

CS 571 - Data Visualization & Exploration

Perception and Cognition

Instructor: Hamza Elhamdadi



UMassAmherst

Upcoming Dates

Feb 6 (Next Class): Group Activity 1

Feb 4 (Today): Homework 0 Due

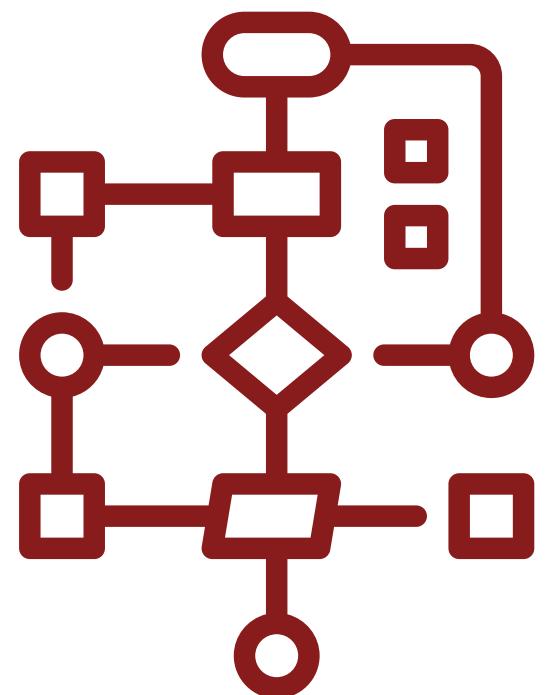
Feb 10: Quiz 1 Due (will be posted Feb 6)

Feb 13: Announce Your Project

Feb 14: Homework 1 Due (will be posted Feb 4)

From Data to Knowledge (with Visualization)

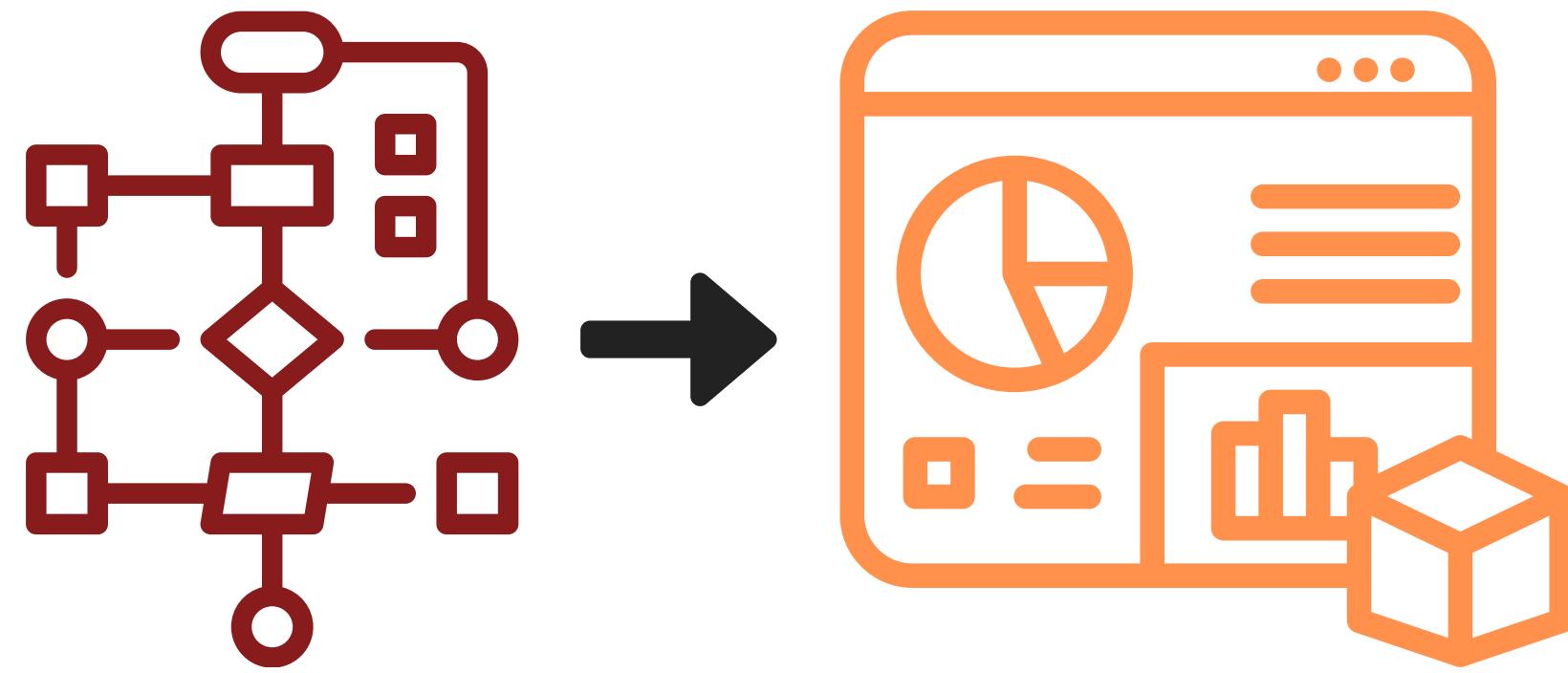
From Data to Knowledge (with Visualization)



Analysis

(Algorithms,
Stats, ML, etc)

From Data to Knowledge (with Visualization)



Analysis

(Algorithms,
Stats, ML, etc)

Visualization

From Data to Knowledge (with Visualization)

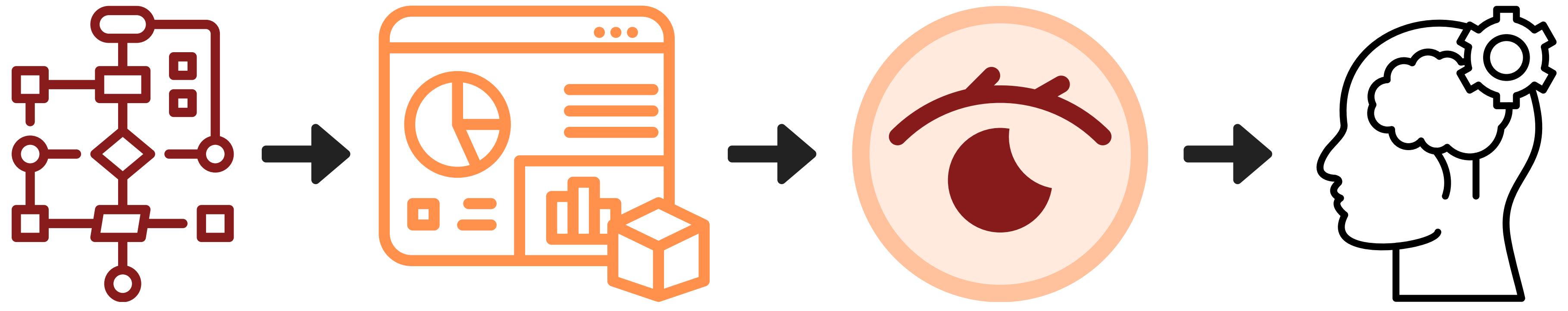


Analysis
(Algorithms,
Stats, ML, etc)

Visualization

Perception

From Data to Knowledge (with Visualization)



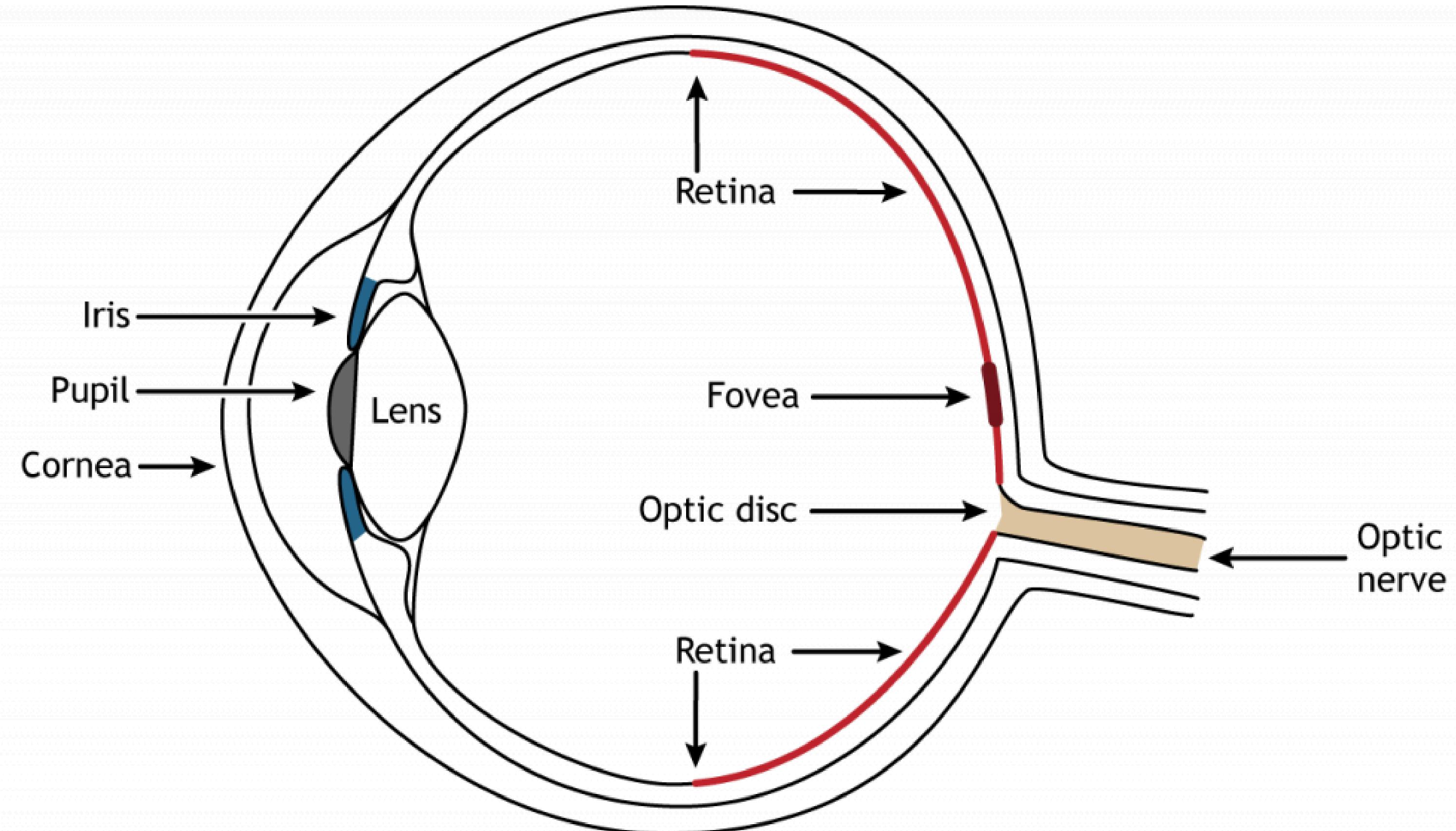
Analysis

(Algorithms,
Stats, ML, etc)

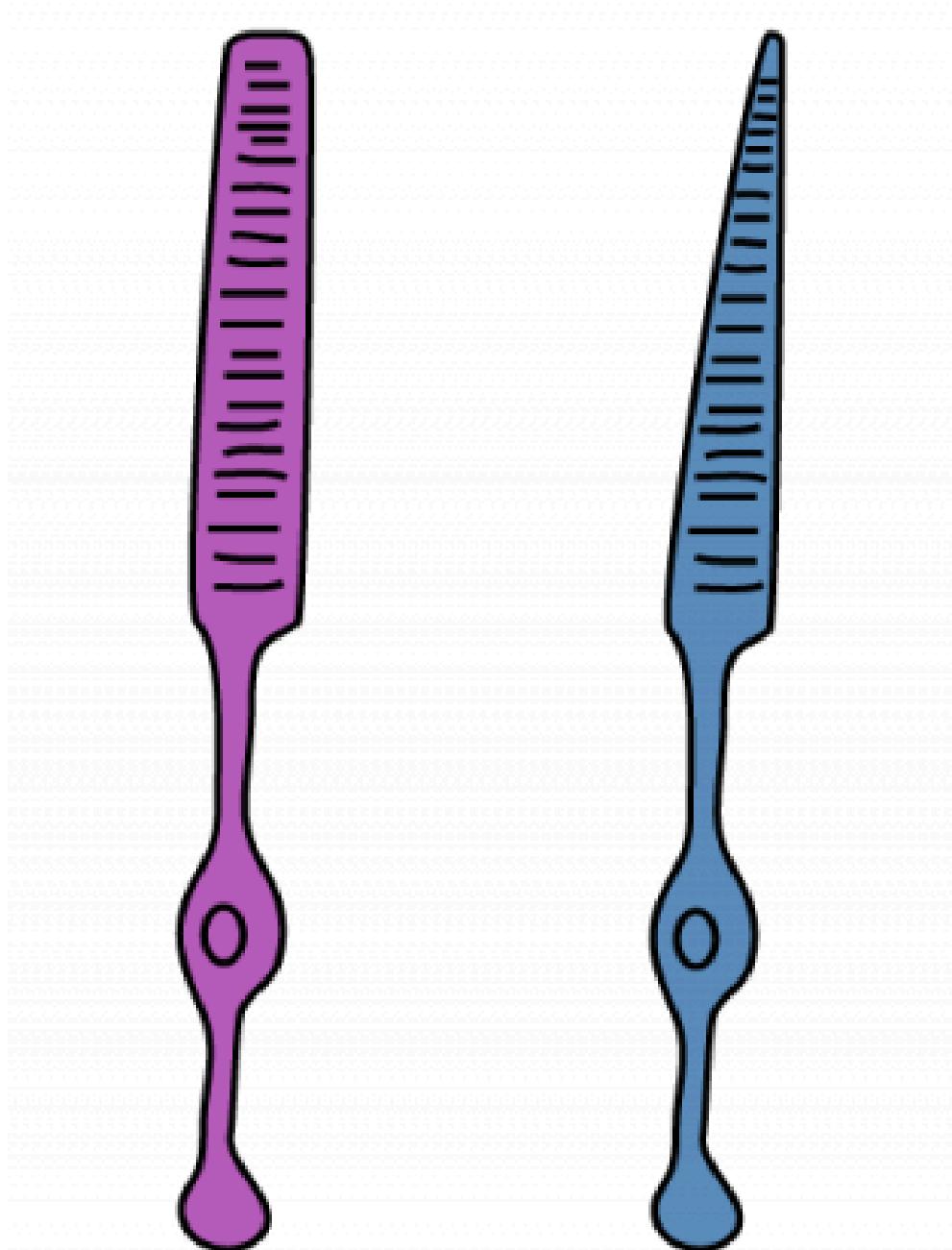
Visualization

Perception

Cognition

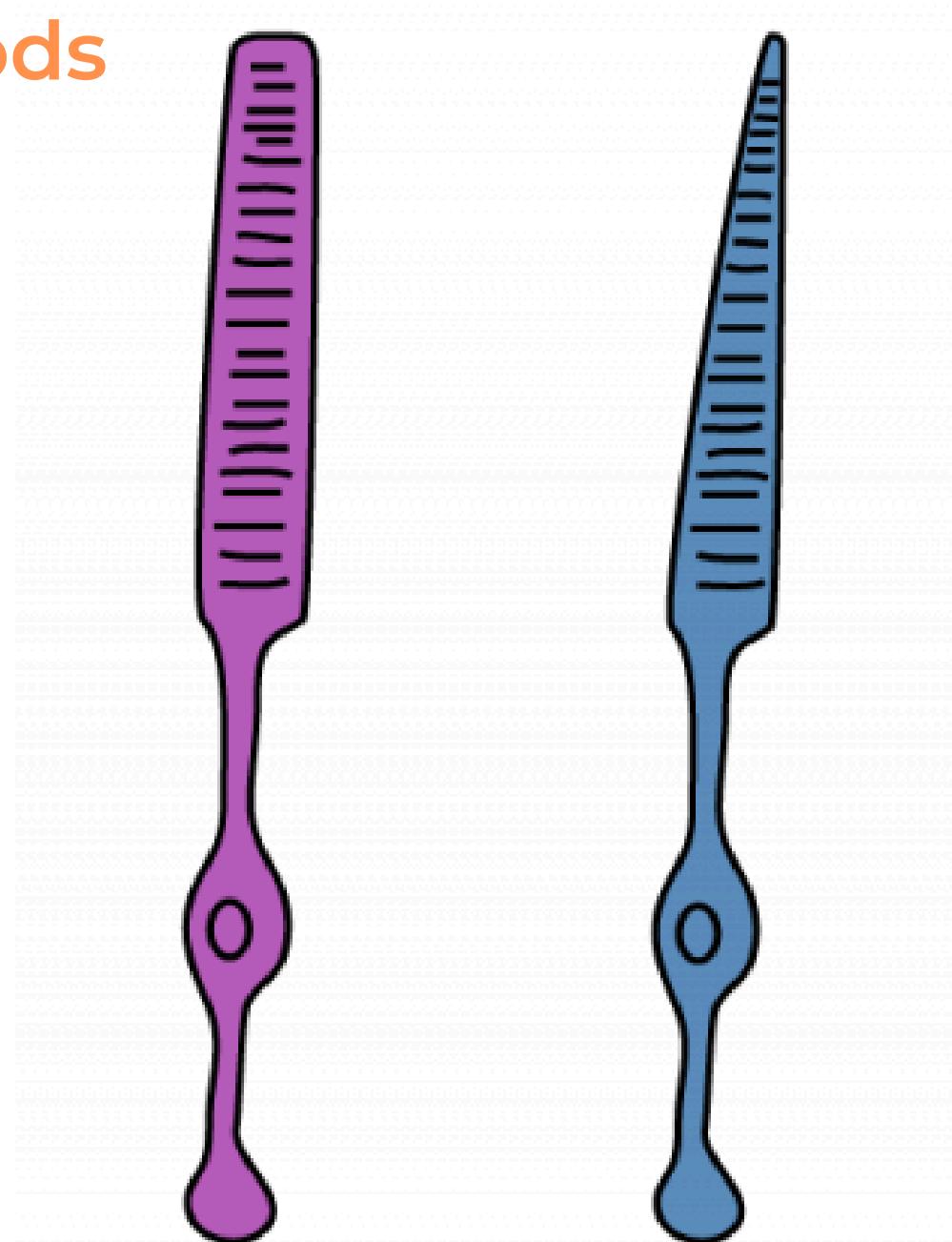


Source: Foundations of Neuroscience (Casey Henley)



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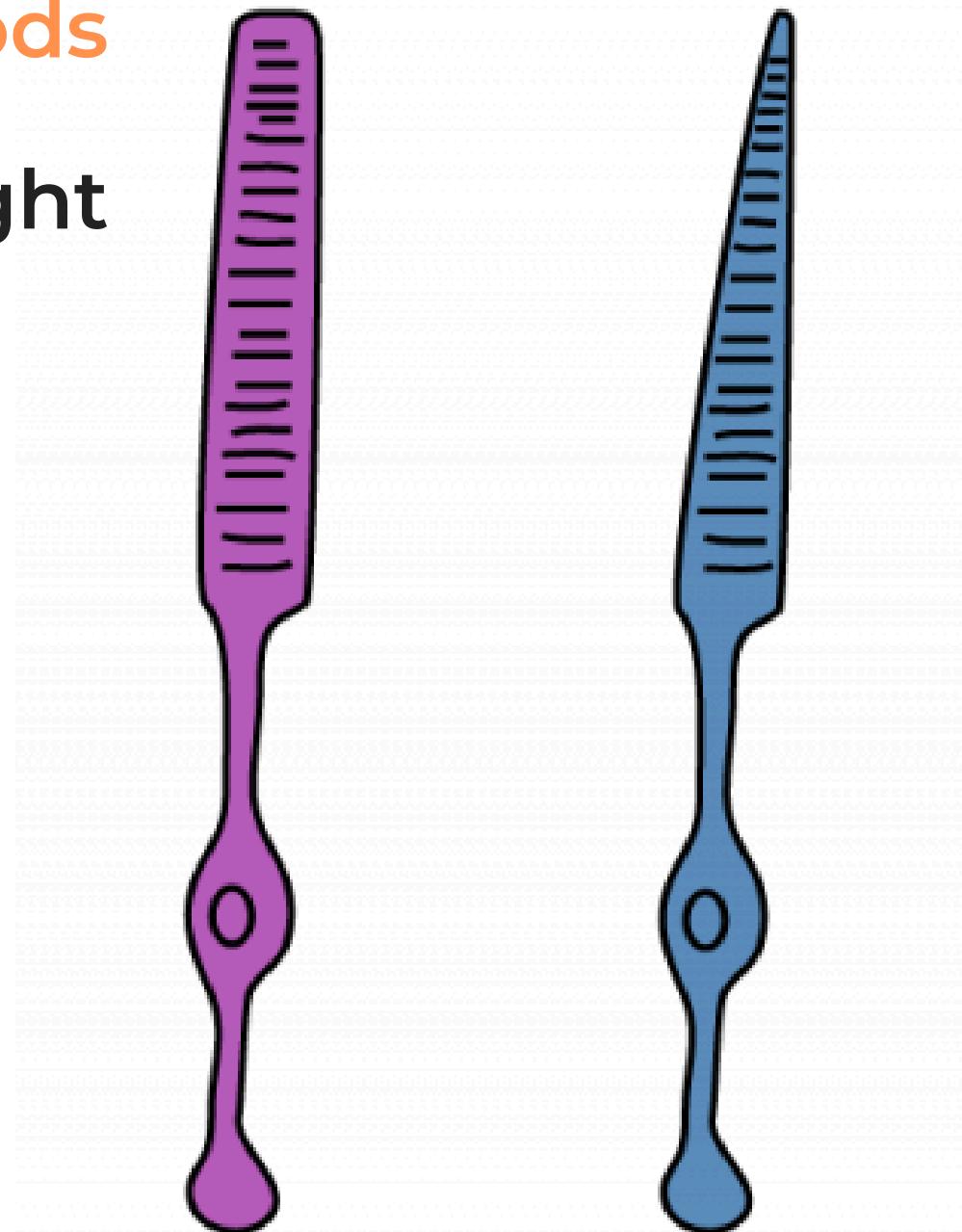
~120 million rods



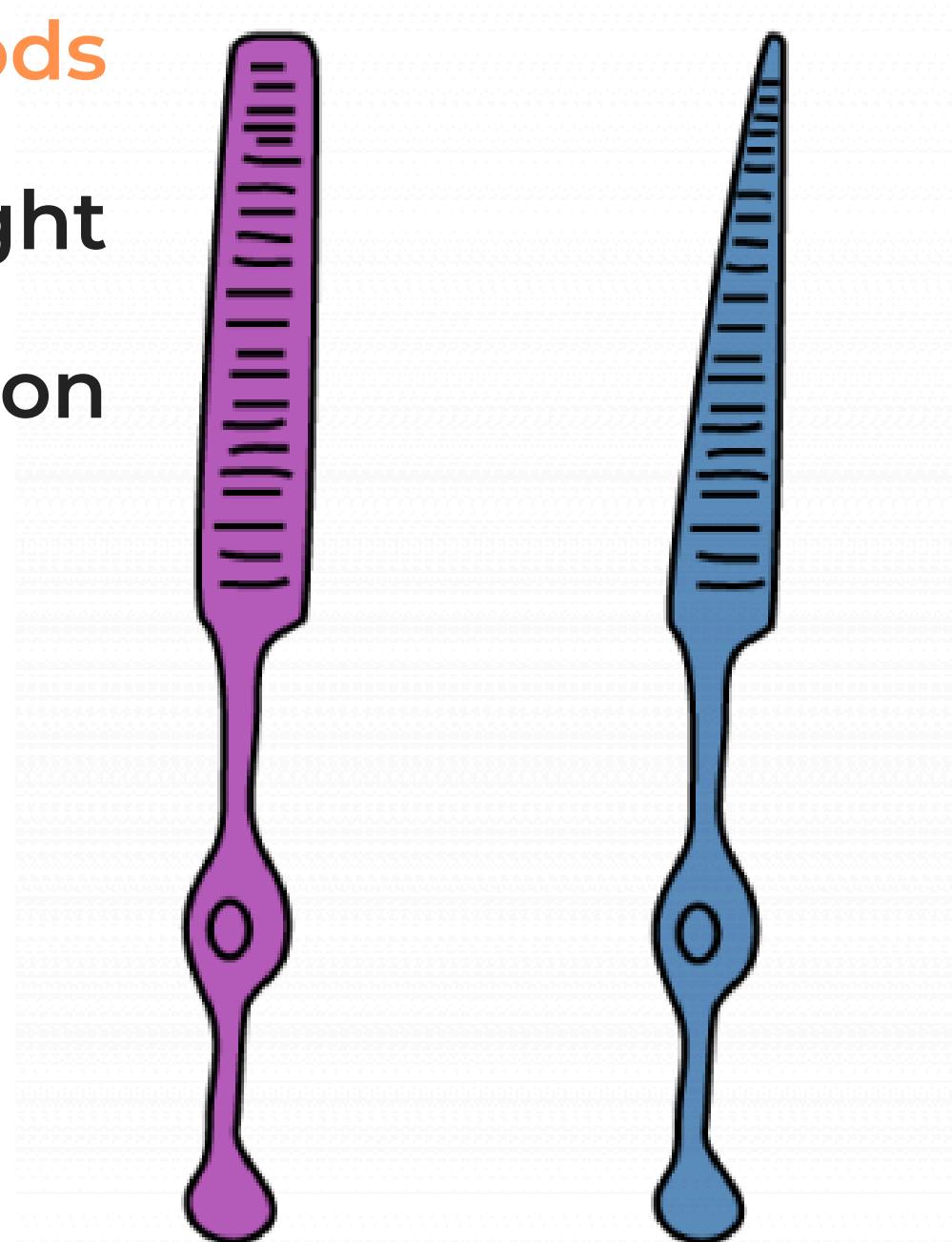
Source: Foundations of Neuroscience (Casey Henley)

~120 million rods

More sensitive to light



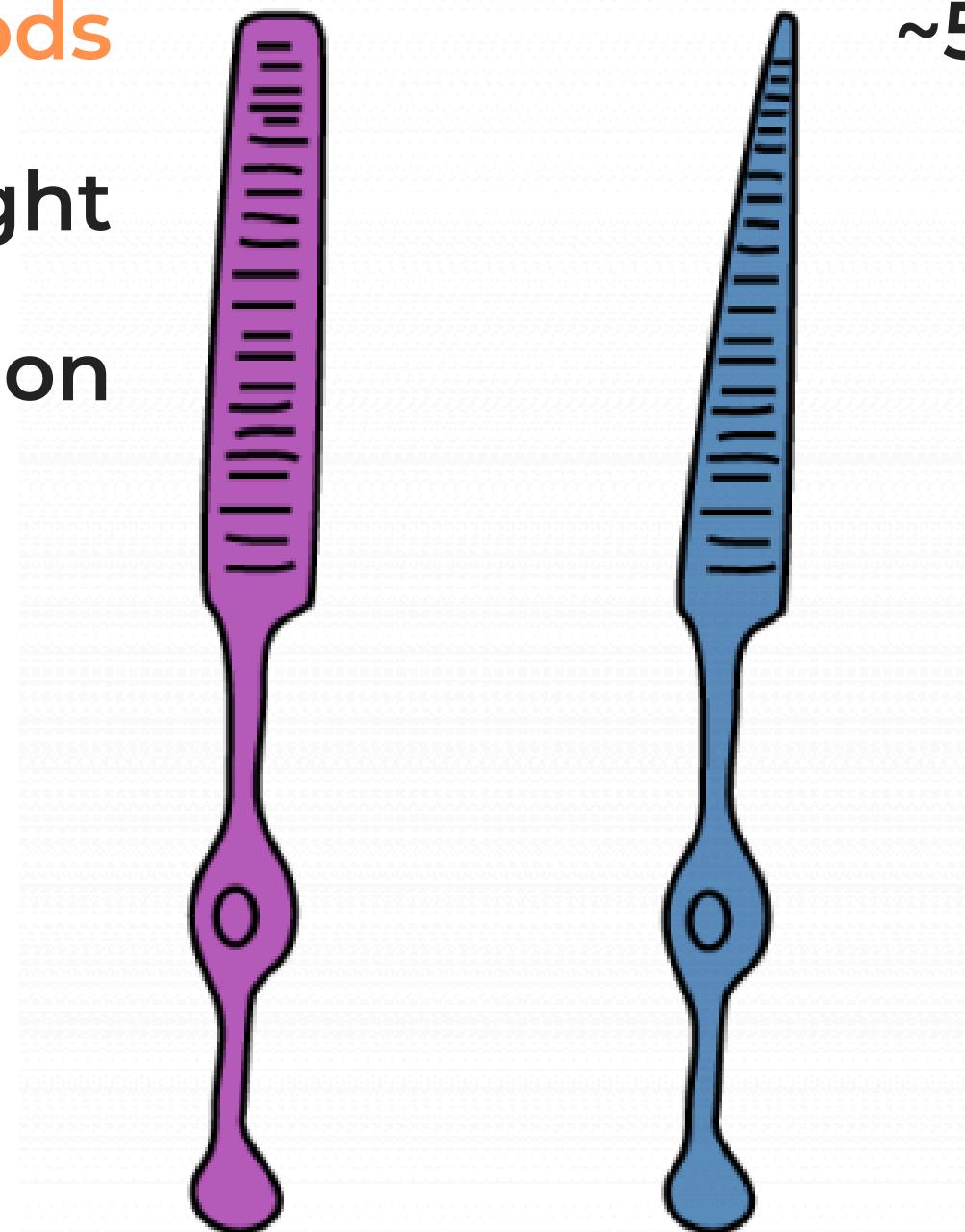
~120 million rods
More sensitive to light
Responsible for low-light vision



