Virtual Reality

NBAY 6120
April 4, 2016
Donald P. Greenberg
Lecture 9

Virtual Reality

- A term used to describe a digitally-generated environment which can simulate the perception of PRESENCE.
- Note that within the context of this course, I refer to VR as containing 3D data as contrasted to just creating a digital copy of information obtained from a film or digital camera.

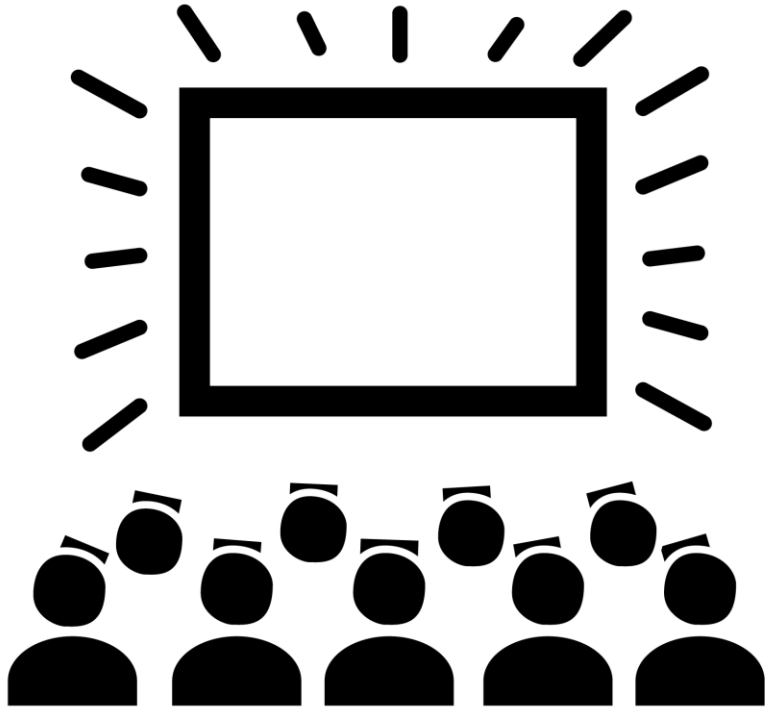
Virtual Reality

- A person immersed within this virtual world can manipulate objects, interact with the environment, and explore the virtual world in the same perceptual way as one interacts with the physical world.

Why is VR different than other modes of watching images and video?

Human in the Loop

- Abstract Interpretation
- Viewing a Picture on Television
- Cinema Viewing
- Presence



Current and Recent Business Investments

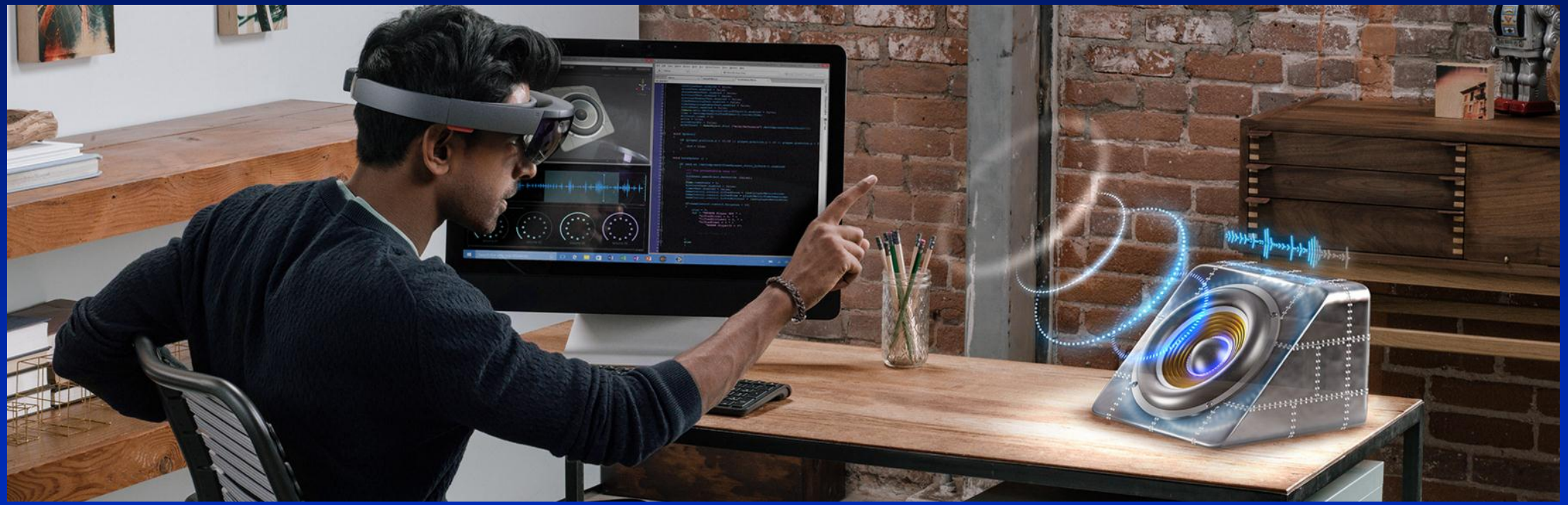
Facebook Buys Oculus Rift

Why did Facebook invest $2 billion in Oculus Rift?

Microsoft's Minecraft

Microsoft's Hololens

Microsoft's Hololens 3/30/16



Why did Microsoft buy Minecraft?

Why is Microsoft building its Hololens?

Magic Leap 2015

Google

Why is Google (and Andressen / Horwitz) investing $500+ million in Magic Leap?

