Visual Thinking

Visual Space

Depth

- Egocentric space consists of up-down, sideways and **towards-away** dimensions
- 2.5 dimensions
  - for every one of the **million brain pixels** recording up and sideways information, there is only, at best, **one point** of depth information
- depth cues are **pictorial** and **non-pictorial**

Depth

- When viewing a graphic, we simultaneously see the flat, 2D picture plane and the 3D picture space

Diego Rodríguez de Silva y **Velázquez, Las Meninas, c. 1656, oil on canvas, 125 1/4 x 108 5/8 in.** (Museo Nacional del Prado, Madrid)

Pictorial Depth Cues

- pictorial (or **monocular**) depth cues can be reproduced in a photograph or painting
  - defined by the projection of points on a plane
  - need only one eye to see them

Pictorial Depth Cues

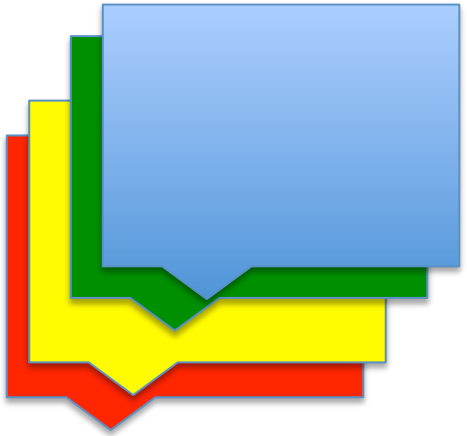
- pictorial depth cues do not have to be defined in an all-or-nothing fashion: they can be applied according to goals of design
  - choice is **not 2D or 3D**, but **which** of the depth cues **to apply**
  - each have unique properties that support different kinds of visual query

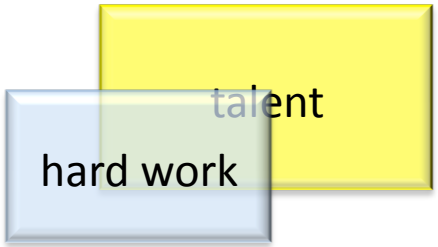
Pictorial Depth Cues: Occlusion

strongest depth cue

- if placed in competition with another, such as size constancy, occlusion wins

- objects near to us block or visually occlude objects further away.
- an object that occludes another appears closer



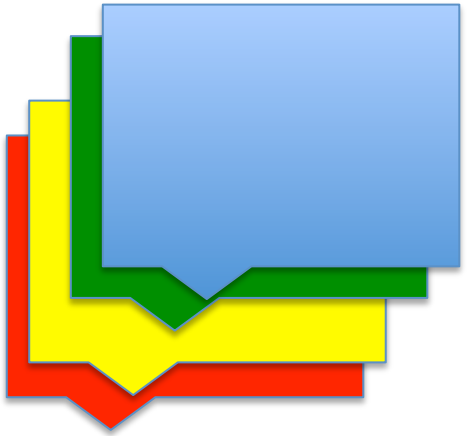


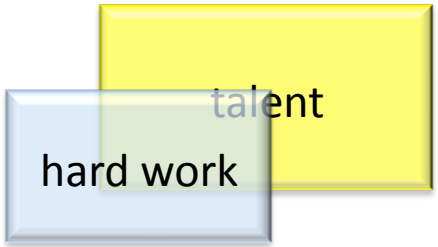
Pictorial Depth Cues: Occlusion

a **method** and **metaphor** for ranking ordered information

- most important partially occlude less important

- **very important** to ensure that the occluded object can still be **identified**

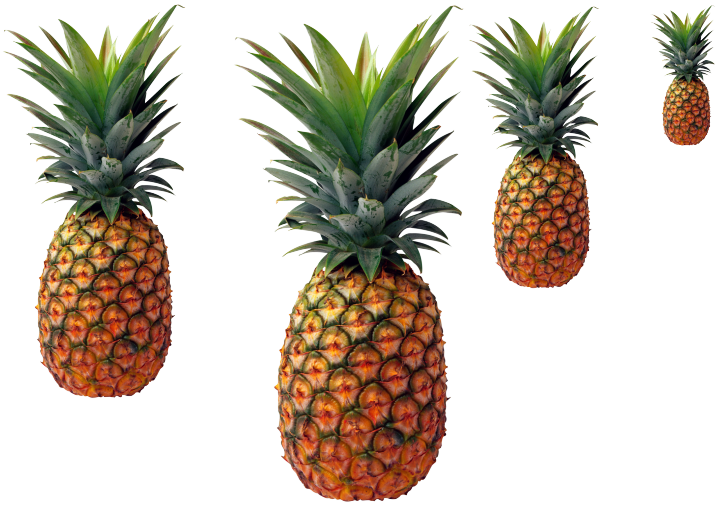




Pictorial depth cues: Perspective

- **Size gradients**: more distant objects are smaller on the picture plane than similarly sized nearby objects
- visual metaphor for relative importance
  - advantage that less important information takes up less space