~120 million rods

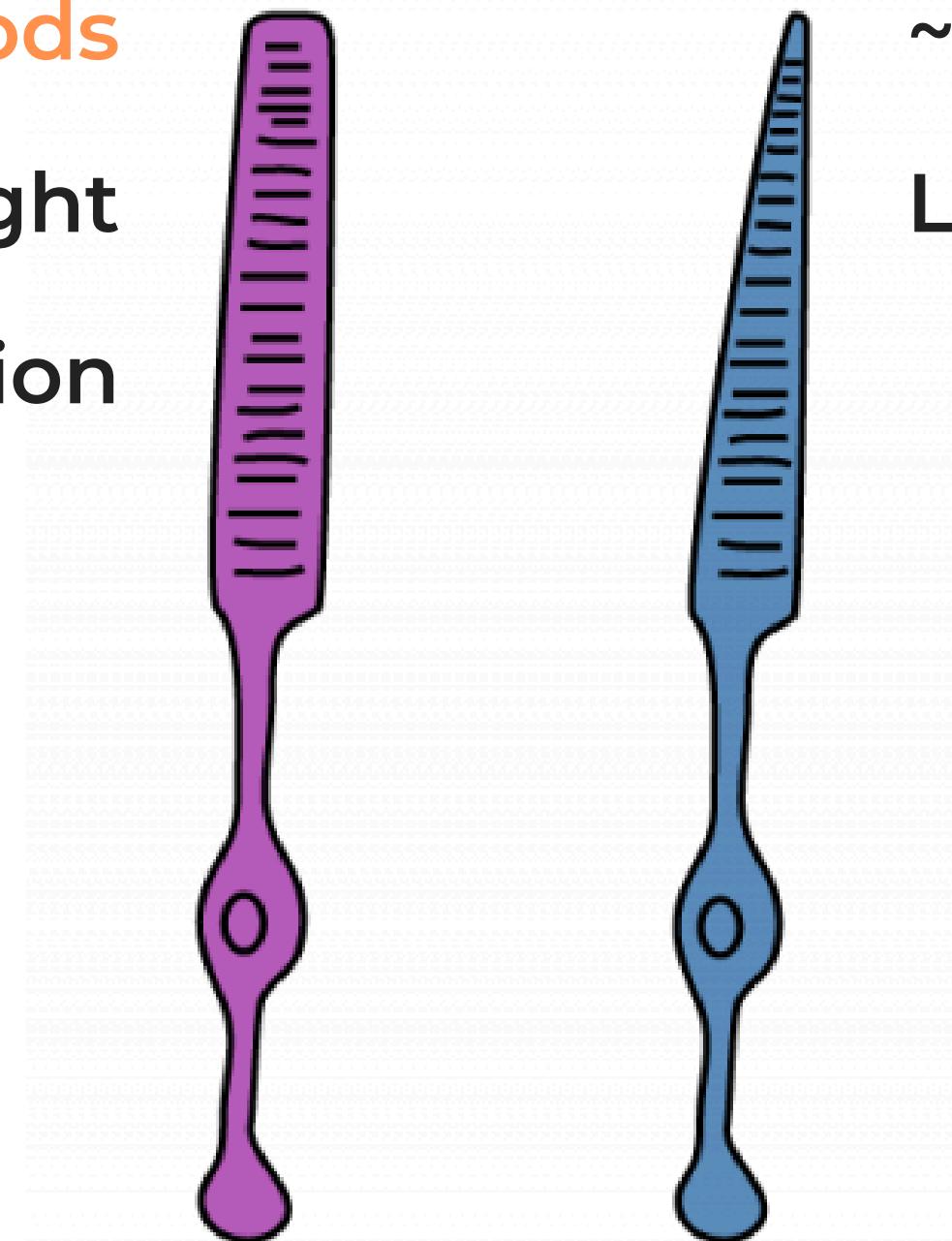
More sensitive to light

Responsible for low-light vision



~5-6 million cones

~120 million rods
More sensitive to light
Responsible for low-light vision

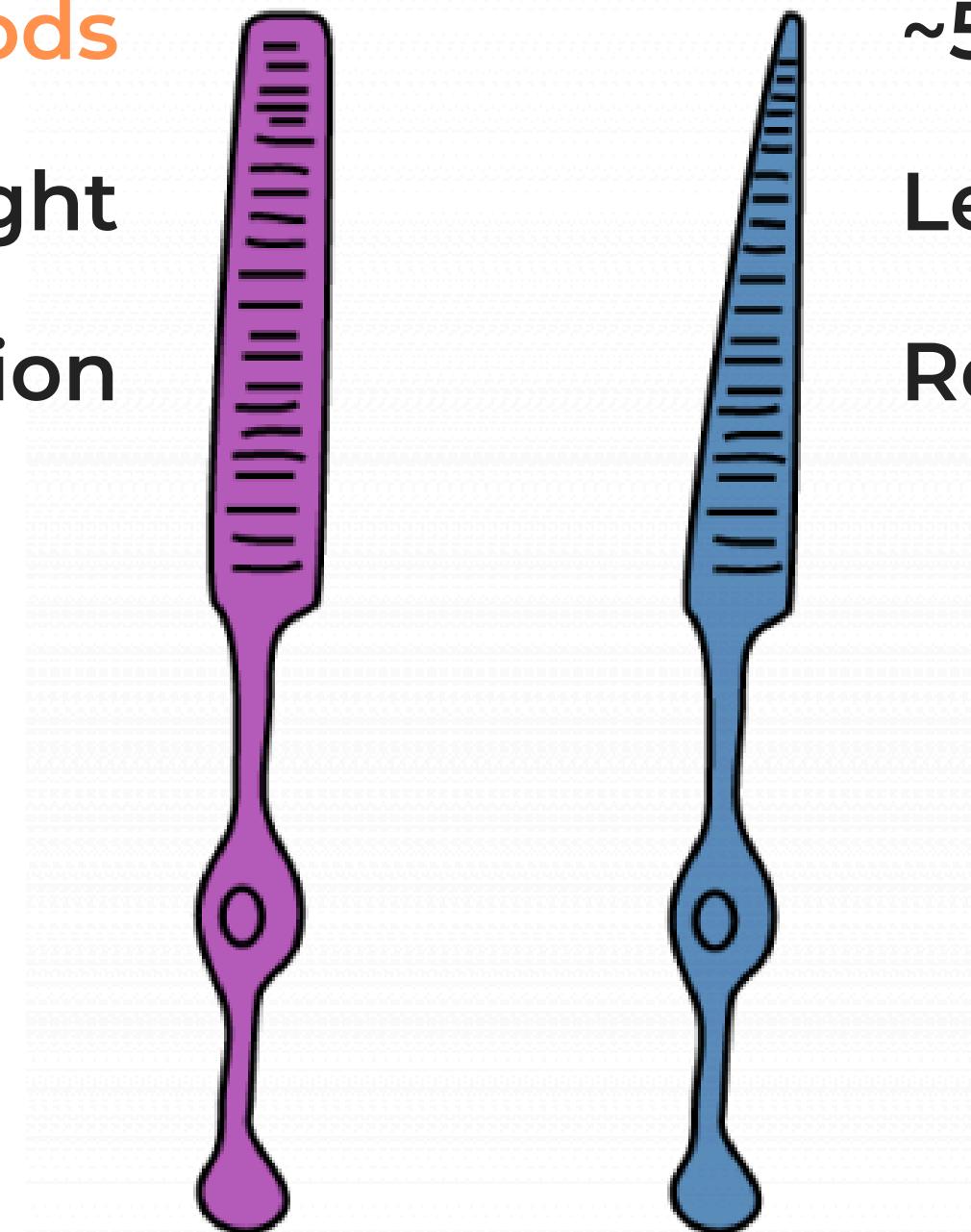


~5-6 million cones
Less sensitive to light

~120 million rods

More sensitive to light

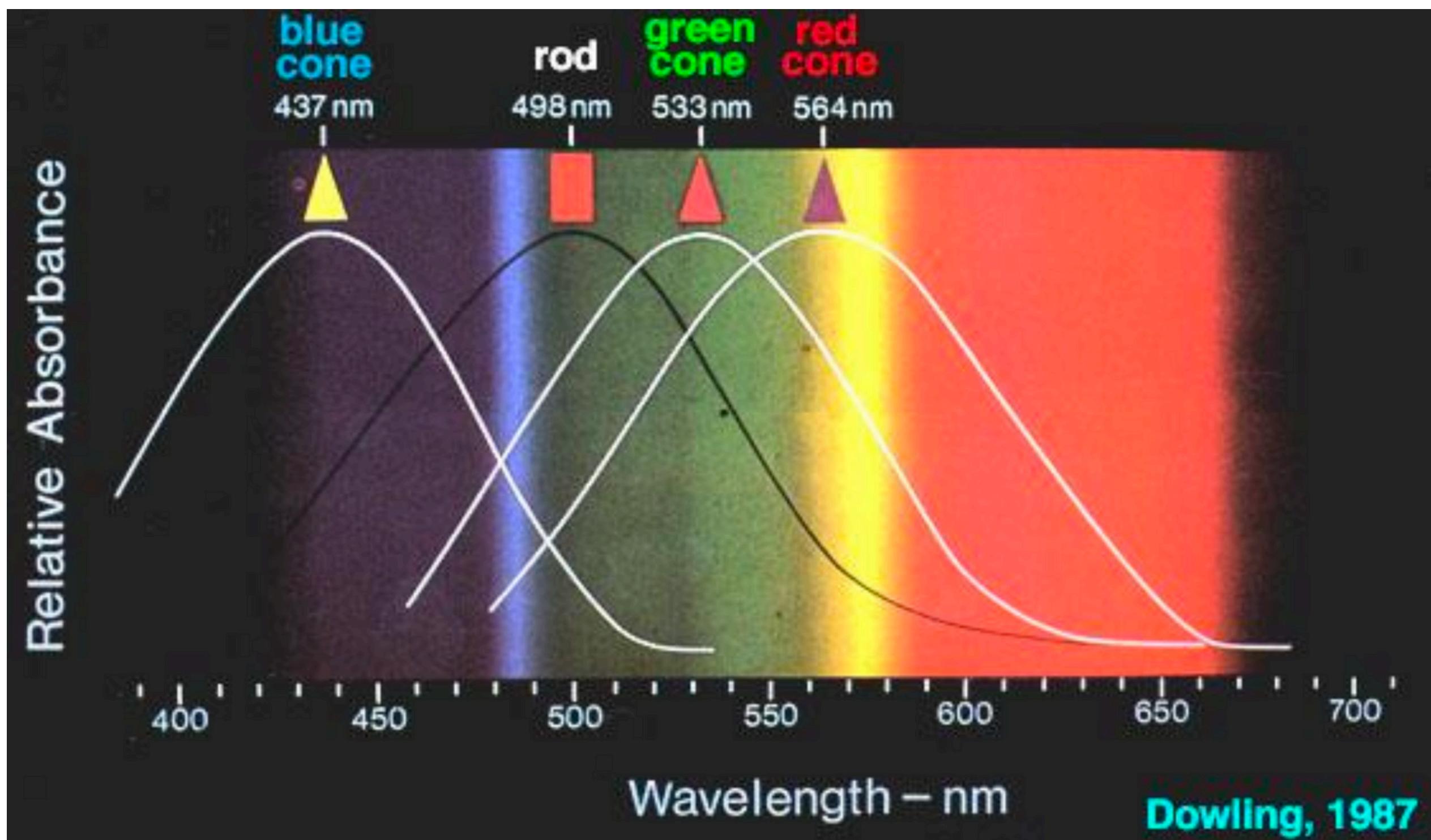
Responsible for low-light vision

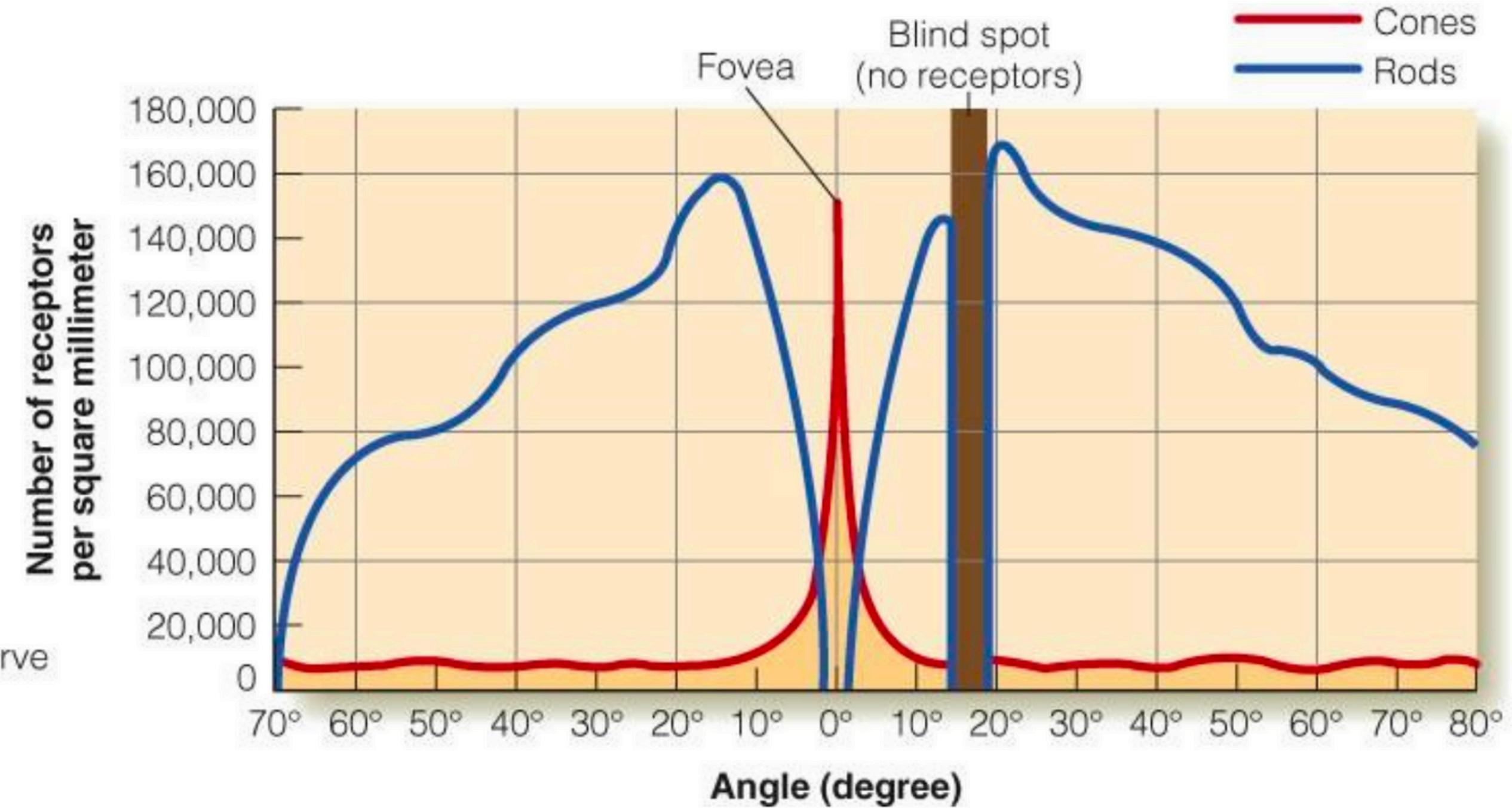
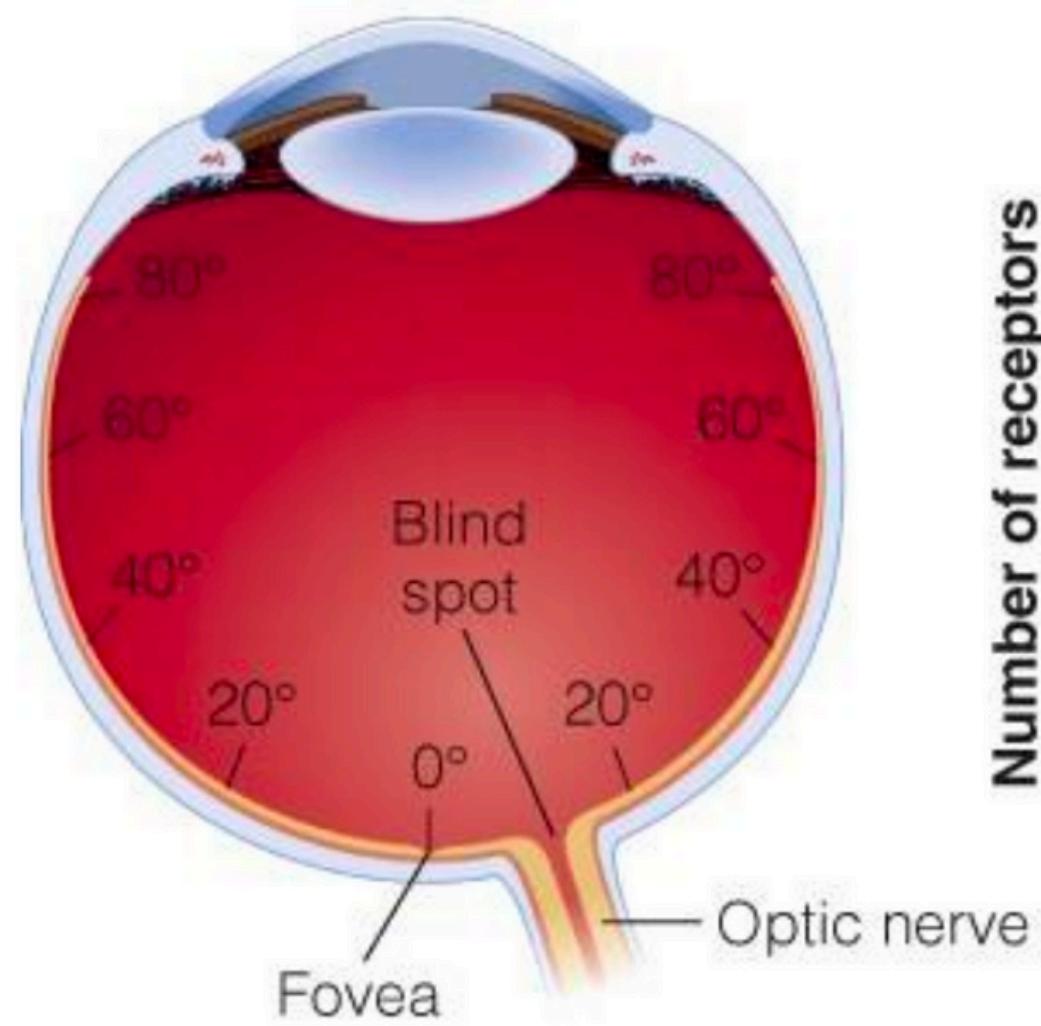


~5-6 million cones

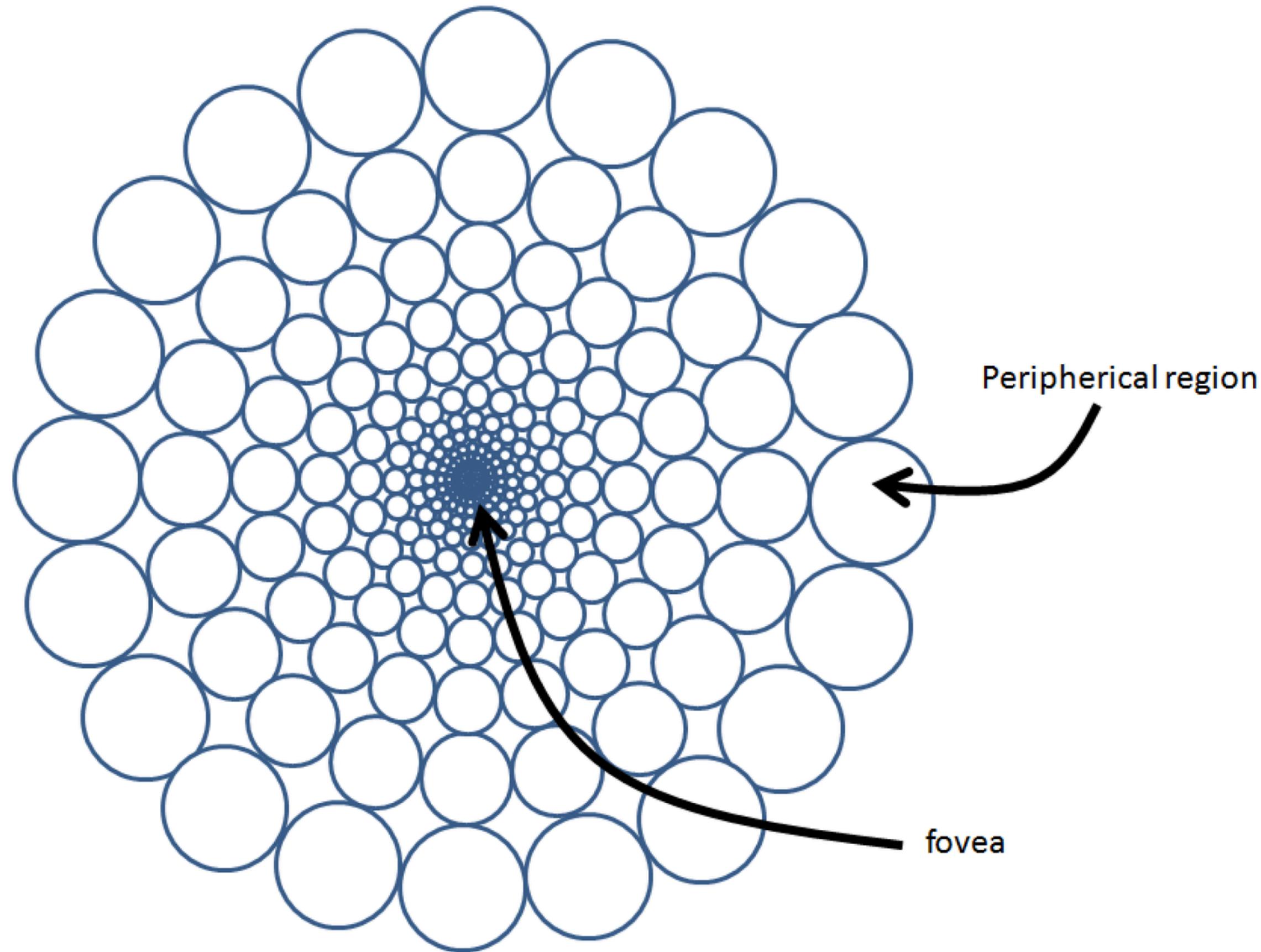
Less sensitive to light

Responsible for color vision



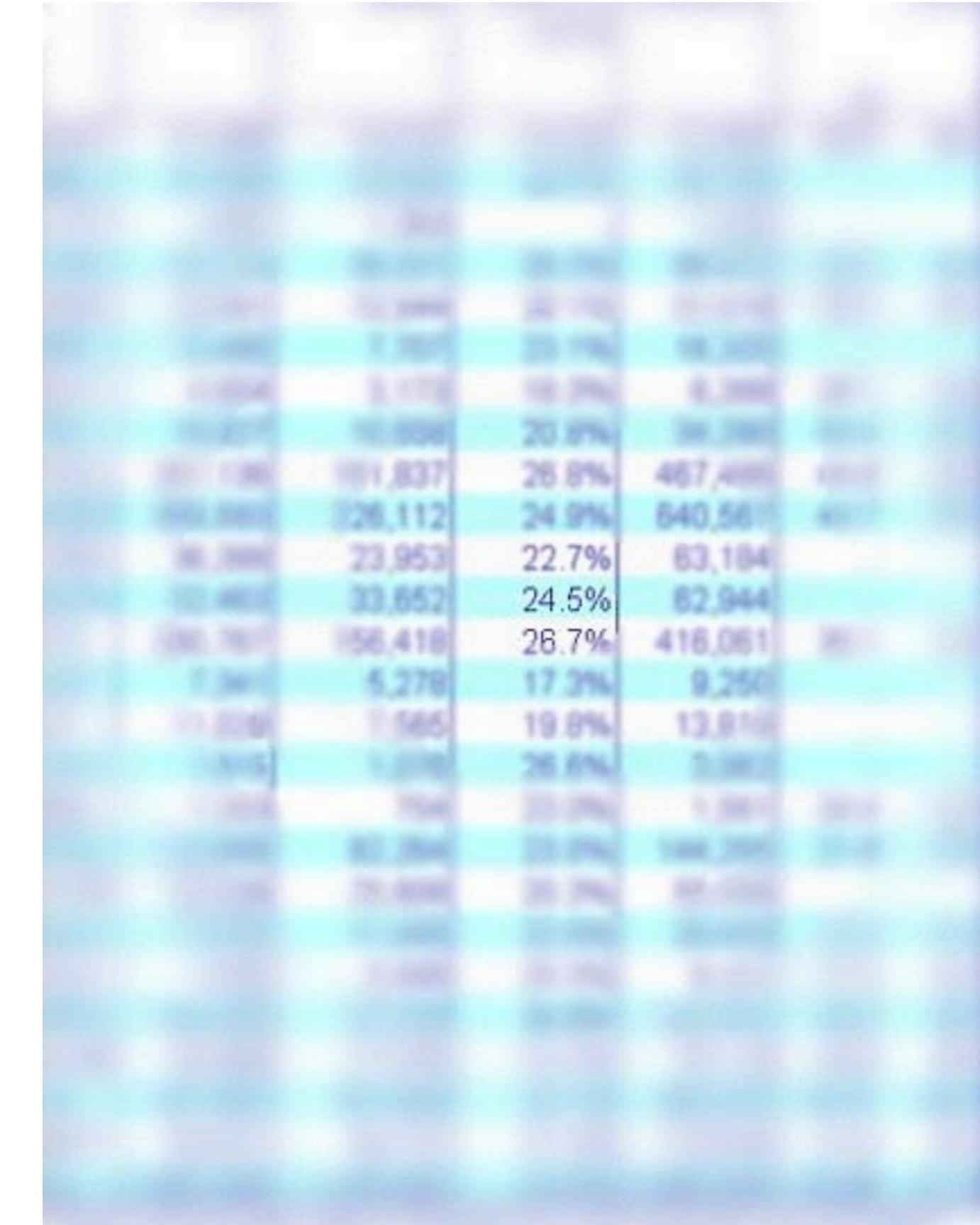


Source: E.B. Goldstein "Sensation and Perception"



Source: González et. al. 2016 (adapted from C. Ware 2008)

Foveation is relatively easy to see. The key to recognizing the phenomenon is to stare at a single **word** on the printed page. Then, without moving your gaze, notice the blurriness of the surrounding text.



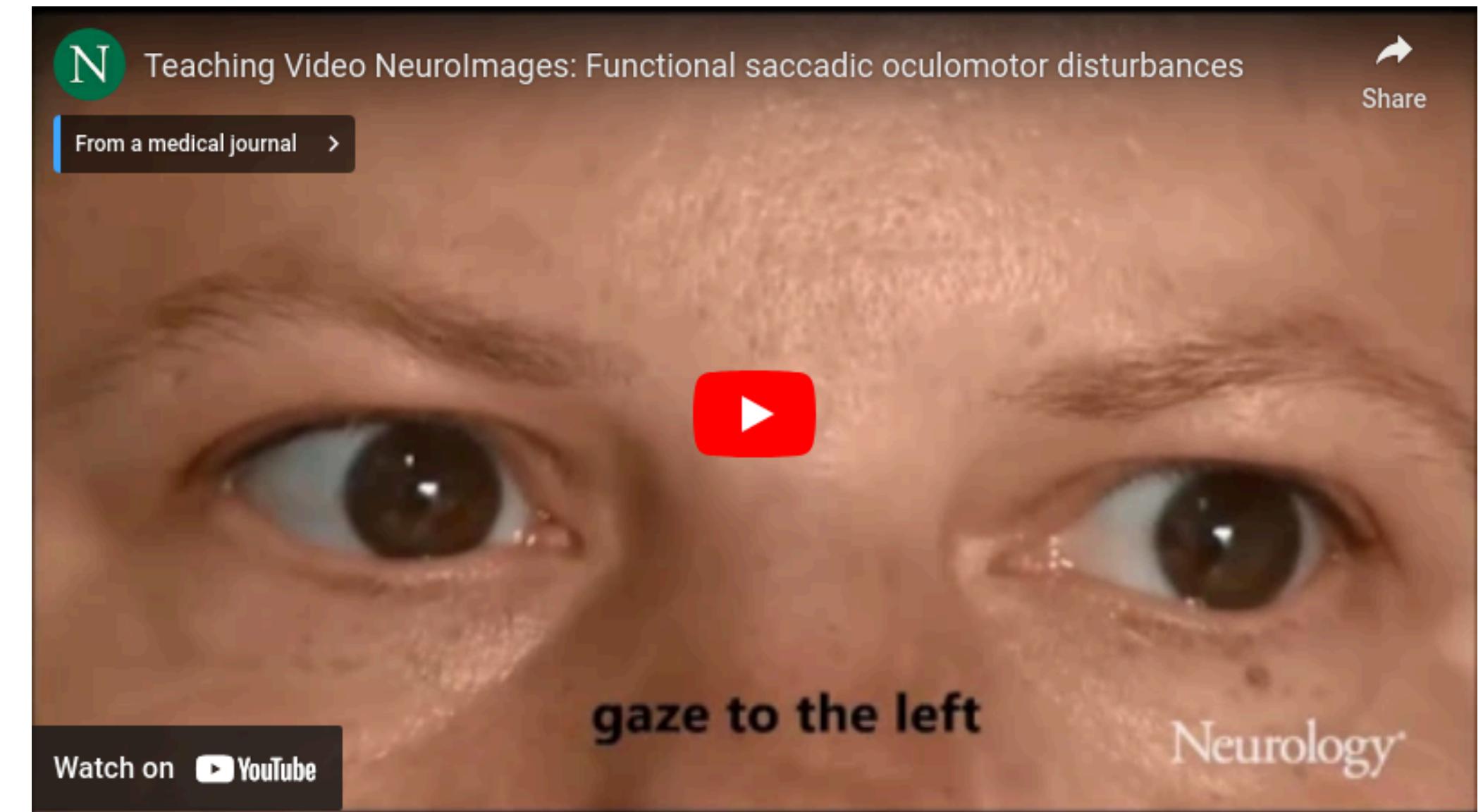
Source: C. Ware “Visual Thinking for Design”

Saccades (Saccadic Eye Movements)

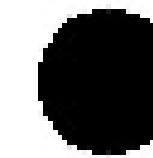
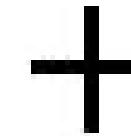
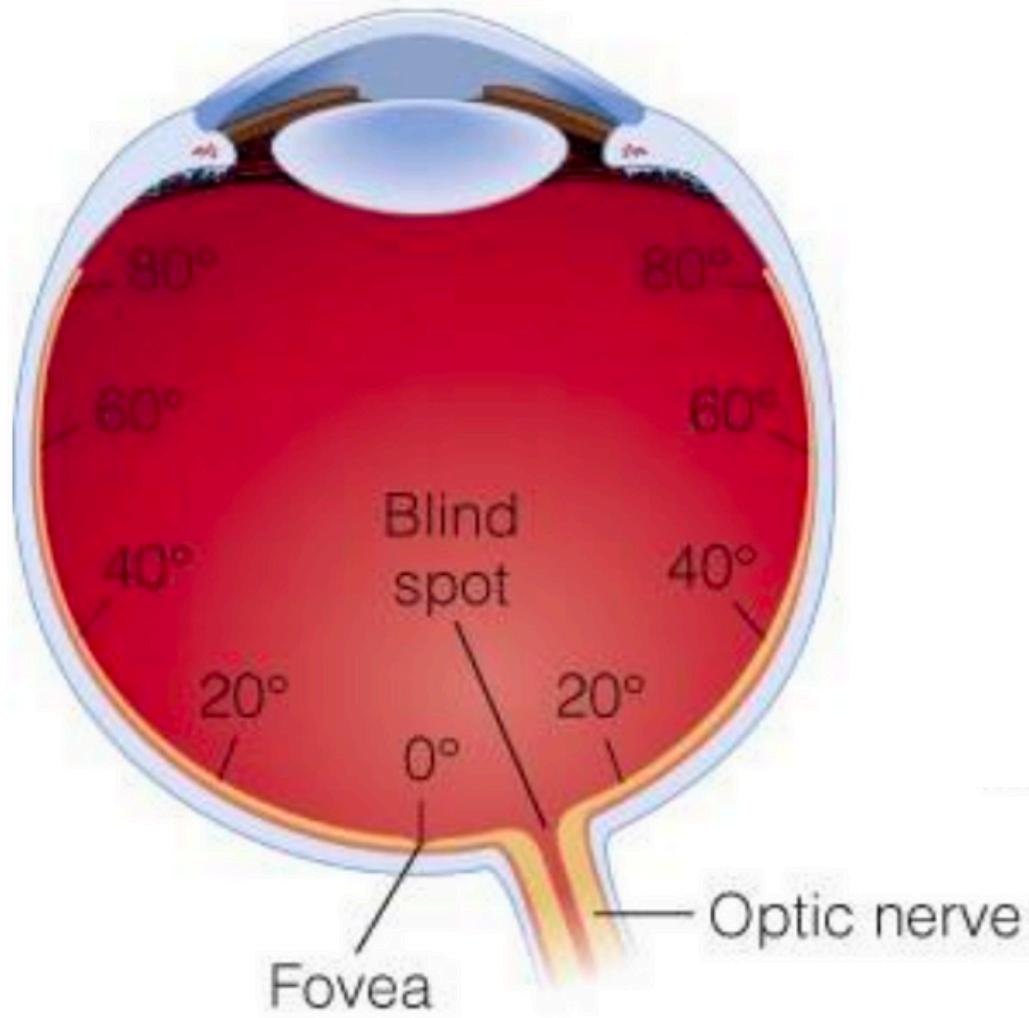
Rapid, involuntary
eye movements

Moving: 20-100ms

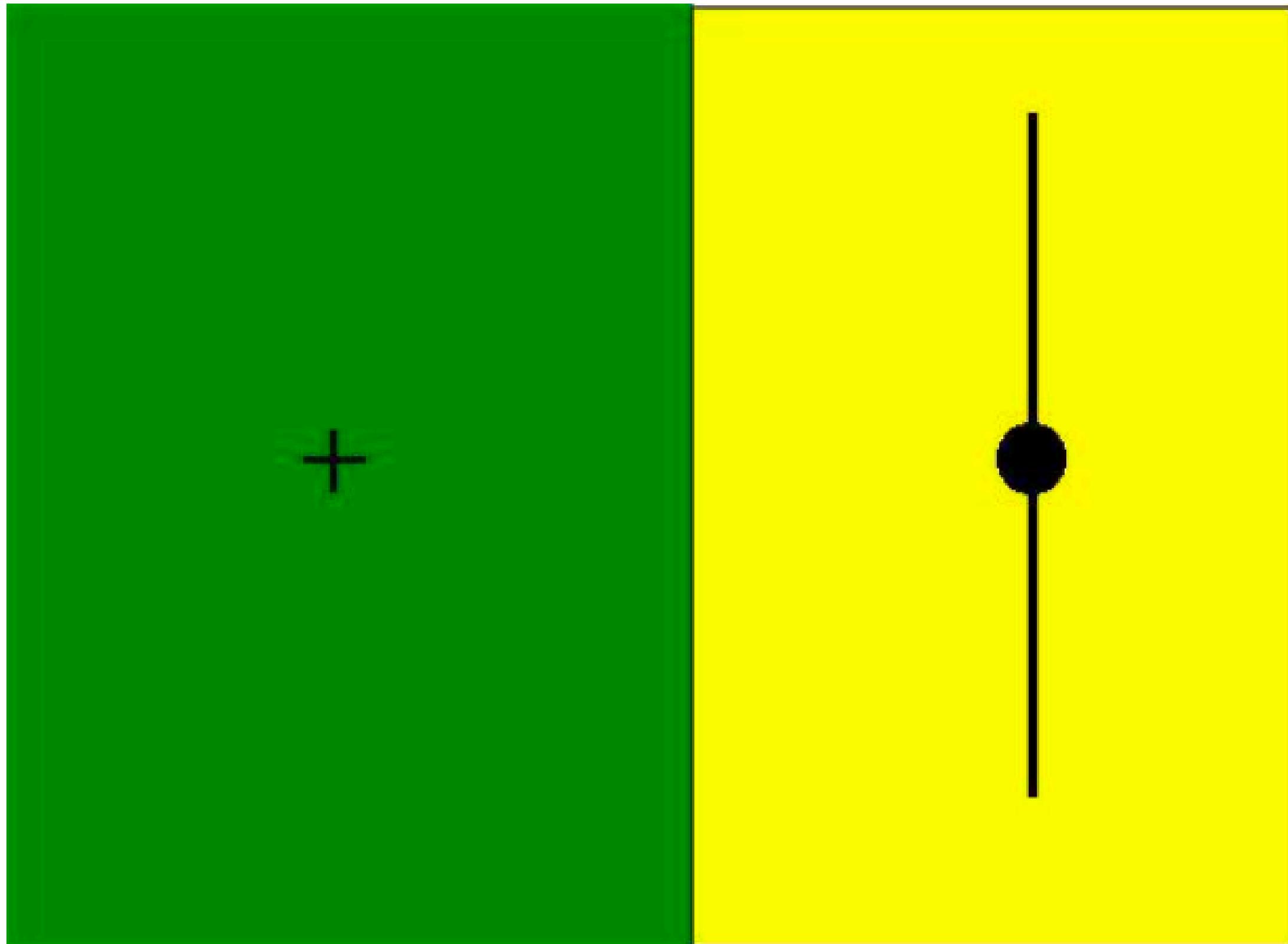
Fixations: 200-600ms

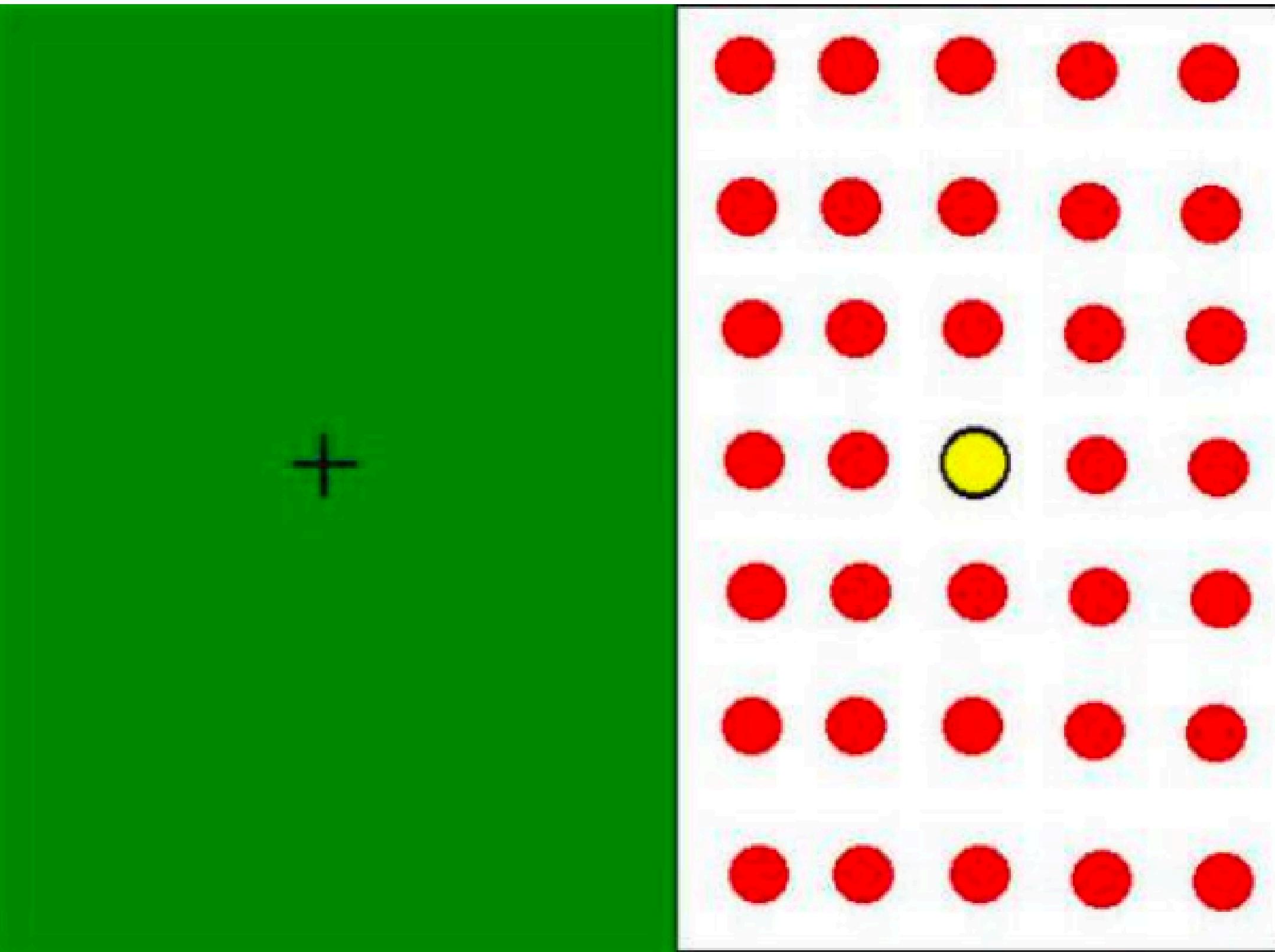


Blind Spot



- Close your **left** eye
- Stare at the crosshairs
- Move forward and backward until the dot disappears



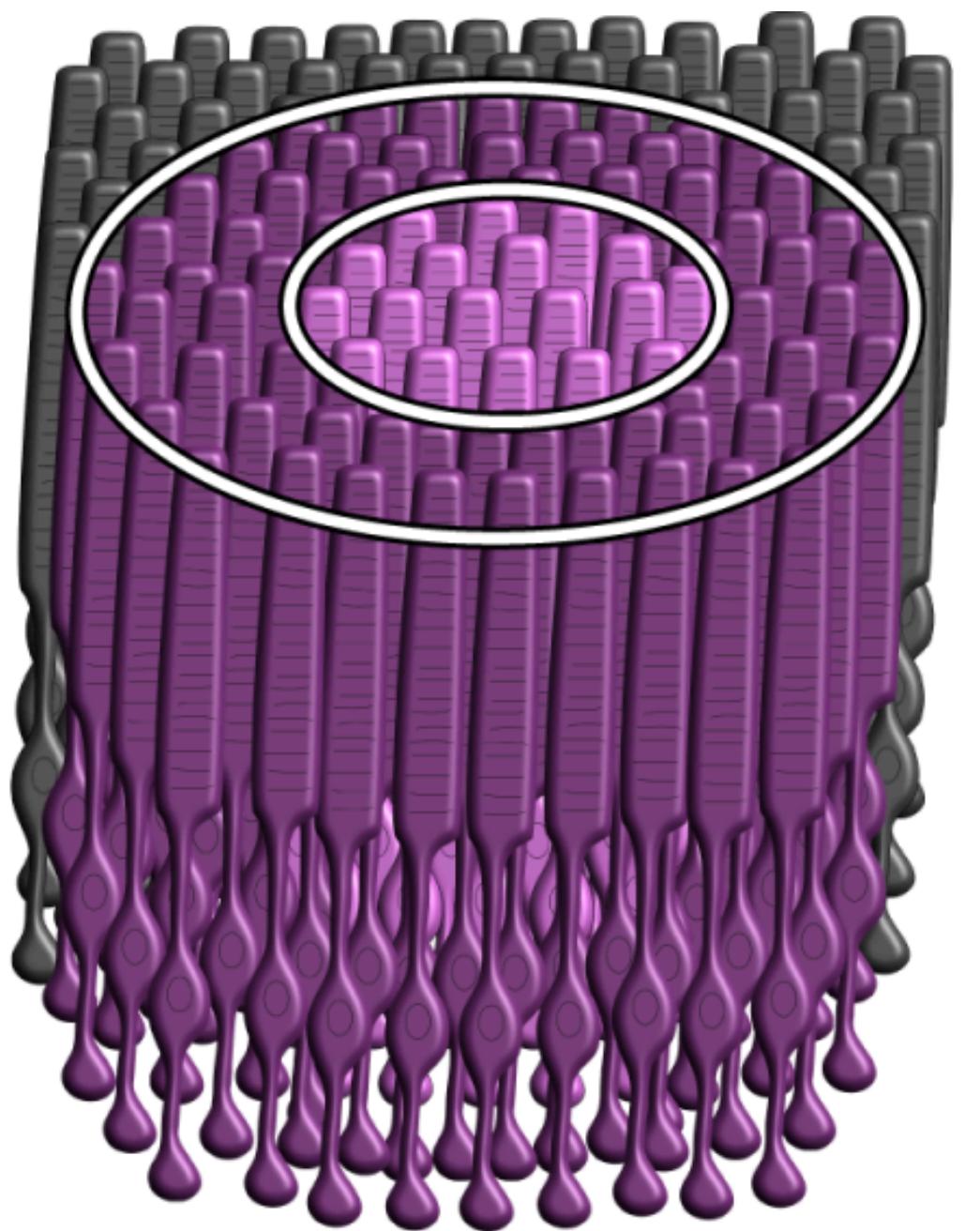


Our vision at any given moment is relatively limited.
Our brain “fills in the missing pieces” using a variety of evolved tools.

