CIS 4930/6930-002
DATA VISUALIZATION

PERCEPTION

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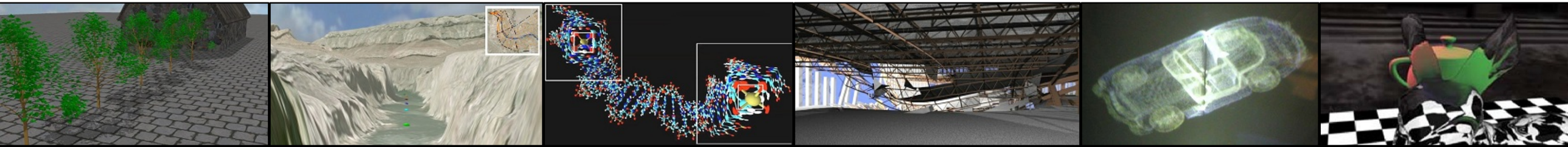
University of South Florida

slides credits Chris Johnson (U of Utah), Hanspeter Pfister (Harvard), BangWong (Broad Institute), Miriah Meyer (U of Utah)



TOPICS

eye construction

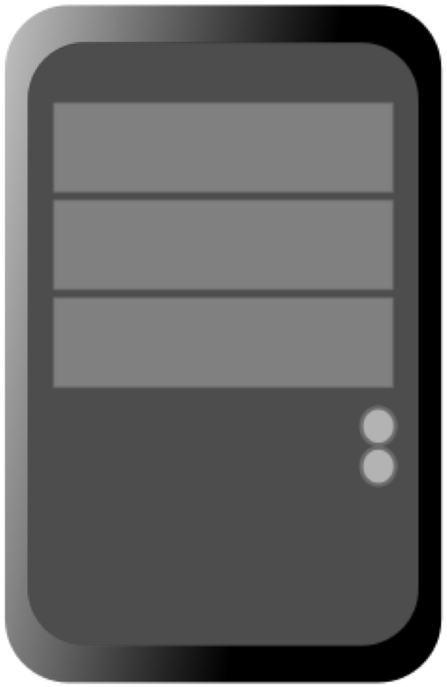
perceptual vulnerabilities

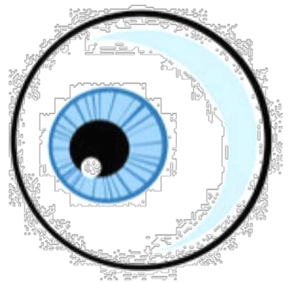
popout

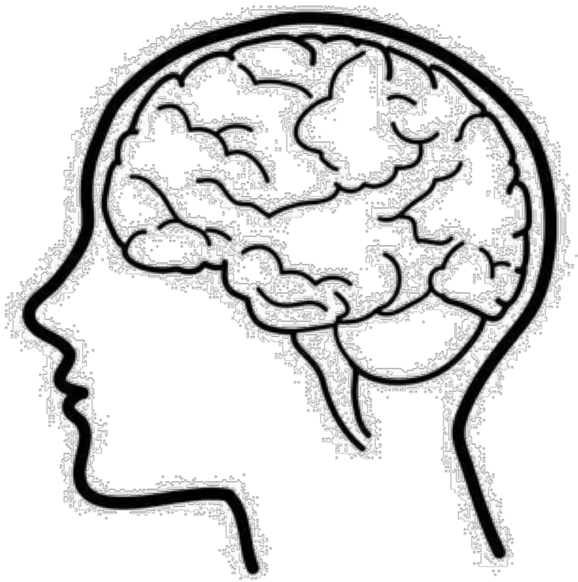
gestalt principles

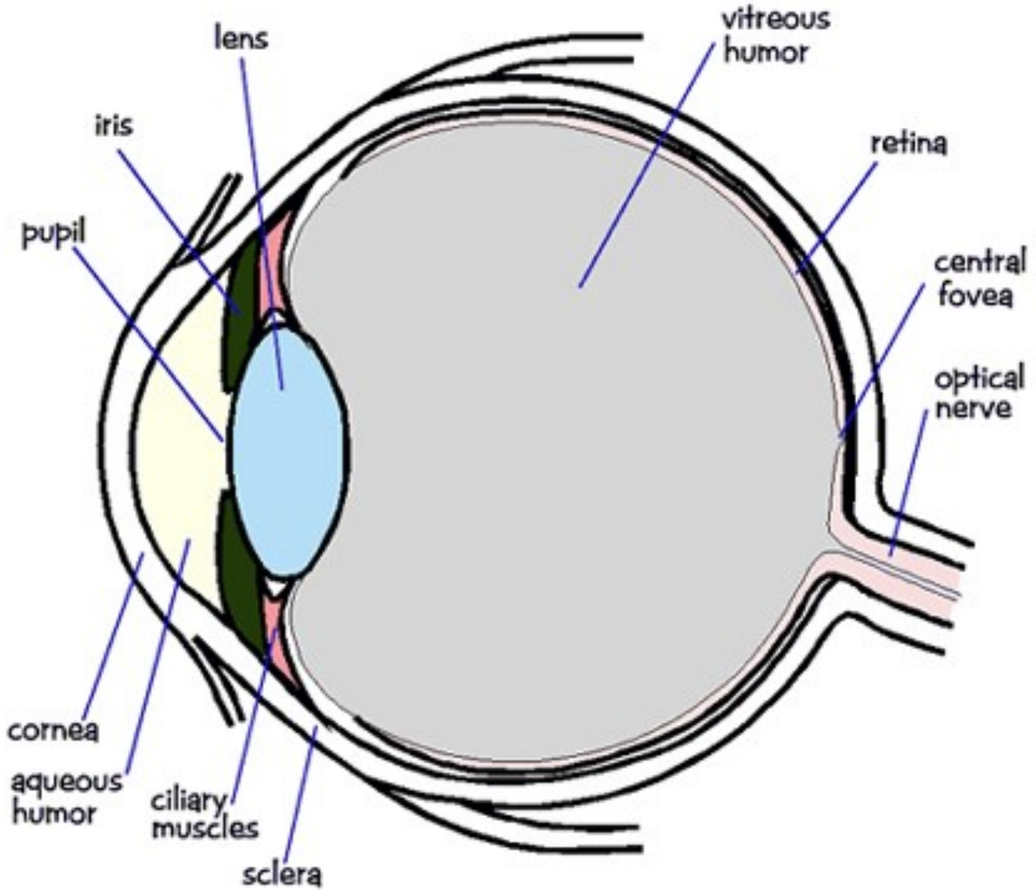
data

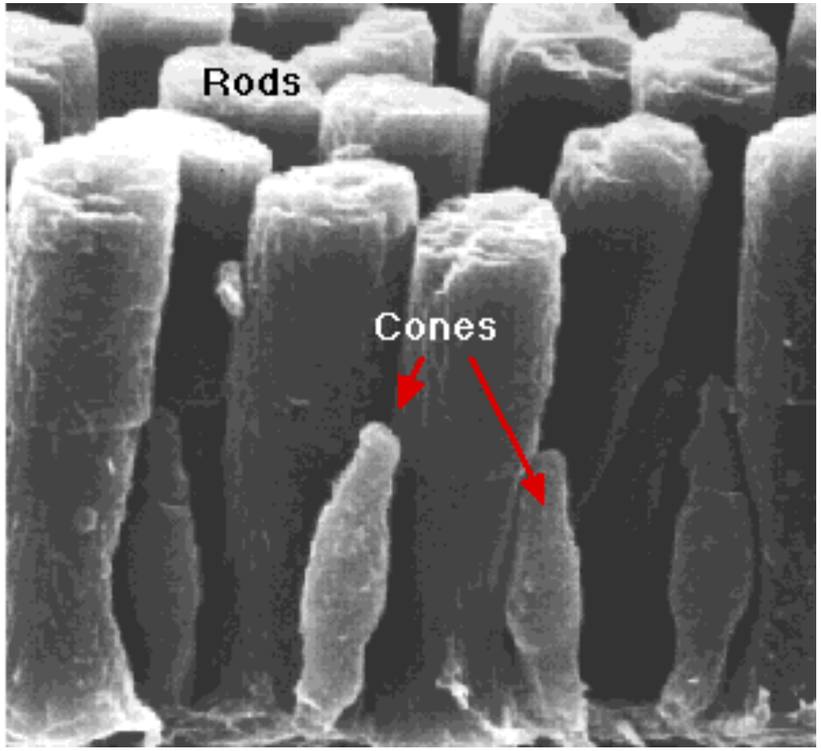
knowledge

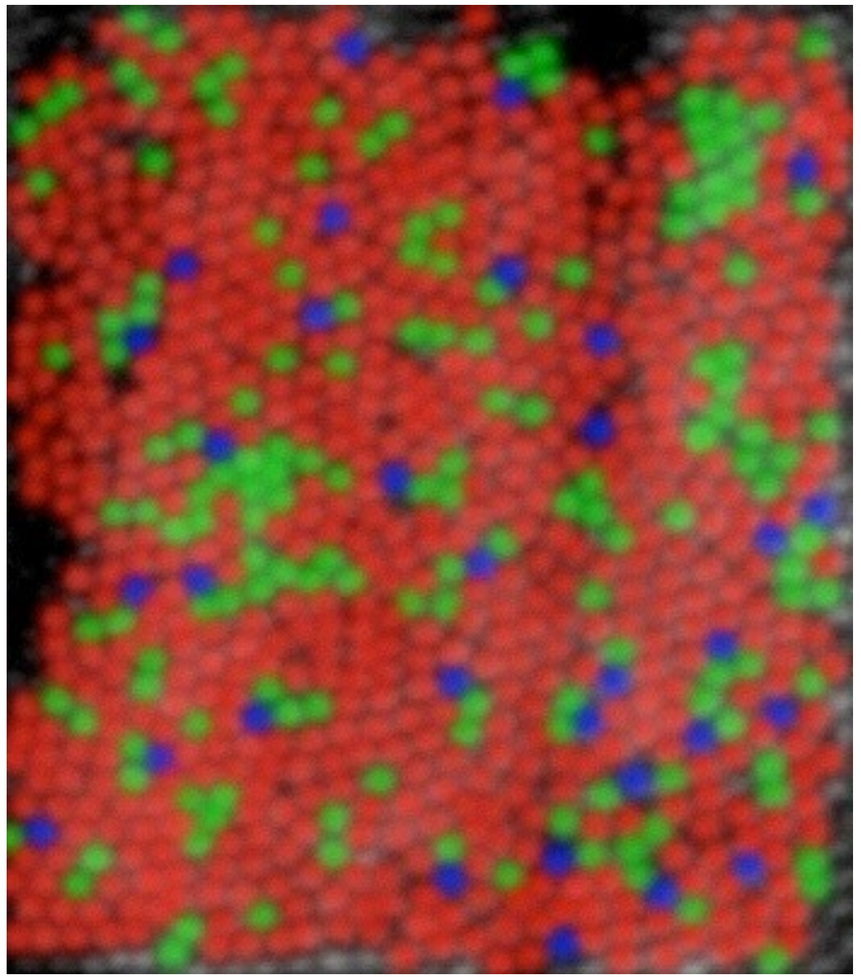







lens
vitreous humor
iris
retina
pupil
central fovea
optical nerve
cornea
aqueous humor
ciliary muscles
sclera



