Image Adapted from cliparts.co

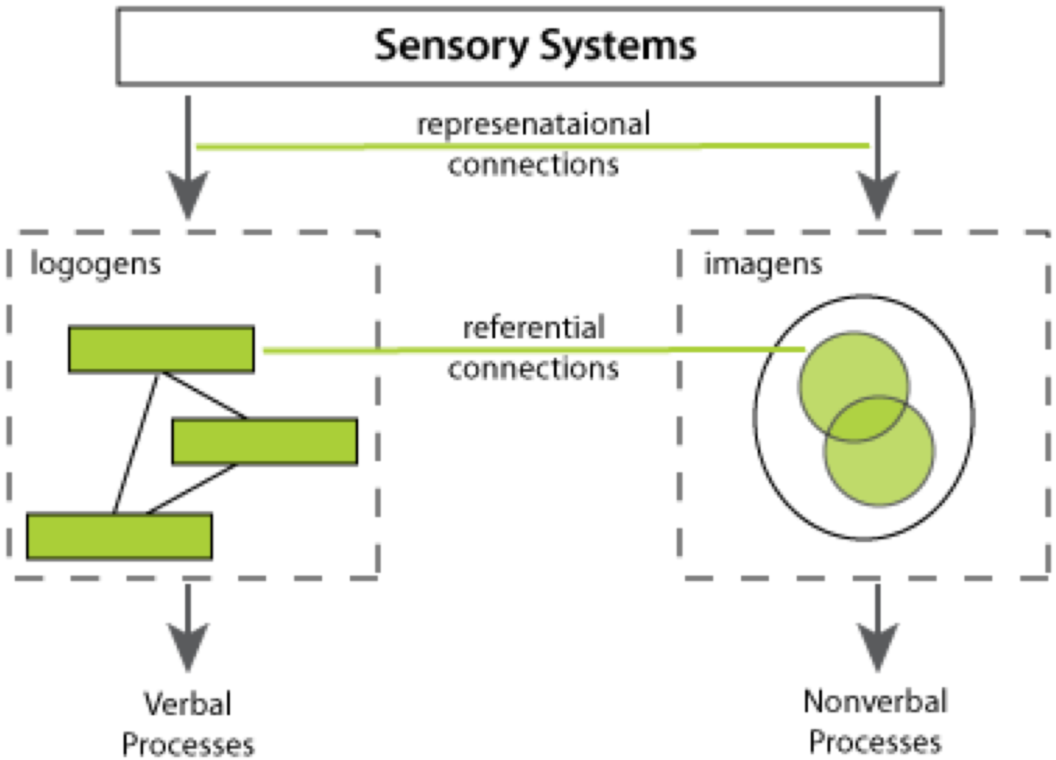
GEOM90007

SPATIAL VISUALISATION

LECTURE 9

GEOVISUALISATION 2 / HCI

DUAL CODING THEORY (by Allan Paivio)



VISUAL THINKING FOR EDA (Ware, 2004)

Referential connections between visual information and verbal or textual information

Dual coding theory (Paivio, 1987)

- Logogens
  Mental representations of basic language information, although not the sounds of the words. Logogens provide support for reading and writing, understanding and producing speech, and logical thought.

- Imagens
  Mental representations of basic visual information. Imagens are objects, natural groupings of objects, and whole parts of objects (for example, an arm), together with spatial information about the way they are laid out in a particular environment, such as a room

