

Data Visualization 3: The Visual System

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So far ...



“While graphics technology is moving along at a rapid pace, the human visual system has remained the same.”

William S. Cleveland

About human vision

It is the sense most connected with cognition

Seeing and thinking are extremely related:

How we **see** ← → how we **think**

Data visualization, in the form of graphics, is mostly visual.

Understanding visual perception is fundamental to design better visual displays.

Vision, of our all senses, is
the most powerful and
efficient channel for receiving
information from the physical
world.

About human vision

Vision dominates our senses

Most powerful channel for receiving information

About half of our brain deals with visual input

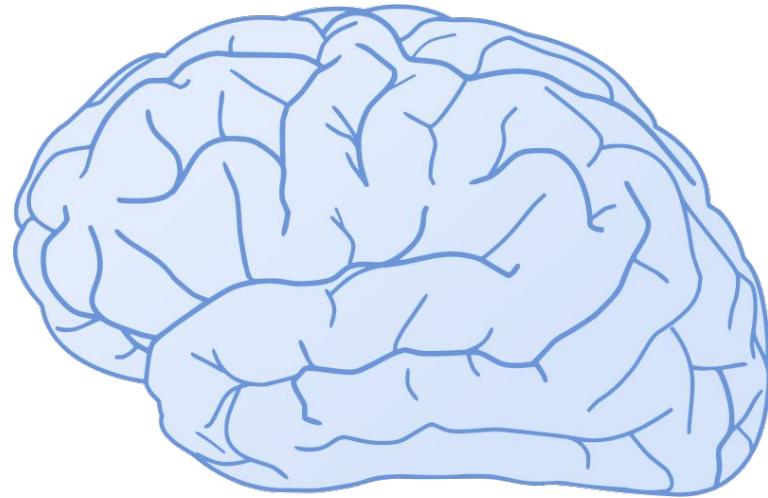
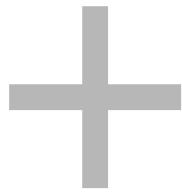
~ 70% of the sense receptors in our bodies are dedicated to vision

Visual System

Seeing and thinking



Eye



Brain

Visual System

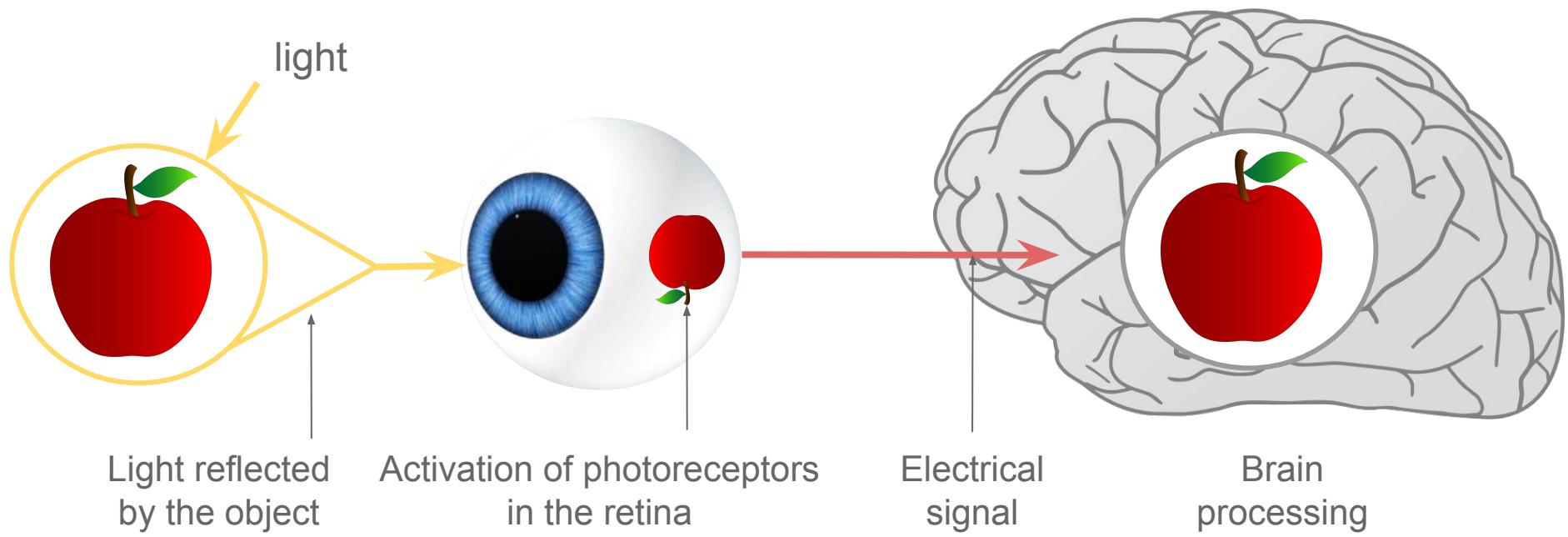
The visual system consists of 2 parts:

- Eyes
- Brain

The **eyes** act as image receptors.

The **brain** acts as an image processing and interpretation unit.

