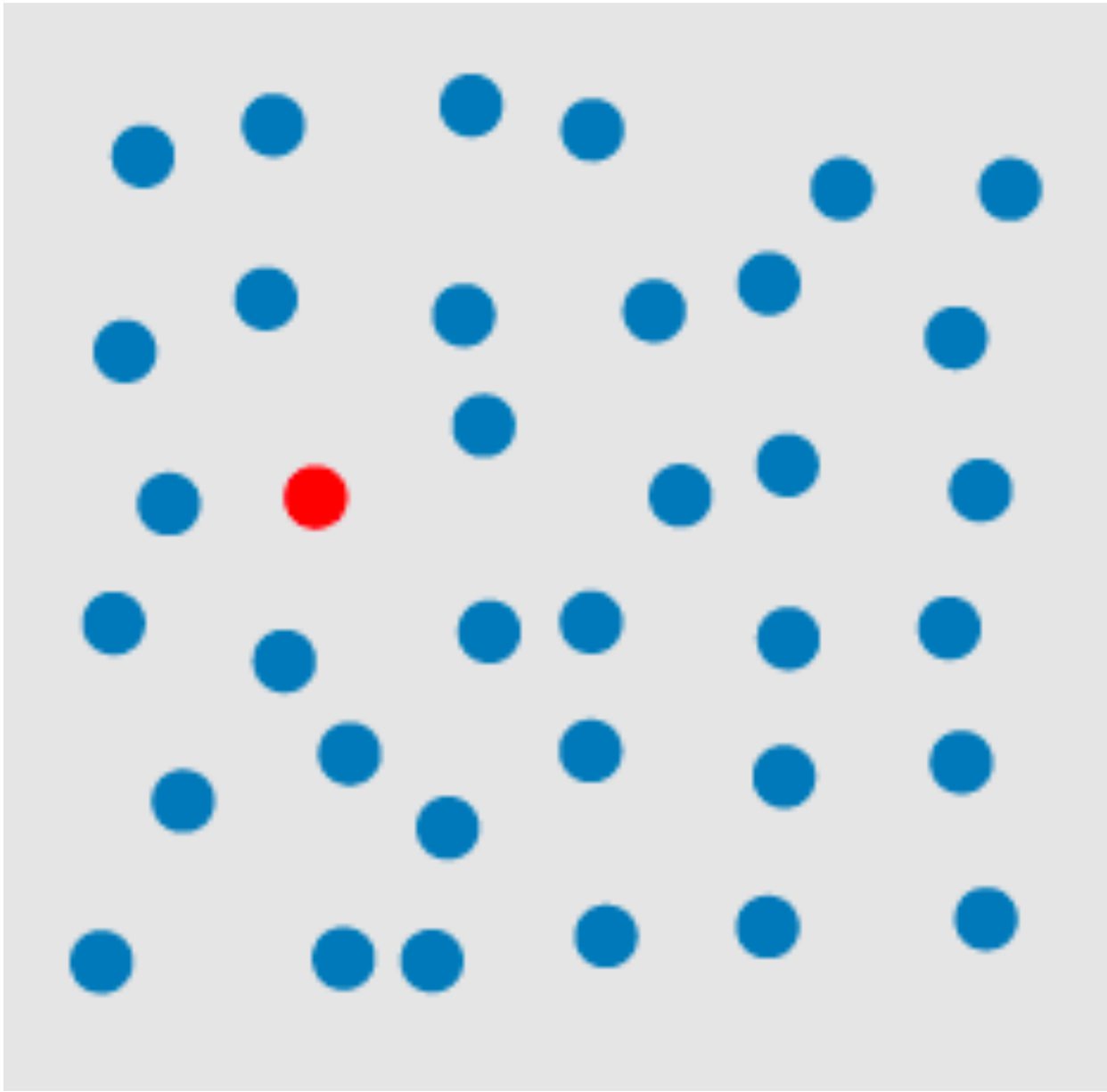
Organization & Evaluation

Interpreting visual data – incorporate knowledge

Pre-attentive Processing

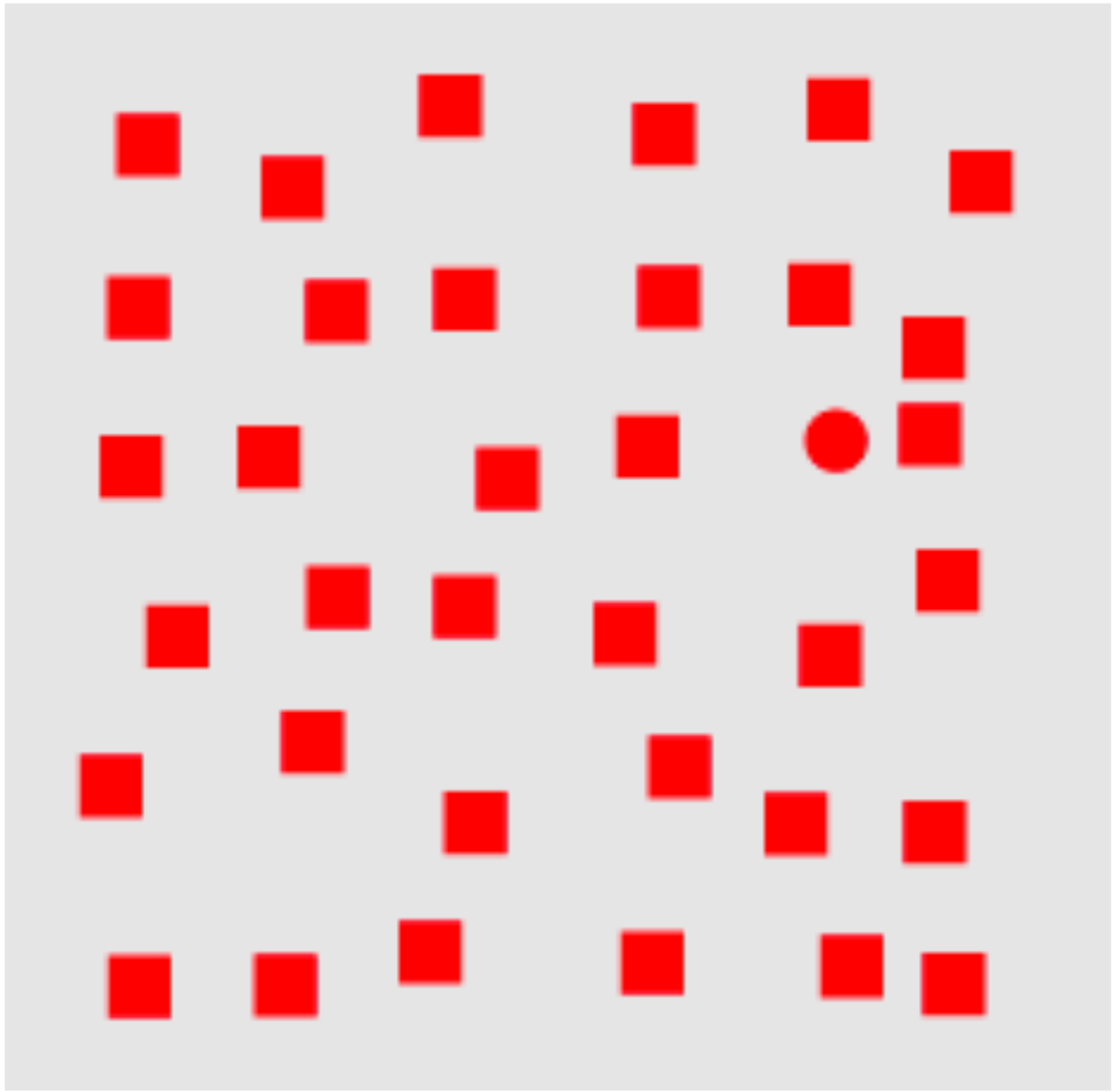
- Incredibly rapid and parallelized
- Low-level, simple features identified subconsciously
- Attention actually involved (but it’s complicated)
- Background knowledge and expectations **NOT** a factor