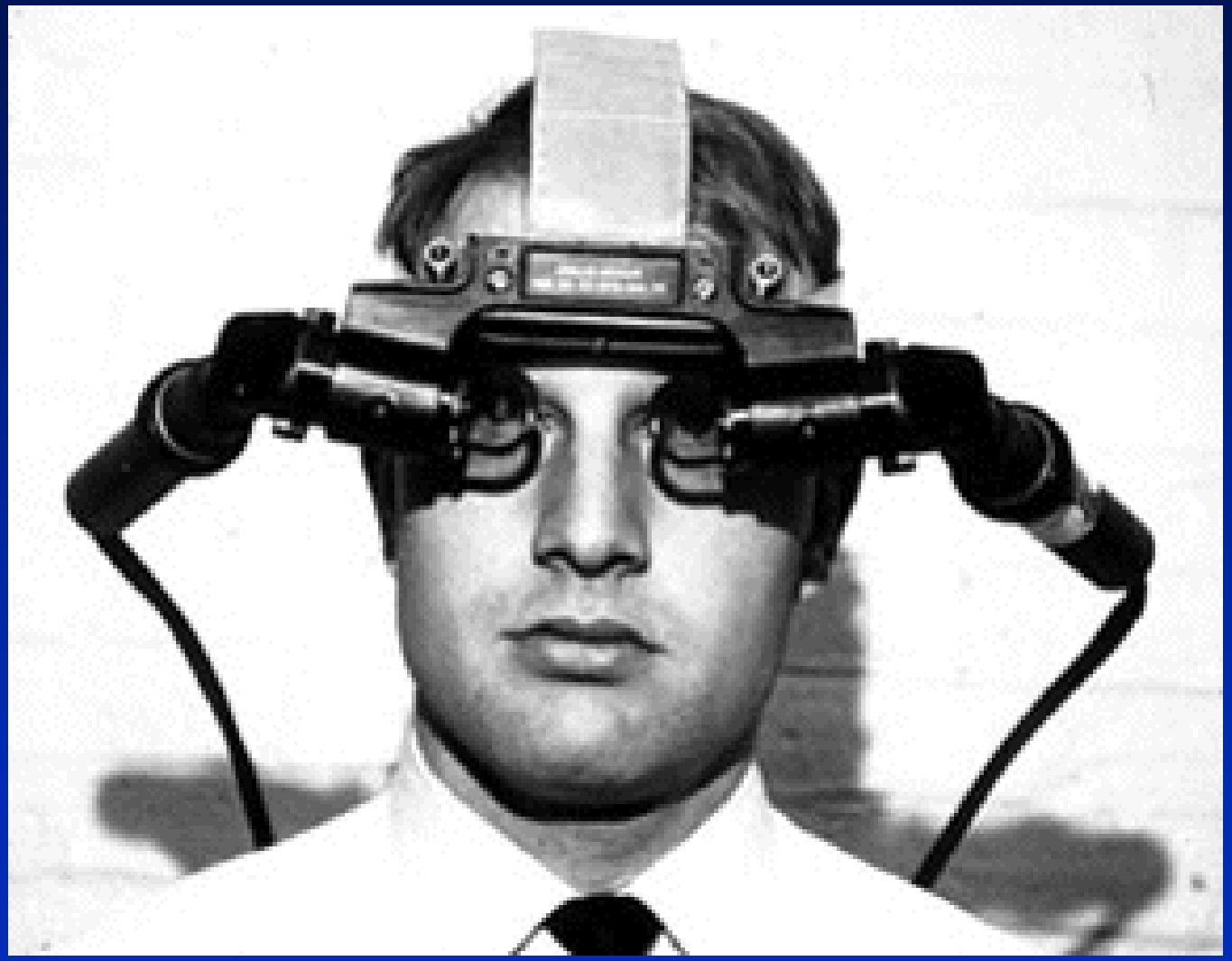
Virtual Reality

- What is necessary to make virtual reality a reality?

Virtual Reality

- Virtual Reality is not new
- The amount of financing which has been made available
- Costs have been sufficiently lowered to bring to the masses