http://art.nmu.edu/



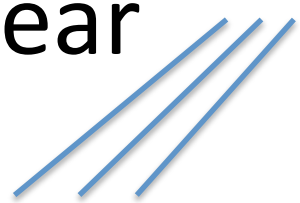
Pictorial depth cues: Perspective

wordle tag cloud for
“Biological components of sex differences in color preference
Anya C. Hurlbert and Yazhu Ling

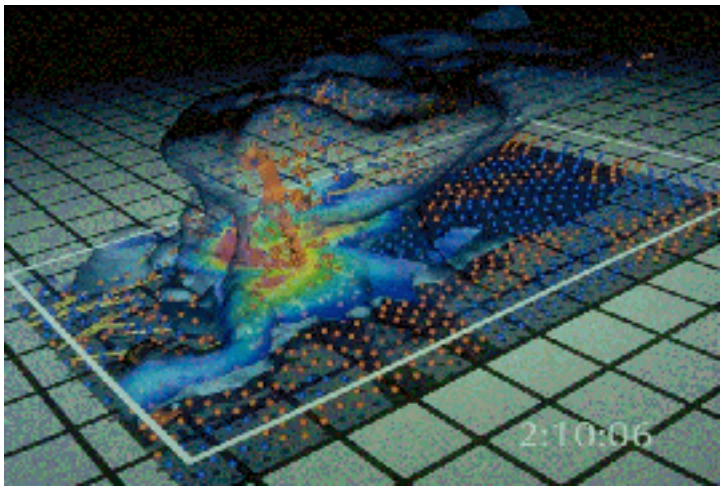
Pictorial depth cues: Perspective

- **Texture gradients**: texture elements reduce in size and increase in density with distance
- Provide a size reference for objects
- but usually less effective than a grid for making size judgements
- also, fine textures usually not reproduced on computer displays

Pictorial depth cues: Linear perspective



- Projections of parallel lines converge on the picture plane
- grid of parallel lines used often in 3D layouts of scientific objects to provide a reference plane for layout and size measurement



visualization of a severe supercell thunderstorm

Pictorial depth cues: Shading and Cast Shadows

- surface of objects reflect more or less light depending on how they are oriented to a light source

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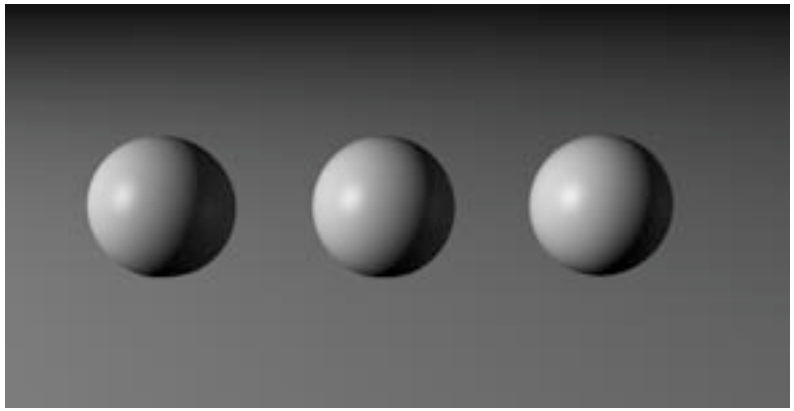
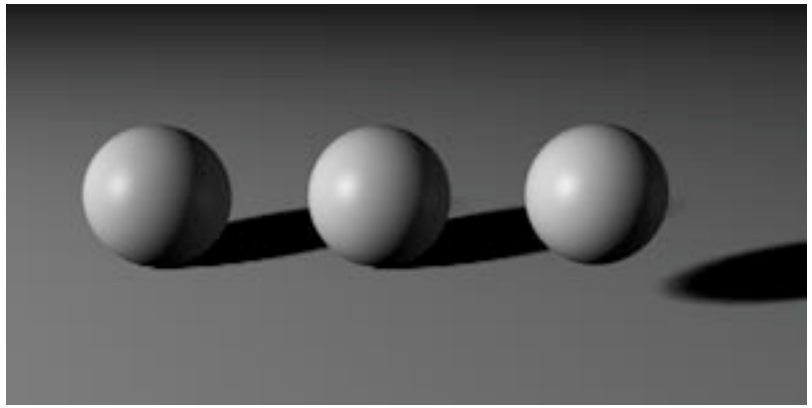
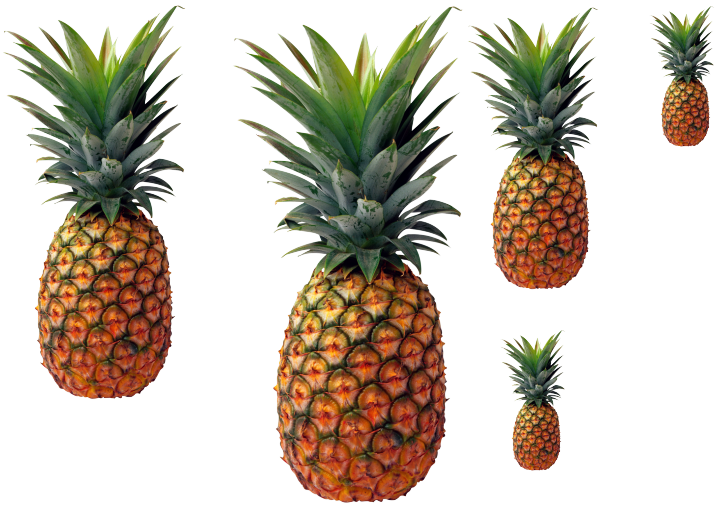