Pre-attentive Processing

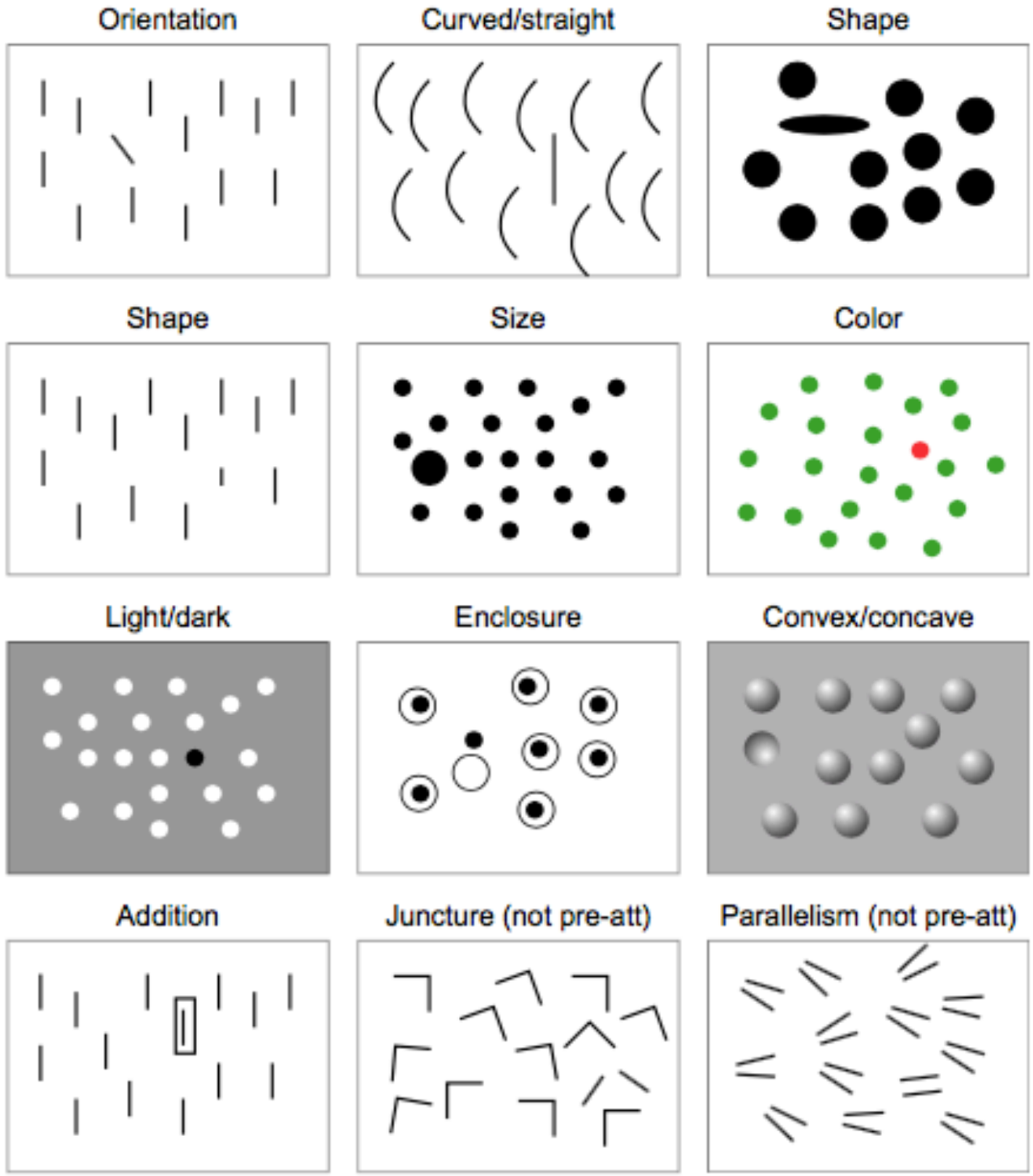


Credit:
Christopher Healey, https://www.csc2.ncsu.edu/faculty/healey/PP/

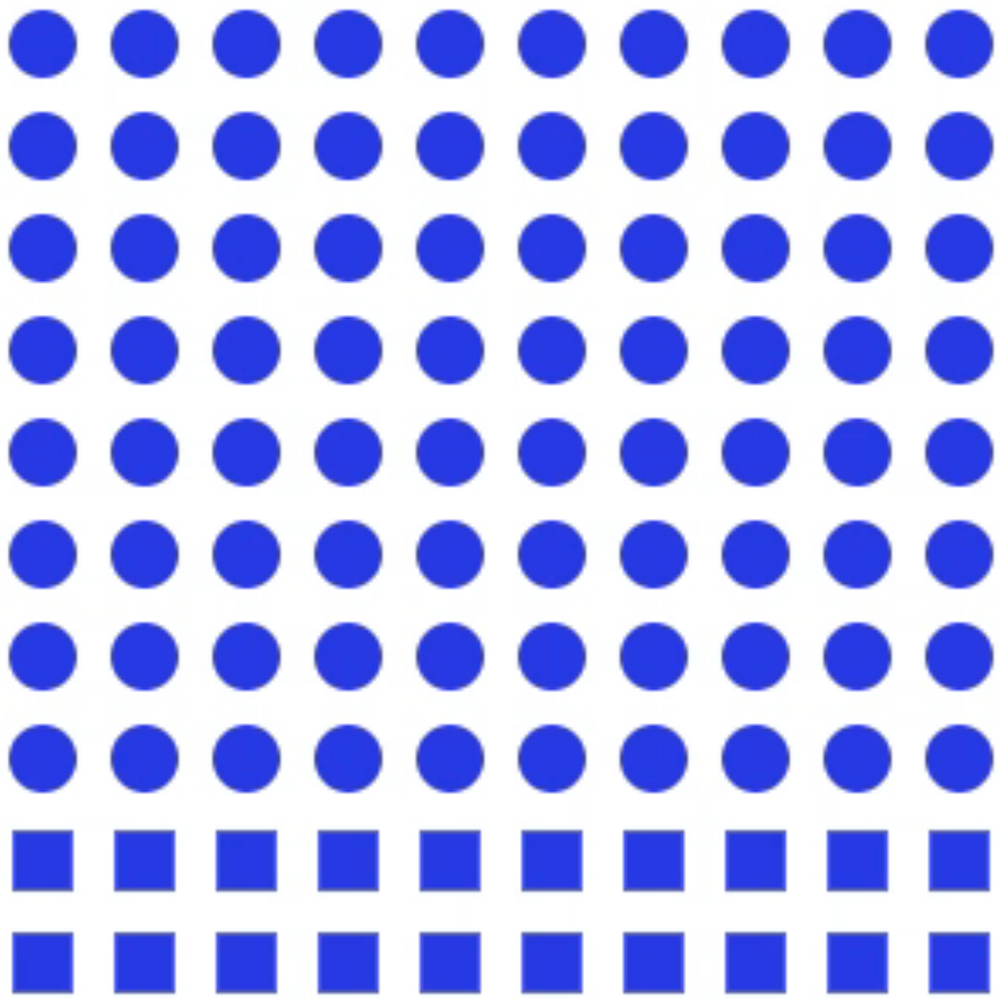
Pre-attentive Processing



Credit:
Christopher Healey, https://www.csc2.ncsu.edu/faculty/healey/PP/



Ware, C., 2000. Information visualization: design for perception. *Morgan Kauffman, San Mateo, CA*.

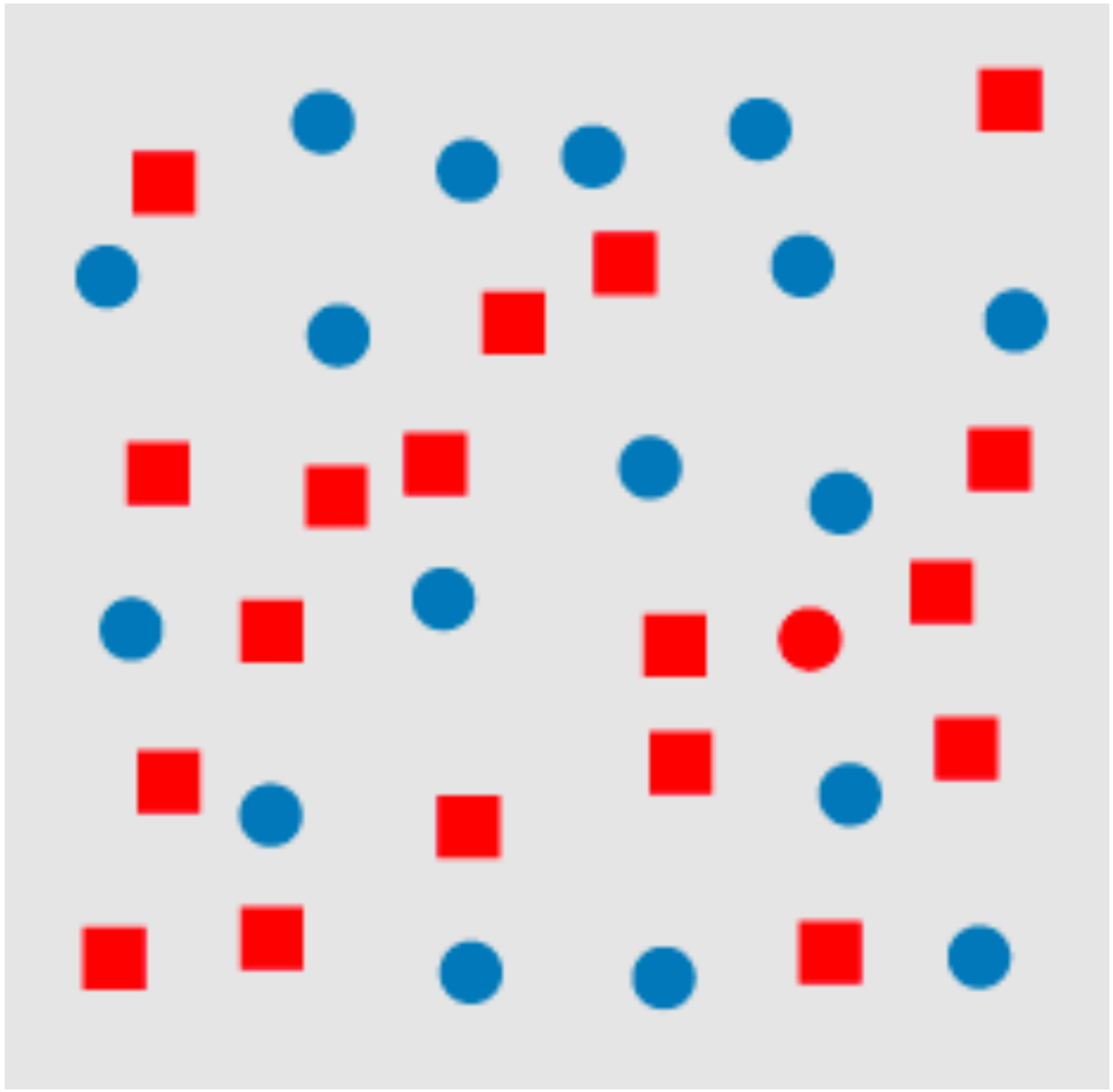


100ms

(demo applet: https://www.csc2.ncsu.edu/faculty/healey/PP/#jscript_boundary)

Credit:
Christopher Healey, https://www.csc2.ncsu.edu/faculty/healey/PP/

Conjunctive Search



Find the red circle!

Credit:
Christopher Healey, https://www.csc2.ncsu.edu/faculty/healey/PP/

Pre-attentive Interference

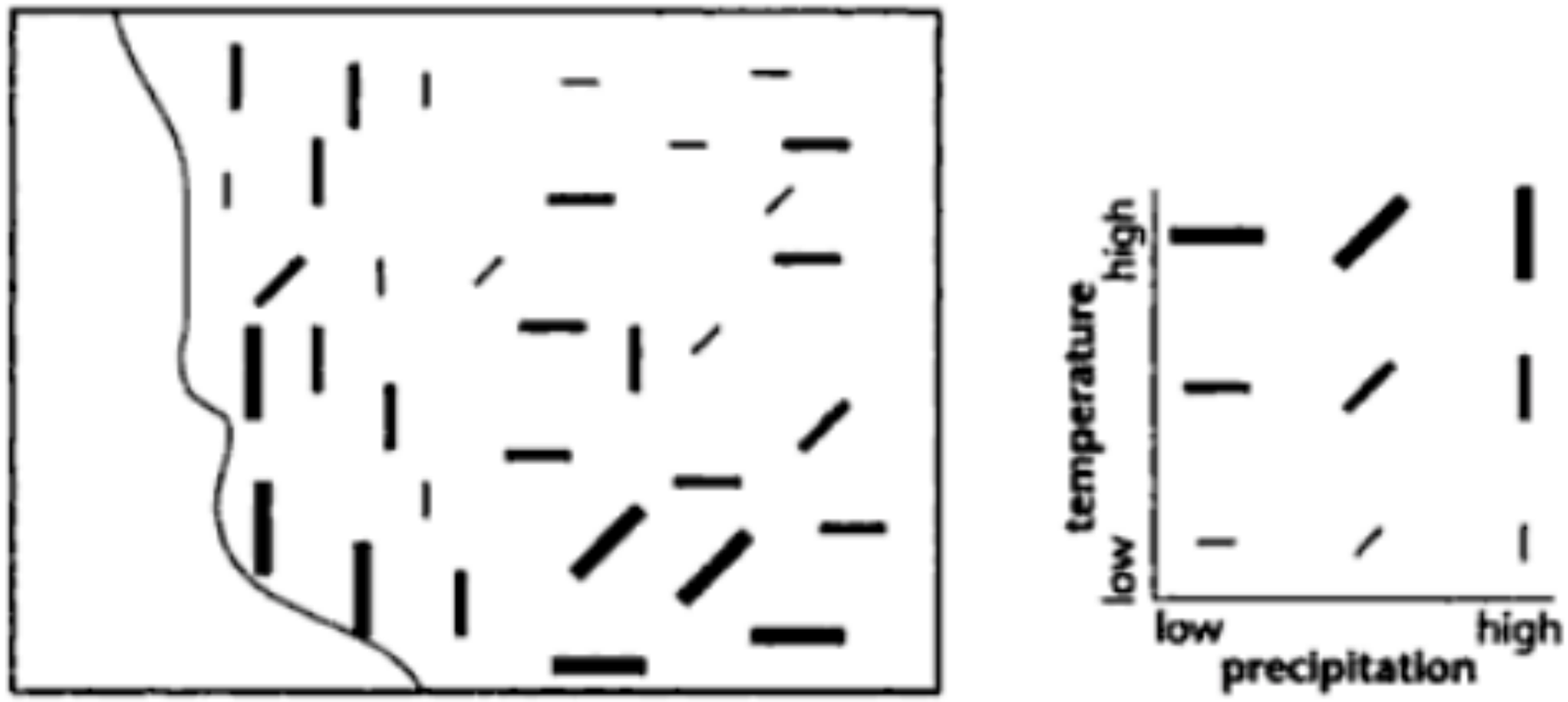


FIGURE 3.36. A map of temperature and precipitation using symbol size and orientation to represent data values on the two variables.