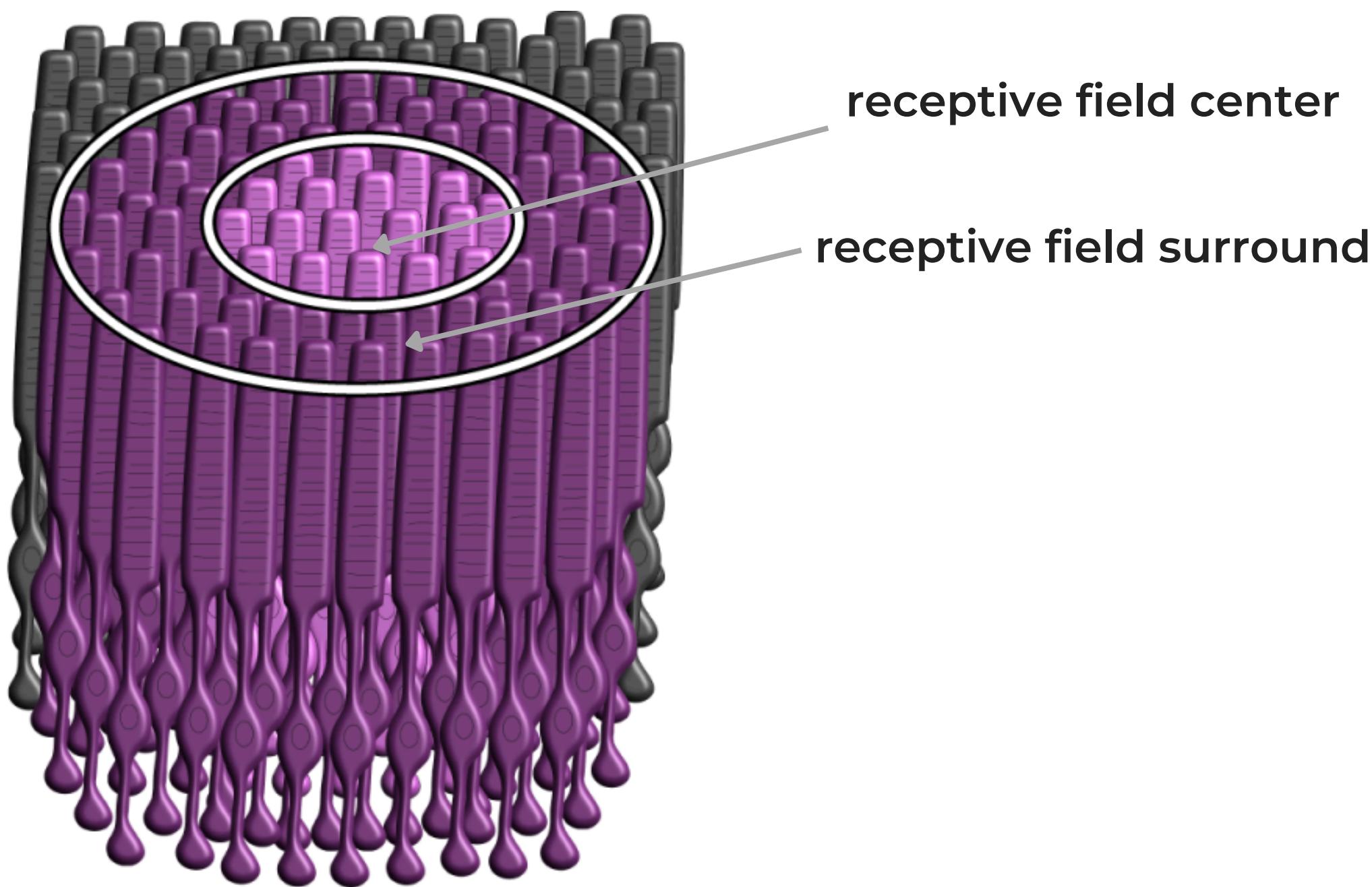
**Be careful placing too much data on the screen.
Crisp and clear visualizations will result in the best interpretation.**

Optical Illusions

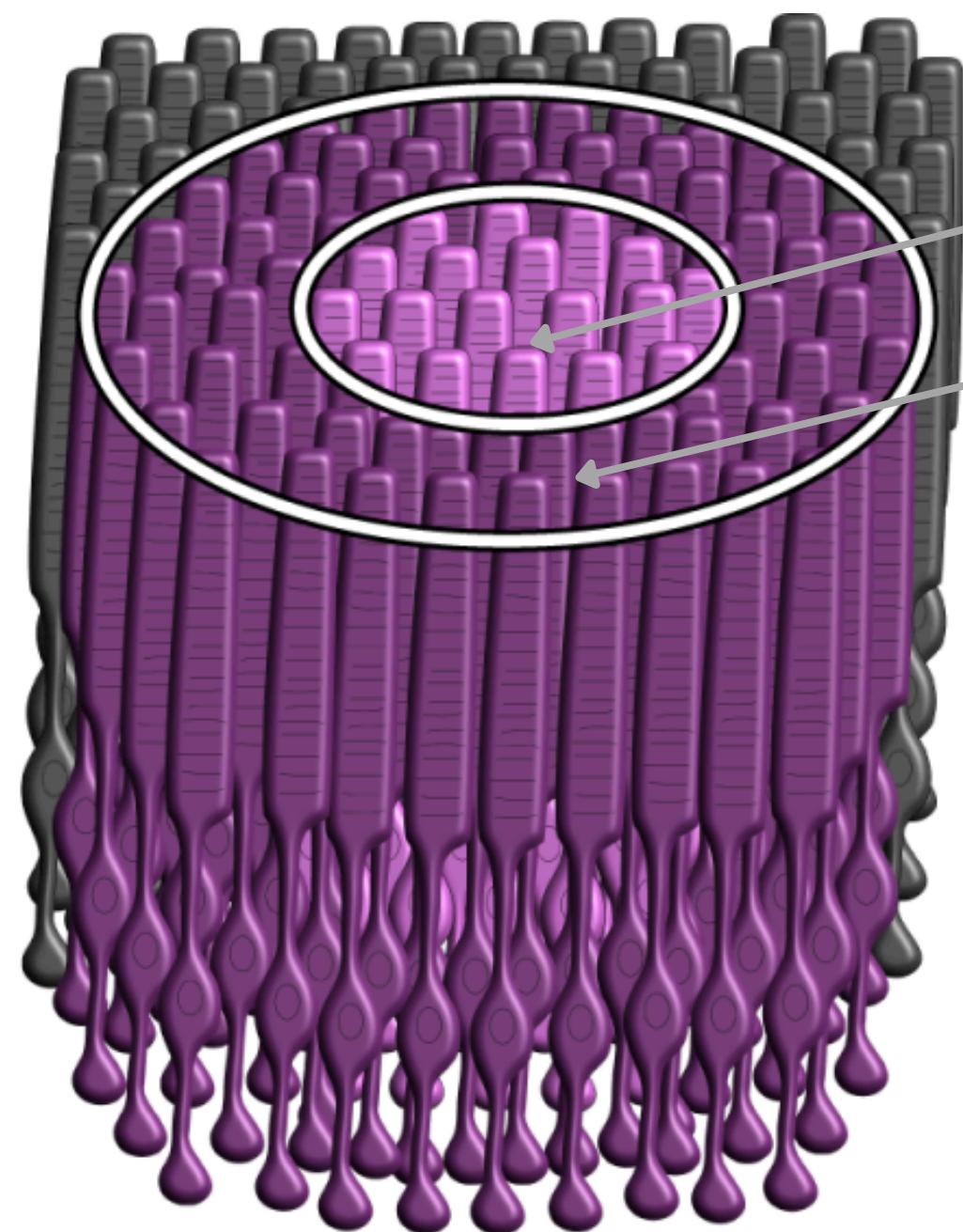
Edge Detection



Edge Detection

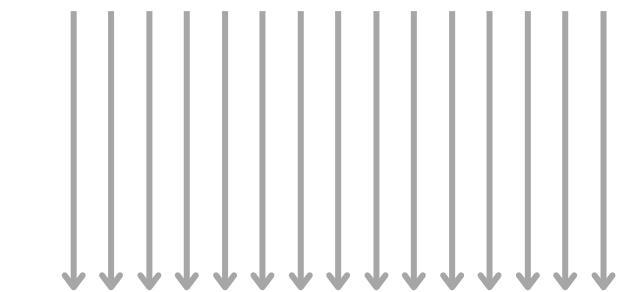


Edge Detection

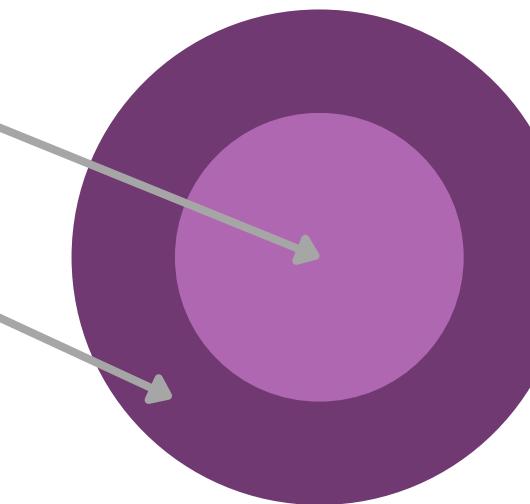


receptive field center

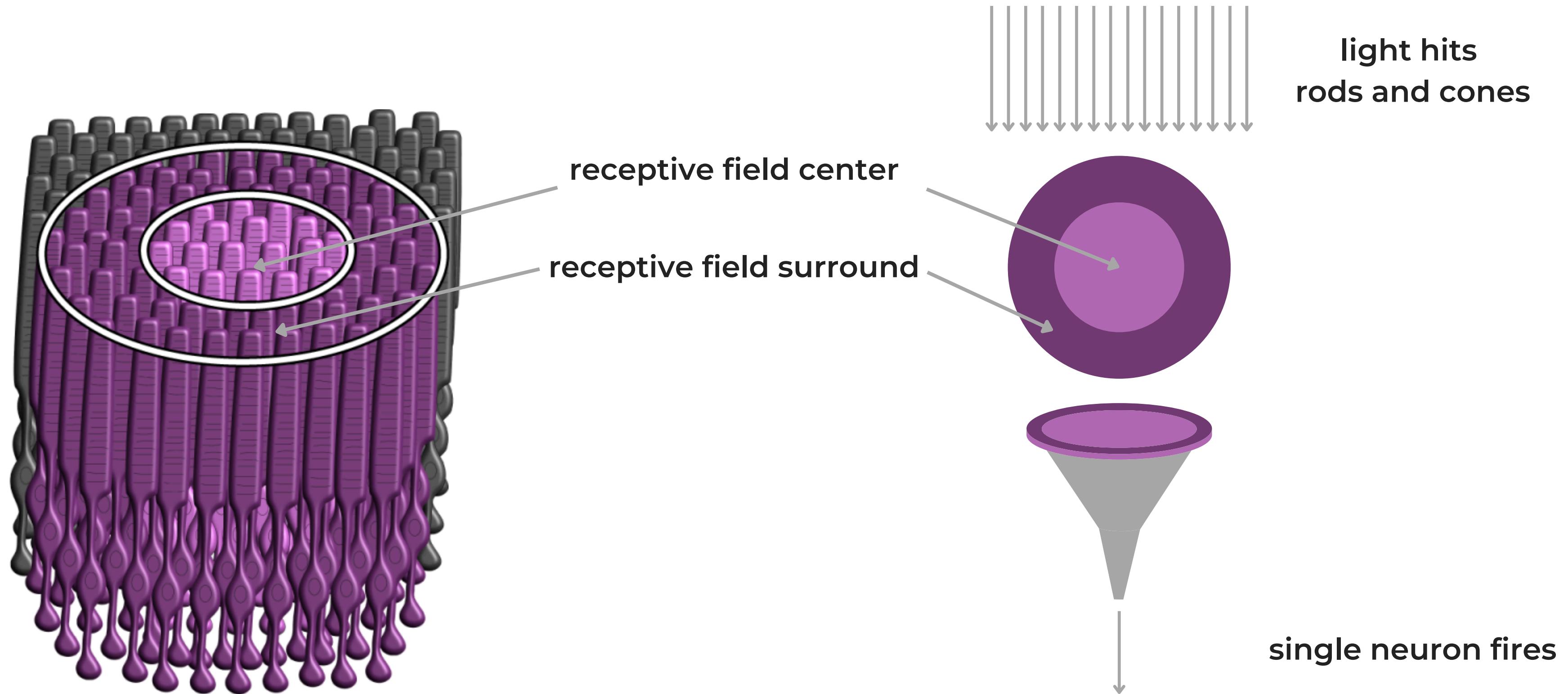
receptive field surround



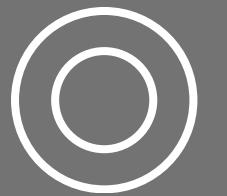
light hits
rods and cones



Edge Detection

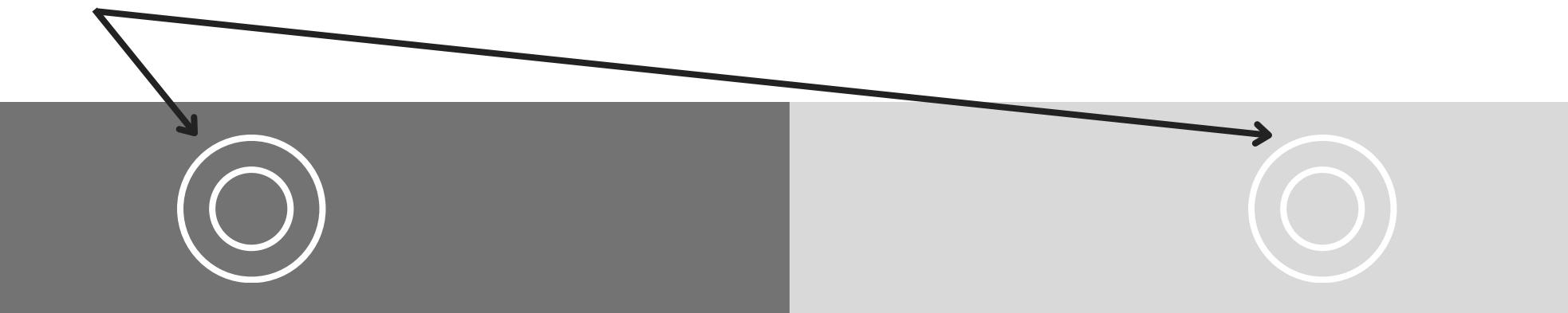






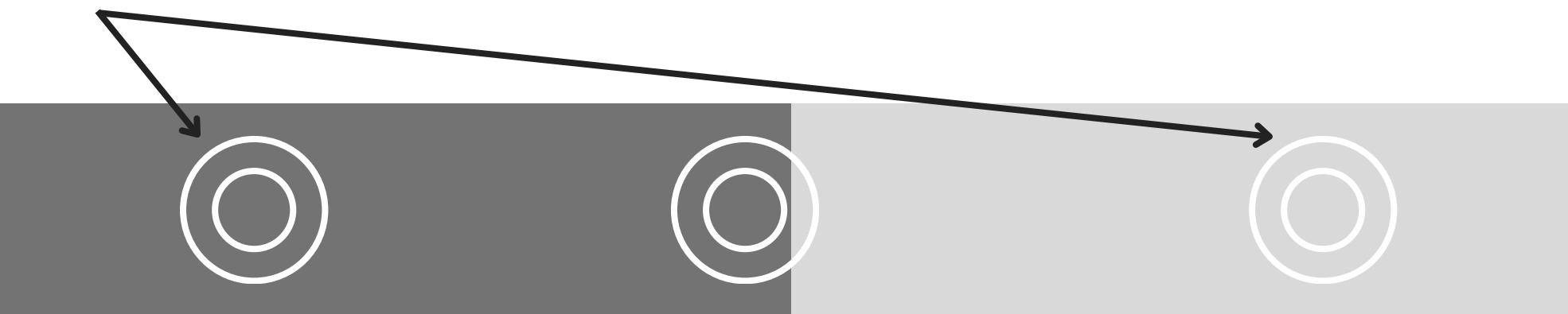
low activity

center and surrounds cancel



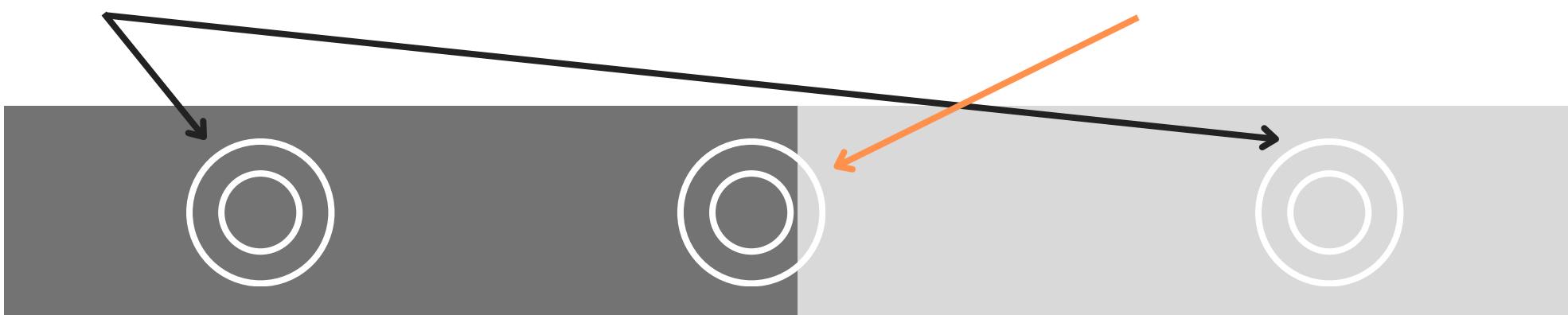
low activity

center and surrounds cancel



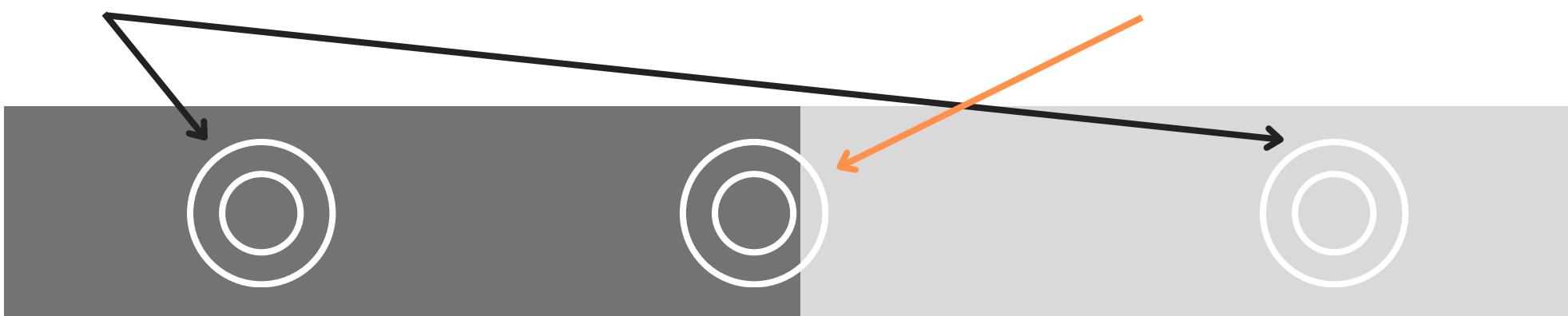
low activity
center and surrounds cancel

**activity increased
(or decreased) at edges**



low activity
center and surrounds cancel

**activity increased
(or decreased) at edges**

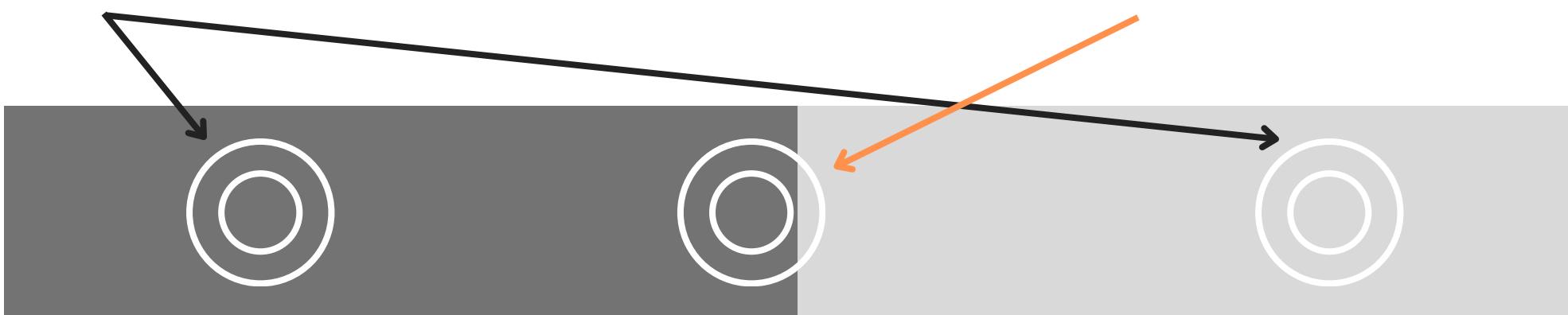


Luminance (L)

dL / dx

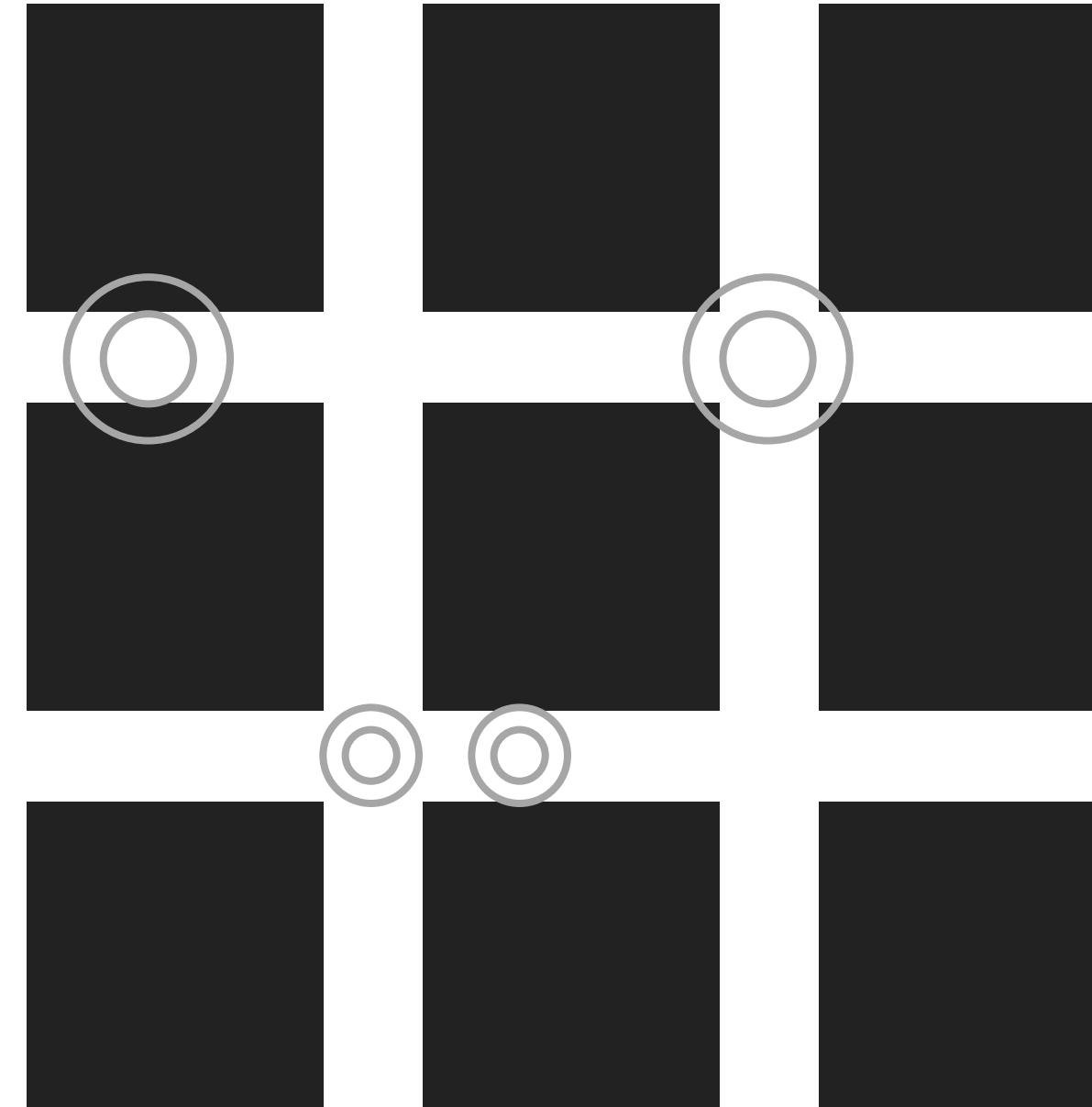
low activity
center and surrounds cancel

**activity increased
(or decreased) at edges**

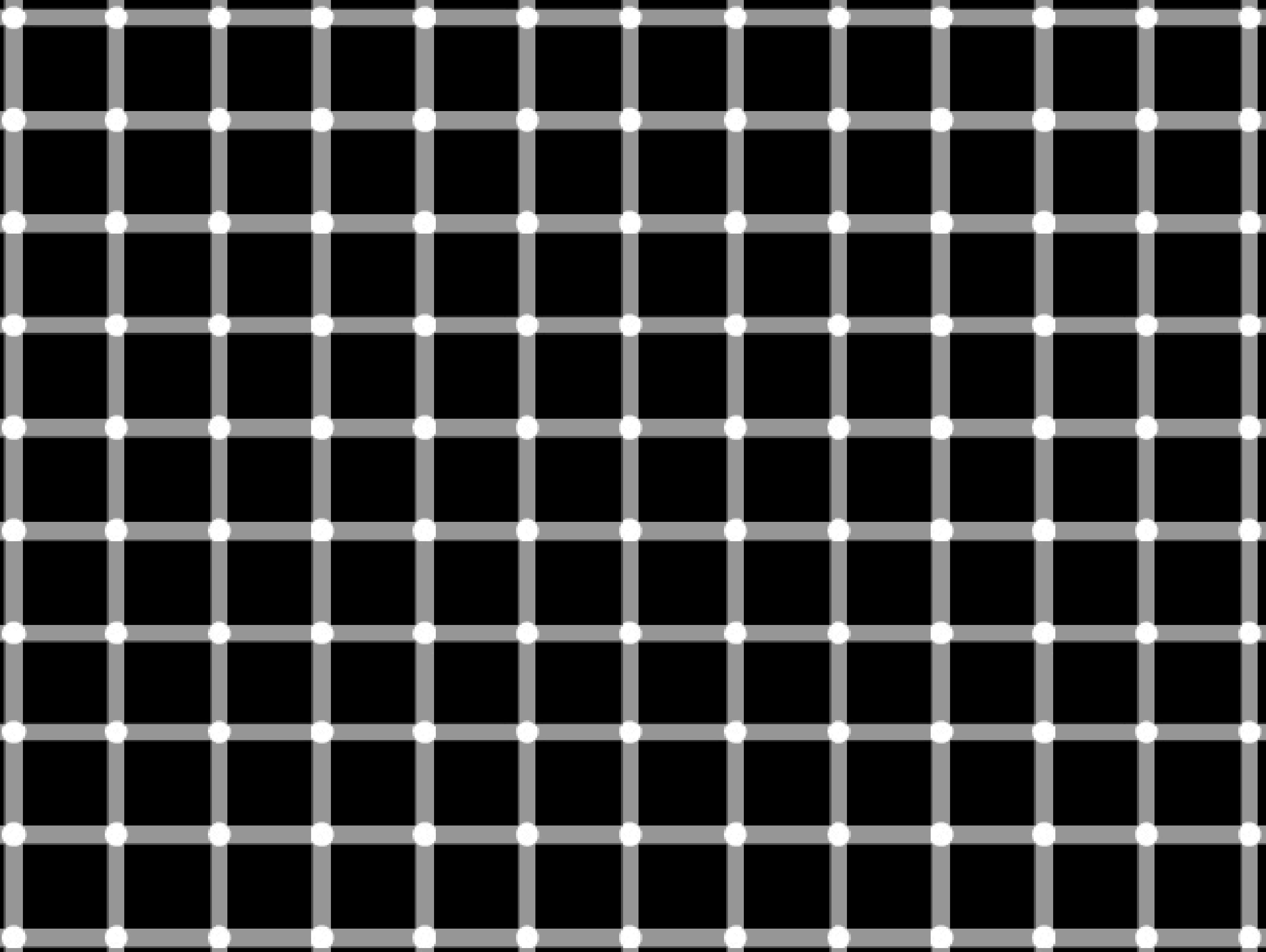


Luminance (L)

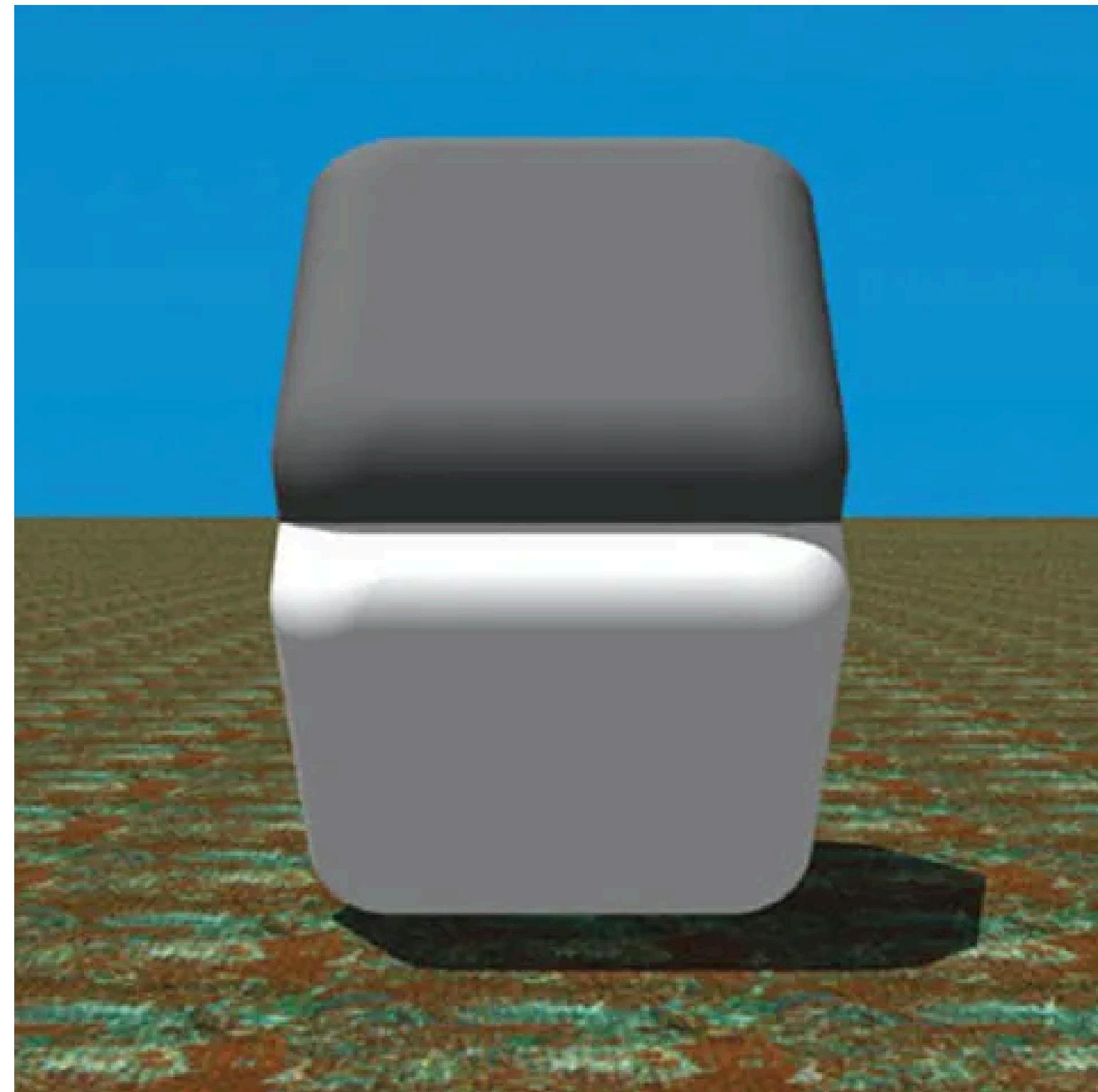
Hermann Grid Effect



Source: Annie Prud'homme-Généreux

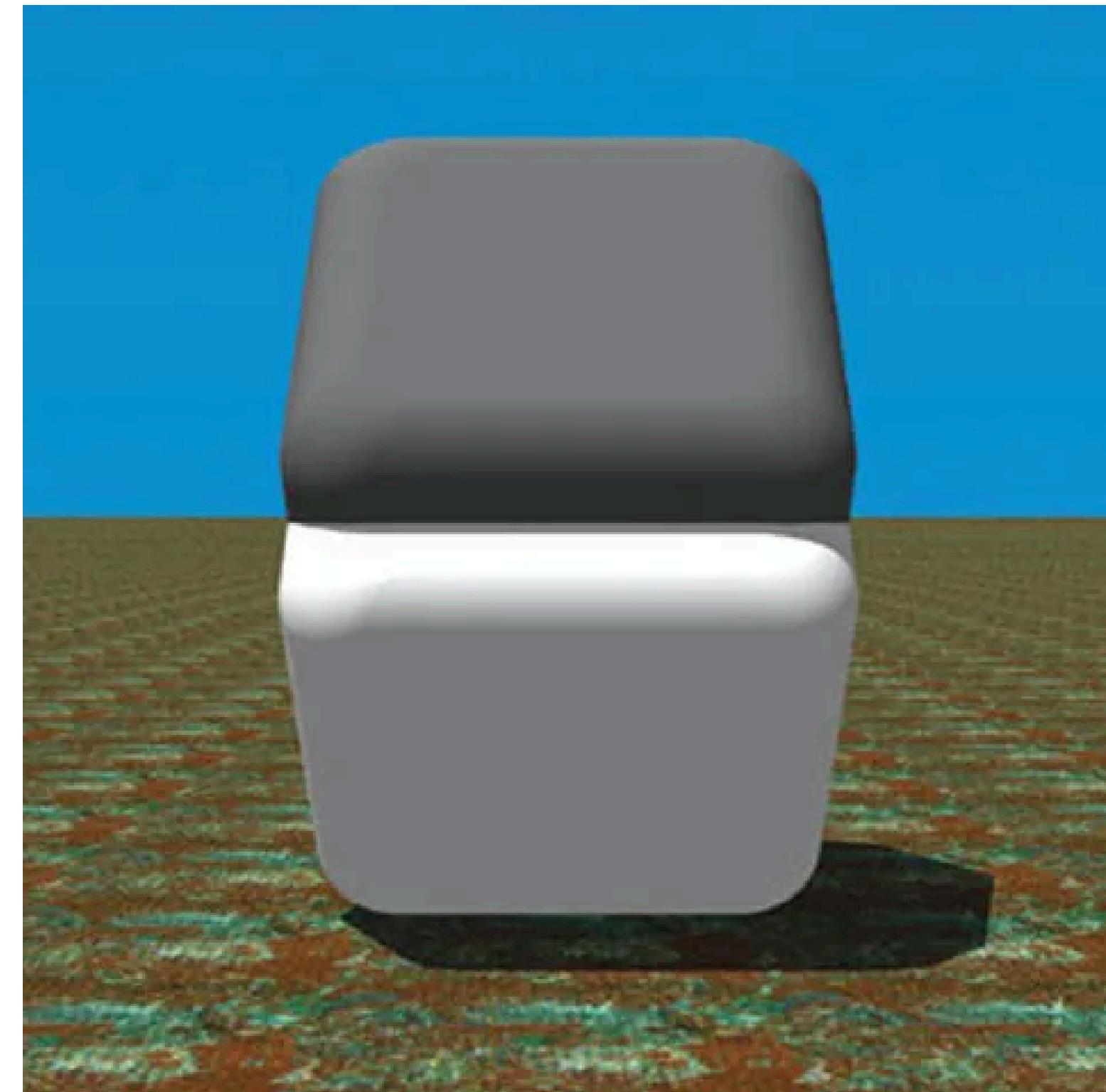


Cornsweet Illusion



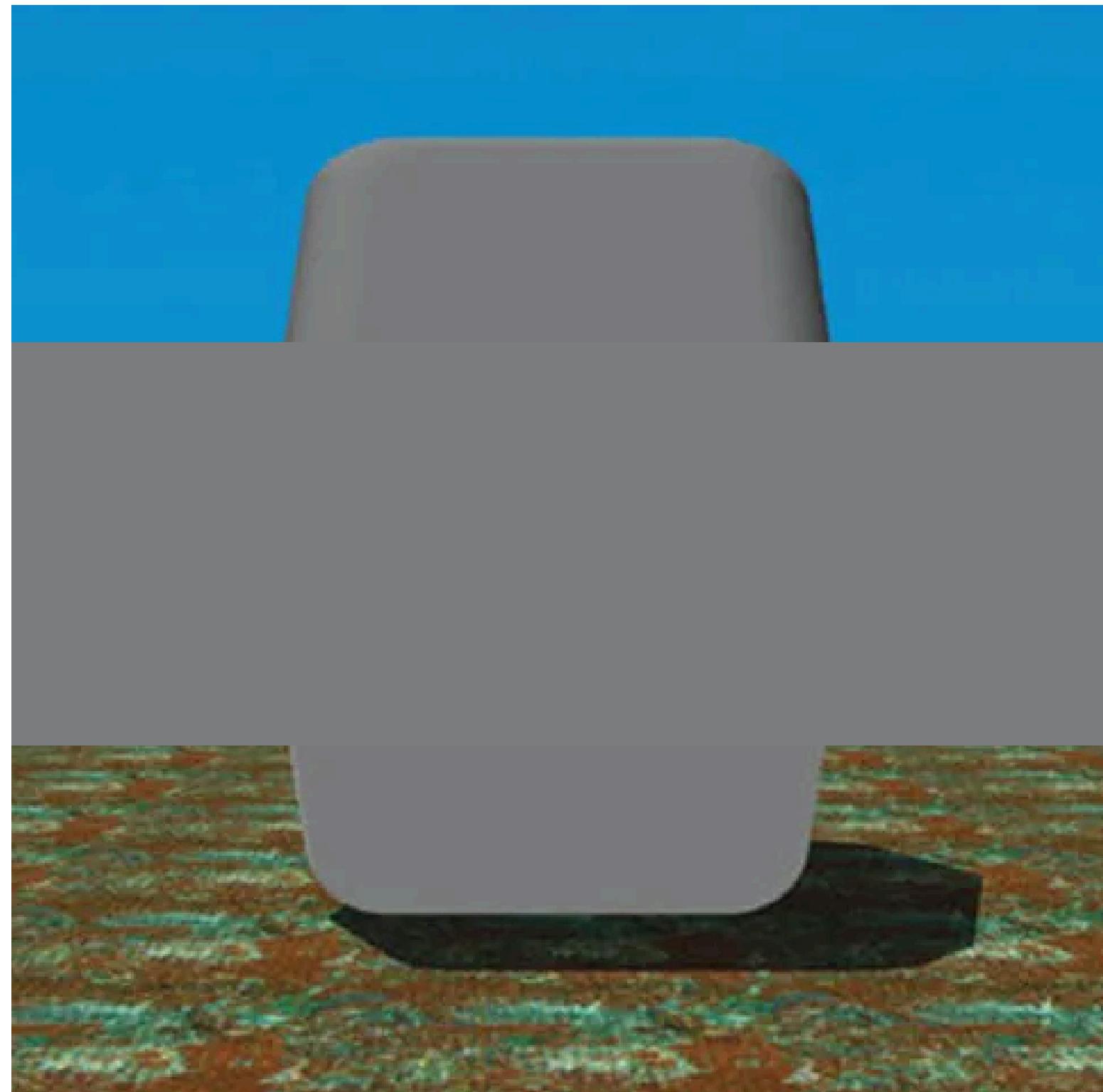
Source: D. Purves and R. B. Lotto

Cornsweet Illusion



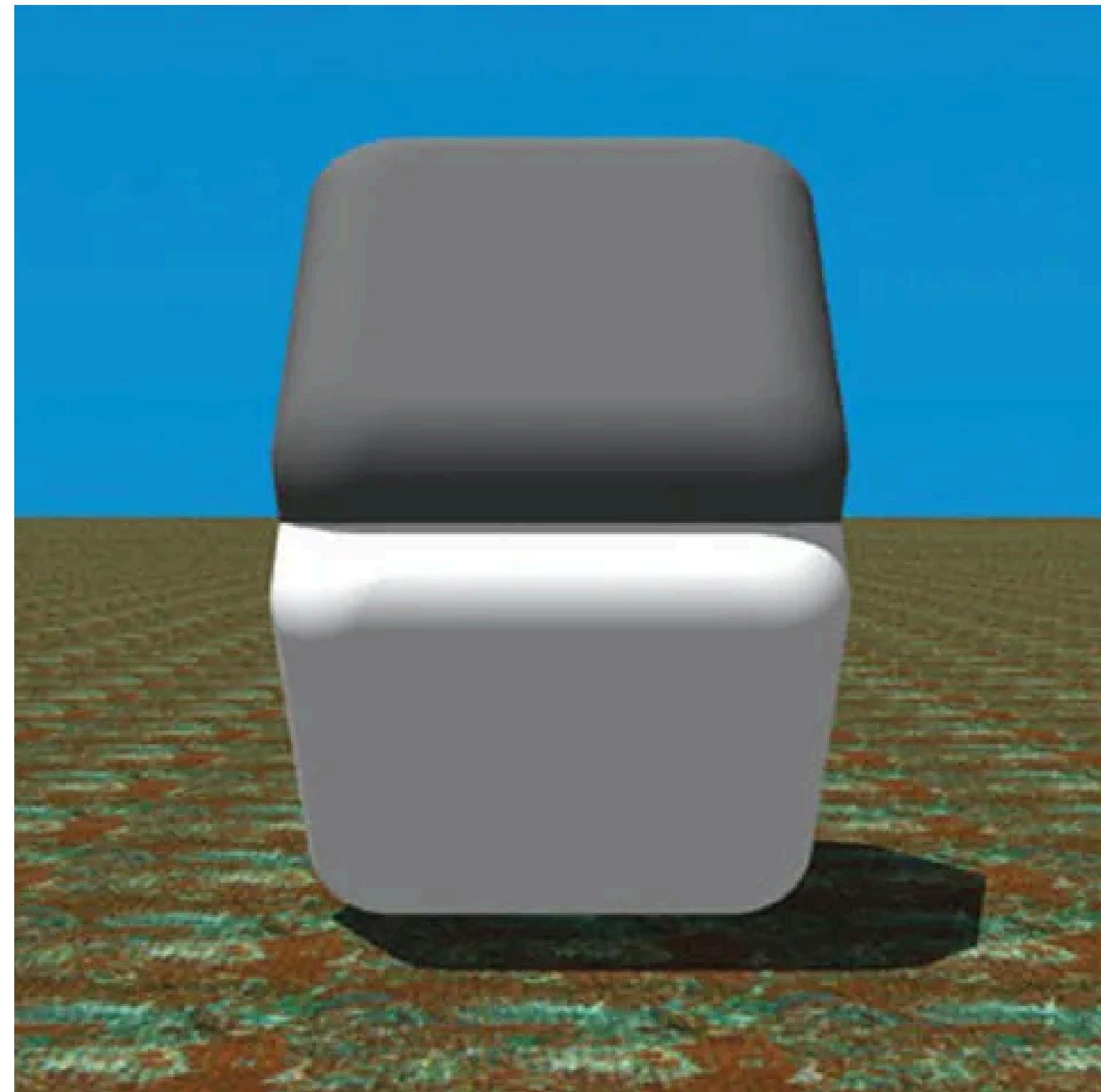
Source: D. Purves and R. B. Lotto

Cornsweet Illusion



Source: D. Purves and R. B. Lotto

Cornsweet Illusion



Source: D. Purves and R. B. Lotto

Mach Banding



Mach Banding



Mach Banding

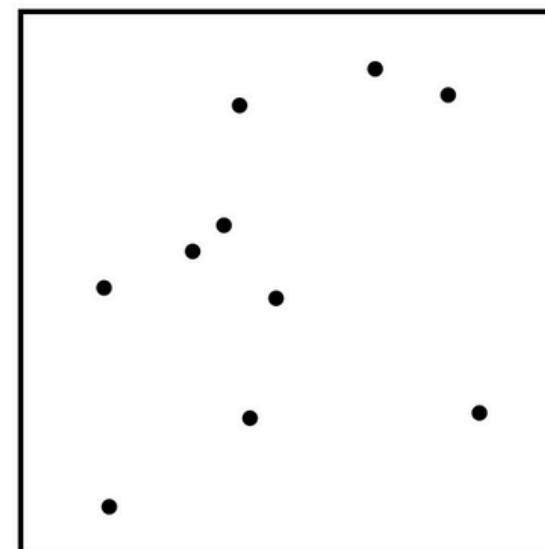


Our visual system is attracted to edges and is sensitive to differences, not absolute values.

