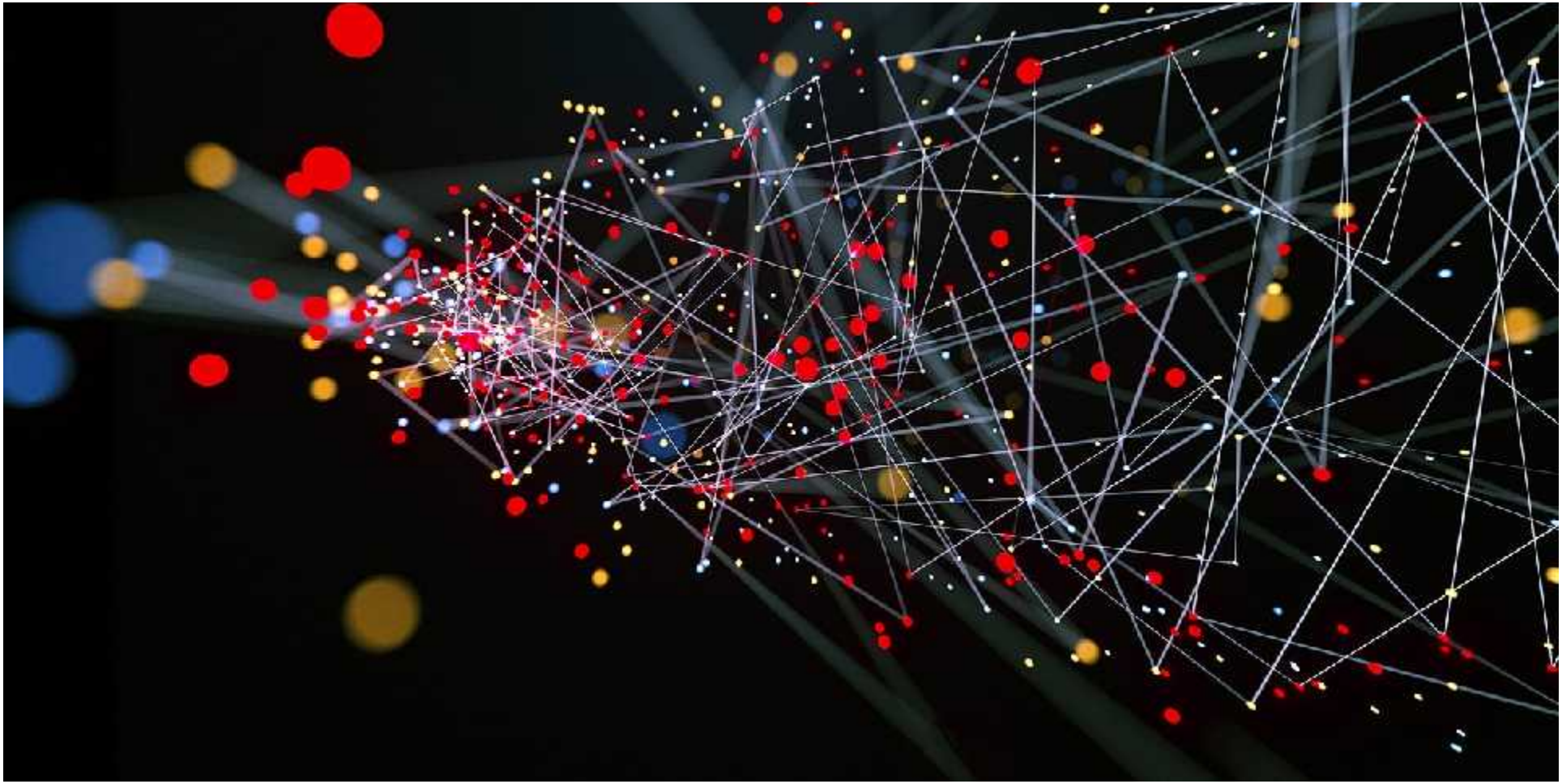


Data and Information Visualization:

Perceptual Issues on Visualization

Semester 2 2018/2019

Tujuan

- Mahasiswa memahami berbagai isu yang terkait dengan **persepsi** dalam visualisasi data
- Mahasiswa memahami bagaimana isu persepsi diteliti atau dievaluasi

Source

- C. Johnson, C. M. Hansen: “The Visualization Handbook”, Elsevier, 2004:
  - Chapter 39: “Extending Visualization to Perceptualization: The Importance of Perception in Effective Communication of Information” by D. S. Ebert
  - Chapter 40: “Art and Science in Visualization” by Victoria Interrante
- C. Ware: “Information Visualization: Perception for Design”
  - Appendix C: “The Perceptual Evaluation of Visualization Techniques and Systems”

Persepsi Visual vs Visual Design

- Research in **cognitive science** aims at explaining how the human visual system creates perceptual experiences from visual stimuli.
- The results of this research have many implications for the design of visualizations.
- For example:
  - due to the different densities and kinds of receptors in the human eye, color should be used for detail information in the user's focus, but not in the periphery (context),
  - and motion can be used as a stimulus in the periphery

Human Perception Processing Categories (1)

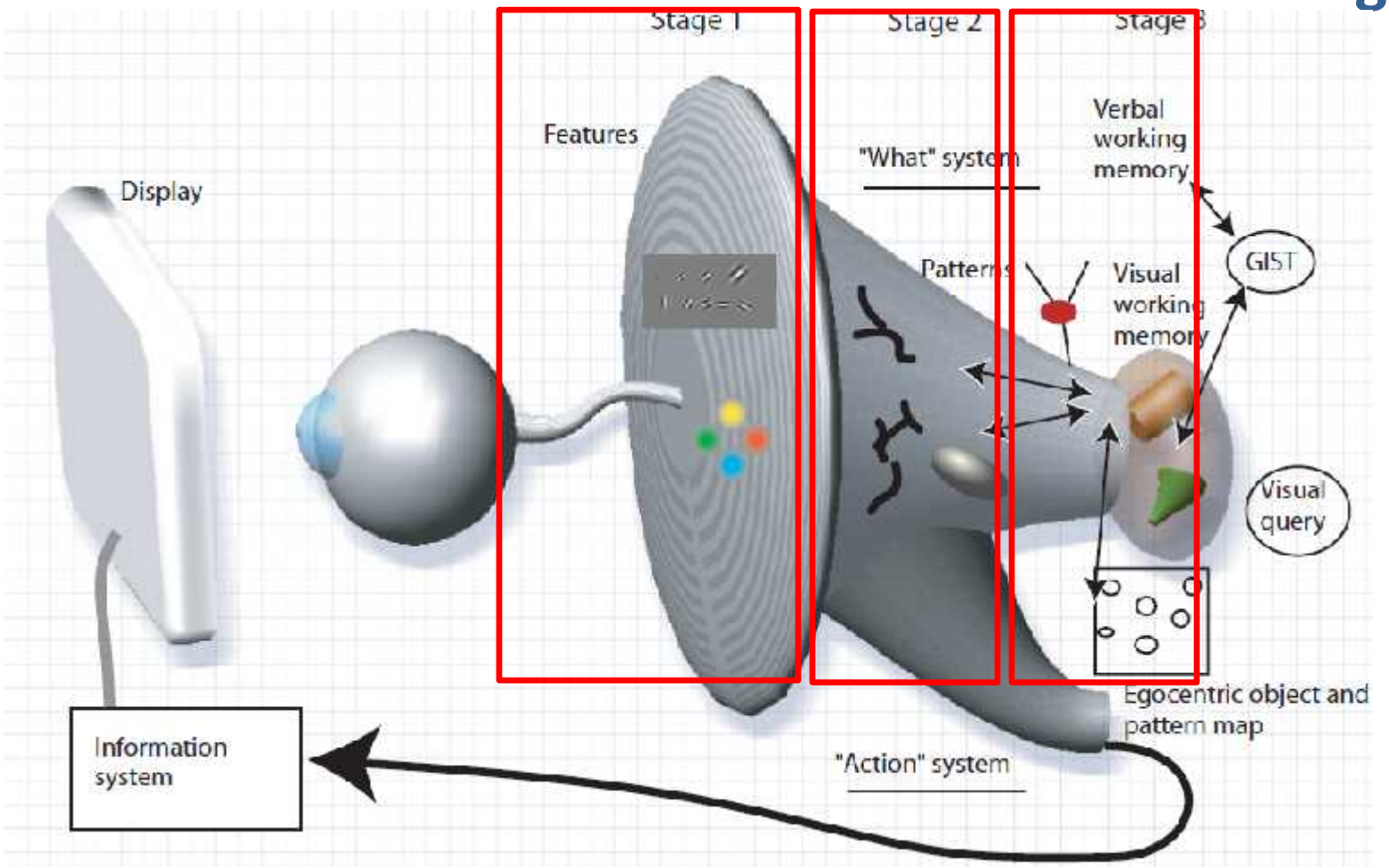
1. Pre-attentive processing: Information is processed at:

- a very low level
- in parallel (simultaneously for the entire visual field of view)
- without conscious thought (accomplished automatically)

Human Perception Processing Categories (2)

- **Attentive processing**:
  - requires attention
  - conscious thought to perceive the information.

