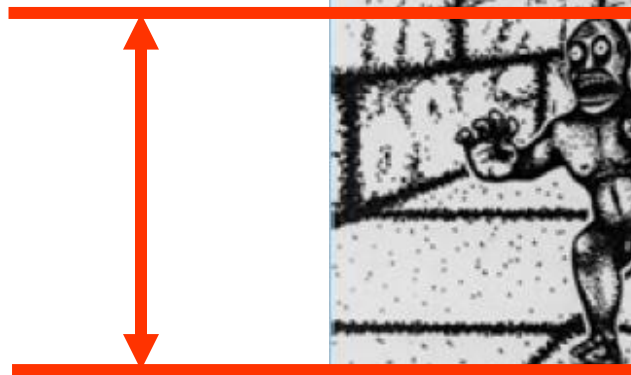
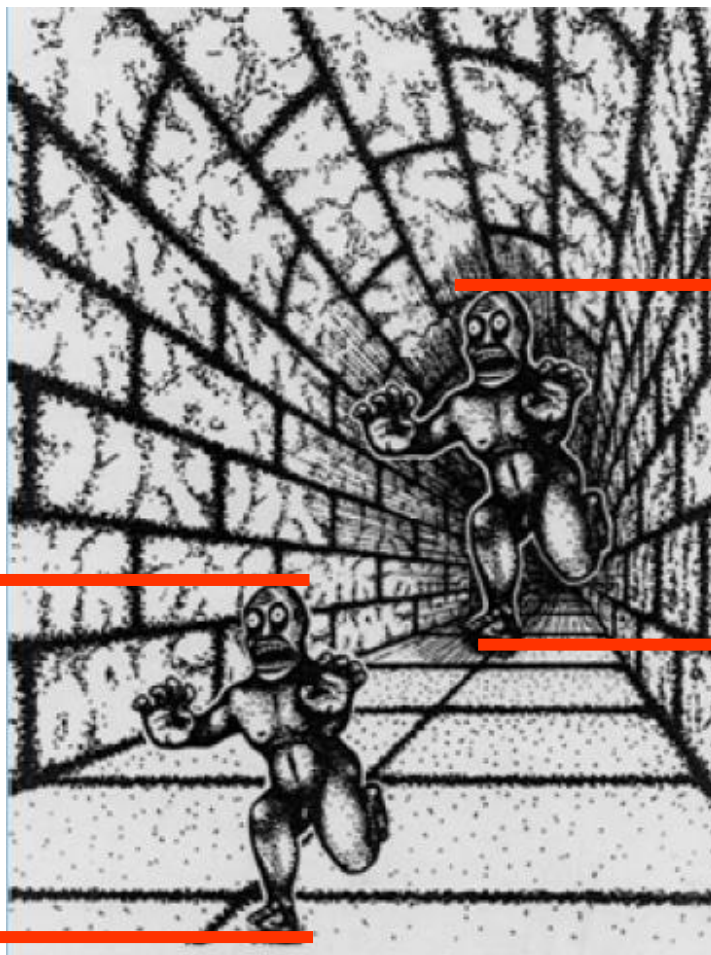
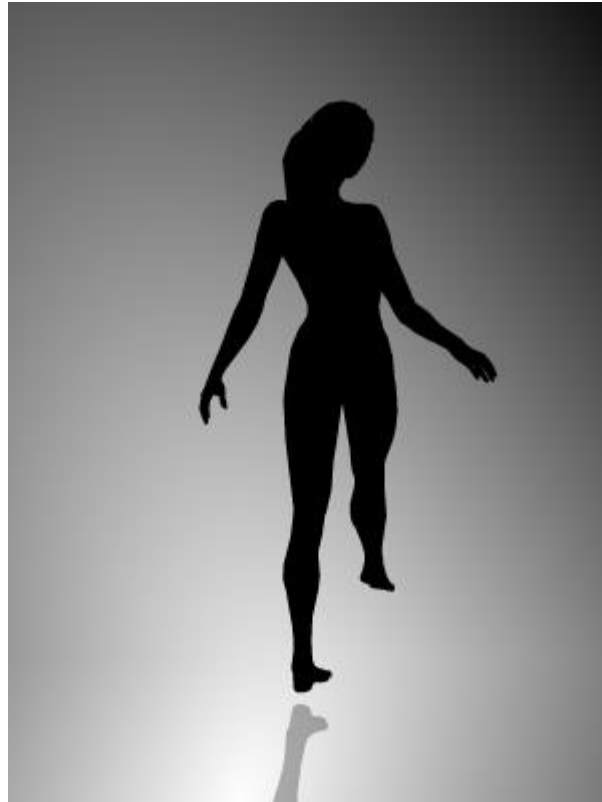


Spatial Perception

A Few Pictures



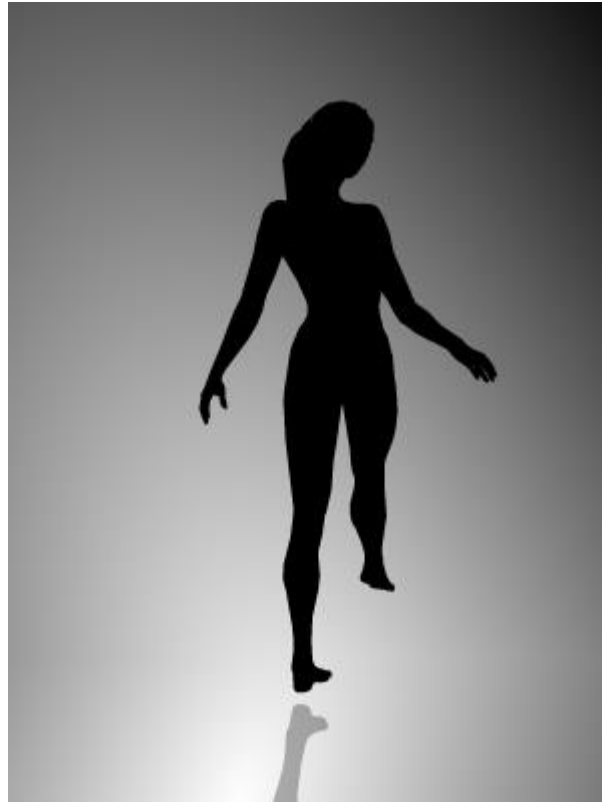


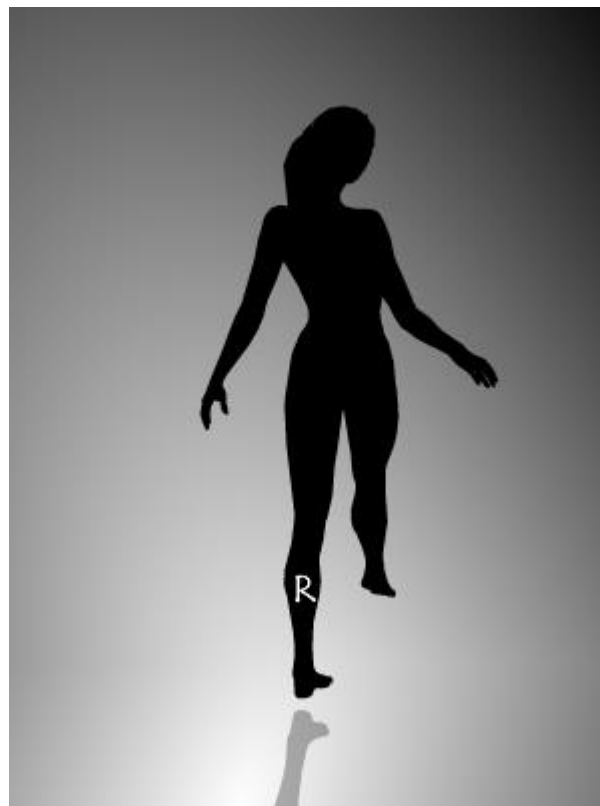
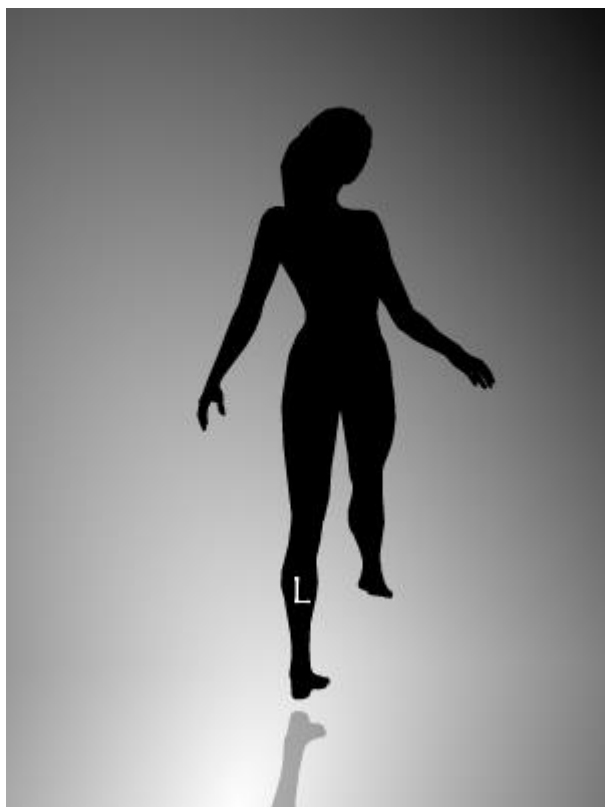
Space Perception Is Important!