MacEachren, A.M., 2004. *How maps work: representation, visualization, and design*. Guilford Press.

Pre-attentive Interference

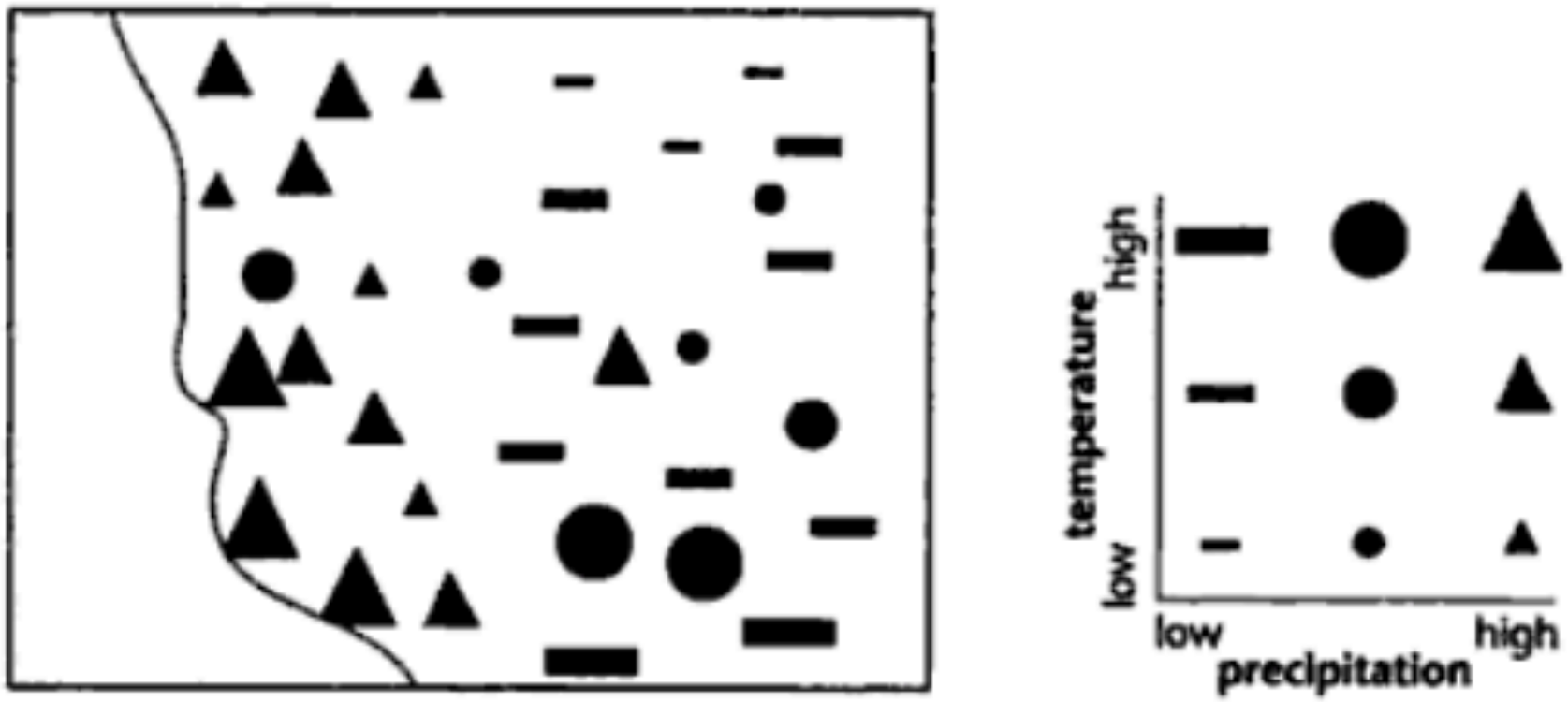
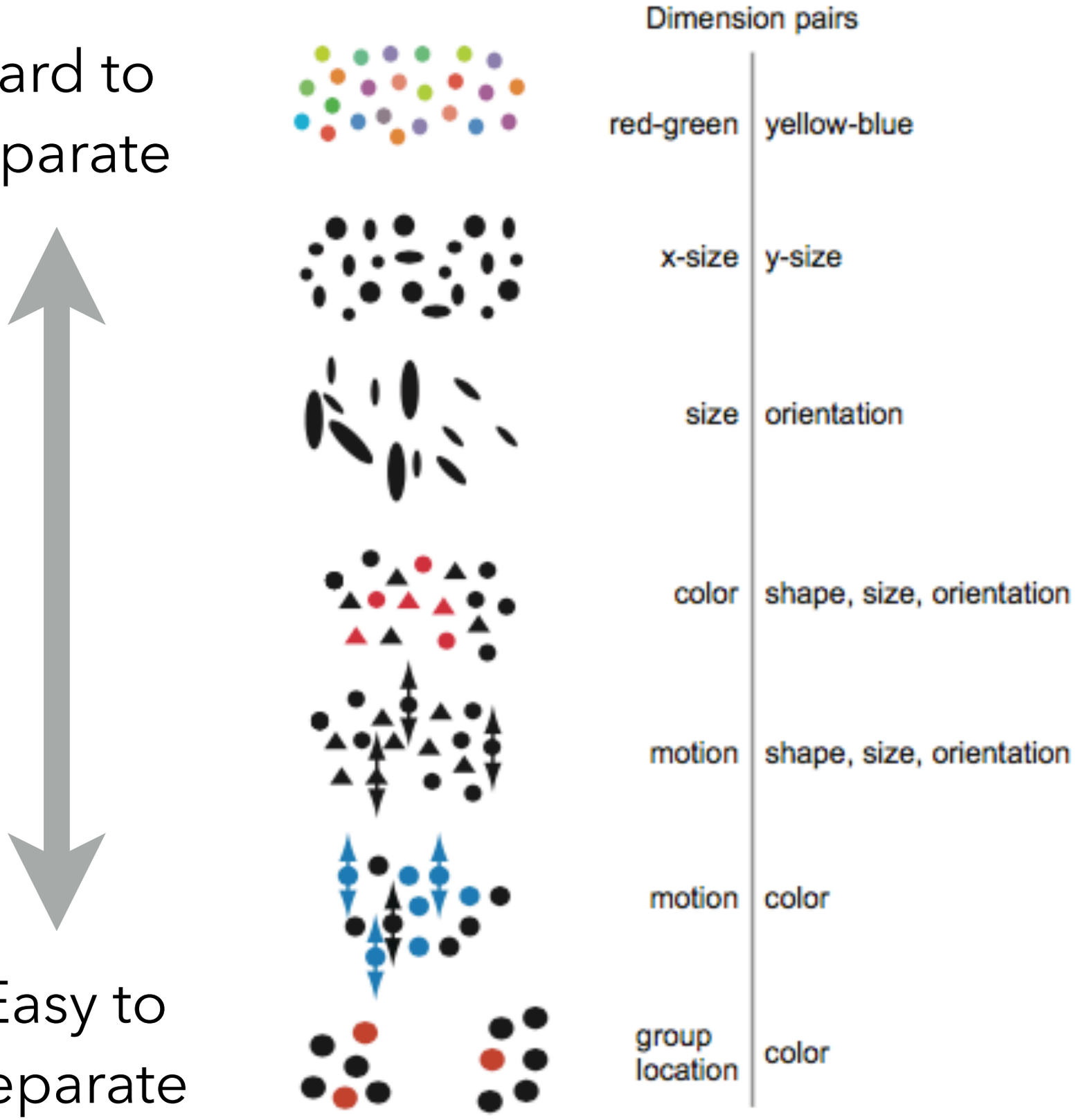


FIGURE 3.40. The bivariate temperature–precipitation map of Figure 3.36, this time using point symbols that vary in shape and size to represent the two quantities.