A Model of Human Visual Information Processing



1. Parallel Processing to Extract Low-Level Properties of the Visual Scene/environment
2. Pattern Perception to pull out structures and segment the visual scene into regions of different color, texture, and motion patterns.
3. Sequential Goal-Directed Processing. The information is reduced to only a few objects held in visual working memory by active mechanisms of attention to form the basis of visual thinking.

Important characteristics of Stage 1

1. Rapid parallel processing
2. Extraction of features:
   - Orientation
   - Color
   - Texture
   - Movement patterns
3. Bottom-up, data-driven model of processing

Important characteristics of Stage 2

1. Slow serial processing
2. Involvement of both working memory and long-term memory
3. More emphasis on arbitrary aspects of symbols
4. In a state of flux, a combination of bottom-up feature processing and top-down attentional mechanisms

Important characteristics of Stage 3

1. Objects held in visual working memory by the demands of active attention. Only a few objects can be held at a time.
2. Construct a sequence of visual queries that are answered through visual search strategies.
   For example, if we use a road map to look for a route, the visual query will trigger a search for connected contours between two visual symbols (representing cities).

Why Visual Perception Design

- 20 billion neurons of the brain devoted to analyzing visual information provide a pattern-finding mechanism.
- Visual displays provide the highest bandwidth channel from the computer to the human.
  - We acquire more information through vision than through all of the other senses combined.

Visual Features

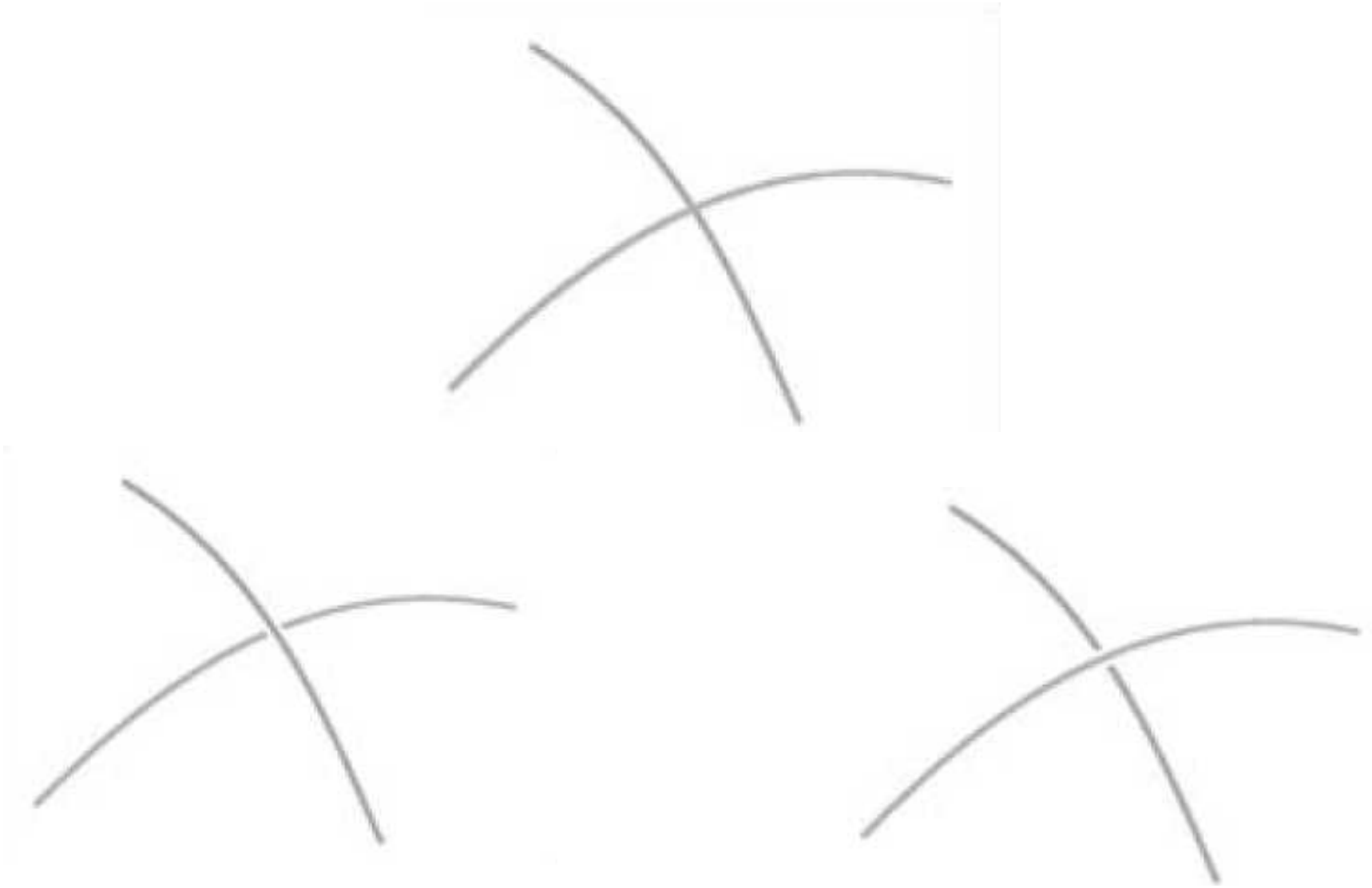
- Form
  - line orientation, length, width, and colinearity
  - size
  - curvature
  - spatial grouping
  - added marks
  - numerosity (number of items)
- Color: hue and intensity
- Motion: flicker and direction of motion
- Spatial position:
  - 2D position
  - Stereoscopic depth
  - convexity/concavity (shape from shading)

We need to understand which visual features are **pre-attentive** to more effectively design visualization systems

Using gaps to indicate the passing of one surface behind another

Prehistoric times: the image of a horse from Paleolithic cave paintings in Lascaux, France

Using gaps to effectively portray dense collections of overlapping lines



Using gaps to effectively portray dense collections of overlapping lines

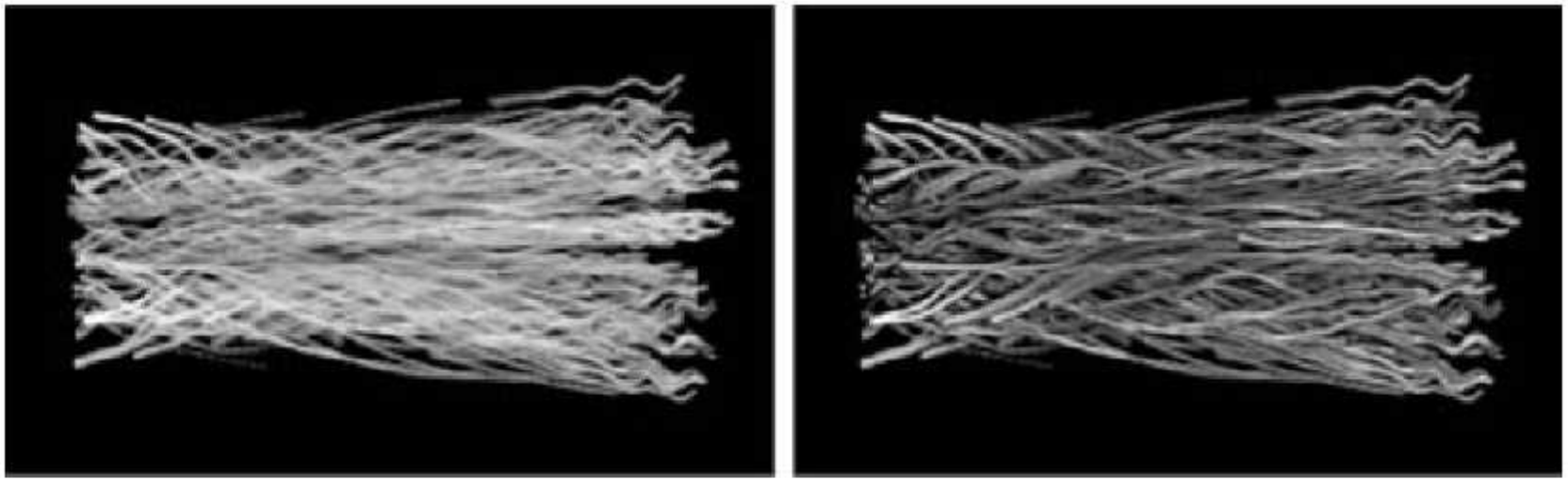


Figure 40.4 A side-by-side comparison, with and without visibility-impeding halos, illustrating the effectiveness of this technique for indicating the presence of depth discontinuities and facilitating appreciation of the extent of depth disparities between overlapping lines in the 3D flow. Data courtesy of Dr. Chester Grosch.