Ivan Sutherland's HMD 1968



Head-mounted Displays 1990s

Henry Fuchs,
University of
North Carolina

Oculus Rift 2016

Not Yet Available

HTC and Valve's SteamVR Vive 2016

Available Tomorrow

HTC and Valve's Tower and Hands

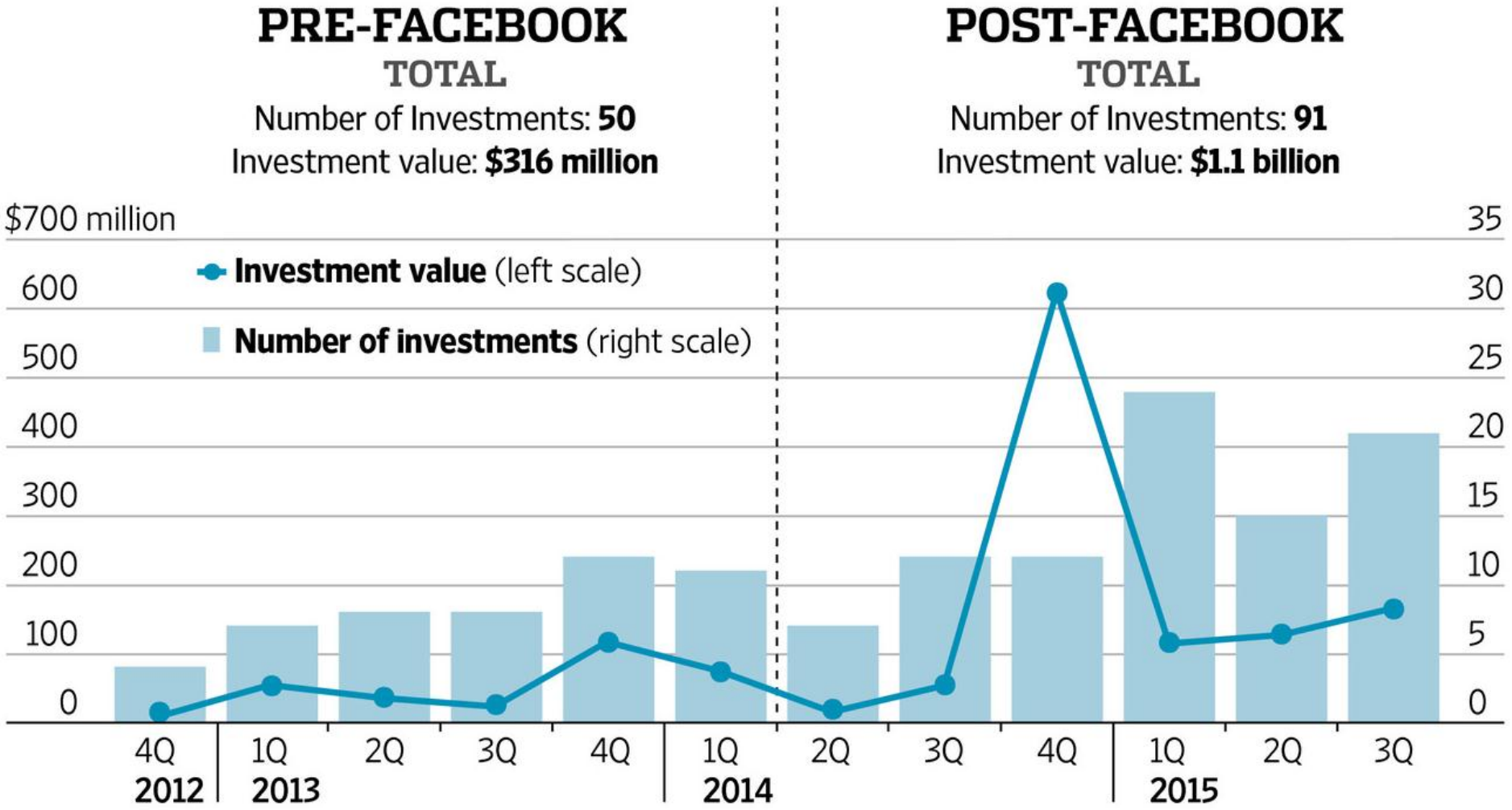
Minecraft and Netflix for VR 9/24/15

John Carmack announces deal for bringing both Minecraft (MSFT) and Netflix to both Gear VR and Oculus VR.

Minecraft was bought by MSFT for $2.5B, and Netflix is responsible for 37% of internet traffic.

Betting on New Worlds

Venture funding for virtual reality and augmented reality (before and after Facebook's purchase of Oculus)



Source: CB Insights

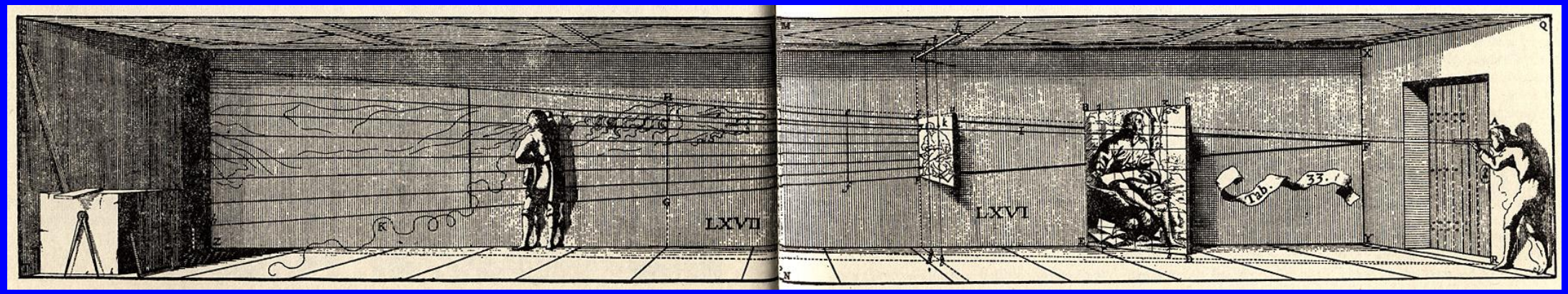
THE WALL STREET JOURNAL.

Google’s Cardboard

Samsung's Cell Phones

- How Do Virtual Reality Goggles Work Today?

Distorted Images



Jean-Francois Niceron. *Thaumaturgus opticus*…(Rome, 1646), illus. 25.

The projection of a screen or grid in anamorphic perspective makes the transfer of a representation possible.

Fred Leeman. “Hidden Images,” 1975, Verlag M. DuMont Schauberg,

Erhard Schon. Picture puzzle: Out, You Old Fool c. 1535. Fred Leeman. Hidden Images, 1975, Harry N. Abrams.