How we see



based on Alberto Cairo's diagram p. 98

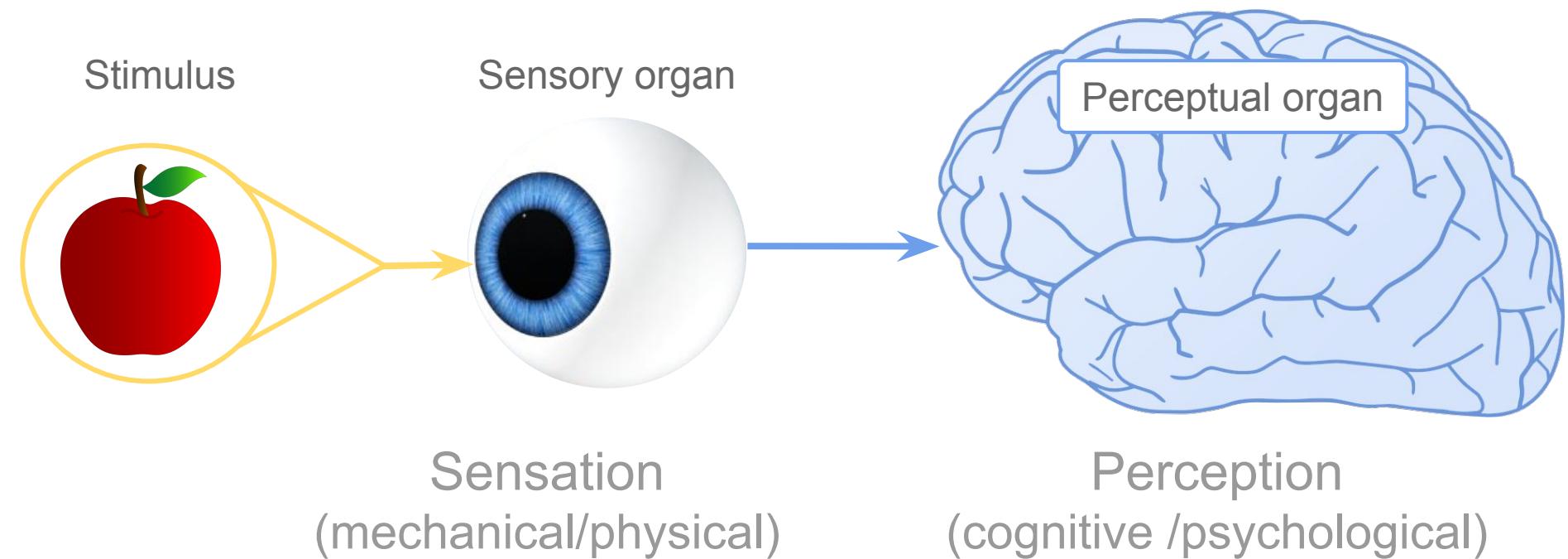
Seeing

What our eyes get is not (really) what our brain perceives

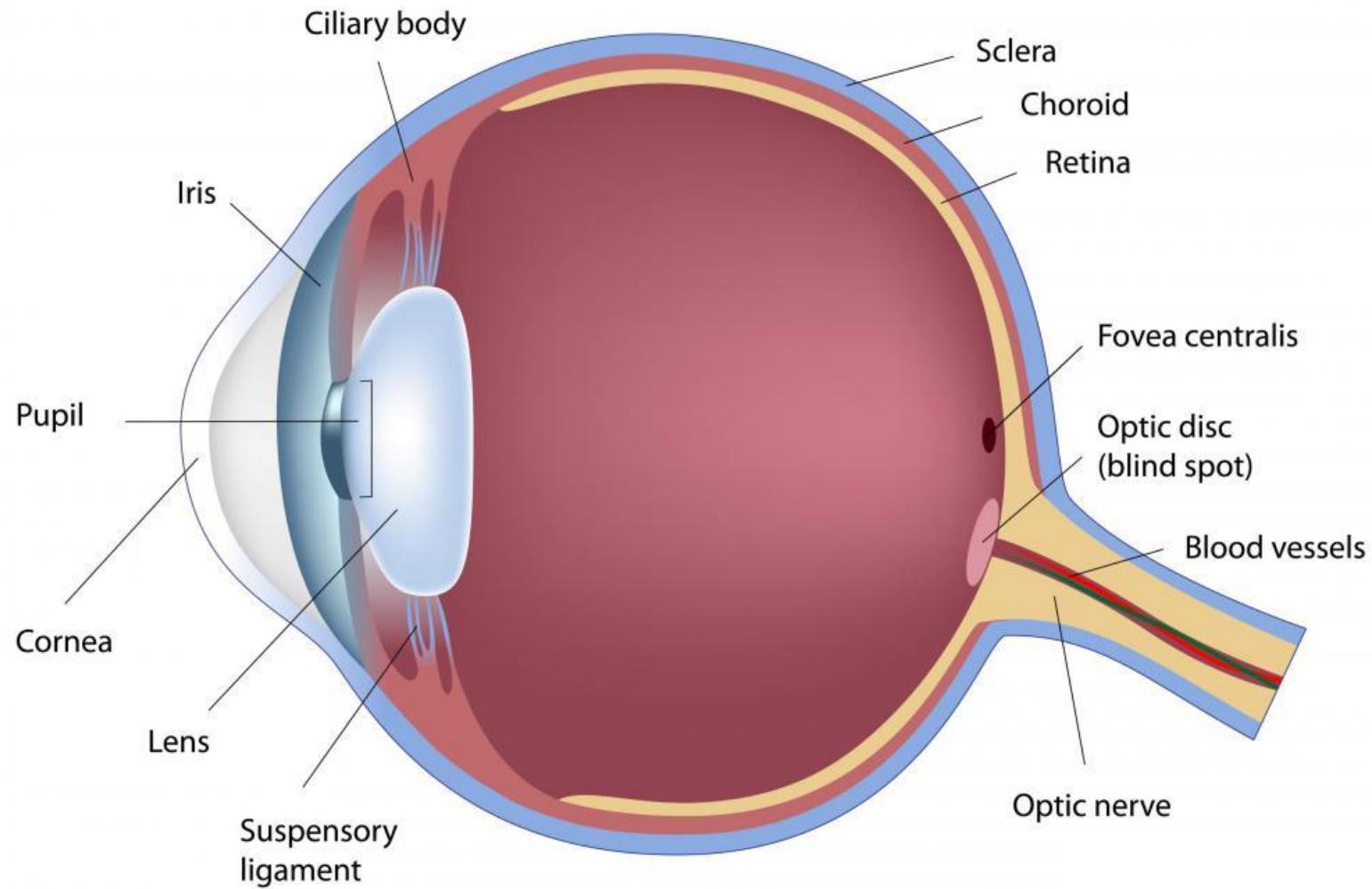
What we commonly call “seeing” is not a single phenomenon but a group of at least 3 operations:

- Sight
- Perception
- Cognition

Psycho-Physical System

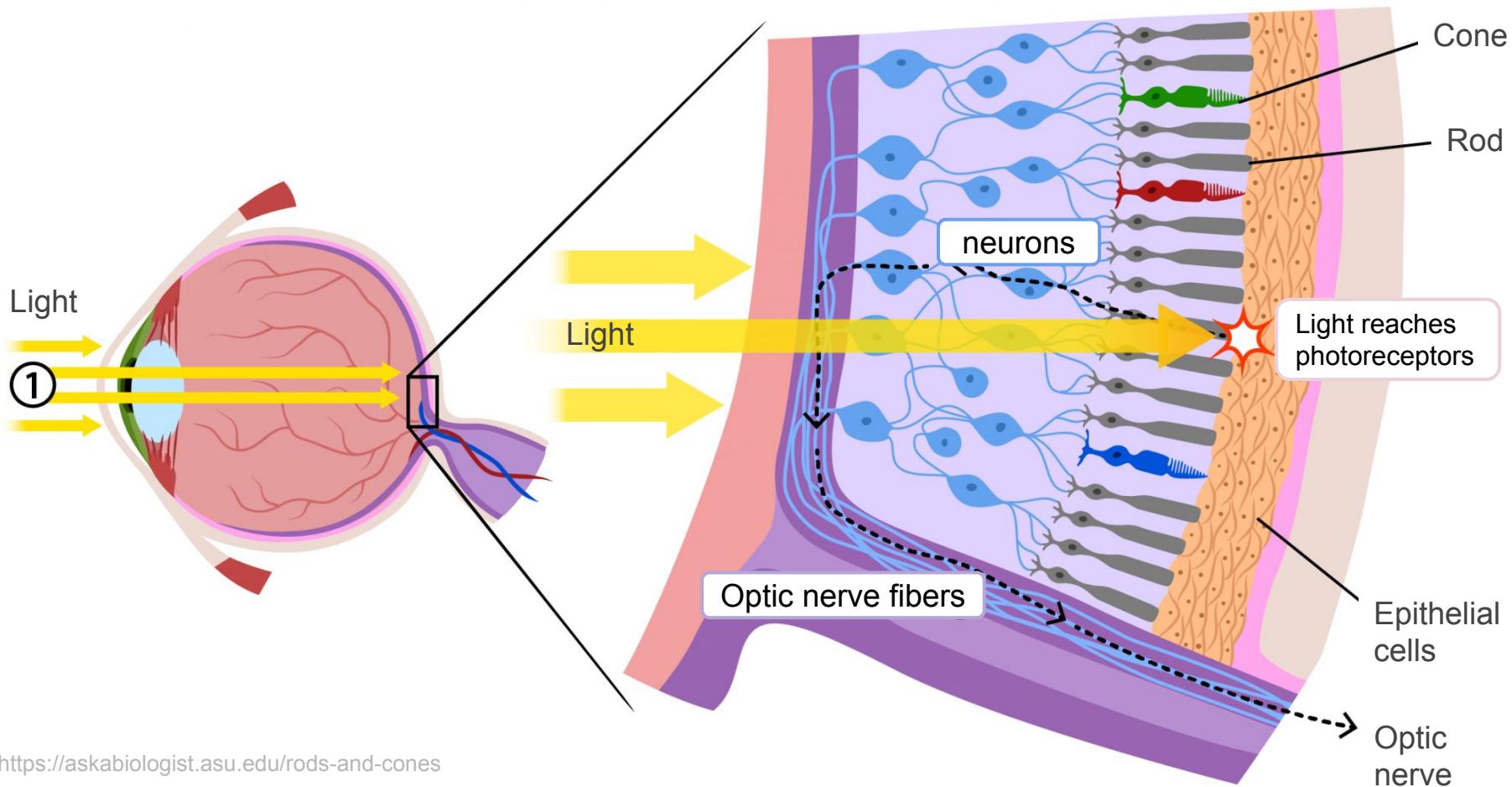


Human Eye Anatomy

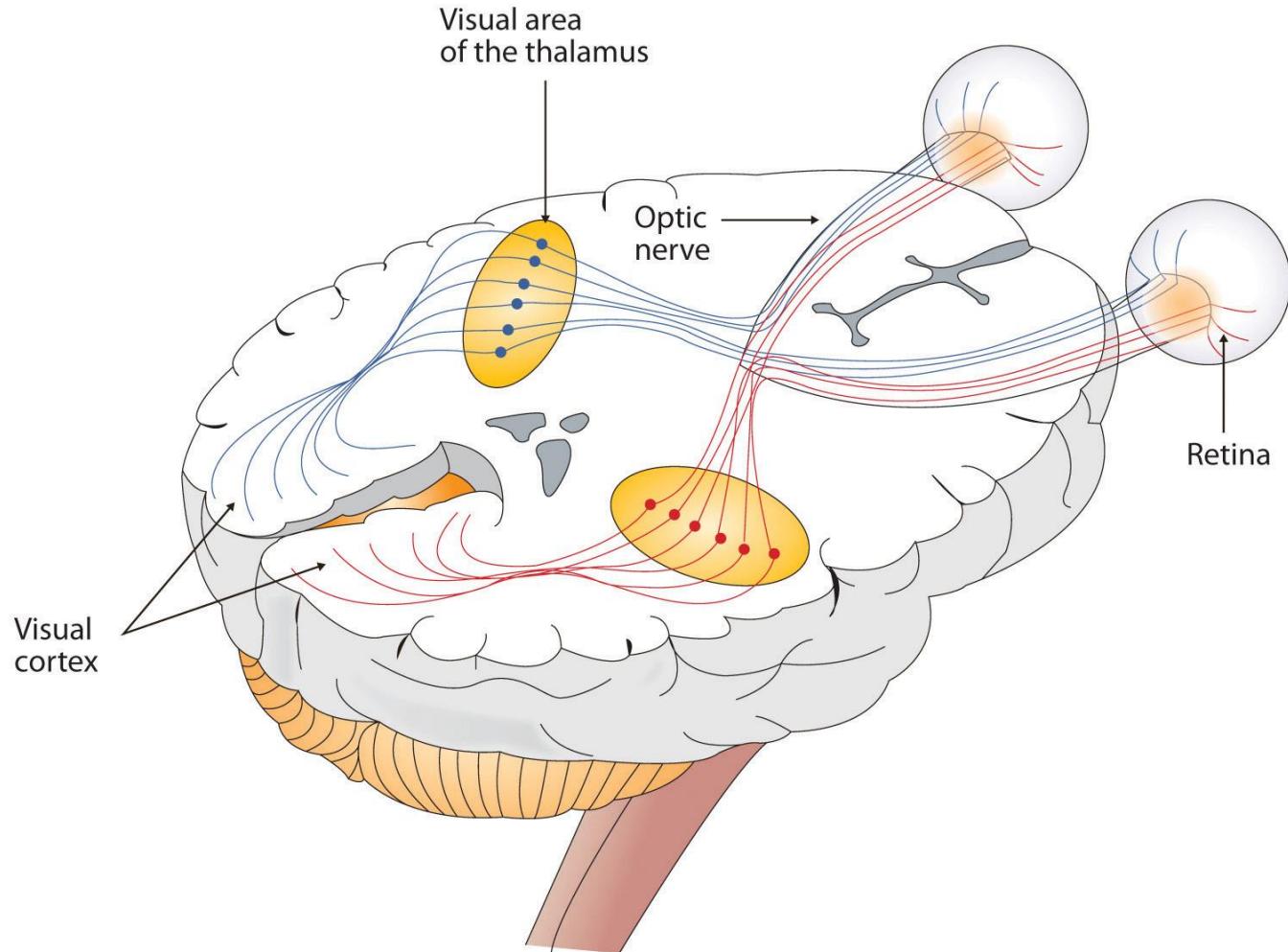


http://www.gridgit.com/postpic/2010/02/human-eye-anatomy-diagram_602620.jpg

Photoreceptors: Rods and Cones



Visual pathways



Foveal and Peripheral Vision

What your brain thinks you are seeing



© Gaston Sanchez

What your eyes are really getting



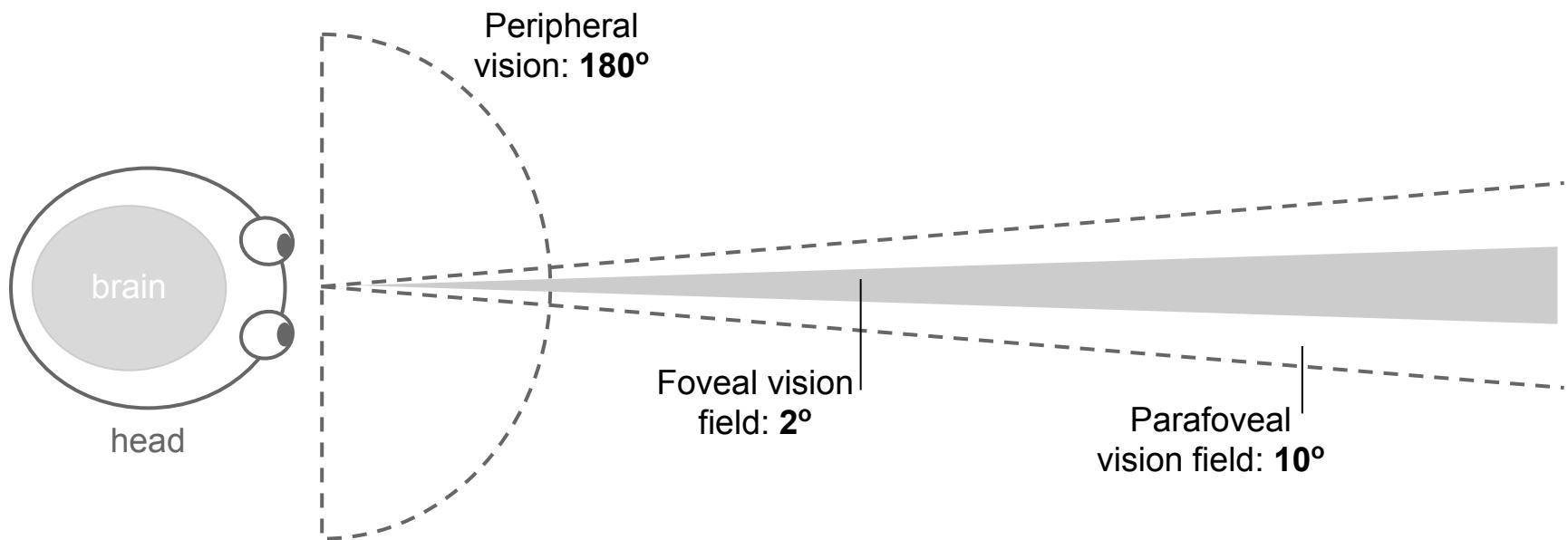
What your eyes are really getting



What your eyes are really getting



Vision Fields



based on Alberto Cairo's diagram p. 102

Foveal and Peripheral Vision

Most visual information falls in the peripheral areas of the retina.

There's one special region in the retina called the fovea.

It is the place that provides the sharpest vision.

The fovea allows us to distinguish small objects, detail, and color.