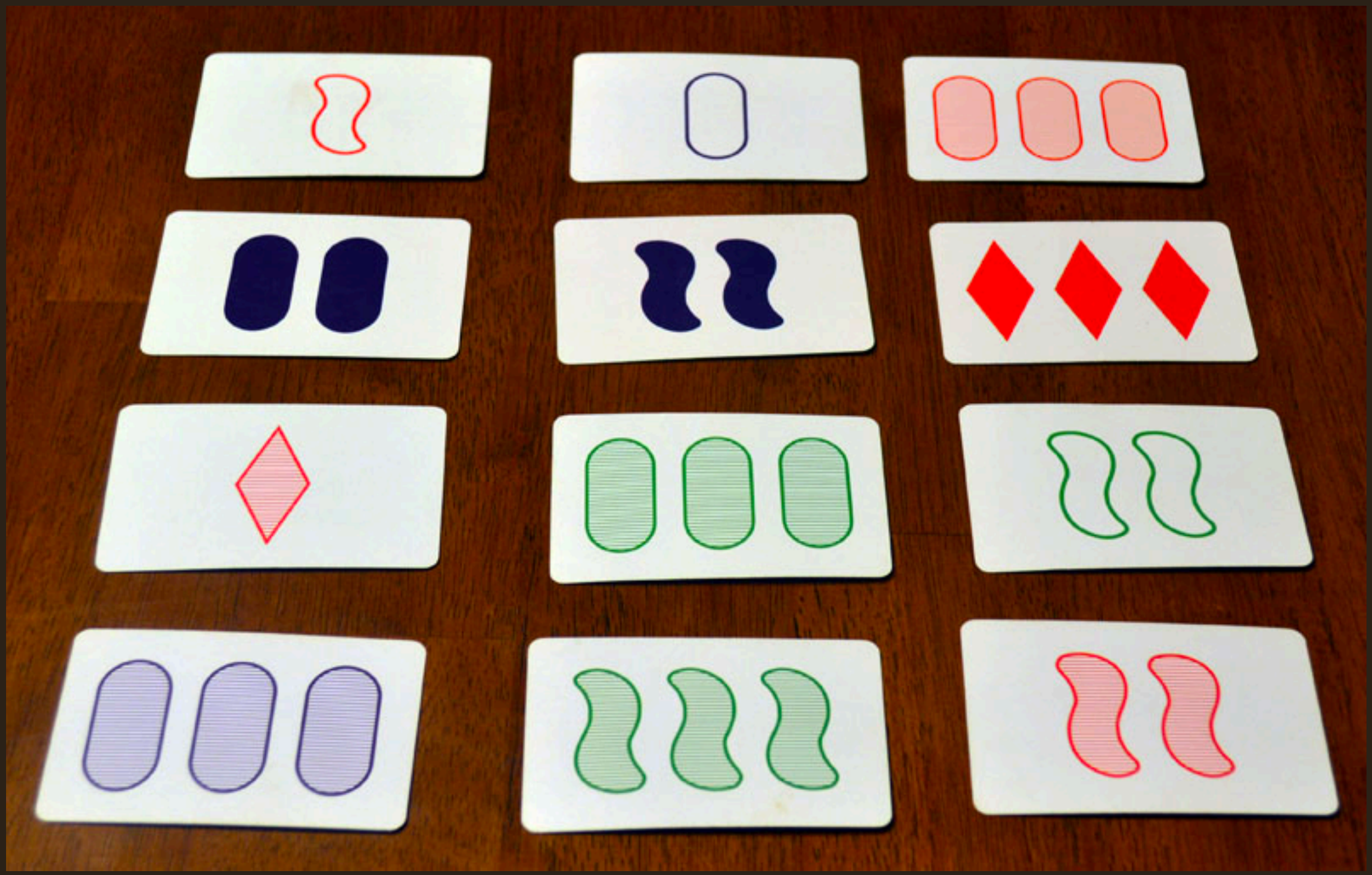
MacEachren, A.M., 2004. *How maps work: representation, visualization, and design*. Guilford Press.

Hard to separate



Easy to separate

Ware, C., 2000. Information visualization: design for perception. *Morgan Kauffman, San Mateo, CA*.



Credit:
The Board Game Family

Pre-attentive Processing

- Can be very, very helpful for identifying unique points
- Easily confused by conjunctions
  (pay attention to separability)
- Works even for animation

Change Blindness

- Small disruptions can make us blind to differences
  - Screen changes, eye saccades, blinks

- Especially relevant for interactive systems

Change Blindness

https://www.csc2.ncsu.edu/faculty/healey/PP/movies/Corner.gif

Credit:
Christopher Healey, https://www.csc2.ncsu.edu/faculty/healey/PP/

Change Blindness

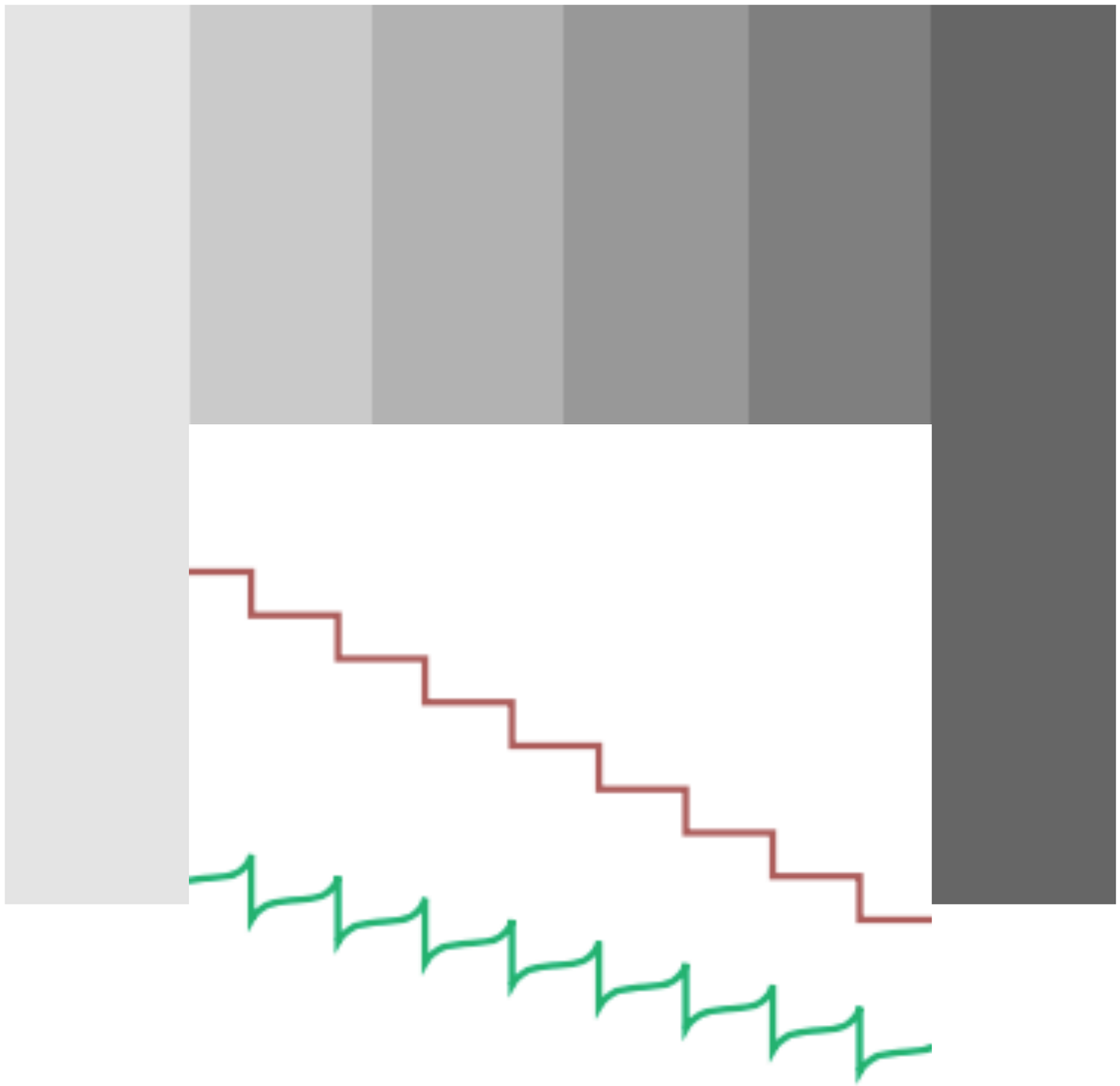
https://www.youtube.com/watch?v=Ahg6qcgoay4