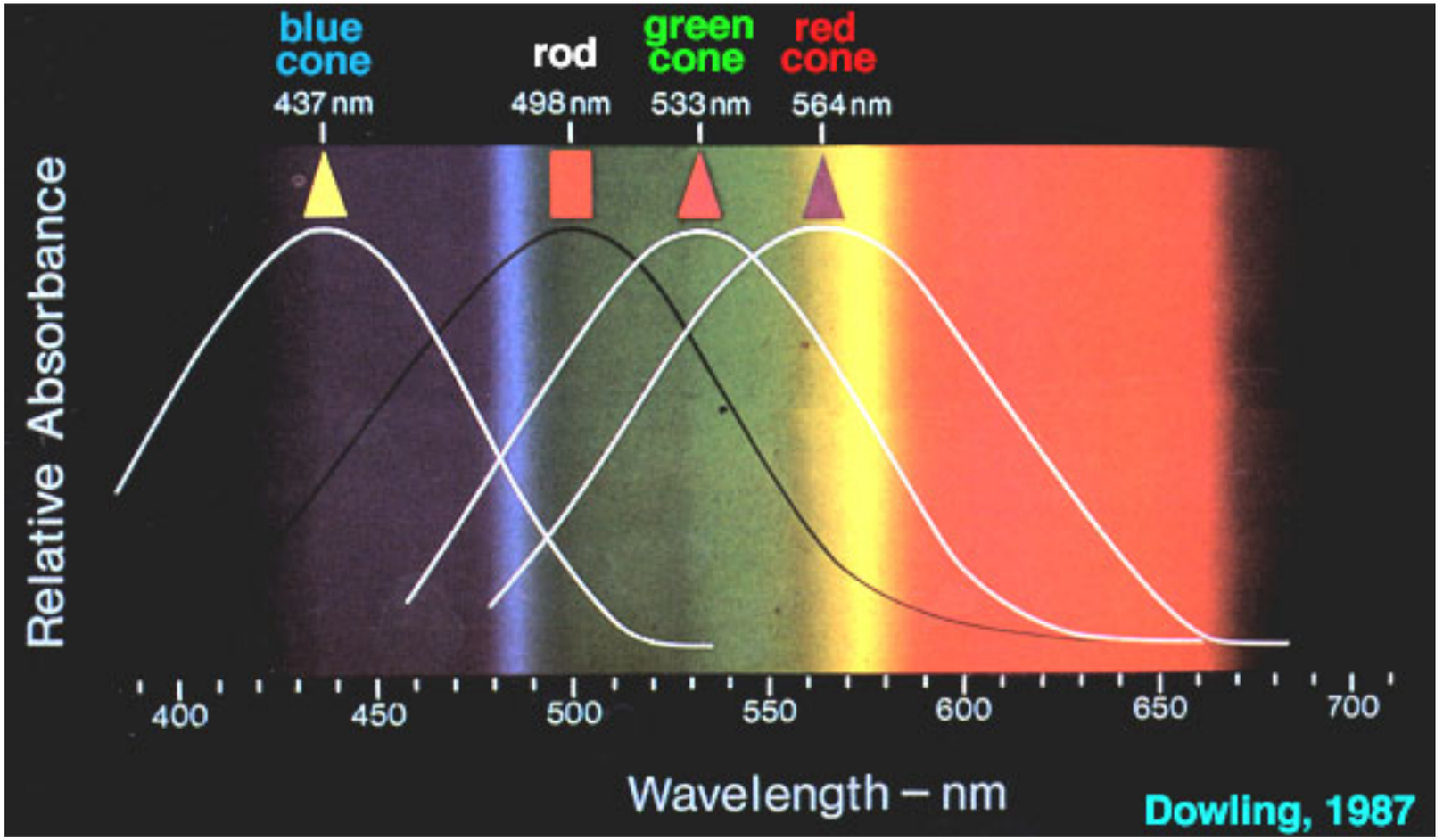


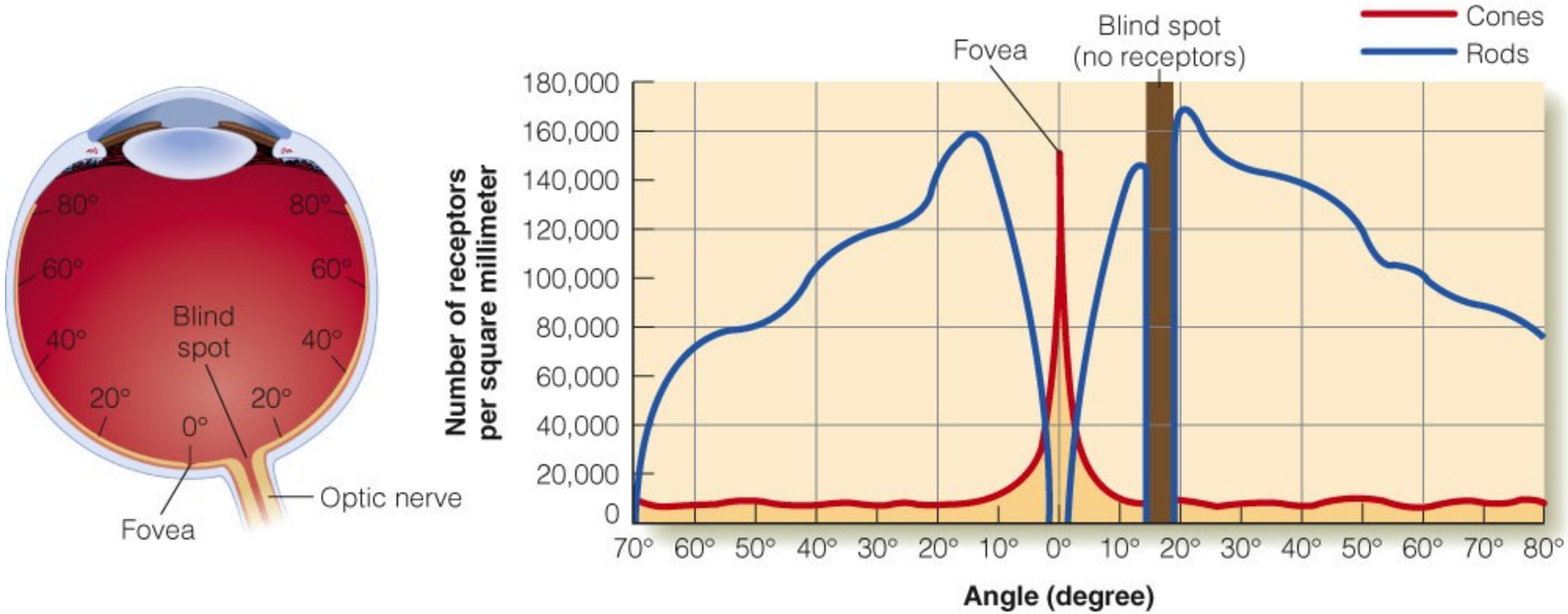
120 million rods

5-6 million cones

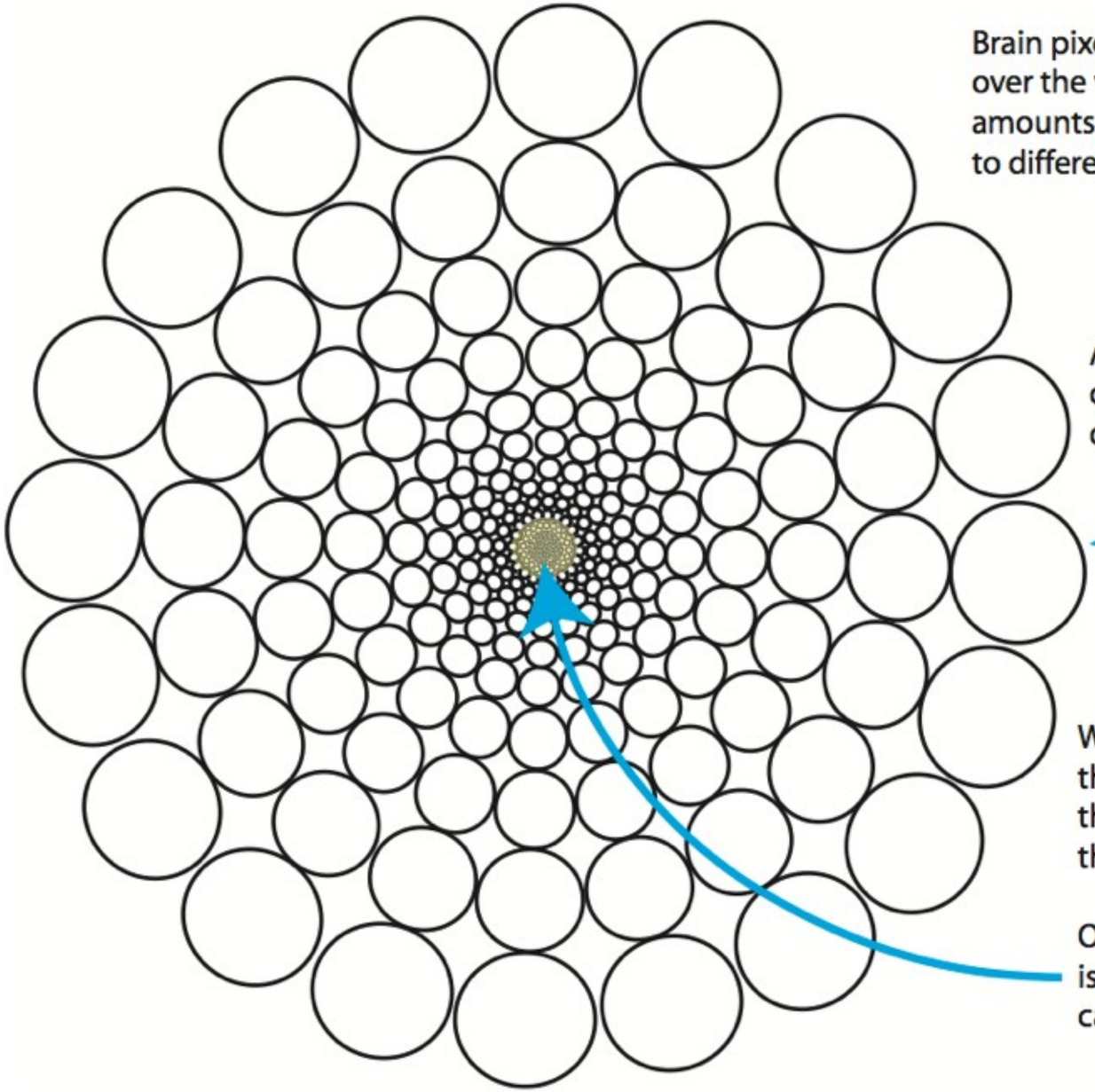
WANDELL, "FOUNDATIONS OF VISION" (LEFT) DAVID R. WILLIAMS, UNIV. OF ROCHESTER (RIGHT)

Cone Response





E. B. GOLDSTEIN "SENSATION AND PERCEPTION" (ADAPTED FROM LINDSAY & NORMAN, 1977)



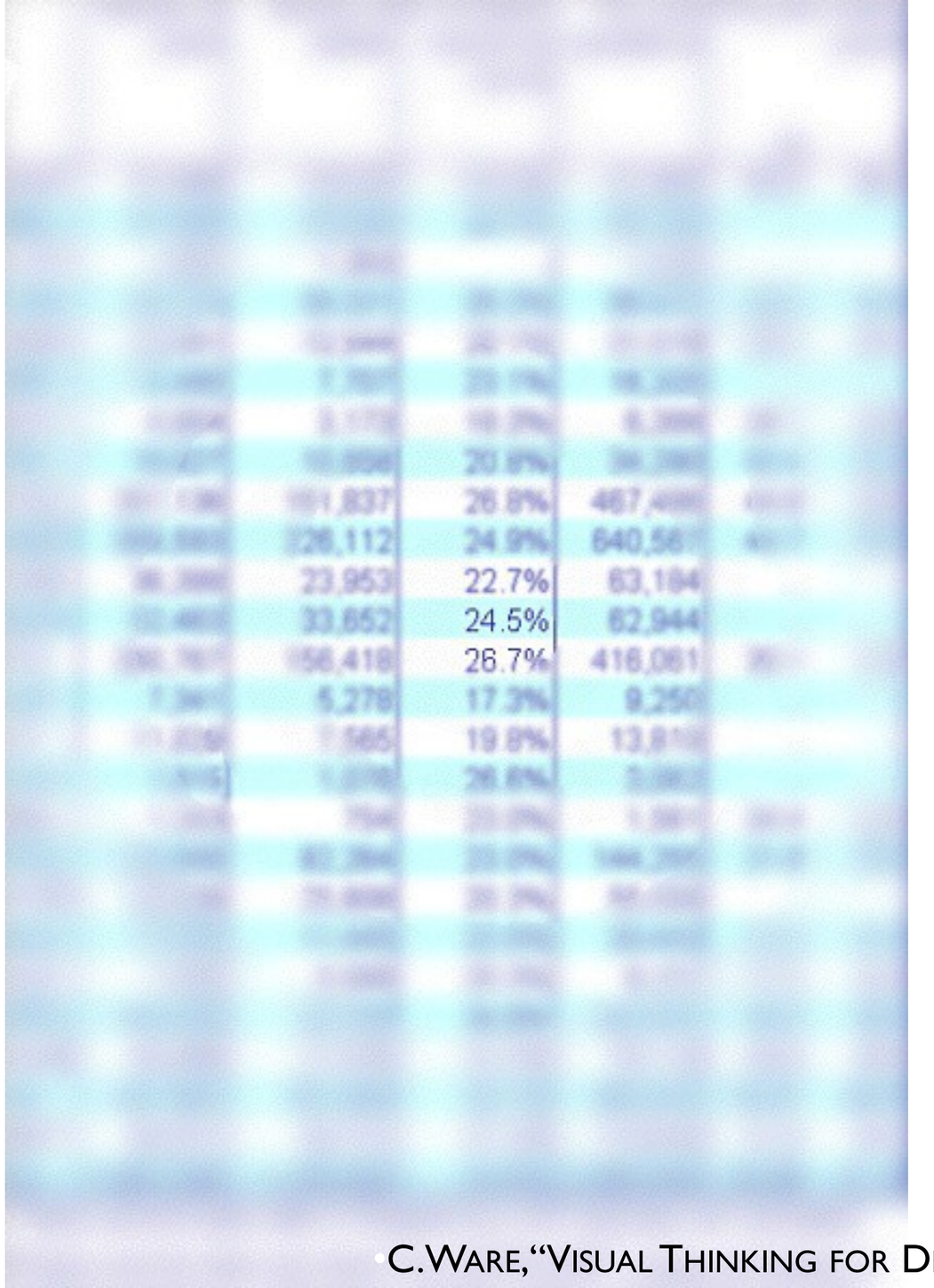
Brain pixels vary enormously in size over the visual field. This reflects differing amounts of neural processing power devoted to different regions of visual space.

At the edge of the visual field we can only barely see something the size of a fist at arm's length.

We can resolve about 100 points on the head of a pin held at arm's length in the very center of the visual field called the fovea.

Over half of our visual processing power is concentrated in a slightly larger area called the parafovea.

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



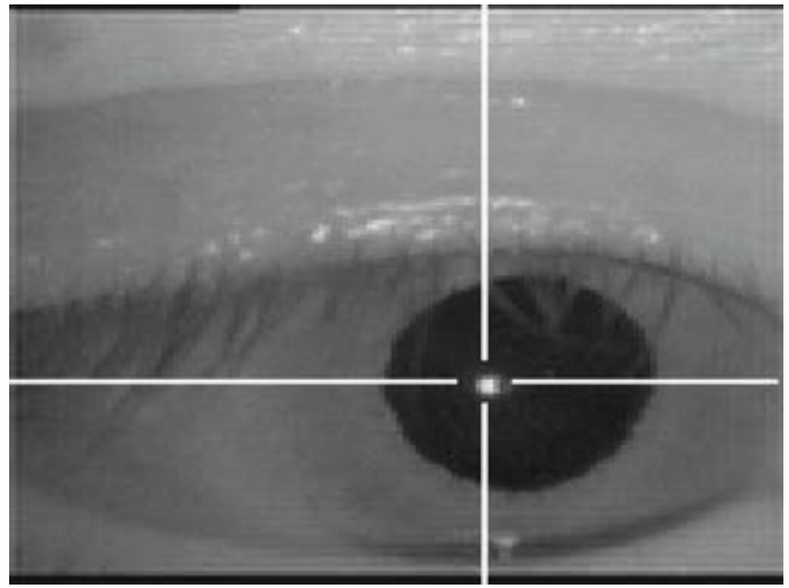
C. WARE, "VISUAL THINKING FOR DESIGN"

SACCADIC EYE MOVEMENTS

rapid involuntary eye movements

moving: 20-100 ms

fixations: 200-600 ms



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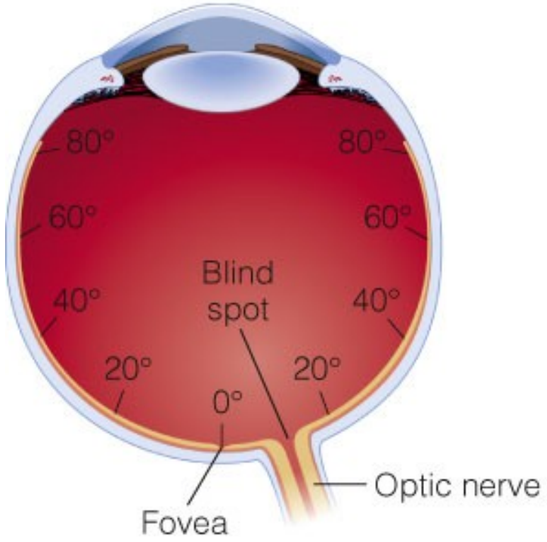
BLIND SPOT



+

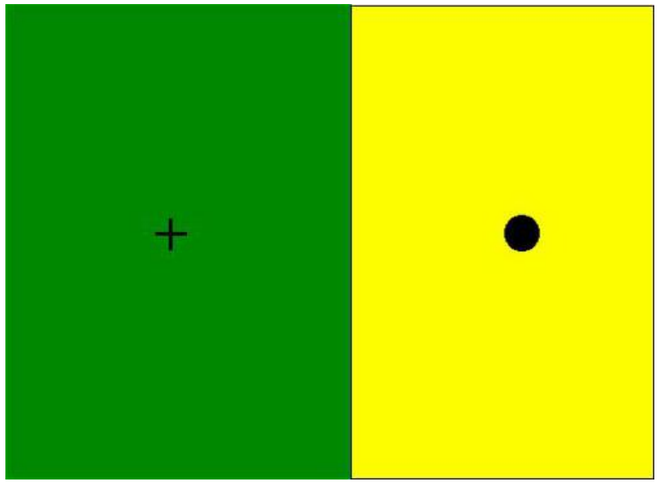
●

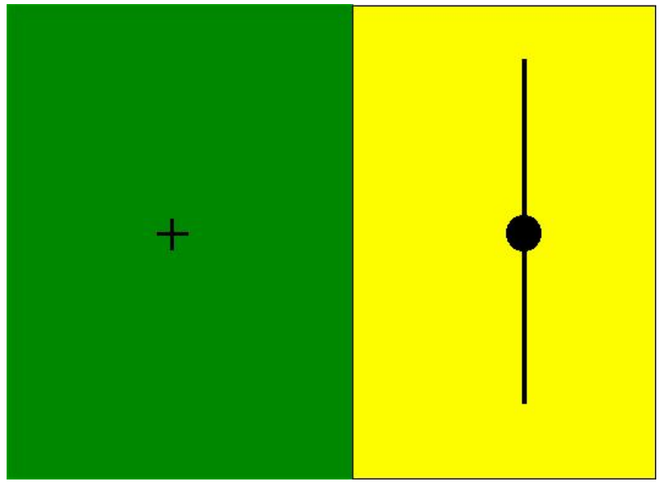
Close **left** eye

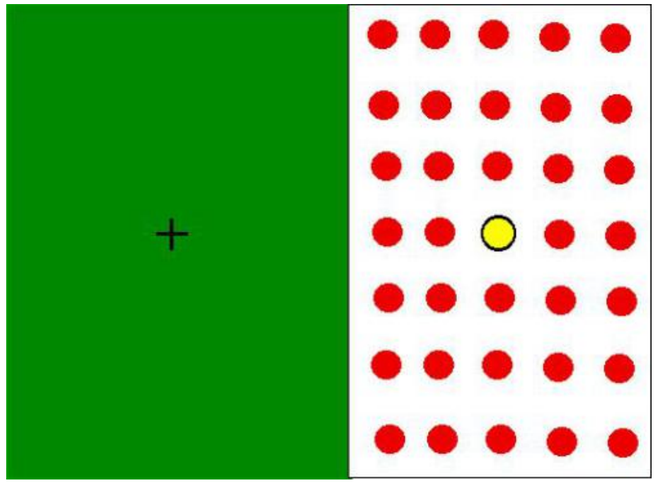
Stair at **+**

Move forward and backward until ● disappears

BLIND SPOT







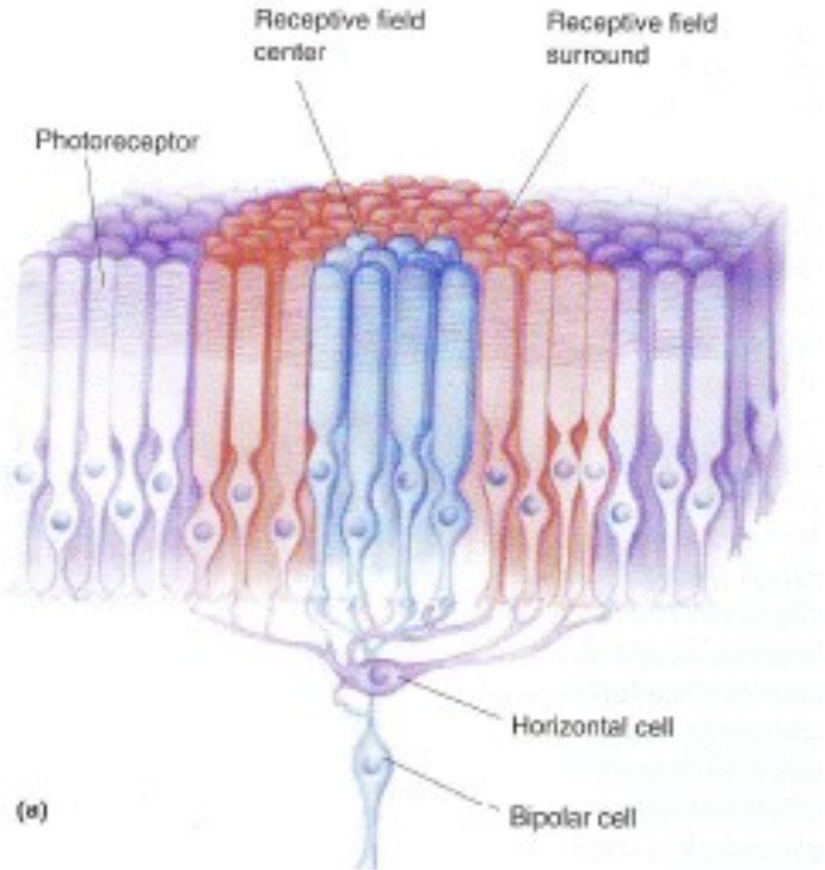
TAKEAWAY

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 will result in the best interpretation.