VISUAL THINKING

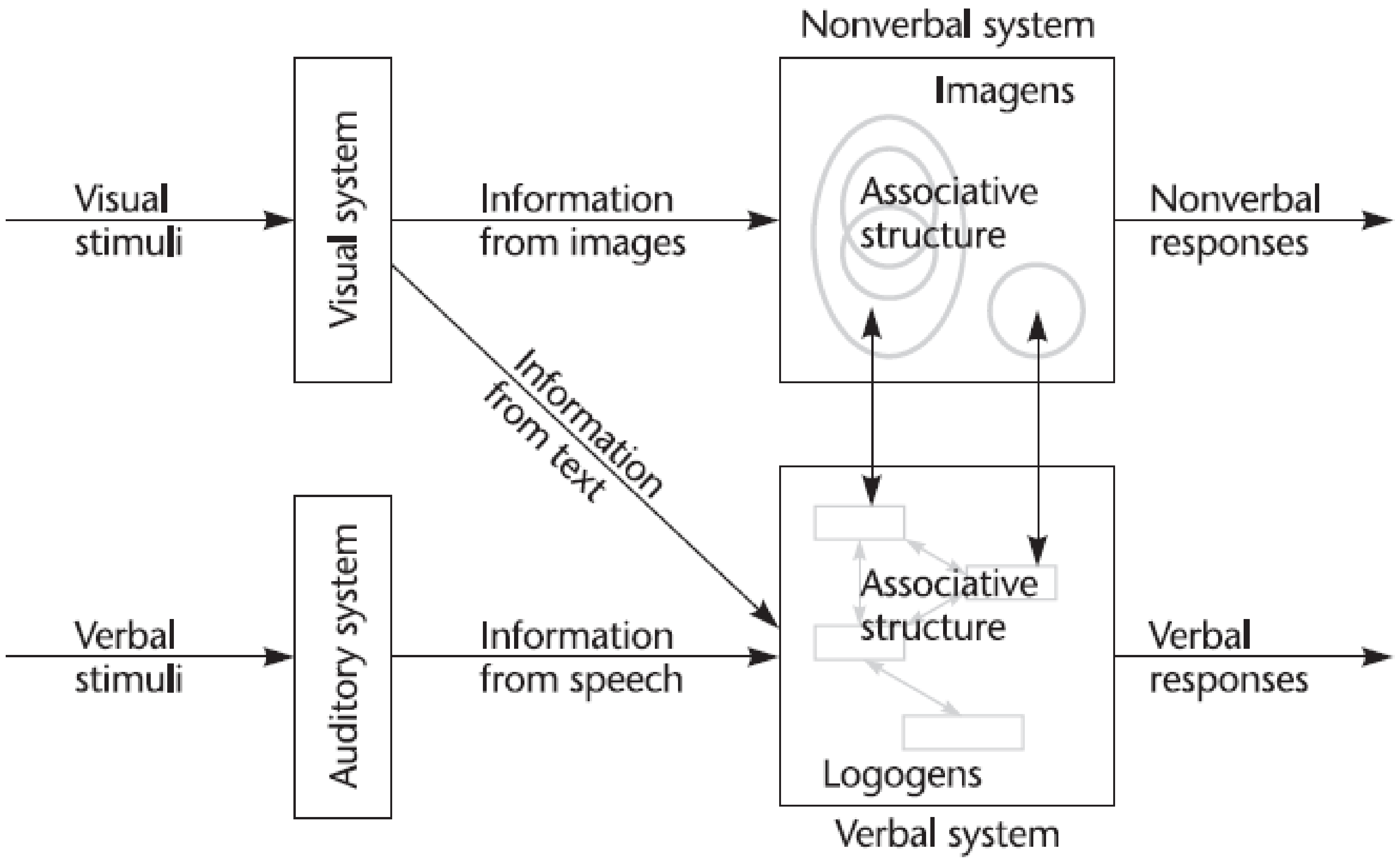


Image: Ware (2004)

OVERVIEW

- 2D representations of 3D
- Virtual reality
- Mixed reality

THREE-DIMENSIONS

Depth cues

- The visual world provides many different sources of information about 3D space

  These sources are usually called *depth cues*

- Multiple cues are OK, the brain is very flexible in weighing evidence from the different depth cues

THREE-DIMENSIONS

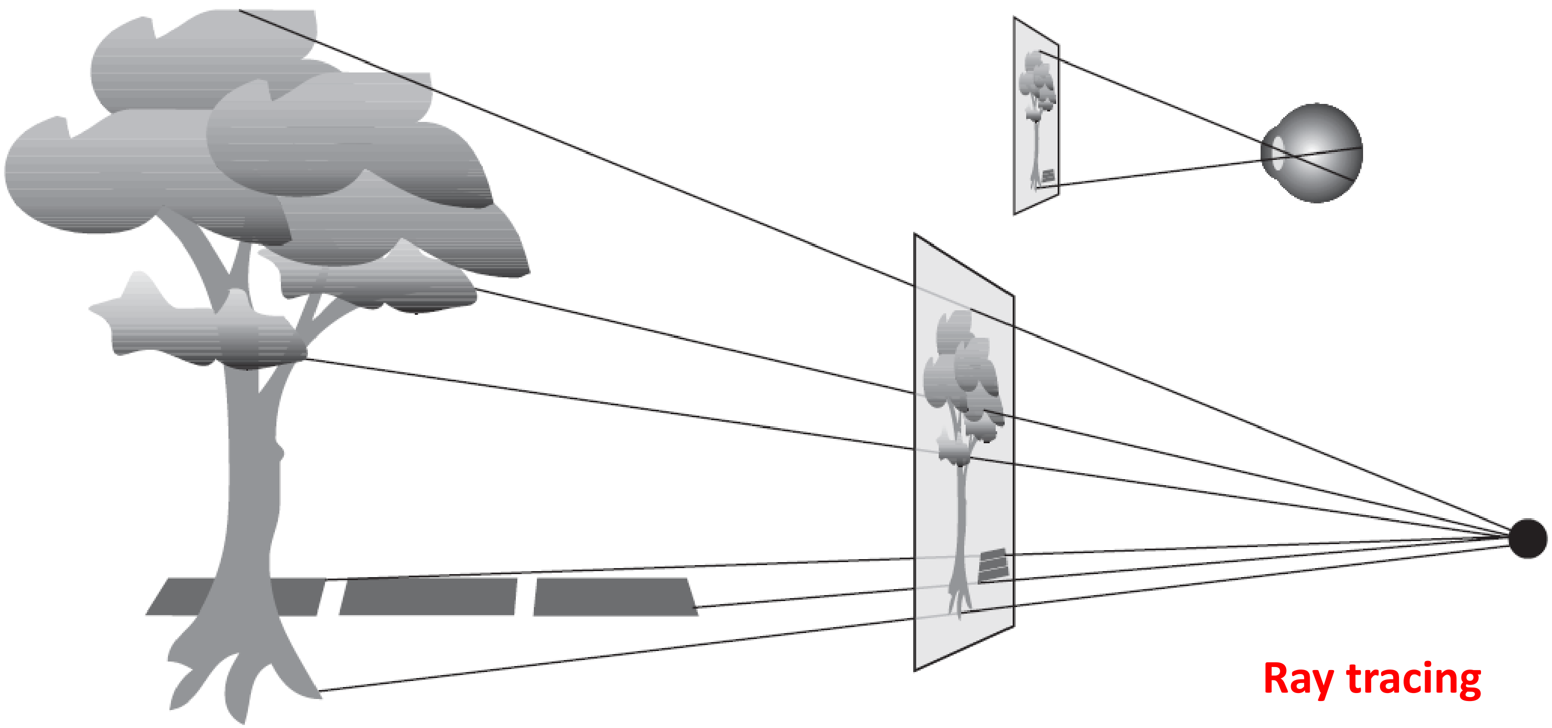
Monocular depth cues

- Perspective
  - Size gradient
  - Texture gradient
  - Linear perspective
- Occlusion related
  - Occlusion
  - Cast shadows
- Other
  - Depth of focus
  - Aerial perspective
  - Shading
  - Motion

PERSPECTIVE CUES

Arise from relative changes in geometry

- Objects vary in size on the picture plane in inverse proportion to their distance
- Similar triangles in eye



Ray tracing

Image: Ware (2004)