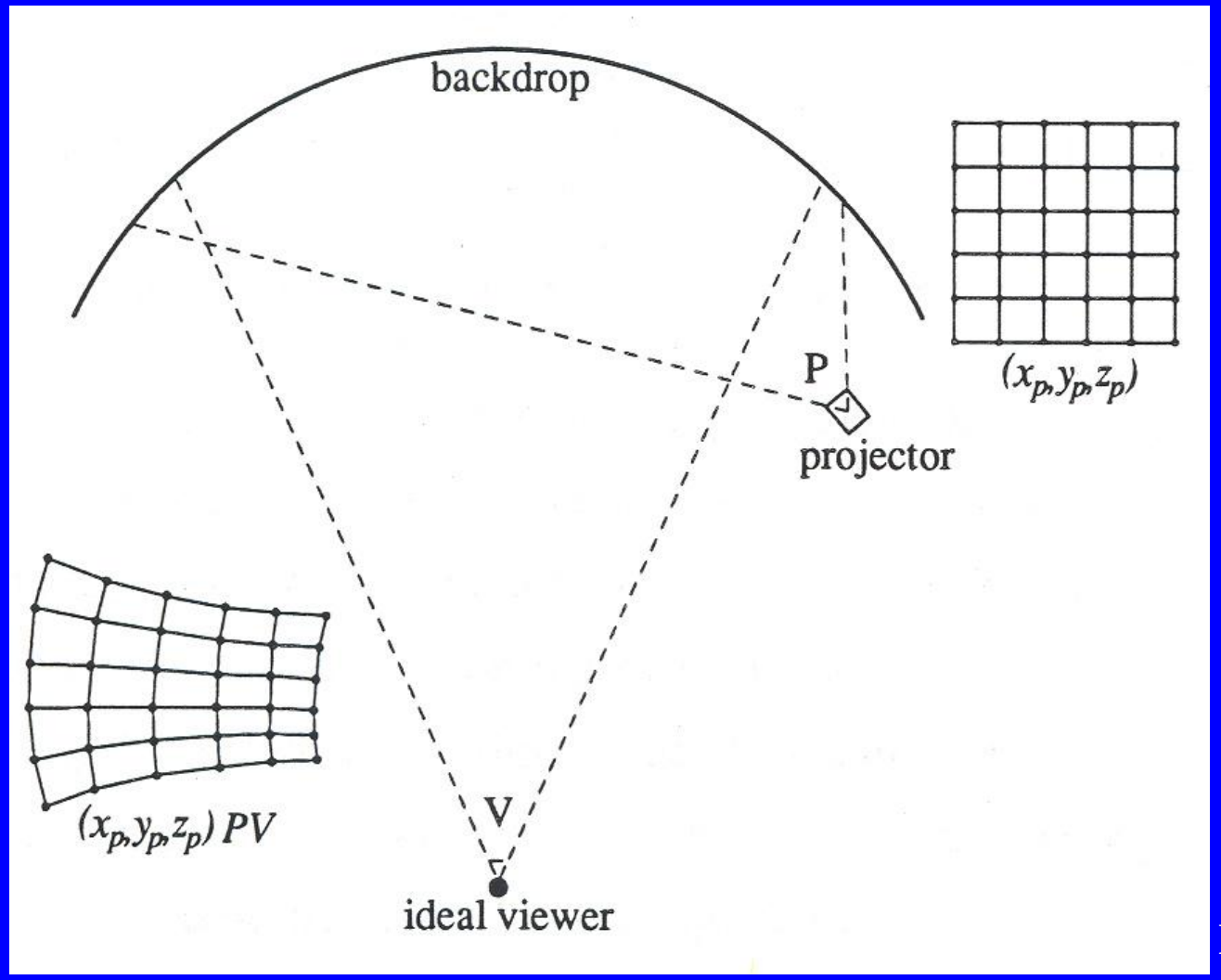
Fred Leeman. “Hidden Images,” 1975, Verlag M. DuMont Schauberg,

Hans Holbein

The Ambassadors

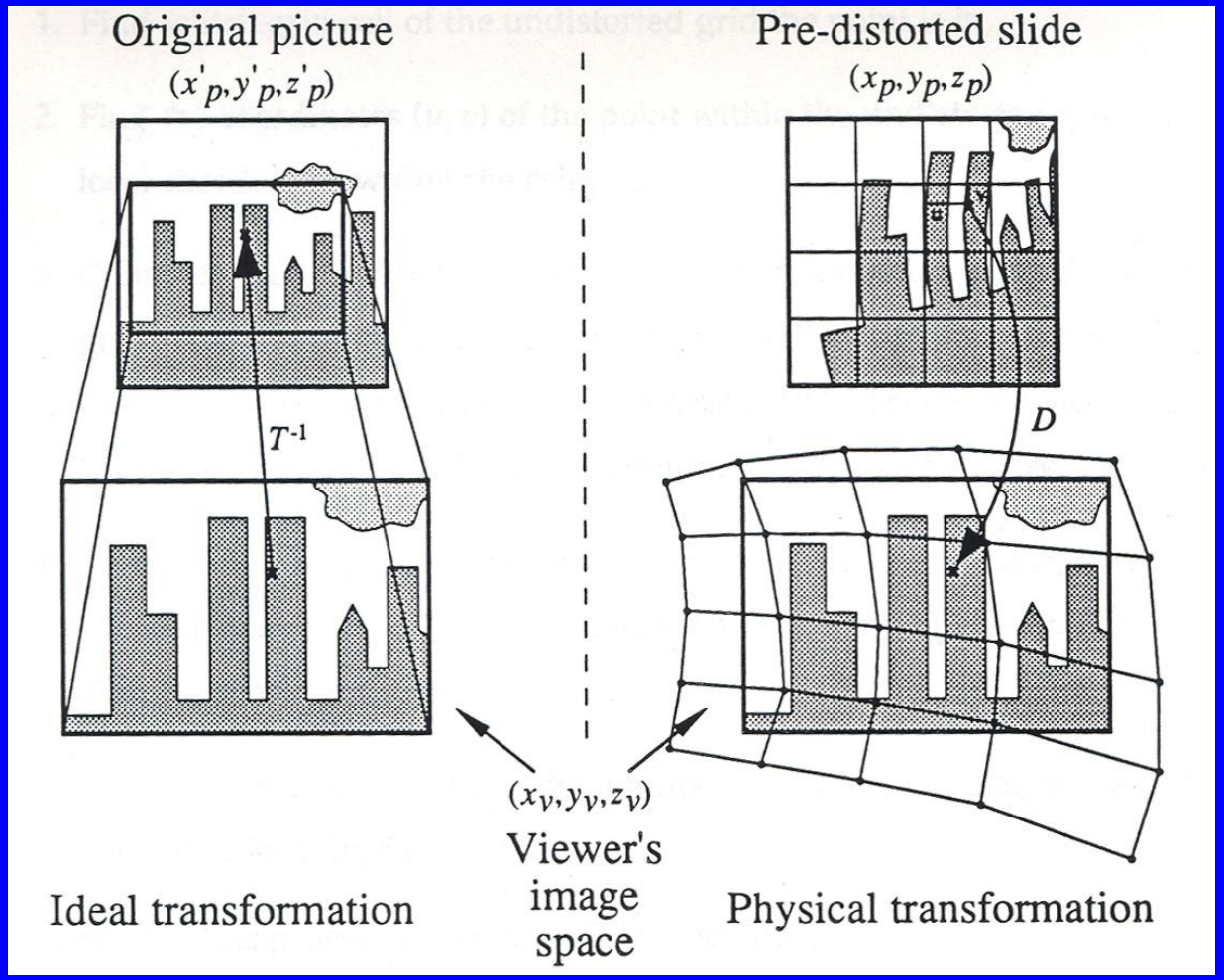
Google Art Project: http://www.googleartproject.com/museums/nationalgallery/the-ambassadors