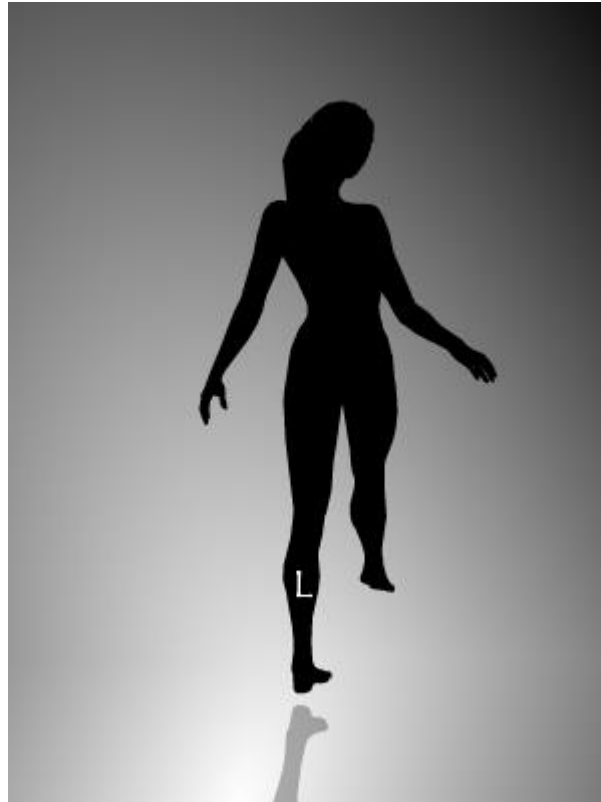
- Desktop is a design using the concept of space.
- 3D virtual environments also use spatial metaphor.

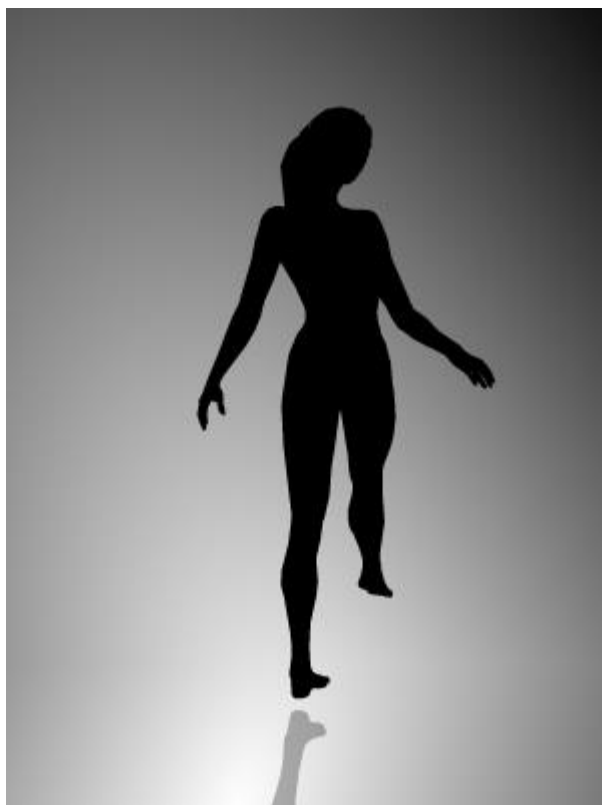
Necker Cube

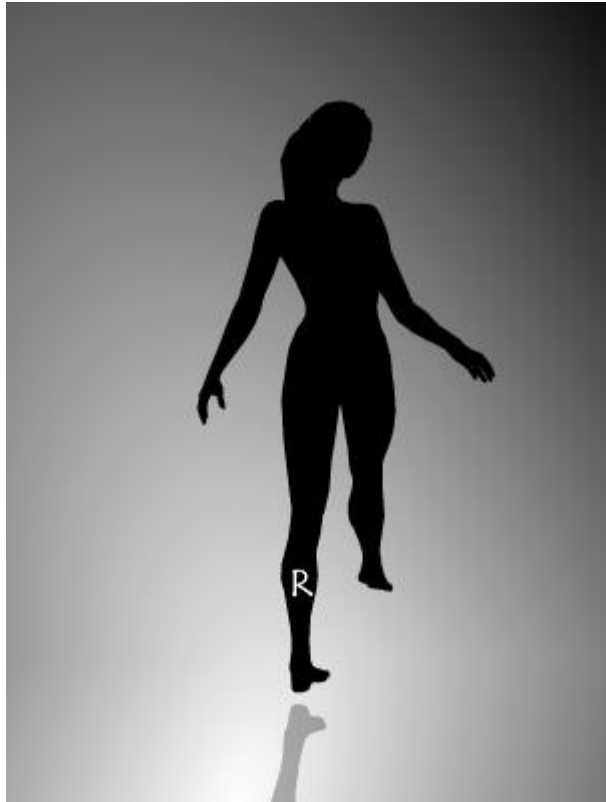
- <https://michaelbach.de/ot/sze-Necker/index.html>

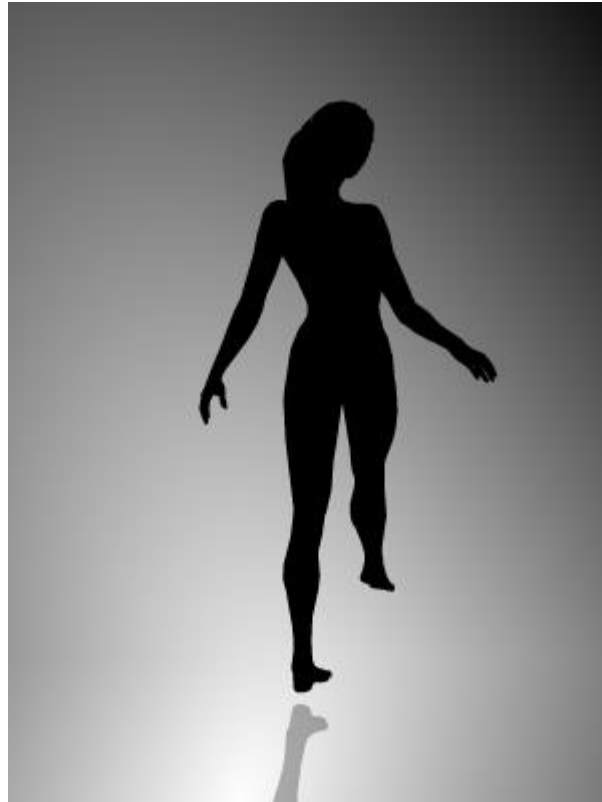












We Rely on Various Cues to
Tell the Depth!