- The shadow cast by one object on another provides information about the distance between them

Pictorial depth cues: Height on the picture plane

- objects higher up the visual field are generally seen as further away



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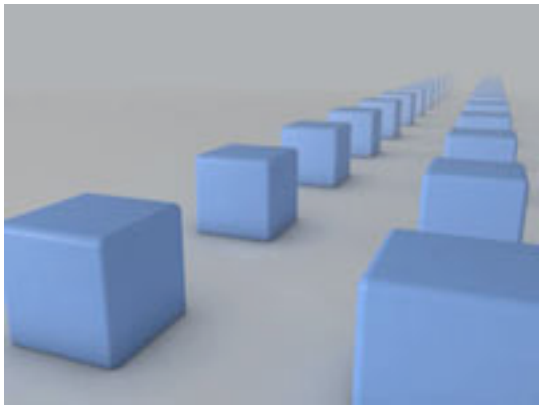
Georges Seurat
A Sunday Afternoon on the Island of La Grande Jatte
1884-86, oil on canvas

Pictorial depth cues: Depth of focus

- The human eye focuses objects at a specific distance:
  - objects closer or further away are blurred
  - degree of blur can be used to direct attention



Pictorial depth: reference to known objects

- objects of known size are a reference against which other objects are judged
  - absolute size
  - knowledge-based, but one of the most important cues to distance

We see the duck as closer than the elephant

http://art.nmu.edu/

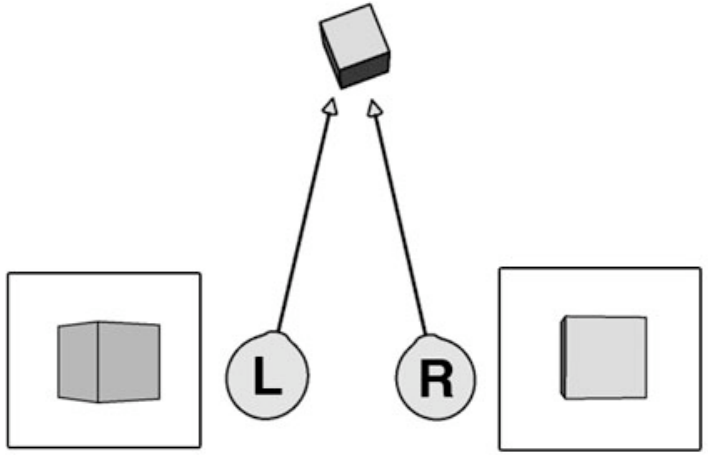
Pictorial depth: Degree of contrast

- Because air and water are not completely transparent, the contrast between an object and its background is reduced as distance increases
- “atmospheric perspective"

http://art.nmu.edu/cognates/concepts/175_depthcues.html

Non-pictorial depth: stereoscopic depth

- Not captured in a static image
- V1 has mechanisms to extract small differences in images on two eyes to get distance information
- stereoscopic information is used for guiding our hands
- for objects at nearly the same depth