Using Feature Lines to Emphasize the Essential 3D Structure of a Form

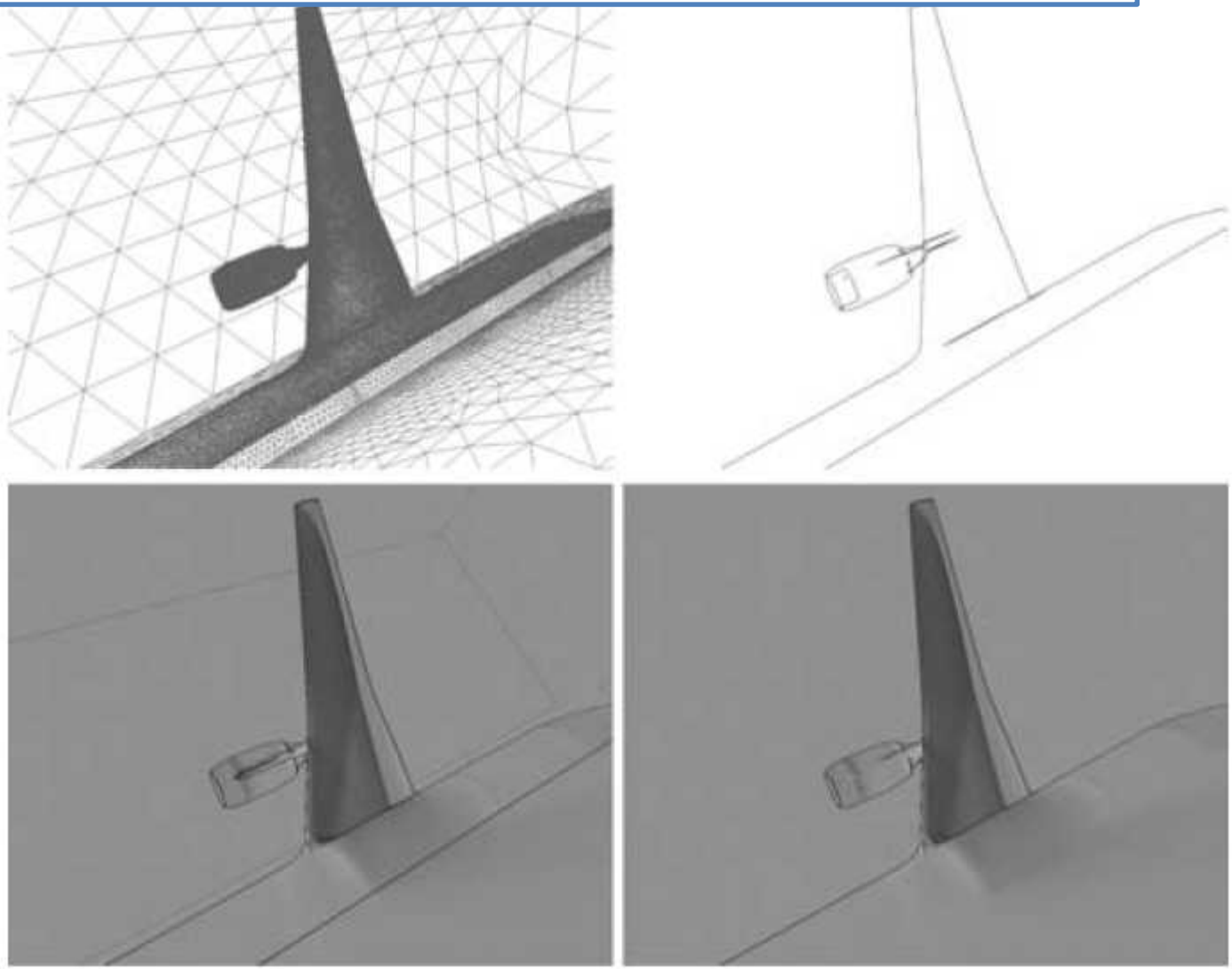
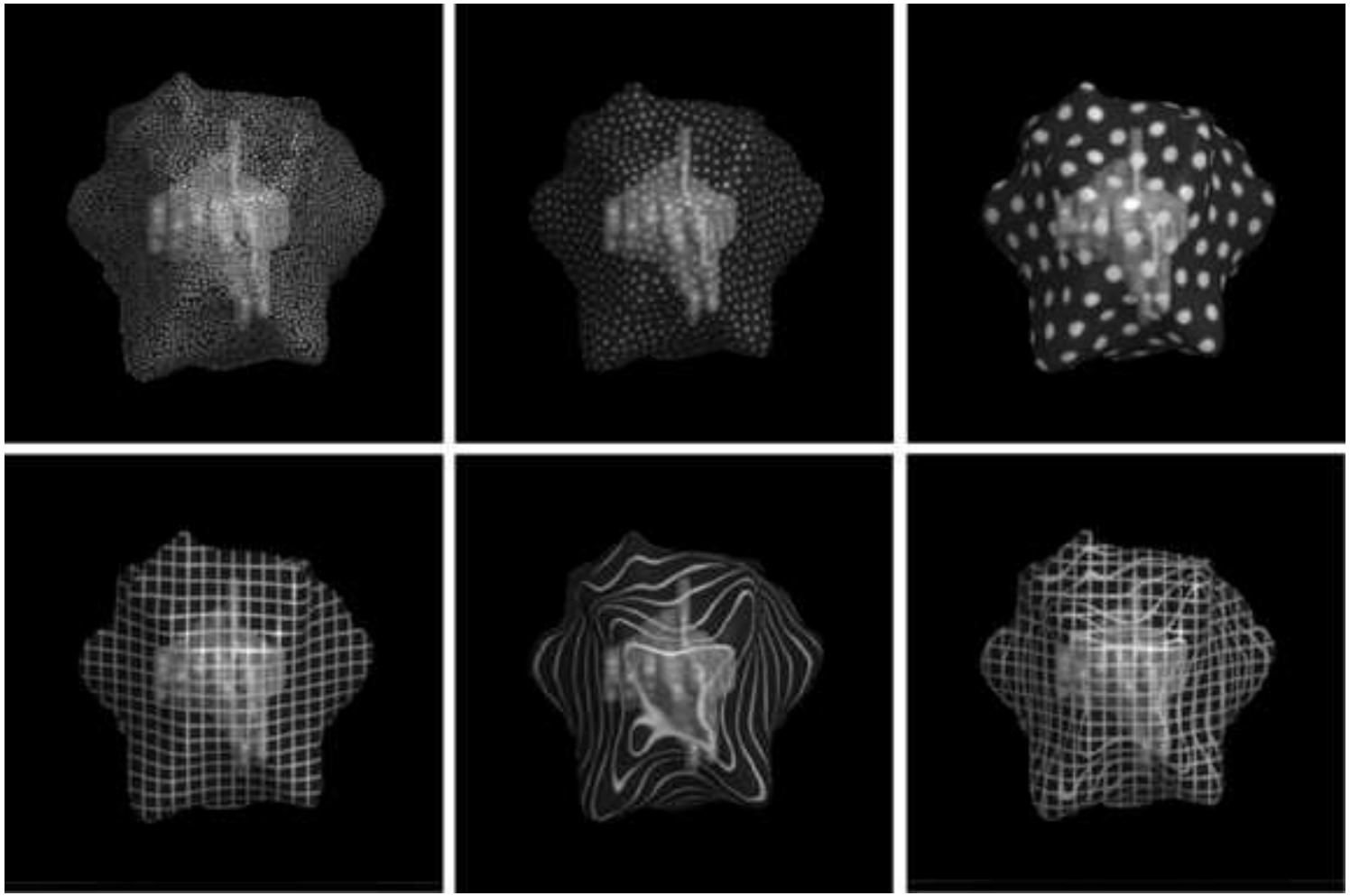


Figure 40.6 By highlighting feature lines on a surface mesh, we may enhance appreciation of the essential structure of the form, a goal that assumes particular importance under conditions where the use of surface shading is problematic. Clockwise from top left: the full original mesh; the silhouette and contour edges only; the silhouette and contour edges highlighted in a surface rendering in which polygon color is defined purely as a function of the value of a scalar parameter that is being visualized over the mesh; same as previous, except that the feature line set is augmented by crease edges determined by our algorithm to be locally perceptually significant. Data courtesy of Dimitri Mavriplis. (See also color insert.)

Using Texture on Surfaces to Clarify Shape



A variety of sparse textures applied to the same external transparent surface.

Semiotics Based on Perception

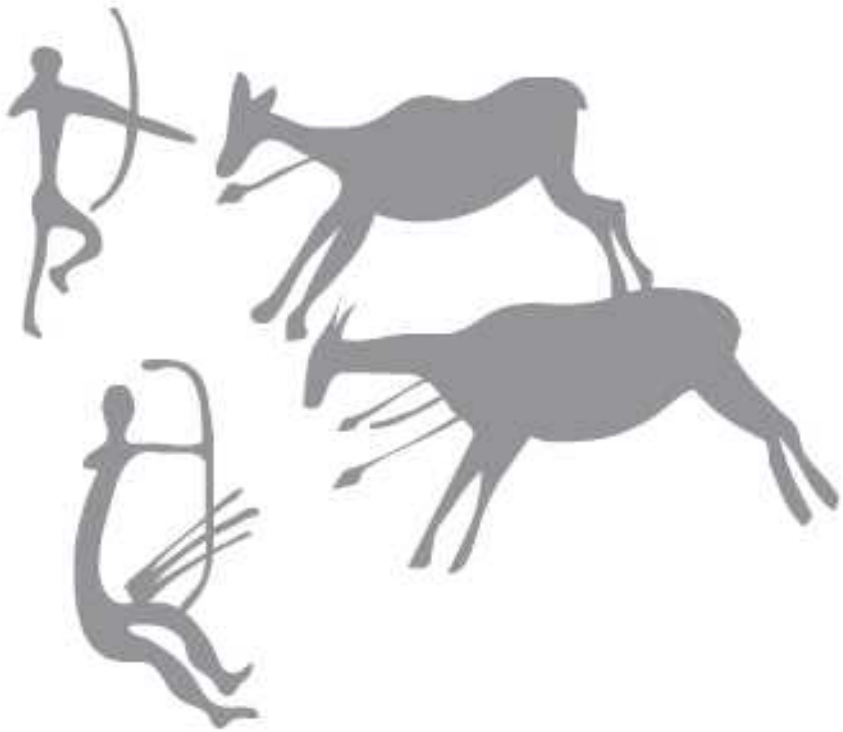
- Semiotics : the study of symbols and how they convey meaning.