Foveal and Peripheral Vision

Our eyes repeatedly move to keep the object of most interest imaged on the fovea.

The central vision is critical for specific object recognition.

Peripheral vision is used for getting the gist of a scene.

Main Takeaways

We use both peripheral and central vision when looking at an image.

Don't assume people will see something on a graphic just because it's there.

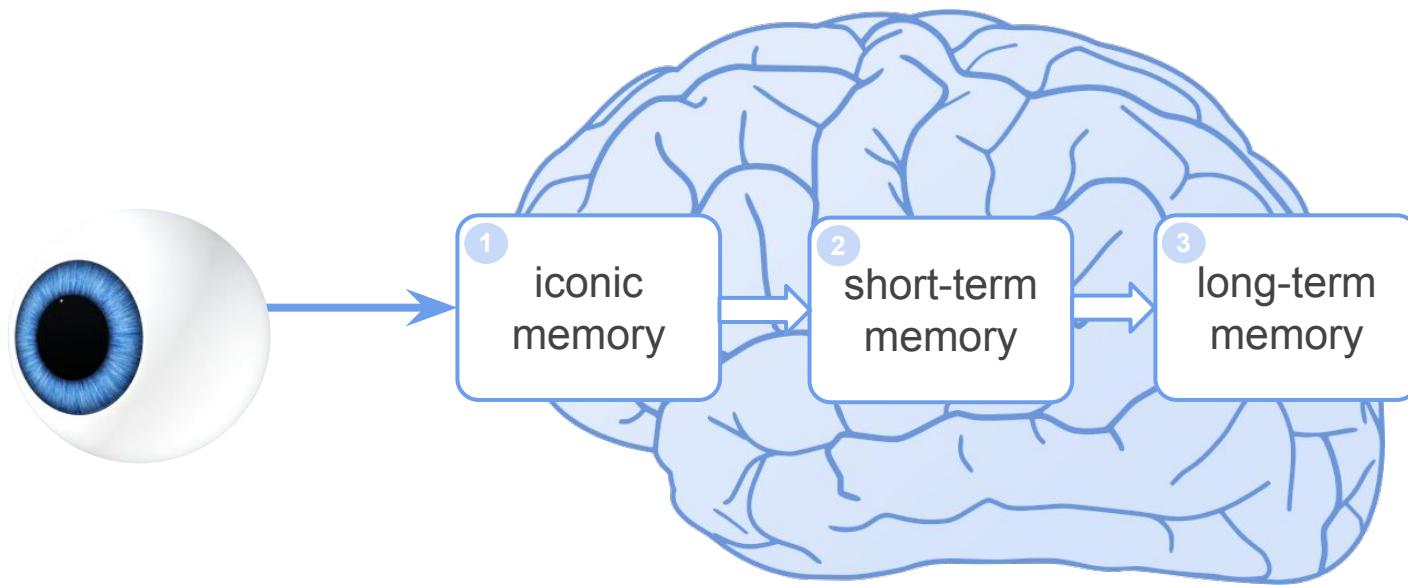
Avoid putting important things on the edges, since we tend not to look there.

Attention and Memory

Brain as a computer

To better understand the process of visual information, it is useful to think about the Brain as a computer.

Information Processing and Memory

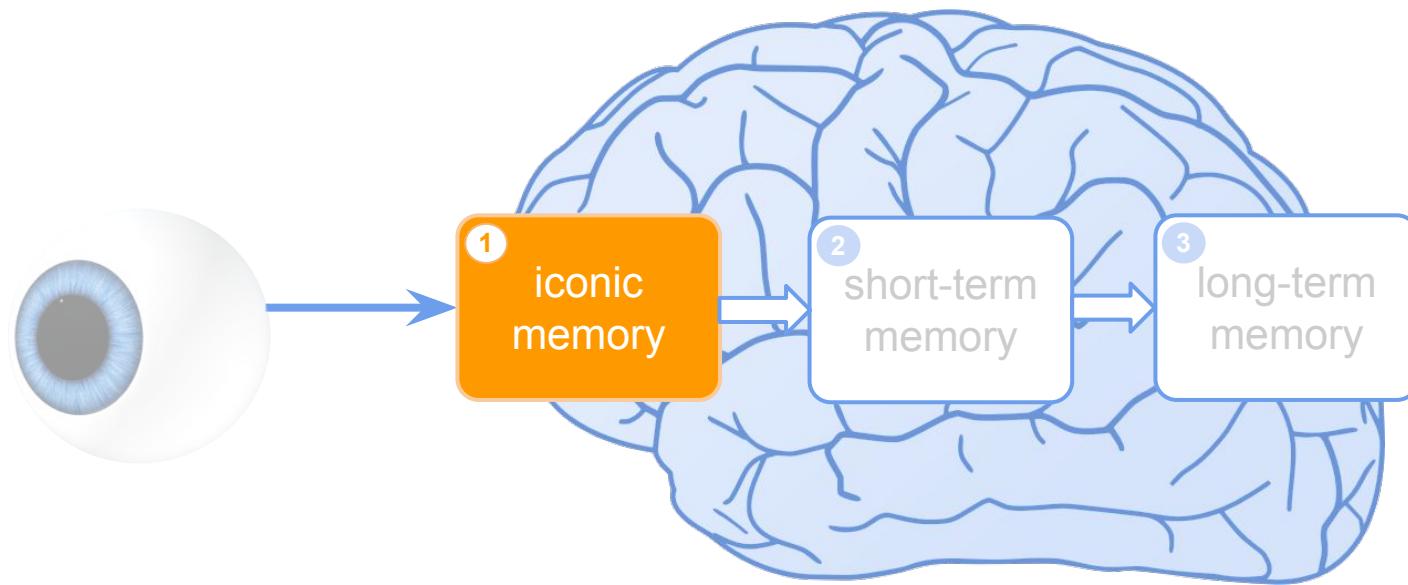


Brain as a computer

Types of memory for processing visual information:

- **Iconic** memory (visual sensory register)
like the buffer or temporary
- **Short-term** memory (working memory)
like the random access memory (RAM)
- **Long-term** memory (“permanent” storage)
like the hard disk

Iconic Memory



Iconic Memory

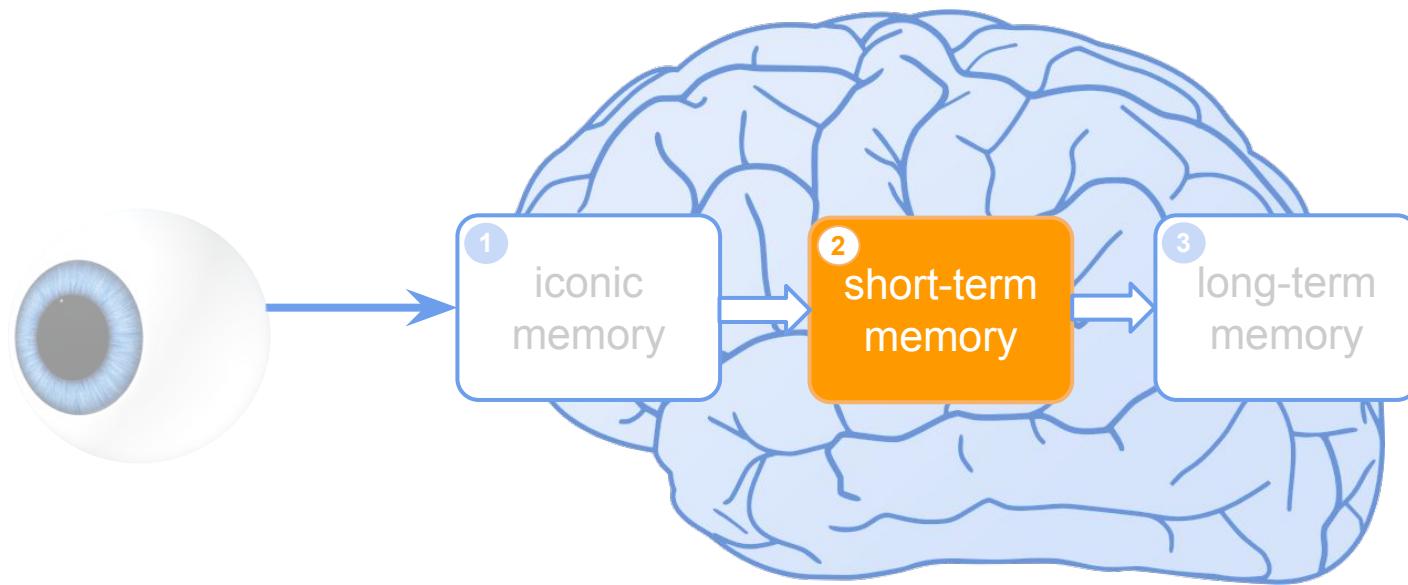
The iconic memory is a sort of waiting room where each snapshot of input waits to be passed on to short-term memory.