Credit:
National Geographic

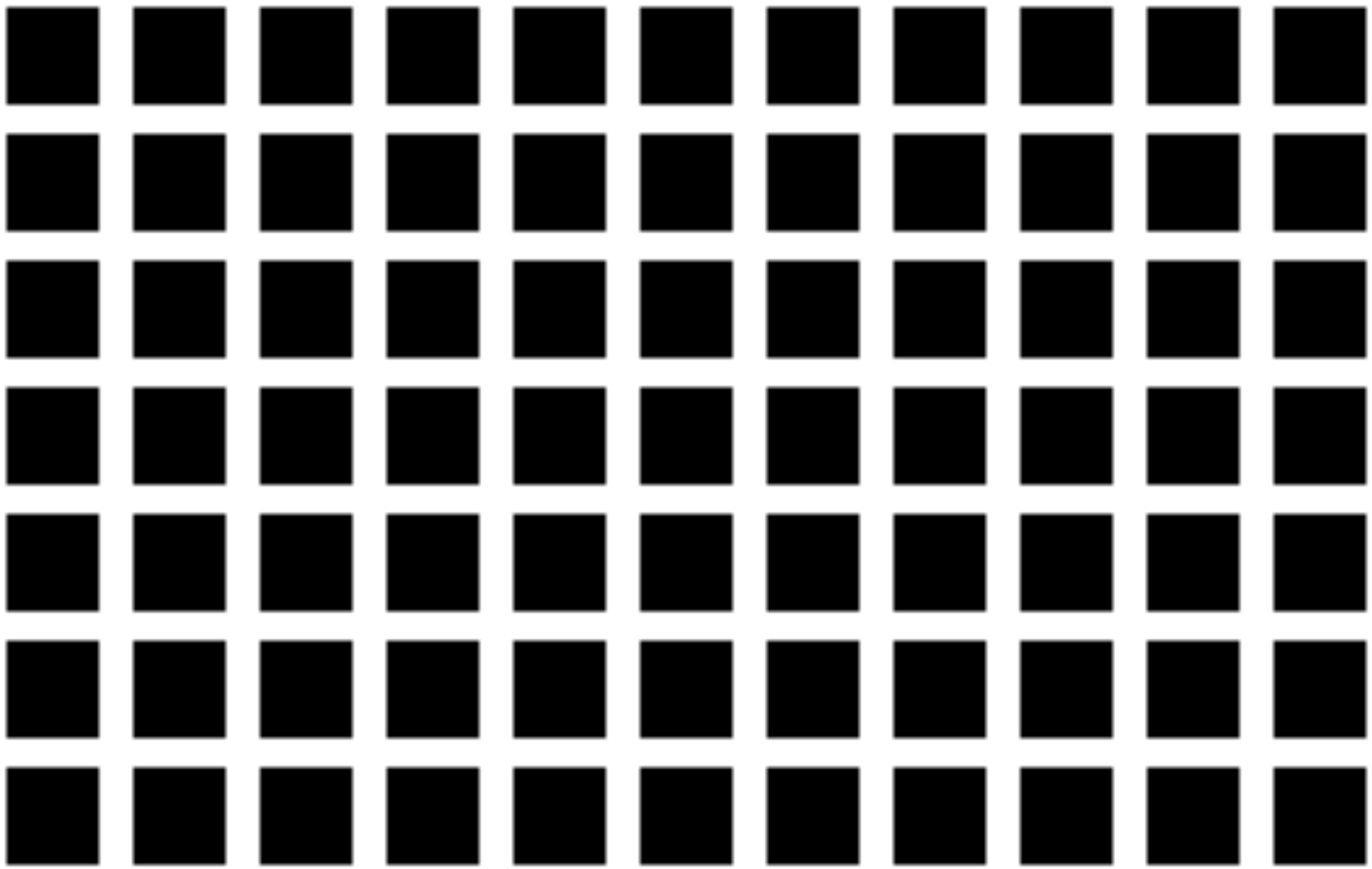
Credit:
Zaha Hadid; Shutterstock

Mach bands

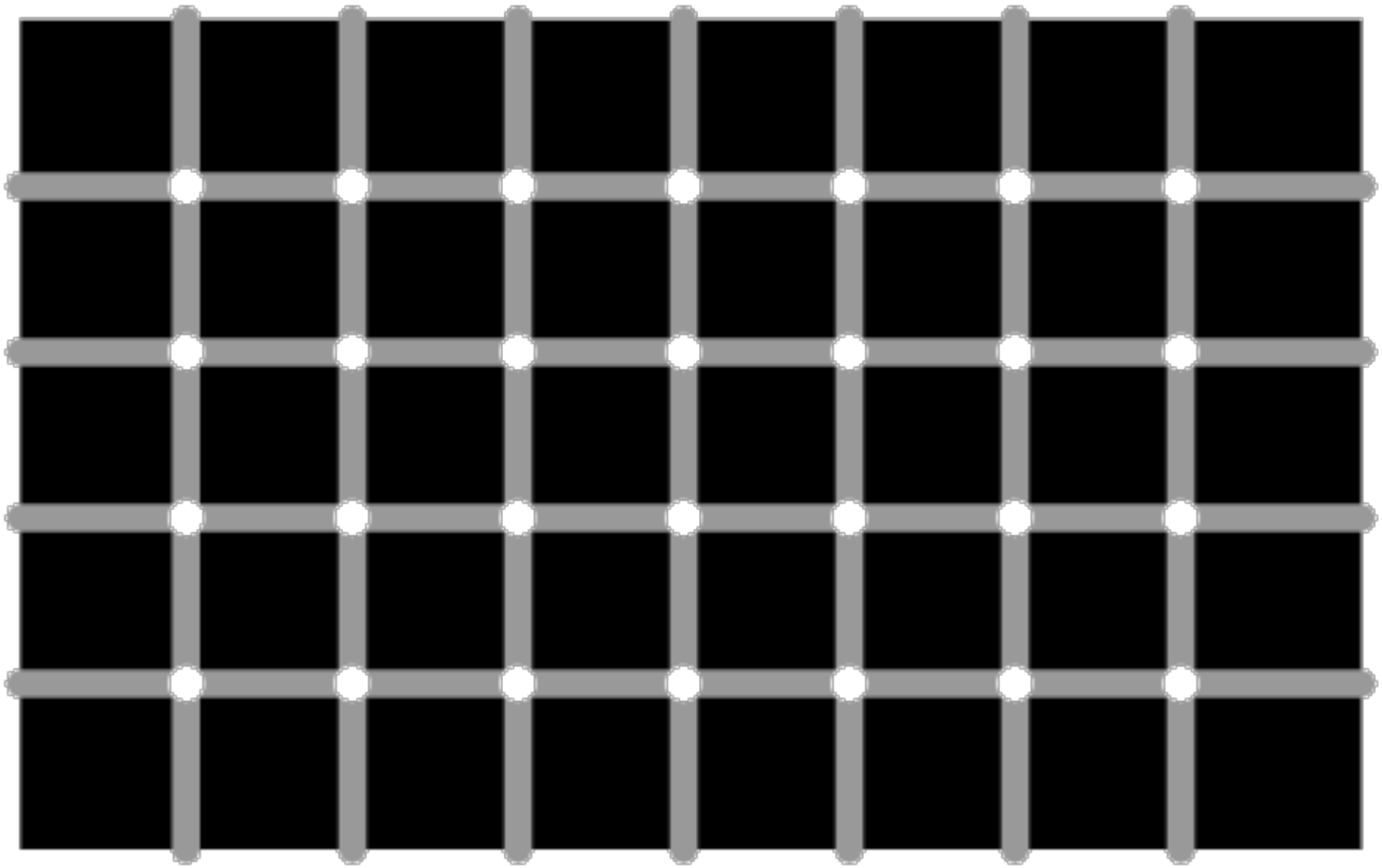
Mach bands

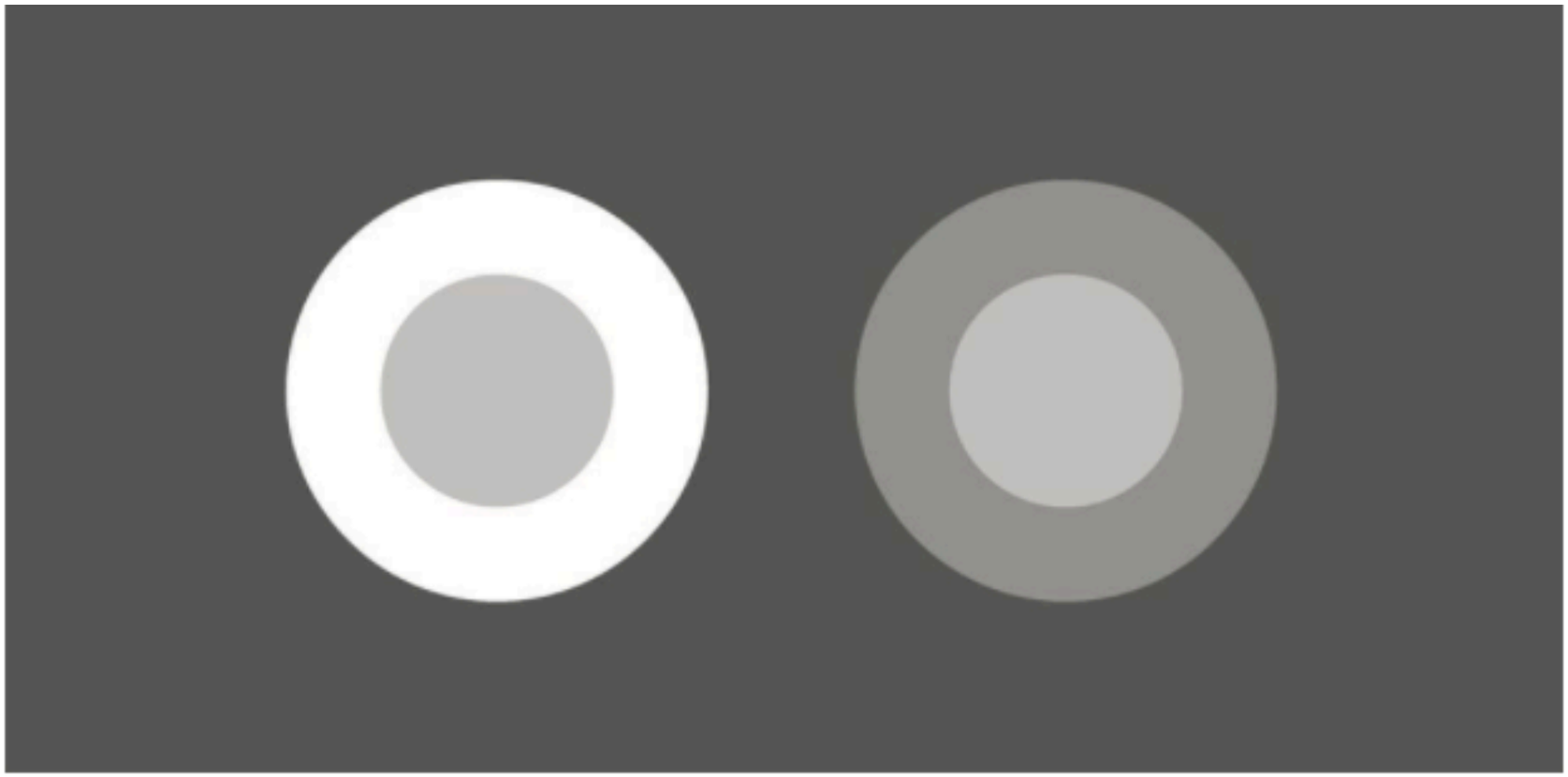


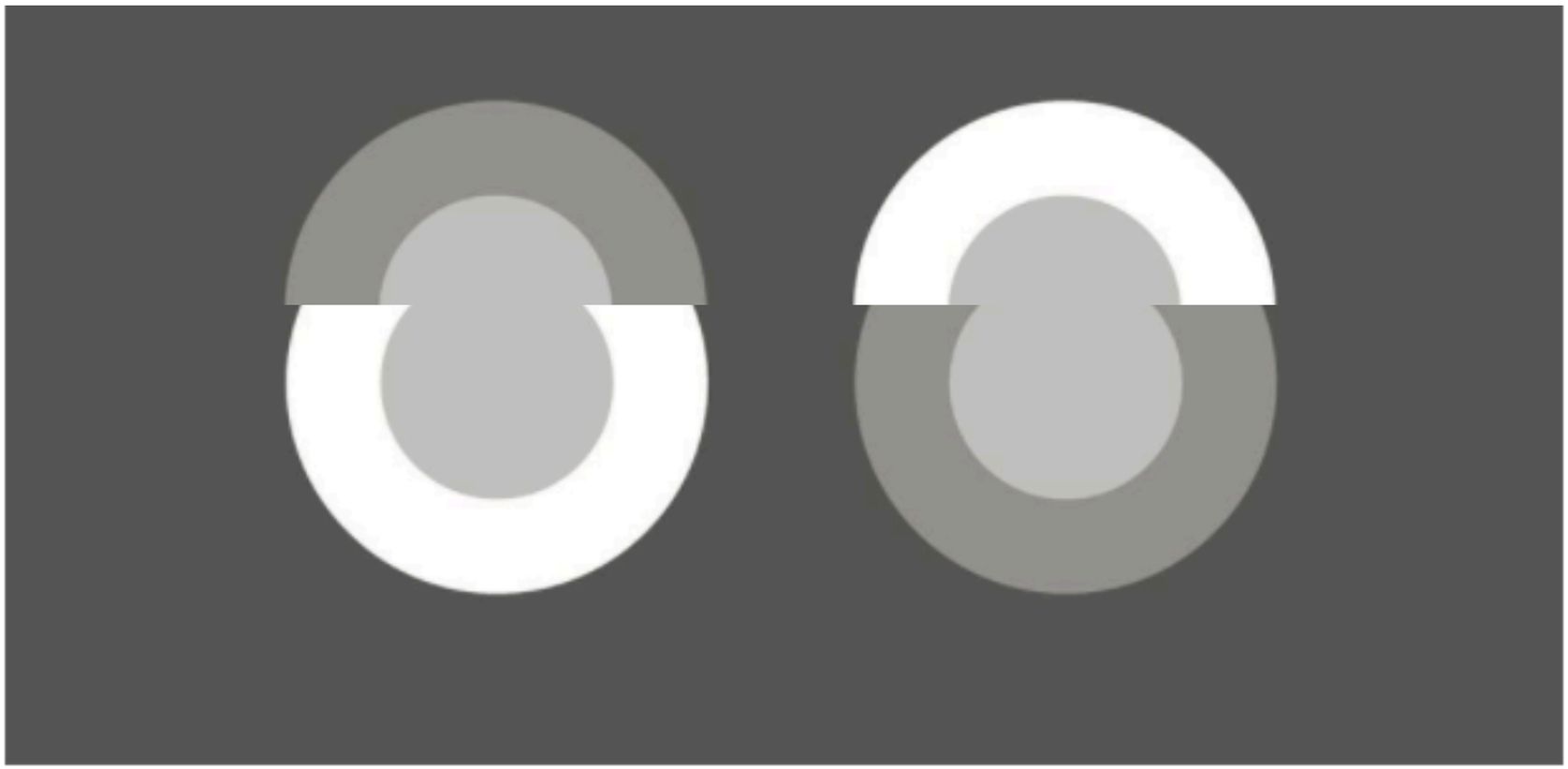
Hermann grid