- A kind of learned language and not as a science at all.
  - Visualization diagrams and how they can convey meaning.
    - Generally, diagrams are held to be made up of symbols
    - The meaning of a symbol is normally understood to be created by convention

- Diagrams are effective in much the same way as the written words:
  - We must learn the conventions of the language
  - It is just a matter of learning the code, and the laws of perception are largely irrelevant.

Visual Language Example (1)

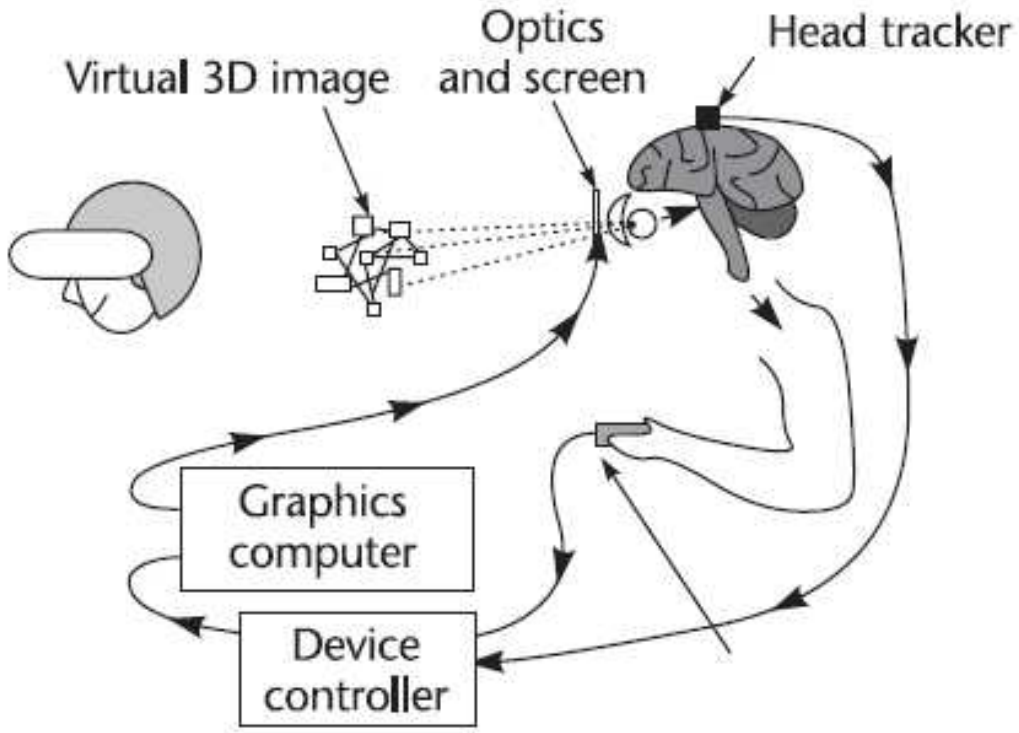
a Cave painting



We can readily interpret human figures and infer that the people are using bows and arrows to hunt deer.

Visual Language Example (2)

b VR diagram



The interaction between a person and a computer in a virtual environment system

Visual Language Example (3)

c Equation

$$\chi \propto \int_{1}^{\infty} \varpi \oint_{\lambda} \left\| \frac{\Pi \lambda_{i}}{\oint \Psi} \right\|$$

The expression of a mathematical equation

Visual Language Learning Degree

- Some visual languages are easier to “read” than others.
  - Perhaps it is simply that we have more experience with the kind of pictorial image.
  - Perhaps the concepts expressed in the cave painting are more familiar than those in the equation.

Pictures are Sensory or Arbitrary

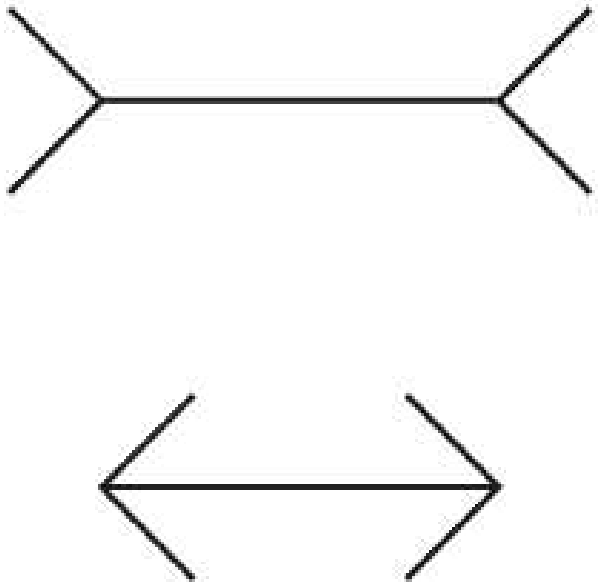
- Pictures and diagrams?
  - are purely conventional ?
    - pictures are every bit as arbitrary as words
  - are perceptual symbols with special properties ?
    - there may be a measure of similarity between pictures and the things that they represent
- Discussion:

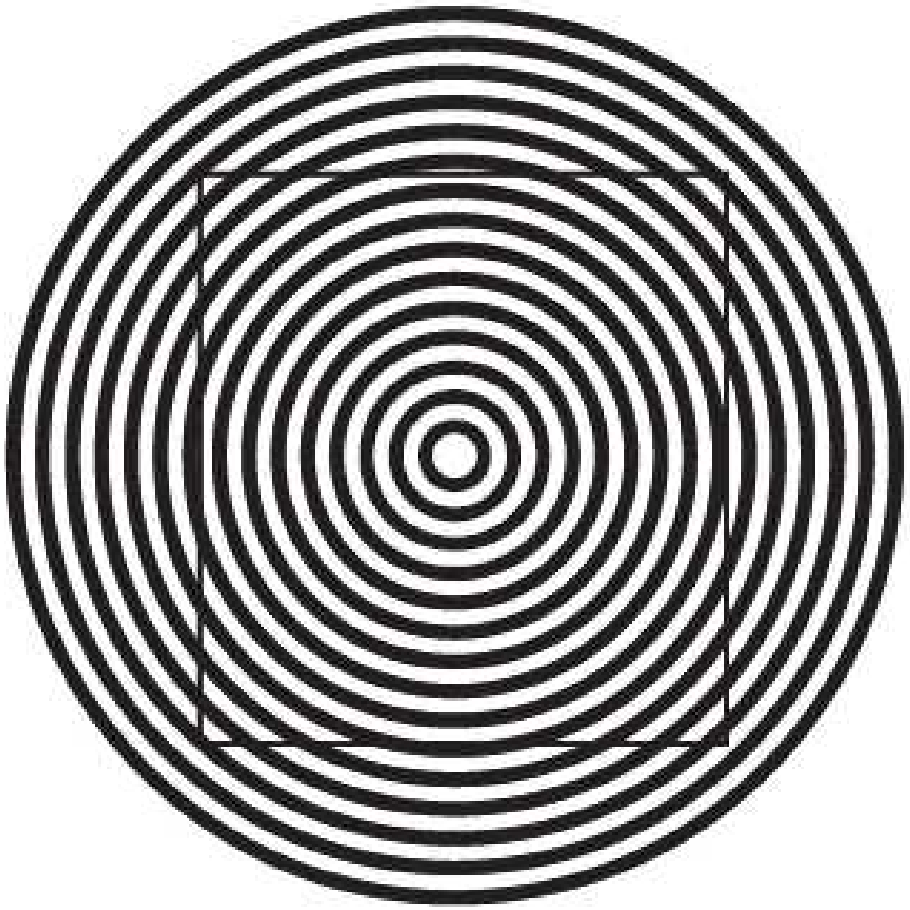
  If “realistic” pictures do not embody a sensory language, it will be impossible to make claims that certain diagrams and other visualizations are better designed perceptually.