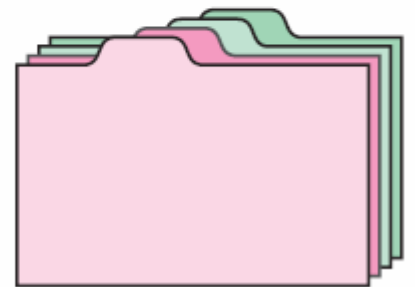
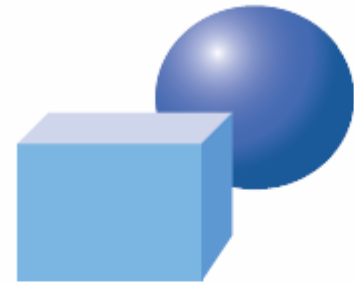
Our Brain Plays a Key Role in
Deciding Which Objects are
Closer and Which are Farther
Away.

Spatial Perception

- Two types of cues
 - Pictorial cues
 - Non-pictorial cues

Occlusion

- Objects closer to us occlude those farther away.
 - The strongest depth cue.



Size Perspective

- Size gradients
 - Using object size as reference
- Can be overridden by other cues



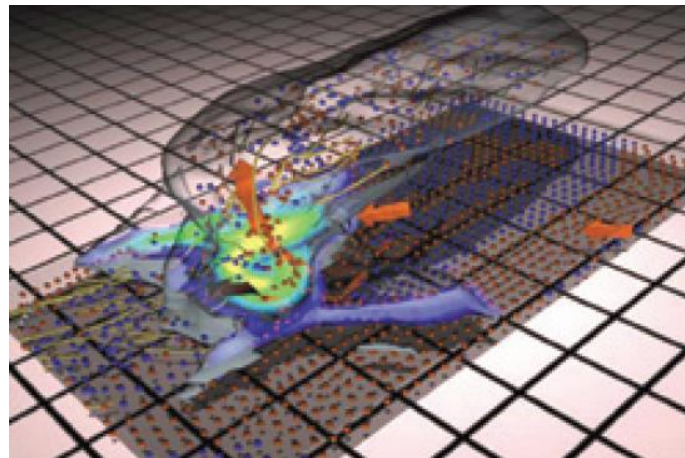
Texture Perspective

- Texture gradients
 - Assuming the same size of repeated patterns



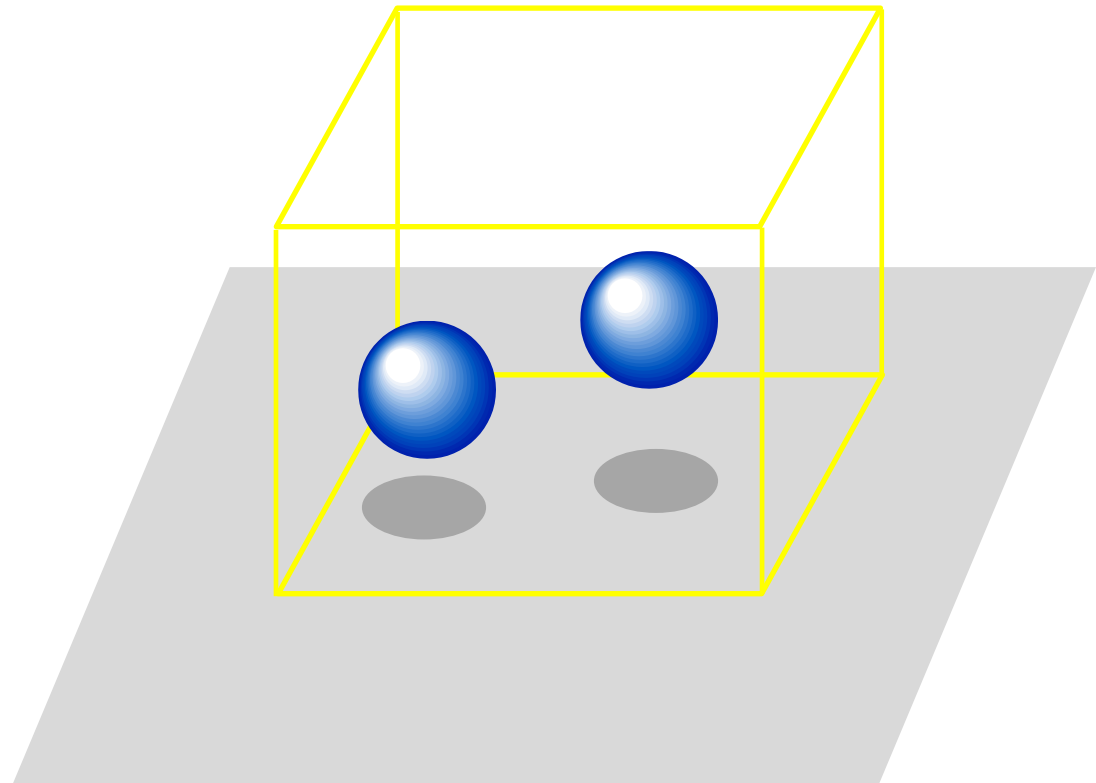
Linear Perspective

- Convergence of parallel lines on the picture plane.
 - Grid lines on the ground.
 - Many 3D environments provide such visual cues.



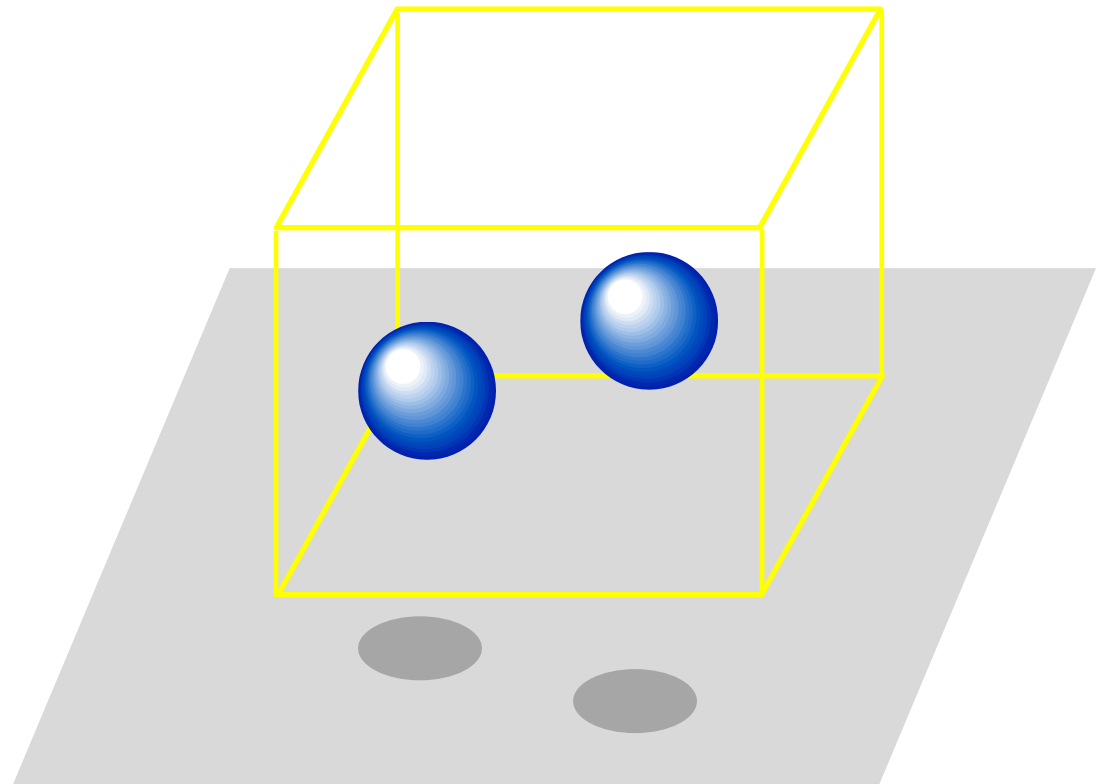
Cast Shadows

- Where are these two spheres?