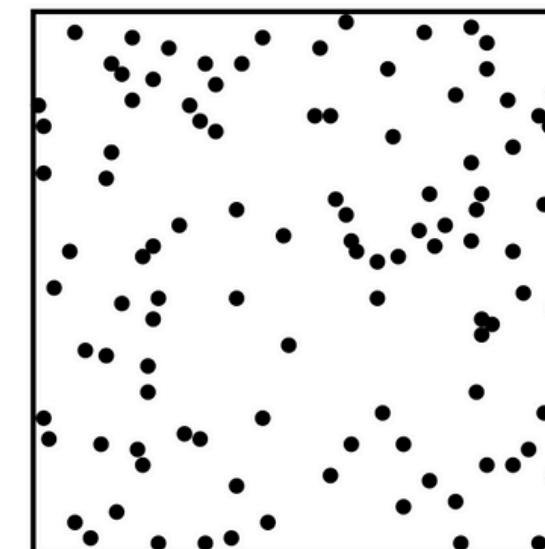
Maximize the contrast with the background if the outlines of shapes are important.

Weber's Law

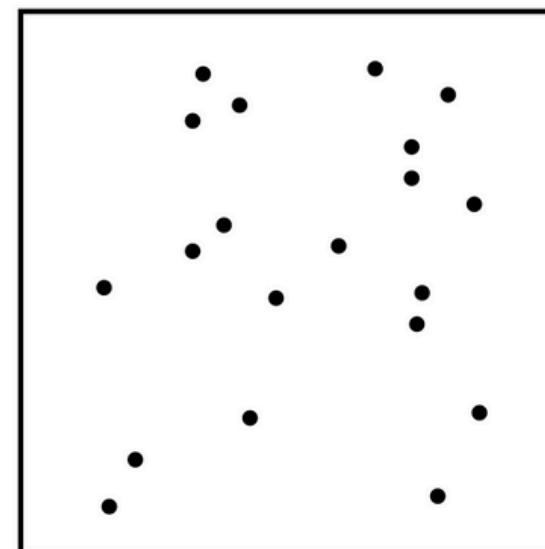
We judge based on relative differences
(not absolute differences)



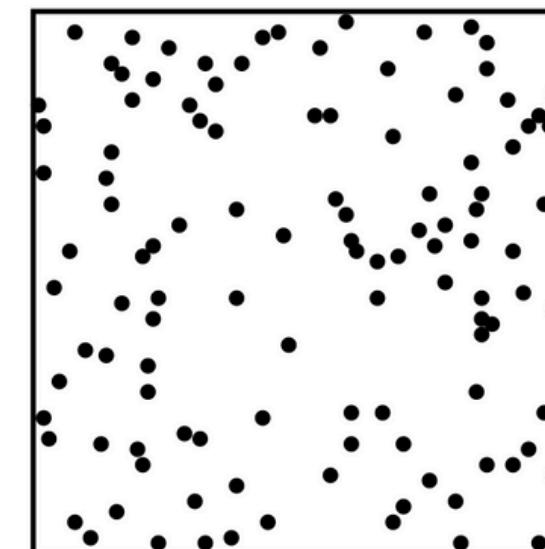
10



110



20

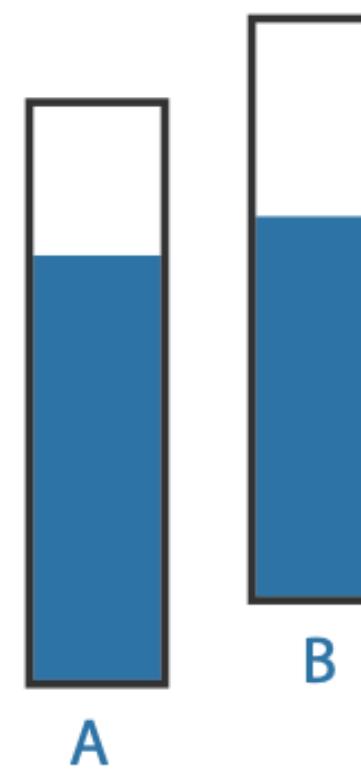


120

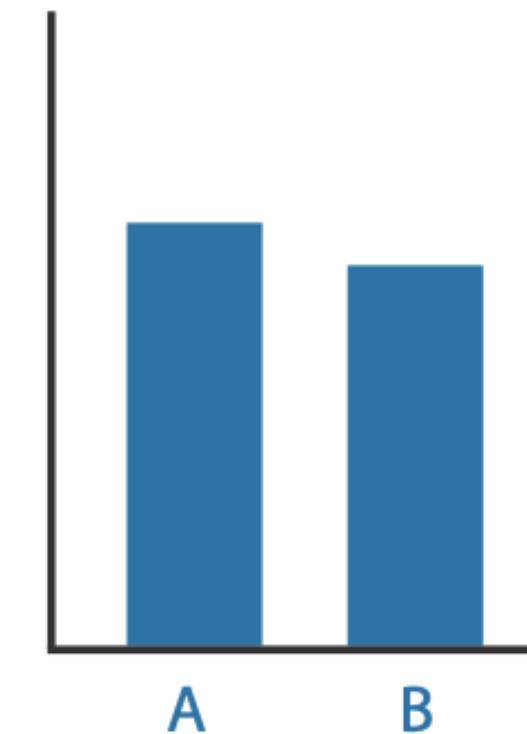
Alignment



Unframed
Unaligned



Framed
Unaligned

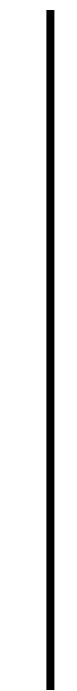


Unframed
Aligned

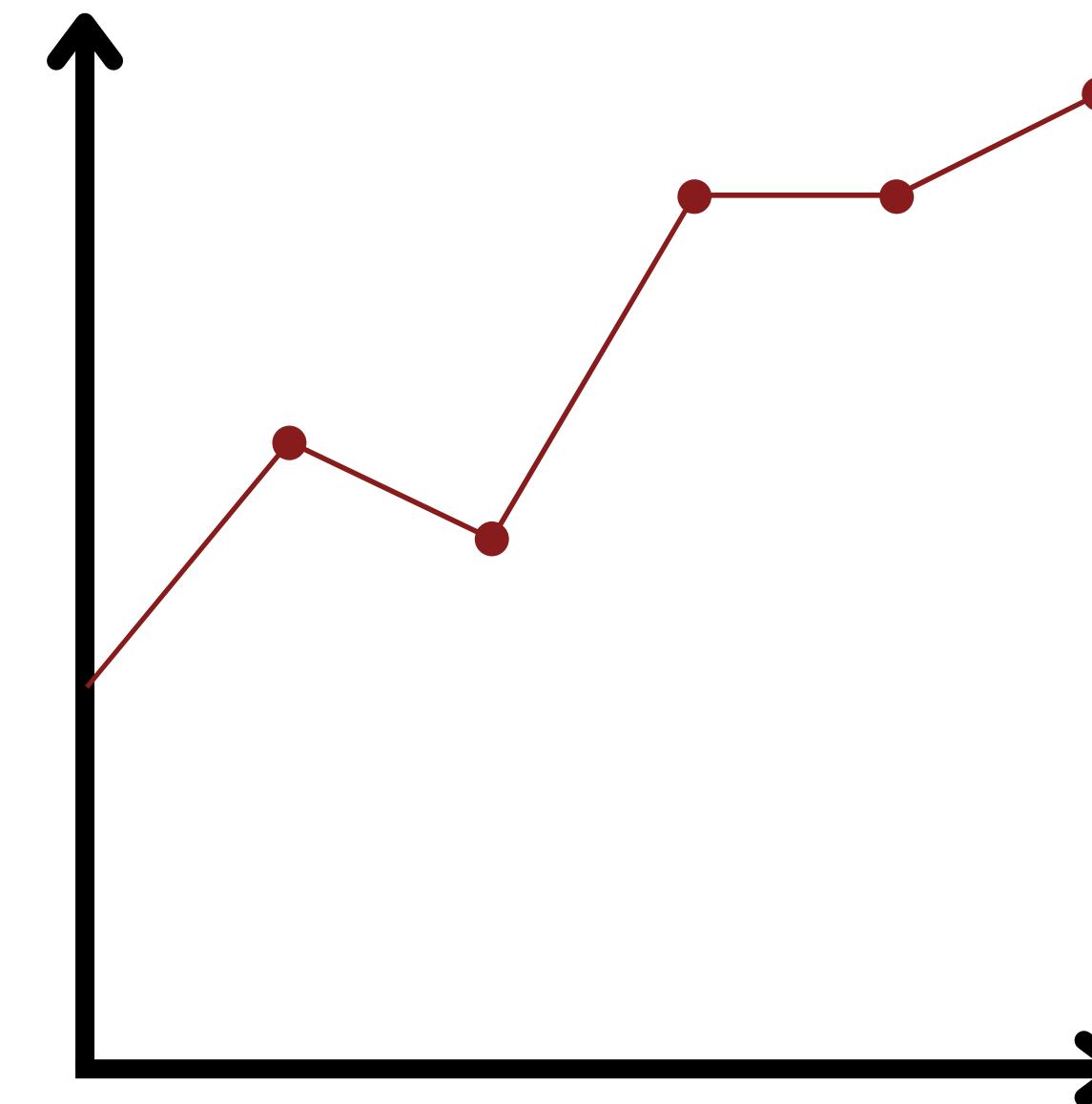
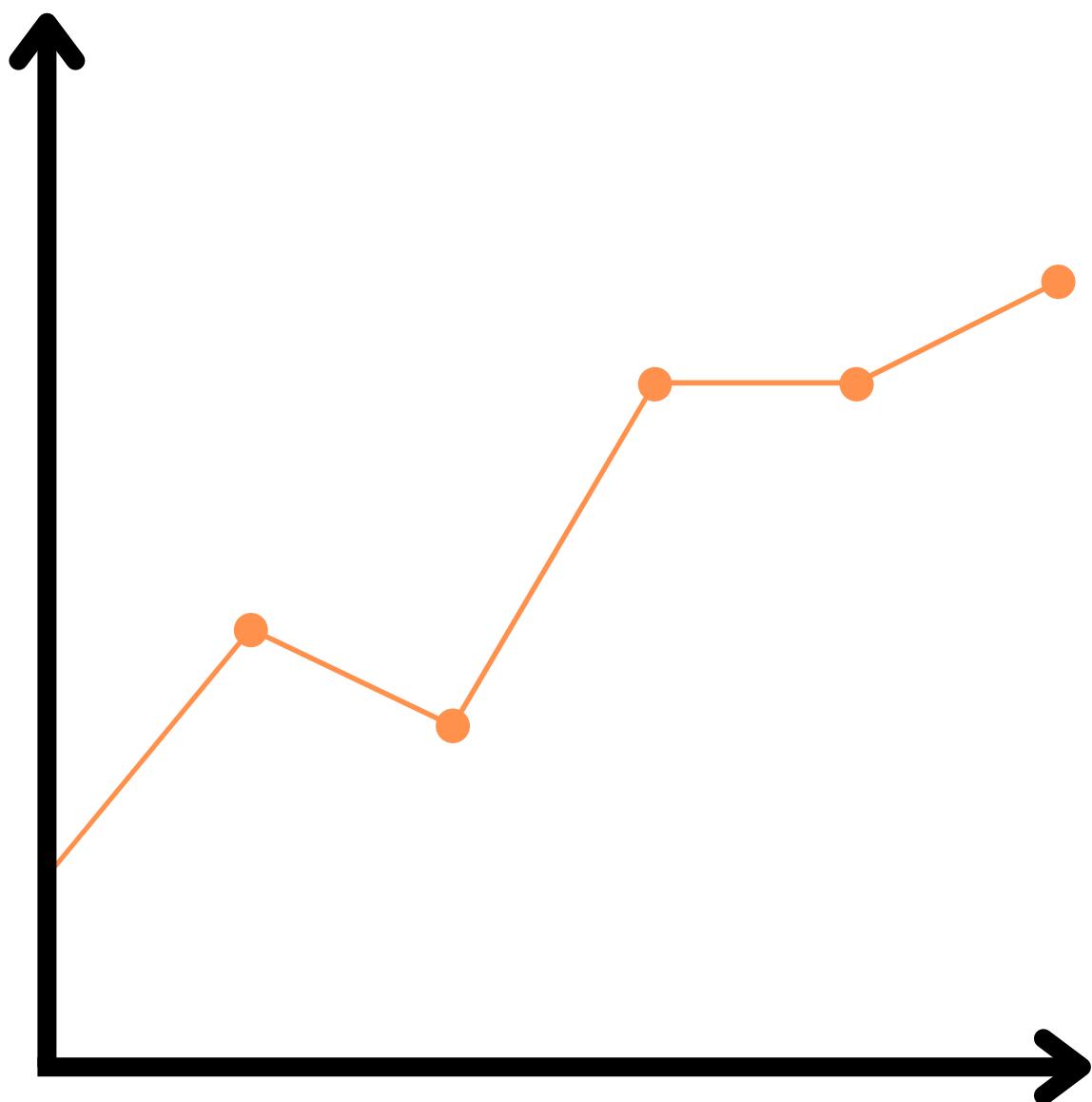
Axis of Alignment



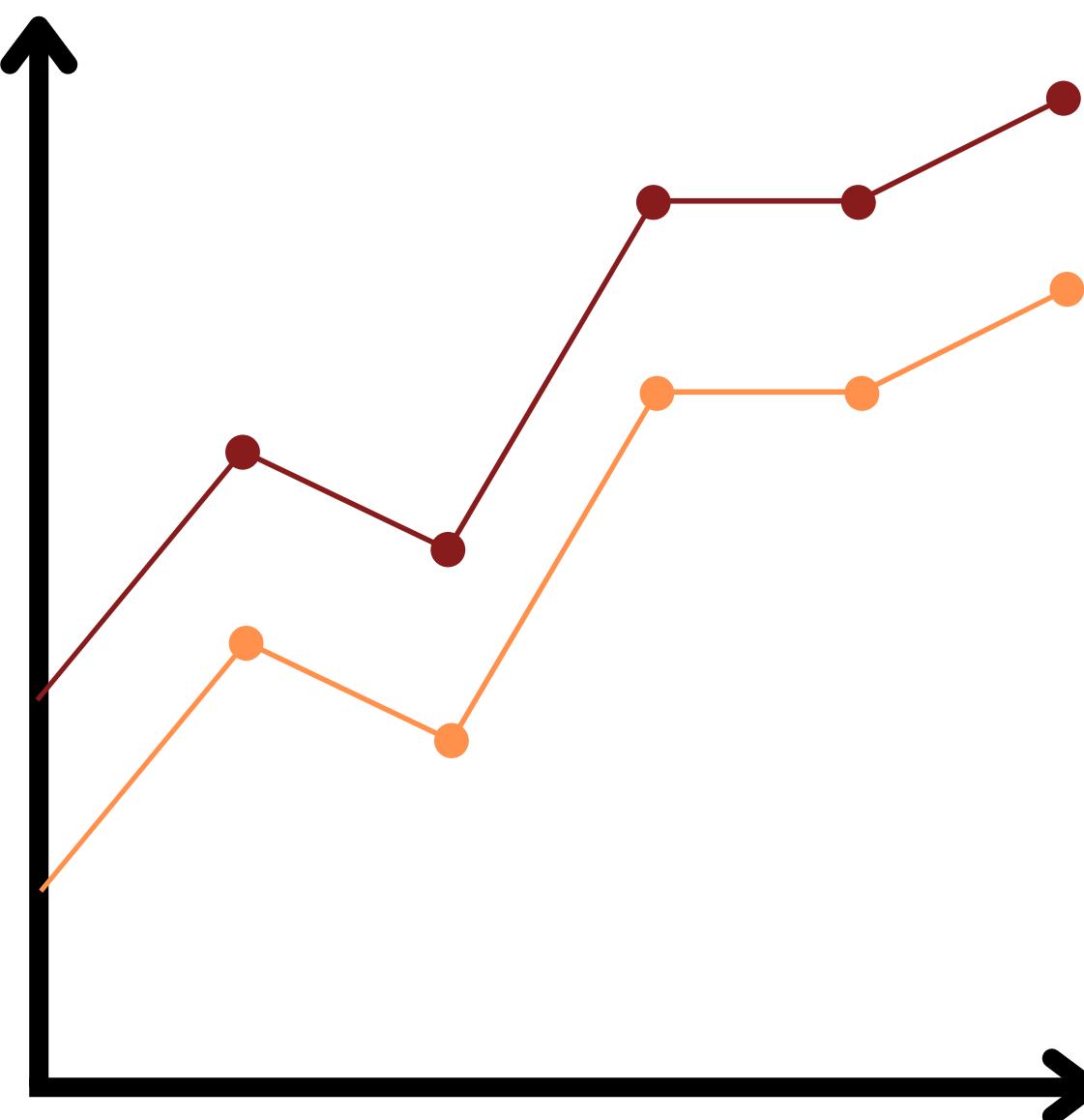
Axis of Alignment



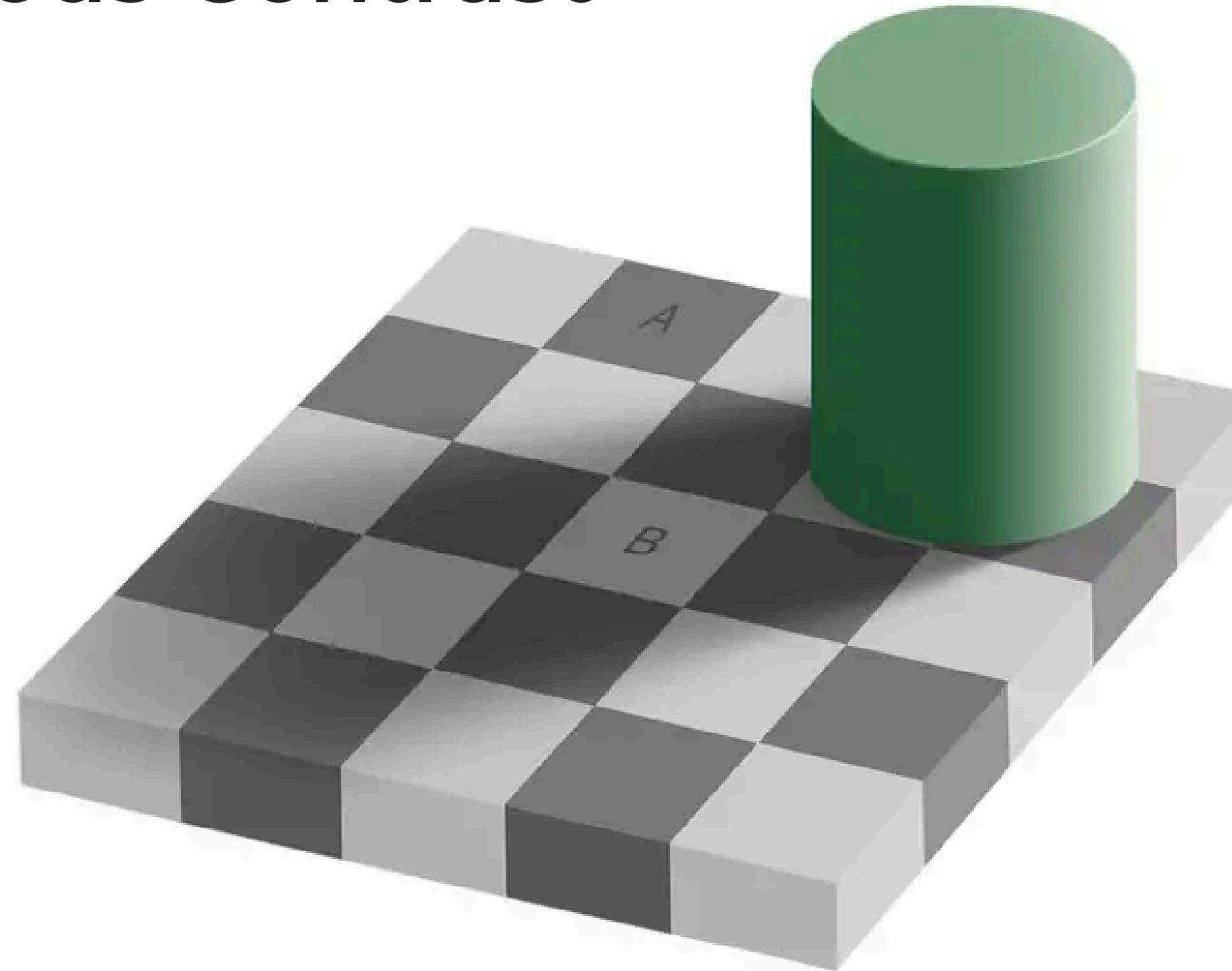
Axis of Alignment



Axis of Alignment

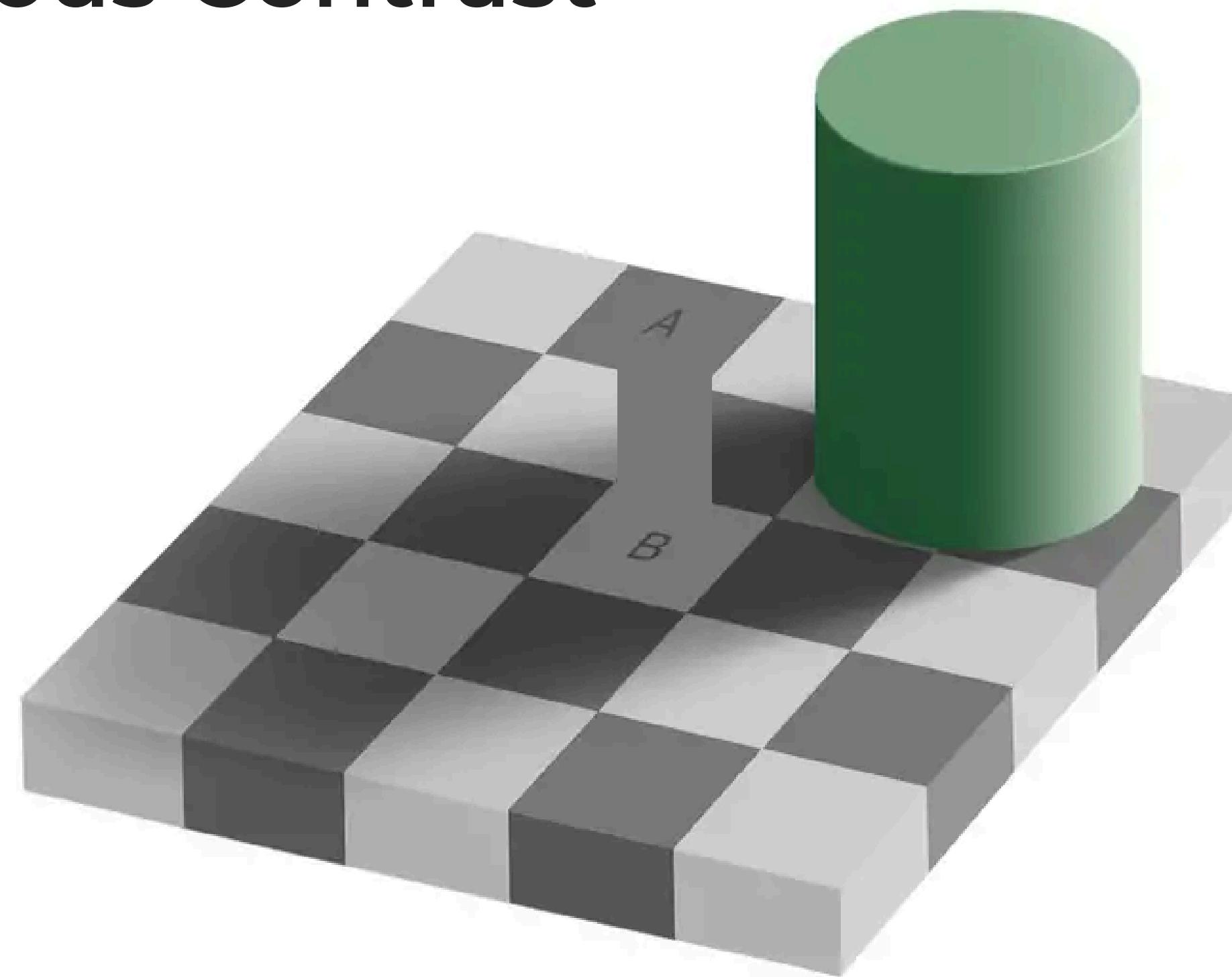


Simultaneous Contrast



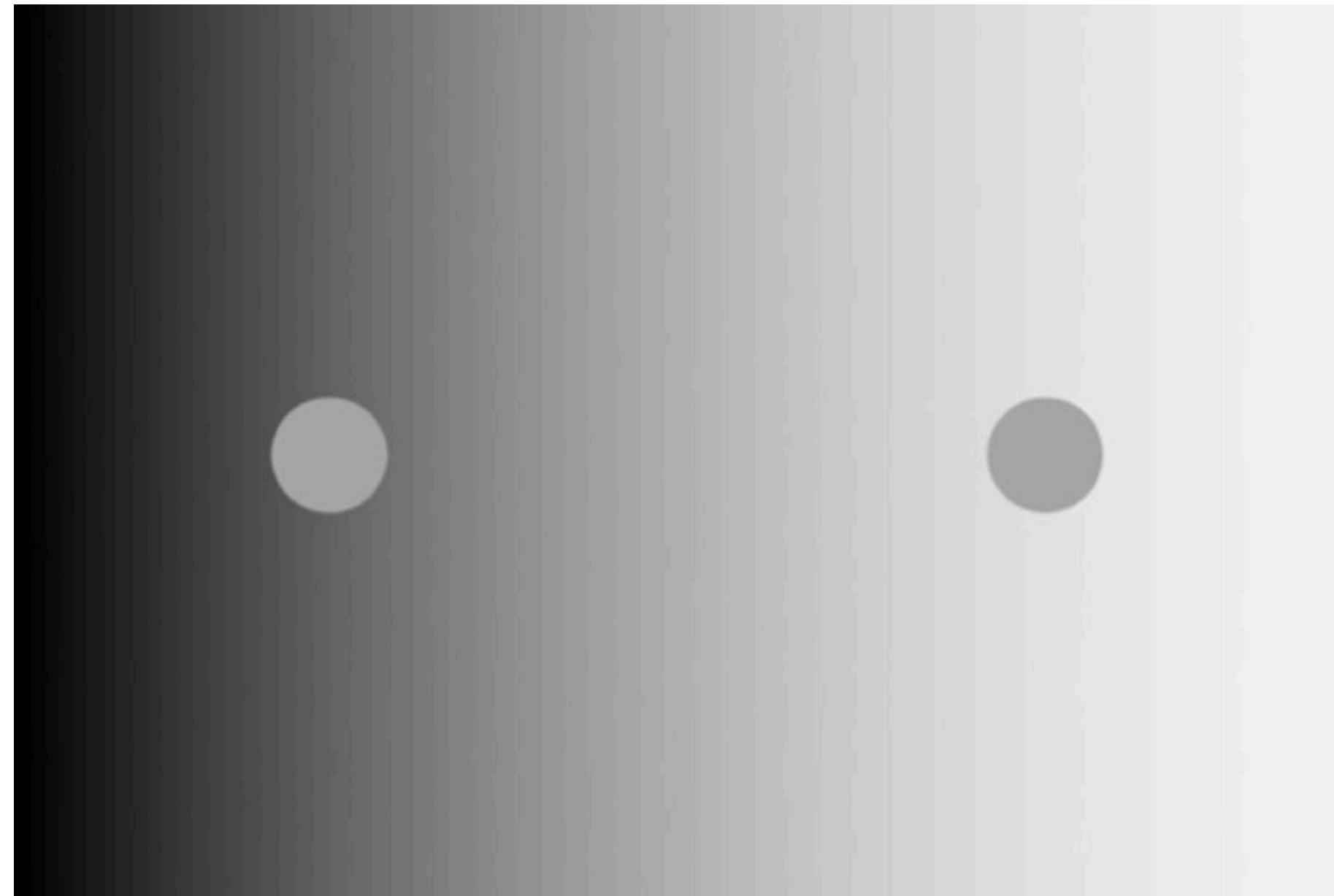
Source: https://persci.mit.edu/_media/gallery/checkershadow

Simultaneous Contrast

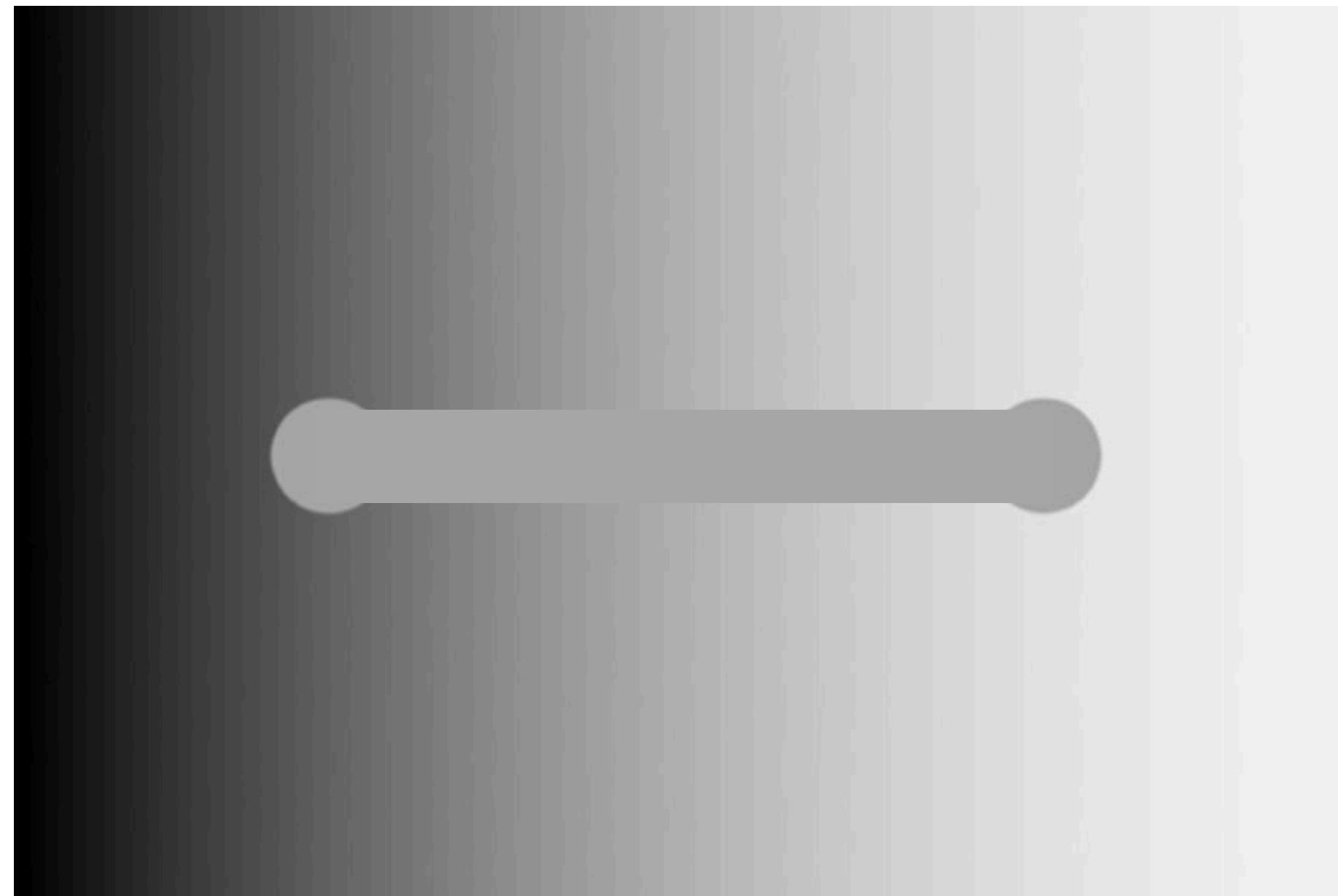


Source: https://persci.mit.edu/_media/gallery/checkershadow

Simultaneous Contrast



Simultaneous Contrast



Simultaneous Contrast



Horizon Illusions



Horizon Illusions



Horizon Illusions



Horizon Illusions



Horizon Illusions



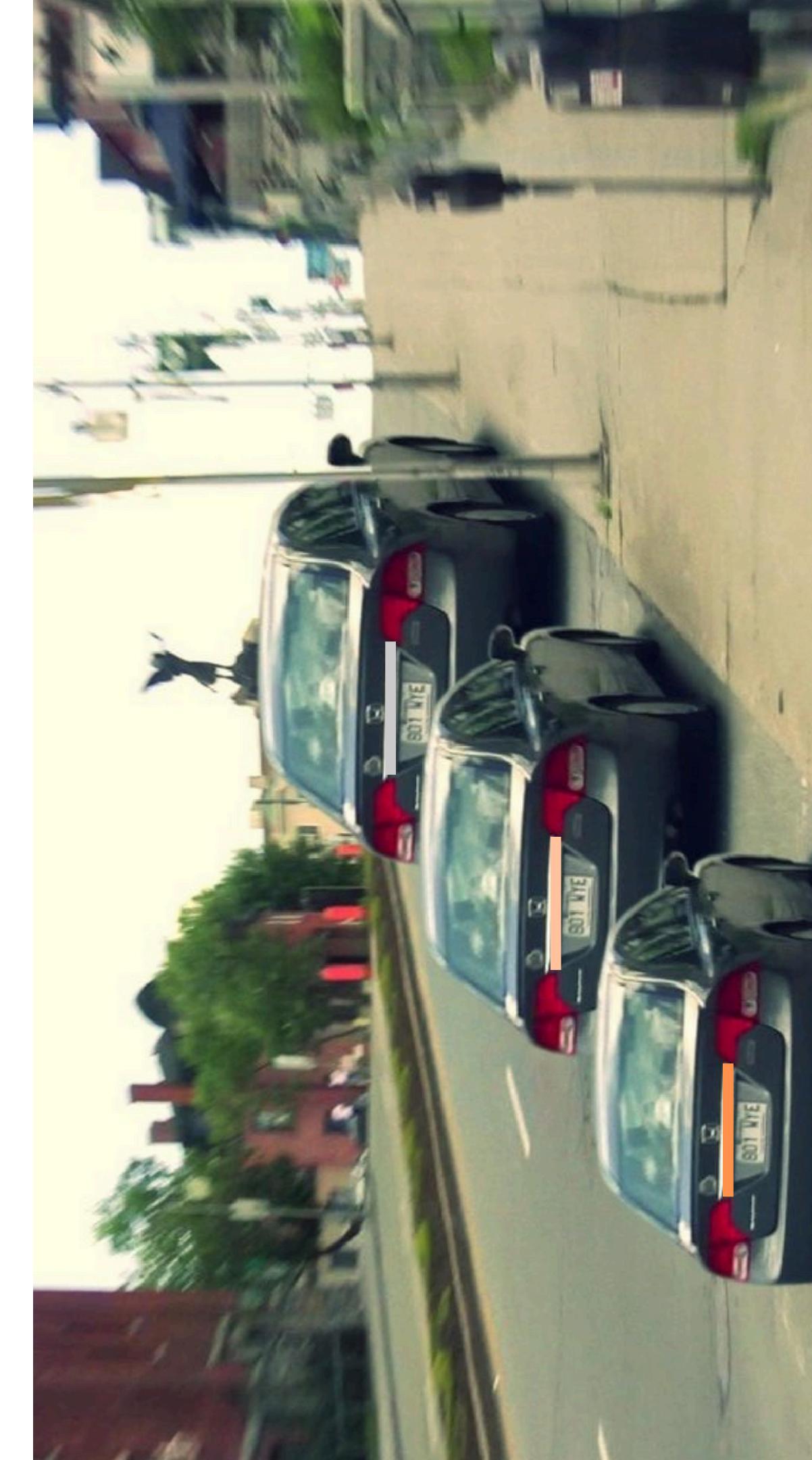
Horizon Illusions



Horizon Illusions



Horizon Illusions



We have a strong propensity to assume our judgments are absolute, when in fact they are generally relative to the local context.