Properties of Sensory

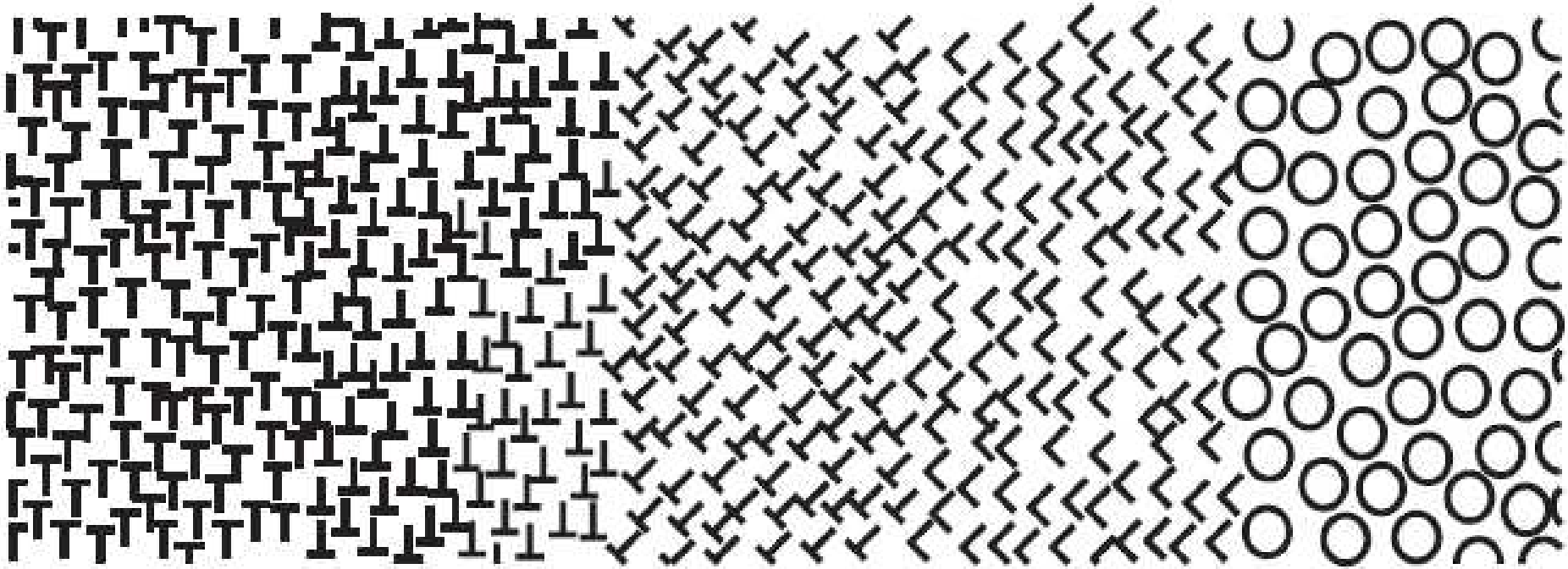
1. Understanding without training
2. Resistance to instructional bias
3. Sensory Immediacy
   - The processing of certain kinds of sensory information is hard-wired and fast.
   - We can represent information in certain ways that are neurally processed in parallel.
   - The way in which the visual system divides the visual world into regions is called *segmentation*.
4. Cross-cultural validity
   - A sensory code understood across cultural boundaries.

Resistance to instructional bias





Sensory Immediacy

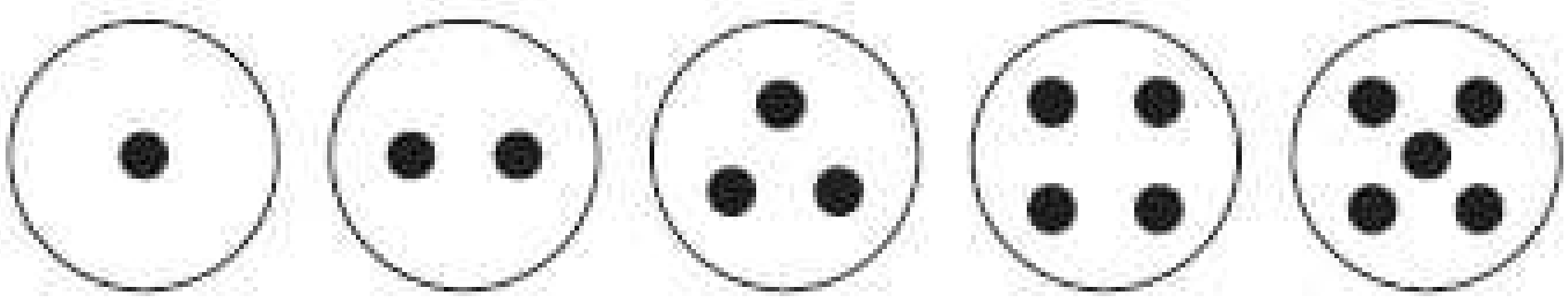


Property of Arbitrary Conventional

1. Hard to learn
2. Easy to forget
3. Embedded in culture and applications
4. Formally powerful
5. Capable of rapid change

Sensory	Arbitrary
Symbols and aspects of visualizations that derive their expressive power from their ability to use the perceptual processing power of the brain without learning	Aspects of representation that must be learned
They are well matched to the early stages of neural processing	The representations have no perceptual basis
They tend to be stable across individuals, cultures, and time	Derive their power from culture (dependent on the particular cultural milieu of an individual)