Cast Shadows

- Where are these two spheres?



Degree of Contrast

- Aerial haze
 - Distant objects are blurrier.
 - Sun, air, etc.



Elevation (Height on Picture Plane)

- Relative height



Importance of View Perspective



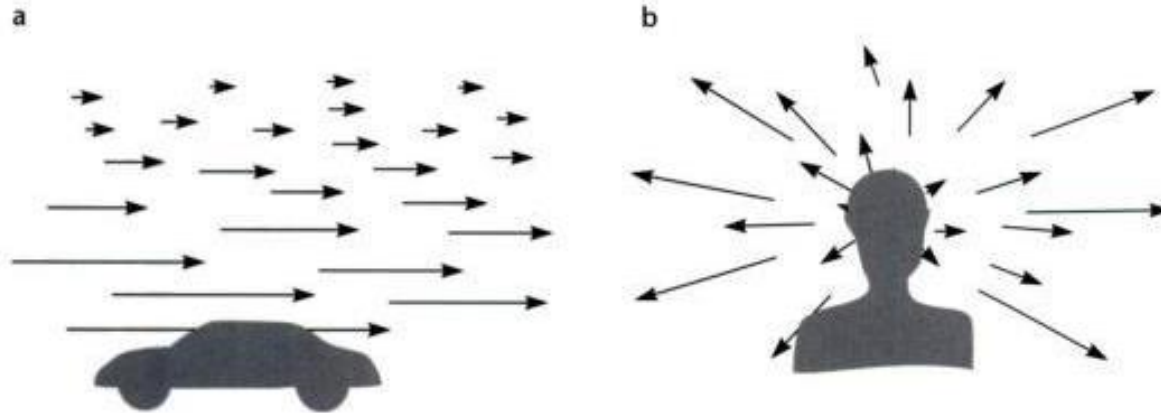
Evolution of Depth Representation





Giotto di Bondone (1266–1337)

Kinetic Cues



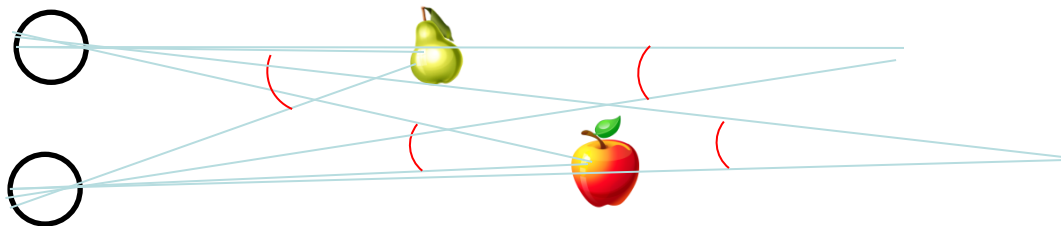
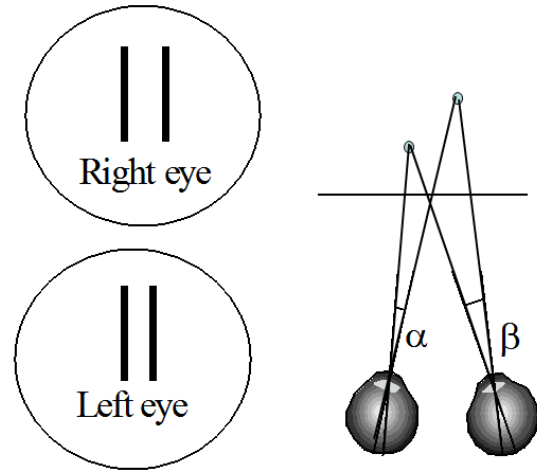
- Motion Parallax
 - Different retina images due to the movement of the view point.

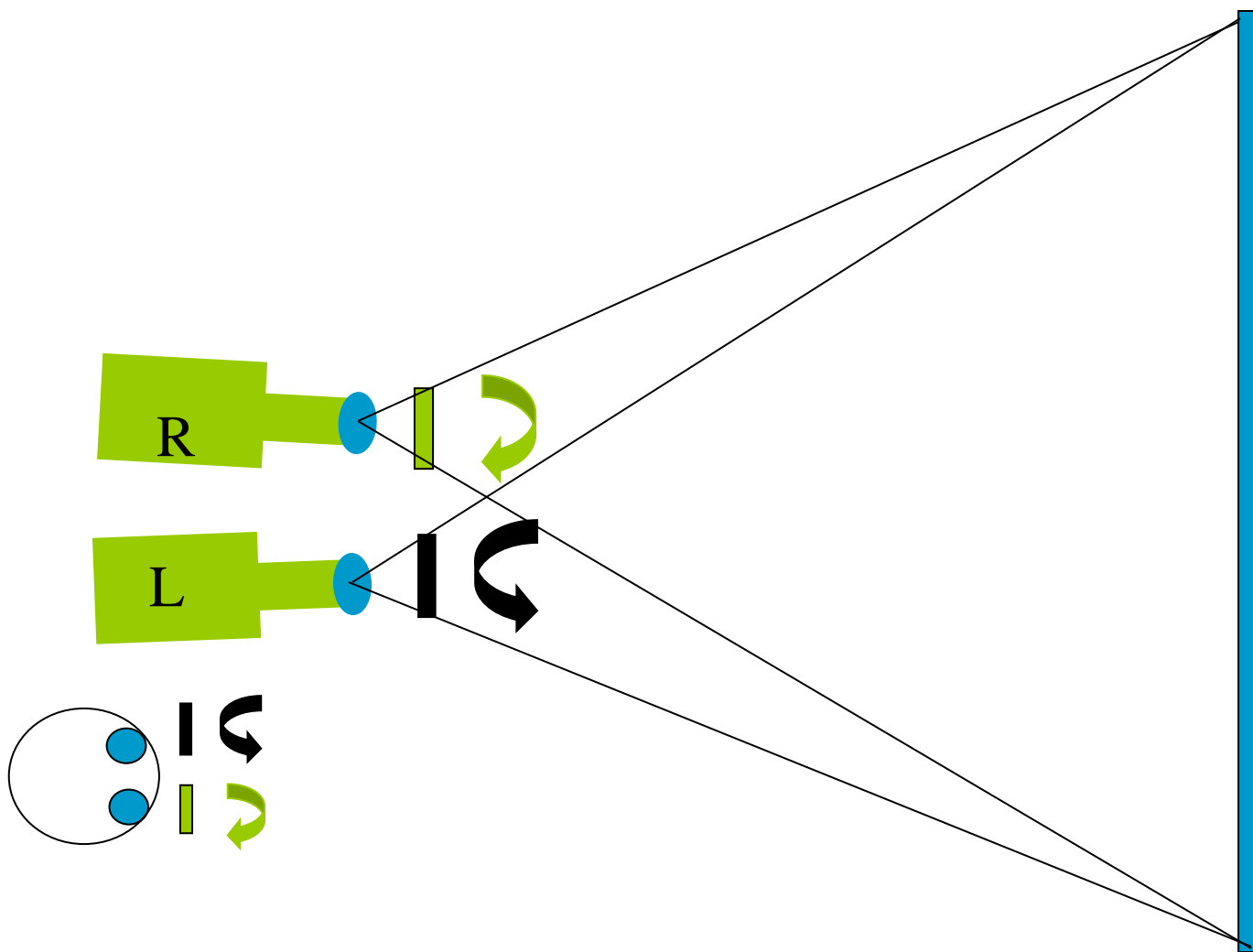




Binocular Disparity (Stereoscopic Depth)

- Binocular disparity
 - Different retina images on left and right eyes.
- Our brain can calculate the distance based on the disparity.
 - Distance is limited.