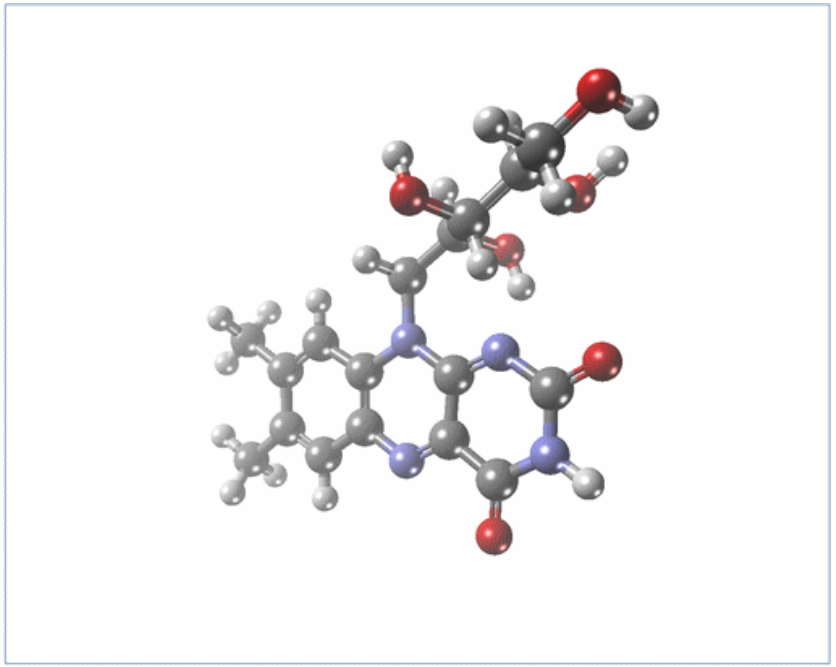


The diagram indicates a left and right eye. Both eyes converge on a box but due to retinal disparity, the angle of viewing is slightly different for each eye. The brain combines the two images to create the perception of a three-dimensional object.

Non-pictorial depth: stereoscopic depth

Non-pictorial depth: depth from motion

- better depth from steropsis
- brain takes advantage of series of views to interpret depth information

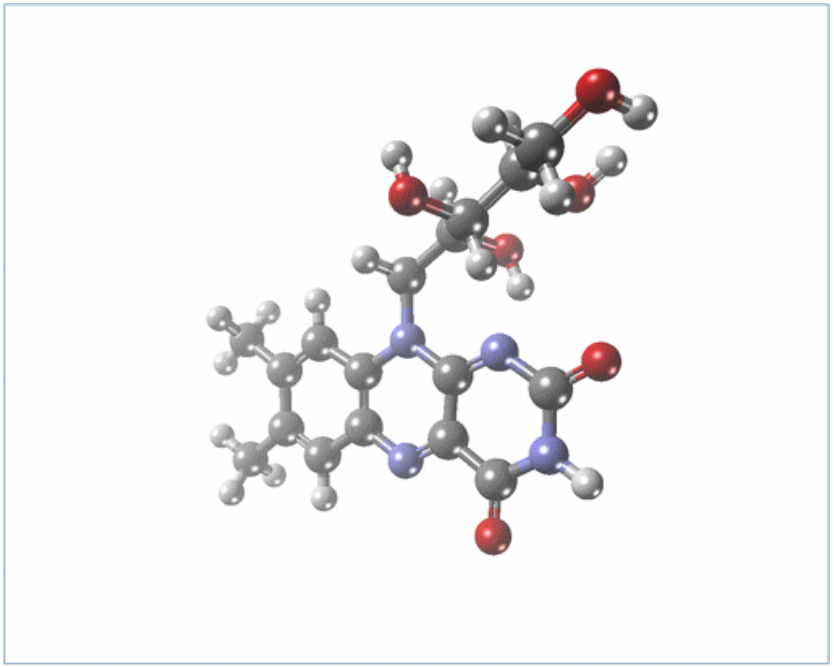


2.5 design

- treat depth very differently from other two dimensions:
  - depth cues used selectively to support design goals
  - objects laid out with minimum of occlusions – minimize depth
  - ensure critical information not occluded – use transparency where necessary
  - display text in the image plane

2D or 3D?

- when deciding whether as display should be 2D or 3D, the nature of what is displayed is very important:
  - some data already has 3D spatial properties
    - architectural designs and physical and biological data



2D or 3D?

- many other kinds of data are not inherently spatial
    - business statistics, social networks, abstract concepts
- some people have tried to use three dimensional representations for these, with the justification that, as we live in a 3D world, 3D must be better than 2D

2D or 3D?

- BUT – we don't perceive 3 dimensions
  - 2.5D or, more realistically, 2.05 D
- The cost of getting a good viewpoint in 3D is almost always higher than clicking to follow a hypertext link or zooming in 2 dimensions
- eye movements are the lowest cognitive cost method we have for getting information on our environment