Arbitrary Vs Sensory
Example

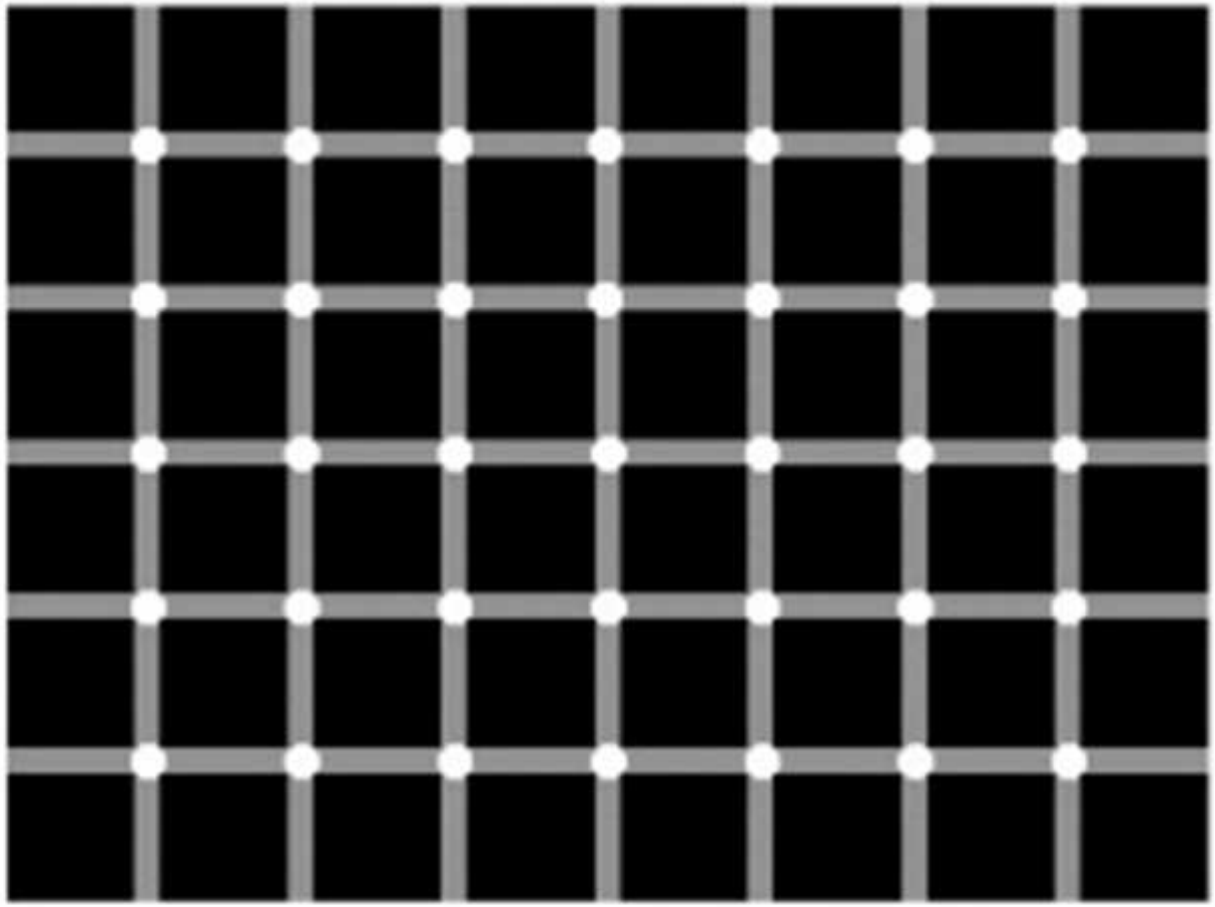


1 2 3 4 5

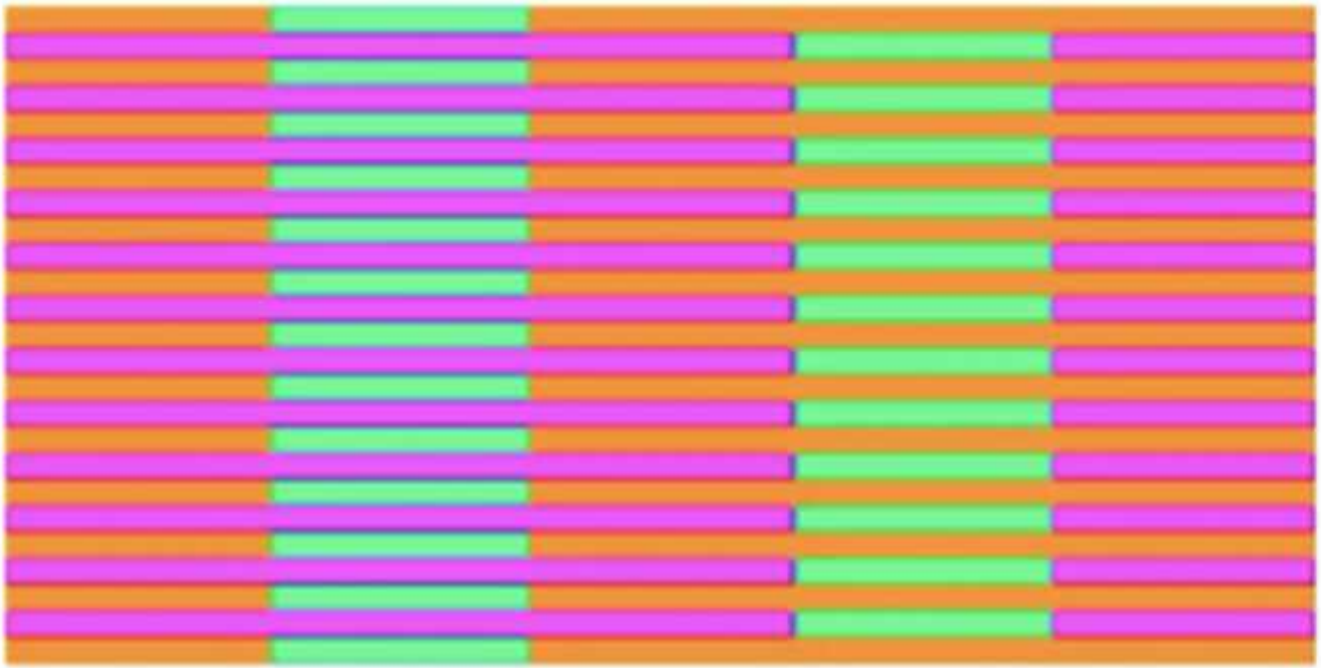
Γ	Δ	H	X	M
Pente	Deka	Hekaton	Khilioi	Murioi

YEAY!

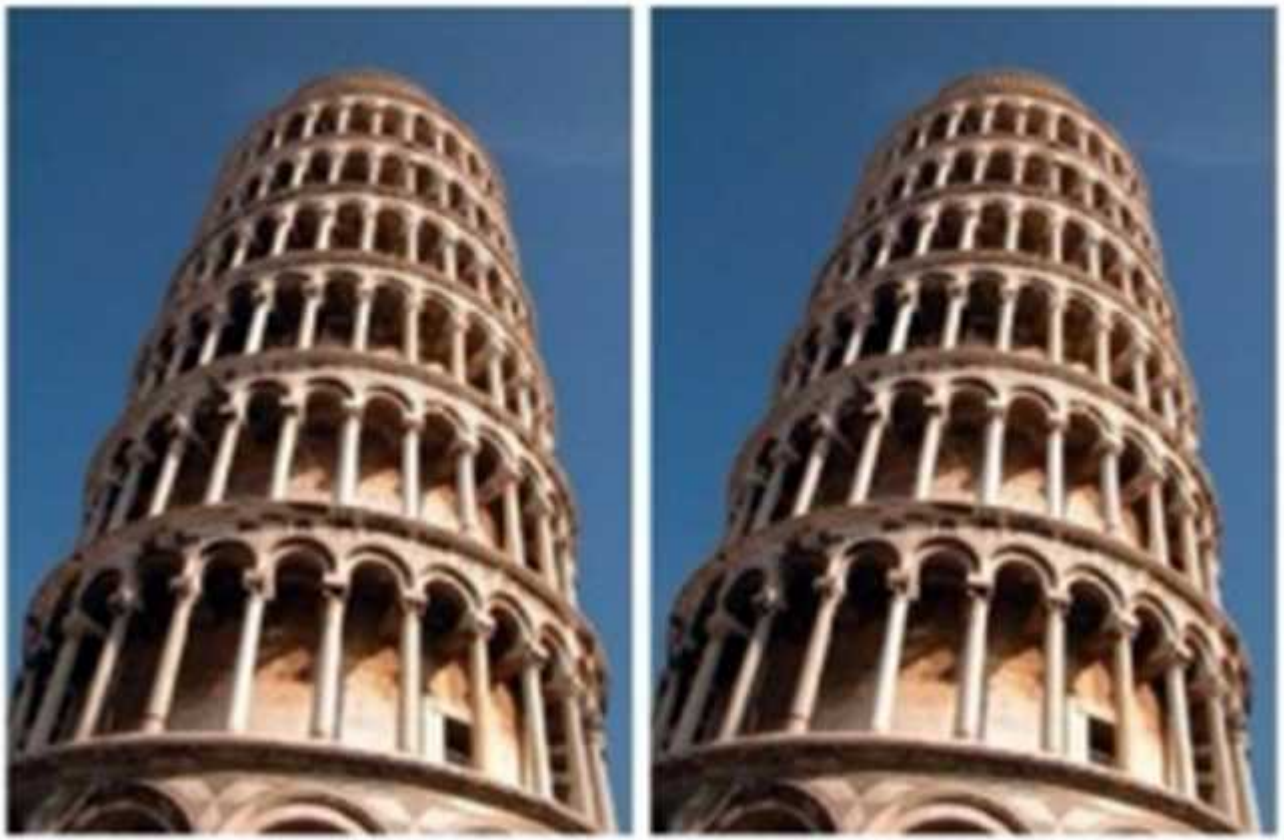
ARE YOU READY FOR QUIZ?



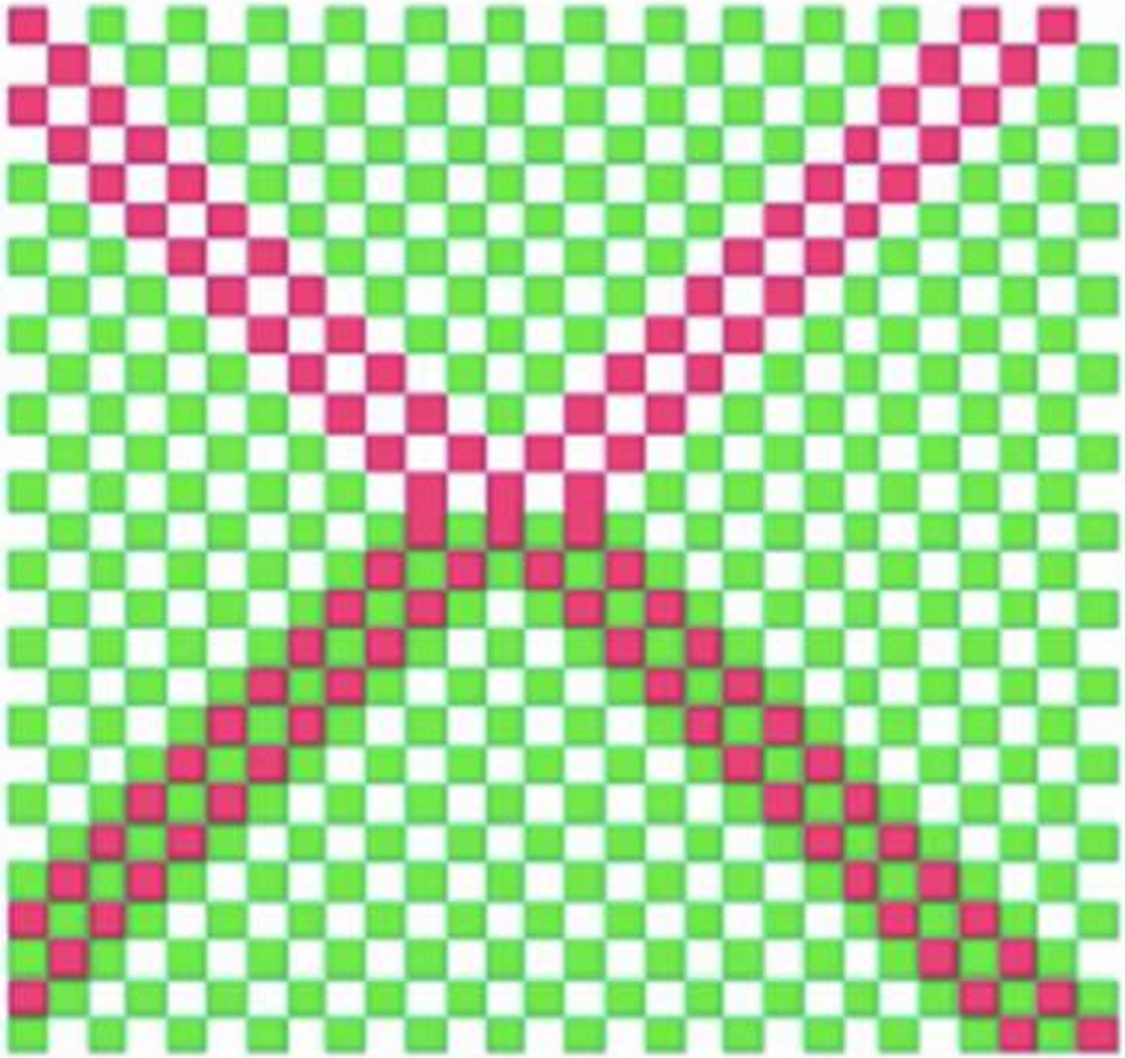
How many black circles are there in the intersections?