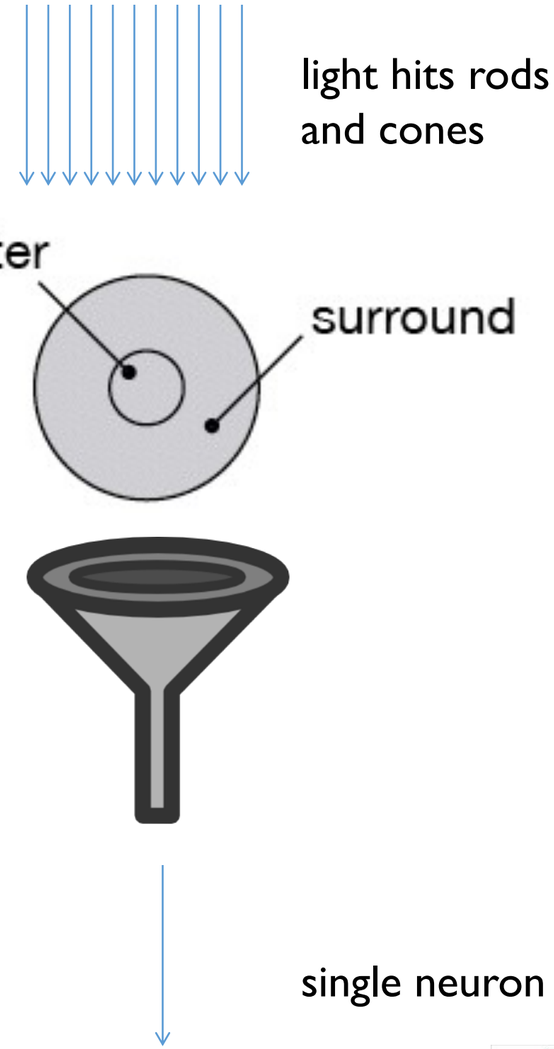
EDGE DETECTION

RECEPTIVE FIELD



100M rods and cones

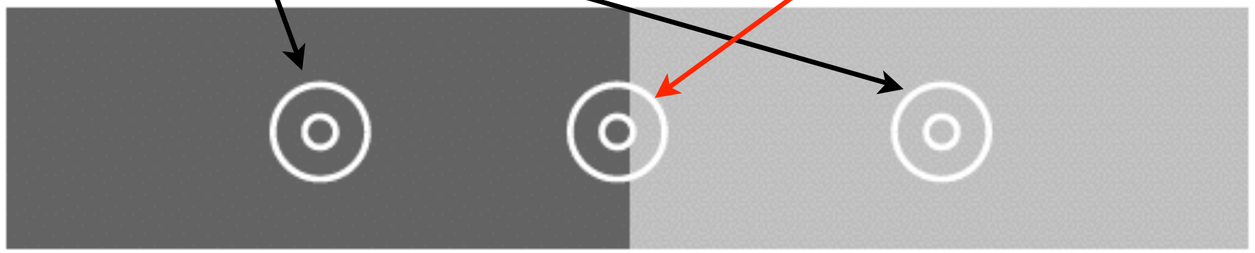
1M ganglion cells



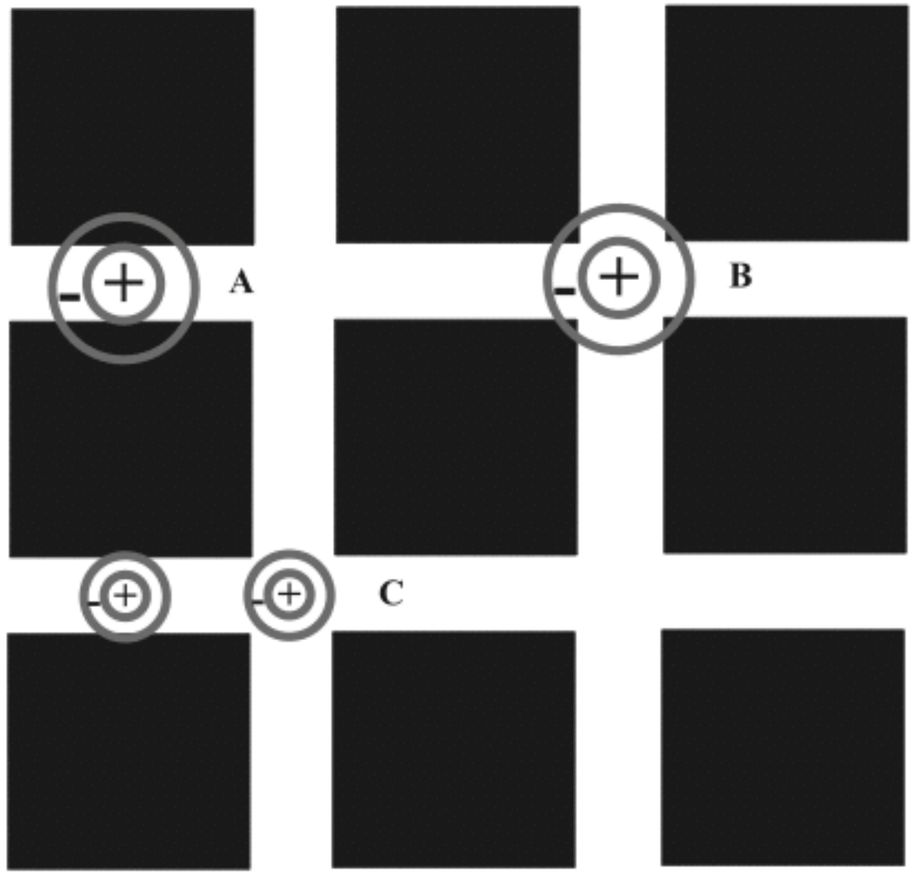
BEAR, CONNORS, PARADISO, "NEUROSCIENCE"

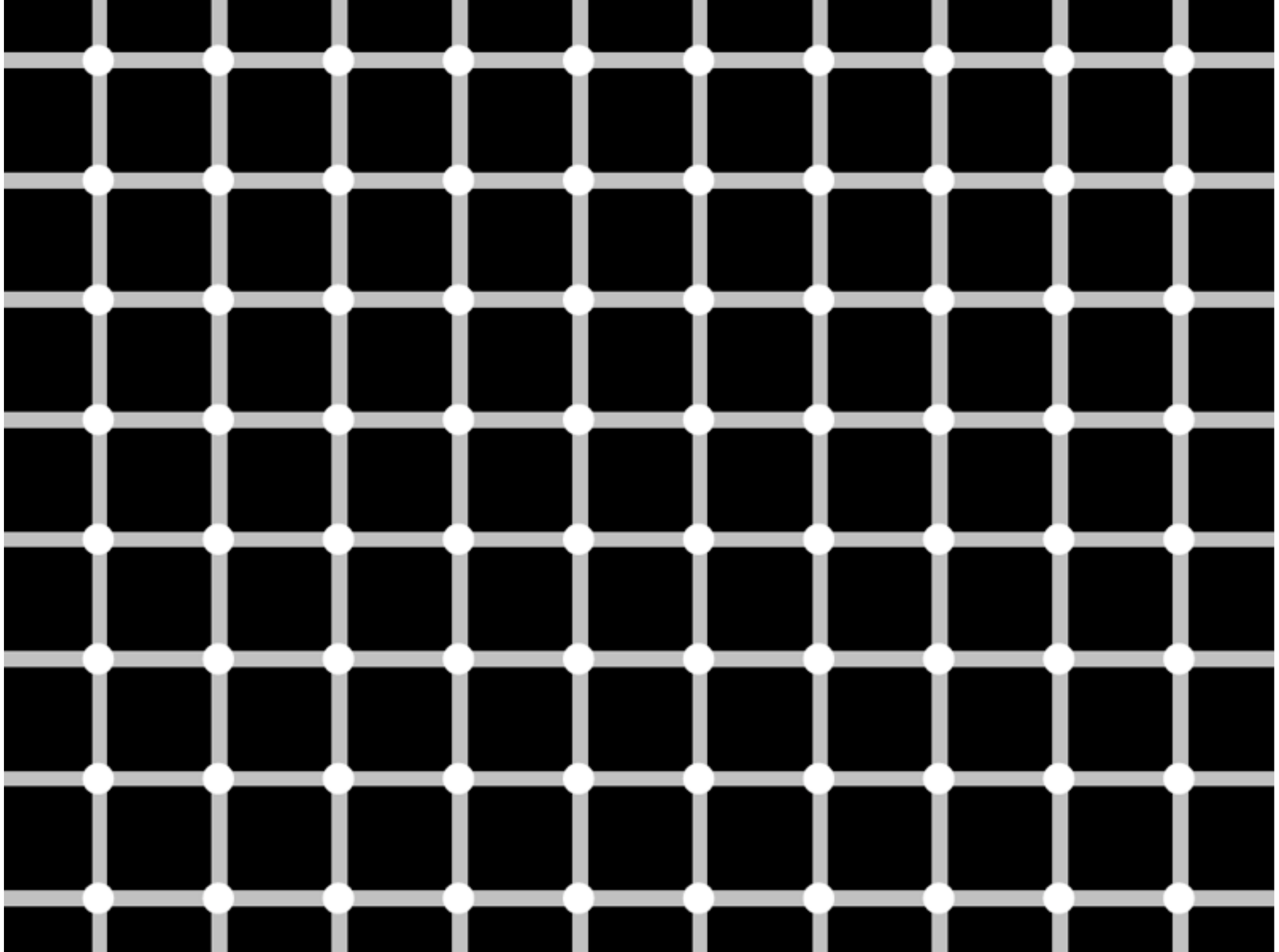
low activity
center and surrounds cancel