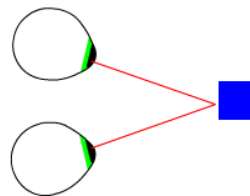
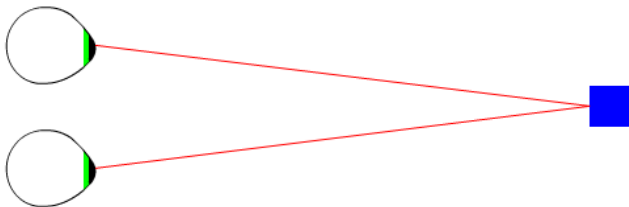
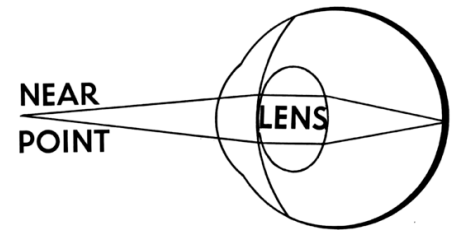
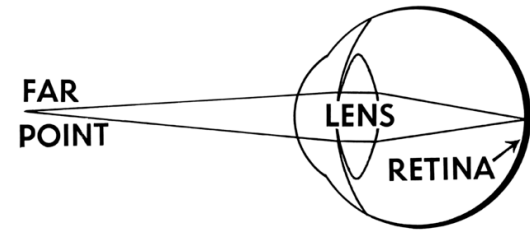






Physiological Cues

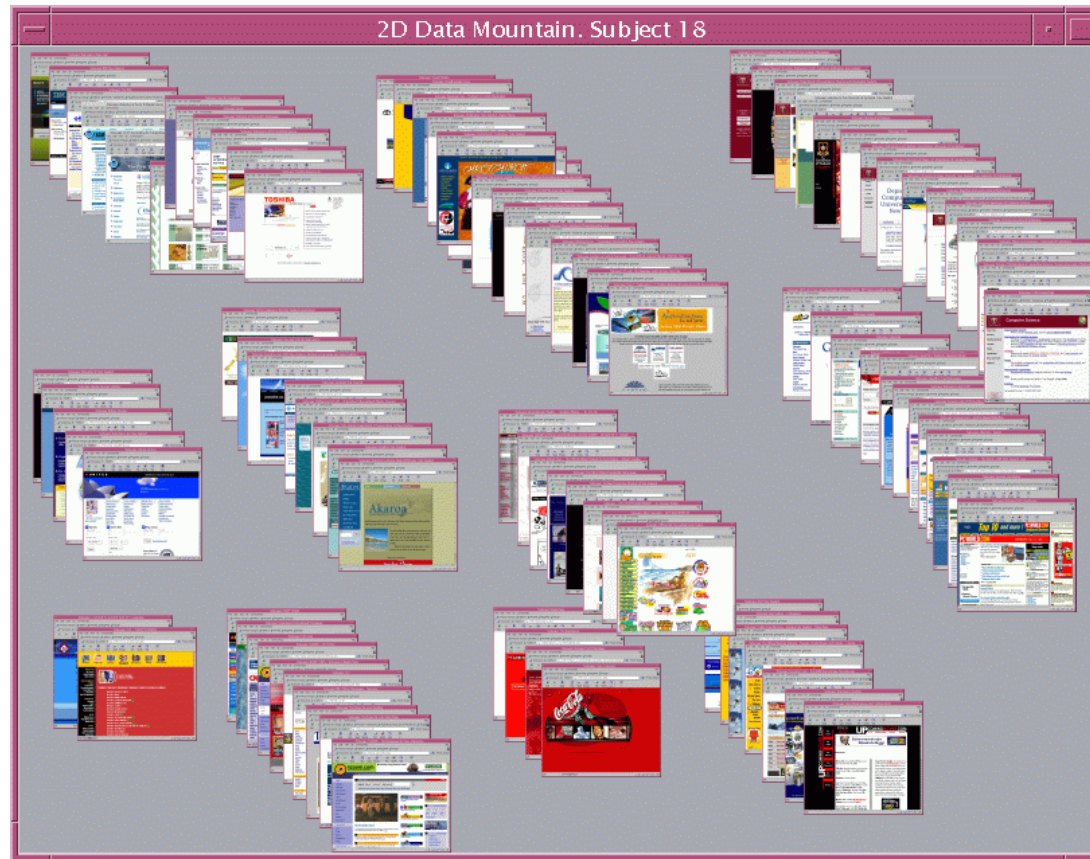
- Non-pictorial cues
- Accommodation
 - Based on the change of eye lens
- Convergence
 - Based on the relative angles of two eyes.



How Should We Incorporate
Depth/Distance in
Visualization Design?

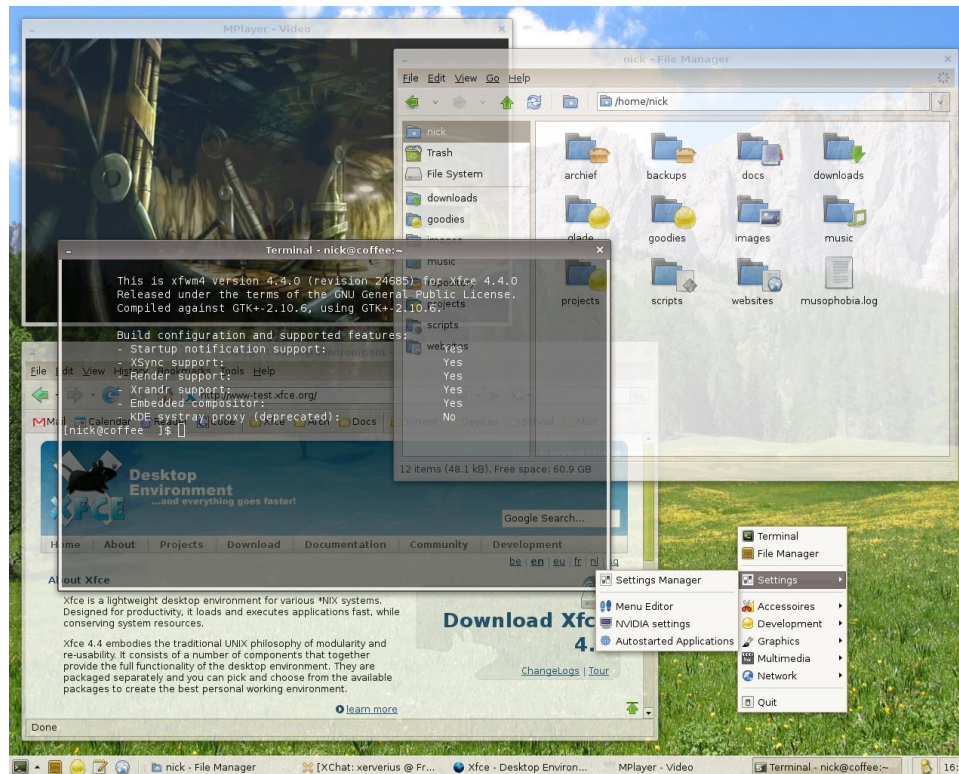
Some Principles

- Depth cues should be tied to design goals.