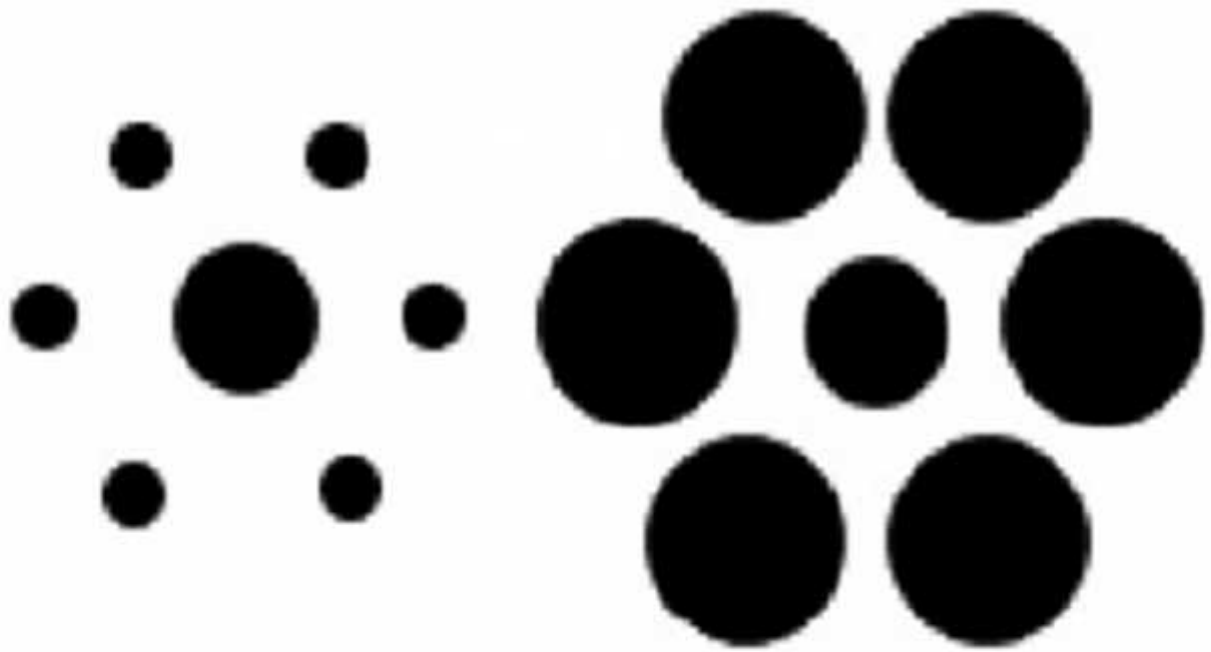
How many colors are in the rectangle?



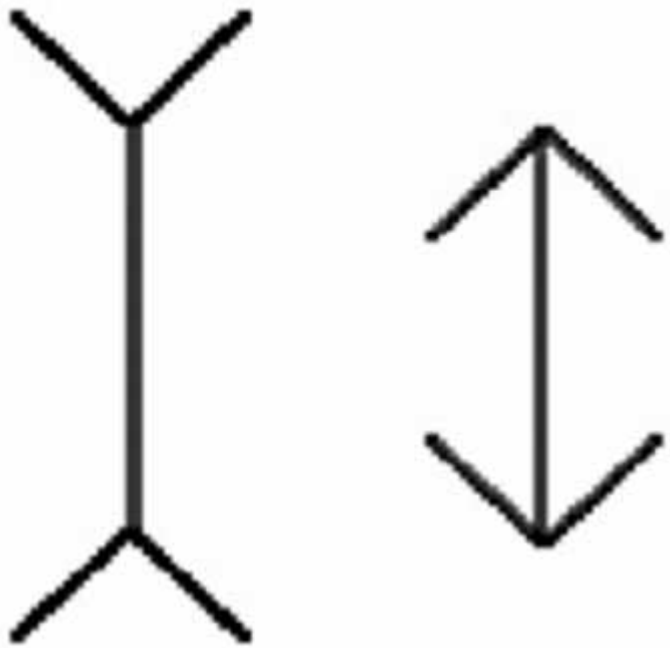
In which image is the Tower of Pisa leaning more?



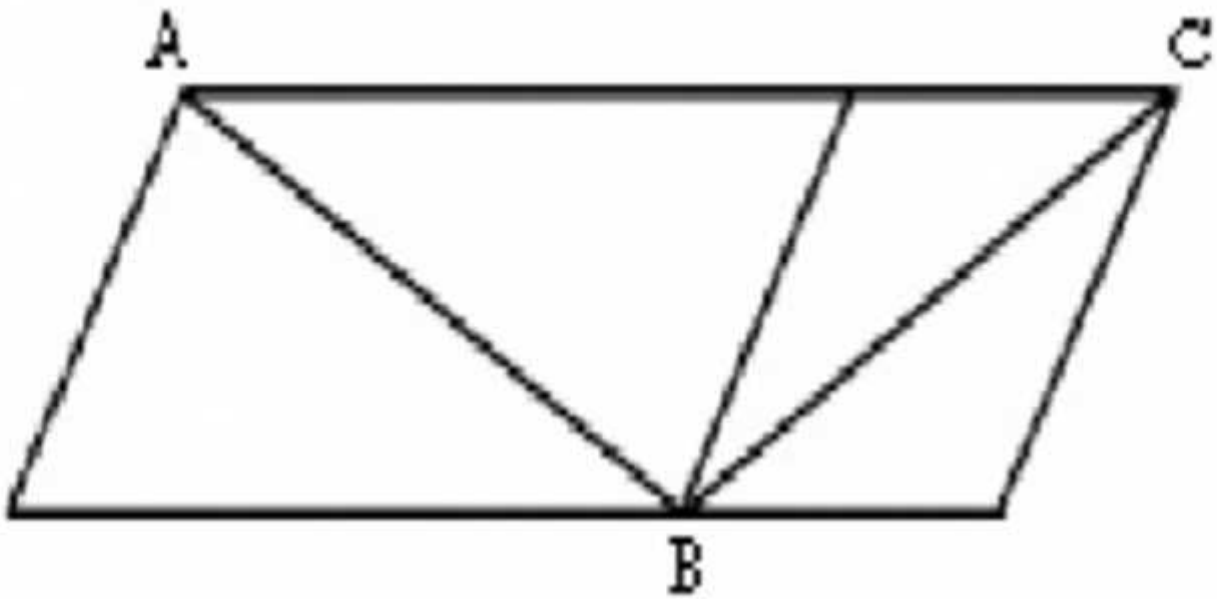
Which part of the X has darker red squares?



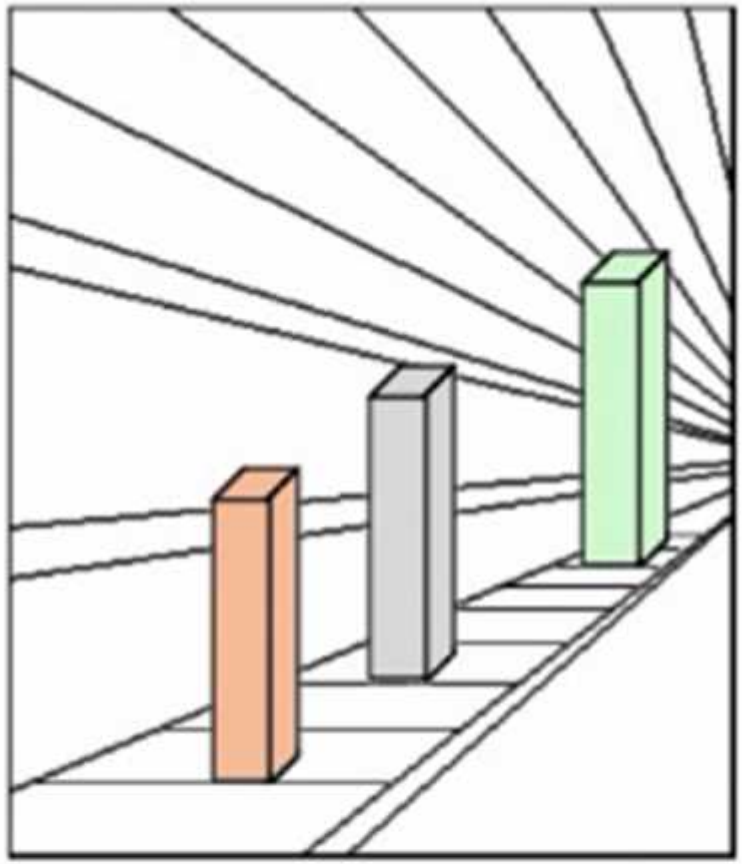
Which of the center circles is larger?



Which line is longer?