activity increased
or decreased at edges



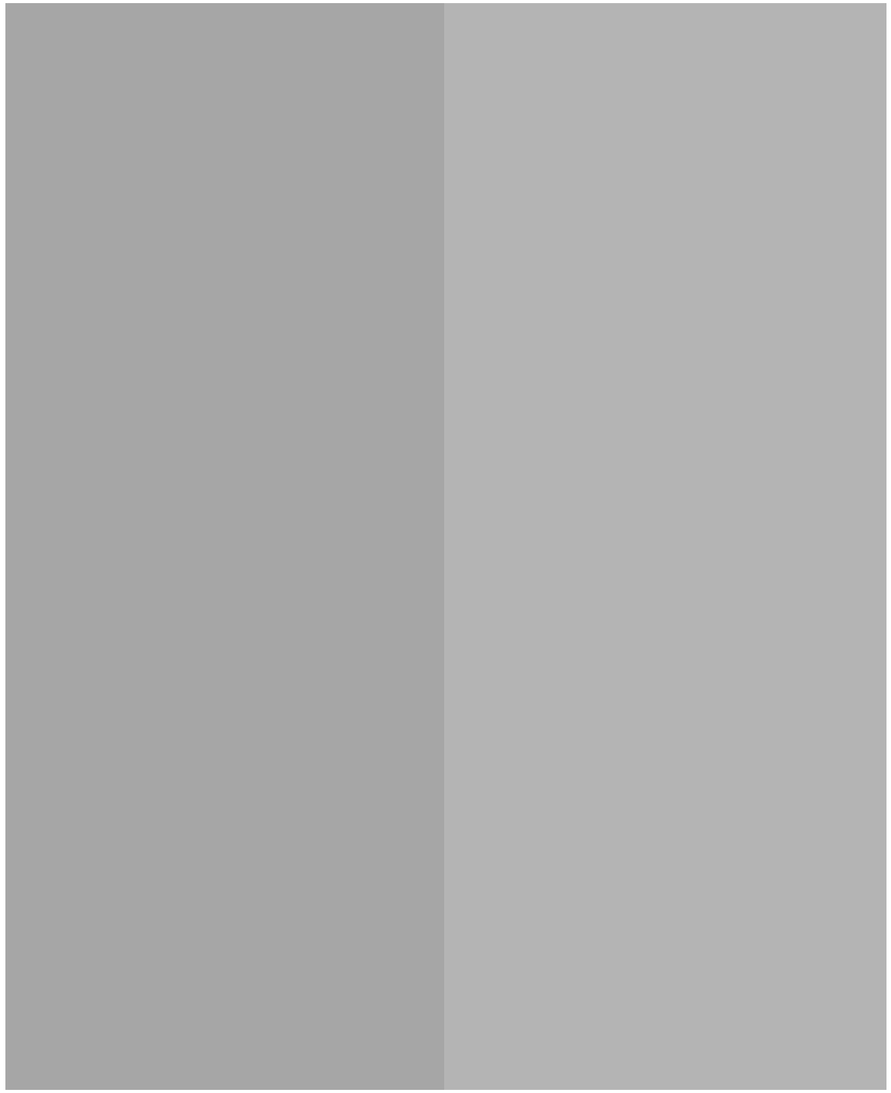
HERMANN GRID EFFECT



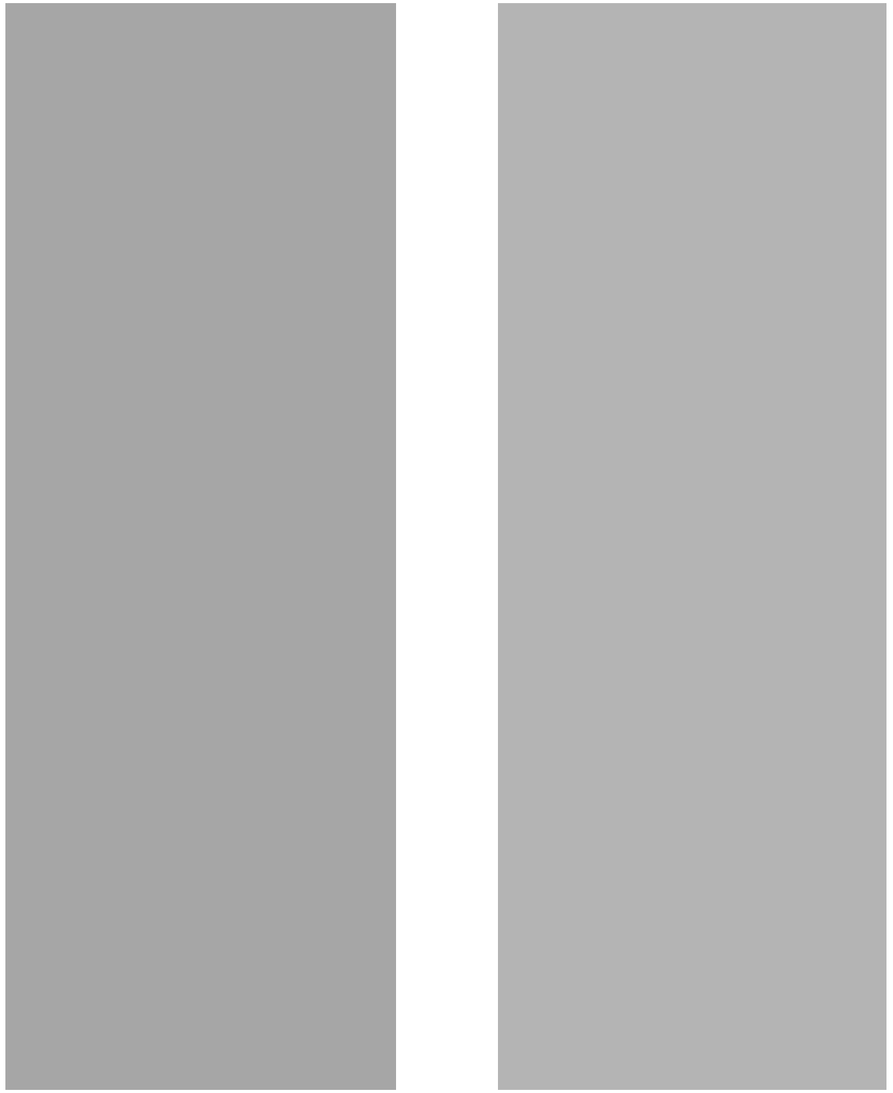


CONSEQUENCES OF EDGE EXTRACTION

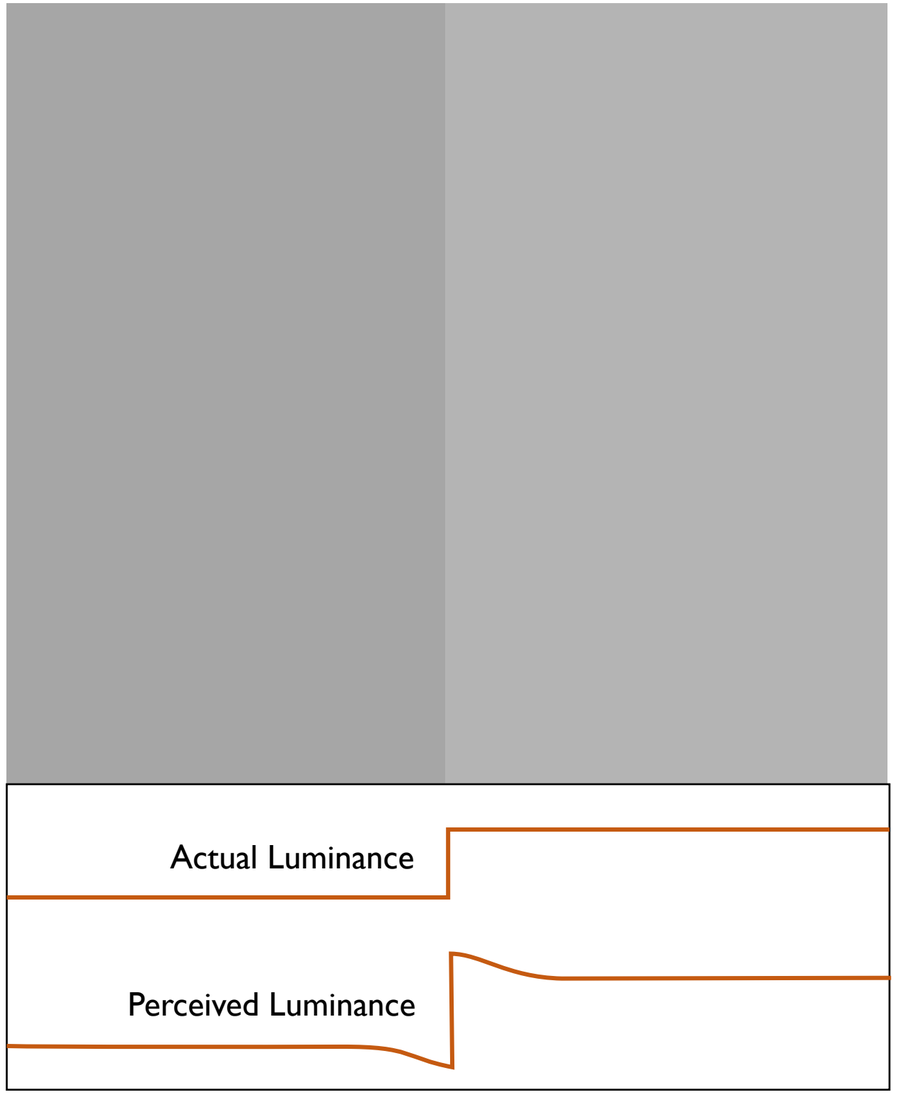
Cornsweet Illusion



Cornsweet Illusion



Cornsweet Illusion



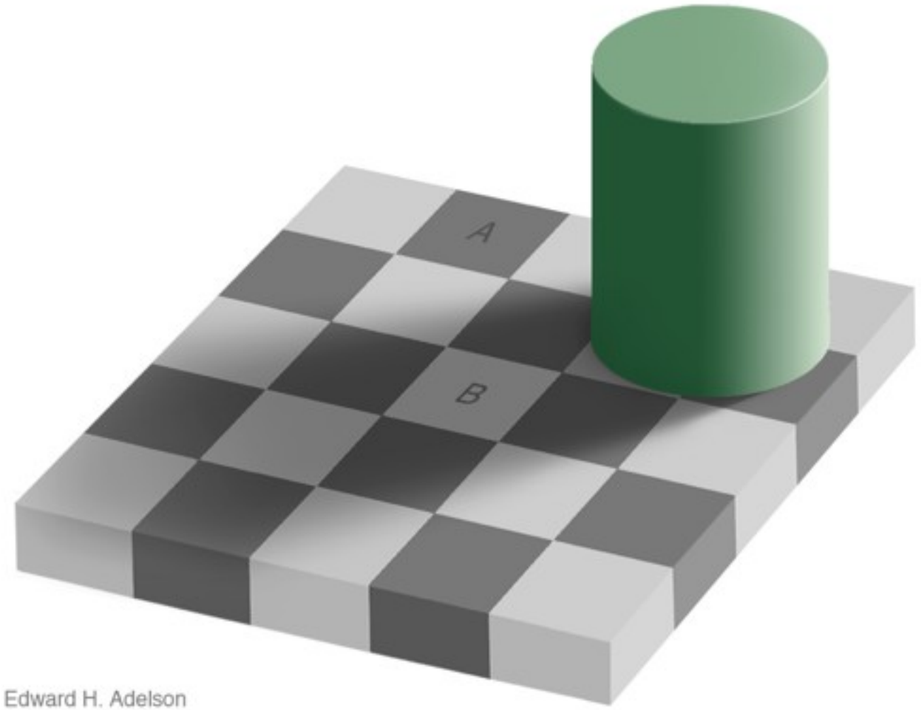
Cornsweet Illusion

D. Purves and R. B. Lotto

Mach Banding

SIMULTANEOUS CONTRAST

SIMULTANEOUS CONTRAST



Edward H. Adelson

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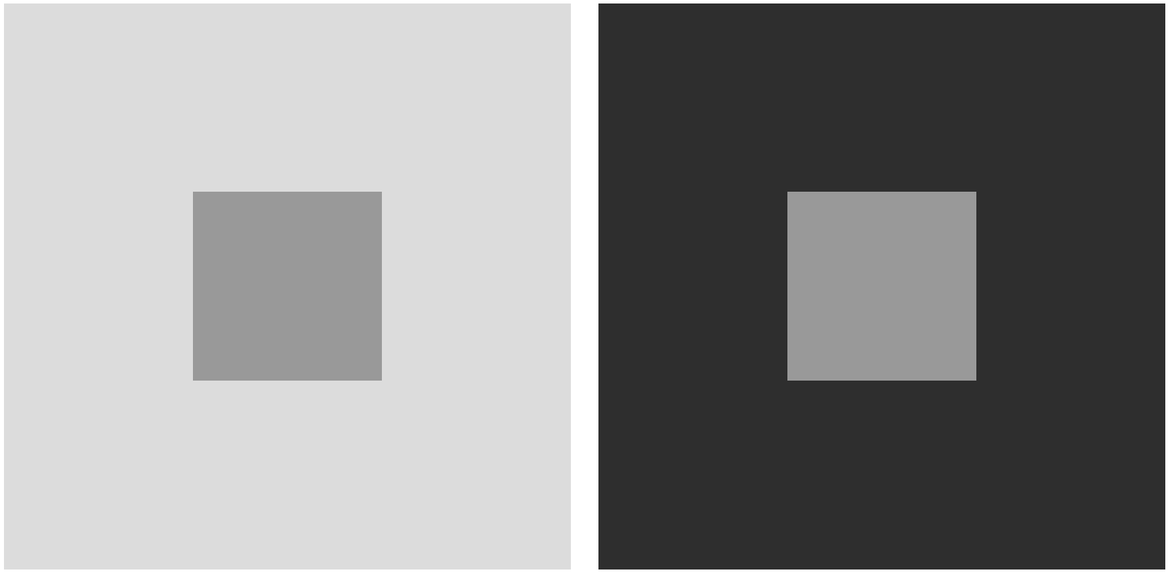
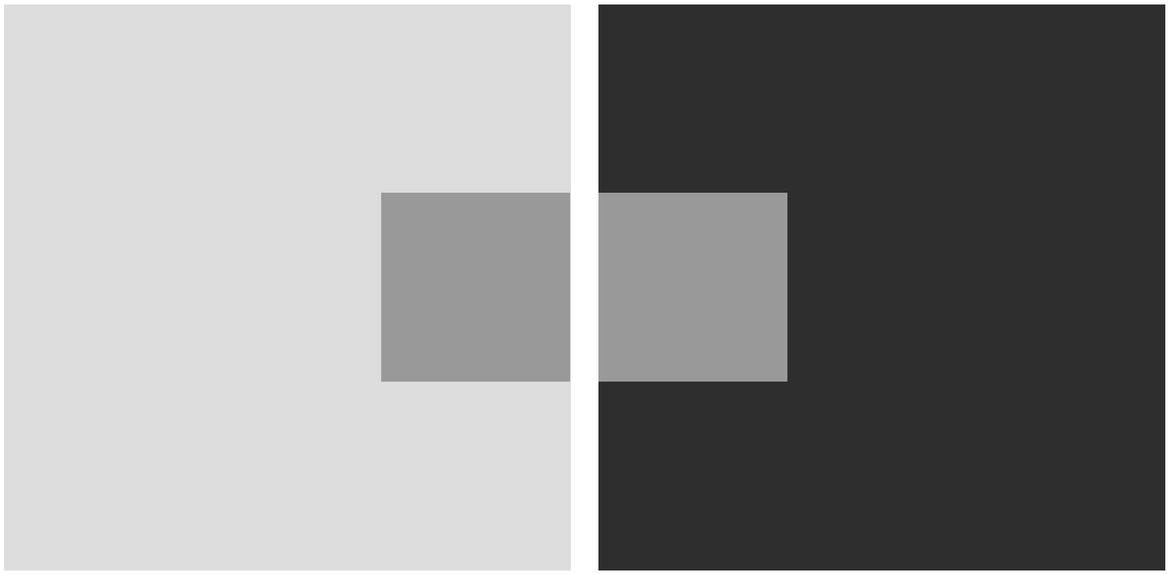
SIMULTANEOUS CONTRAST



SIMULTANEOUS CONTRAST



SIMULTANEOUS CONTRAST

TAKEAWAY

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

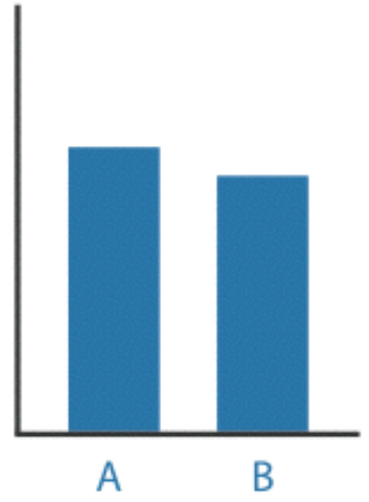
Maximize the contrast with the background if the outlines of shapes are important.