Rapid processing: almost automatic, parallel, and unconscious

Also called preattentive processing.

Processes primitive visual features.

Short-term Memory



Short-term Memory

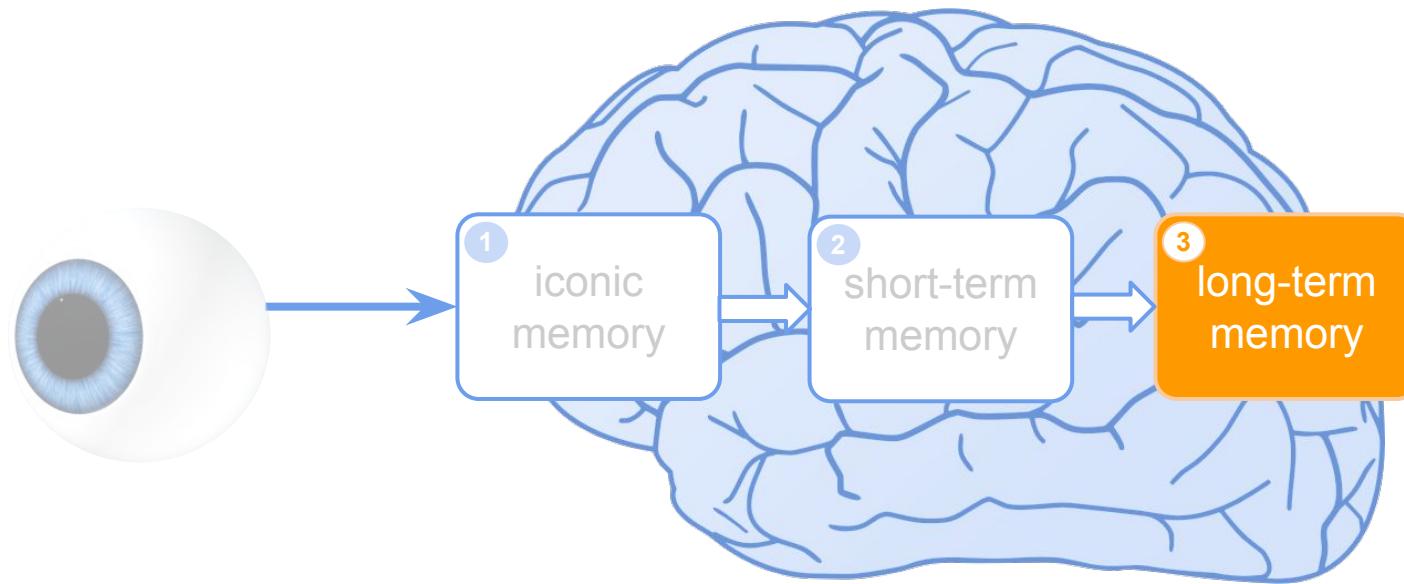
The short-term memory is a sort of RAM.

This is where conscious mental work is performed to support cognition, and information is combined into meaningful visual chunks.

This memory is temporary and has limited storage capacity.

Where the attentive process of perception occurs.

Long-term Memory



Long-term Memory

The long-term memory is a sort of hard disk.

It's a dynamic structure that retains everything we know.

Involves an intricate network of links and cross-references that help us find information.

Holds our ability to recognize images and detect meaningful patterns.

Early Vision and Preattentive Vision

Iconic memory is related with
the Early Vision, aka
preattentive vision.

Preattentive Processing

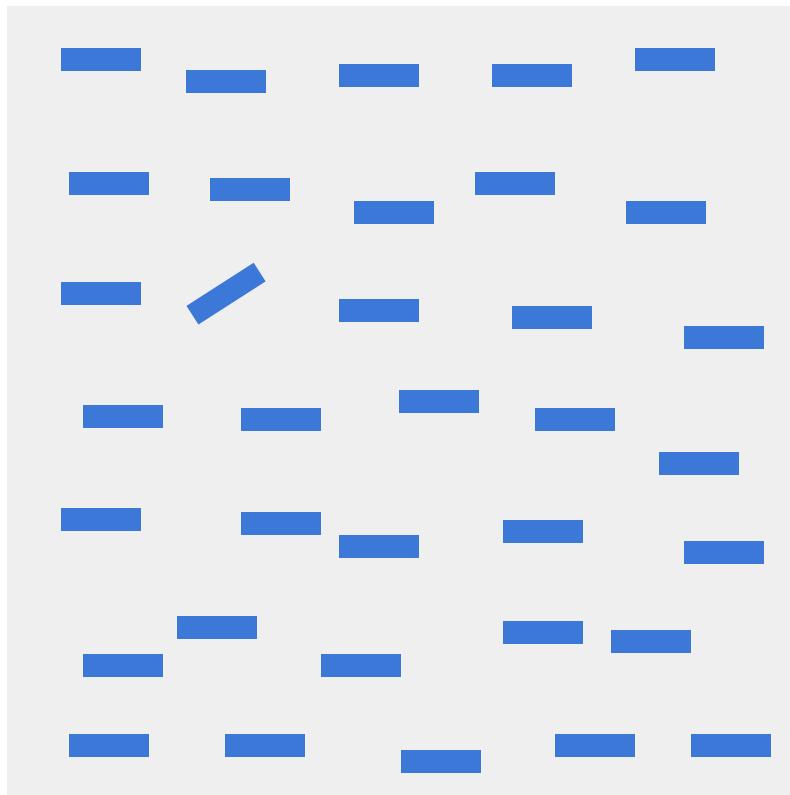
Arrays on neurons work in parallel.

Requires attention despite the name.

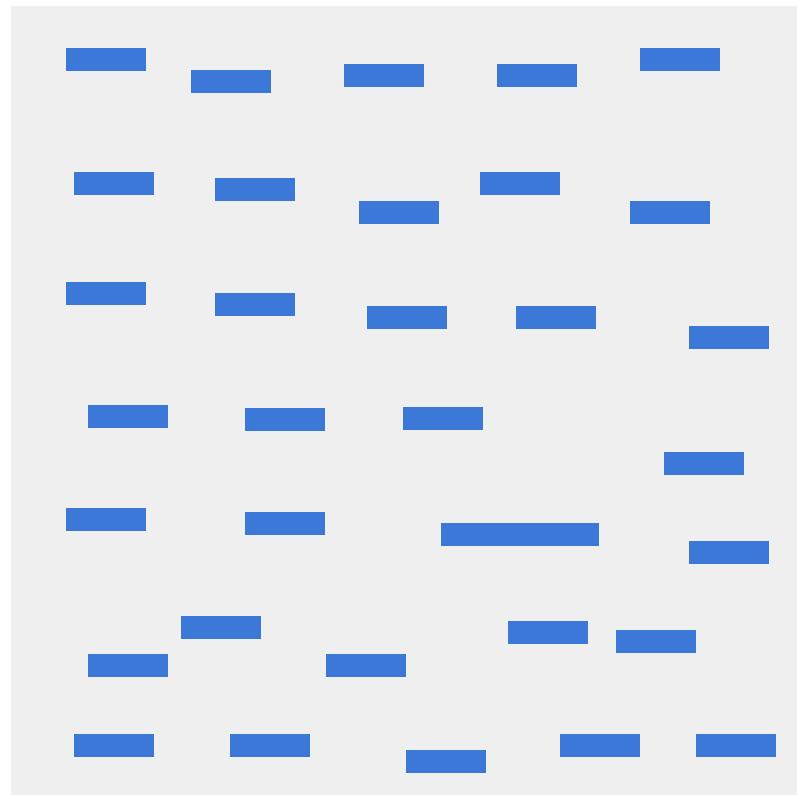
Occurs almost automatically.