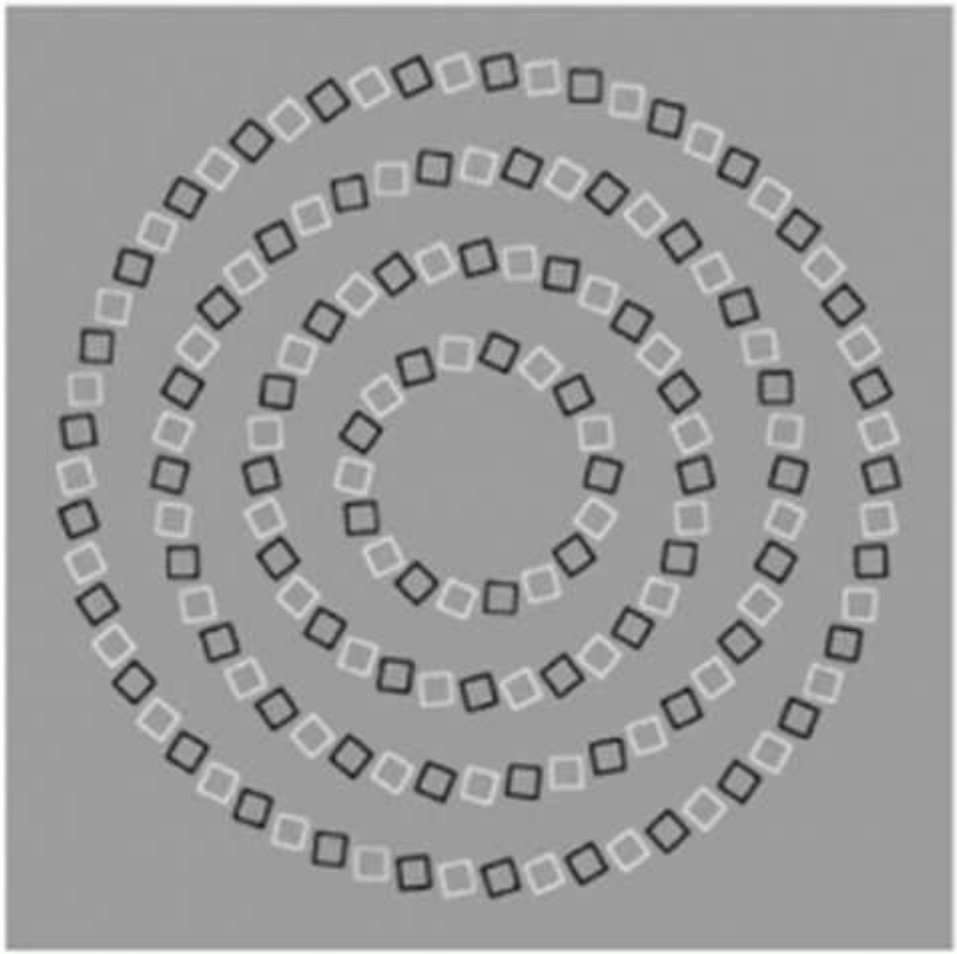


Which diagonal line is longer?

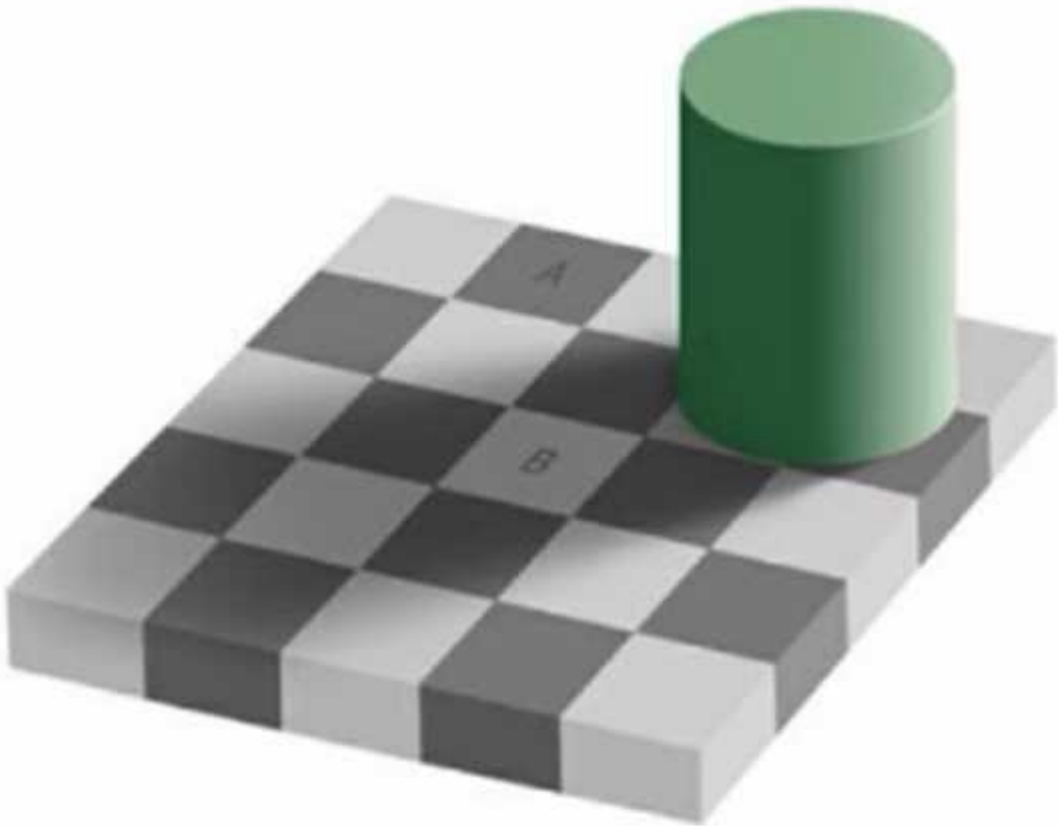


Which pillar is the tallest?

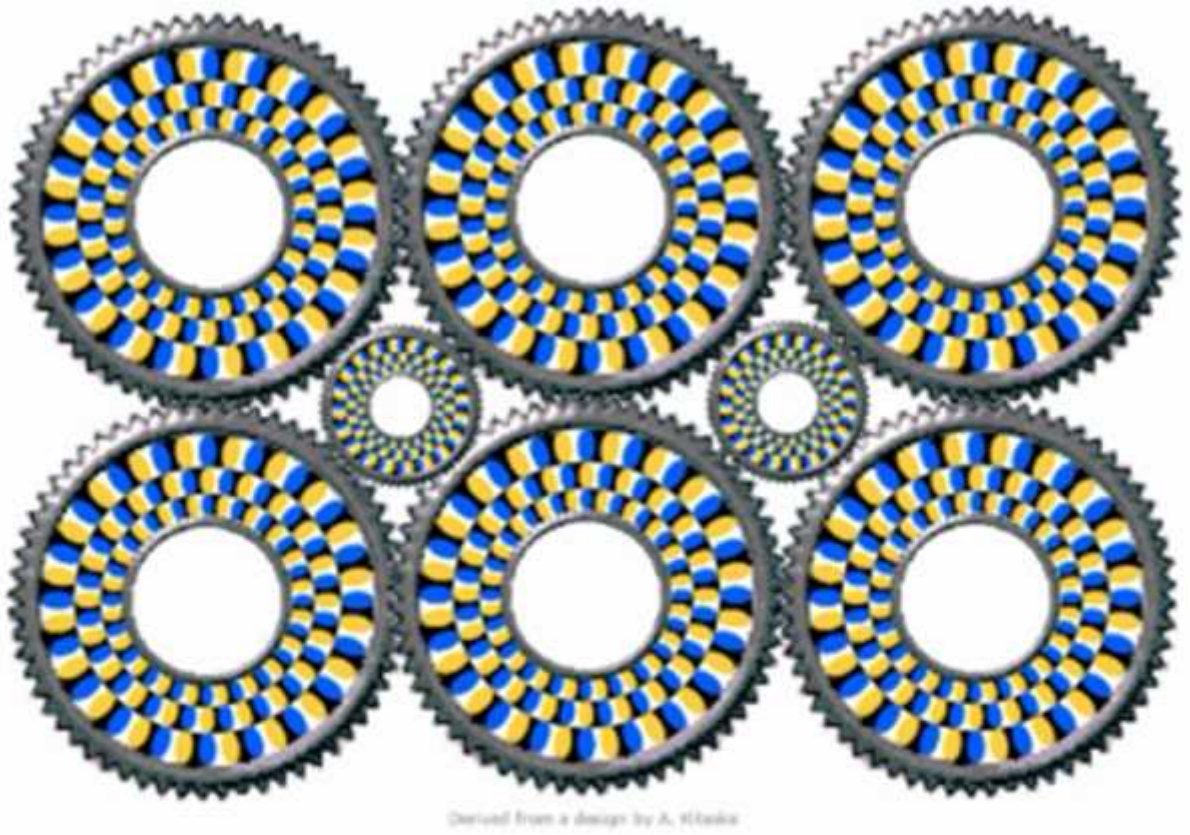
How many different shades are the circles?



How many rings are formed with the squares?



Which of the letters "A" or "B" is printed with a darker shade of grey?



Derived from a design by A. Kitaoka

How many of the gears are moving in this image?