Opera Lighting Siggraph 1991



Dorsey, Sillion and Greenberg

Opera Lighting Siggraph 1991



Dorsey, Sillion and Greenberg

Opera Lighting Siggraph 1991

Dorsey, Sillion and Greenberg

Opera Lighting Siggraph 1991

Dorsey, Sillion and Greenberg

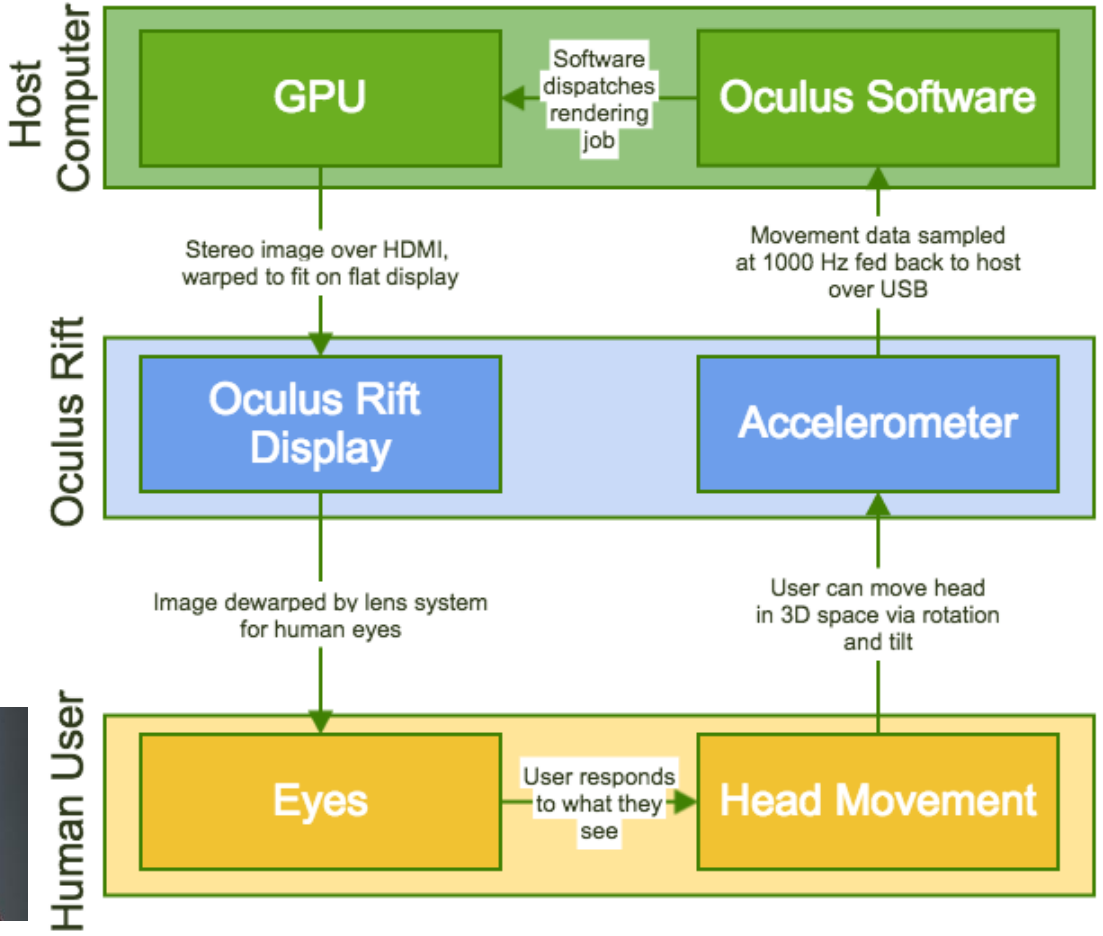