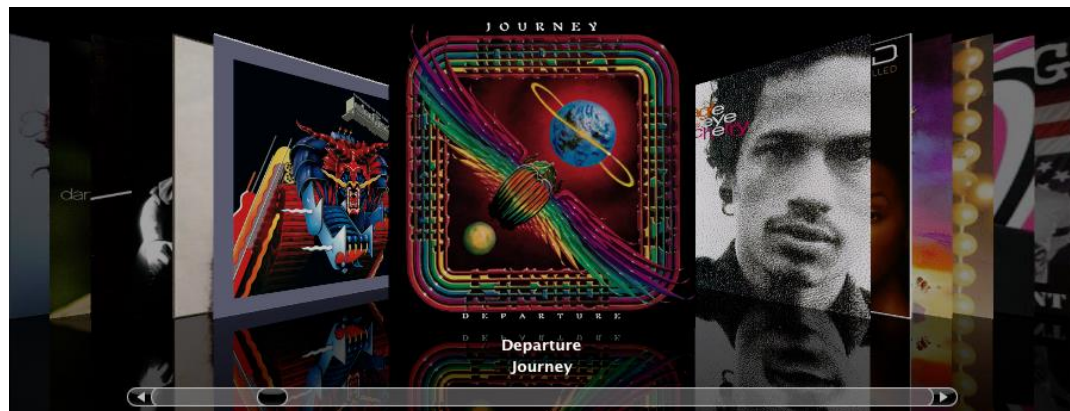
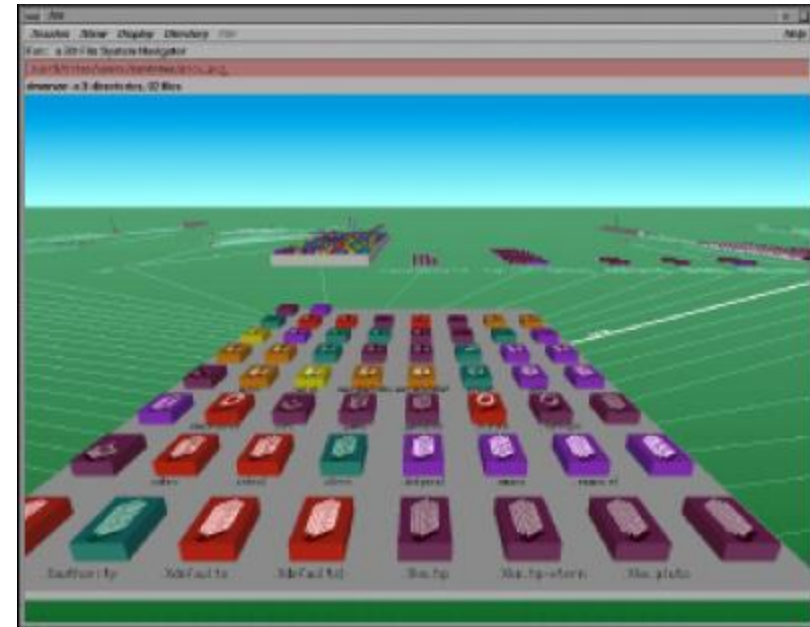
Some Principles

- Avoid occlusion.
 - If necessary, make critical information visible.



Some Principles

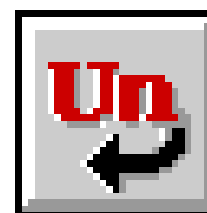
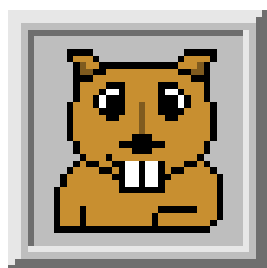
- Provide appropriate depth cues.