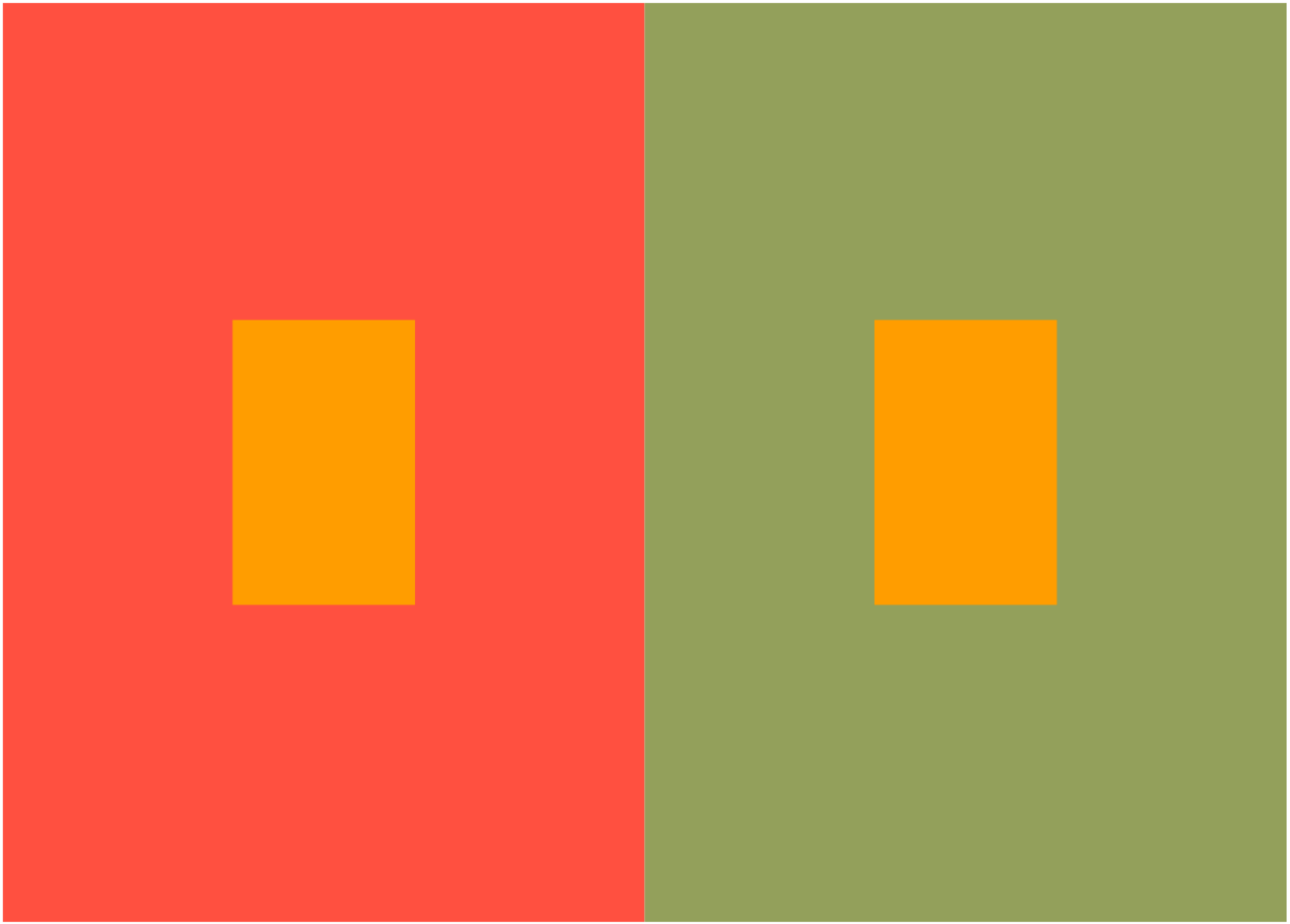


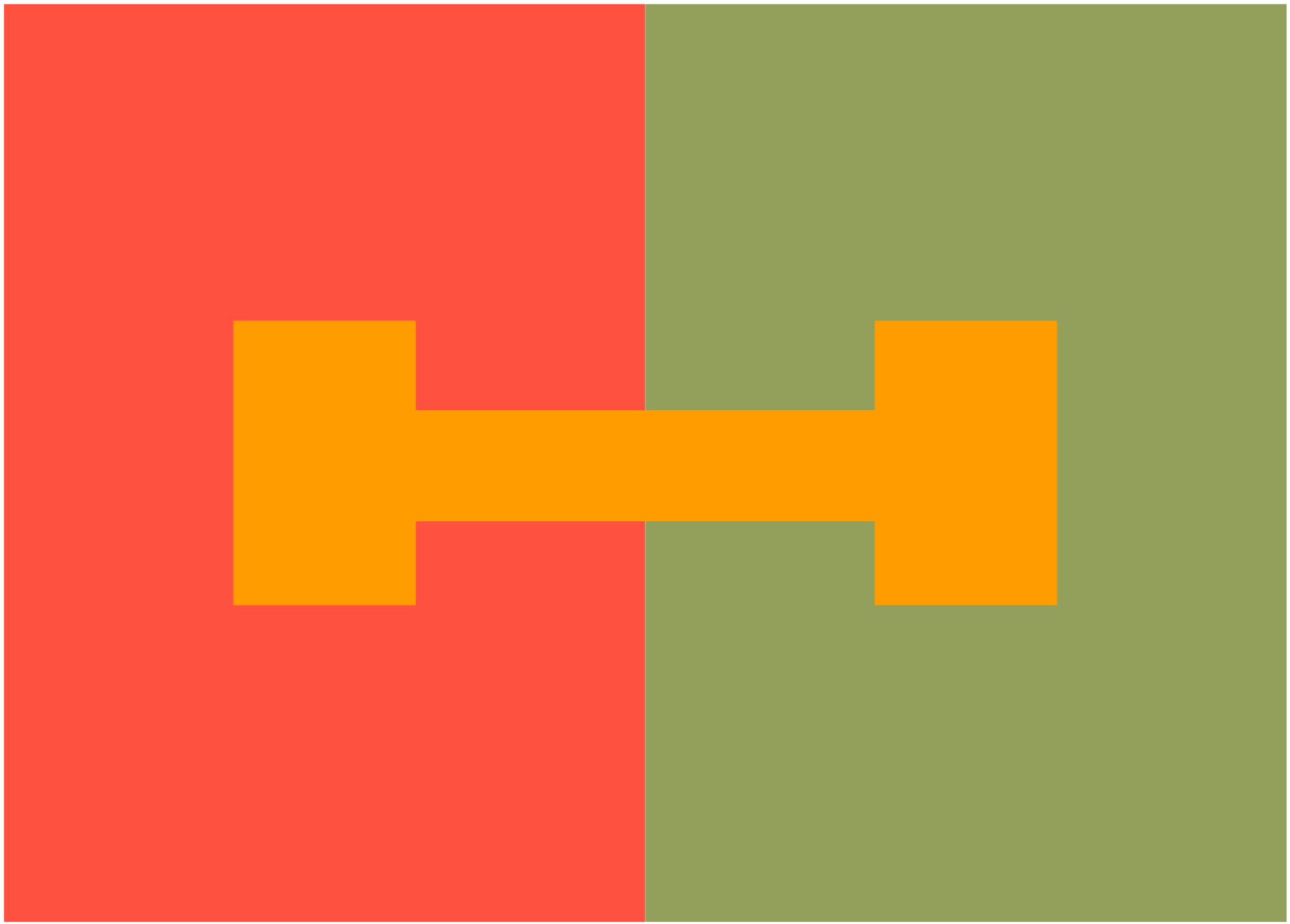
Hermann grid (Lingelbach var.)











Georges Seurat, The Bathers

Optical Illusions

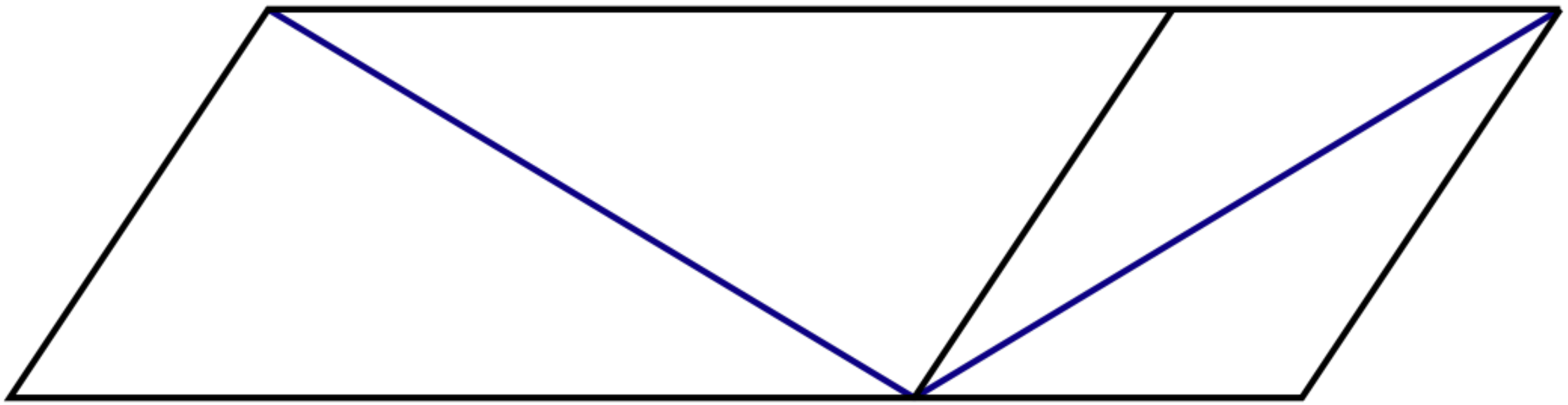
Physiological

Competing stimuli early in processing
(Mach bands, Hermann grid illusion)

