

Visual Perception

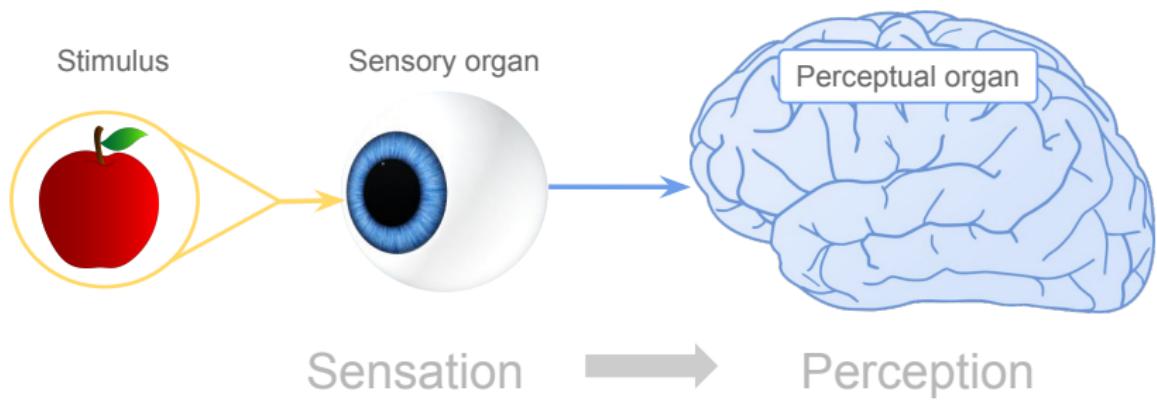
Intro to Data Visualization

Gaston Sanchez

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Visual Perception

Visual Brain



What is Perception?

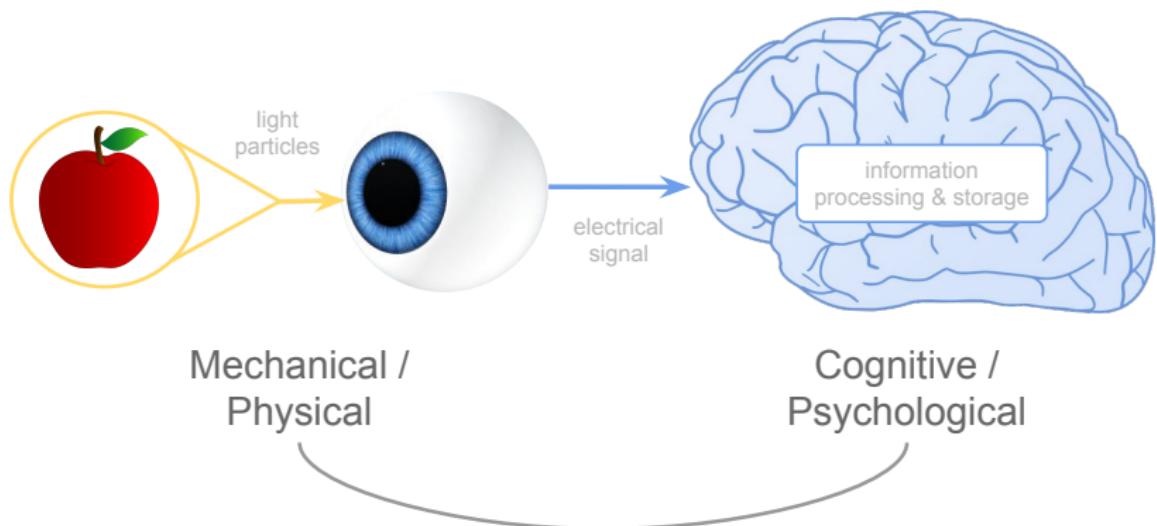
- ▶ It's a cognitive process.
- ▶ Involves interpretation of the world around us.
- ▶ Allows us to form mental representations of the environment.
- ▶ Our brain makes assumptions about the world to overcome the inherent ambiguity in all sensory data.

Many definitions and theories of perception

Most theories define perception as the process of:

- ▶ **Recognizing** (being aware of) sensory information
- ▶ **Organizing** (gathering and storing) sensory information
- ▶ **Interpreting** (binding to knowledge) sensory information