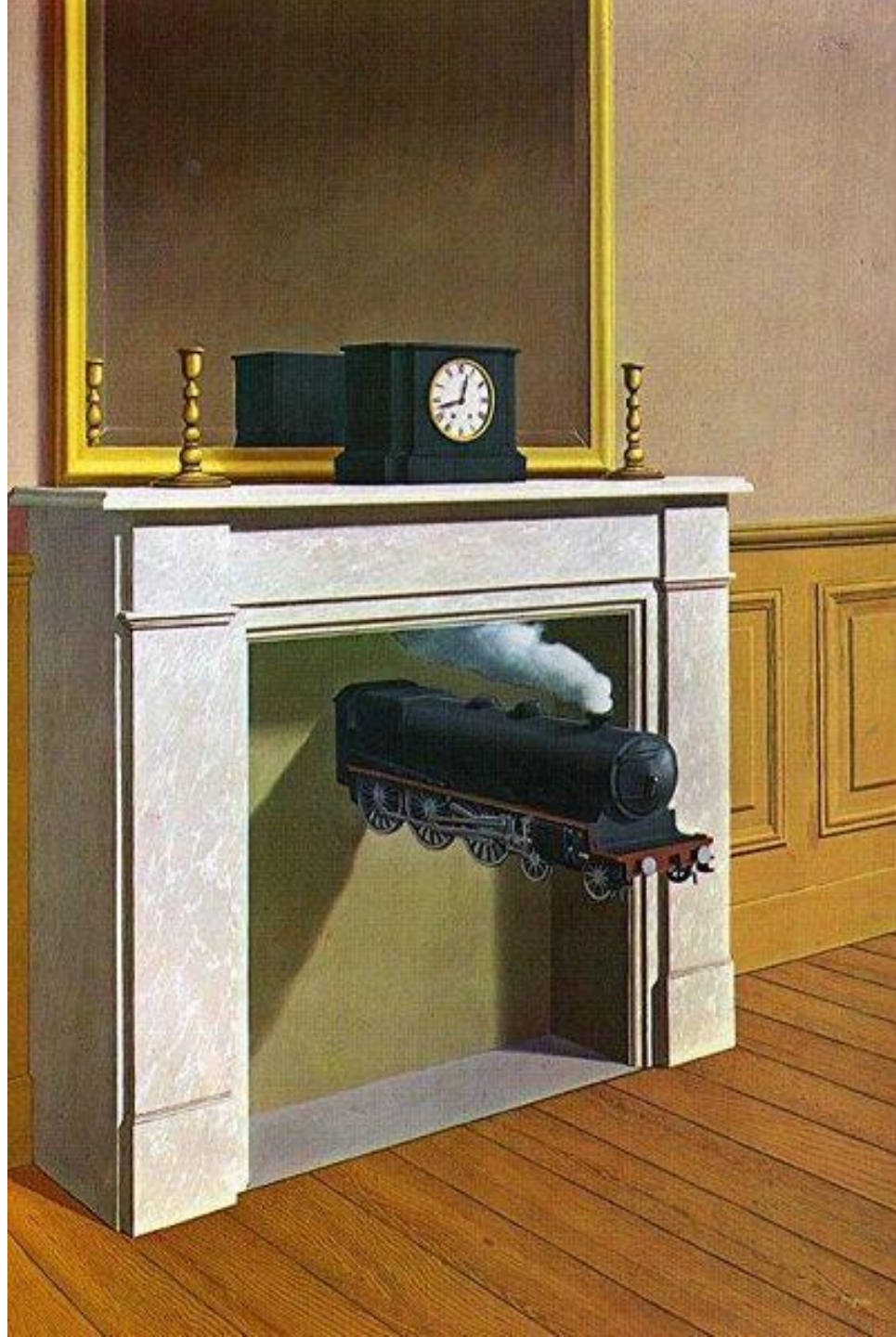


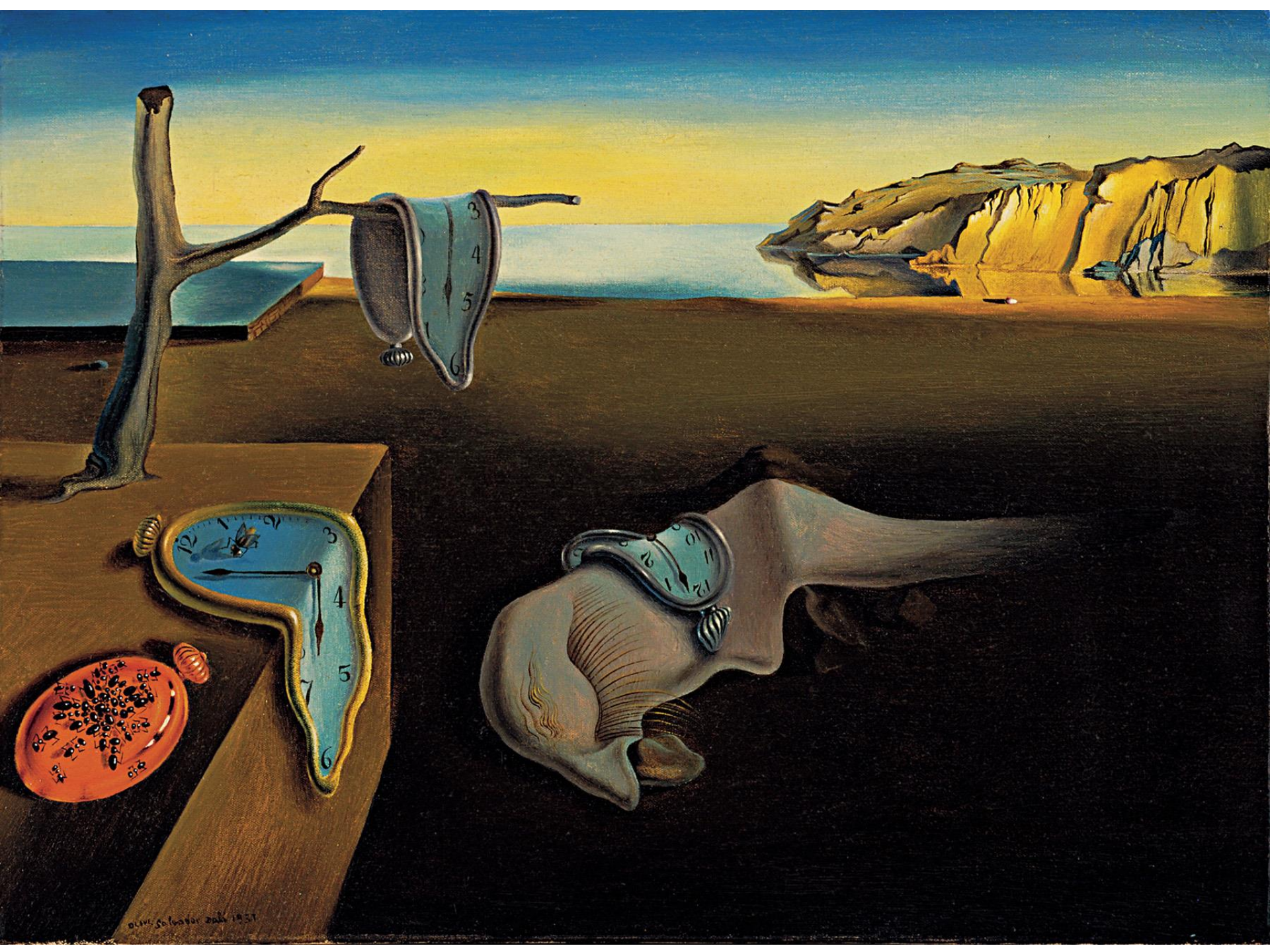
3D Style vs. 3D Space

- 3D Style
 - Using depth information to enrich information presentation
 - No need to navigate through the depth dimension.
 - Conventional 2D navigation techniques.
 - 2.5 D
- 3D Space
 - Users have to move around in 3D spaces.
 - Need special designs to support 3D space exploration.

Some Pictures







OLIVE SALVADOR DALI 1931

Visual Object and Meaning

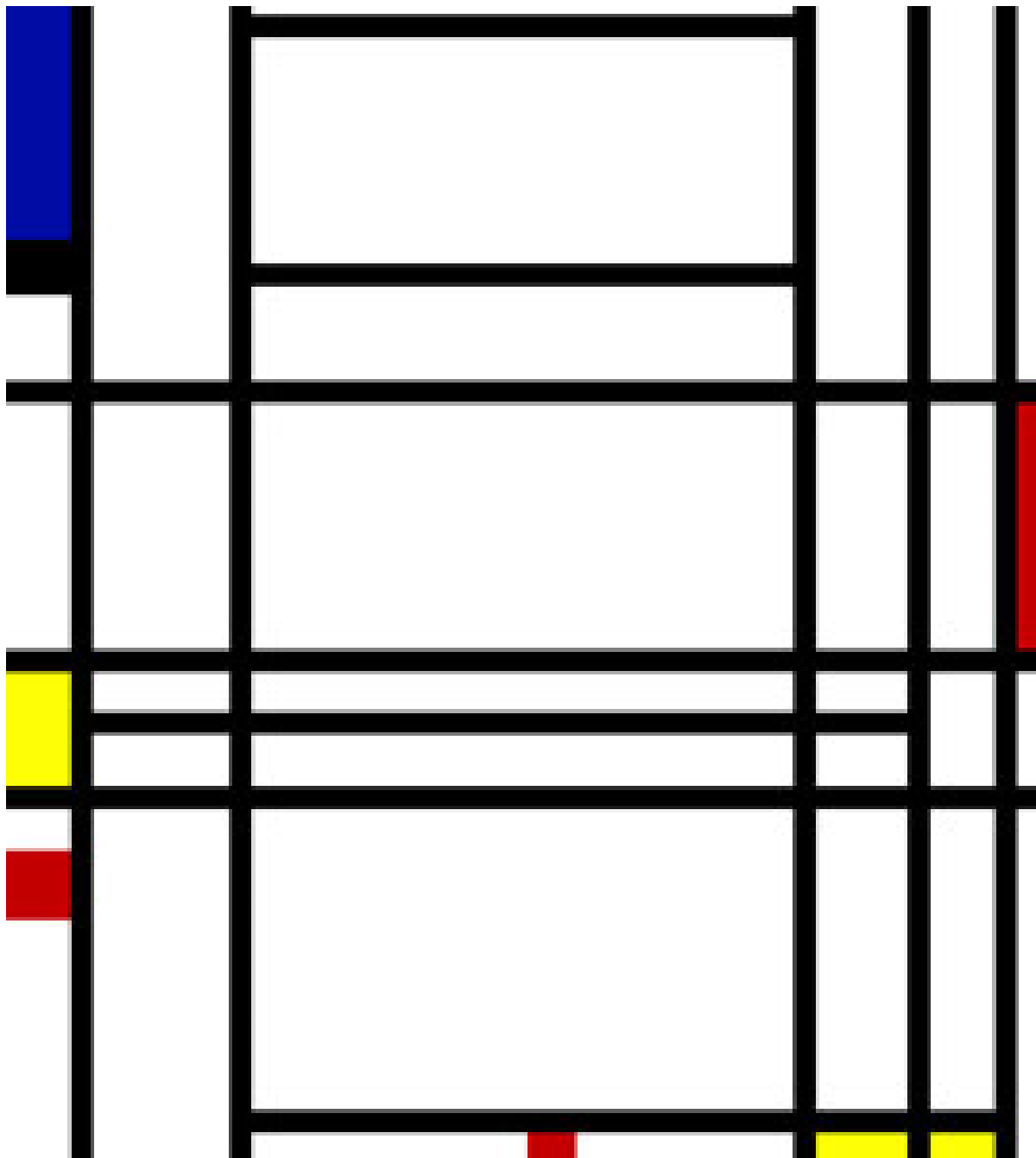
"A picture is worth a thousand words"

- We human beings are very good at picking up the meaning of visual objects.
 - A small fraction of a second.