**Do your best not to place data in difficult contexts.
Choose position and orientation of objects carefully.**

Two Types of Processing

Two Types of Processing

Pre-attentive

Immediately notice variations with little to no conscious effort

Two Types of Processing

Pre-attentive

Immediately notice variations with little to no conscious effort

Attentive

Requires mental effort to perceive visual differences

Attentive Processing

MTHIFLWYADCEQGHKILKMTWYN
ARDCAIREQGHLGKMFPSTWVARN
GFPsvcvilqkmfpssnvrcedqi
PSGHLMFHKMVPSTWYACEQTWRN

Pre-Attentive Processing

MTHIFLWYADCEQGHKILKMTWYN
ARDCAIREQGHLGKMFPS**TWV**ARN
GFP**SVC**VILQGKMFPSN**VR**CEDQDI
PSGHLMFHKMVPSTWYACEQ**TWR**N

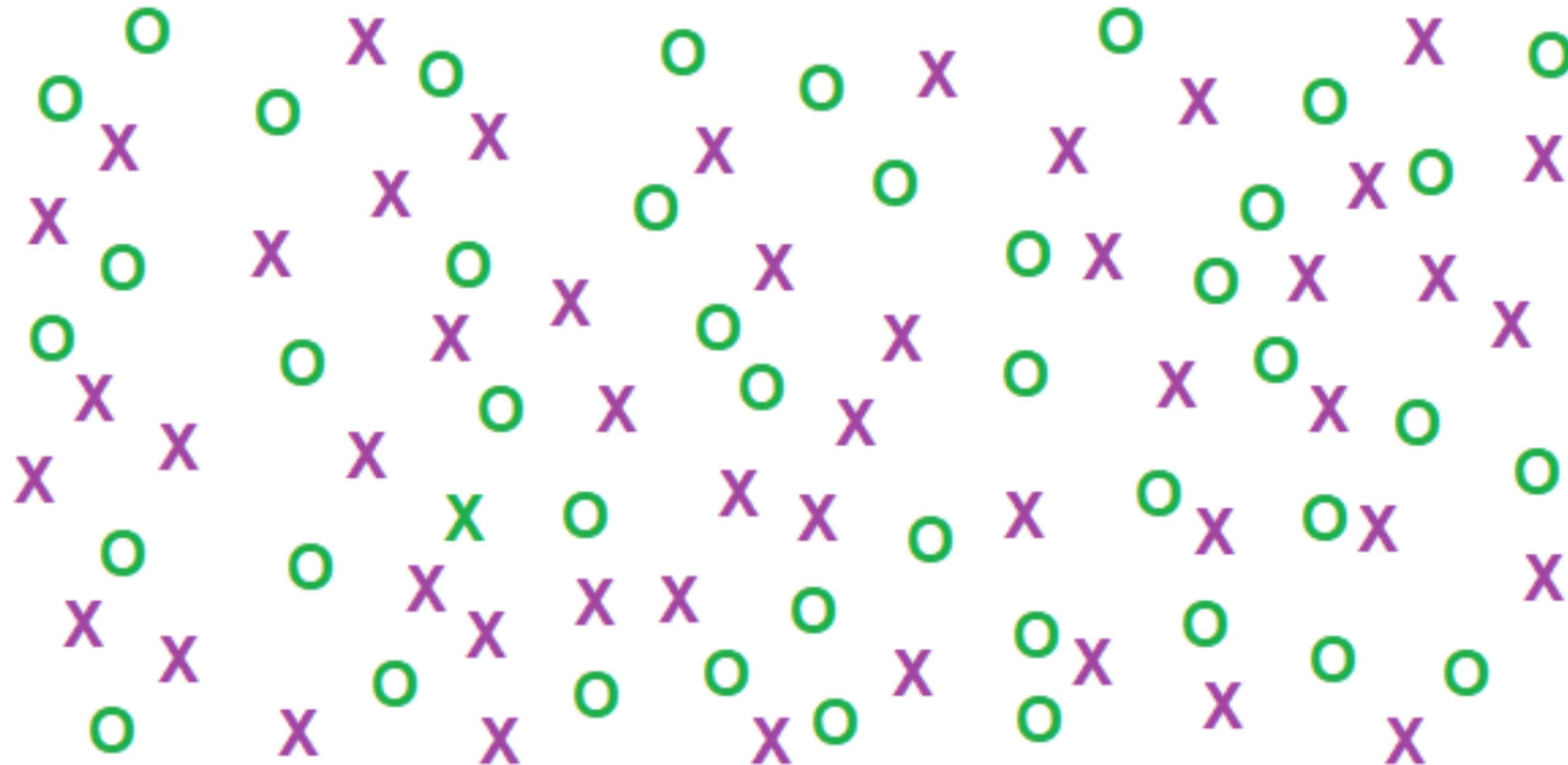
Pre-attentive? or Attentive?

Notice the yellow umbrella



Pre-attentive? or Attentive?

Find the green X



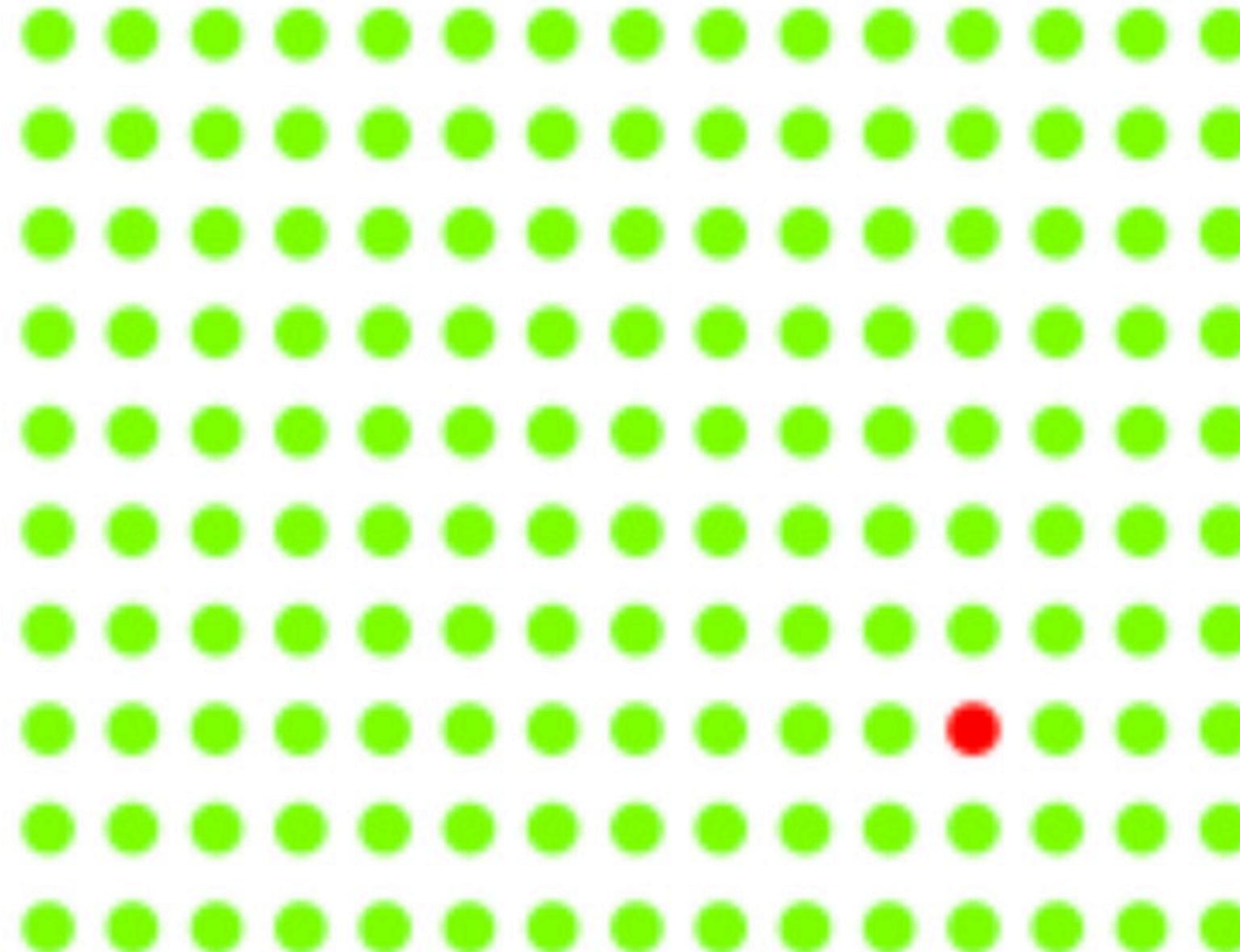
Pre-attentive? or Attentive?

Find the red circle

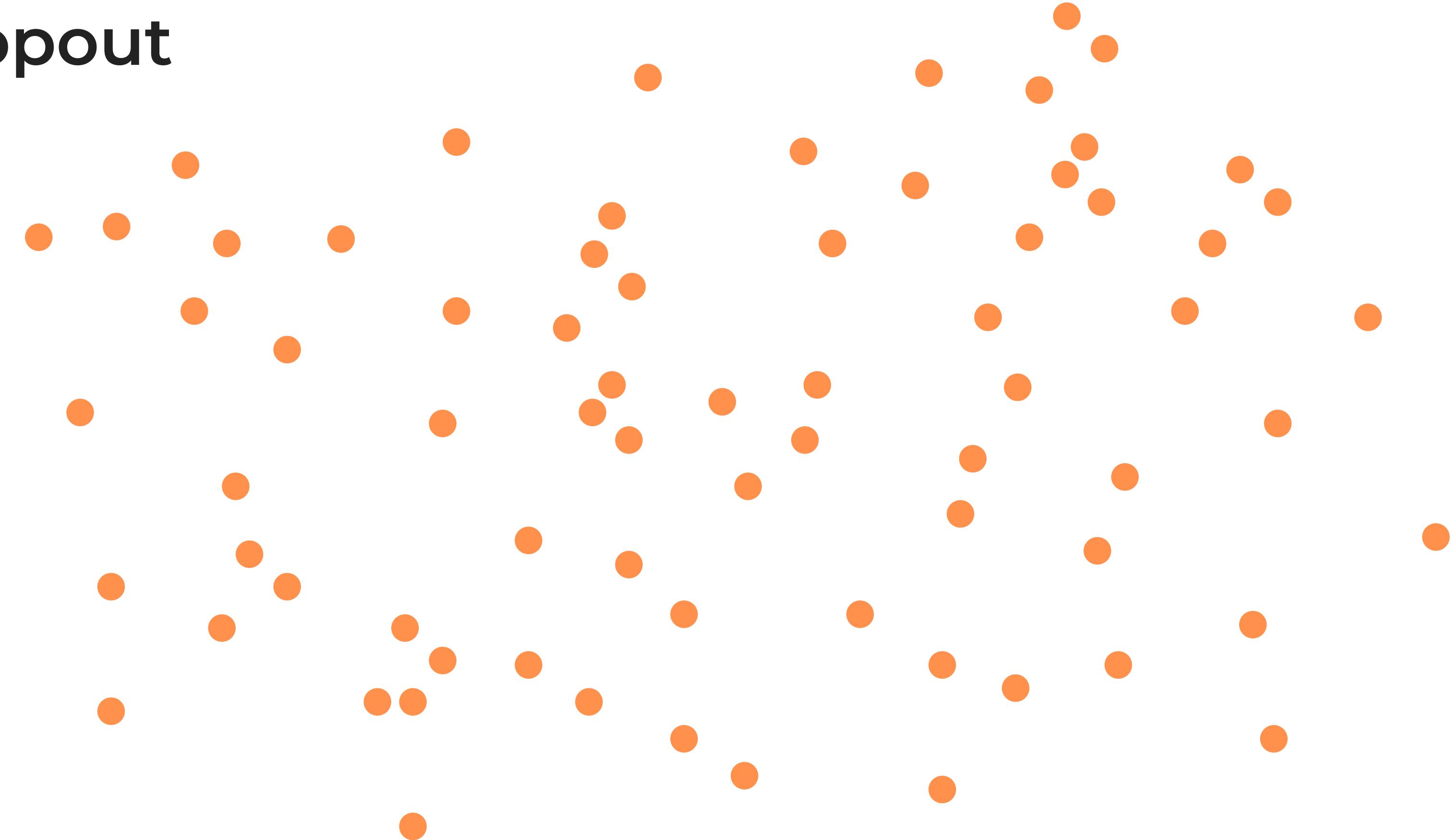


Pre-attentive? or Attentive?

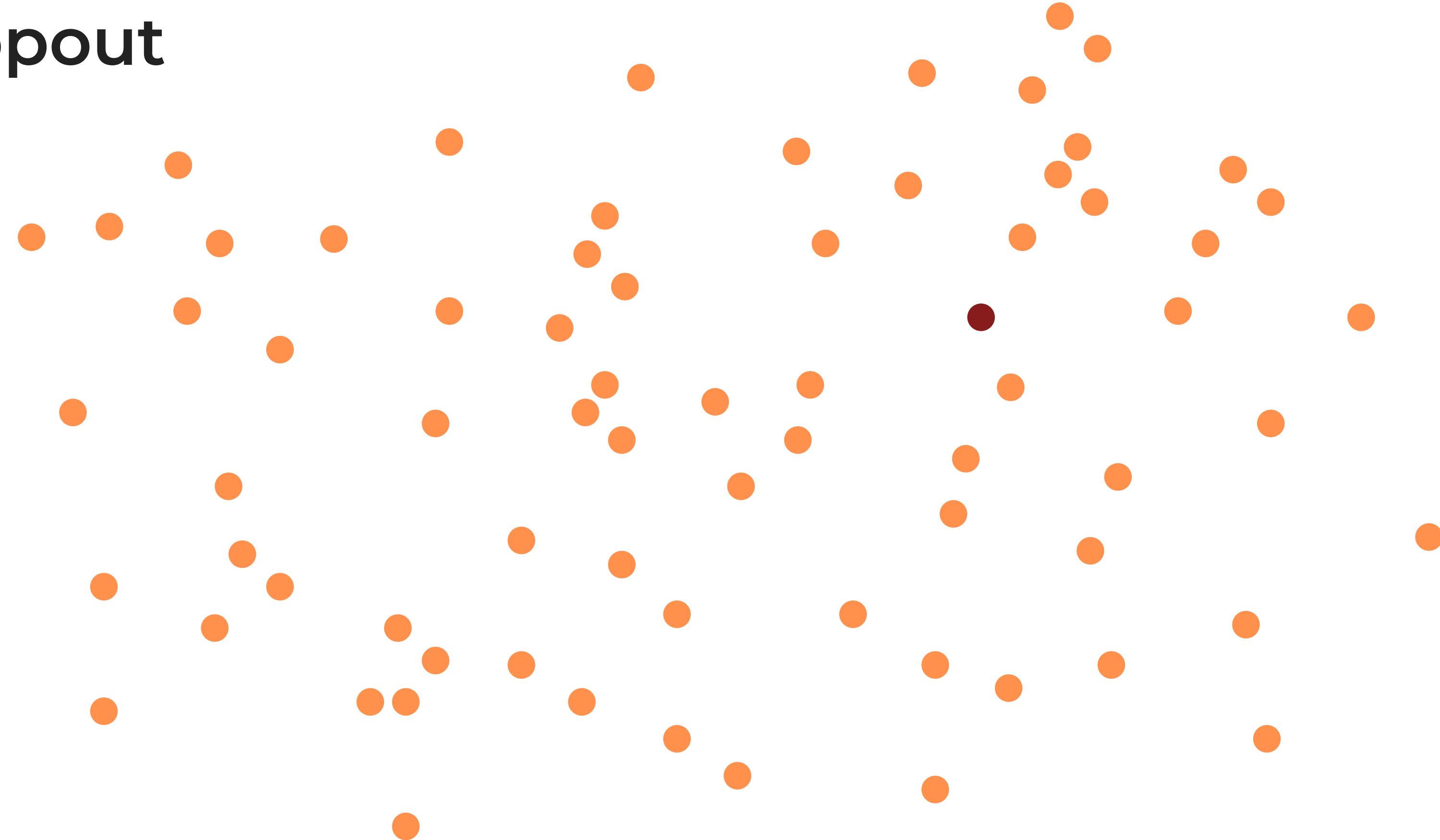
Find the red circle



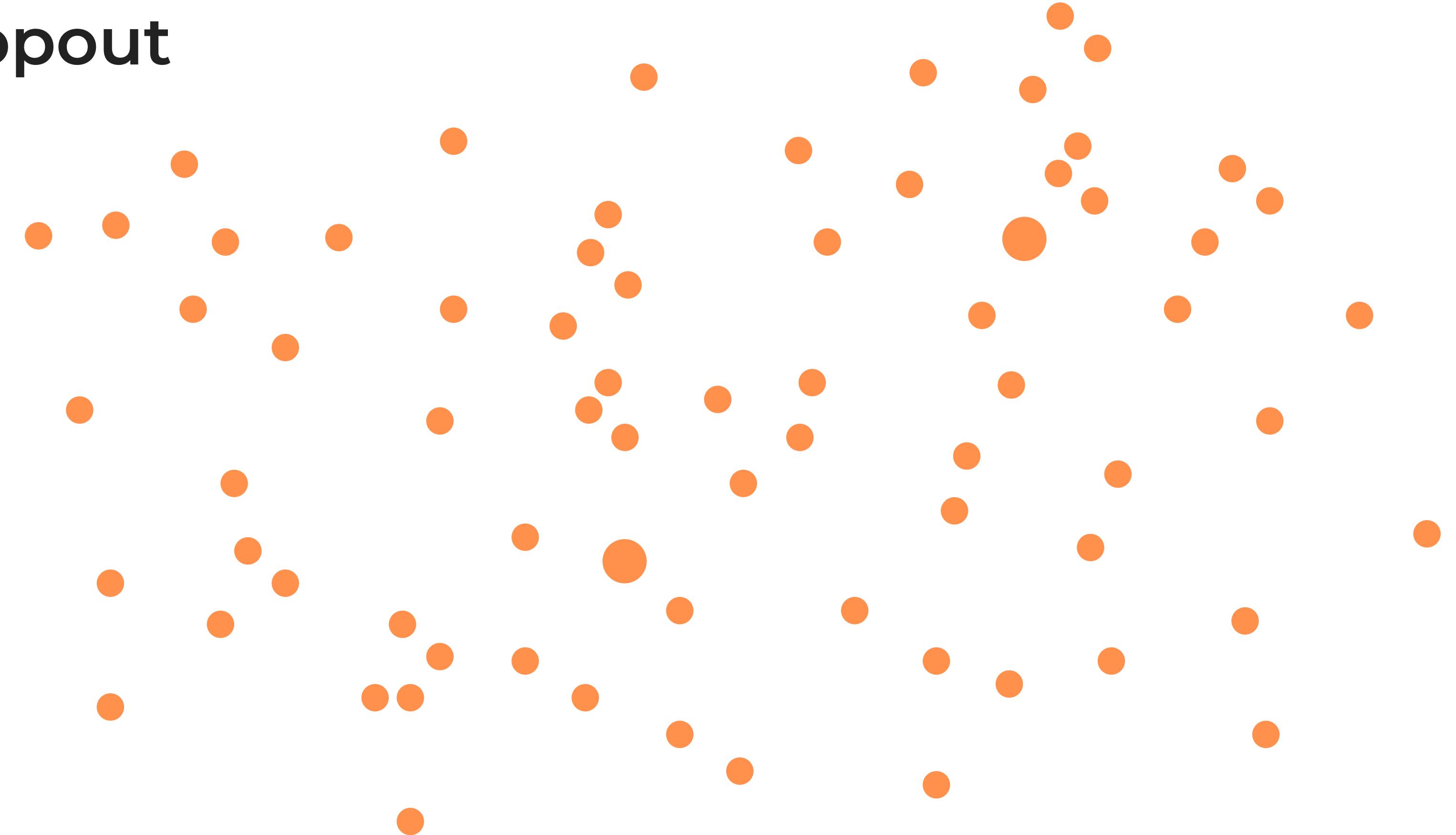
Popout



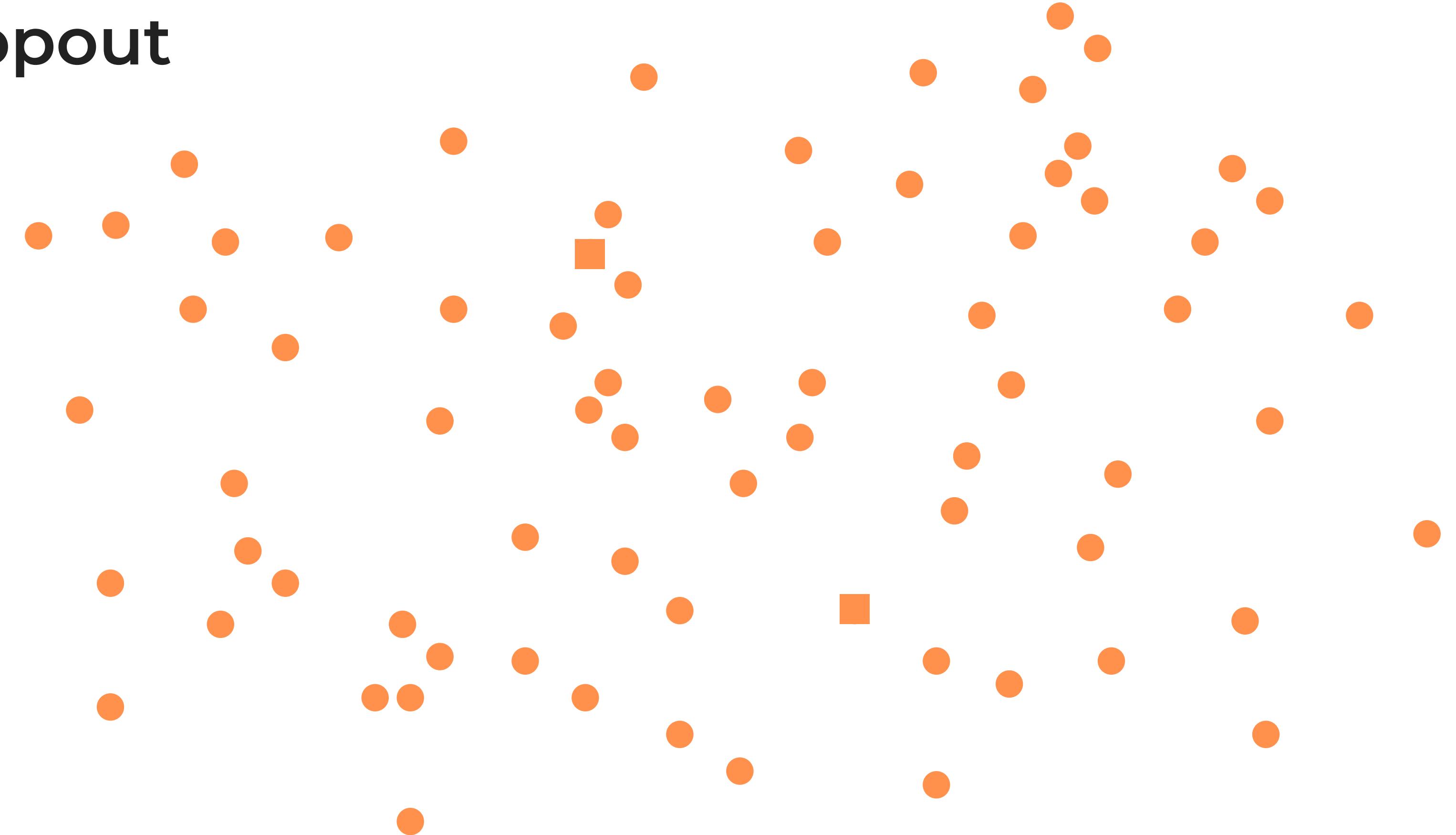
Popout



Popout

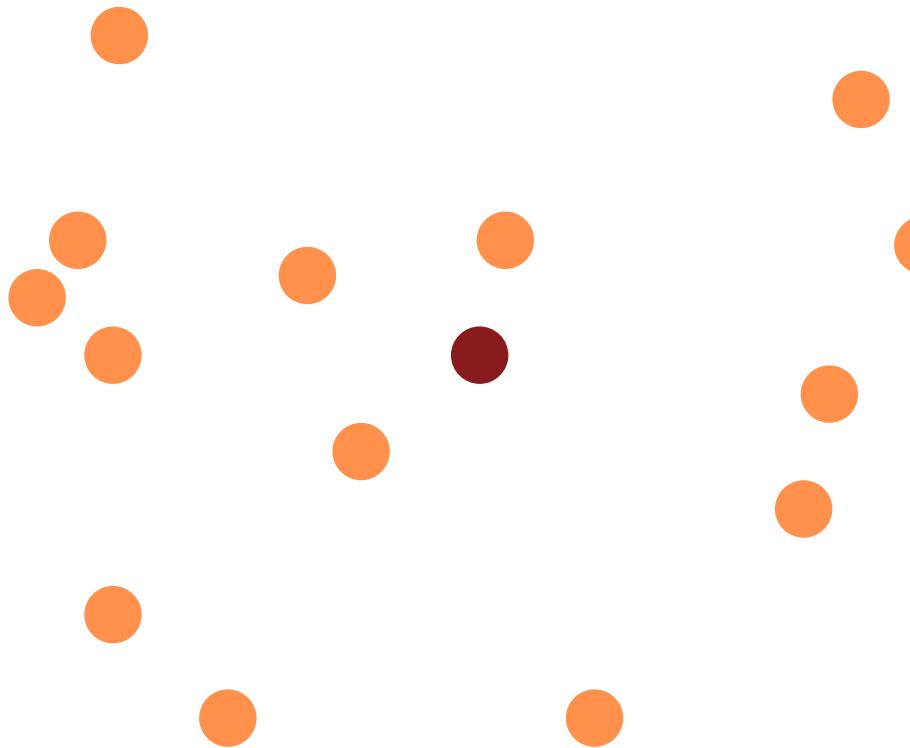


Popout



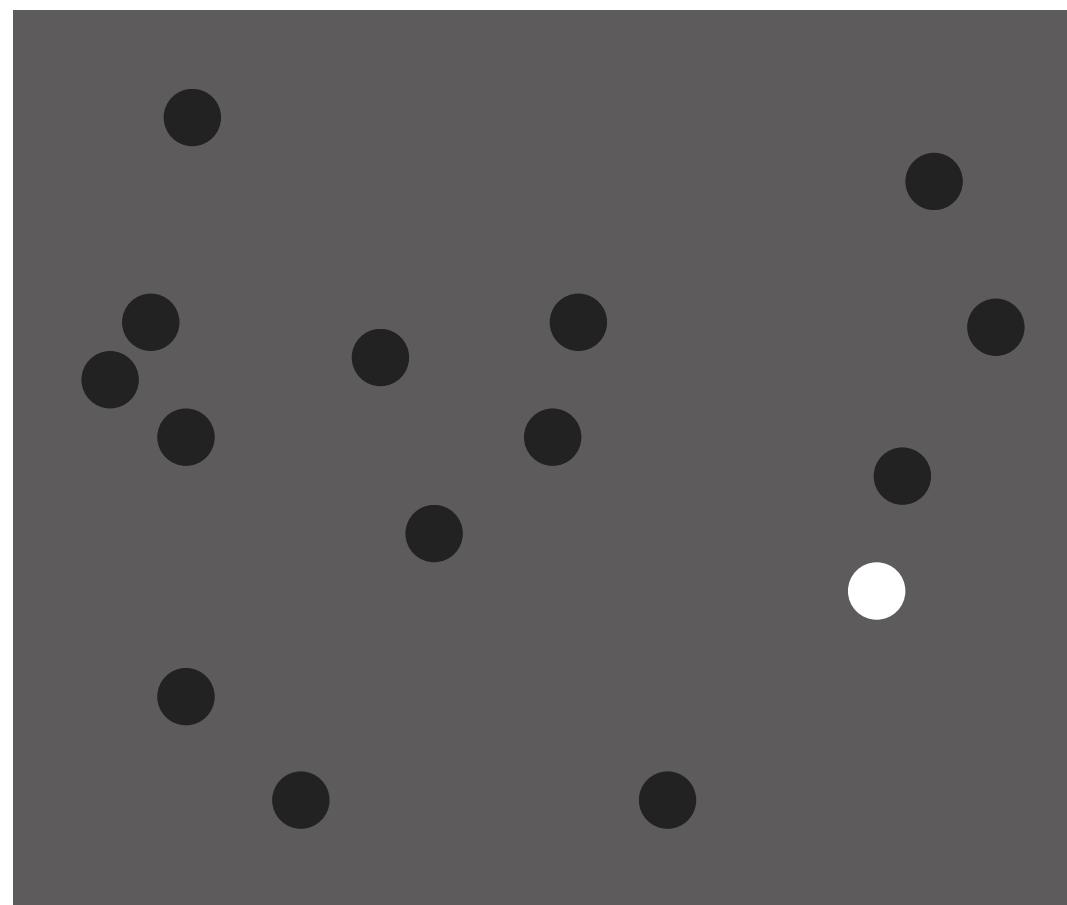
Basic Popout Channels

Color (Hue)



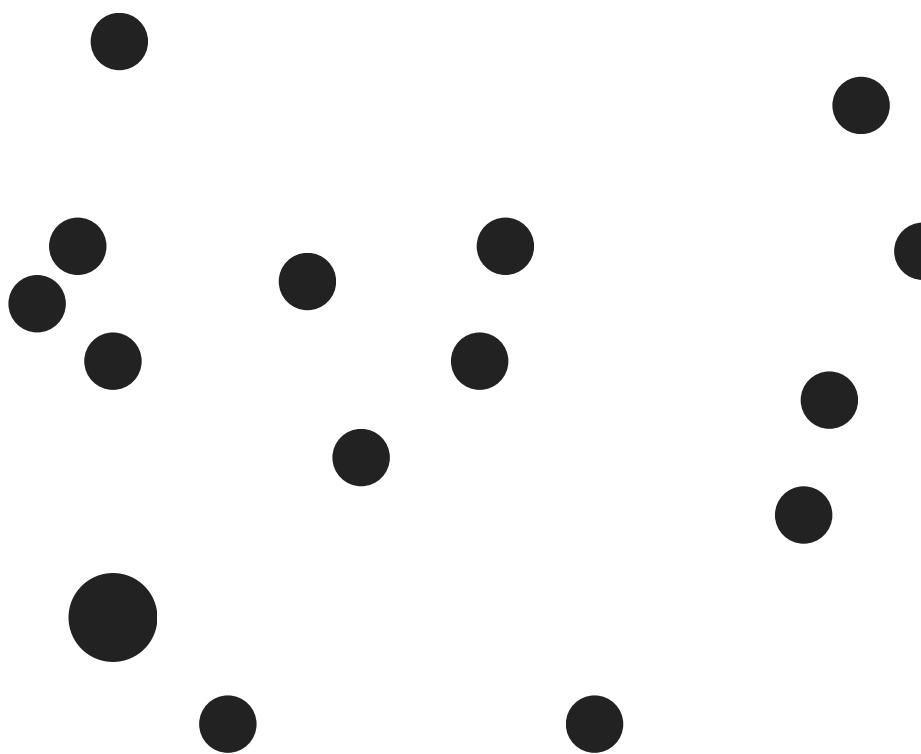
Basic Popout Channels

Color (Lightness)