Visual Brain



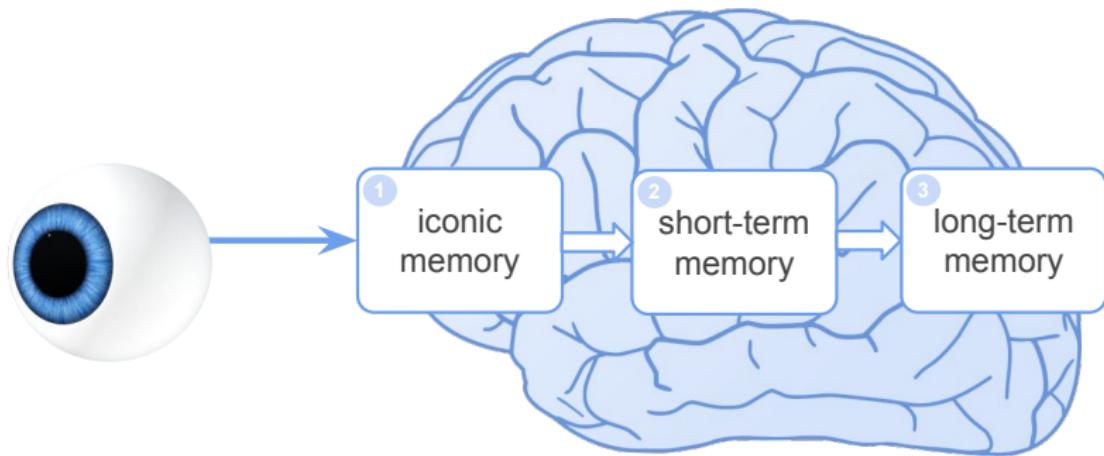
Brain as a computer

Brain as a computer

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

Attention and Memory

Information Processing and Memory

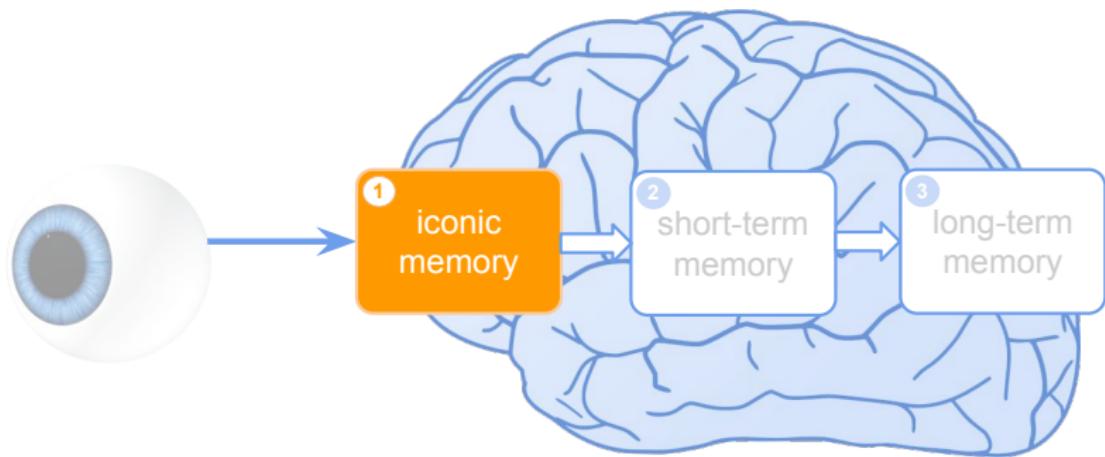


The brain as a computer

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

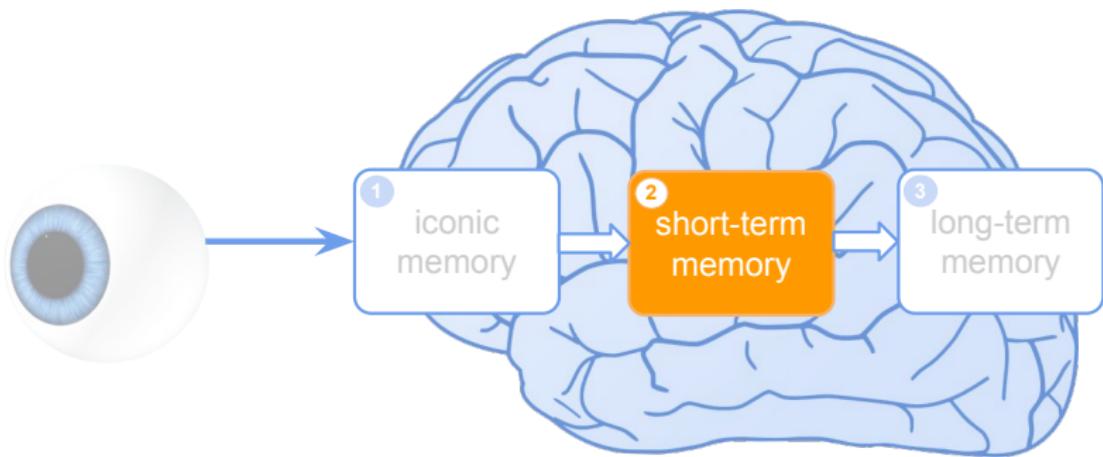
Iconic Memory



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 and unconscious.
- ▶ Also called **preattentive processing**.
- ▶ Extremely fast and parallel processing.
- ▶ Processes primitive visual features.

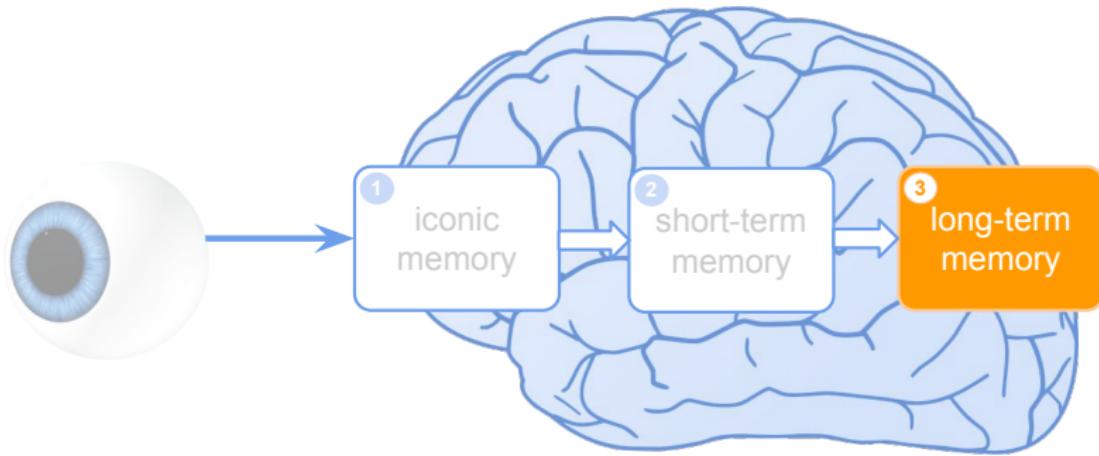
Short-term Memory



Short-term Memory

- ▶ The short-term memory is a sort of RAM.
- ▶ This is where conscious mental work is performed to support cognition.
- ▶ Information is combined into meaningful visual chunks.
- ▶ This memory is temporary and has limited storage capacity.
- ▶ Where the attentive process of perception occurs.

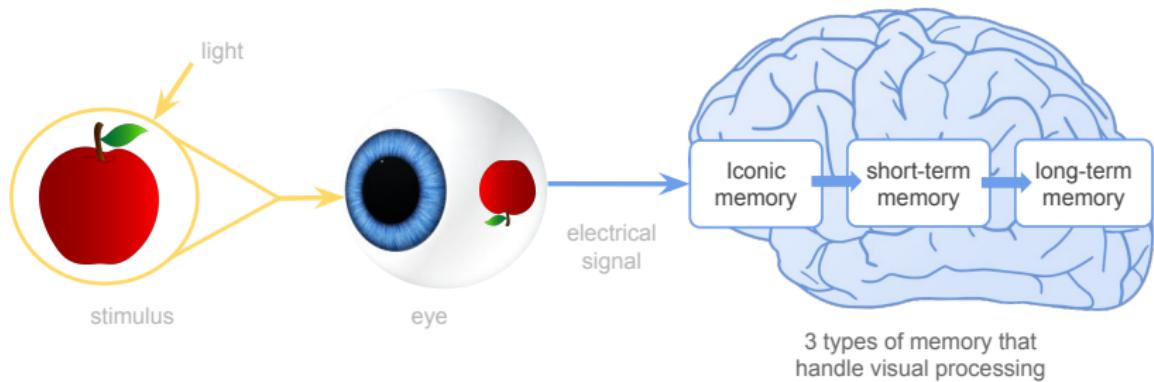
Long-term Memory



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.
- ▶ When you selectively pay attention to information in working memory, it is likely to get transformed and encoded into long-term memory.