What matters most is the contrast between features.

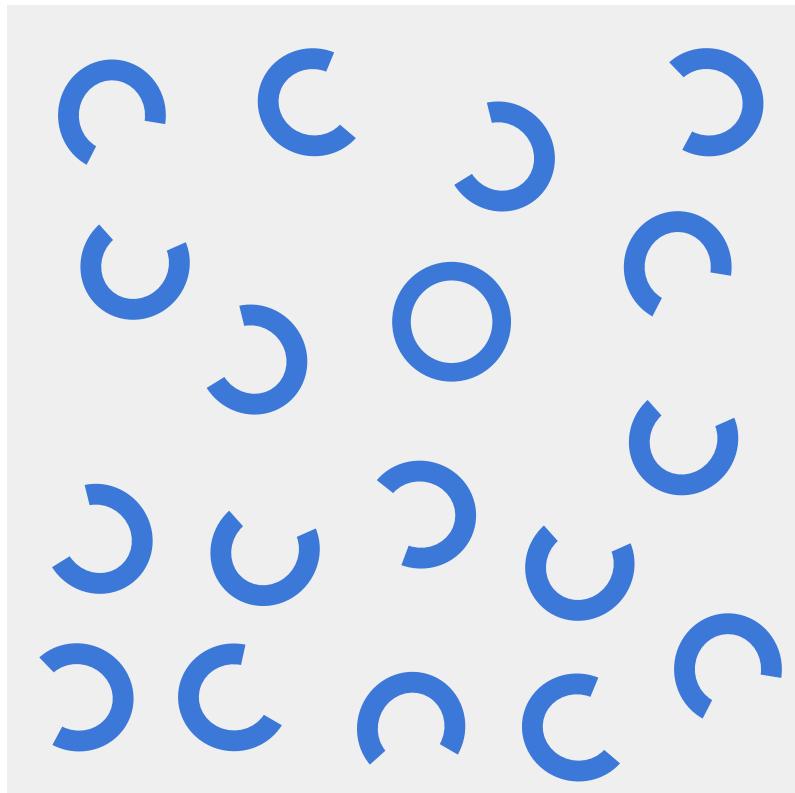
Orientation



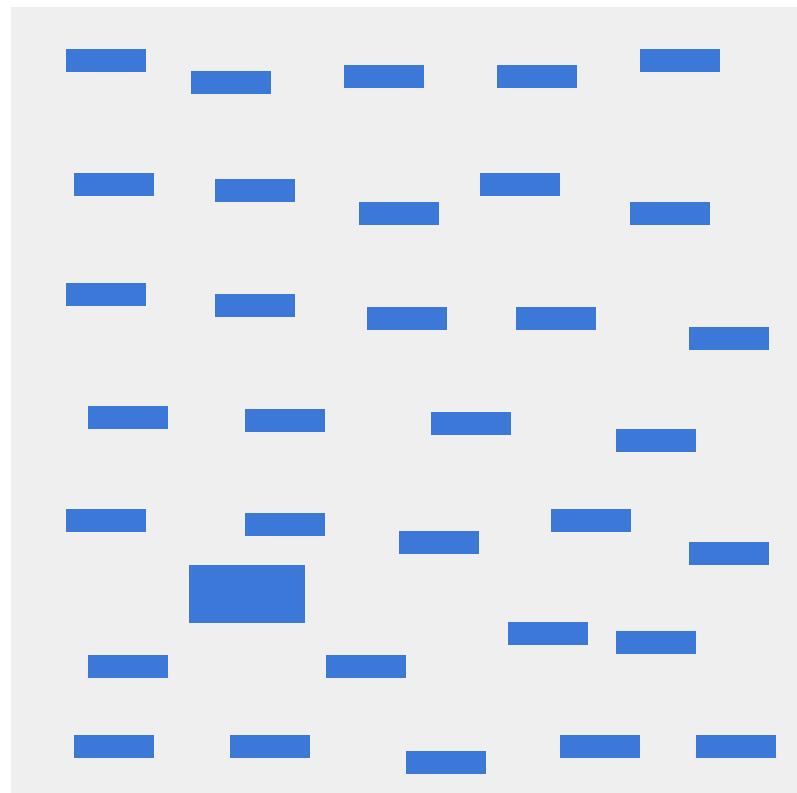
Length



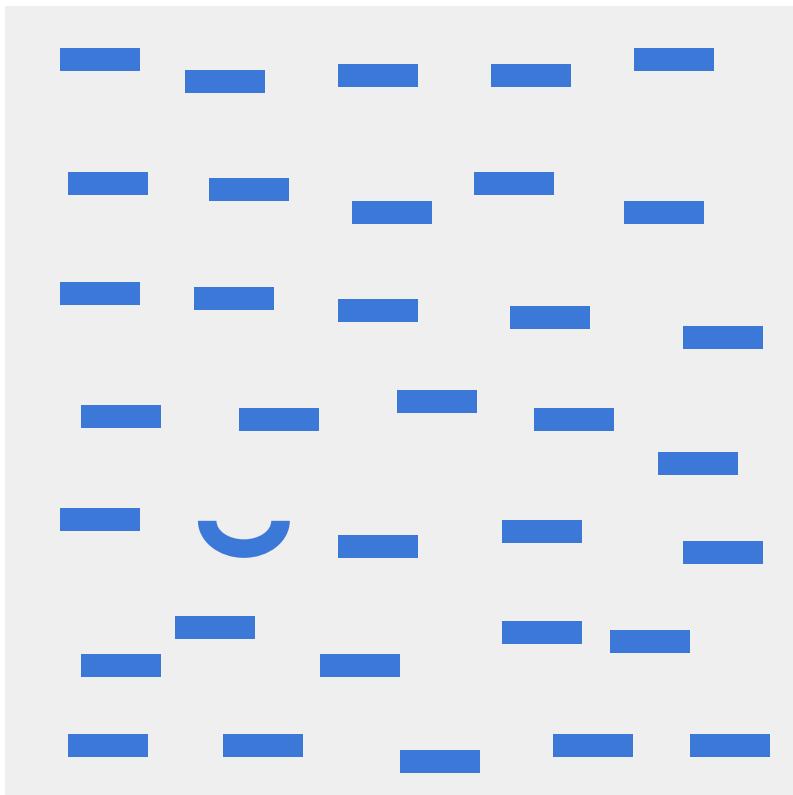
Closure



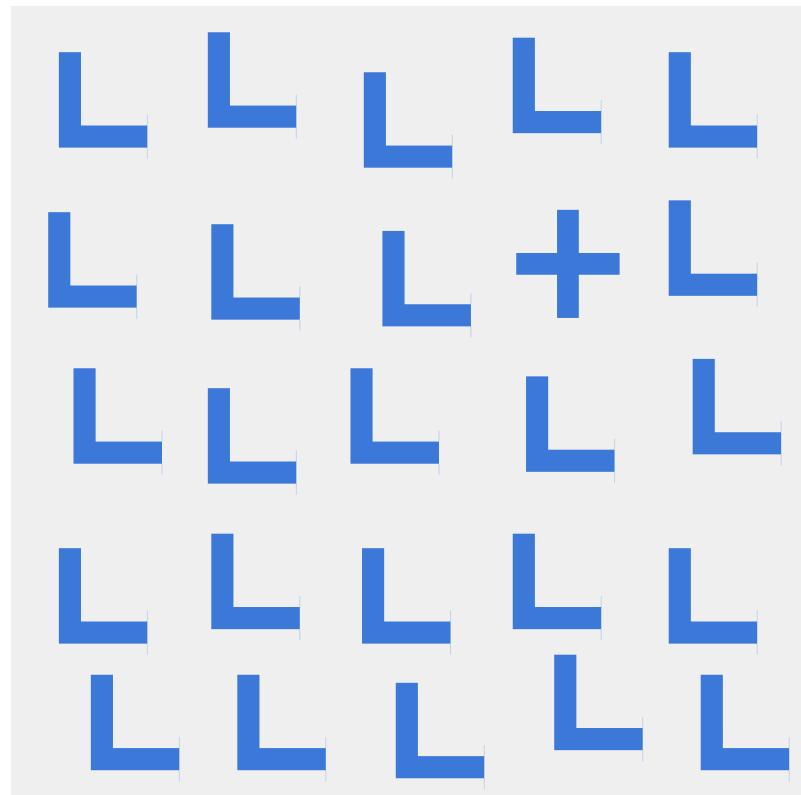
Size



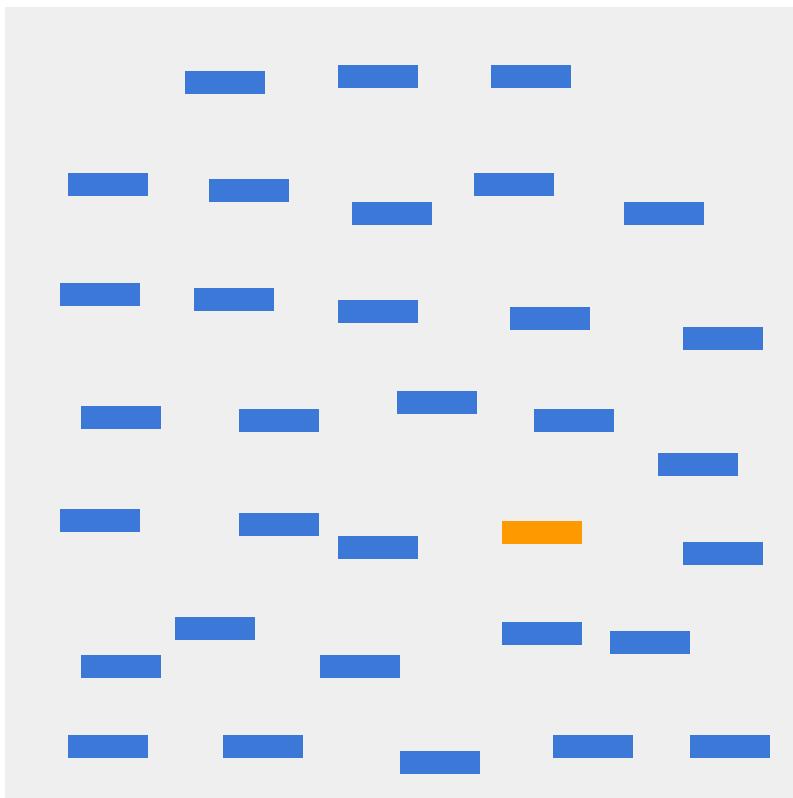
Curvature



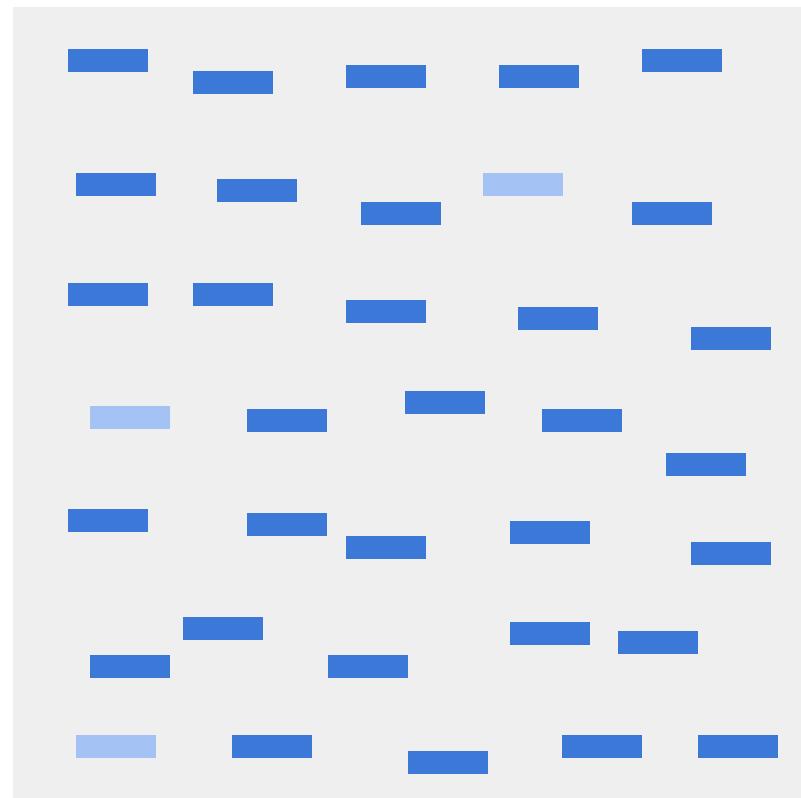
Intersection



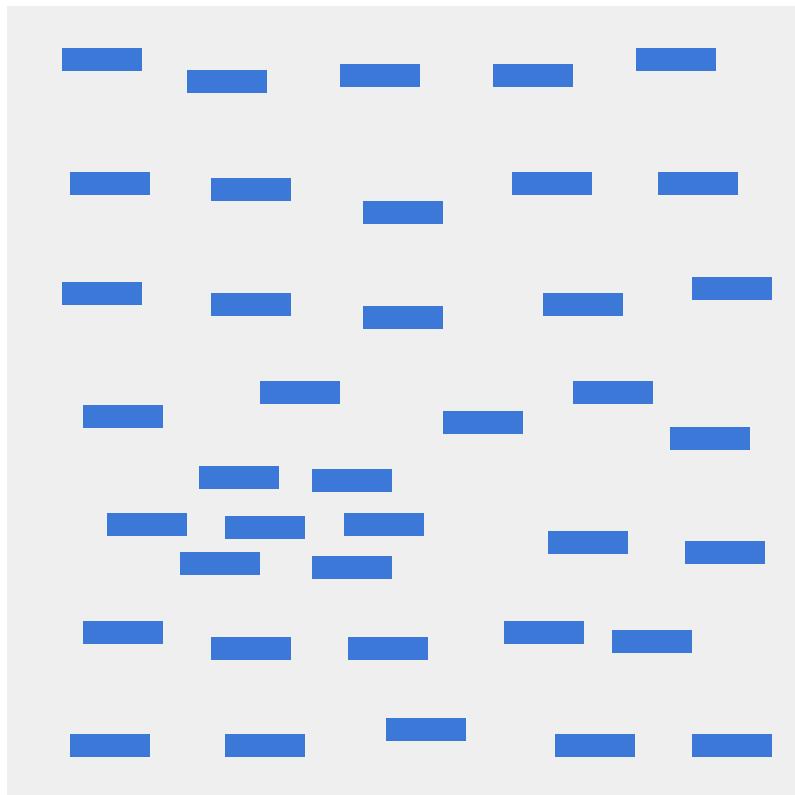
Hue



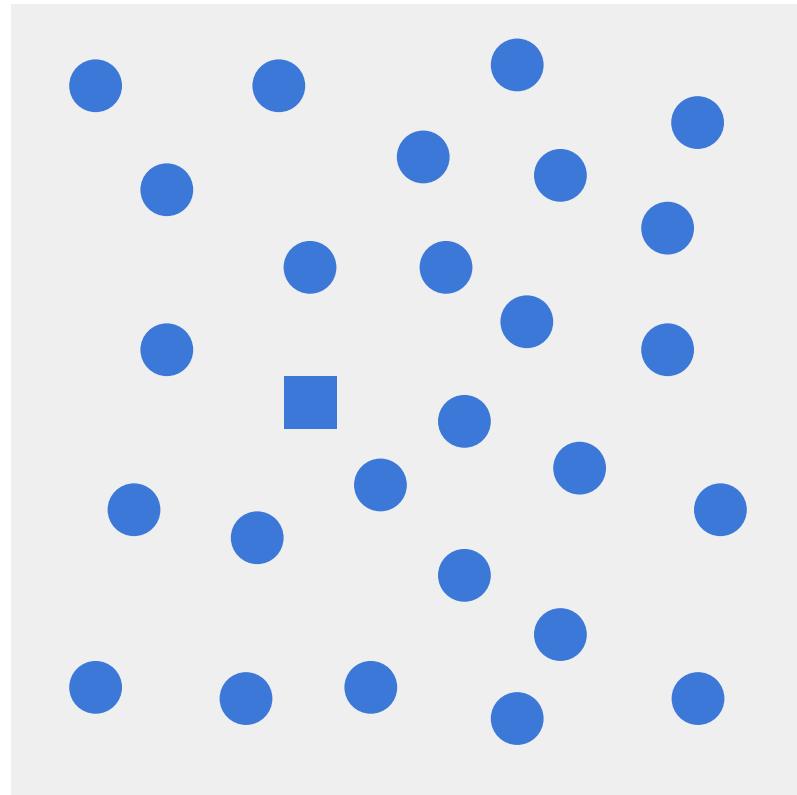