WEBER'S LAW

we judge based on relative, not absolute, differences

Unframed
Unaligned

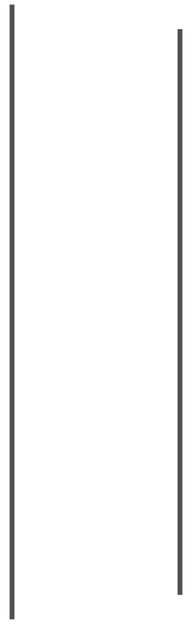
Framed
Unaligned



Unframed
Aligned

AXIS OF ALIGNMENT

AXIS OF ALIGNMENT

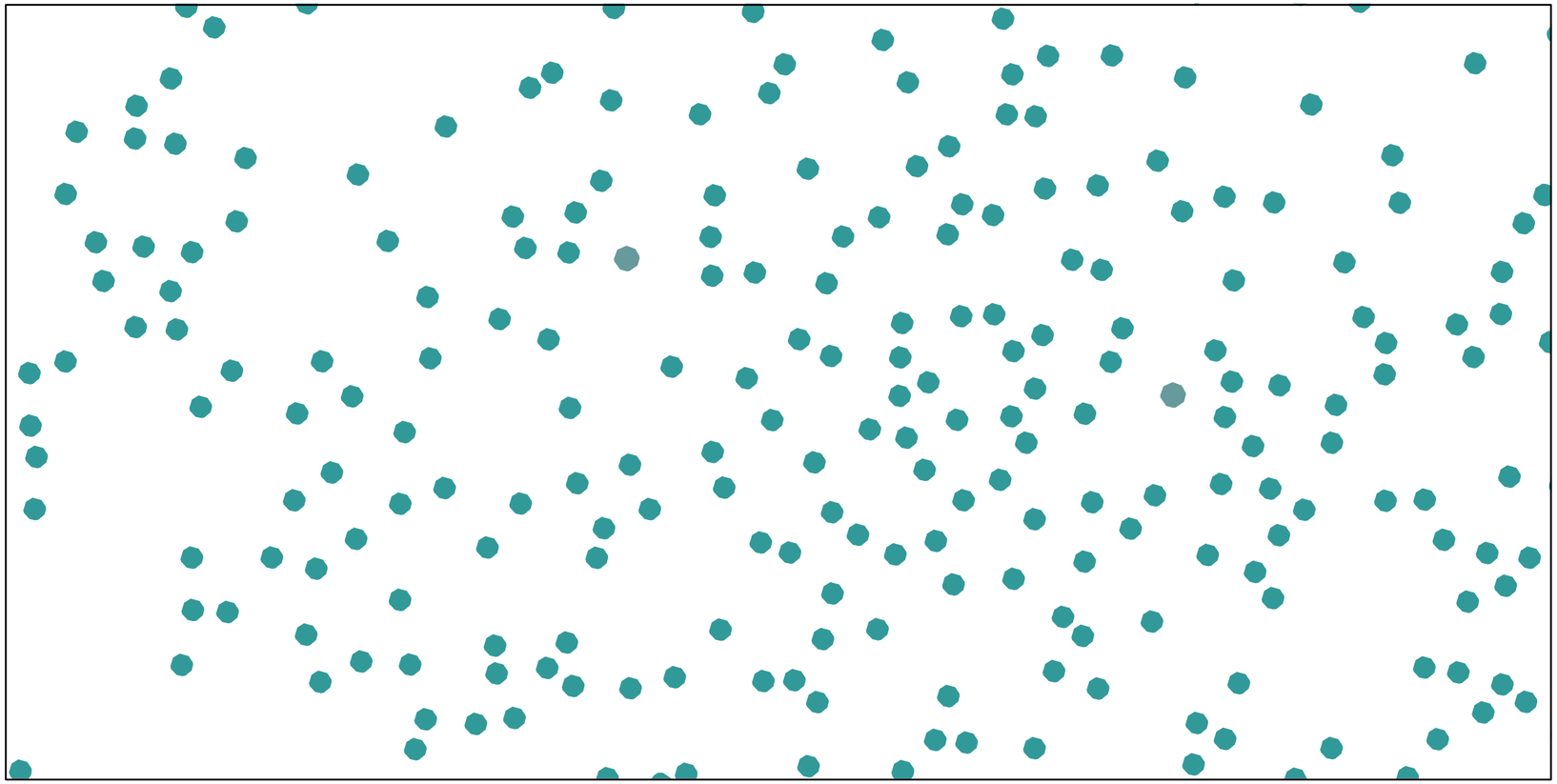


TAKEAWAY

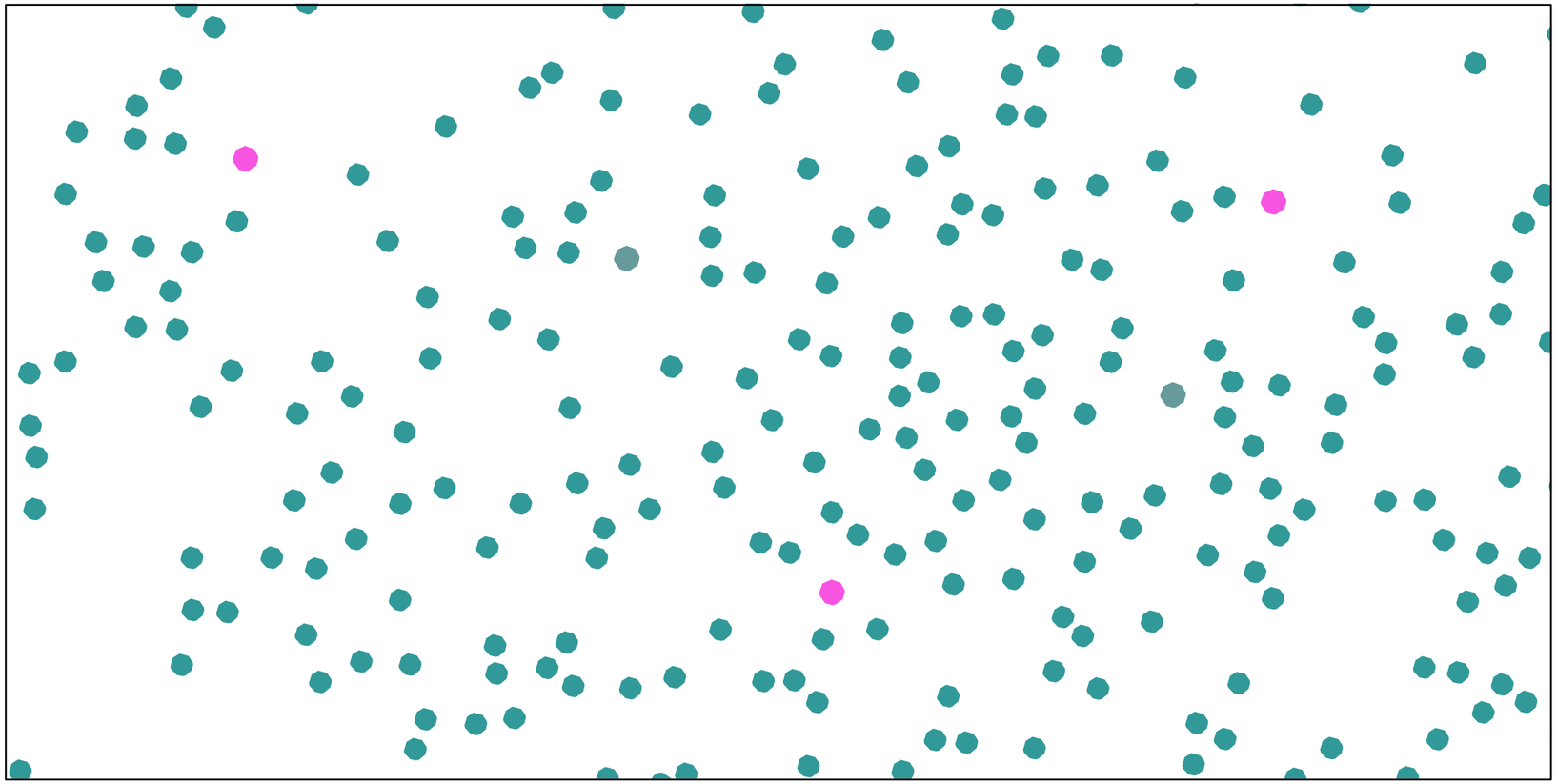
We have a strong propensity to assume our judgments are absolute, when in fact they are generally relative to the local context.

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

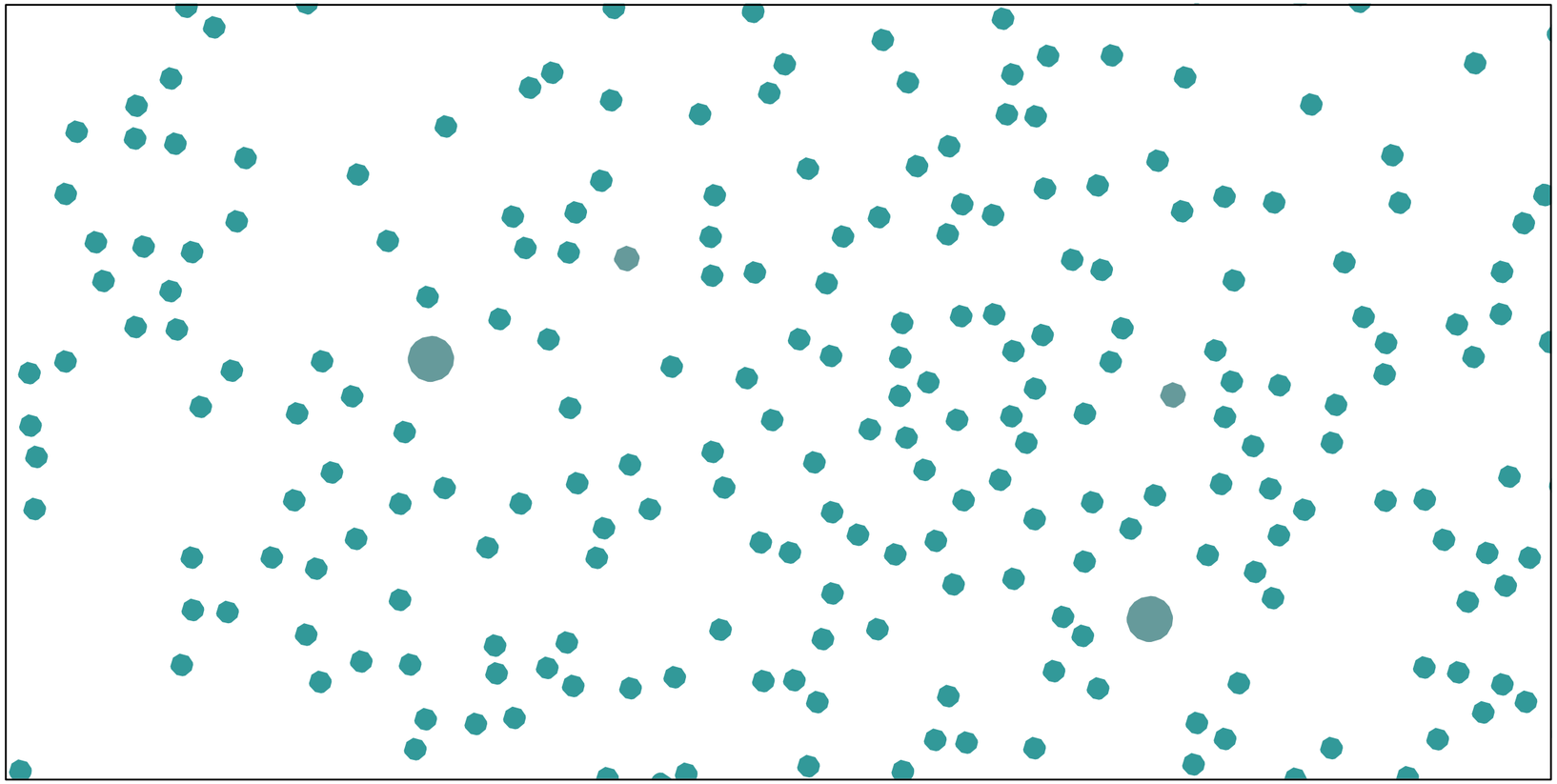
POPOUT



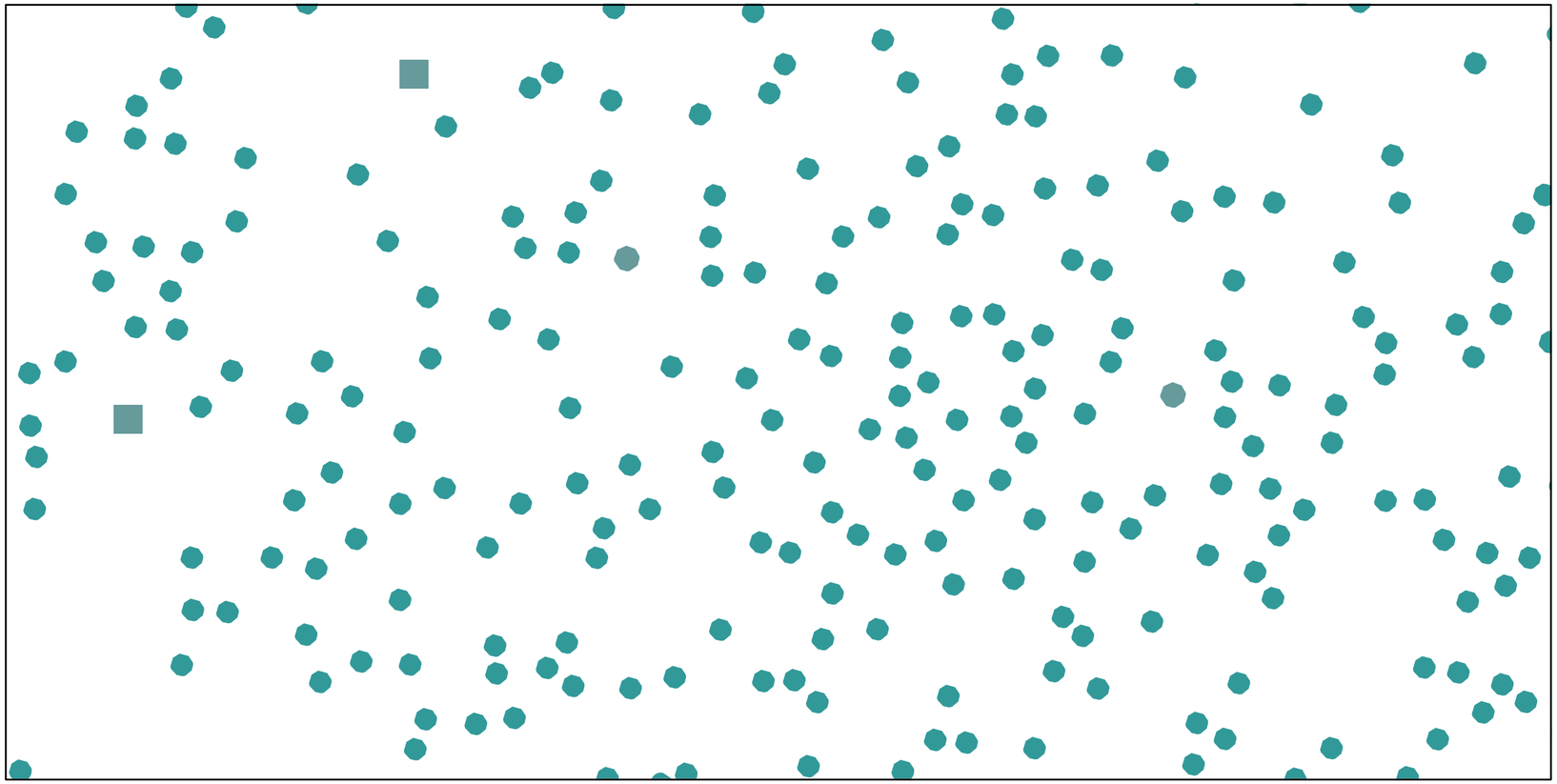
POPOUT



POPOUT



POPOUT



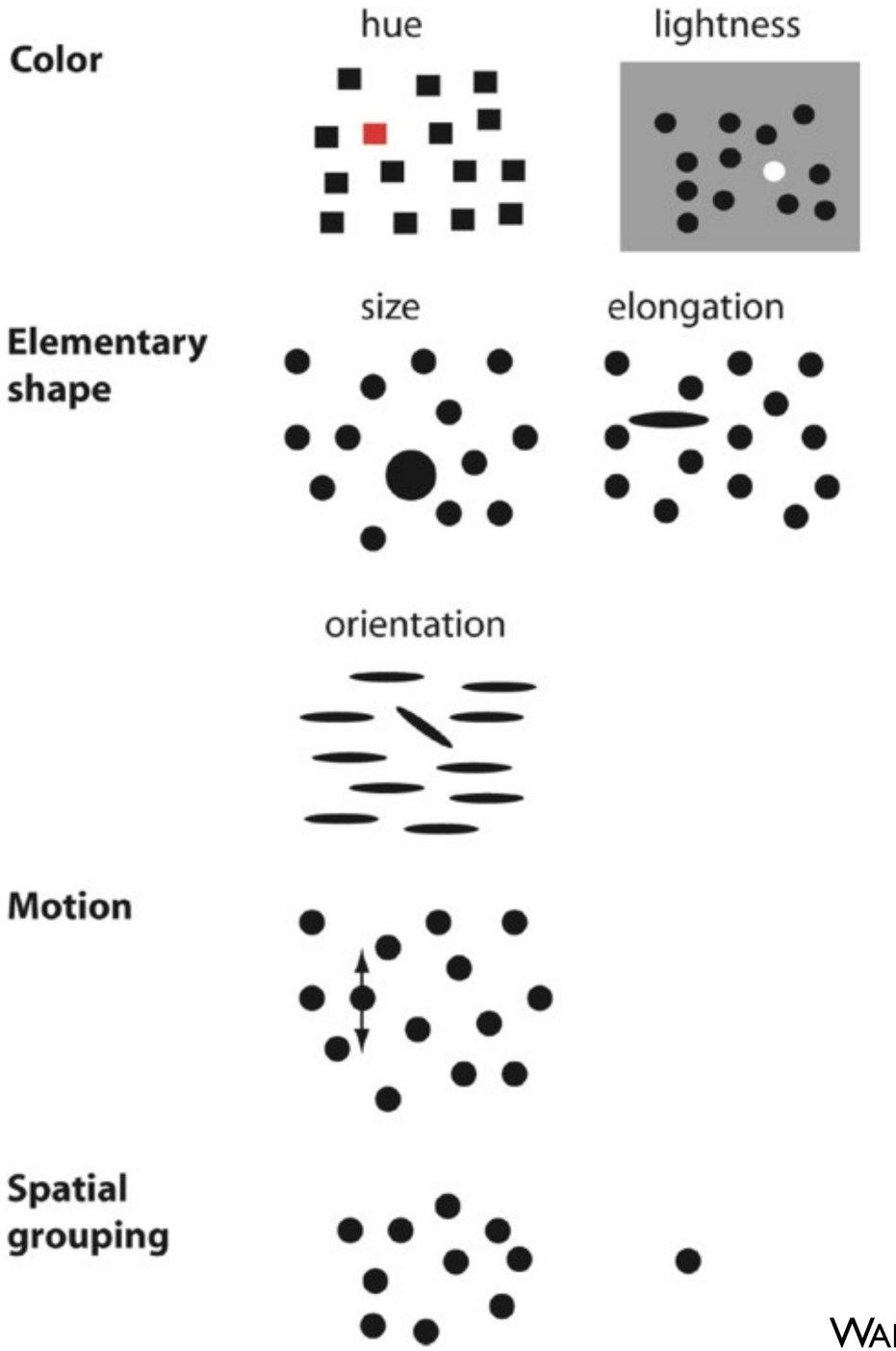
PRE-ATTENTIVE PROCESSING

requires attention, despite name

very fast: <200 ms

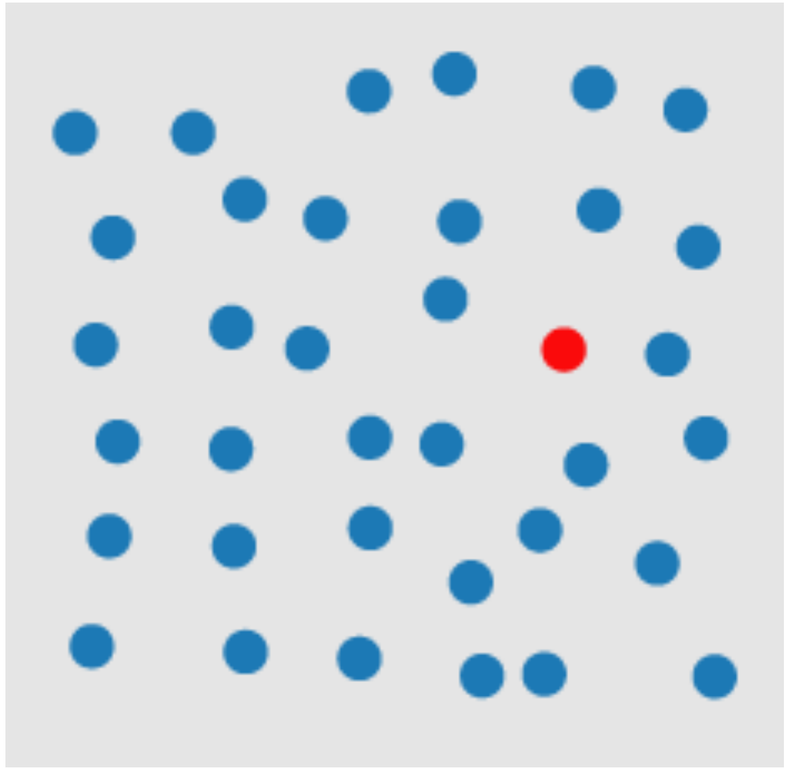
what matters most is contrast between features