Truck Art

http://www.wltc.org/Documents/TruckArt.htm

Julian Beever - **Chalk Drawings**

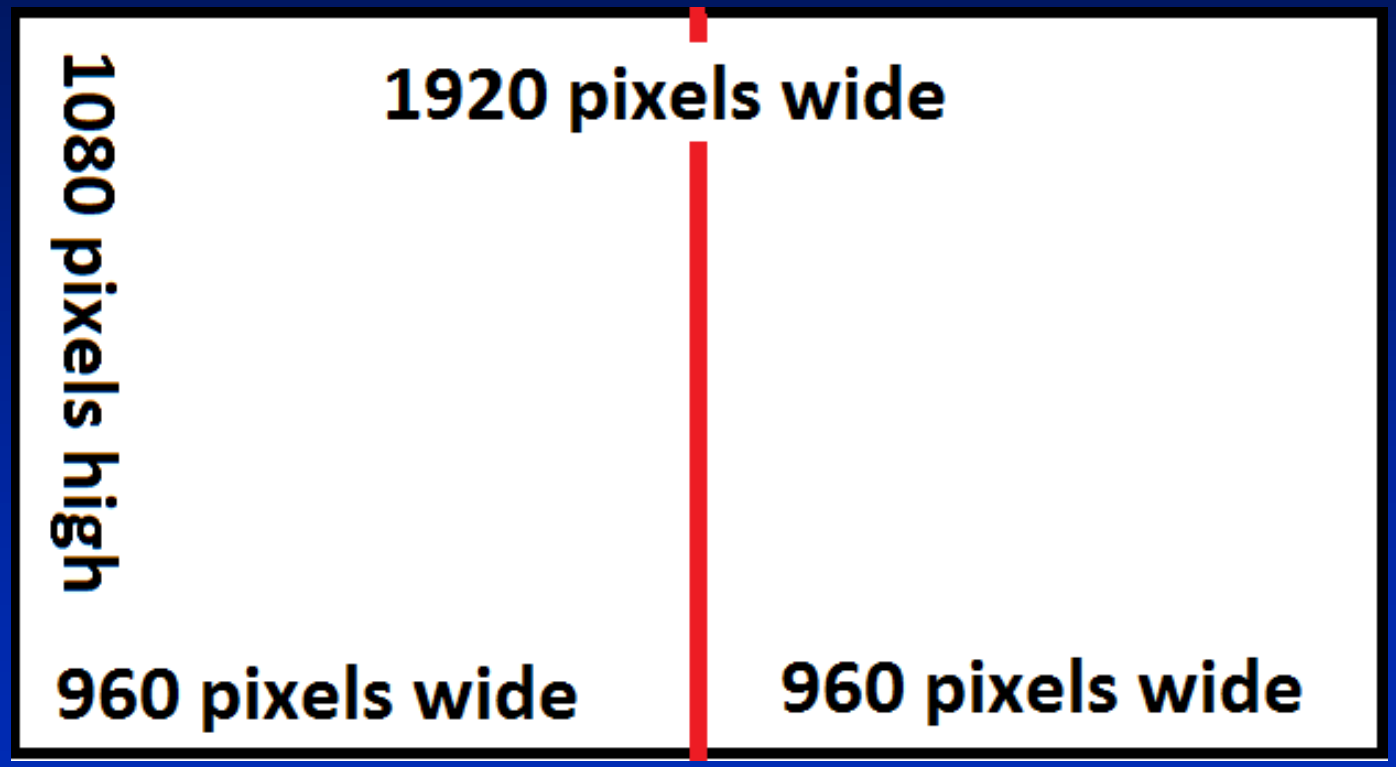
How the Oculus Rift DK2 Works 2014

Oculus Rift DK2

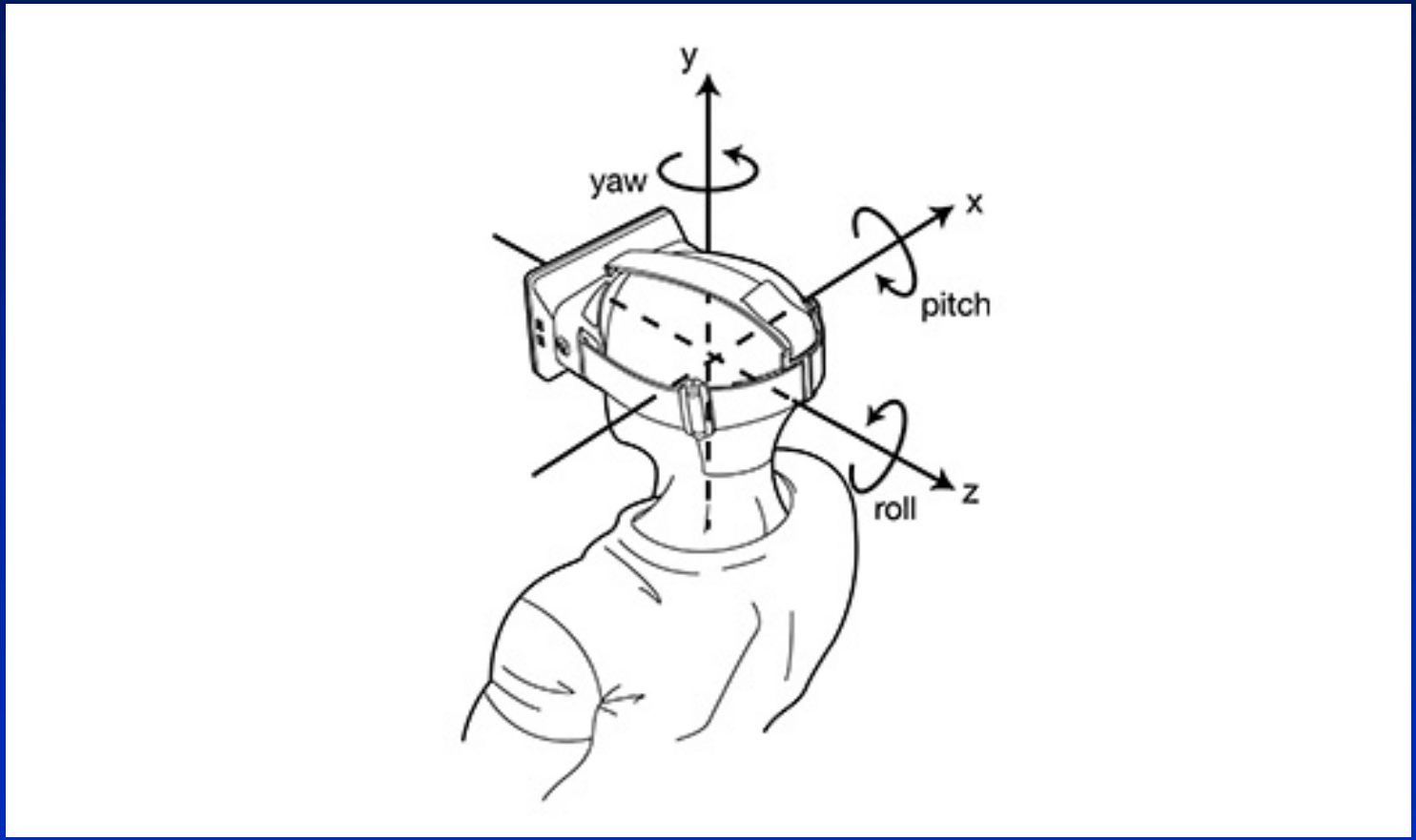


Oculus Rift DK2 Components

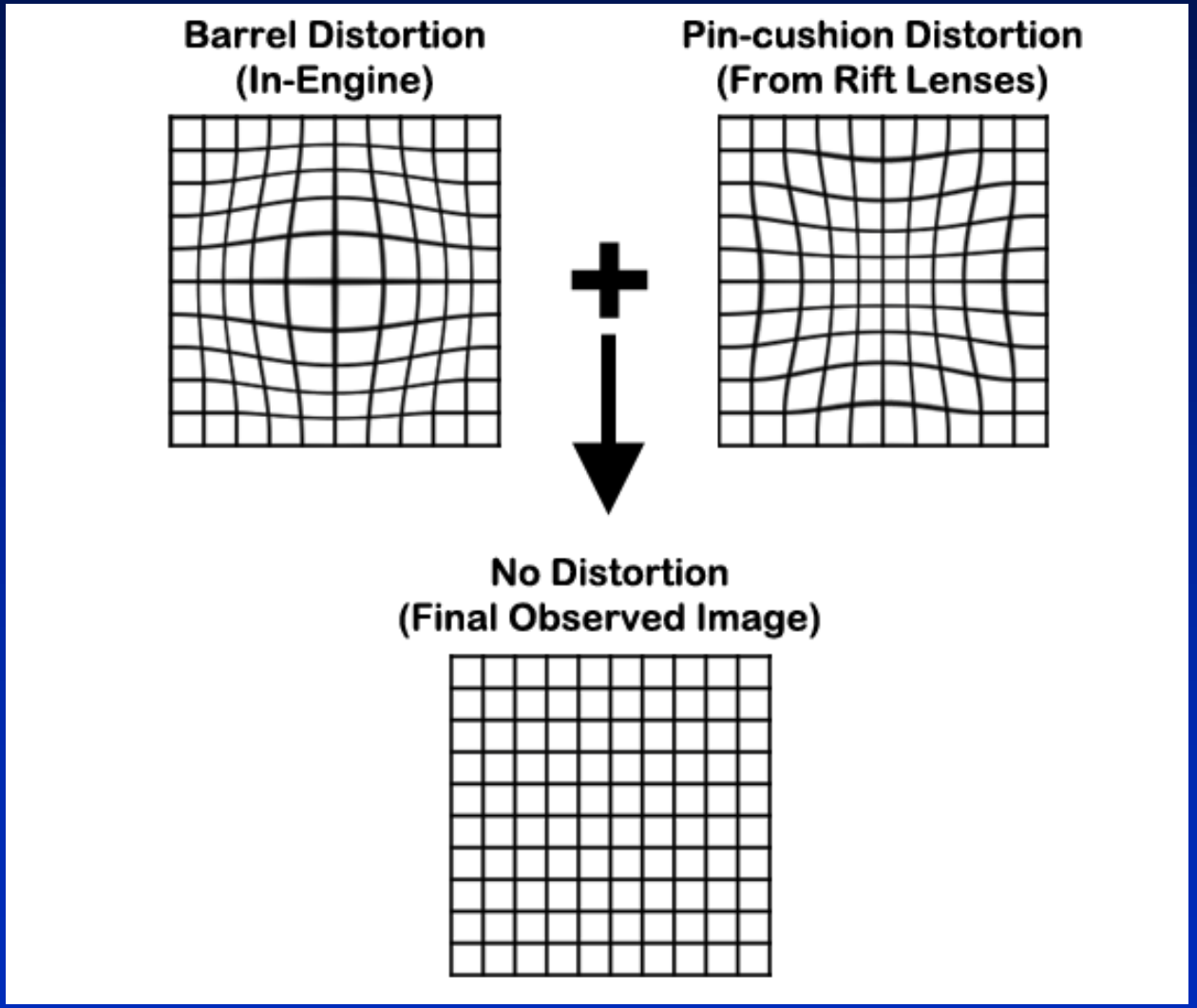