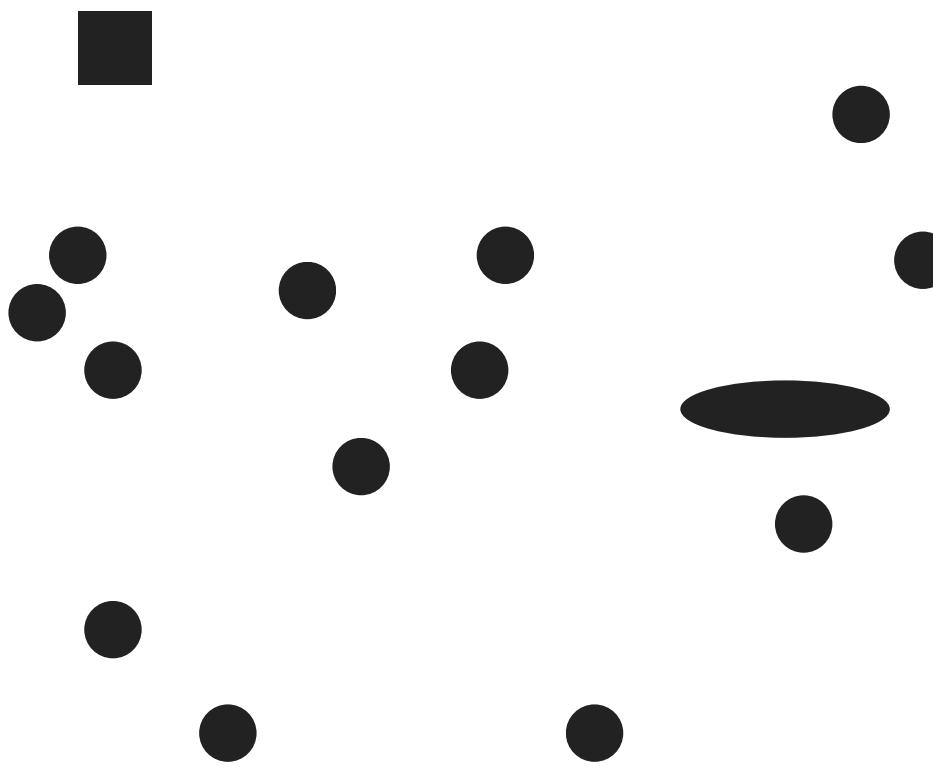
Basic Popout Channels

Size



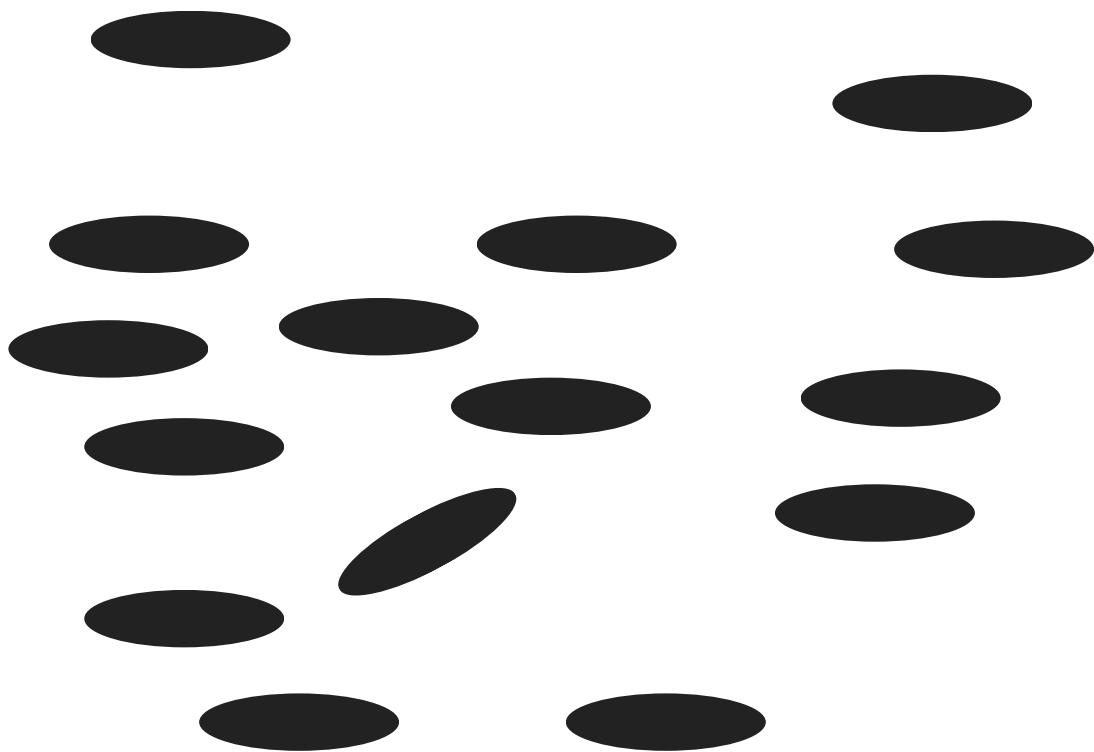
Basic Popout Channels

Shape



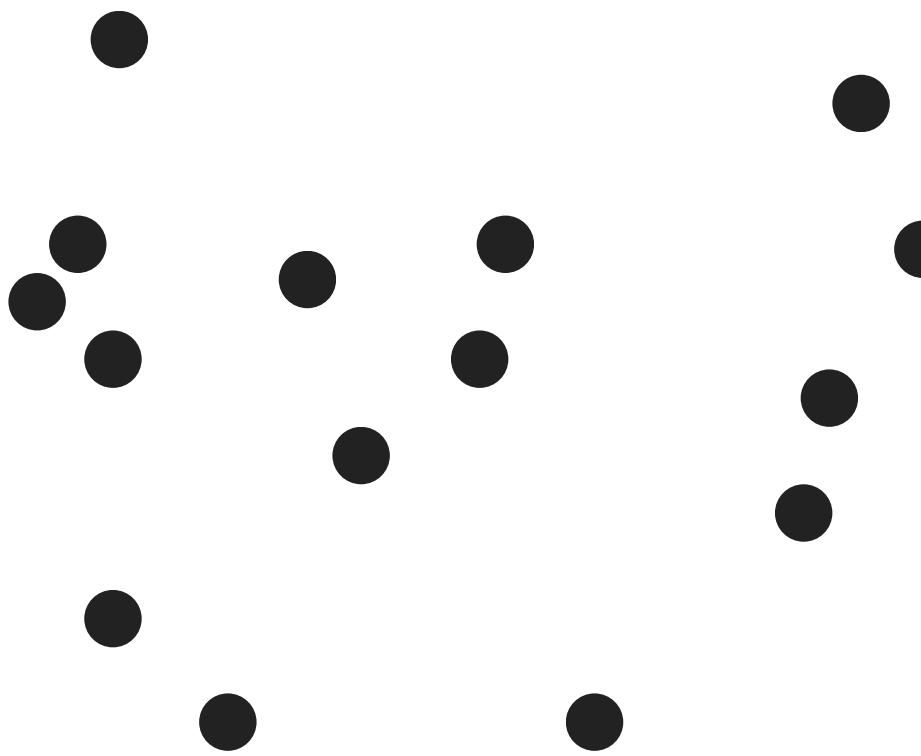
Basic Popout Channels

Orientation



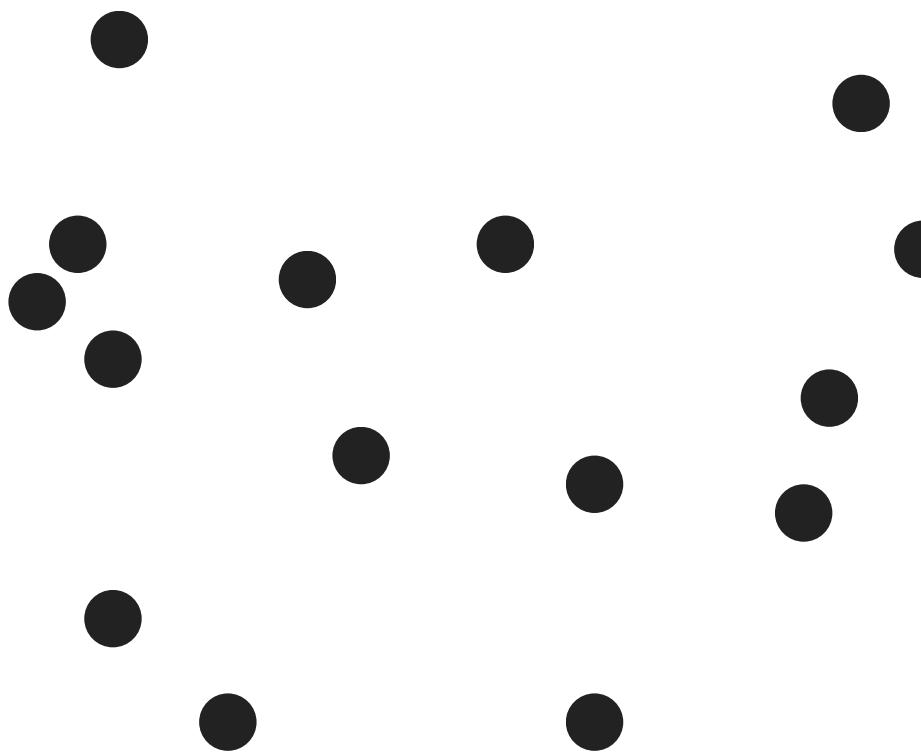
Basic Popout Channels

Motion



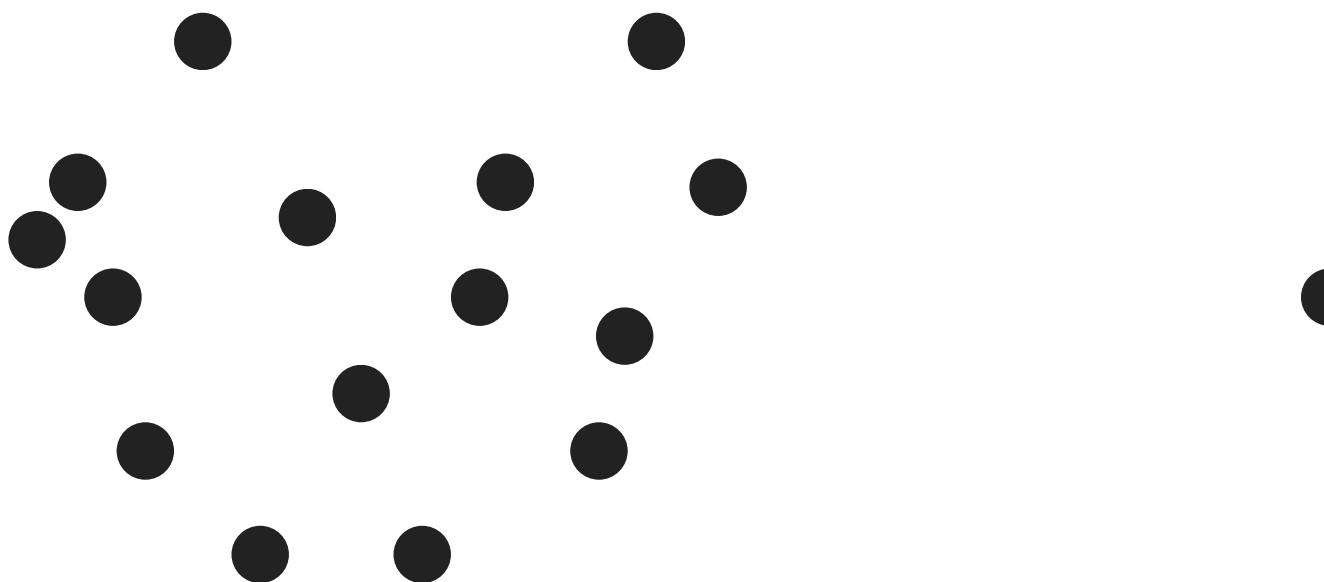
Basic Popout Channels

Motion

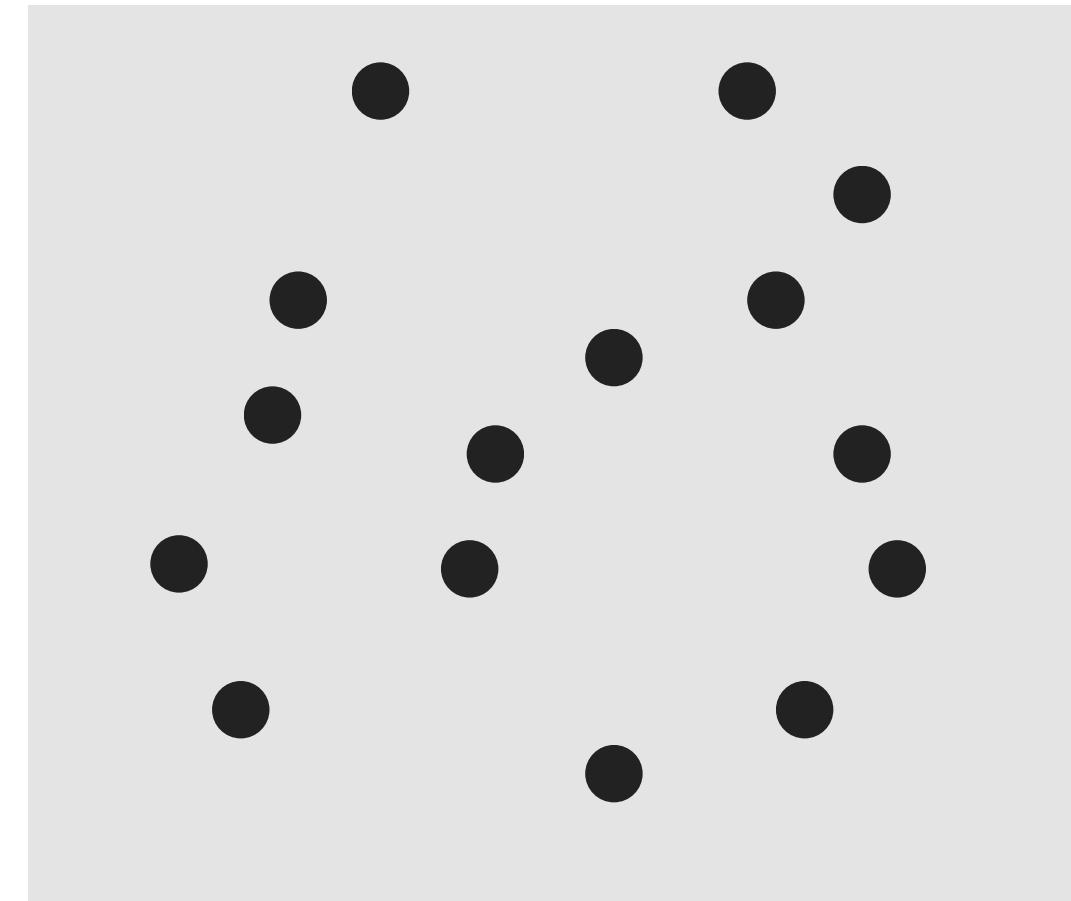
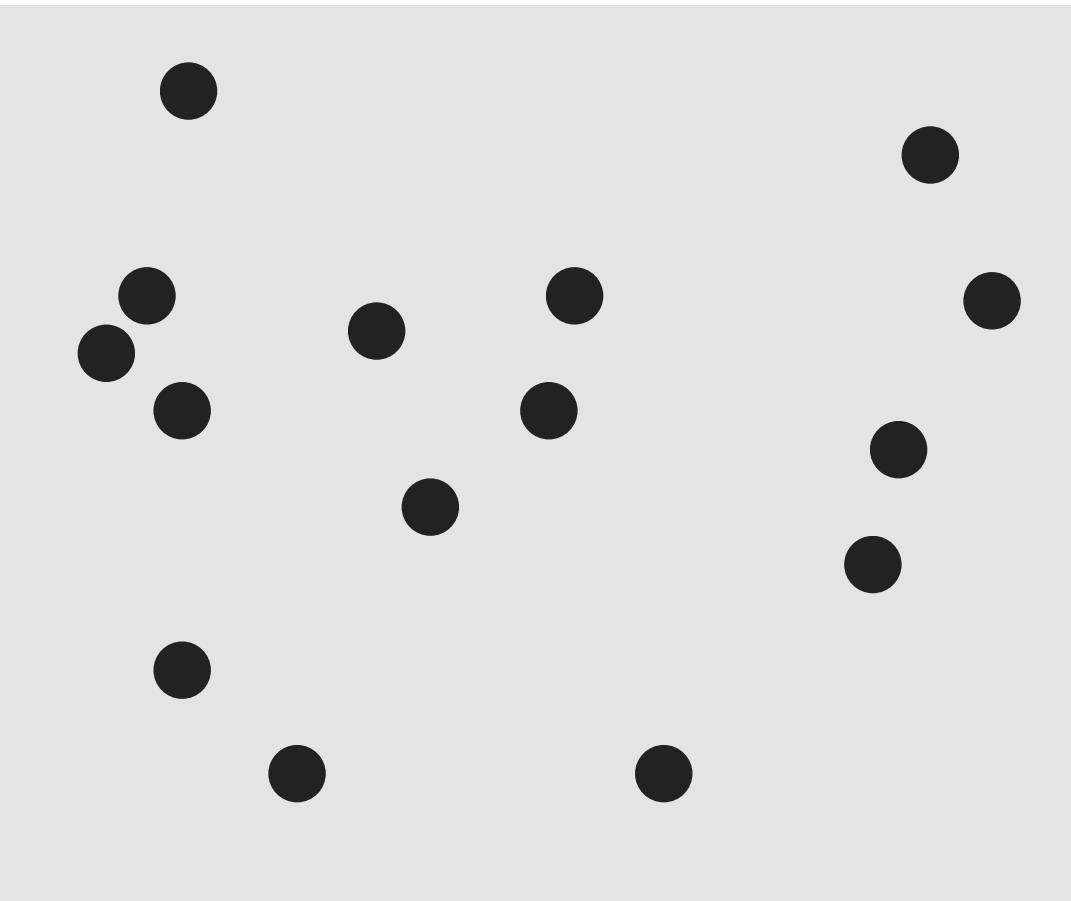


Basic Popout Channels

Spatial Grouping

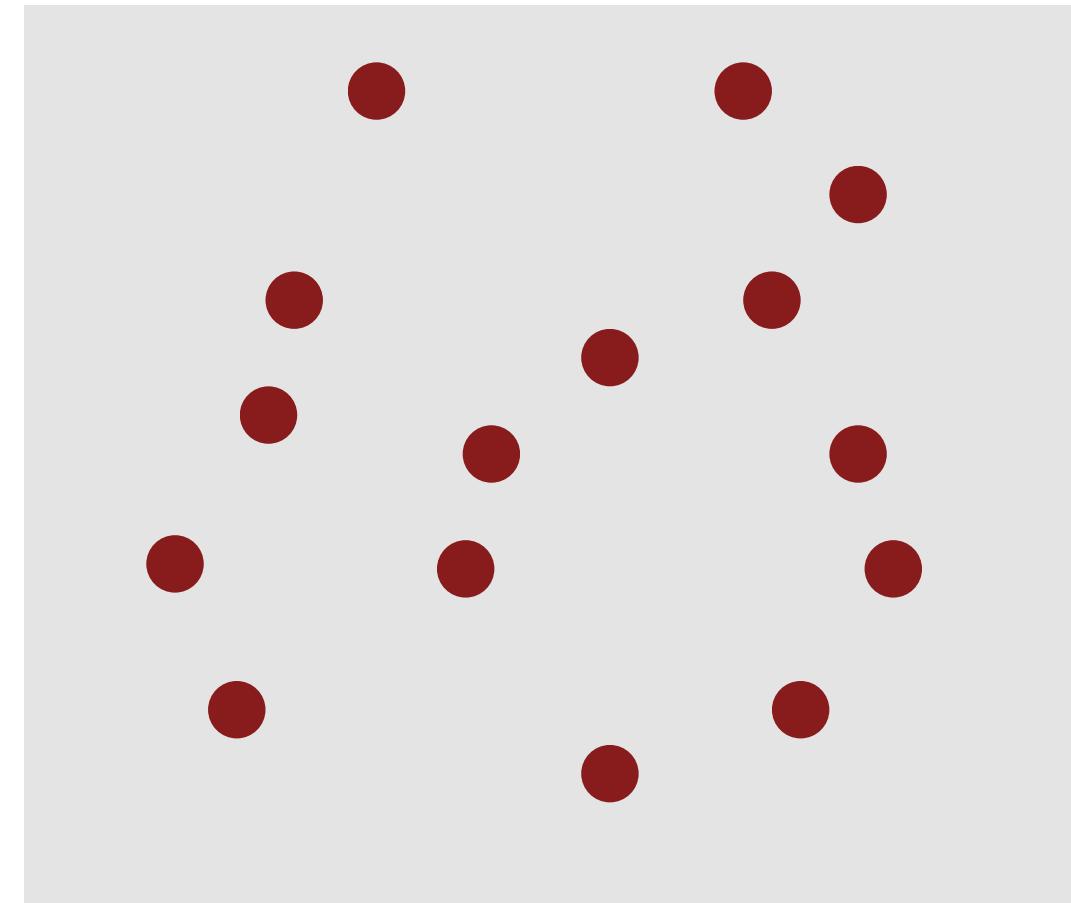
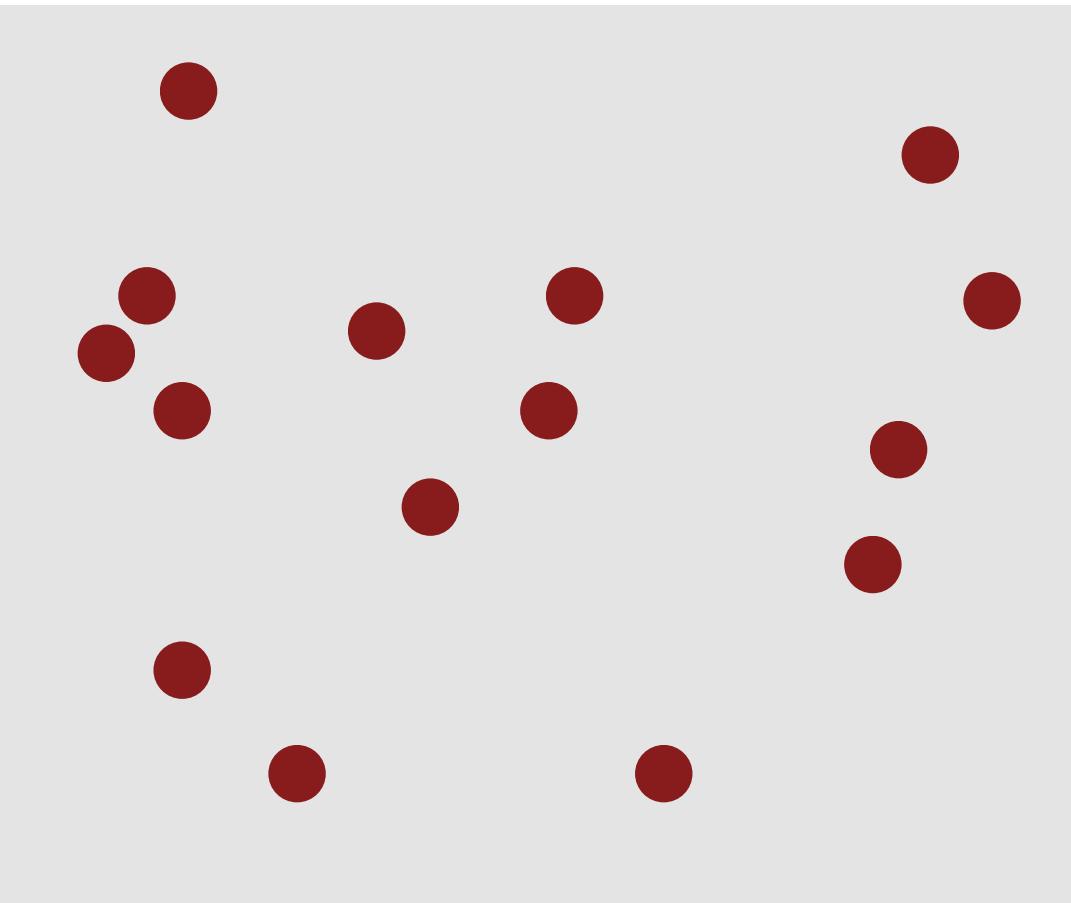


Pick The Outlier



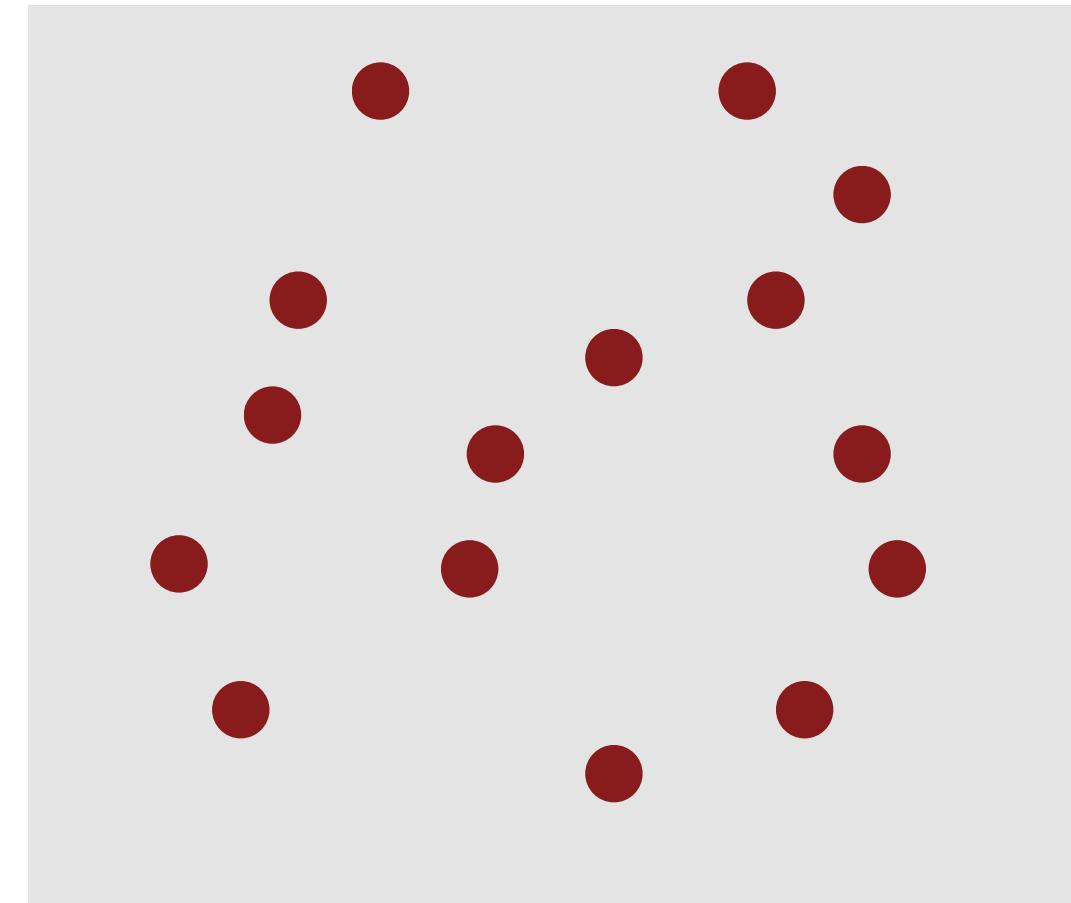
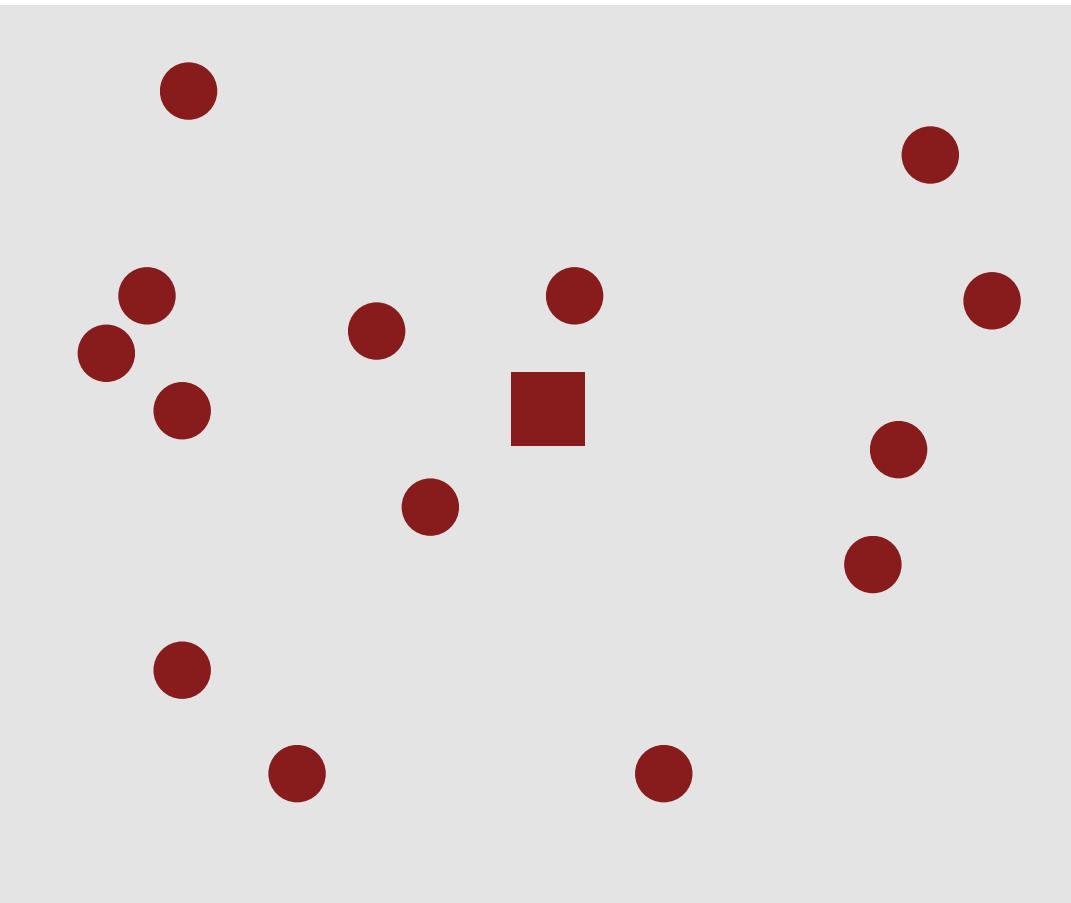
Pick The Outlier

Pick The Outlier



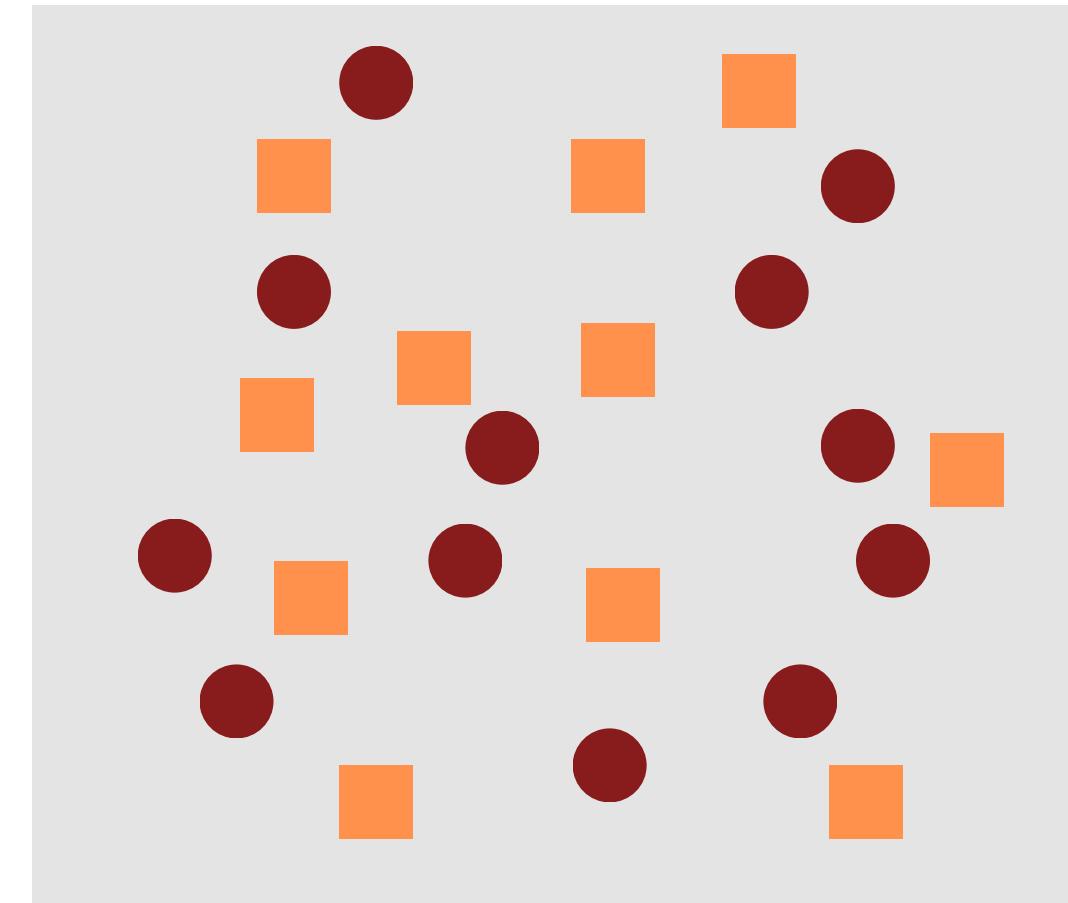
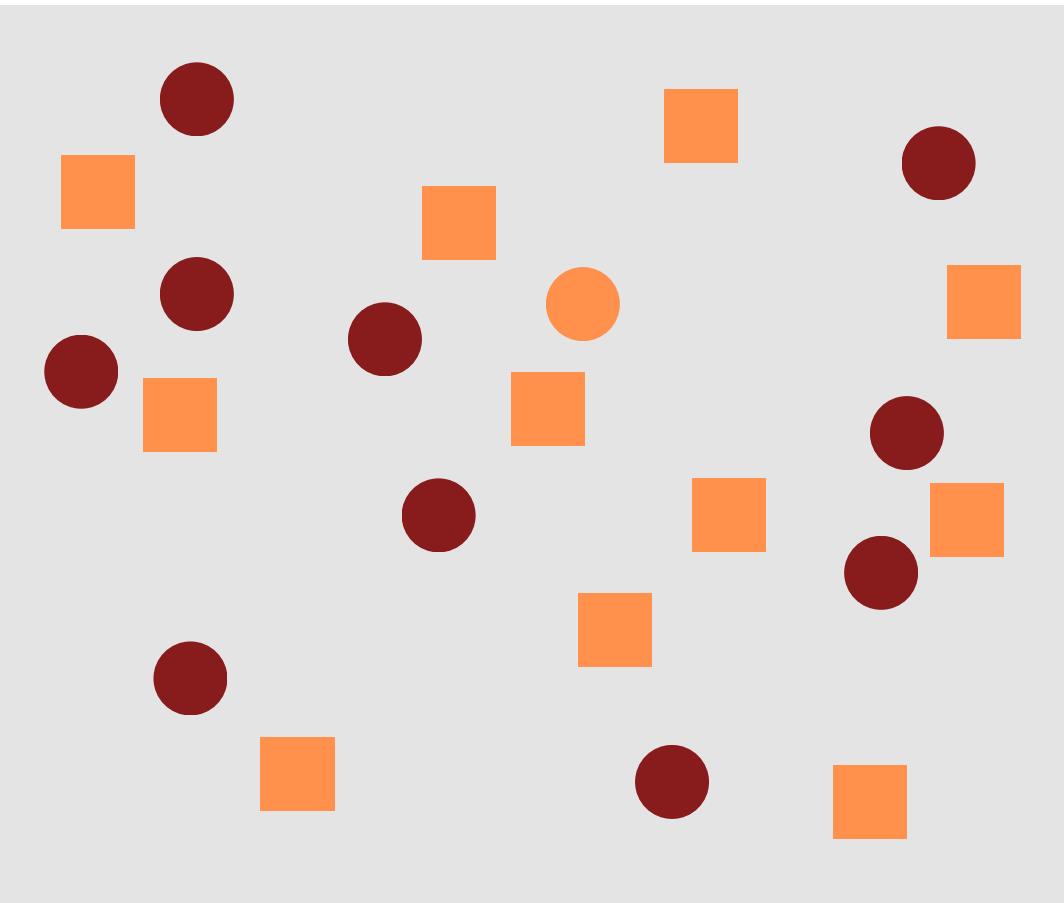
Pick The Outlier

Pick The Outlier



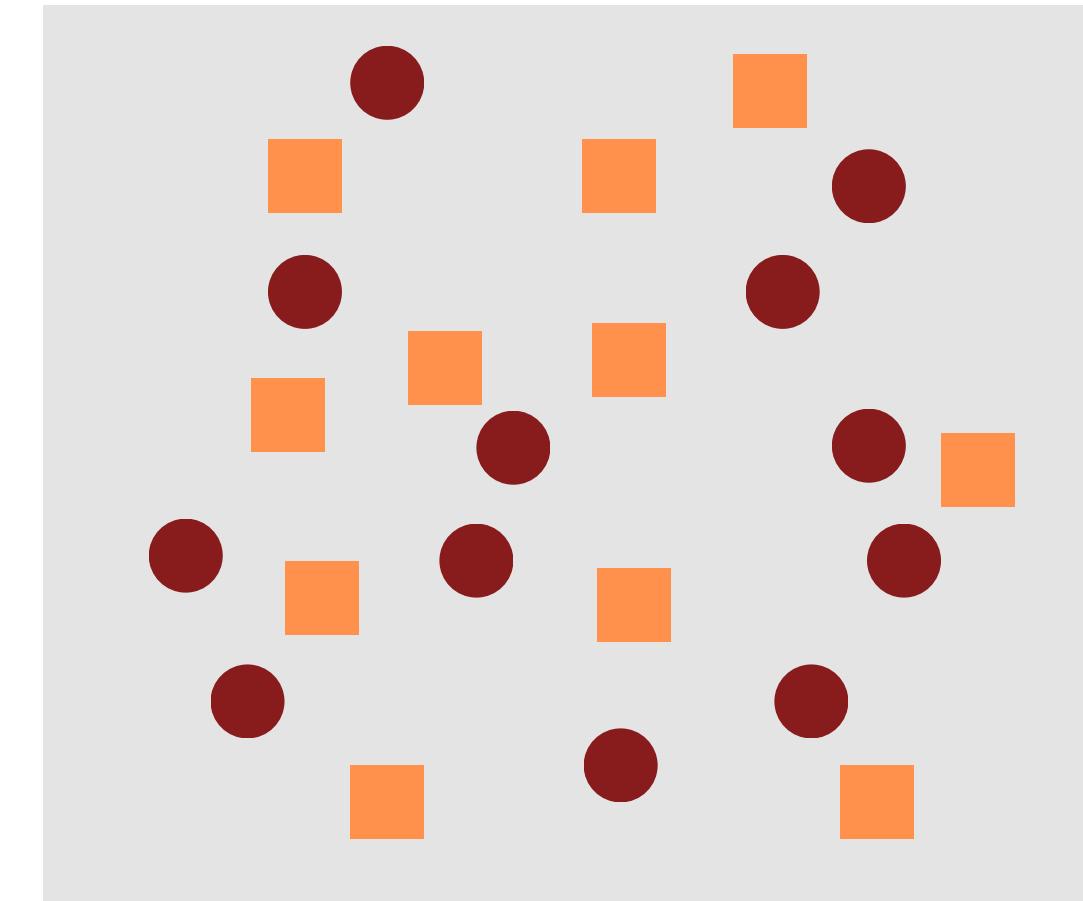
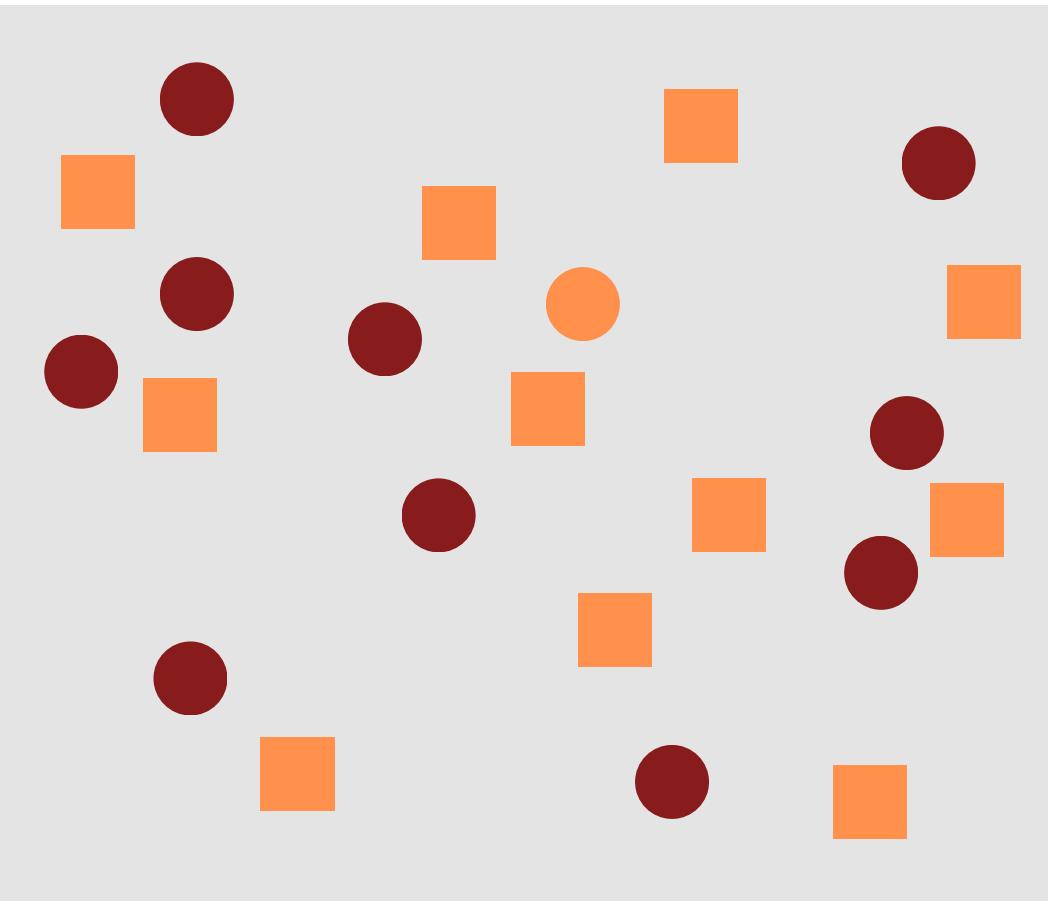
Pick The Outlier