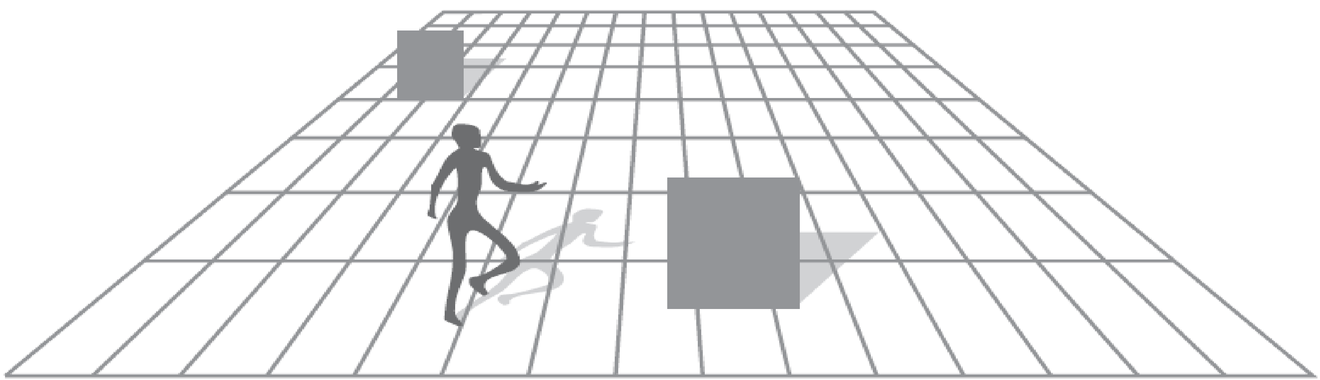
PERSPECTIVE CUES

Linear perspective:

- At least two parallel lines converge to a single point

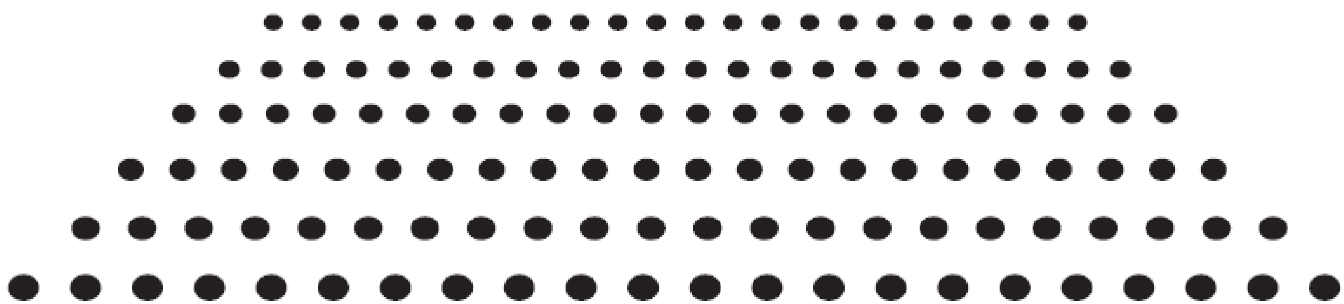
Size gradients

- Same object at a distance appears smaller



Texture gradients

- Texture elements become smaller with distance



Images: Ware (2004)

PERSPECTIVE USER INTERFACE

Use of perspective to show more information

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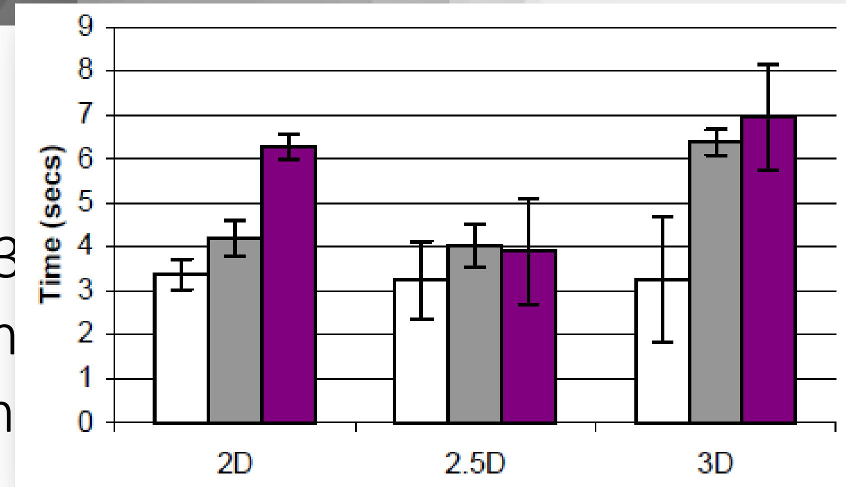


2D 2½D 3D

Source: Cockburn and McKenzie (2002)

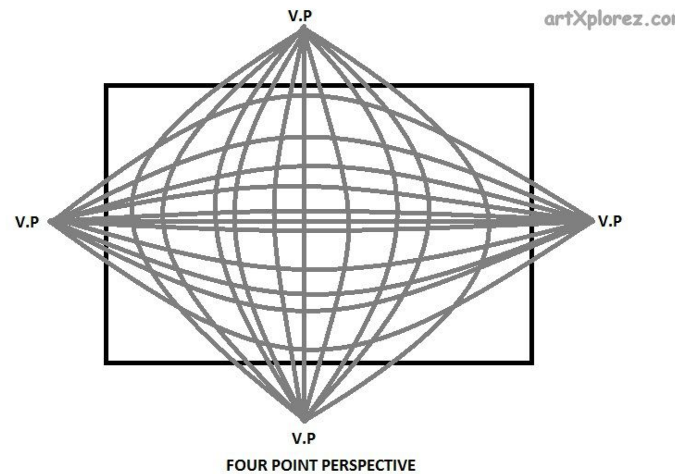
Data Mountain (1998)
http://dl.acm.org.ezp.lib.unimelb.edu.au/citation.cfm?id=288596

2D vs. 3D virtual environments (2002, 2003)
http://dl.acm.org.ezp.lib.unimelb.edu.au/citation.cfm?id=503413

OTHER PERSPECTIVE CUES

Source: http://www.op-art.co.uk/history/perspective/

Images: Brunnelleshi (1415)



Curvilinear perspective

Beware using junk!