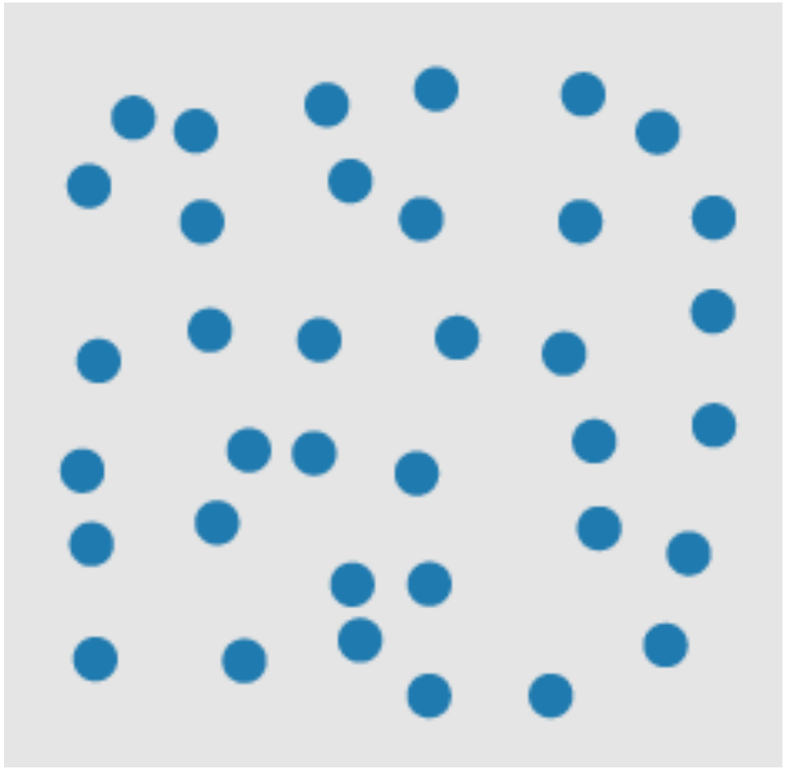
BASIC POPOUT CHANNELS



WARE 2008

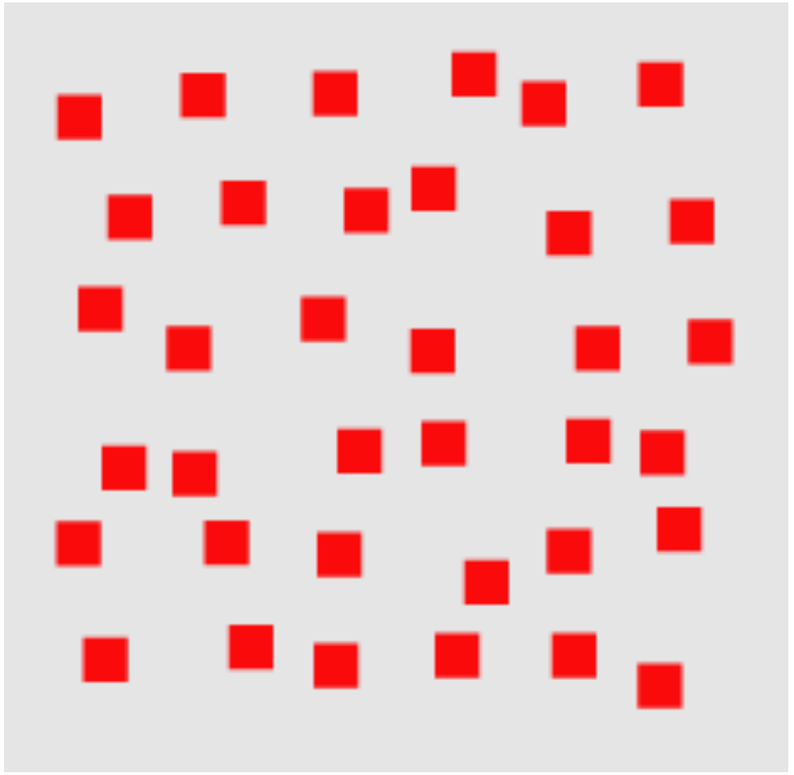
PICK THE OUTLIER

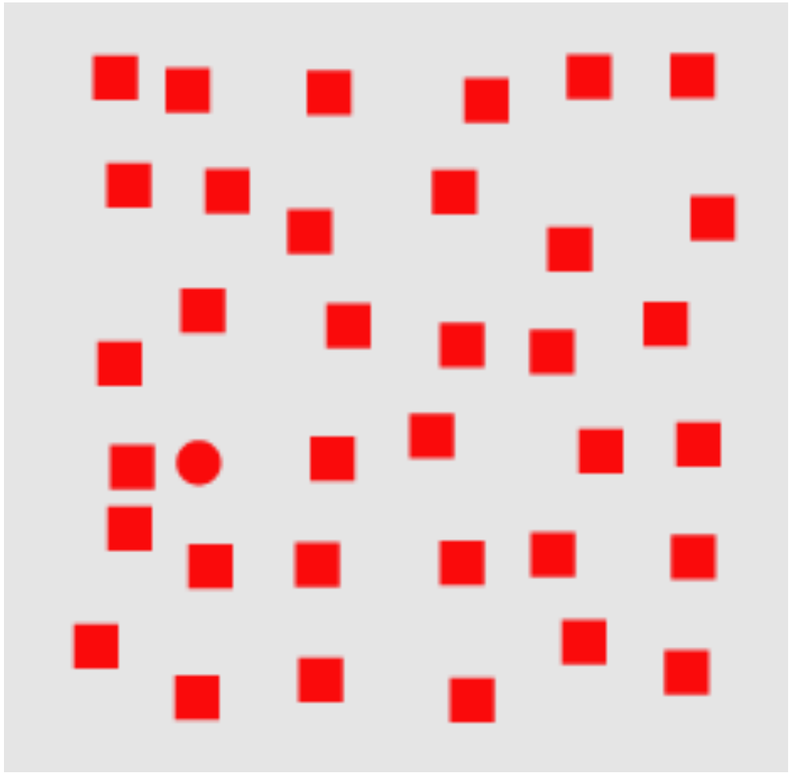




HEALY 2007

PICK THE OUTLIER





HEALY 2007

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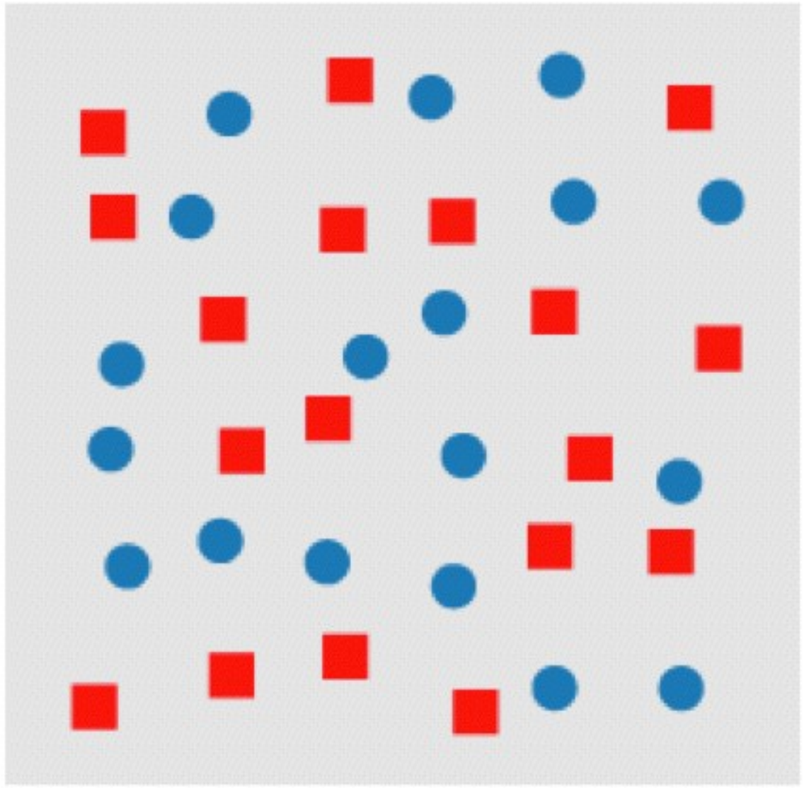
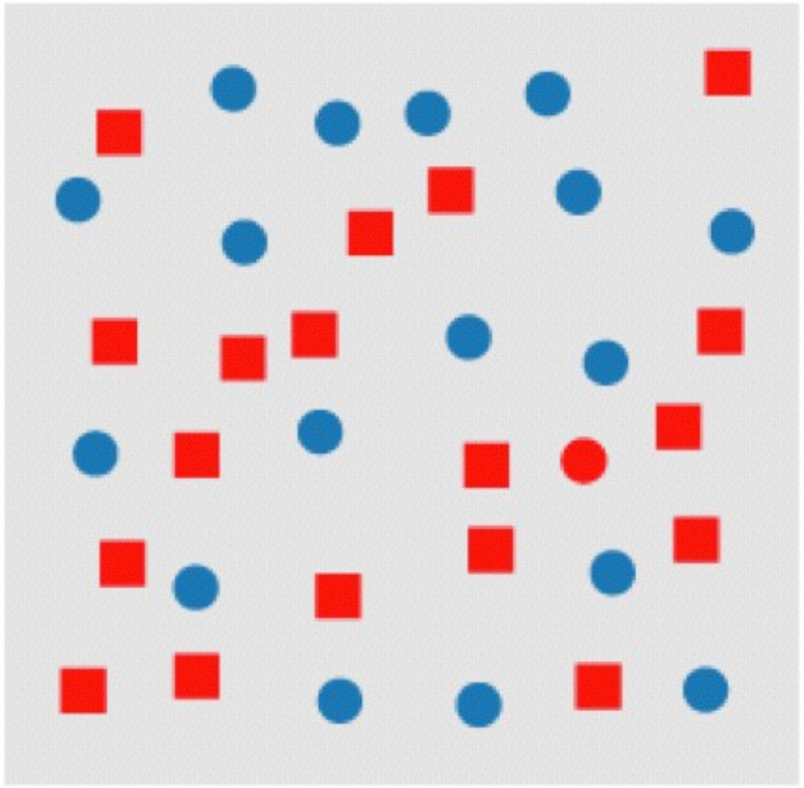
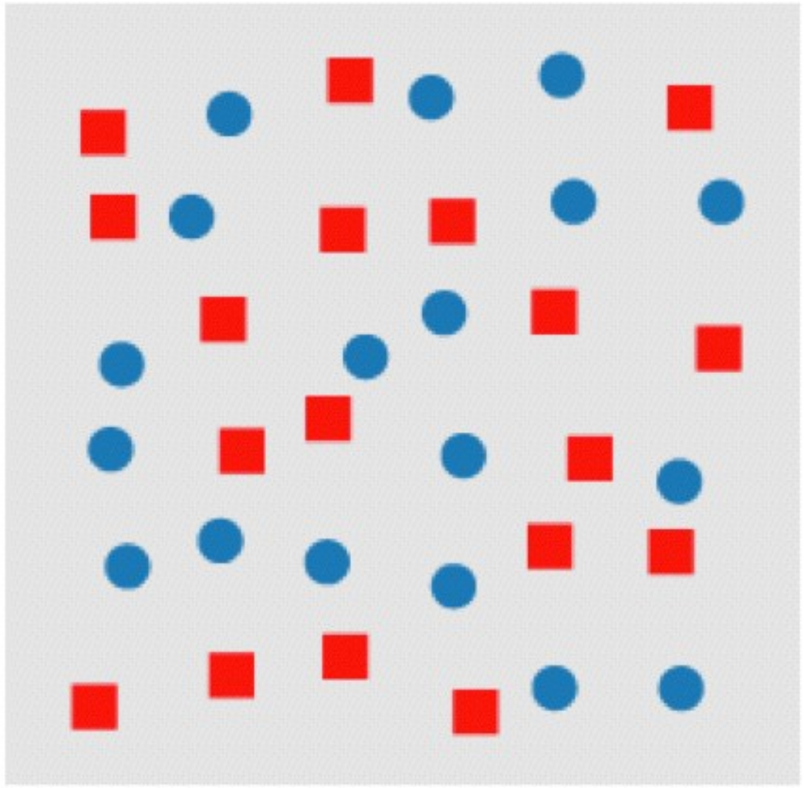


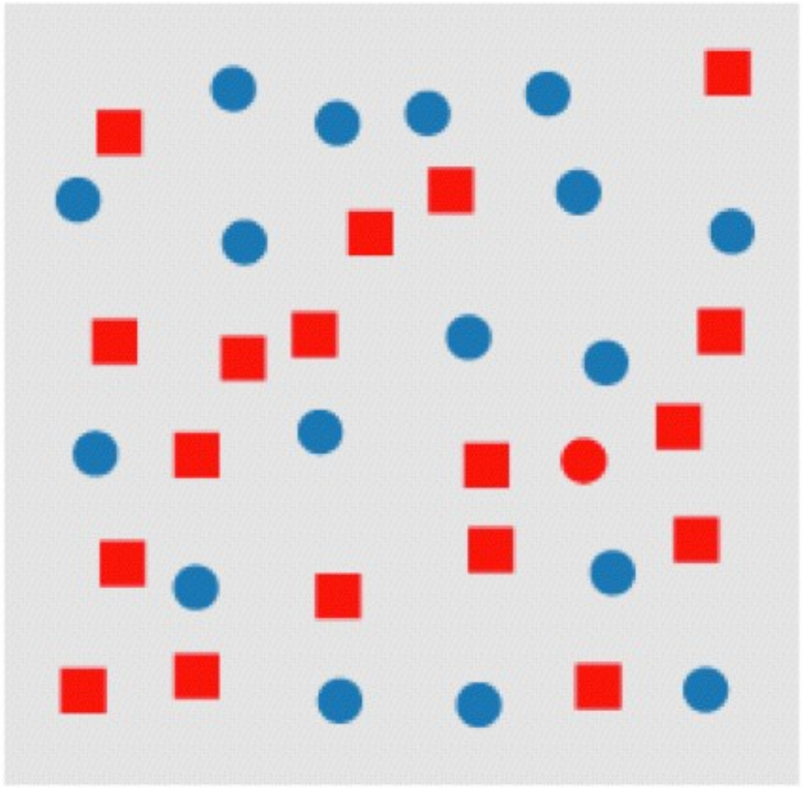


HEALY 2007

CONJUNCTION

or, why to use a single channel at a time





HEALEY 2007

CONJUNCTION

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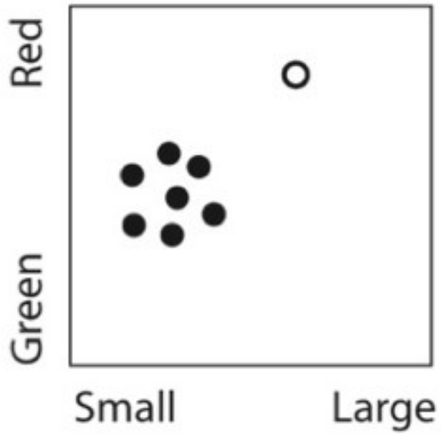
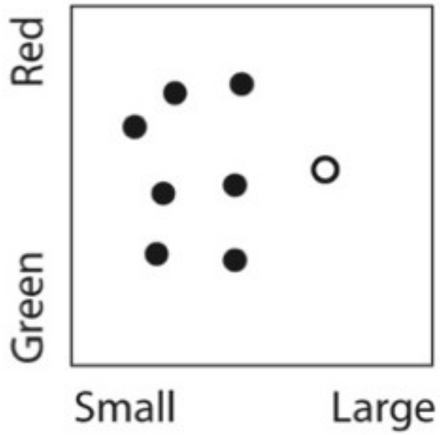
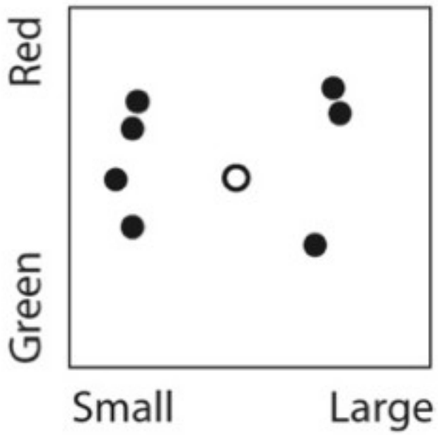
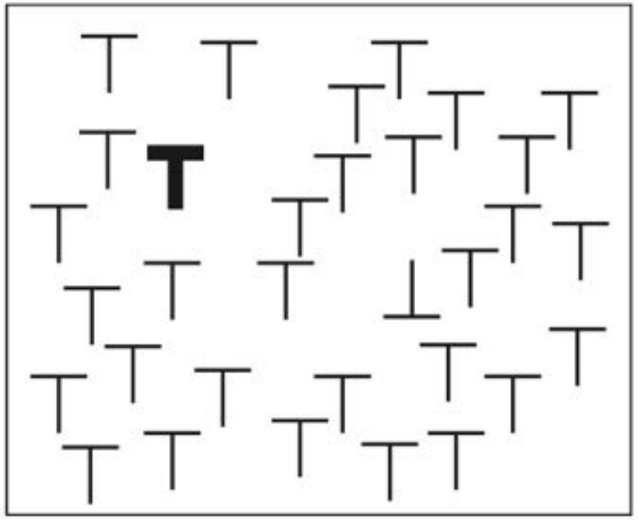