Processing Visual Information



3 Stages of perceptual processing

- ▶ *Iconic memory*: early, parallel detection of color, texture, shape, and spatial attributes.
- ▶ *Short-term memory*: dividing visual fields into regions and simple patterns.
- ▶ *Working-memory*: holding objects in working memory by demands of active attention.

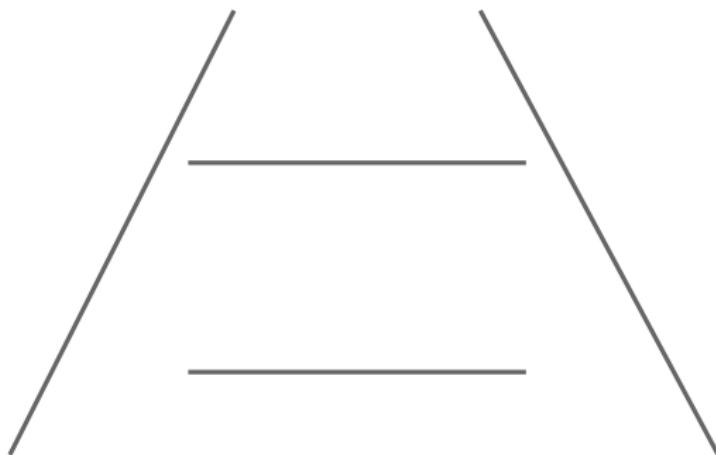
Illusions

Visual Perception and illusions

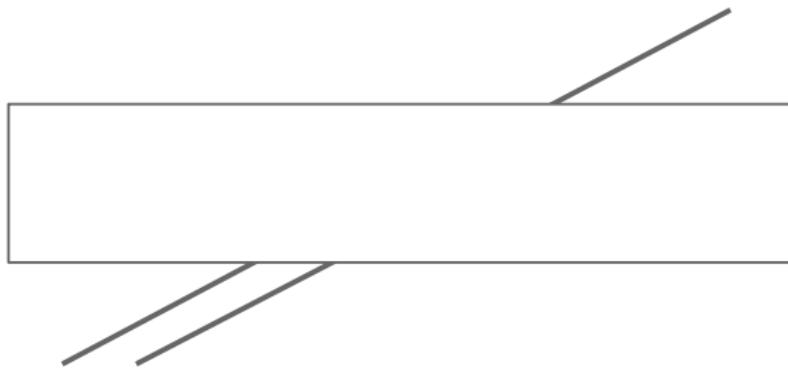
Visual representations of objects are often misinterpreted.

- ▶ Illusions are a primary source of misinterpretations.
- ▶ They come in a variety of forms.
- ▶ Common geometric illusions are:
 - distortions of lengths
 - distortions of angles
 - distortions of areas
 - distortions of shapes