Source: http://www.op-art.co.uk/history/perspective/

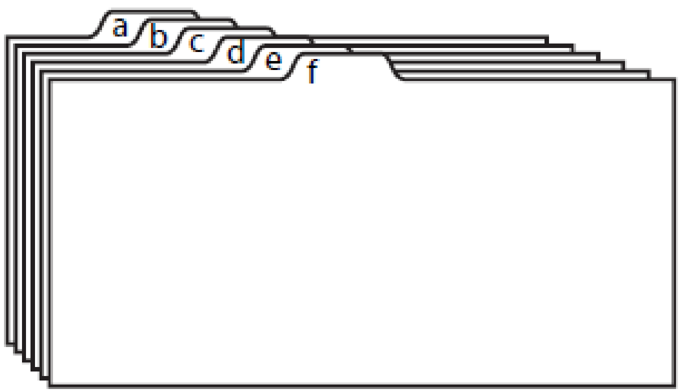
OCCLUSION RELATED

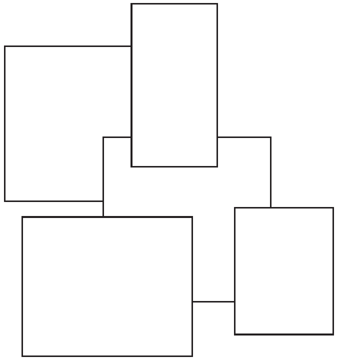
Two techniques result in a ‘depth hierarchy’ – valuable for design

- Occlusion
- Cast shadows

OCCLUSION

If one object overlaps or occludes another, it appears closer to the observer (Ware, 2004)





Images: Ware (2004)

Partial occlusion occurs when one object is transparent/translucent

- Be careful however!*

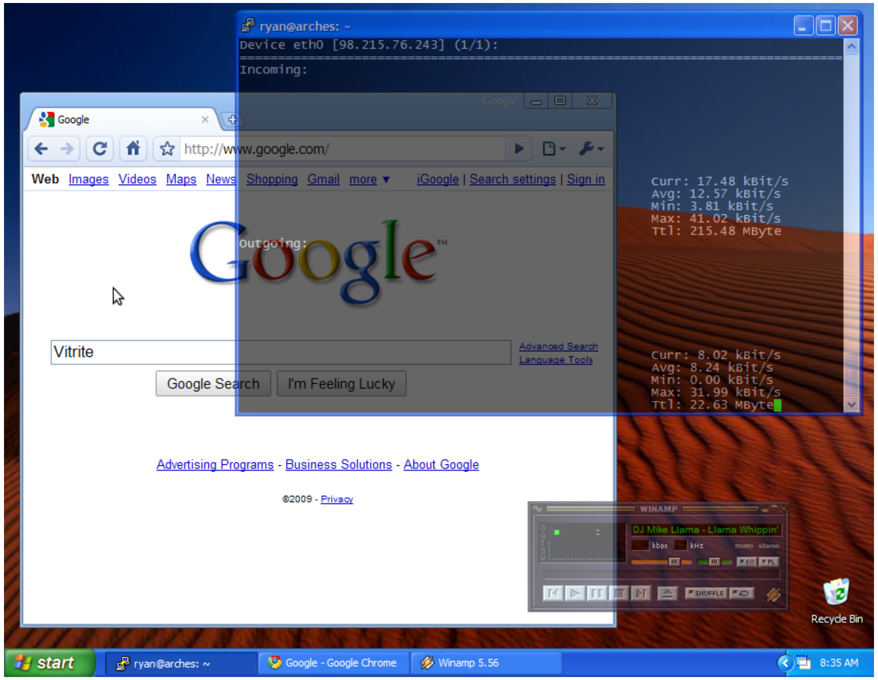
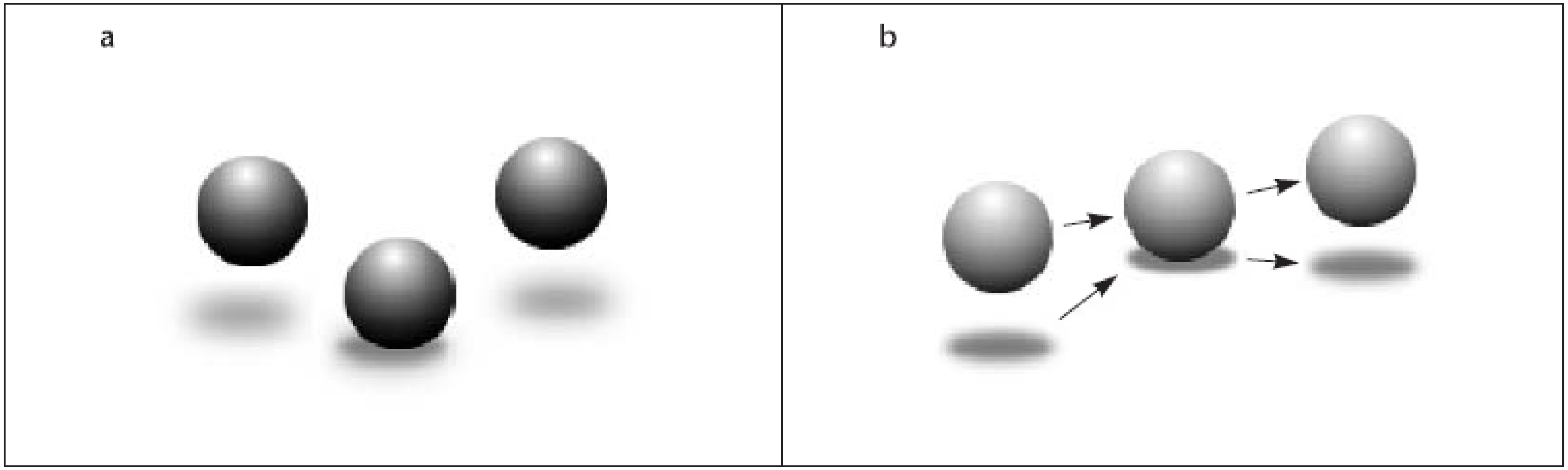