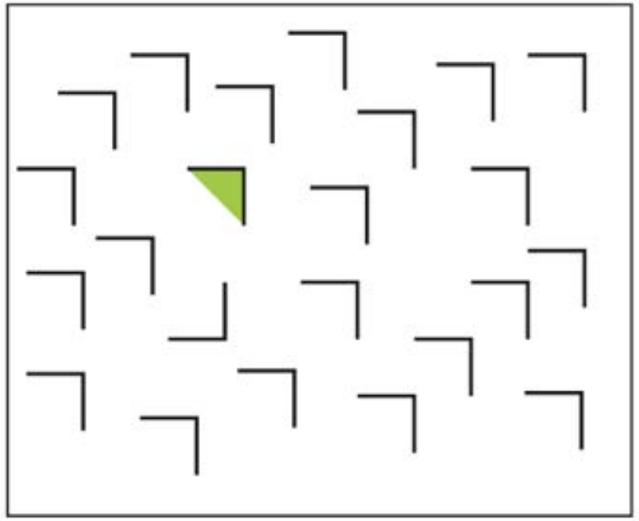
difficult



T

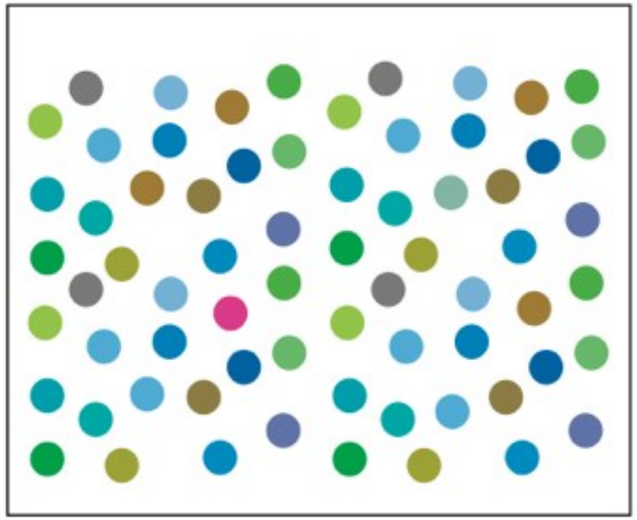
easy

difficult



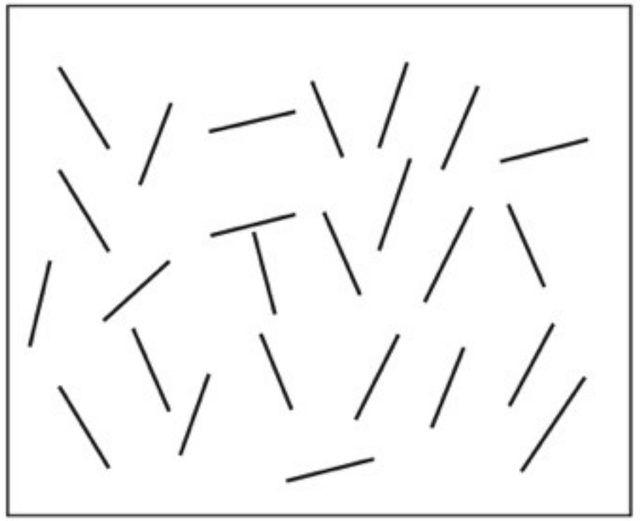
easy

difficult



easy

difficult



easy

TAKEAWAY

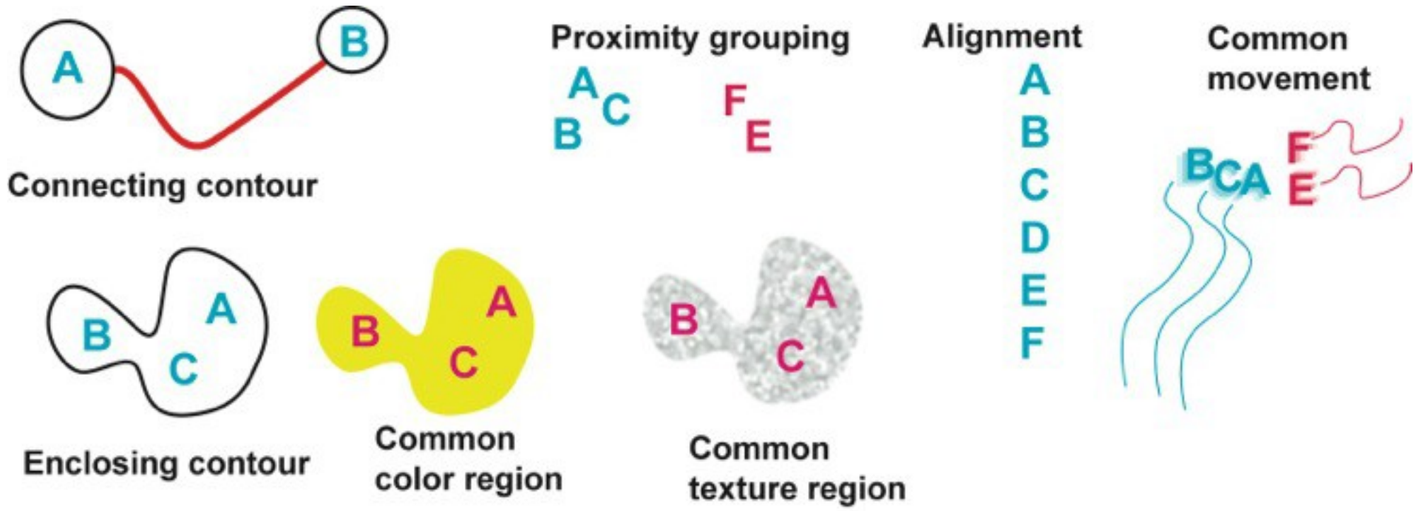
We can easily see objects that are different in color and shape, or that are in motion.

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

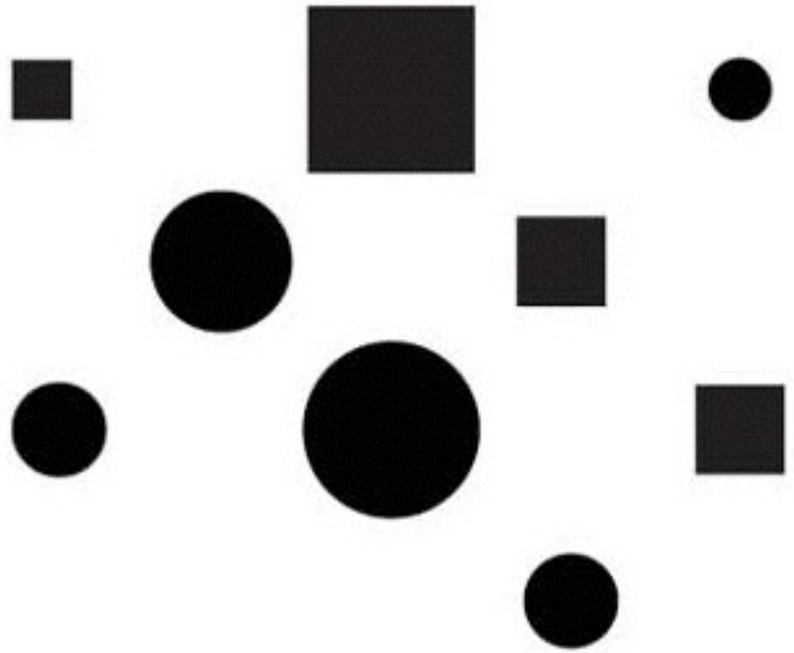
GESTALT PRINCIPLES

German: "Gestalt" = form

patterns transcend the visual stimuli that produced them

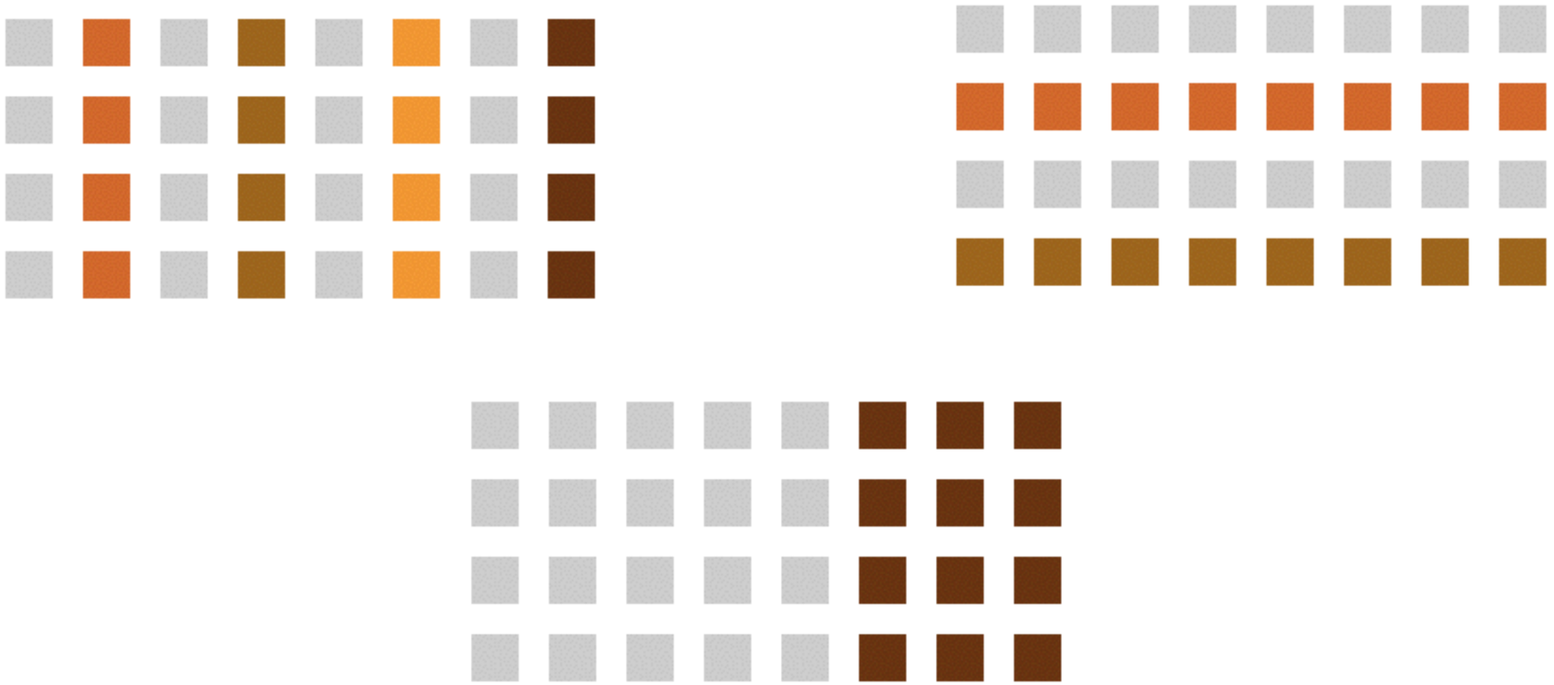


SIMILARITY



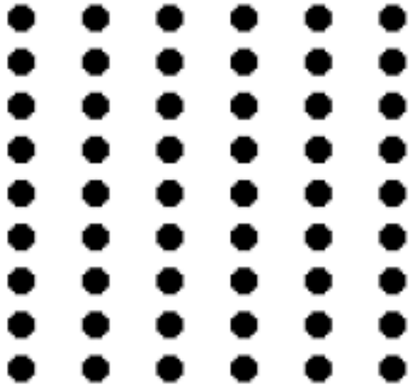
BANG WONG, "GESTALT PRINCIPLES, I", NATURE METHODS

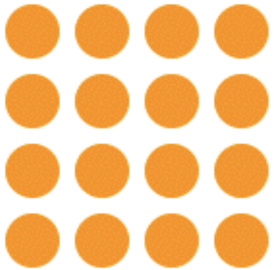
SIMILARITY

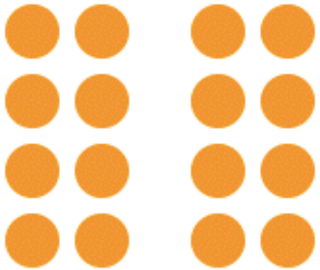


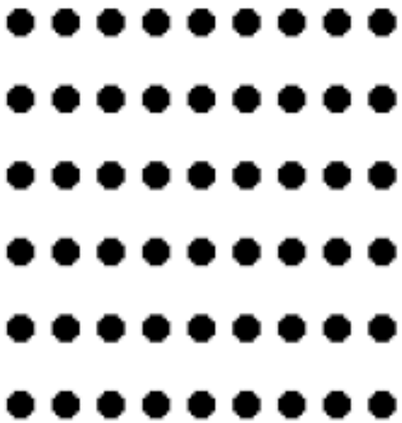
ANDY RUTLEDGE, "GESTALT PRINCIPLES OF PERCEPTION"