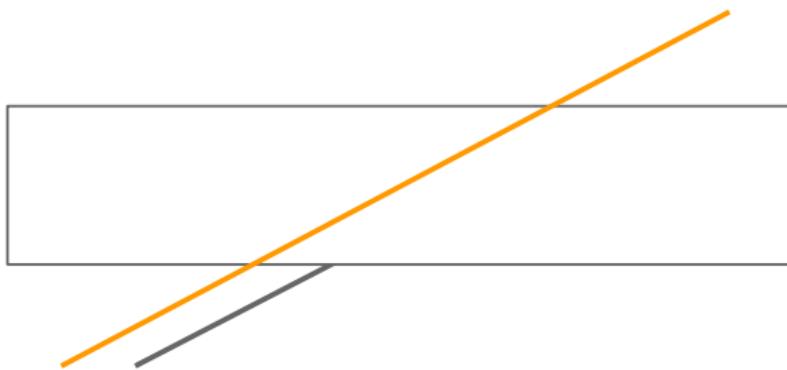
Ponzo illusion



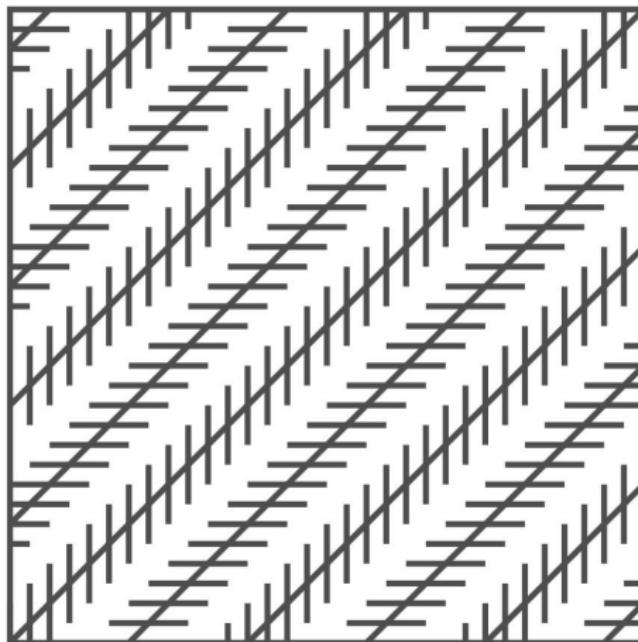
Poggendorf illusion



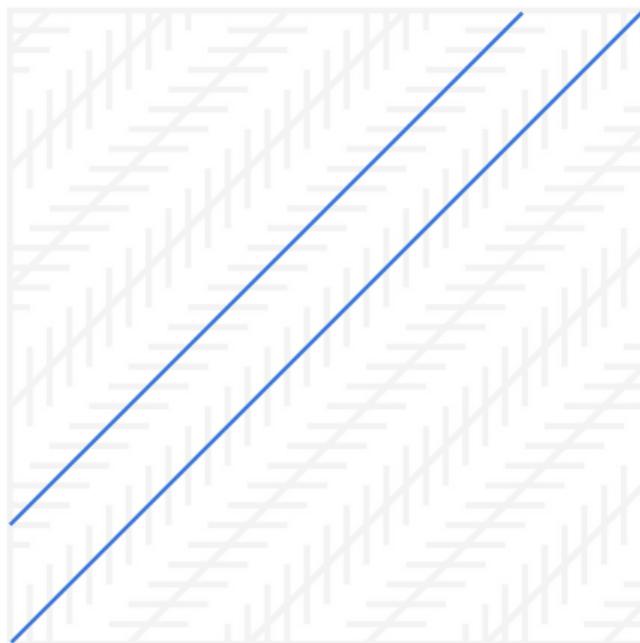
Poggendorf illusion



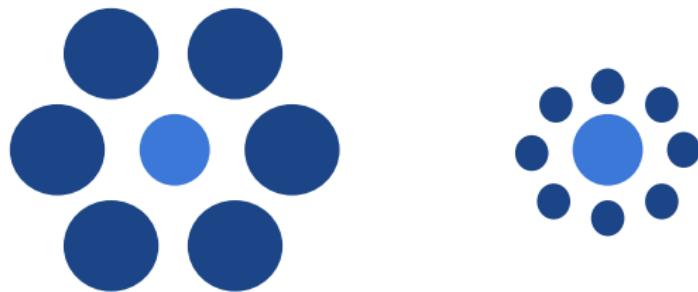
Zollner illusion



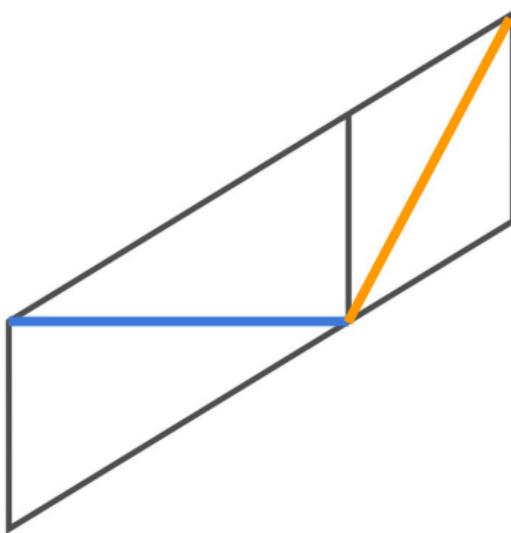
Zollner illusion



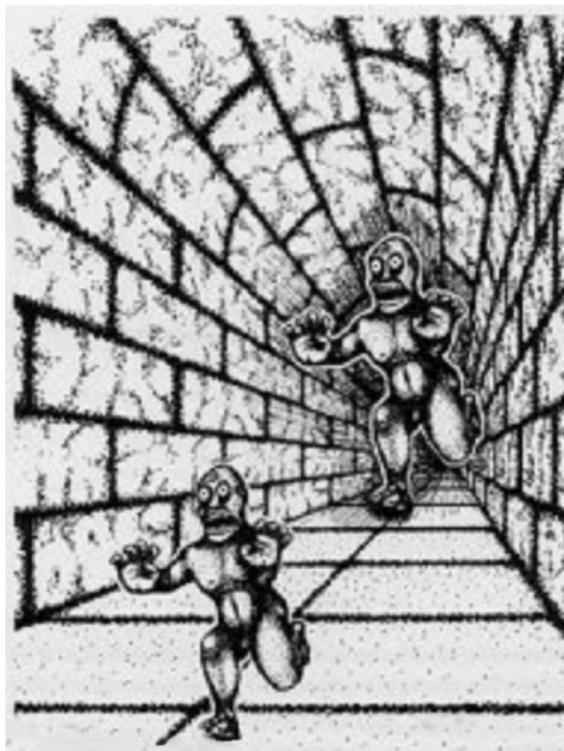
Tichener illusion



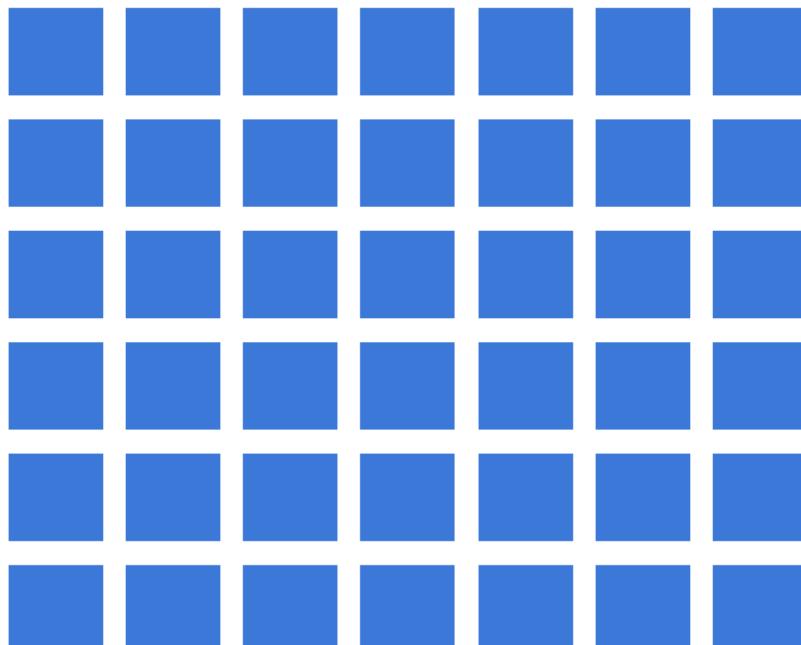
A Line Length illusion



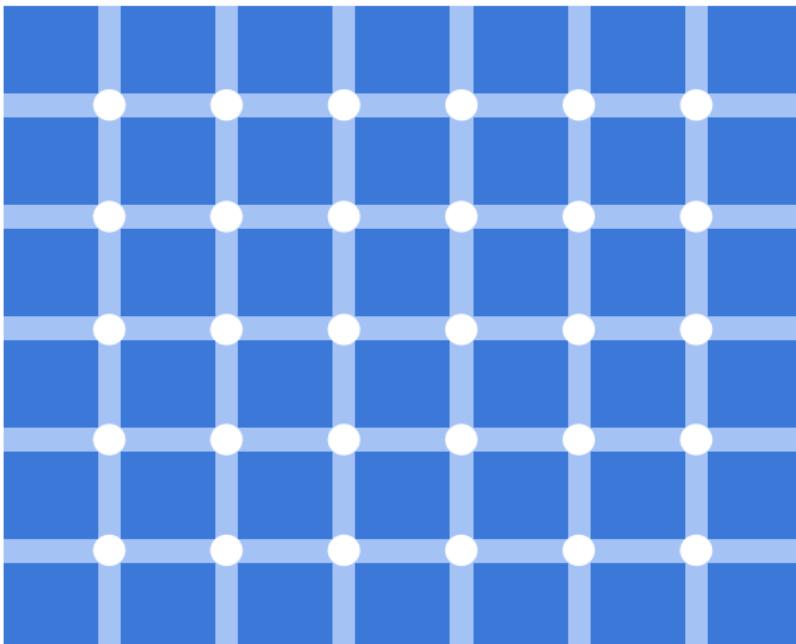
Perspective illusion



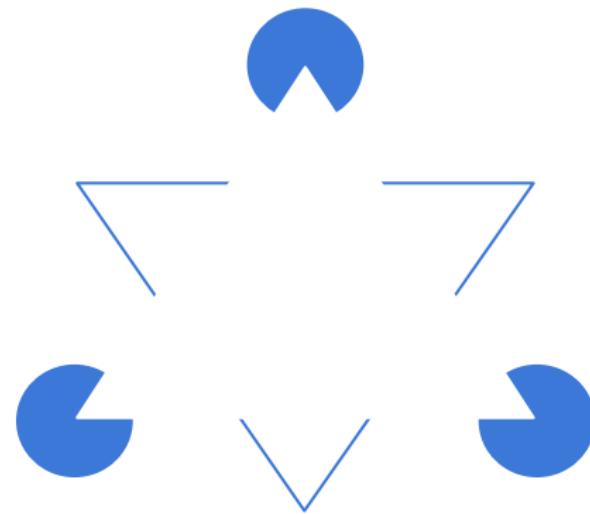
The Herman Grid



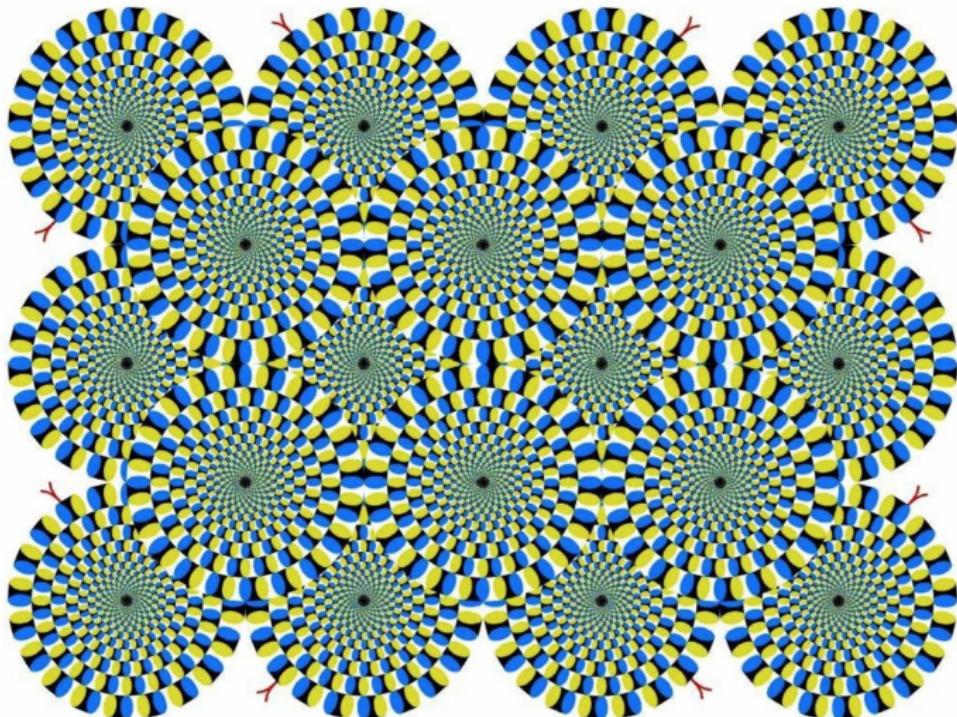
The Herman Grid



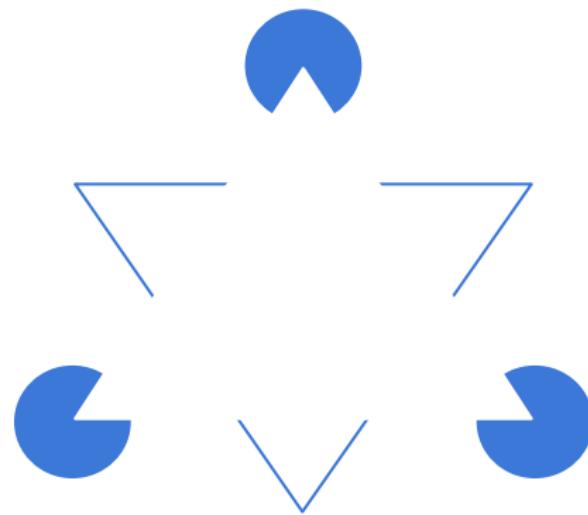
Kanizsa illusion



More illusions



Kanizsa Illusion