Image: Vitrite http://vitrite.vanmiddlesworth.org/vitrite/shot-full.png

SHADOWS

An indirect depth cue used to indicate height above a plane

- Very effective at small heights



Images: Ware (2004)

- Very confusing at large heights with many shadows

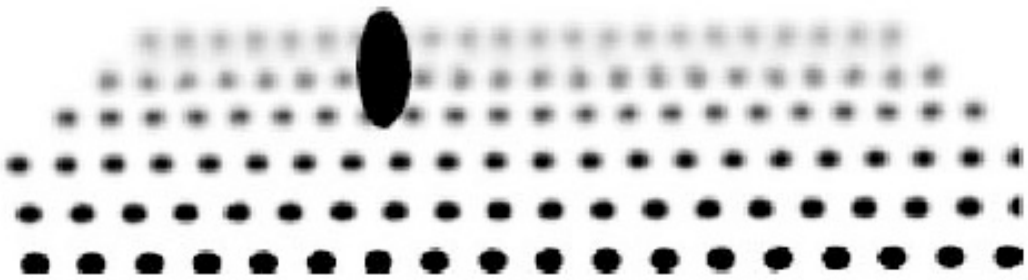
OTHER CUES

DEPTH OF FOCUS

Physical movement to bring images of objects into sharp focus on the fovea

- distant objects out of focus, closer ones in focus

Images: Ware (2004)



AERIAL PERSPECTIVE (Ortega et al., 2016)

Simulates the effect of atmospheric particles absorbing light

Closer objects appear brighter (with higher contrast), sharper and more saturated in colour than objects further away
Can be artificially created using 'atmospheric depth'

Images: Wikimedia Commons

◀ Distant objects appear blurry and more blue

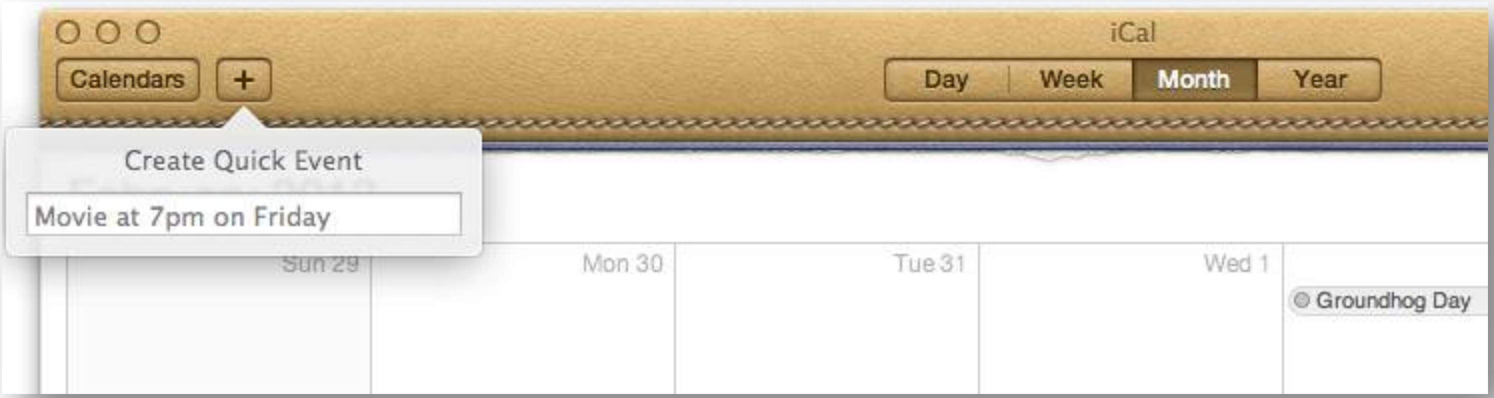
SHADING

Shading can be used to indicate a shape that may have affordances

Can be useful to signify **where** an interaction can occur
e.g., buttons and widgets such as sliders

More information:
http://dspace.mit.edu.ezp.lib.unimelb.edu.au/bitstream/handle/1721.1/6885/AITR-232.pdf?sequence=2

Images: Apple iCal



MOTION PARALLAX

A velocity gradient is applied to objects to represent varying distances

Example: http://vimeo.com/50672419
Example: http://mashable.com/2012/04/28/google-maps-parallax/#ldYYhzEI_mqR

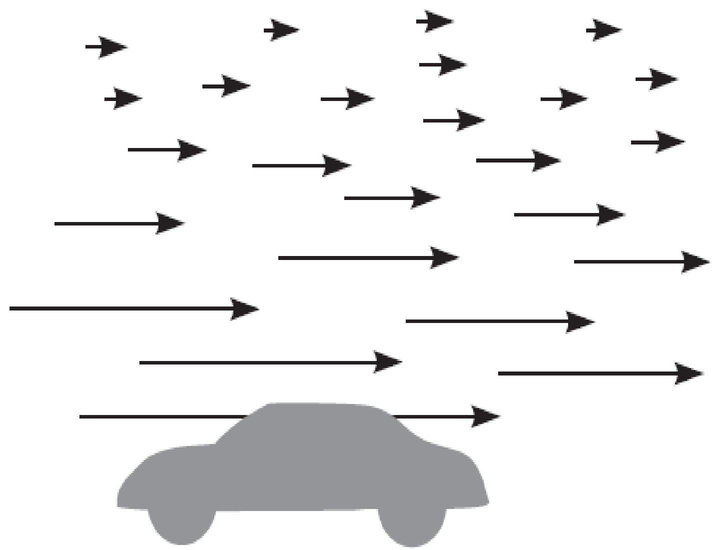
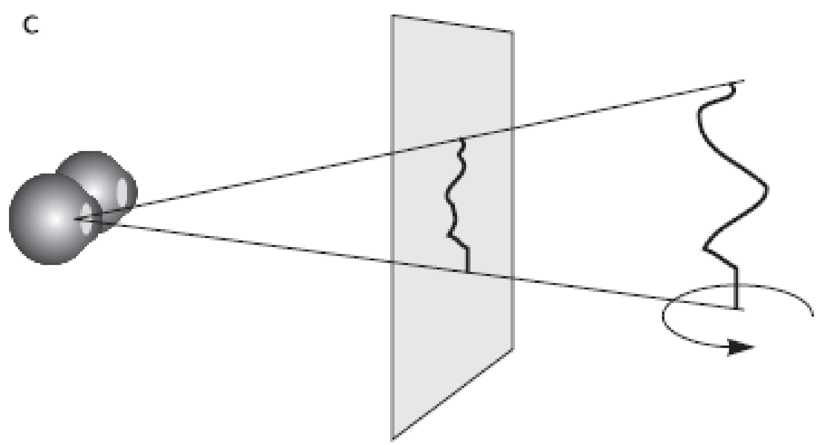