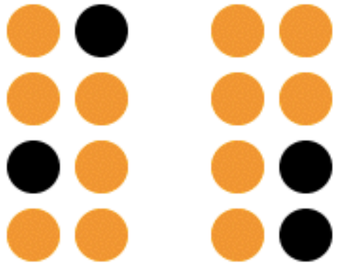
PROXIMITY





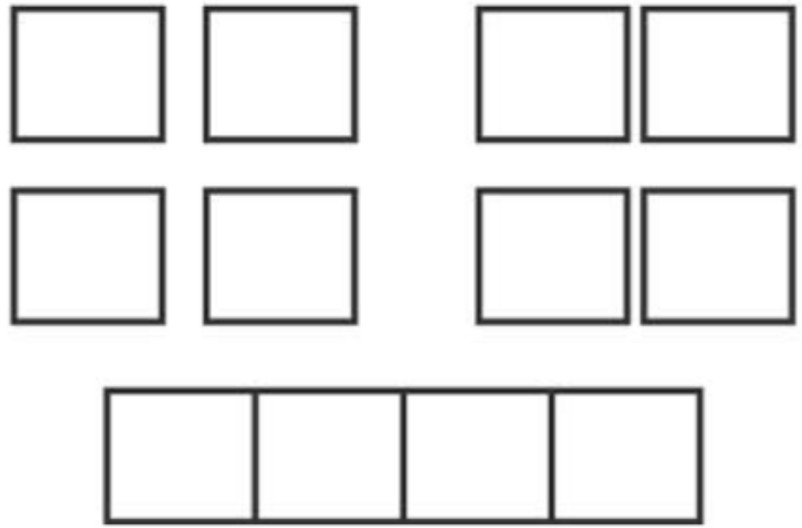






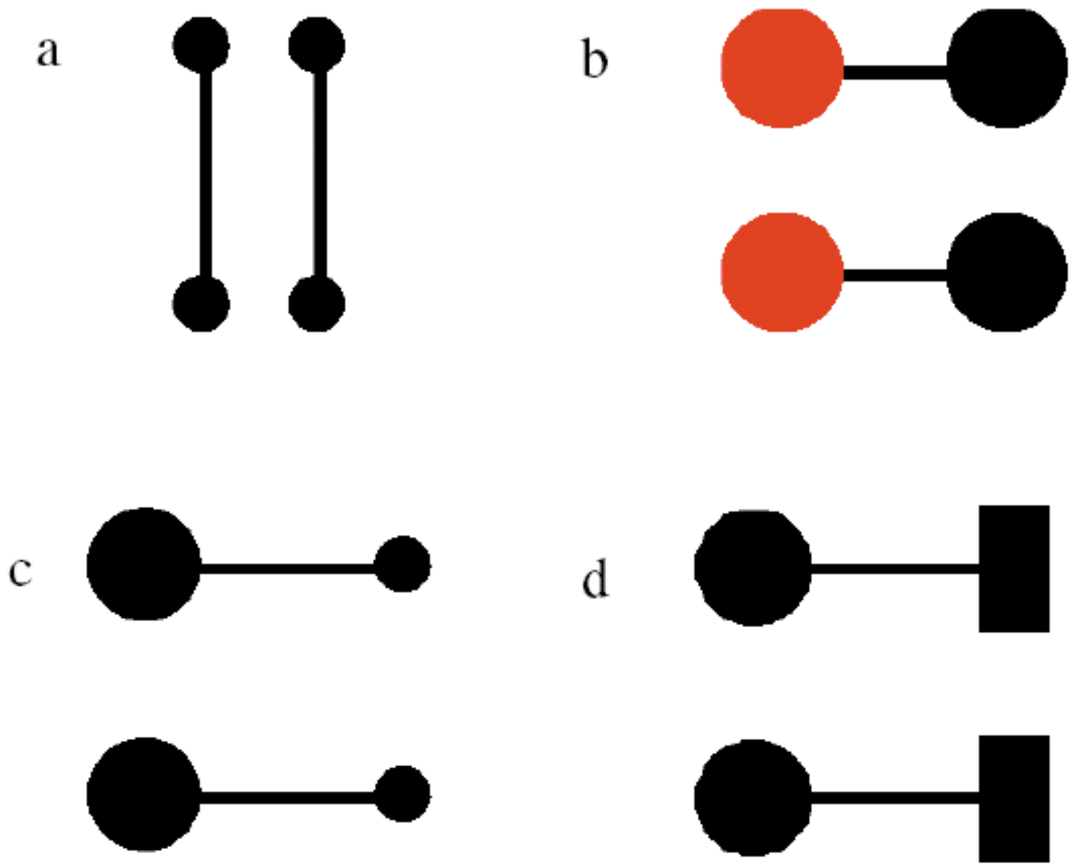
ANDY RUTLEDGE, "GESTALT PRINCIPLES OF PERCEPTION"

PROXIMITY



BANG WONG, "GESTALT PRINCIPLES, I", NATURE METHODS

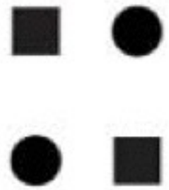
CONNECTEDNESS



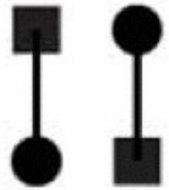
WARE, "INFORMATION VISUALIZATION"

GROUPING

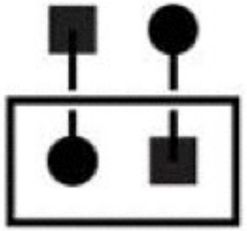
Similarity



Connection



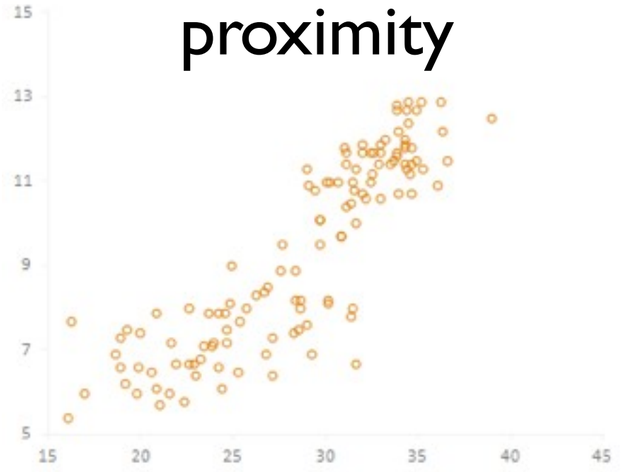
Enclosure



BANG WONG, "GESTALT PRINCIPLES, I", NATURE METHODS

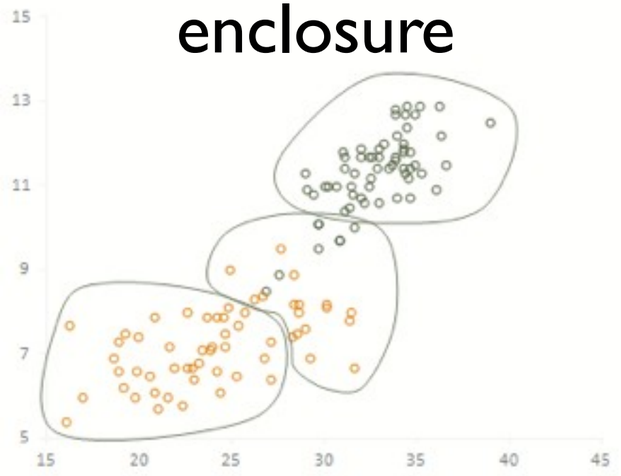
GROUPING

proximity



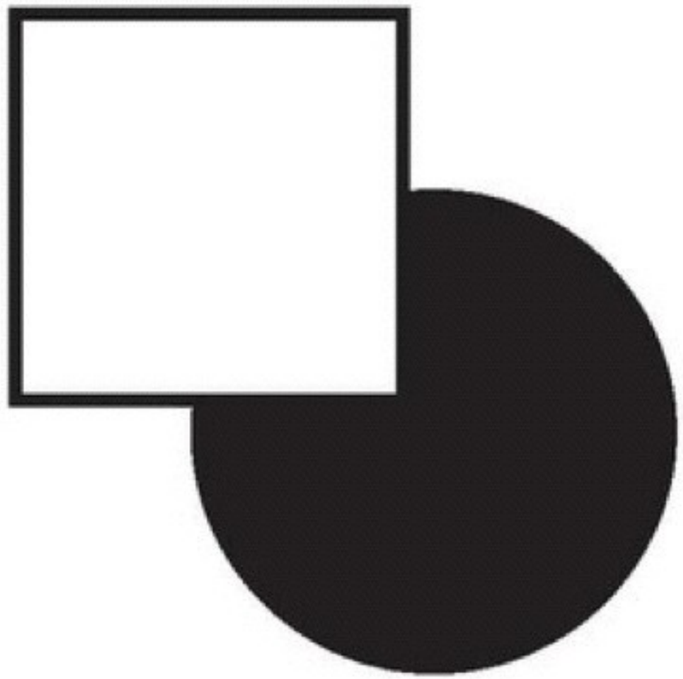
similarity

enclosure



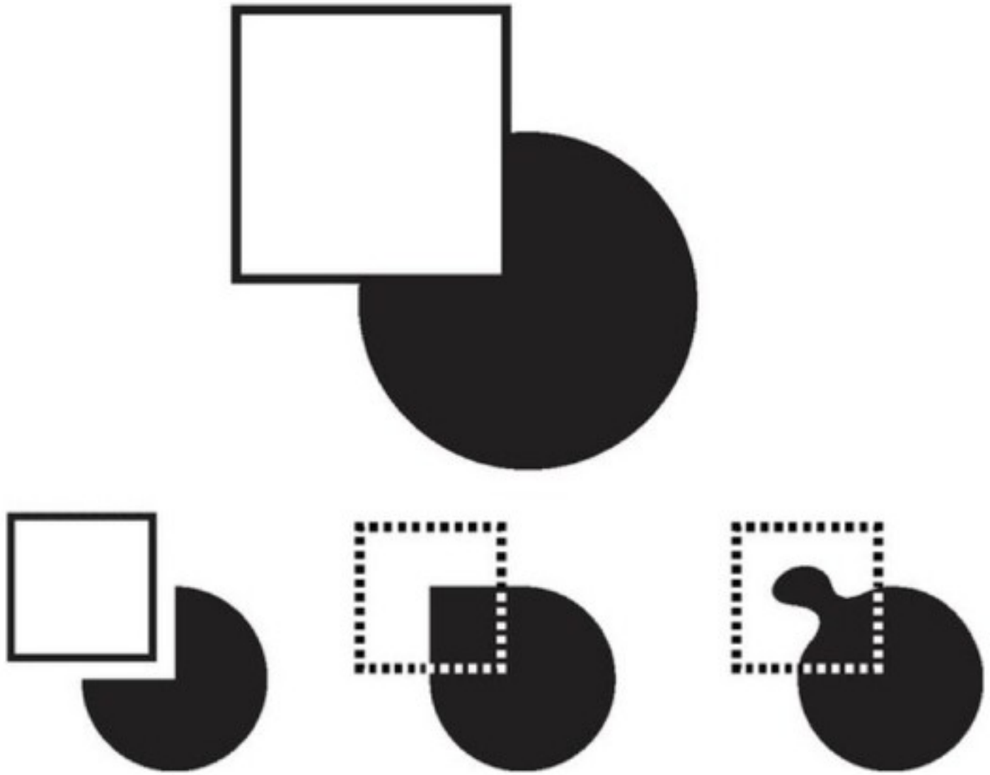
JORGE CAMOES

CONTINUITY



BANG WONG, "GESTALT PRINCIPLES, II", NATURE METHODS

CONTINUITY



BANG WONG, "GESTALT PRINCIPLES, II", NATURE METHODS

CLOSURE

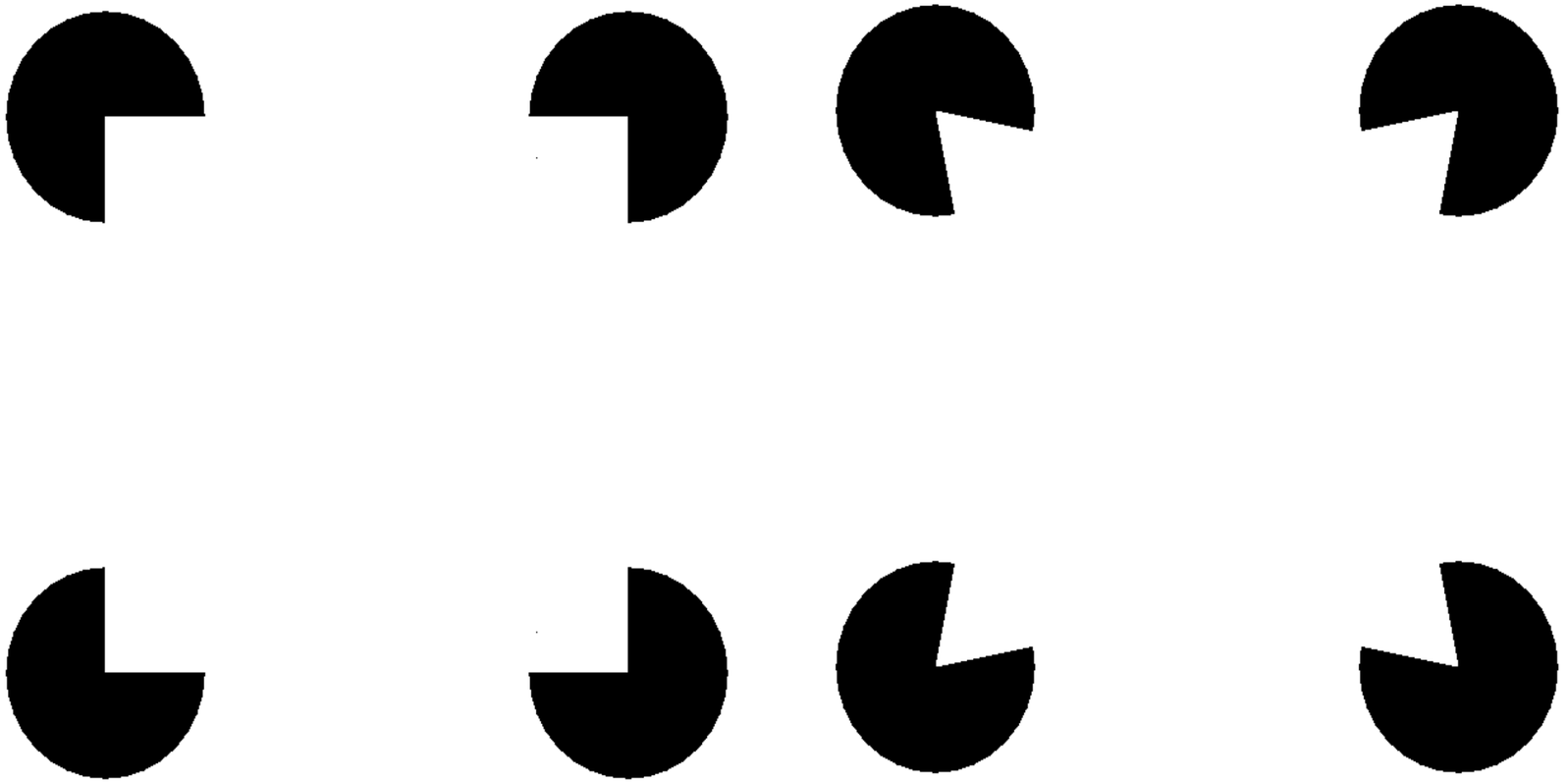
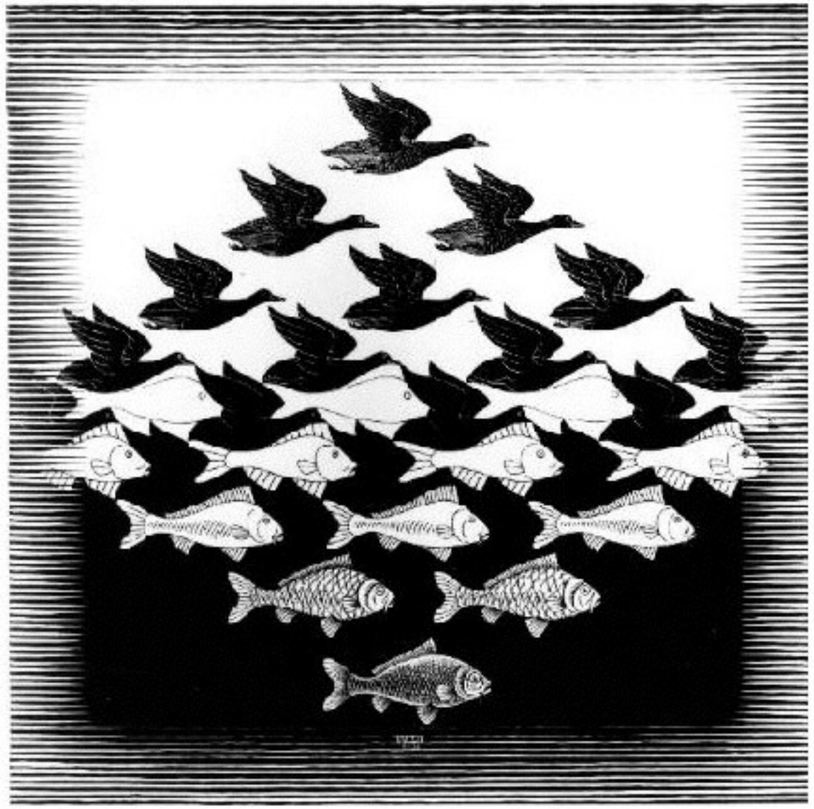


FIGURE / GROUND



M.C. Escher: *Sky and Water I* 1938 woodcut

COMMON FATE

GESTALT PRINCIPLES

similarity: things that look like each other (size, color, shape) are related

proximity: things that are visually close to each other are related

connection: things that are visually connected are related

continuity: we complete hidden objects into simple, familiar shapes

closure: we see incomplete shapes as complete

figure / ground: elements are perceived as either figures or background

common fate: elements with the same moving direction are perceived as a unit

TAKEAWAYS

Gestalt principles give us a conceptual understanding of the way our mind converts shapes into structured thought.

Using the Gestalt principles wisely will lead improve performance in interpretation of visualizations. Poor use may cause users to see things that aren't there…