Perceptual Processing

Perceptual Processing

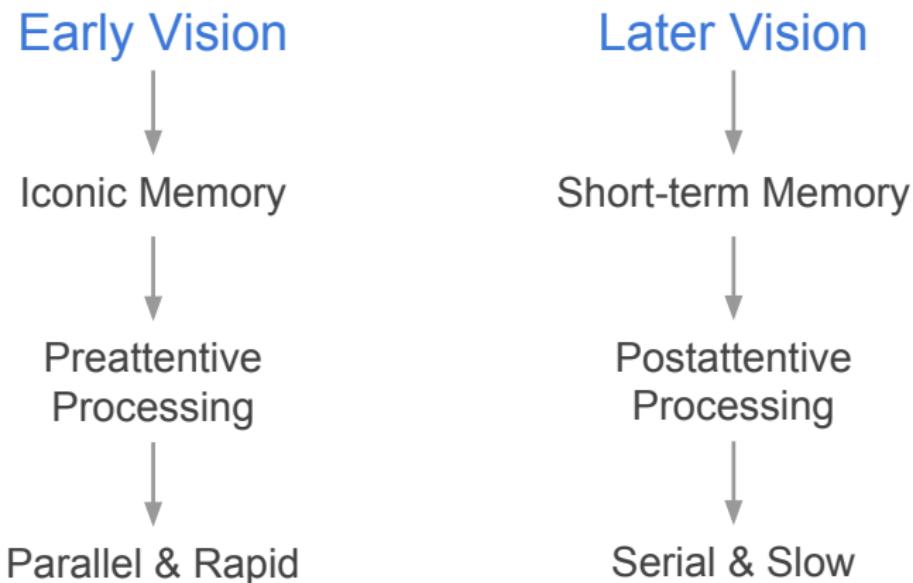
- ▶ Classic model of information processing
- ▶ Simple model for understanding the flow of sensory information
- ▶ Processing divided into preattentive and postattentive

Preattentive Processing

About Preattentive Processing

Researchers have discovered a limited set of individual properties that are detected very rapidly and accurately by the low-level visual system. These properties were initially called *preattentive*. We now know that attention plays a critical role in what we see. The term *preattentive* continues to be used. Preattentive tasks are those performed in less than 200 to 250 milliseconds.