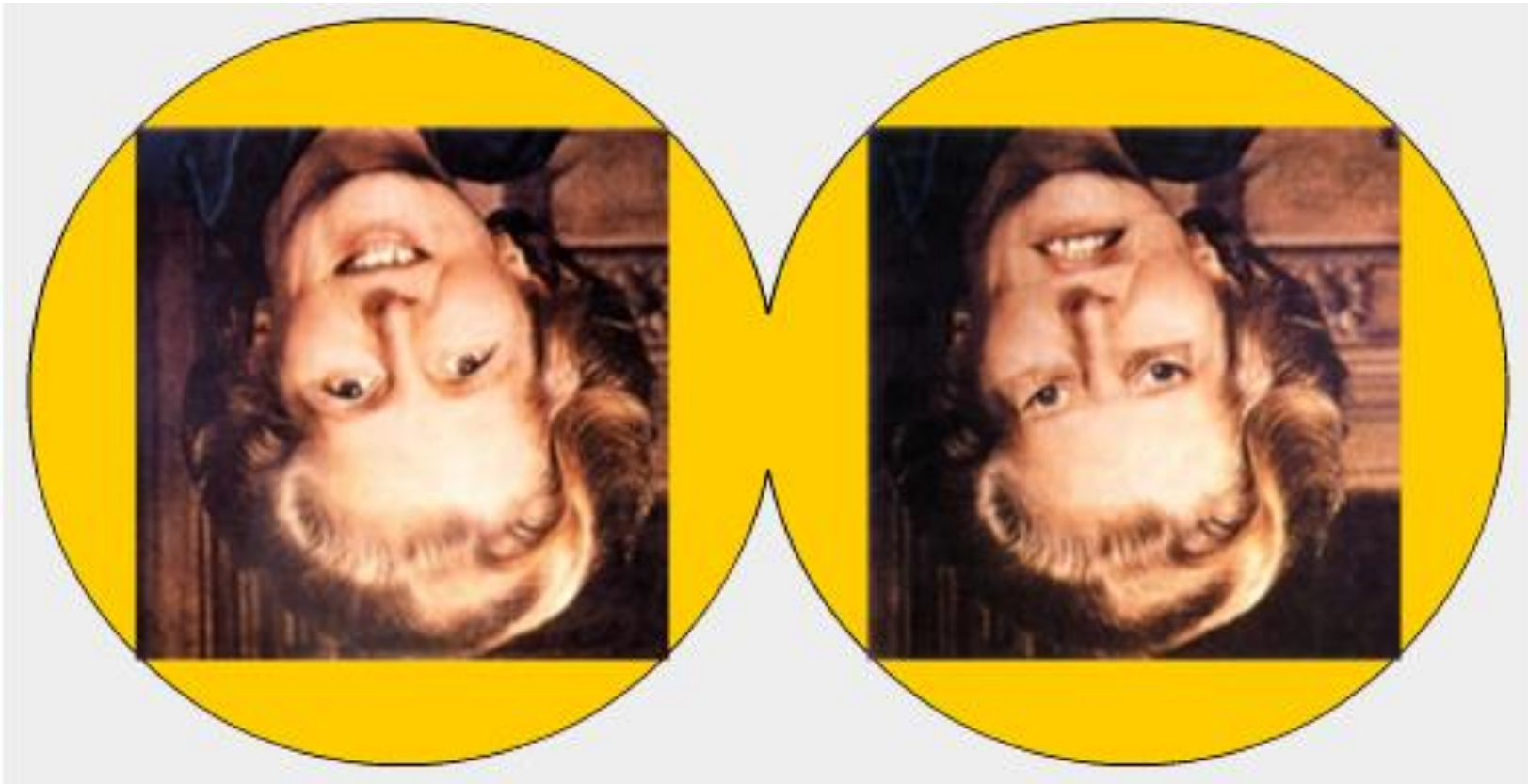
"A picture is worth a thousand words"

- We human beings are very good at picking up the meaning of visual objects.
 - A small fraction of a second.
- However, not every picture can be quickly picked up.



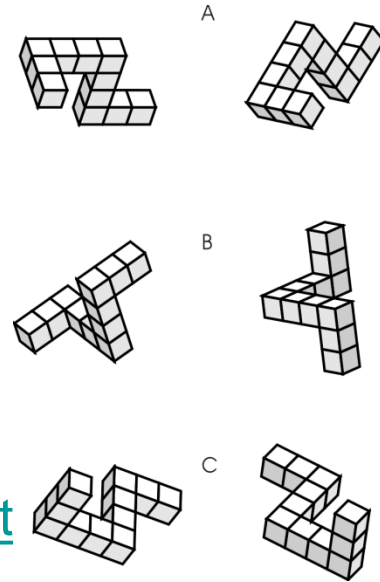
Object Recognition

- Easier from a familiar viewpoint



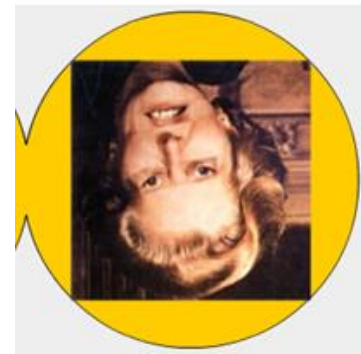
Limited Tolerance of Transformation

- Mental Rotation Is Difficult
 - Are the objects in each pair same?



- Pattern identification with rotation

<https://michaelbach.de/ot/fcs-thompsonThatcher/index.ht>



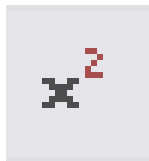
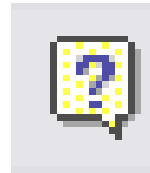
Familiar Structure



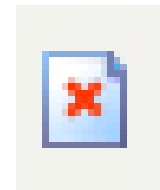
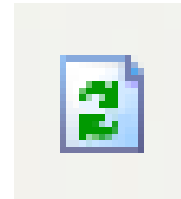
Design Implications

- Making objects easy to identify
 - Using typical members or instances of their class
 - Showing from a typical viewpoint
 - Presenting structural relationships clearly
 - Using commonly seen, familiar objects
- E.g., Icon design
 - Don't invent new icons unless it is absolute necessary.

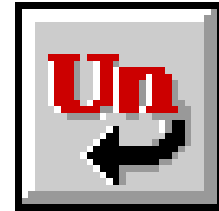
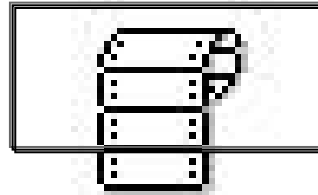
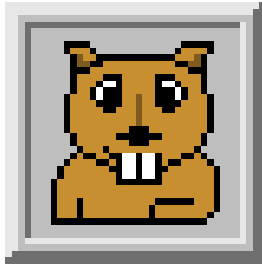
The Good (?)



The Bad



The Ugly



Meanings of Visual Objects

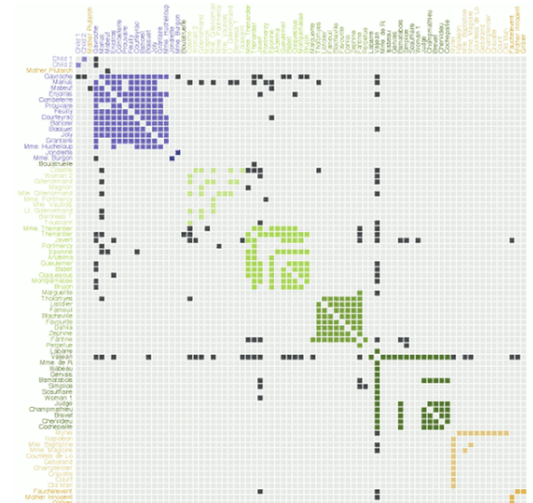
- Emotion



- Action



- Knowledge



Summary on Visual Perception

- Visual perception is the result of eye and brain activities.
 - Mental interpretation on physic objects
- What we see is very selective, and goal-oriented.
 - We cannot see everything.
- Good designs often leverage the characteristics of visual perception.
 - Be aware of what we are good at and what we are not.
 - Pop-up, depth perception, icons, etc.
- Some high-level skills (e.g., pattern recognition) are trainable.
 - Importance of prior knowledge and exercises.

About Midterm I

- 20 multiple-choice questions.
- Basic concepts about visualization, visual analytics, visual perception.
 - Focus on lecture notes on Mondays.