Pick The Outlier

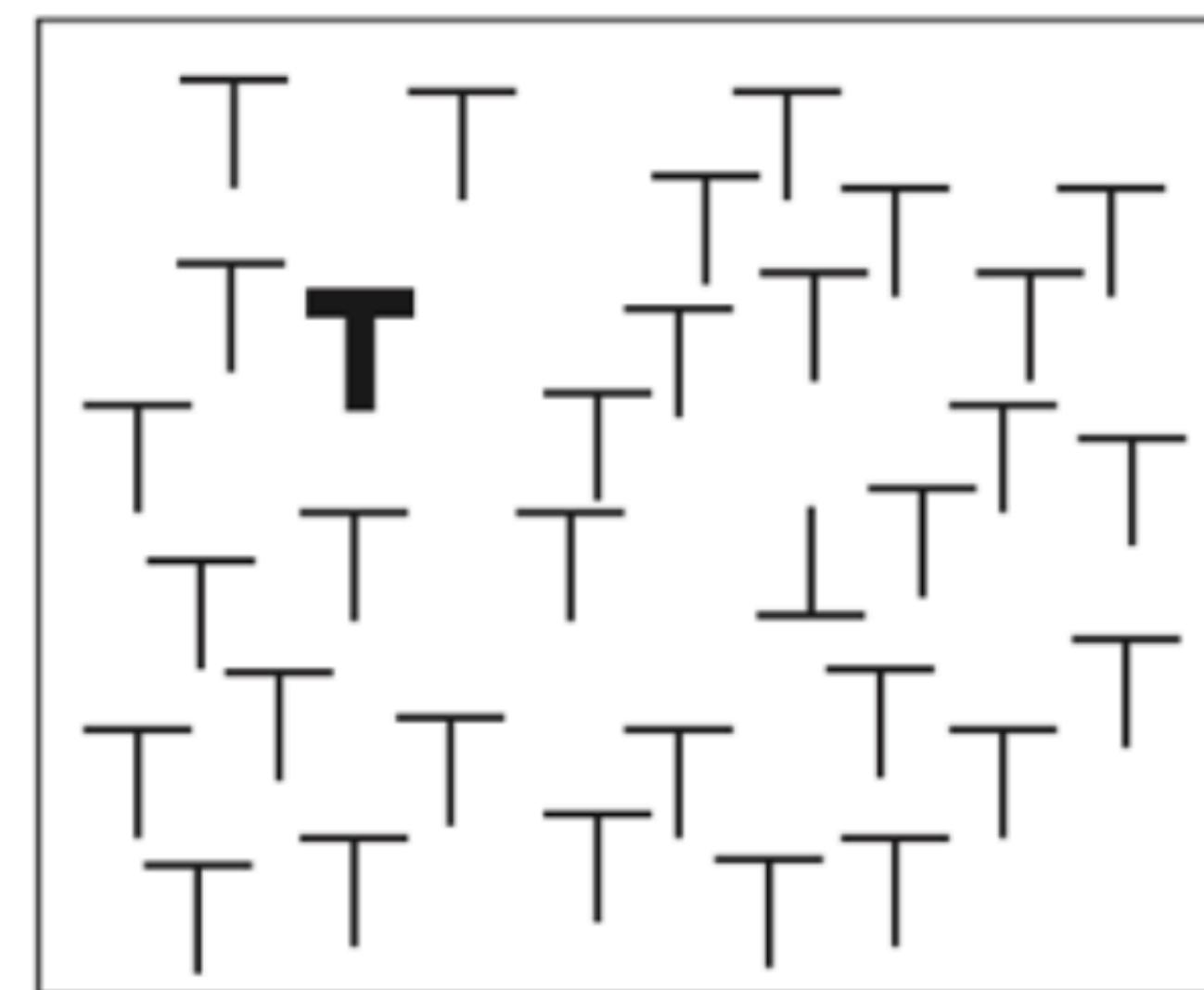


Conjunction

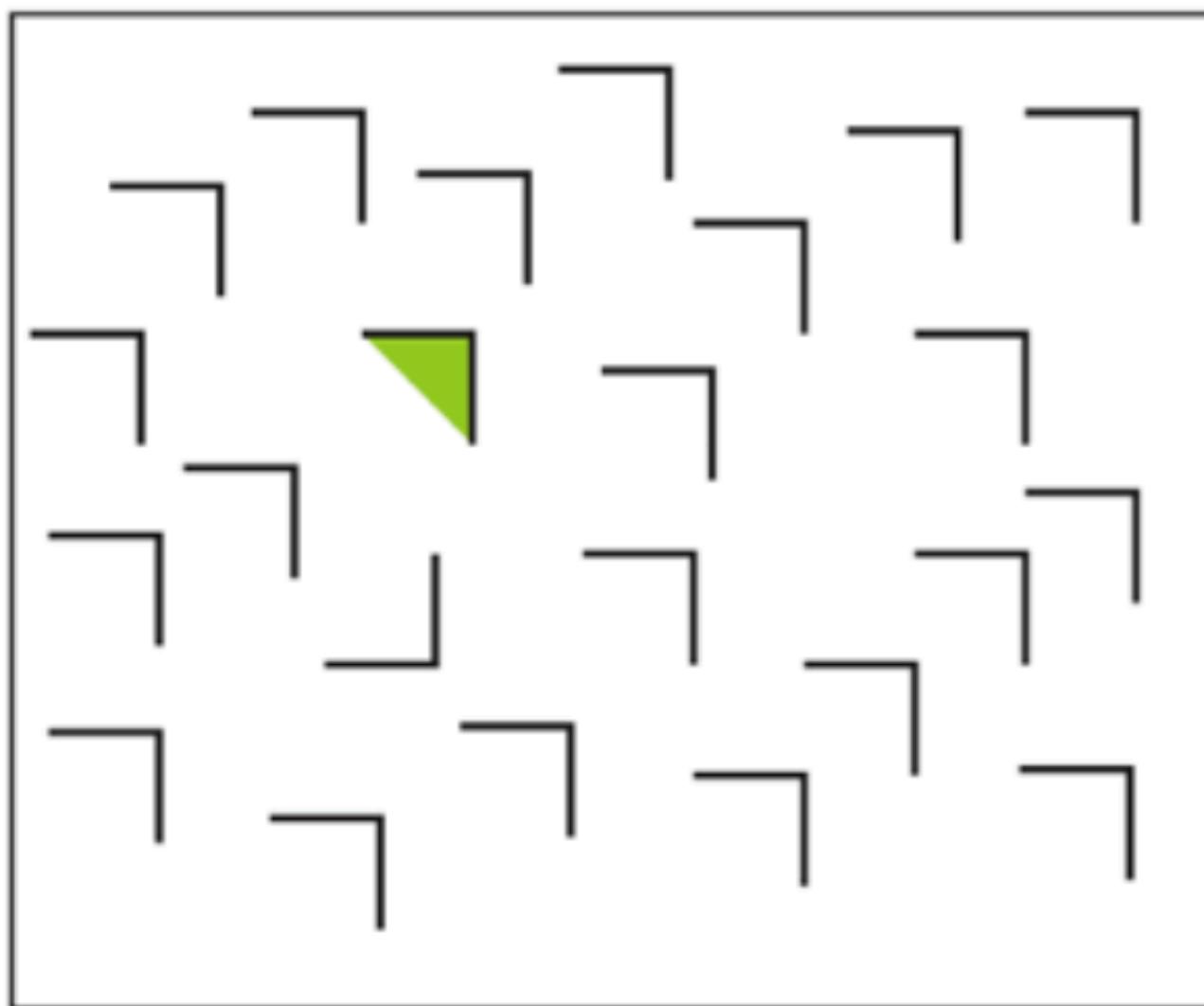
(or, why to use a single channel at a time)



\perp
difficult
T
easy

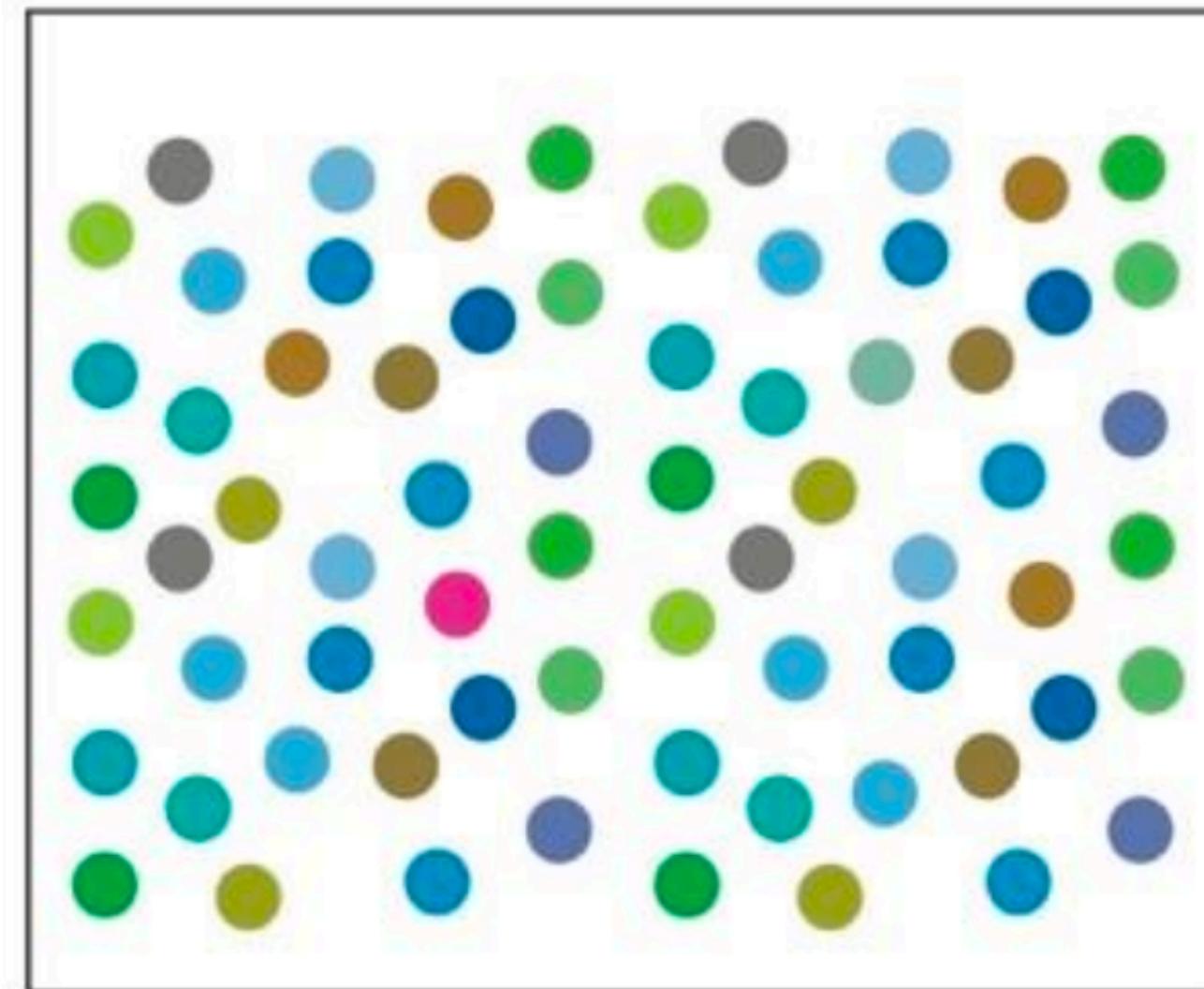


 difficult
 easy



difficult

easy



We can easily see objects that are different in color and/or shape, or that are in motion

Use color and shape sparingly to make the important information pop out.

Gestalt Principles

“Gestalt” (from German, meaning form)

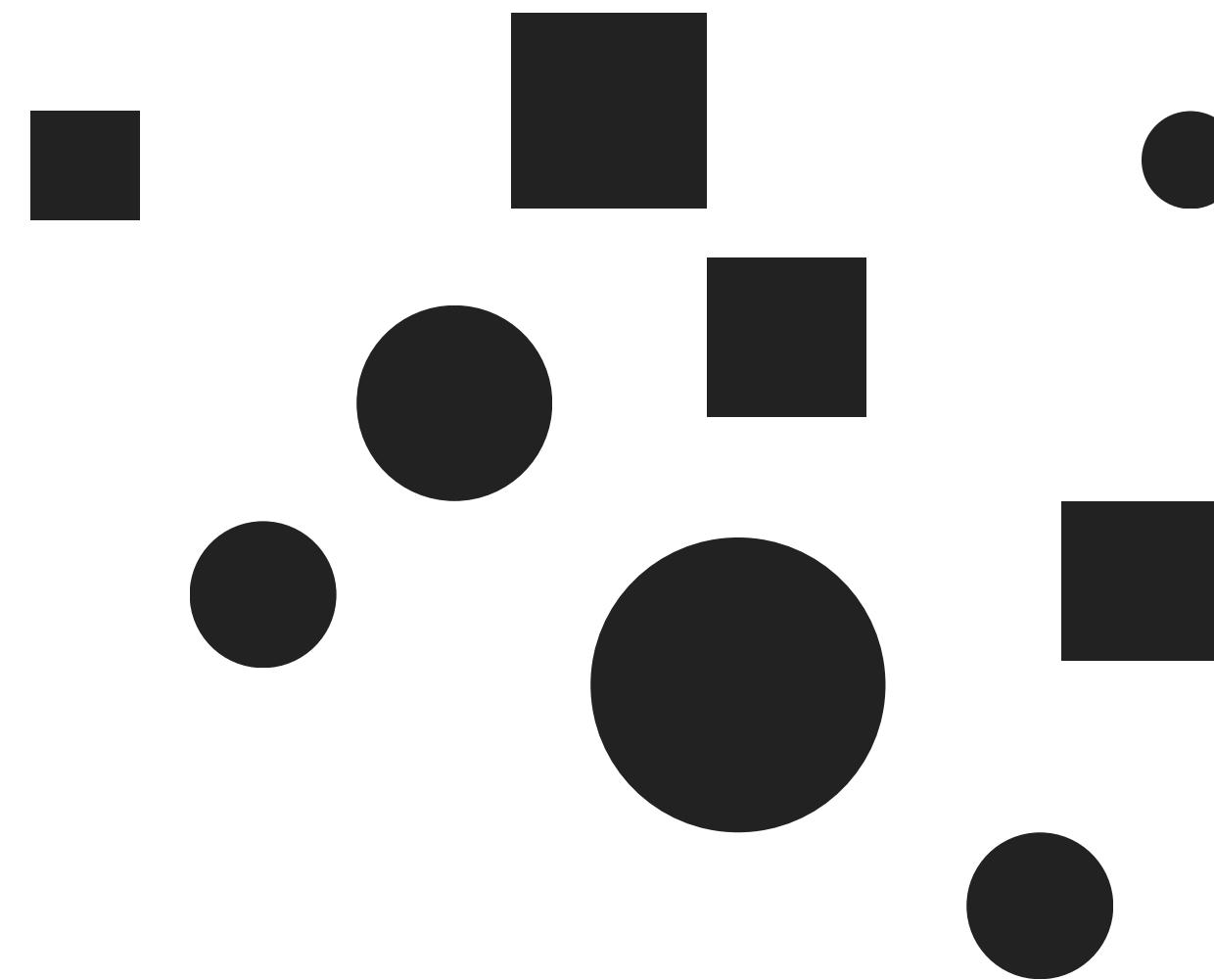
patterns transcend the visual stimuli that produced them

7 principles:

- similarity
- proximity
- connectedness
- continuity
- closure
- figure/ground
- common fate

Gestalt Principle: **Similarity**

We perceive things that look alike (in size, color, shape) as related



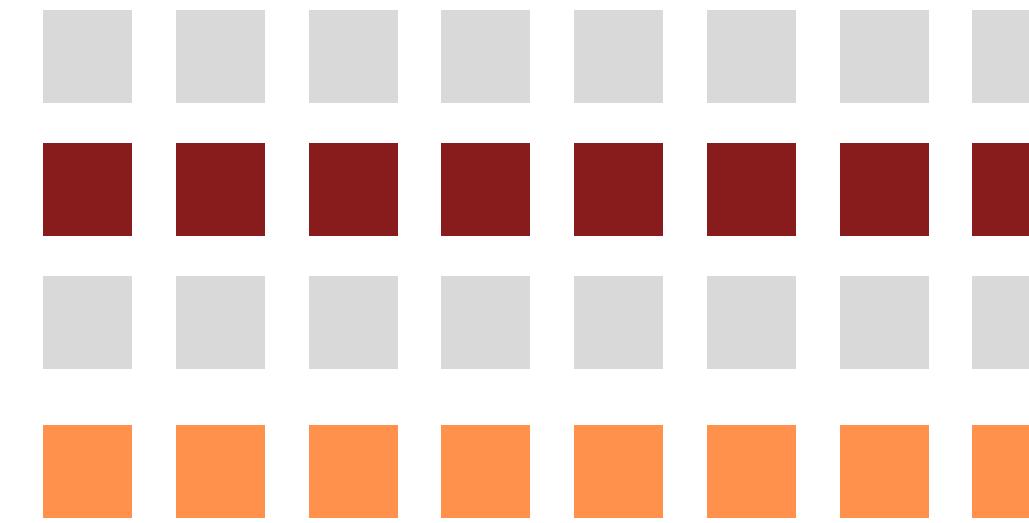
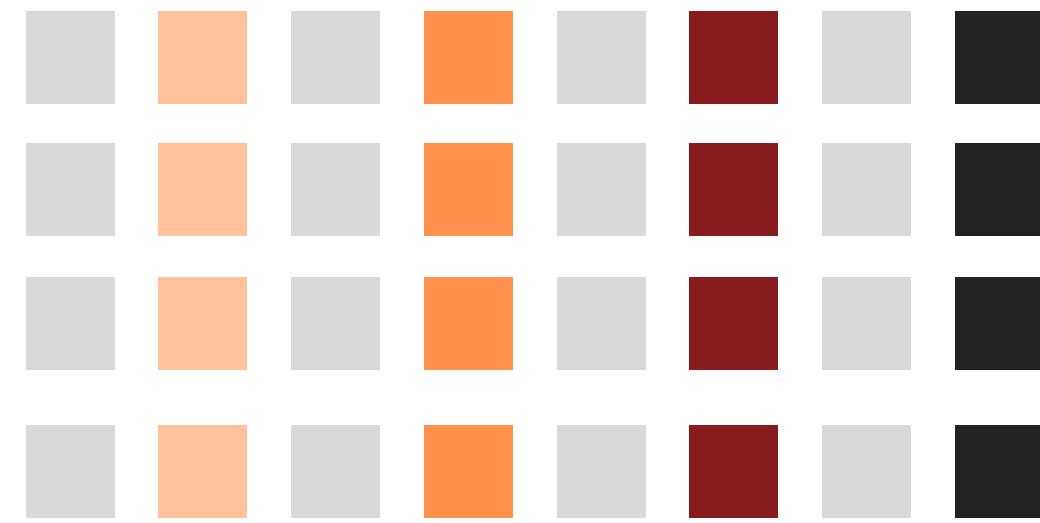
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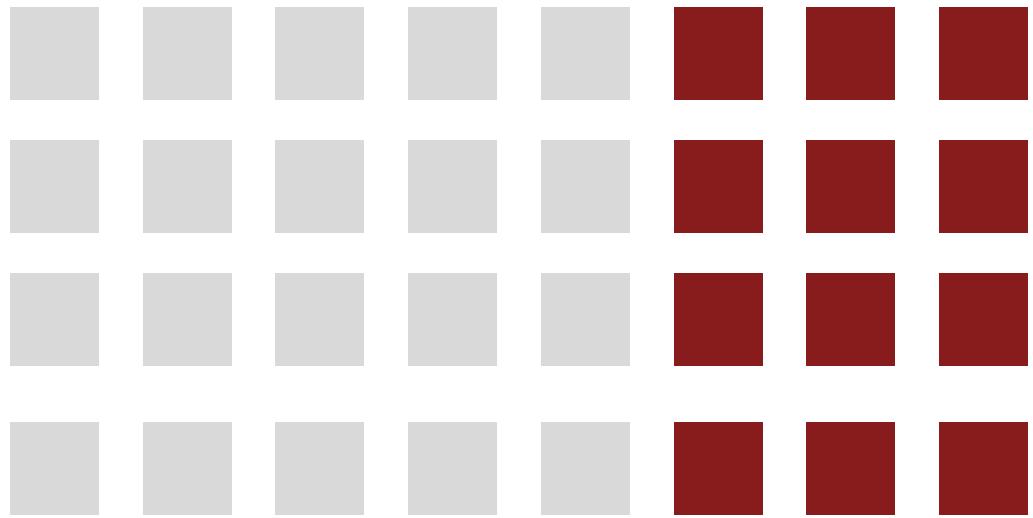
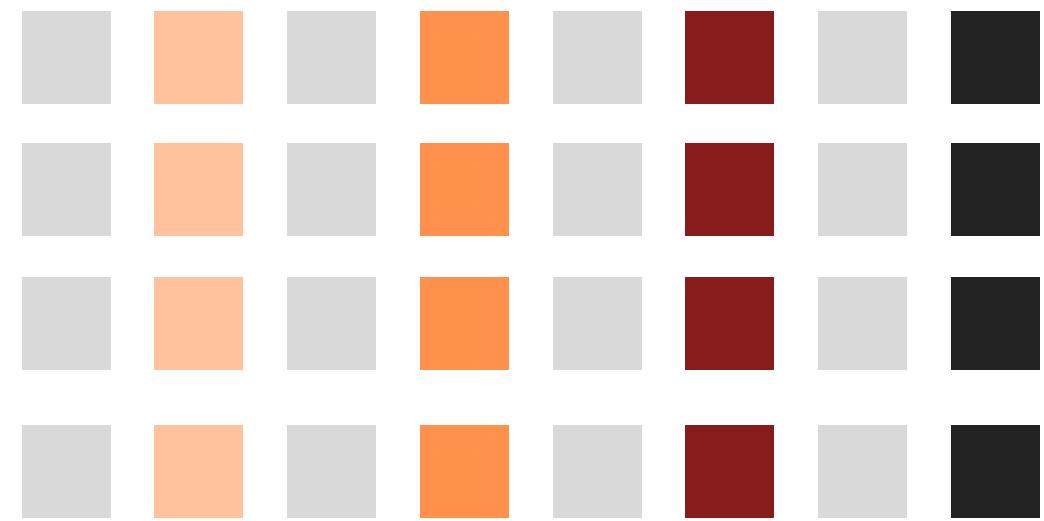
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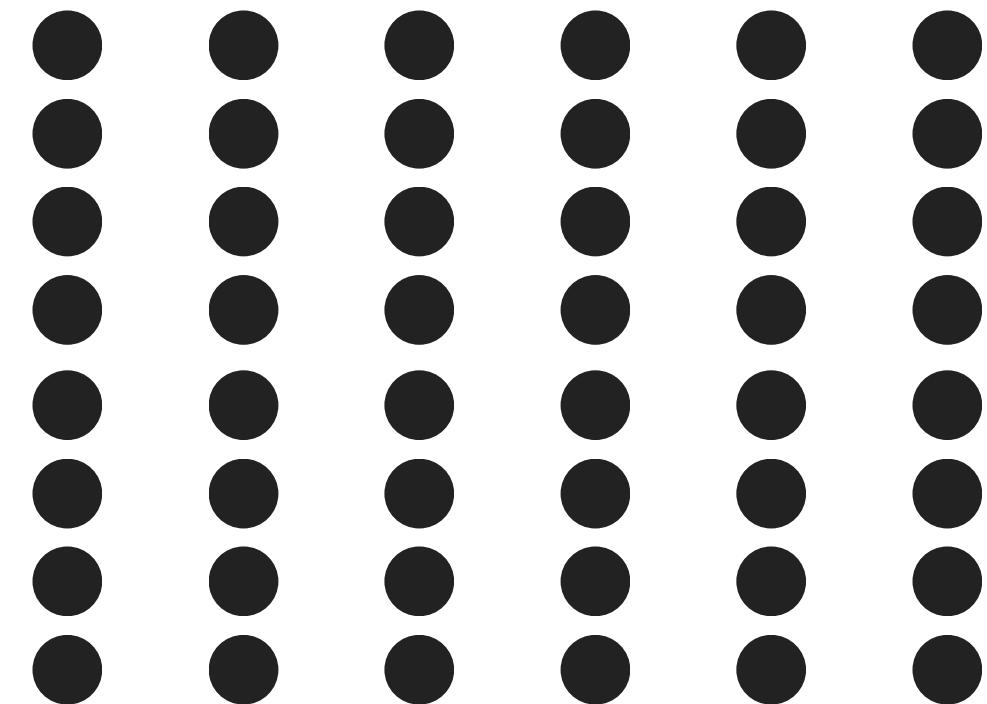
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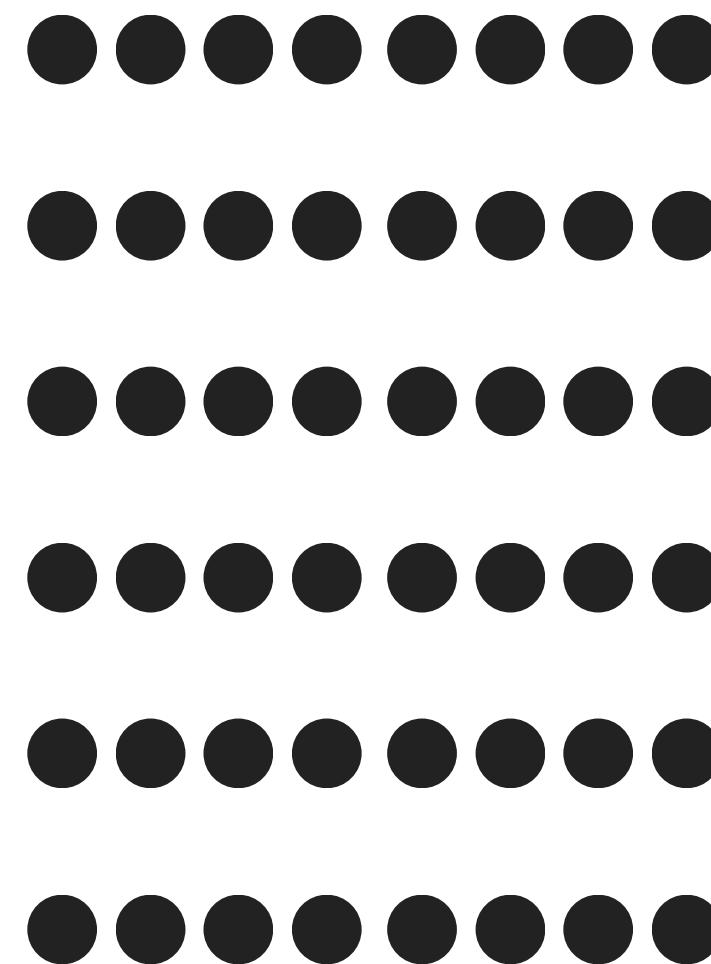
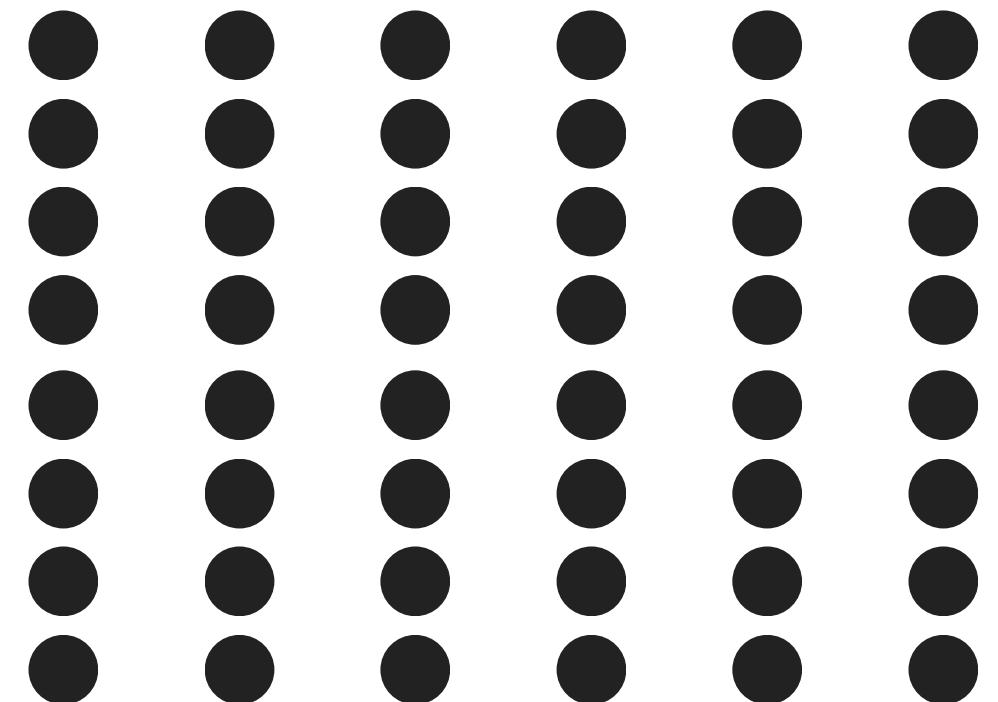
Gestalt Principle: Proximity

We perceive things that are visually close to each other as related



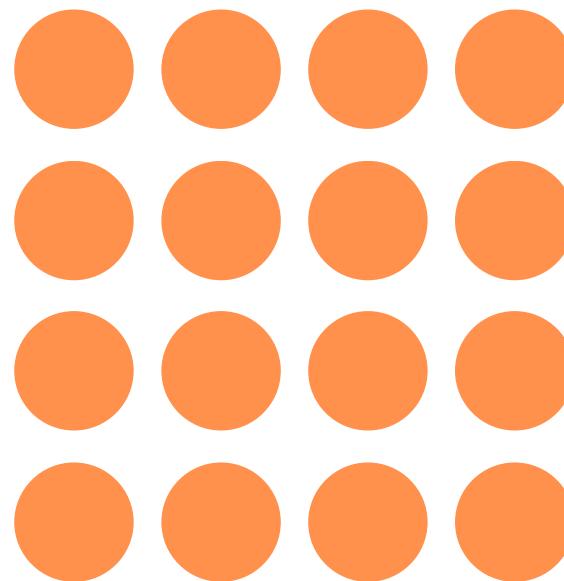
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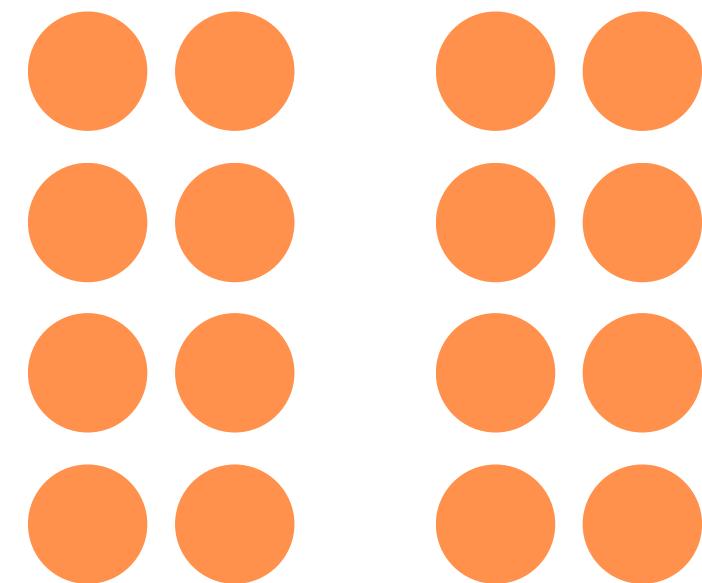
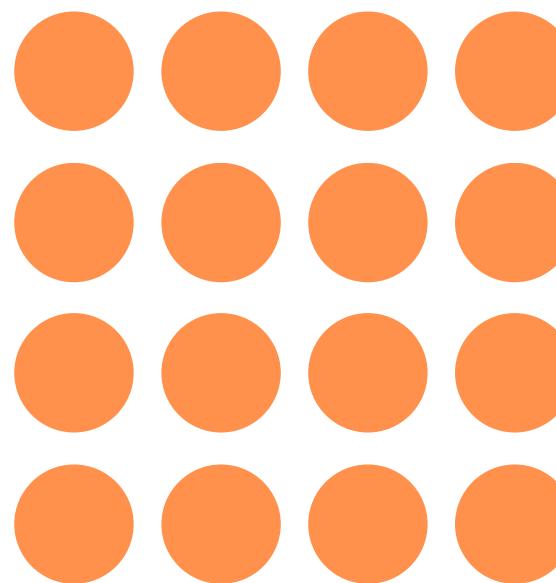
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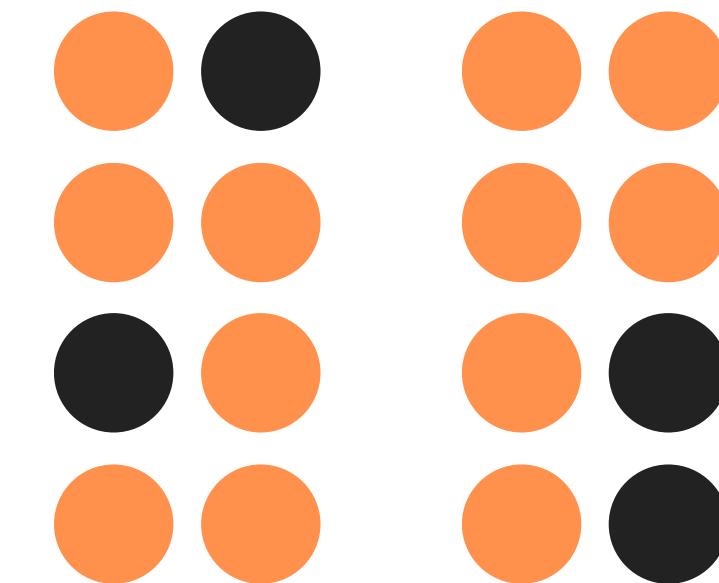
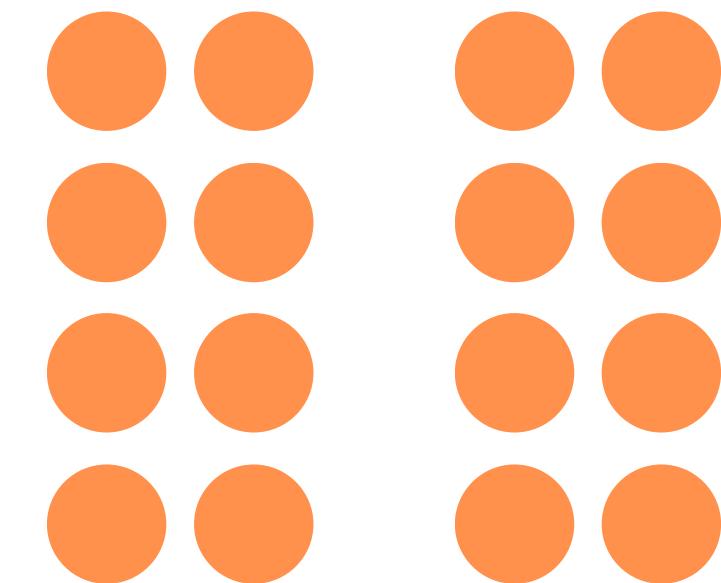
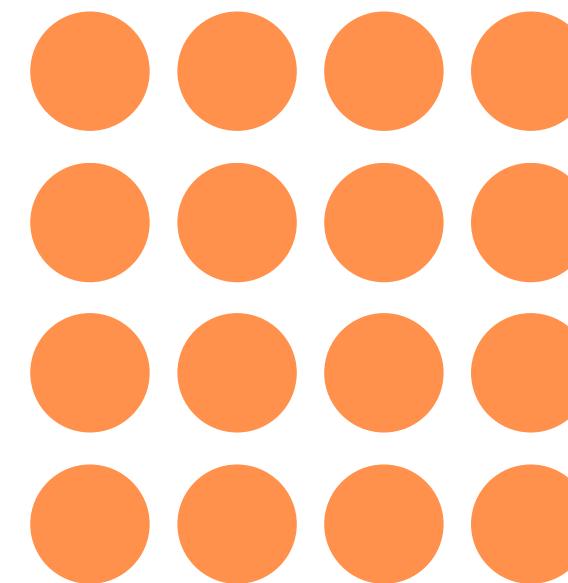
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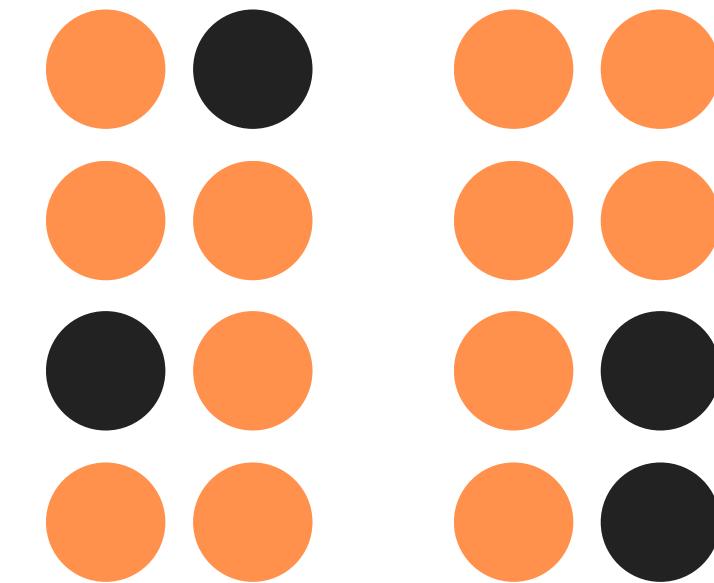
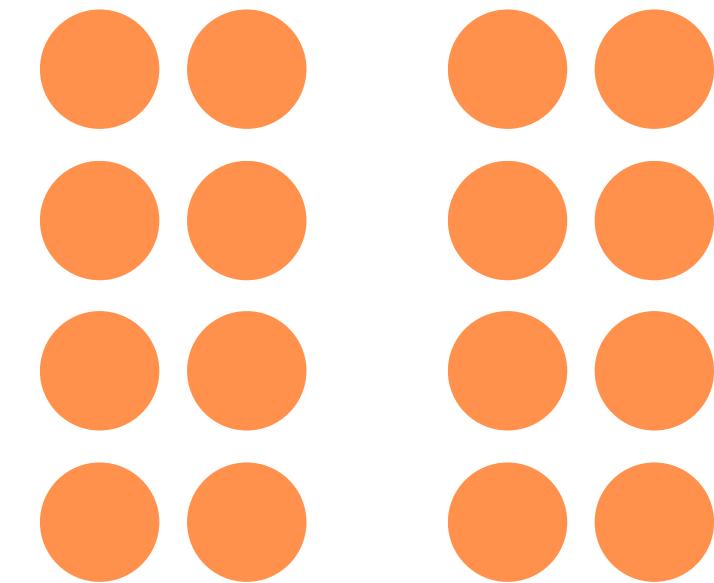
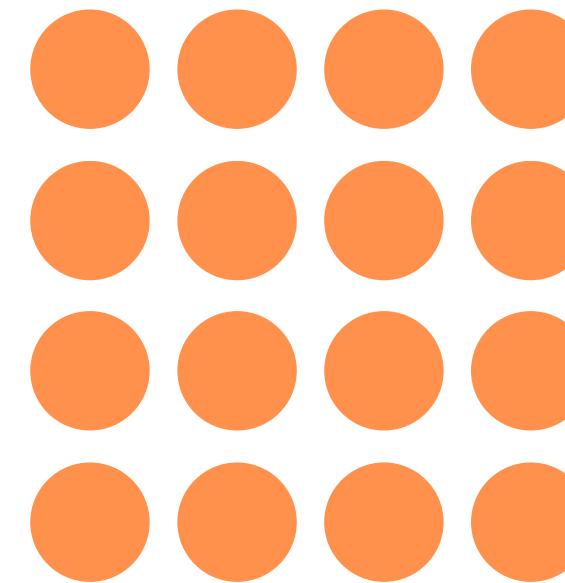
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We perceive things that are visually close to each other as related



Gestalt Principle: Proximity

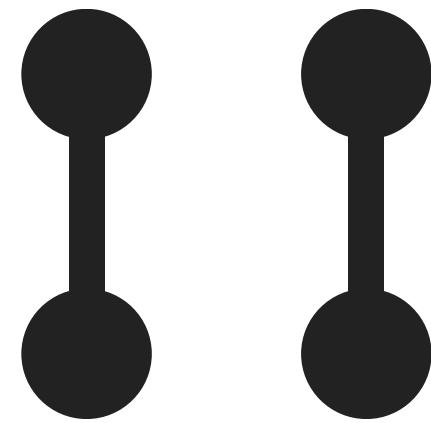
We perceive things that are visually close to each other as related