Early Vision -vs- Later Vision



Early Vision and Preattentive Processing

Stage 1: Low-level Preattentive Processing

- ▶ Arrays of neurons work in parallel
- ▶ Requires attention despite the name
- ▶ Occurs almost automatically (very fast: < 200-250 ms)
- ▶ Information is transitory, briefly held in iconic store
- ▶ What matters most is the contrast between features

Preattentive Processing

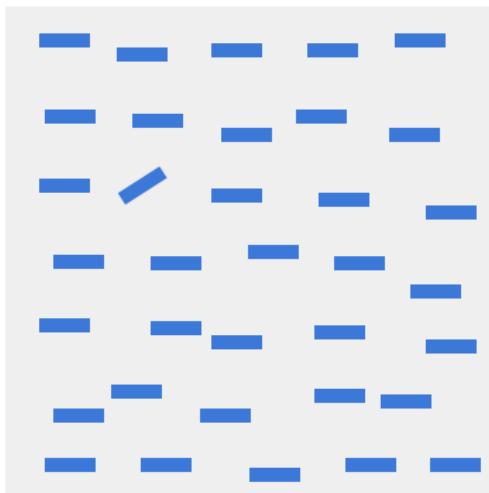
Preattentive Features

Visual features have been identified as preattentive in various experiments in psychology to perform 4 major visual tasks:

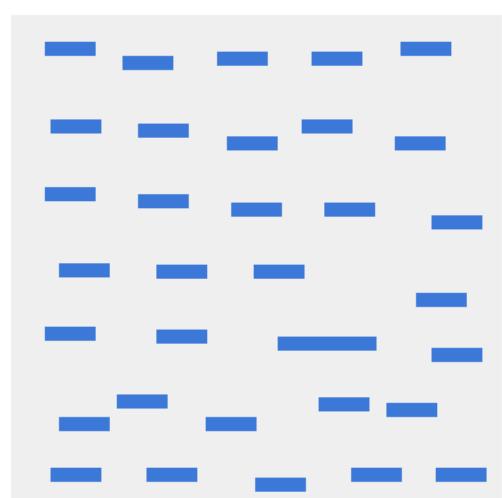
- ▶ target detection
- ▶ boundary detection
- ▶ region tracking
- ▶ counting and estimation