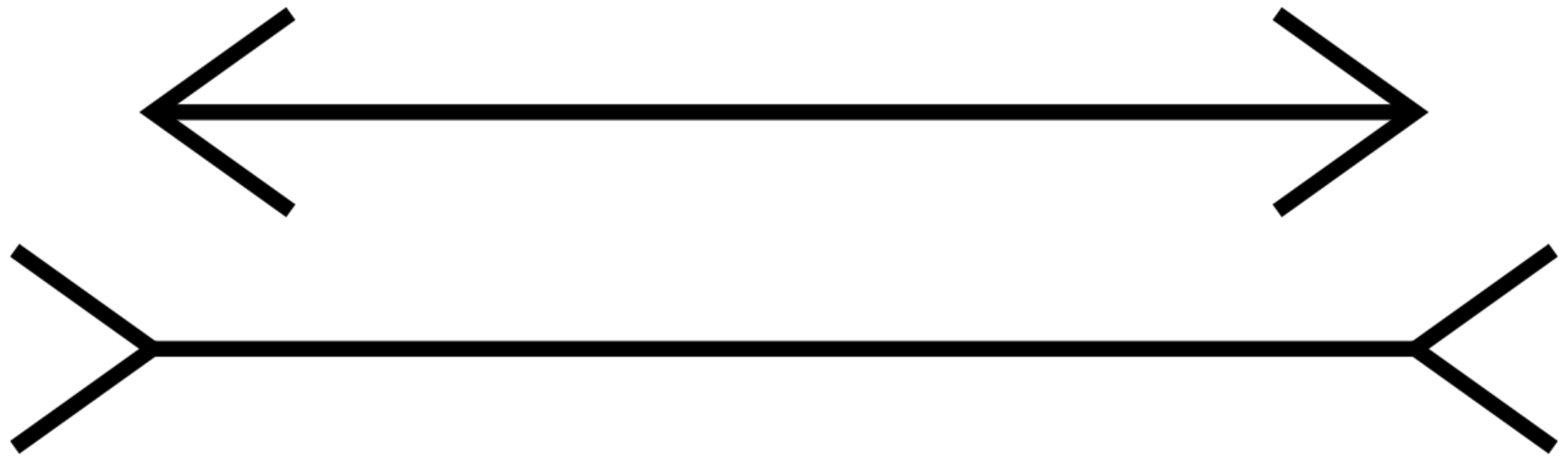
Cognitive

Interactions with “hard-coded” assumptions
(Ebbinghaus illusion, Müller-Lyer illusion)