More powerful than similarity

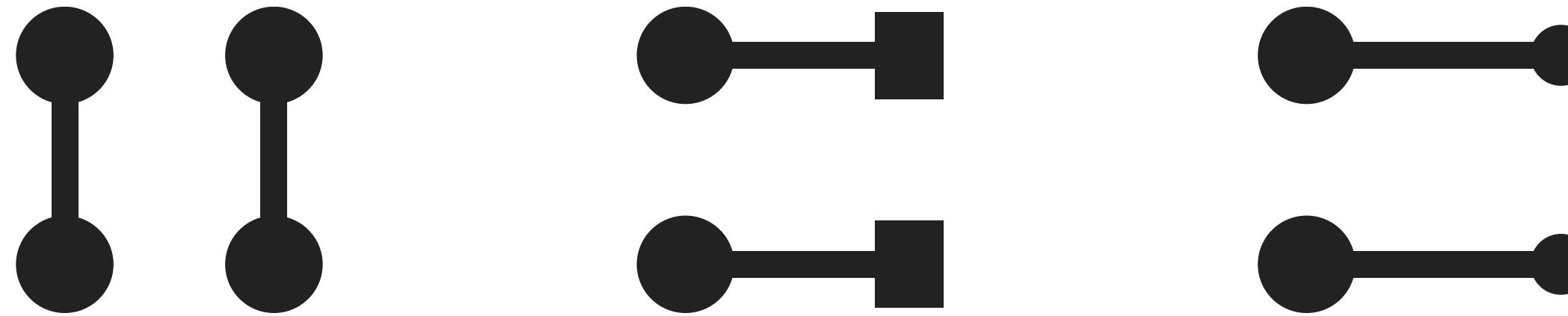
Gestalt Principle: Connectedness

We perceive things that **are visually connected** as related



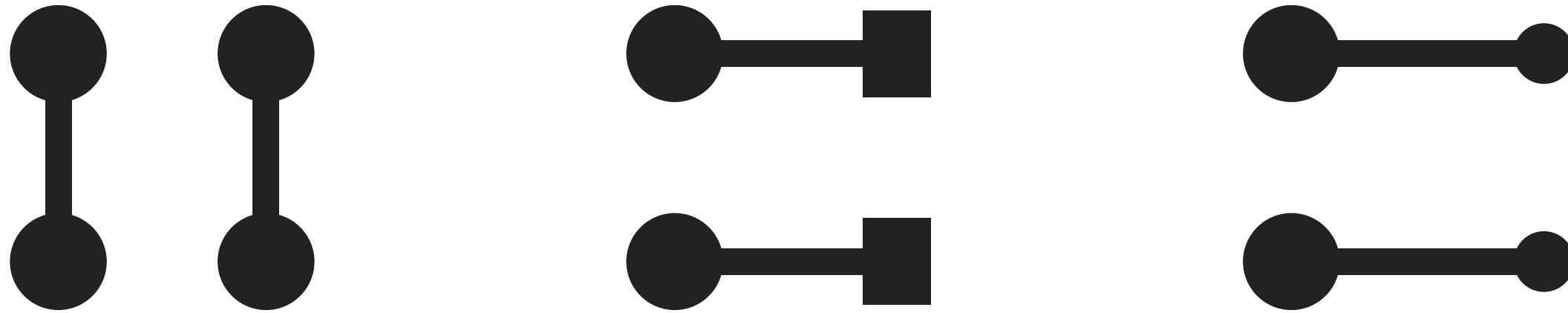
Gestalt Principle: Connectedness

We perceive things that **are visually connected** as related



Gestalt Principle: Connectedness

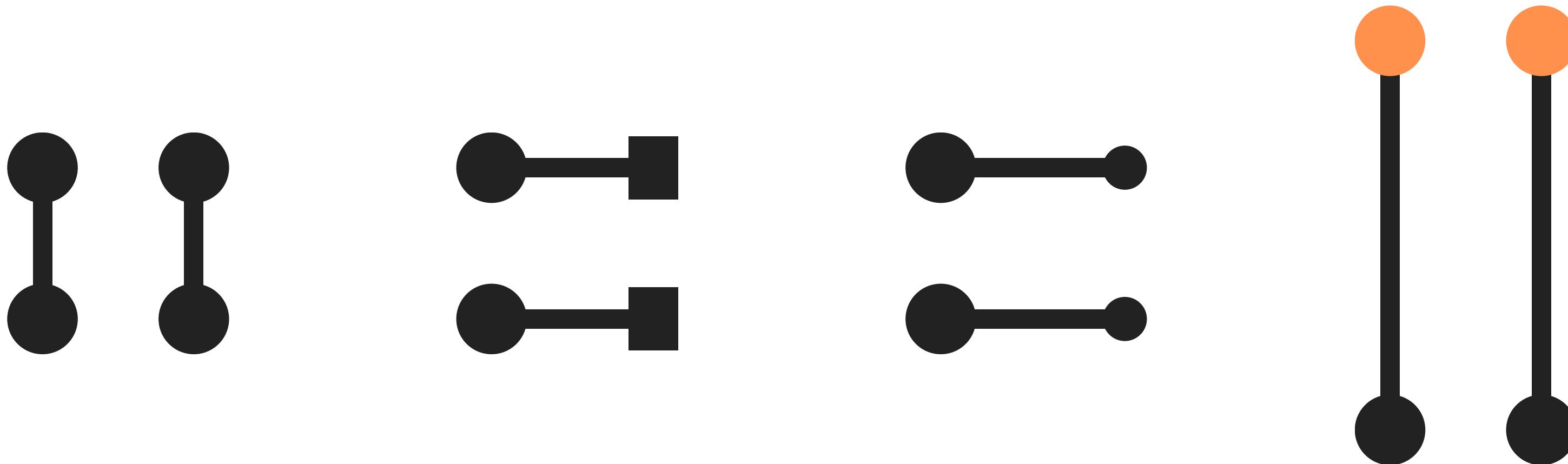
We perceive things that **are visually connected** as related



More powerful than similarity

Gestalt Principle: Connectedness

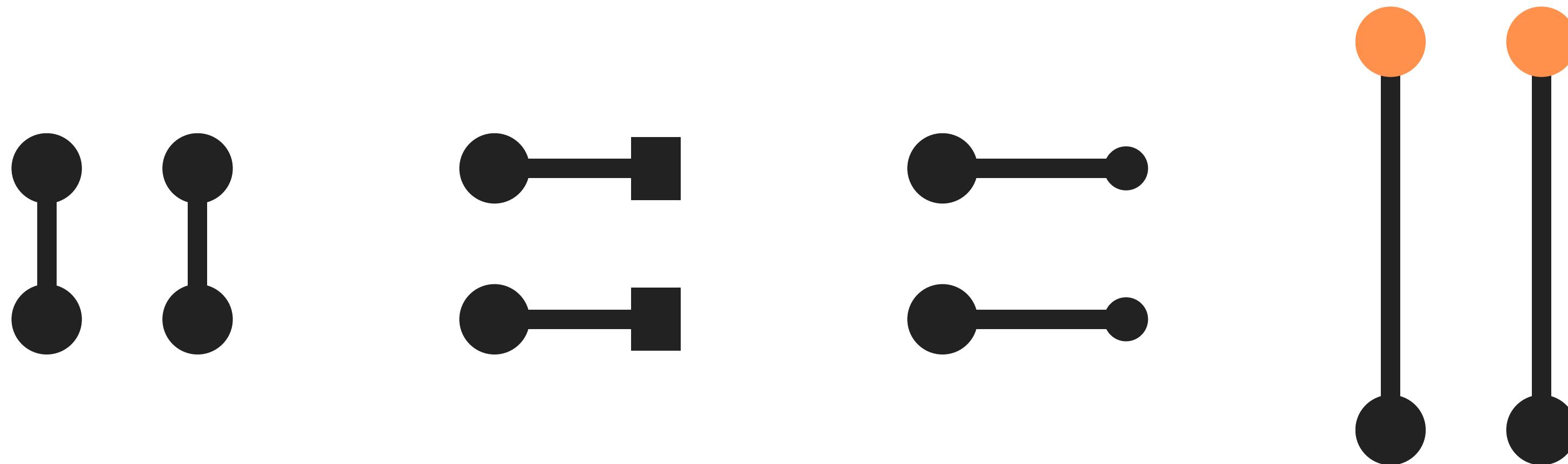
We perceive things that **are visually connected** as related



More powerful than similarity

Gestalt Principle: Connectedness

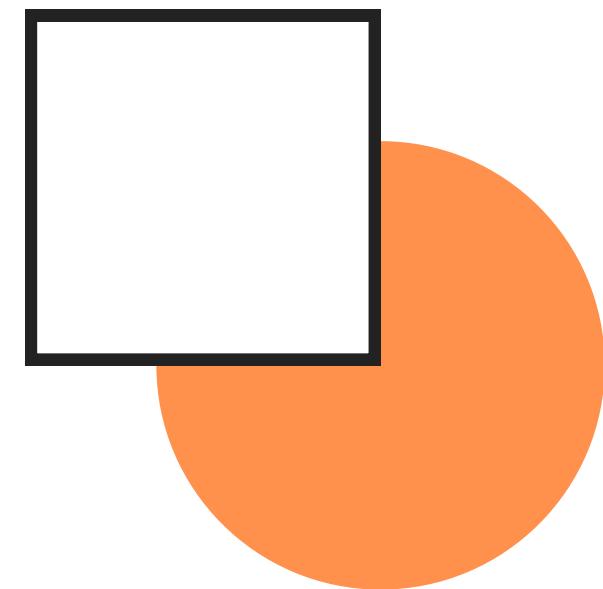
We perceive things that **are visually connected** as related



More powerful than similarity and proximity

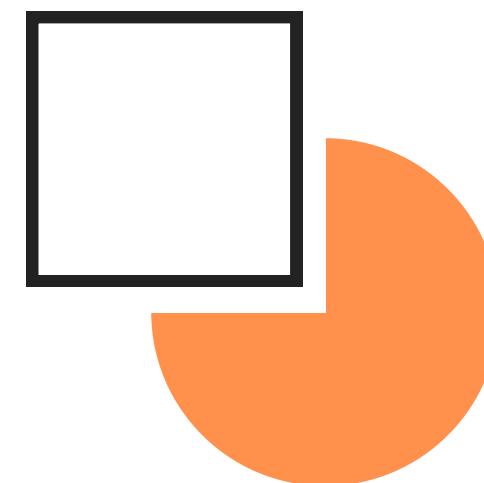
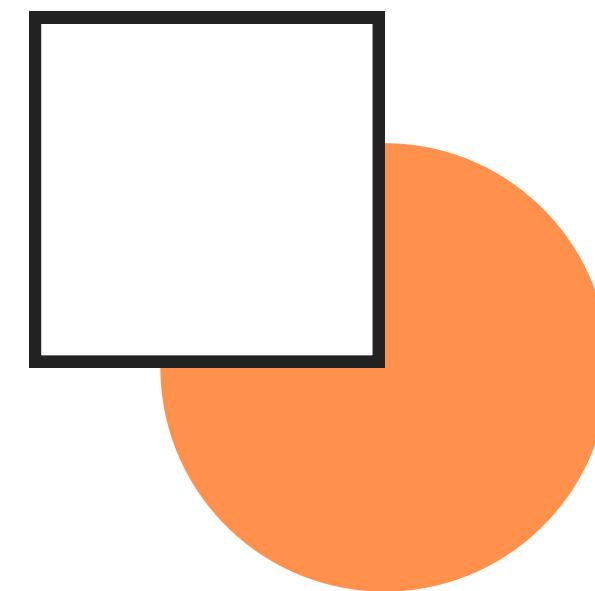
Gestalt Principle: Continuity

We complete hidden objects into simple, familiar shapes



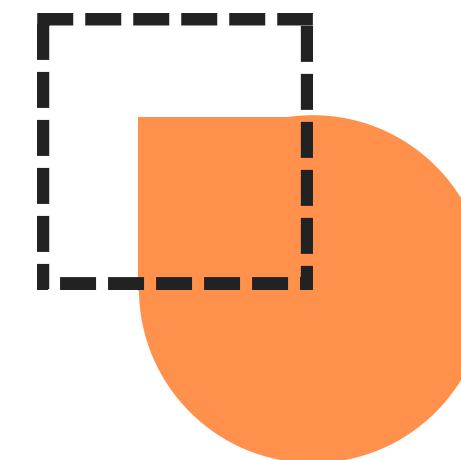
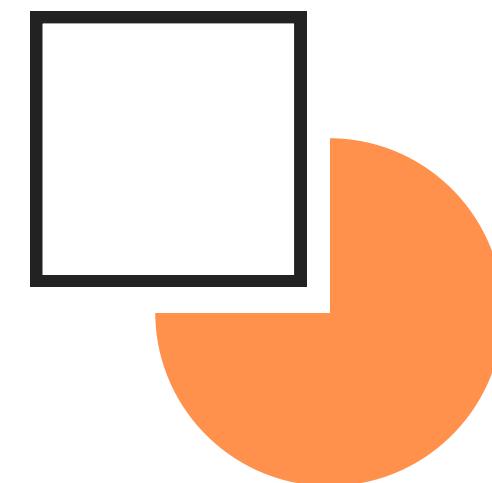
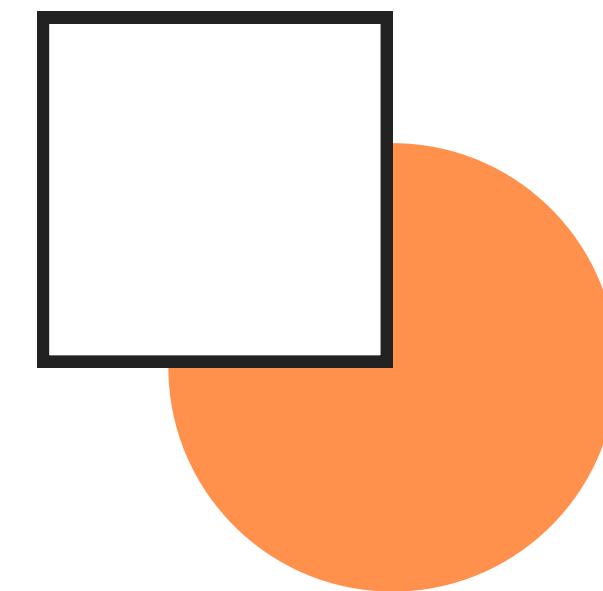
Gestalt Principle: Continuity

We complete hidden objects into simple, familiar shapes



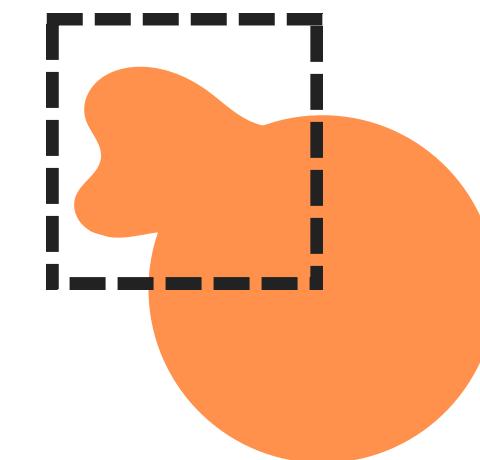
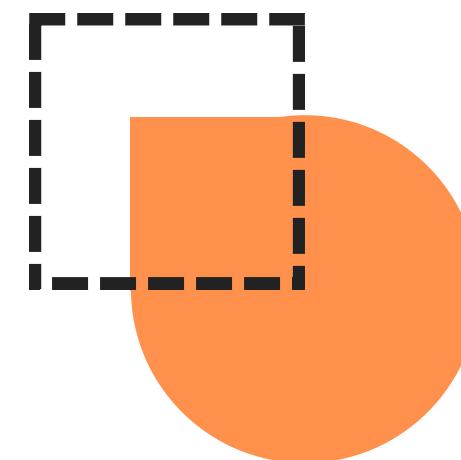
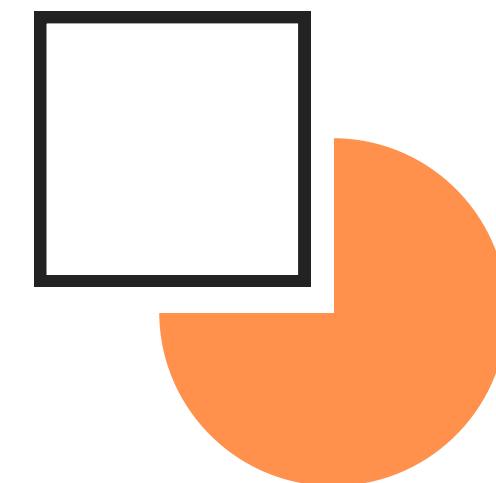
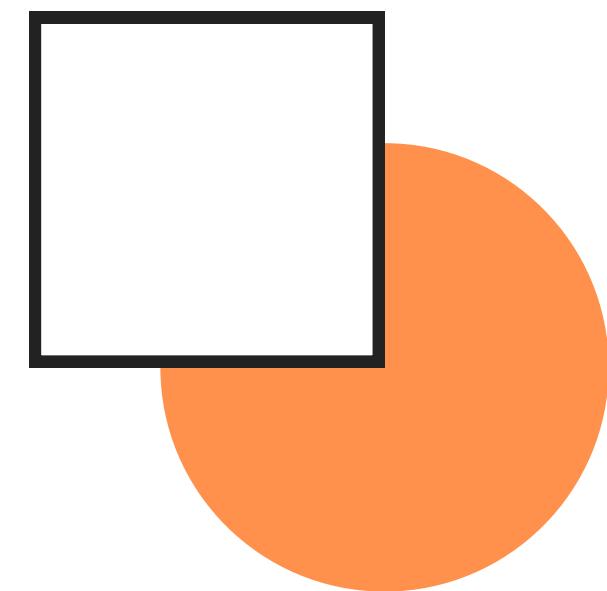
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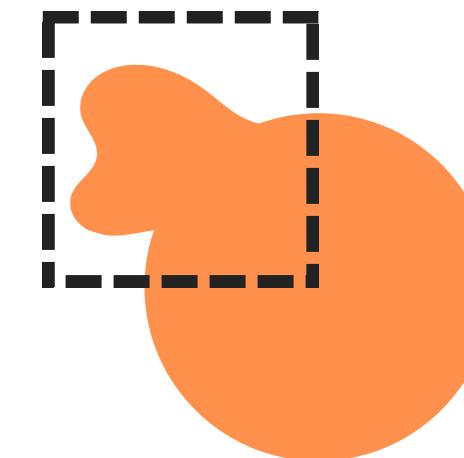
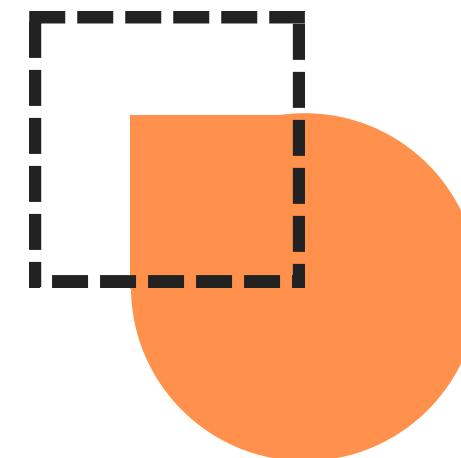
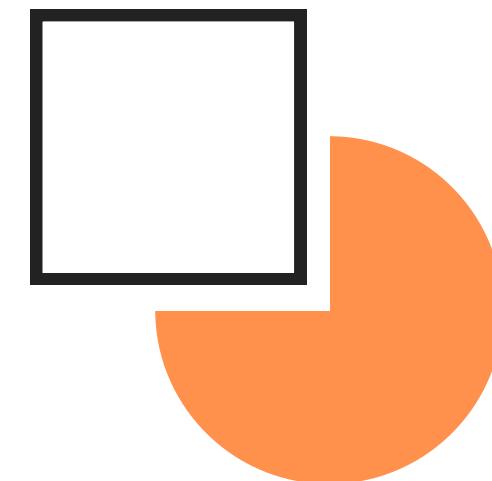
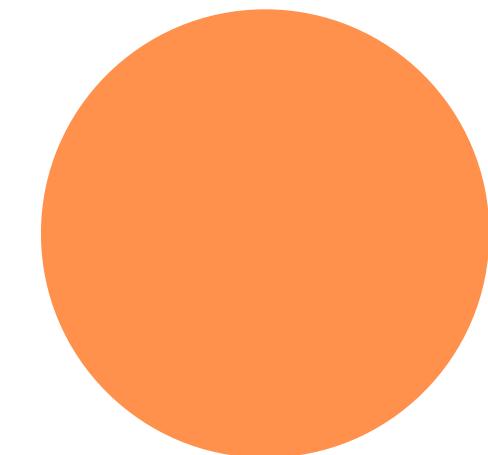
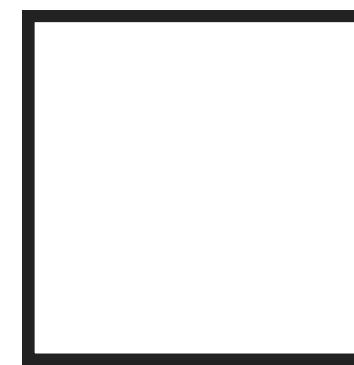
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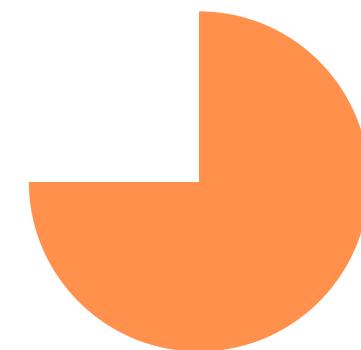
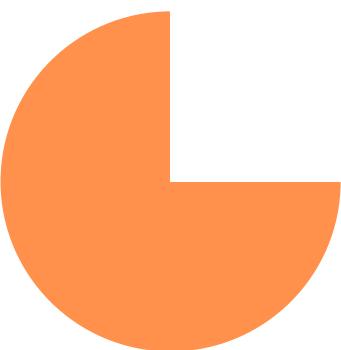
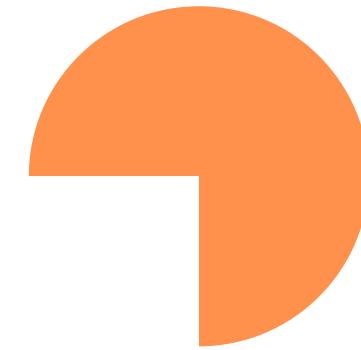
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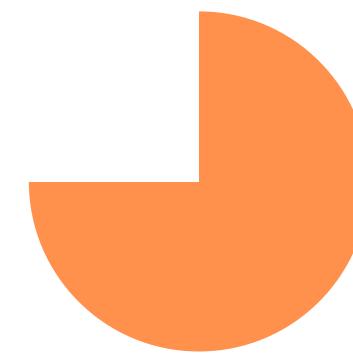
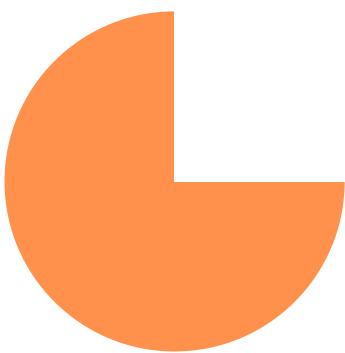
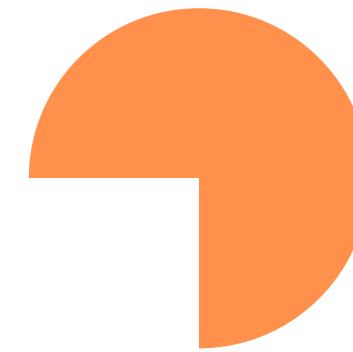
Gestalt Principle: Closure

We see incomplete shapes as complete



Gestalt Principle: Closure

We see incomplete shapes as complete



Gestalt Principle: Closure

We see incomplete shapes as complete



Gestalt Principle: Closure

We see incomplete shapes as complete



Gestalt Principle: Closure

We see incomplete shapes as complete



Gestalt Principle: Figure / Ground

Visual elements are perceived as either figures or background



Gestalt Principle: Figure / Ground

Visual elements are perceived as either figures or background



Gestalt Principle: Figure / Ground

Visual elements are perceived as either figures or background



Gestalt Principle: Figure / Ground

Visual elements are perceived as either figures or background



Gestalt Principle: Figure / Ground

Visual elements are perceived as either figures or background



Gestalt Principle: Common Fate

Visual elements that move in the same direction
are perceived as a unit



Gestalt Principle: Common Fate

Visual elements that move in the same direction
are perceived as a unit



Gestalt Principle: Common Fate

Visual elements that move in the same direction
are perceived as a unit



Gestalt Principle: Common Fate

Visual elements that move in the same direction
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Gestalt Principles

“Gestalt” (from German, meaning form)

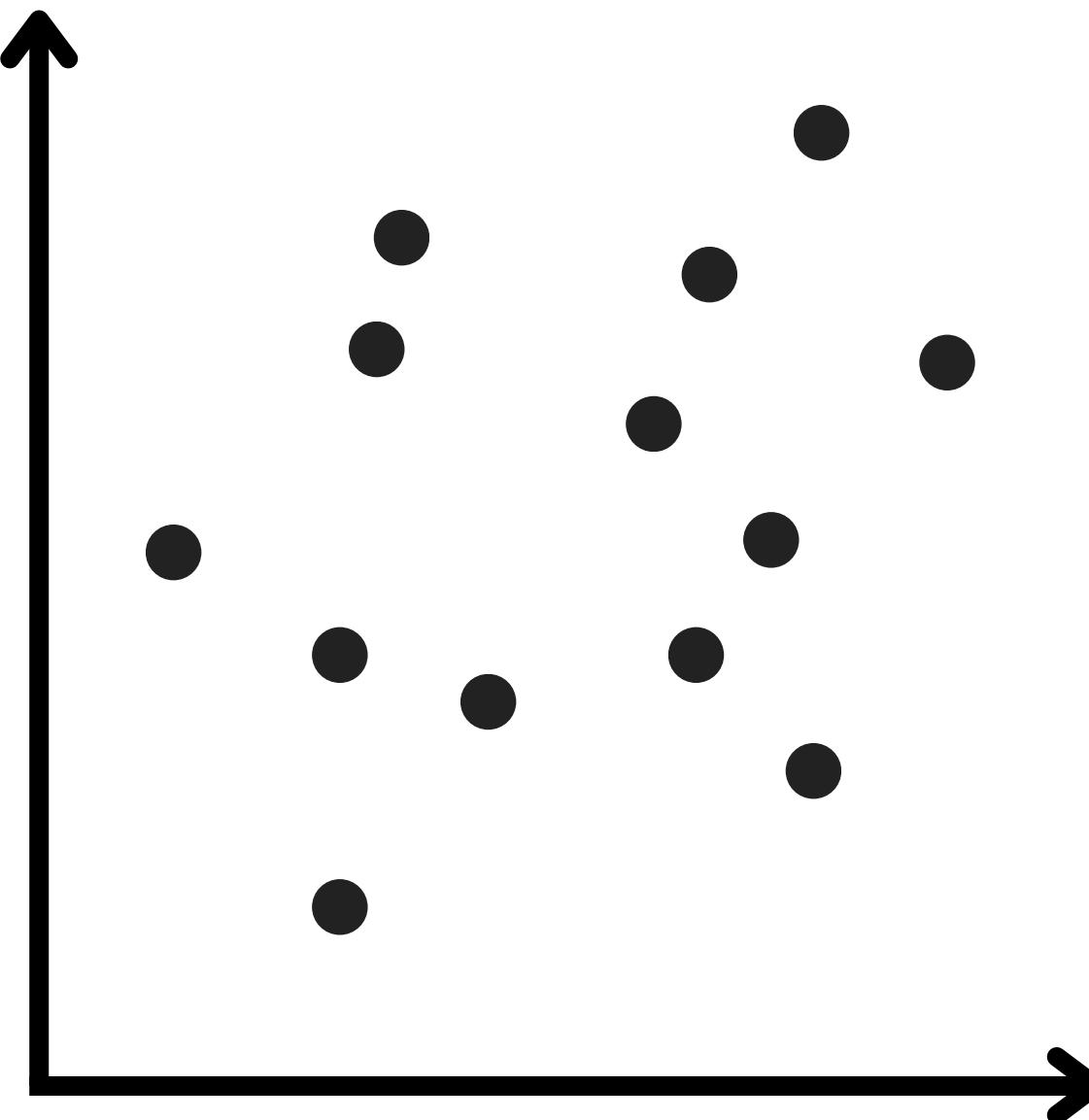
patterns transcend the visual stimuli that produced them

7 principles:

- similarity
- proximity
- connectedness
- continuity
- closure
- figure/ground
- common fate

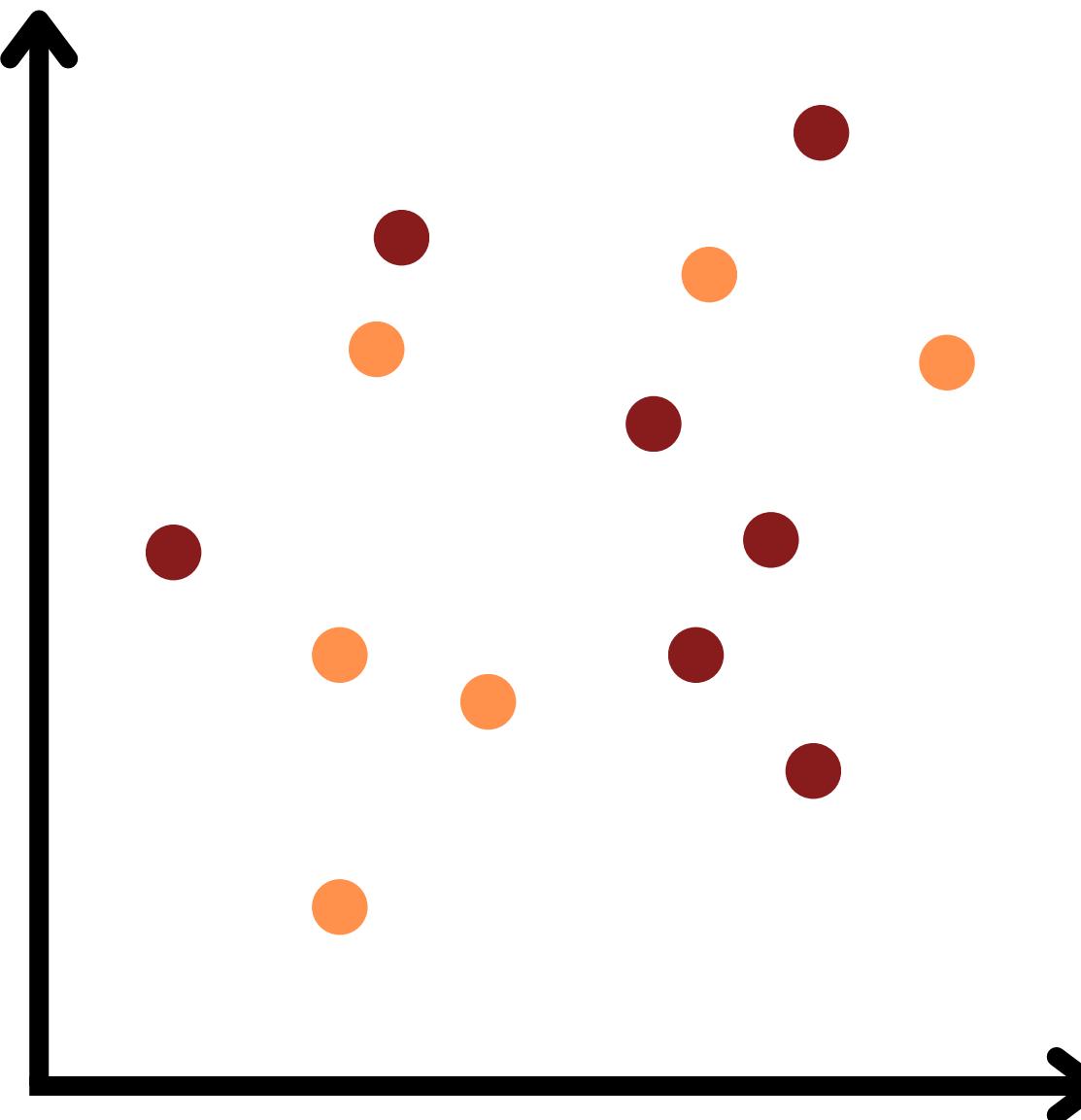
Grouping

We can group elements on a visualization using **similarity**



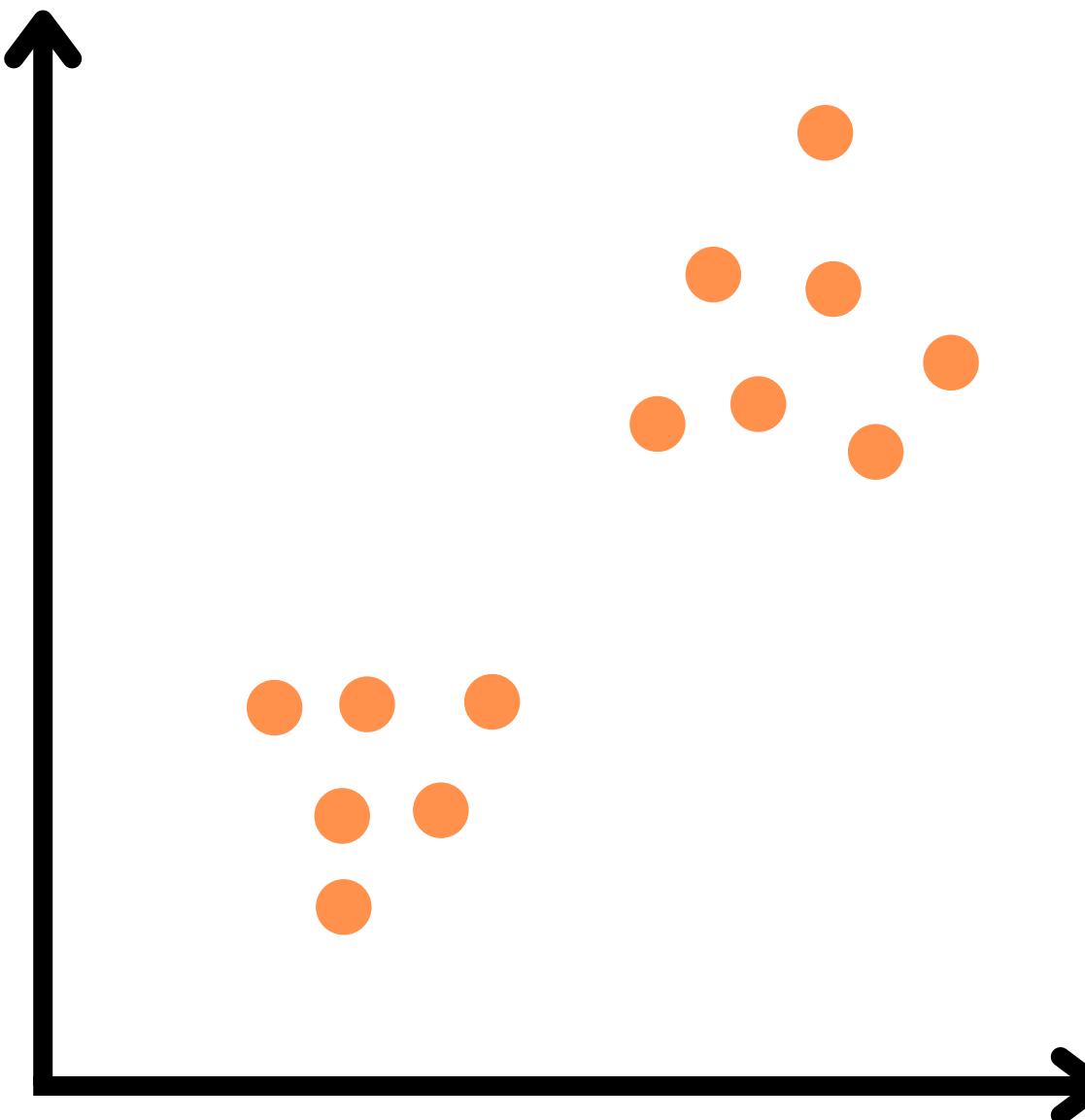
Grouping

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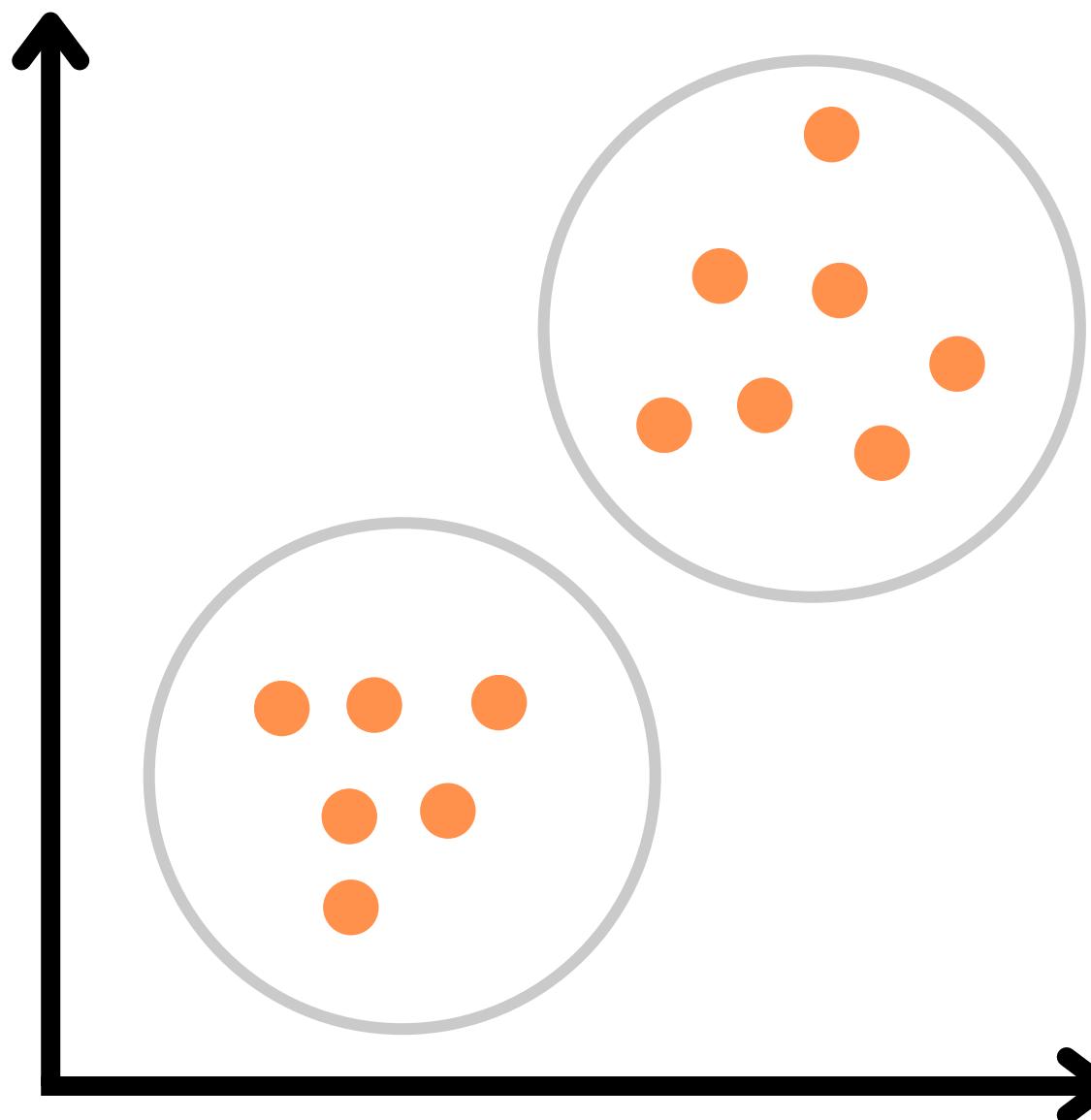
Grouping

We can group elements on a visualization using proximity



Grouping

We can group elements on a visualization using **enclosure**



Gestalt principles allow us to understand how our mind converts abstract shapes into conceptual structures

Using these principles wisely will help viewers better interpret your visualizations. Poor use may cause viewers to see things that aren't there...

FIN

Upcoming Dates

Feb 6 (Next Class): Group Activity 1

Feb 4 (Today): Homework 0 Due

Feb 10: Quiz 1 Due (will be posted Feb 6)

Feb 13: Announce Your Project

Feb 14: Homework 1 Due (will be posted Feb 5)