Orientation, and Length-Width

Orientation

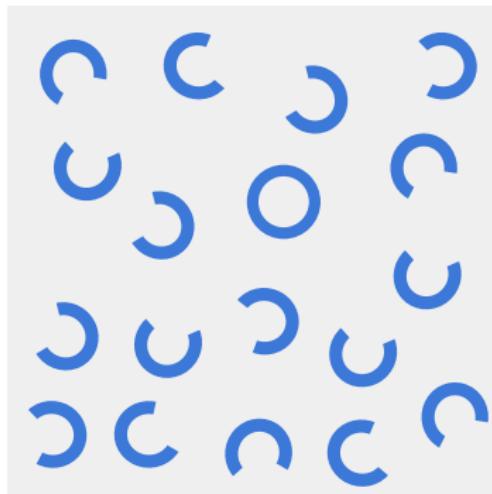


Length-Width

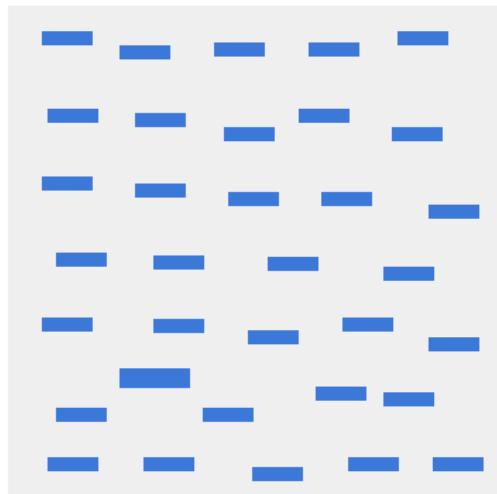


Closure and Size

Closure

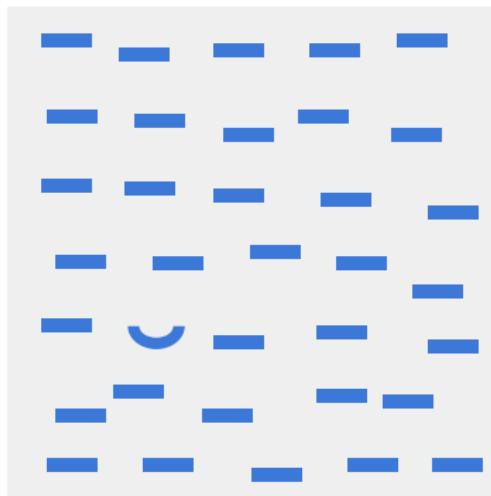


Size

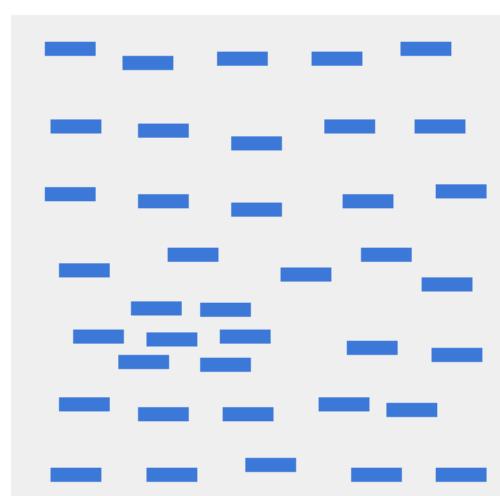


Curvature and Density

Curvature

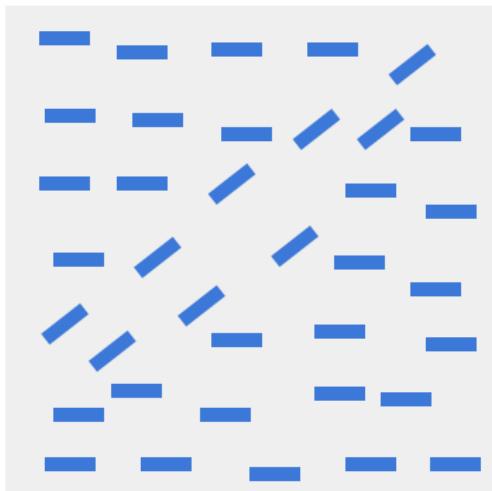


Density

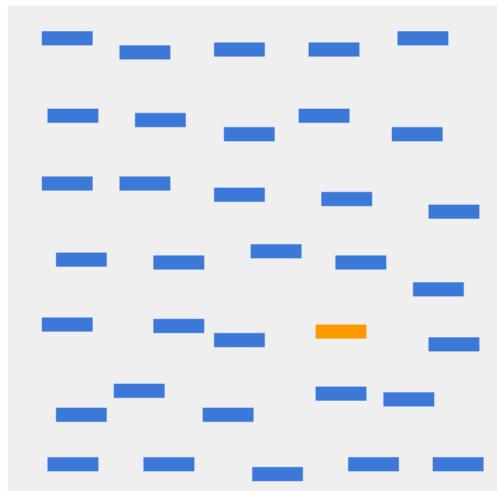


Number Estimation and Color Hue

Number

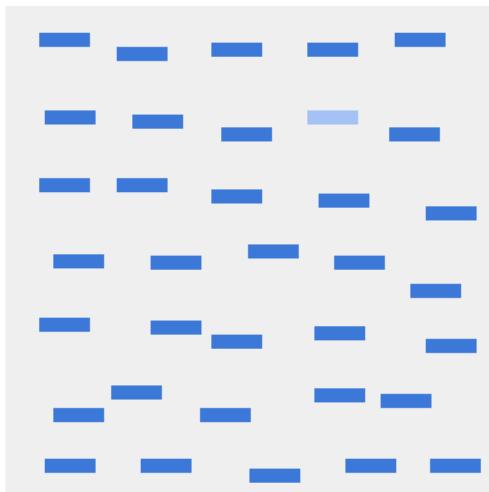


Color Hue

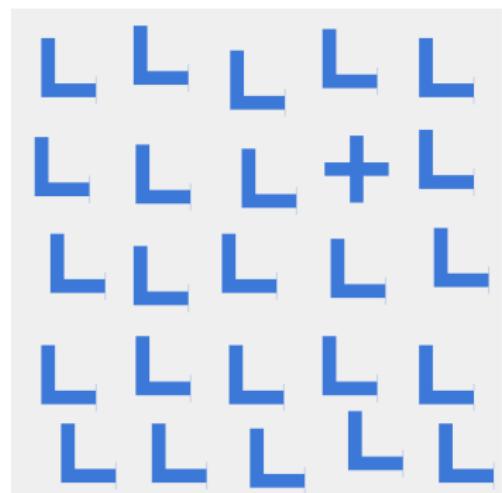


Intensity and Intersection

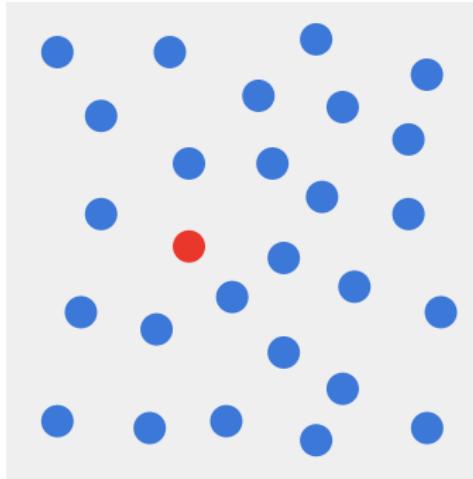
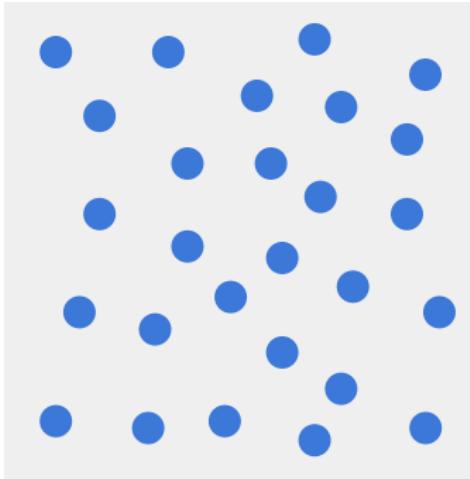
Intensity



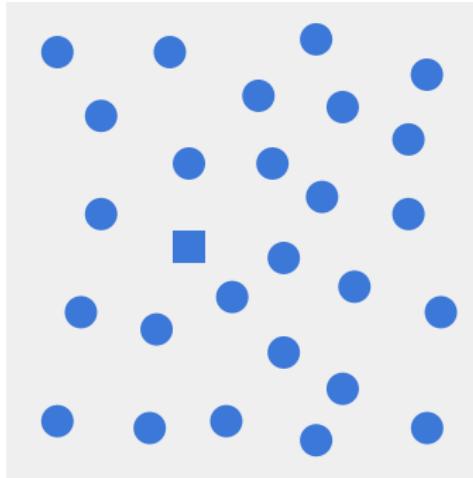
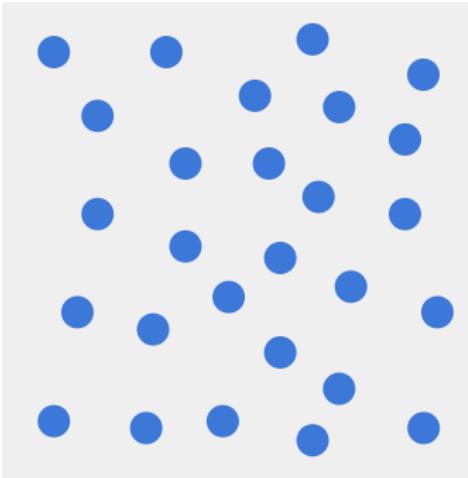
Intersection