Image: Ware (2004)

MOTION KINETIC

The 3D structural form of an object can be perceived in 2D when the object is moving

Example: A wire is bent into a complex 3D shape and then projected to a 2D plane



Example video: https://www.youtube.com/watch?v=RrX2yTGJ6N0

REPRESENTING THREE-DIMENSIONS

Binocular depth cue

- Stereoscopic depth
- Binocular disparity
- Simulated depth cues

STEREOSCOPIC DEPTH

Created from the fusing of two overlapping images called **stereopsis**

The difference between the two images is called *binocular disparity*

Vergence angle θ (convergence, divergence)

Approximately 10-20% of the population has **stereo blindness**

Binocular rivalry occurs when images can not be fused

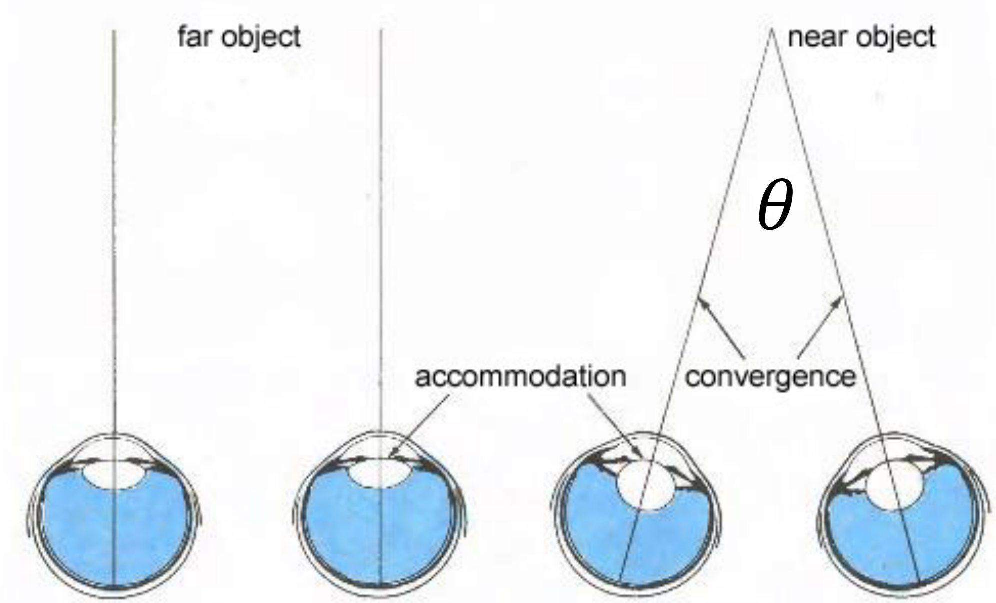
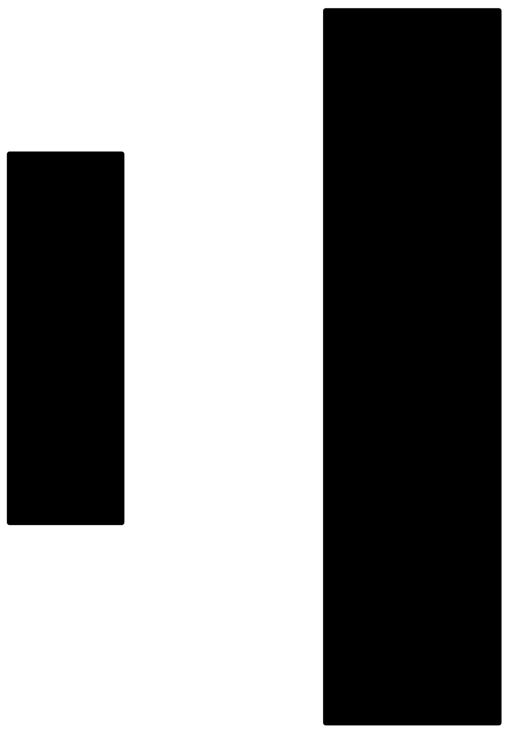


Image: www.forbestvision.com

STEREOSCOPIC DEPTH (disparity)



Real World

A normal process arising from physical depth

Display

MagicEye Or Stereoscopy

Image: Ware (2004)

PROBLEMS CREATING STEREO (Ware, 2004)

Frame cancellation

If an object moves towards the edge of the display, it may become occluded in one image collapsing stereo, creating **binocular rivalry**

Distance variation

The stereoscopic depth cue is most useful for 30 meters or less from the viewer. Beyond this, disparities are too small to be resolved. May be optimal for objects held roughly at arm's length.