Intensity



Density



Shape



Later Vision and Postattentive Vision

Short-term and Long-term
memories are related with
the Later Vision, aka
postattentive vision.

Postattentive Processing

Slow serial processing.

Involves working and long-term memory.

Different pathways for object recognition and visually guided motion.

Ron Rensink's examples



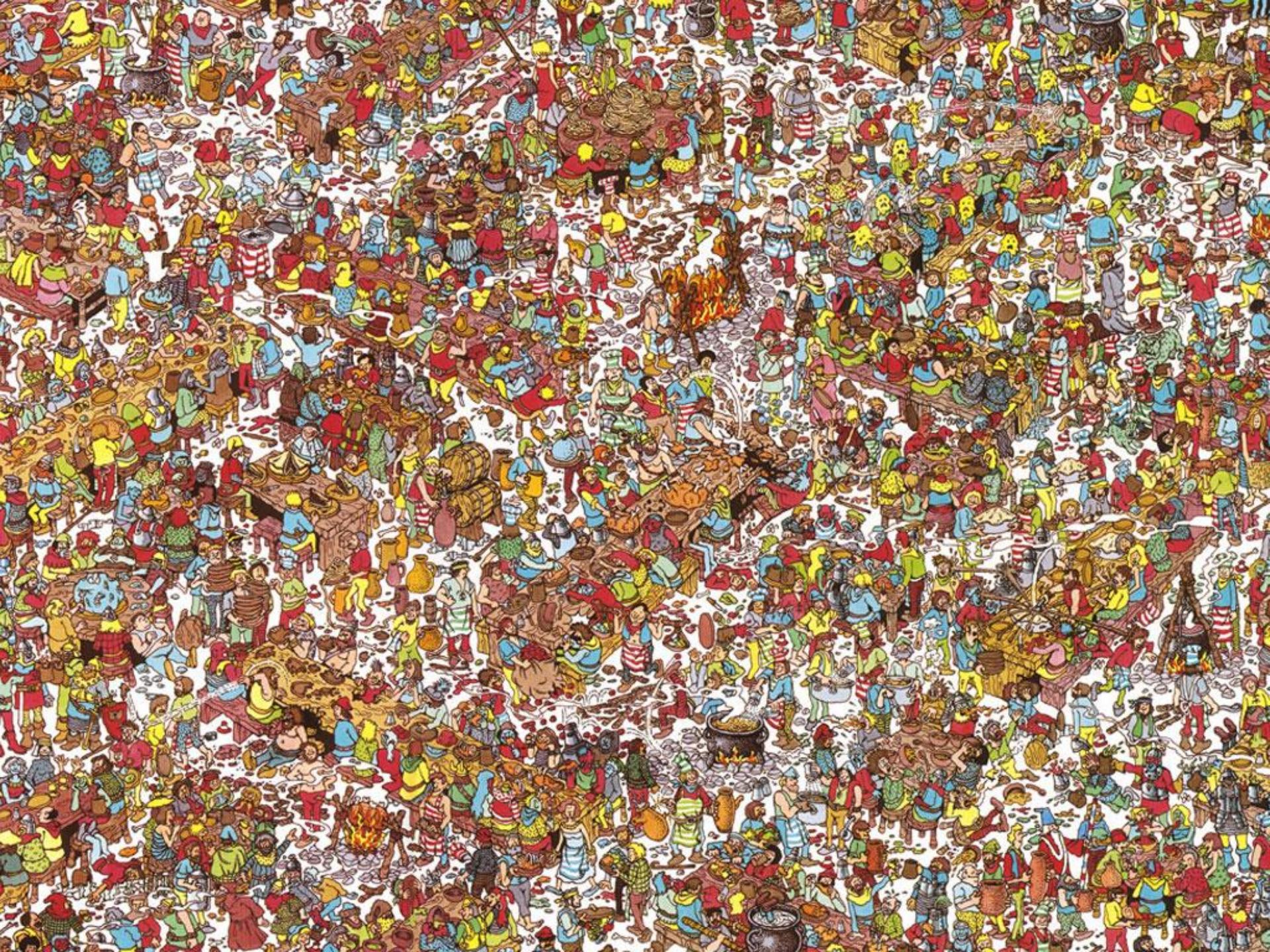
Ron Rensink's examples



Ron Rensink's examples







Postattentive: How many sixes?

4 3 6 7 9 8 1 2 5 5 1 1 5 6 1 1 5 8 1 3 4 1 5 9 1 5

1 5 3 4 5 1 1 5 2 5 1 3 1 9 2 5 1 2 1 8 9 1 4 1 1 6

5 2 1 6 1 1 6 1 2 4 1 8 1 6 1 5 8 2 4 1 4 1 5 1 9 1

1 4 1 8 1 9 5 2 1 8 1 9 1 1 5 1 1 5 1 6 1 8 2 6 1 2

Preattentive: How many sixes?

4 3 6 7 9 8 1 2 5 5 1 1 5 6 1 1 5 8 1 3 4 1 5 9 1 5

1 5 3 4 5 1 1 5 2 5 1 3 1 9 2 5 1 2 1 8 9 1 4 1 1 6

5 2 1 6 1 1 6 1 2 4 1 8 1 6 1 5 8 2 4 1 4 1 5 1 9 1

1 4 1 8 1 9 5 2 1 8 1 9 1 1 5 1 1 5 1 6 1 8 2 6 1 2