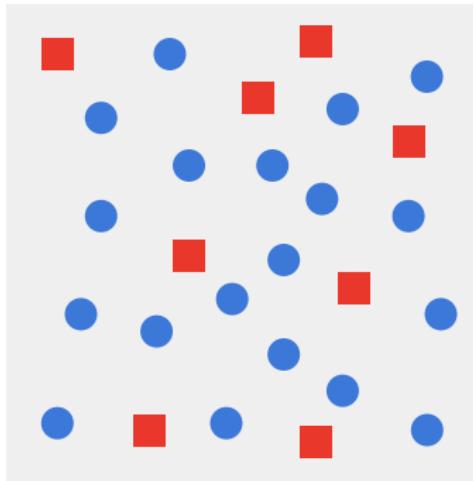
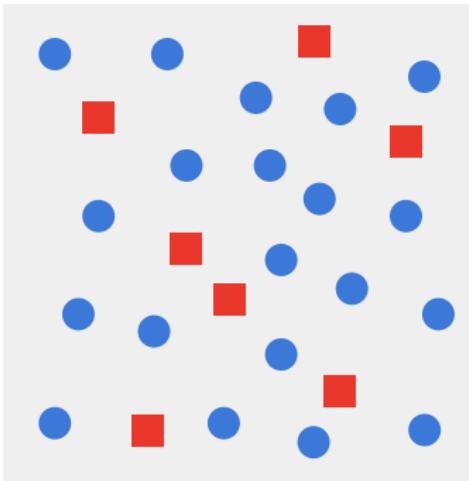
Color



Shape



Conjunction



Theories of Preattentive Processing

- ▶ “Feature Integration Theory” by Anne Treisman.
- ▶ “Texton Theory” by Bela Julesz.
- ▶ “Similarity” Theory by Quinlan and Humphreys.
- ▶ “Guided Search” Theory by Jeremy Wolfe.
- ▶ “Boolean Map” Theory by Huang et al.

Later Vision and Postattentive Processing

Postattentive Processing

Preattentive processing asks in part:

“What visual properties draw our eyes, and therefore our focus of attention”.

Postattentive processing asks:

“What happens to the visual representation of an object when we stop attending to it (and look at something else)?”

Later Vision: Pattern Perception

- ▶ Slow serial processing
- ▶ Involves working and long-term memory
- ▶ A combination of bottom-up feature processing and top-down attentional mechanisms
- ▶ Different pathways for object recognition and visually guided motion

Ron Rensink's examples



Ron Rensink's examples



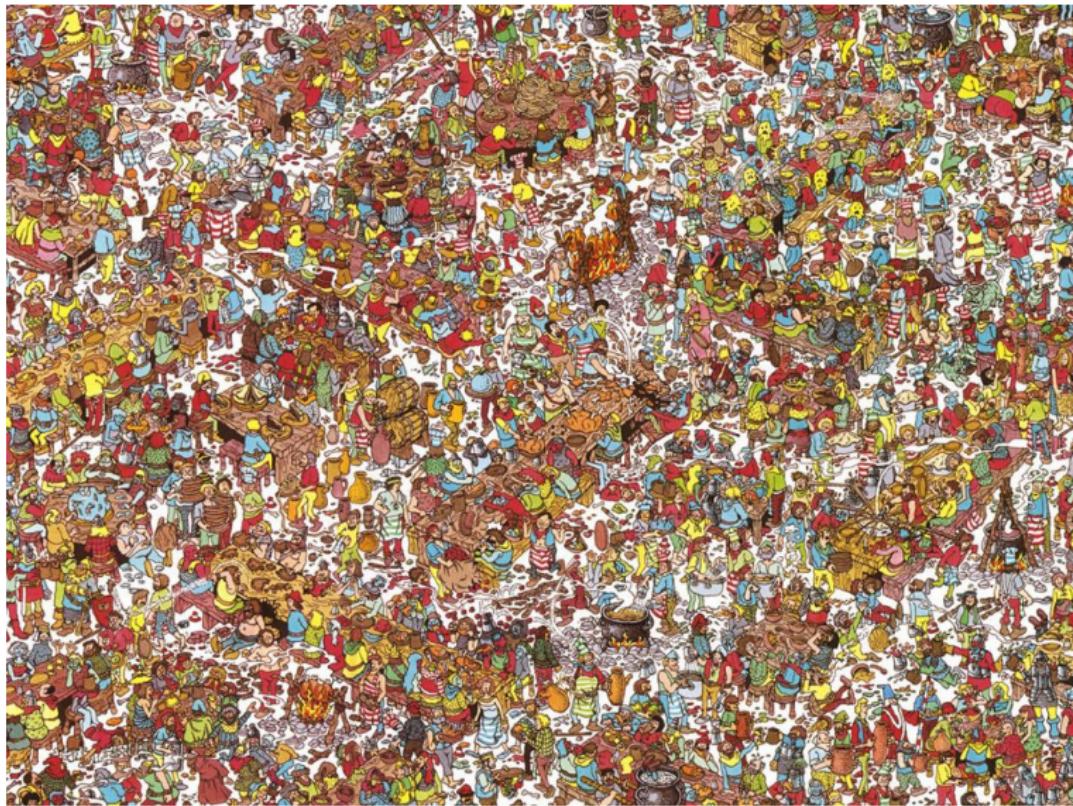
Ron Rensink's examples



Postattentive: Where is Waldo?



Postattentive: Where is Waldo?



Postattentive: How many 5s?

1 5 0 2 2 9 5 1 9 4 2 4 2 1 6 2 9 1 1 3 6 8 5 0 2 8
9 1 4 6 5 0 7 4 3 0 1 7 0 4 9 9 7 7 6 2 2 4 8 6 7 4
6 4 0 9 4 0 8 3 5 1 8 6 9 2 8 3 9 8 4 1 0 7 8 9 6 0
7 0 8 2 8 5 4 3 2 1 8 7 7 4 6 3 8 3 8 2 0 4 1 0 2 3

Preattentive: How many 5s?

1 5 0 2 2 9 5 1 9 4 2 4 2 1 6 2 9 1 1 3 6 8 5 0 2 8
9 1 4 6 5 0 7 4 3 0 1 7 0 4 9 9 7 7 6 2 2 4 8 6 7 4
6 4 0 9 4 0 8 3 5 1 8 6 9 2 8 3 9 8 4 1 0 7 8 9 6 0
7 0 8 2 8 5 4 3 2 1 8 7 7 4 6 3 8 3 8 2 0 4 1 0 2 3

References

- ▶ **Perception in Visualization** by Christopher Healey.
- ▶ **The Functional Art** (chapter 6) by Alberto Cairo.
- ▶ **Visual Language for Designers** (principle 1) by Connie Malamed.
- ▶ **Information Dashboard Design** (chapter 4) by Stephen Few.
- ▶ **Interactive Data Visualization** (chapter 3) by Ward, Grinstein and Keim.
- ▶ **100 Things Every Designer Needs to Know About People** (chapter 1) by Susan M. Weinschenk.