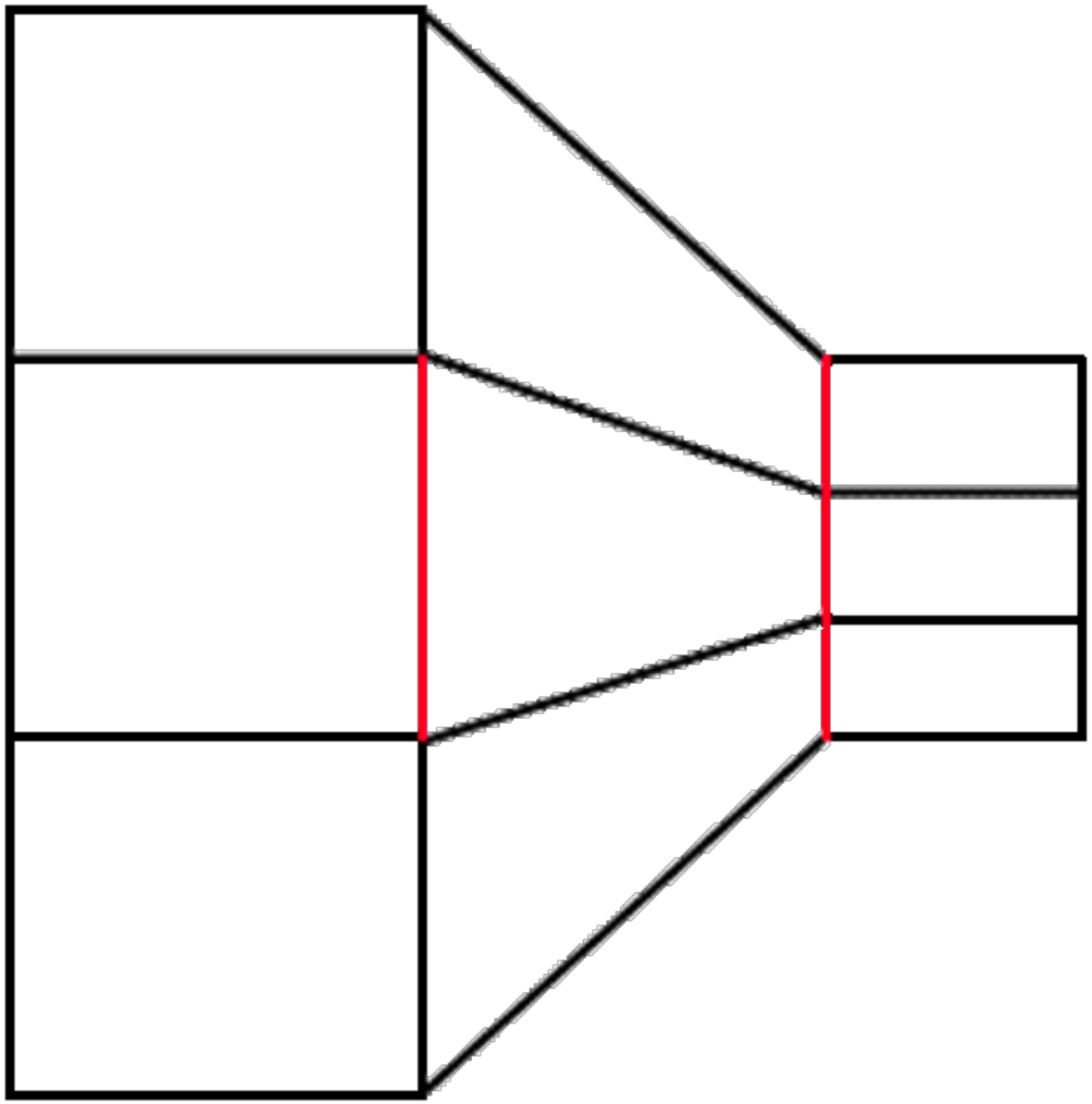
Sander's Parallelogram

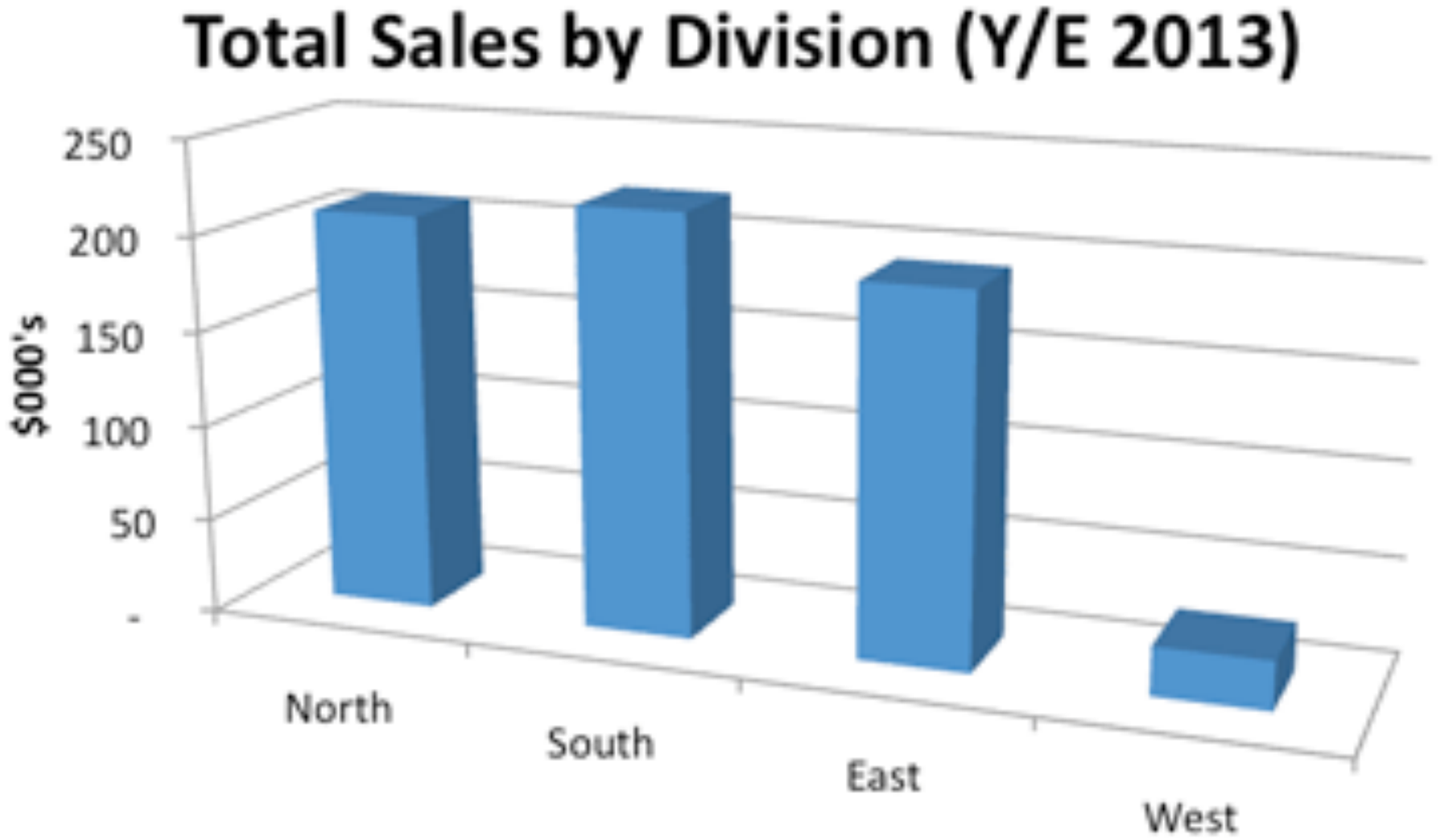


Müller-Lyer

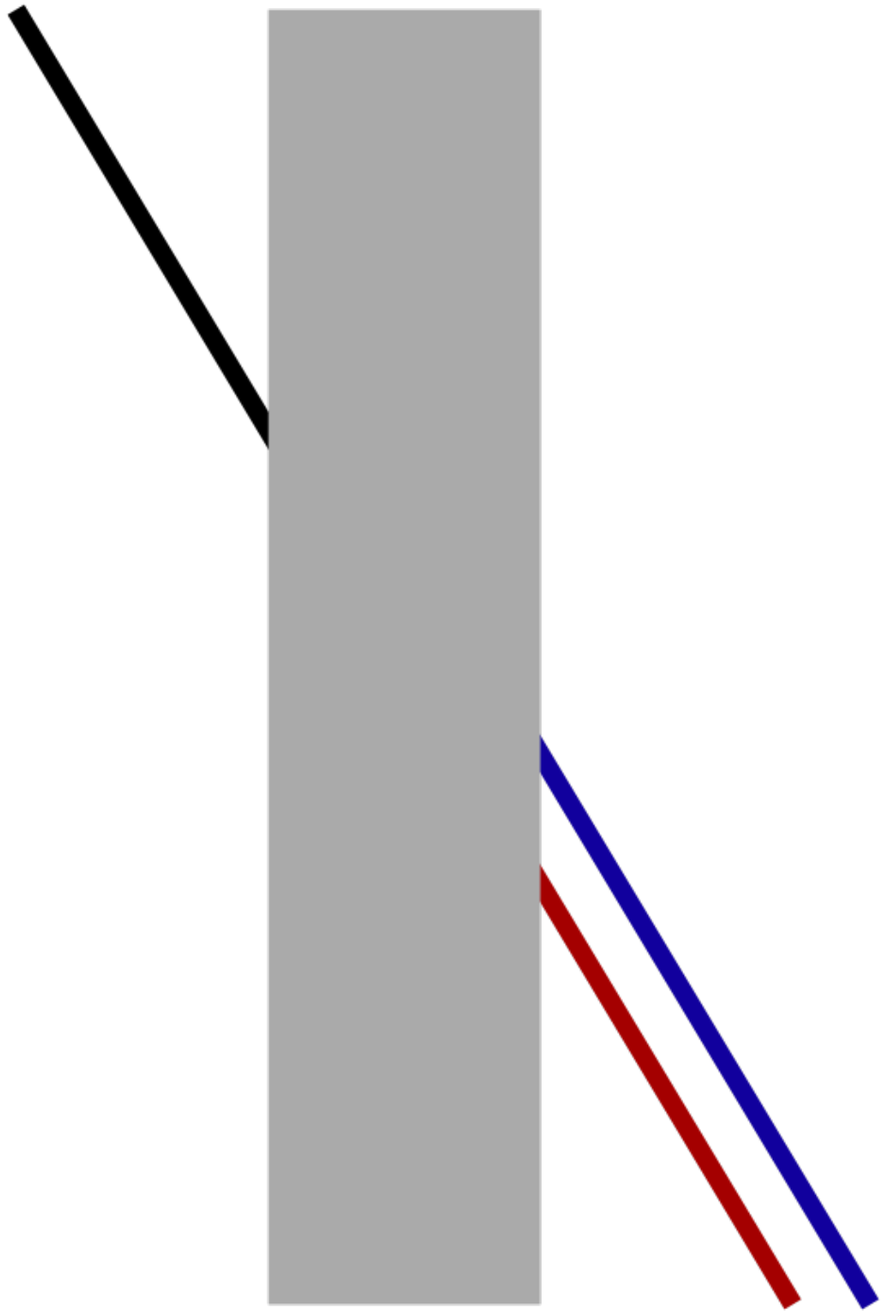


Perspective

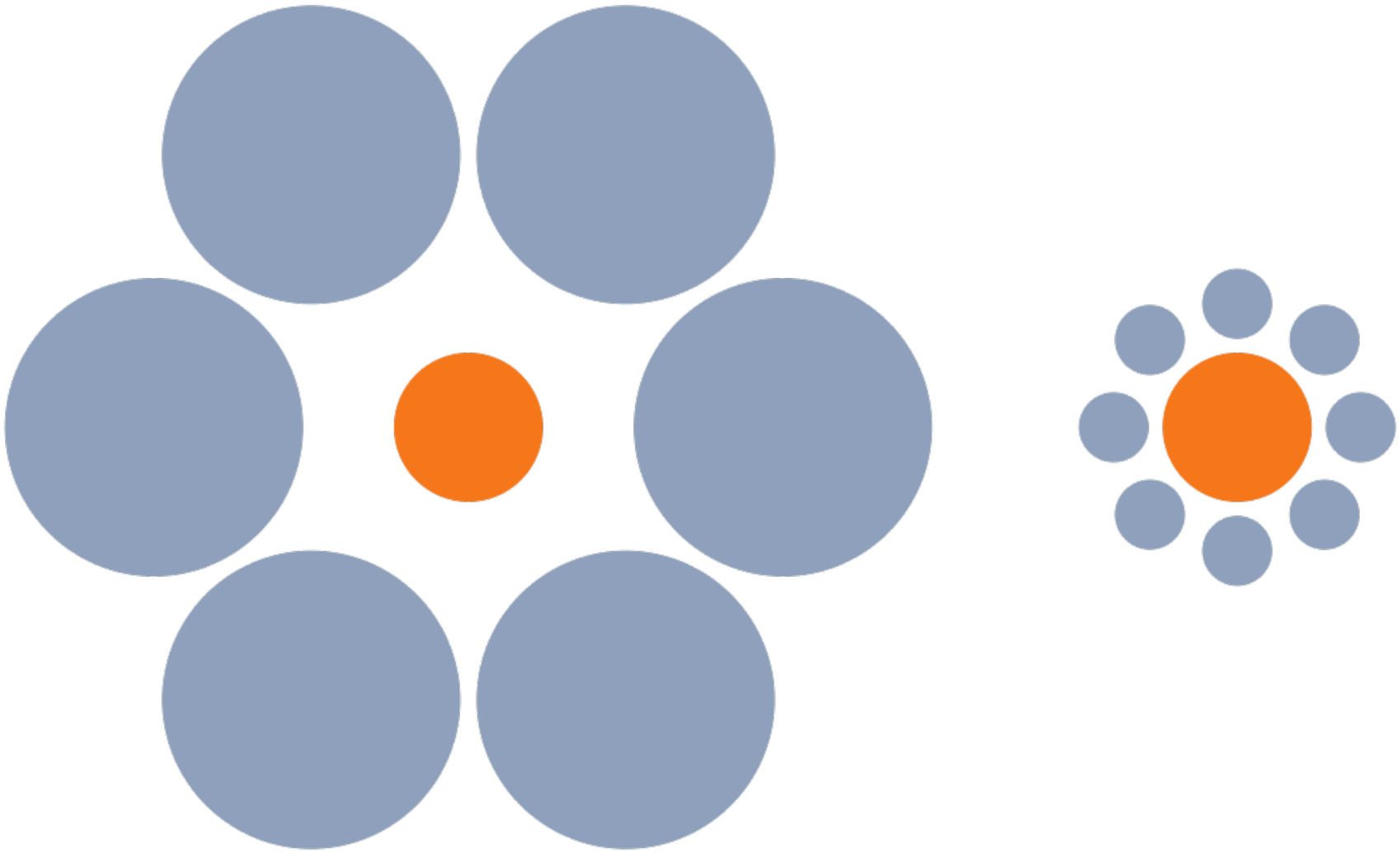



Total Sales by Division (Y/E 2013)
$000's
250
200
150
100
50
-
North
South
East
West

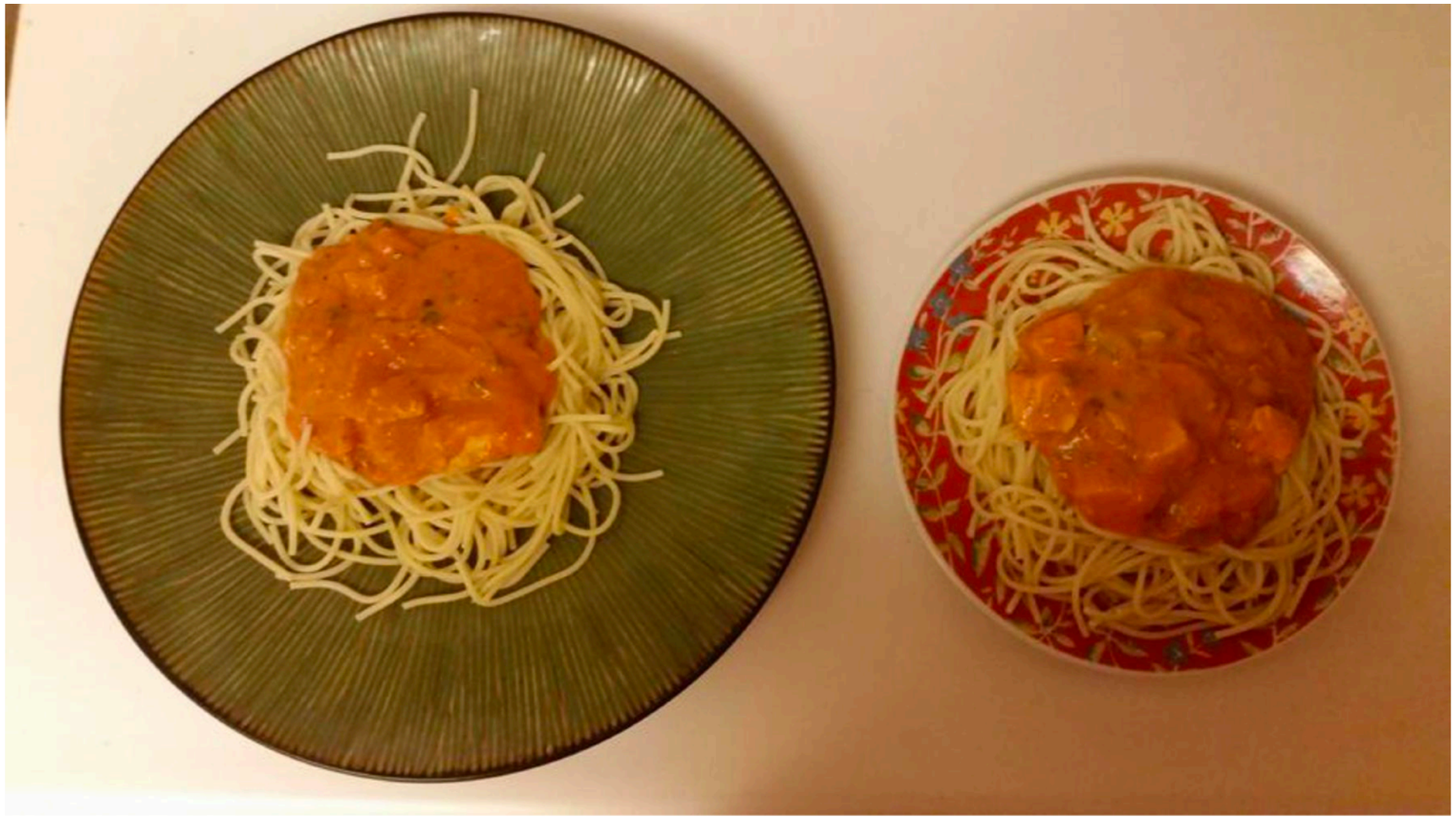
Poggendorff



Ebbinghaus



Ebbinghaus



Credit:
Unknown CMU IDeATe student

More Illusions

Color

Irradiation, Mach, Hermann, Simultaneous contrast

Length

Ponzo, Perspective, Müller-Lyer, Sander's parallelogram

Angles

Poggendorff, Zöllner, Ehrenstein

Size

Tichener/Ebbinghaus