Stereo blindness

.Approximately 5-15% of the population

STEREOSCOPIC DEPTH

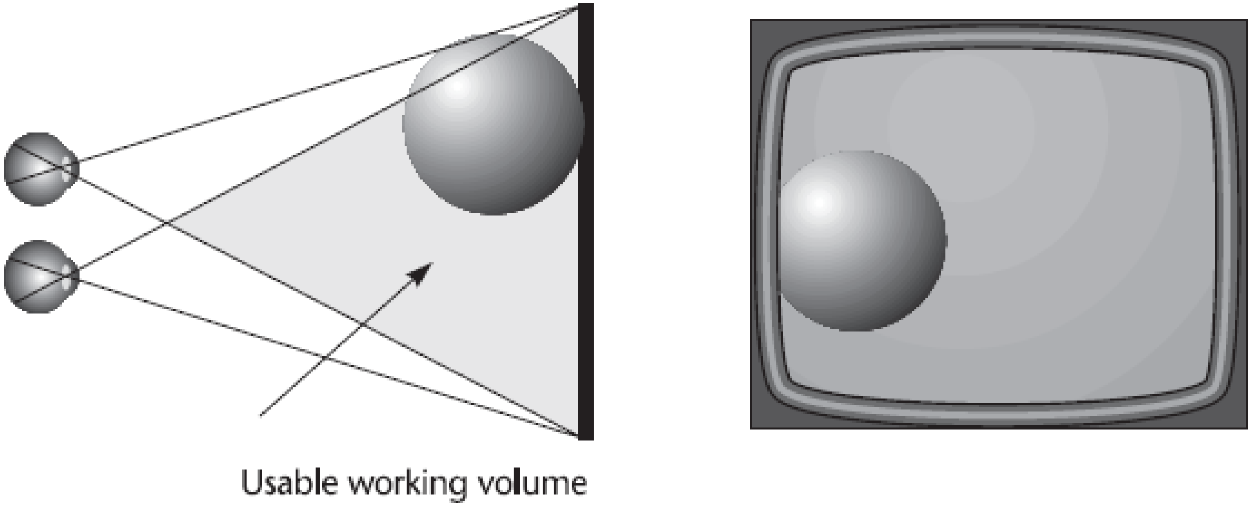
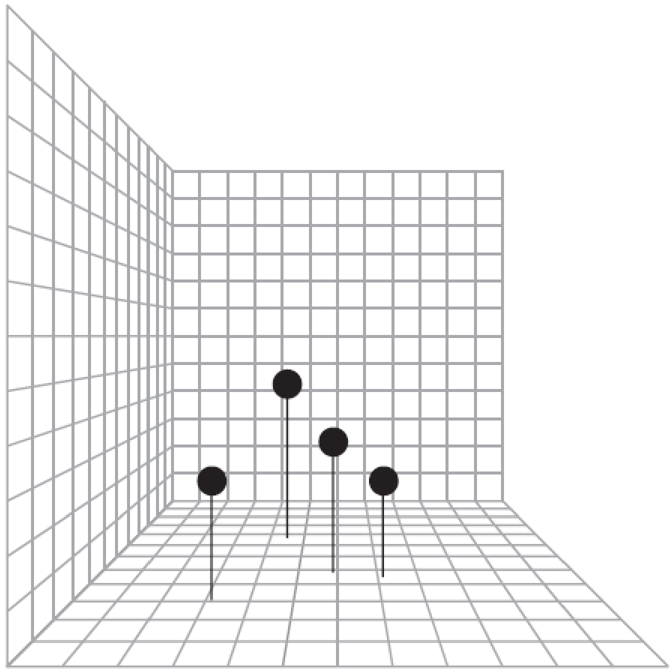


Image: Ware (2004)

ARTIFICIAL CUES (Ware, 2004)

Drop Lines

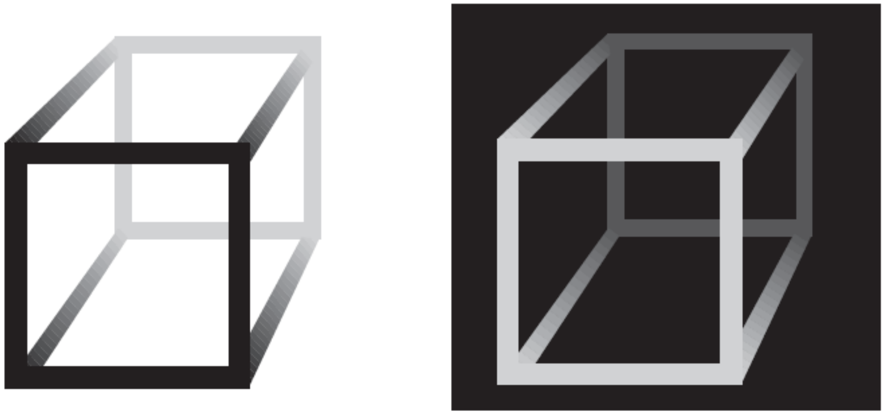
A line is dropped from each data point to the ground plane to assist with depth perception.
Without these lines, only a 2D judgment of spatial layout is possible.
With the lines, it is possible to estimate 3D position.



ARTIFICIAL CUES (Ware, 2004)

Proximity luminance covariance
Change colour of object depending on distance from the viewpoint

Mirrors atmospheric depth



COMBINING CUES (Ware, 2004)

A general theory of space perception should
make it possible to determine which depth cues are likely to be most valuable

Unfortunately, there is no single, widely accepted unifying theory of space perception

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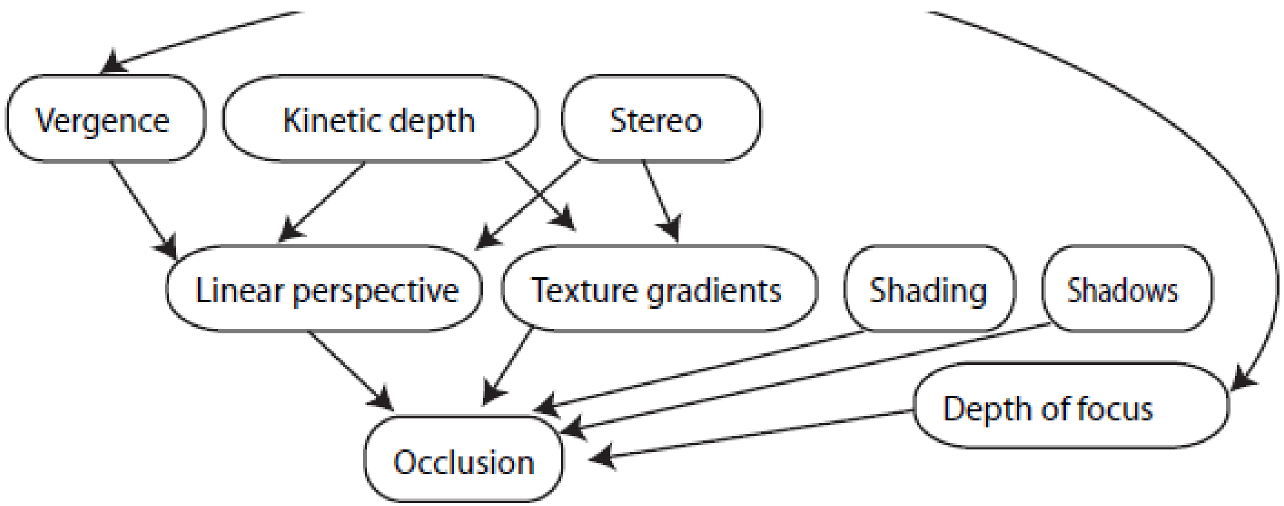


A dependency graph for depth cues. Arrows indicate how depth cues depend on each other for undistorted appearance.

Experimental evidence shows that depth cues (C1 . . . CN) are weighted very differently for different tasks, suggesting that there is no unified cognitive spatial model.

VISUALISING 3D SPATIAL OBJECTS

Scene parameters

- Camera settings
- Lightings and illumination
- Shading and shadows
- Atmospheric and Environmental effects
- …

Considerations

- Position, size, orientation > Not suitable (?)
- Shape variable > Level of detail (LoD)
- Brightness > Good (?)
- Colour, texture > Excellent (?)
- Motion > Further research required

Careful not to change the object's meaning!

What else might be considered?

More reading:
http://icaci.org/files/documents/ICC_proceedings/ICC2015/papers/31/243.html

Virtual Reality (VR)

VR

A fully immersive, interactive experience generated by a computer (Ryan, 2015)

Key components:

1. Immersion
2. Interactivity

Typically three (or four) dimensions, 360° view.

Hardware + Software dependent

VR

1. Immersion
   a. Physical
   b. Psychological (emotional)
   c. Cognitive

Presence

Real time and space ‘fade’ into the background of consciousness

Flow

Intrinsically motivating, energized focus, pleasurable, rewarding

VR

2. Interactivity

Dialogues for control in virtual environments (VE)
e.g., walking or flying

Low visual latency (instantaneous system feedback)

CURRENTLY TWO TYPES OF VR

1. Head in jar

Headseat tracking only

High resolution OLED per eye

Examples: Standard Oculus Rift, Samsung Gear VR

2. Room-scale

Headset + body tracking

Greater interactivity using tracked controllers

More immersive, as you can wander around in an area

Example: HTC Vive

CYBERSICKNESS

- Nausea
- Oculomotor problems
- Disorientation

Focus for designers:

1. *Accommodation-vergence conflict (e.g., eye strain)*
2. *Perception-proprioception issues (e.g., fast VE)*

"In natural vision, binocular disparity and focus cues provide comparable signals about object distance… These two cues are involved in depth and distance perception.

In stereoscopic displays, focus cues are, however, inconsistent with the displayed pattern of disparity because they signal a flat object"

VR

Perception-proprioception issues

"During almost all natural forms of self-motion, there are several sensory systems that provide redundant information about the extent, speed, and direction of egocentric movement, the most important of which include dynamic visual information

self-motion perception is critical

https://www.ncbi.nlm.nih.gov/books/NBK92853/

CONSUMER EXAMPLES

Envelope VR
(infinite monitors)

Occulus

https://developer3.oculus.com/documentation/intro-vr/latest/concepts/bp_app_imaging/

VIRTUAL ENVIRONMENTS (VE)

Classic CAVEs are virtual-reality rooms with stereoscopic 3D computer graphics rear-projected onto the walls and down-projected onto the floor

CAVE2
https://www.evl.uic.edu/entry.php?id=2016

37 Megapixels in 3D or 74 Megapixels in 2D with a horizontal visual acuity of 20/20

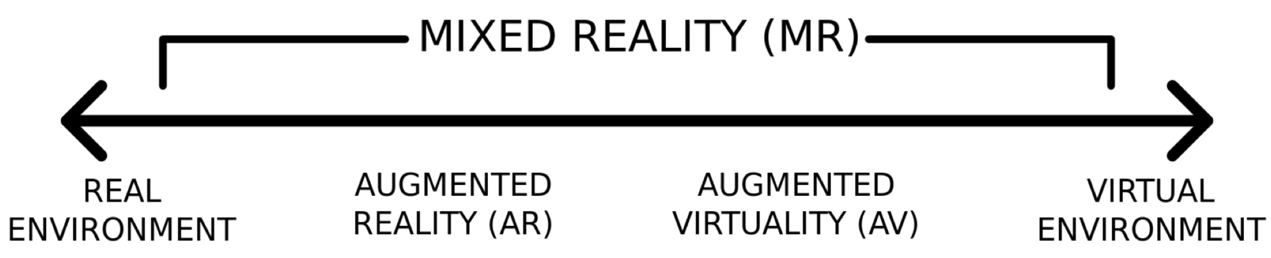
Exploring big data sets. Interaction is key.

CAVE2

MR/AR

Merge real + virtual worlds (not fully immersive)

Augmented reality: Virtual objects *float* in the real world
Mixed reality: Virtual objects are *spatially accurate* in the real world



MICROSOFT HOLOLENS

Self-contained holographic computer

Electronic input:
IMU, cameras, microphones, light sensors

Spatial mapping
Virtual objects interact with the real world

Human input: Gaze, gestures, voice/sounds

Example: https://www.youtube.com/watch?v=BMW2Pe6j6Bk

OTHER LINKS

Rashid and Couture (1998) Virtual NYSE

http://wwwandia.tripod.com/art/100.html

MR data visualisation (2014)

http://www.euronews.com/2014/02/10/beyond-the-Subconscious

Hololens geovisualisation example (2016)

https://www.youtube.com/watch?v=J7M-klKHLys

Hololens mars + 3D video (2016)

(play from 7 minutes)
https://www.youtube.com/watch?v=kjAHwLaLjUw