Oculus Rift DK2



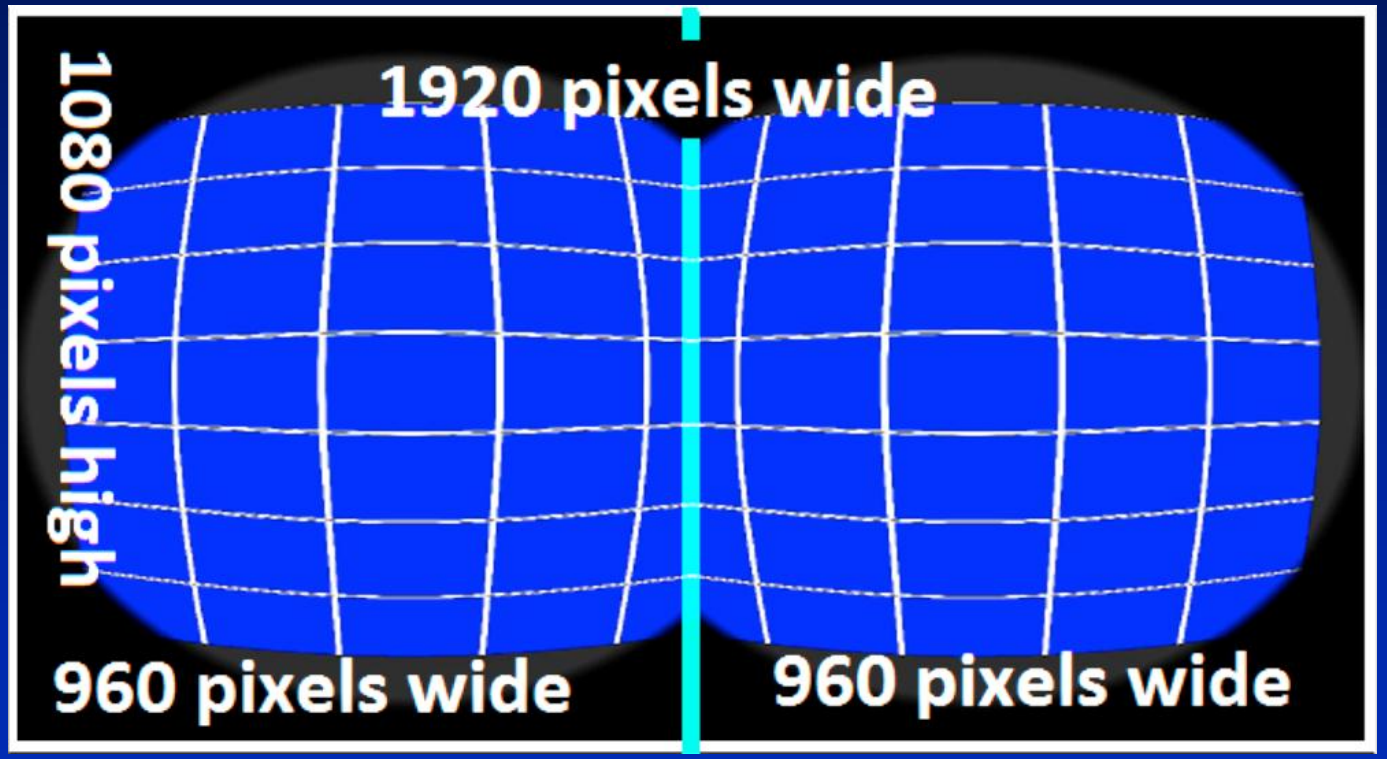
Oculus Rift DK2 Angular Rotation



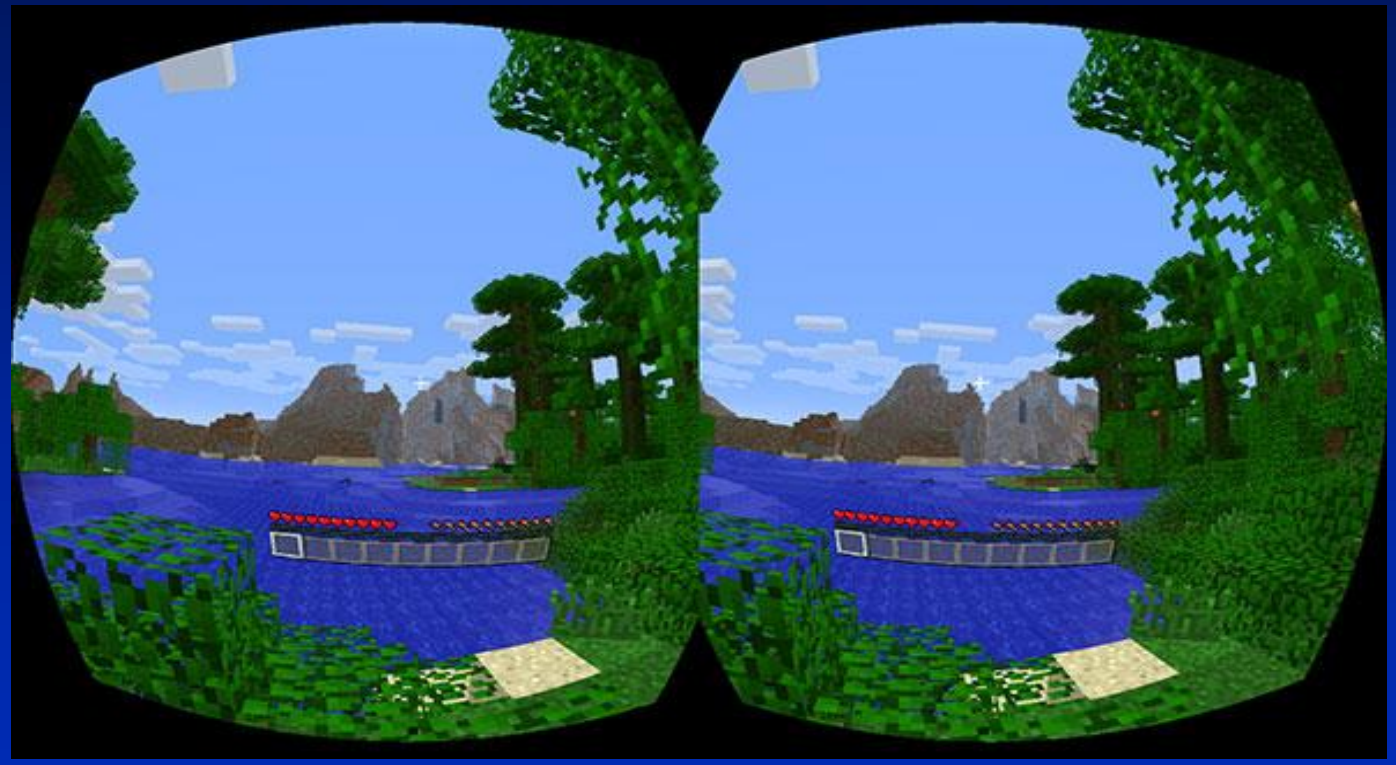
Oculus Rift DK2 Distortion Strategy



Oculus Rift DK2 Distorted Image



Oculus Rift DK2 Distorted Image



Requirements for “PRESENCE”

Need to be able to see (understand) correct DEPTH information

Need to have significant RESOLUTION to merge virtual and real imagery

Need to render images that are physically accurate and perceptually indistinguishable from real world scenes

and

all of this must be done fast enough to imply motion

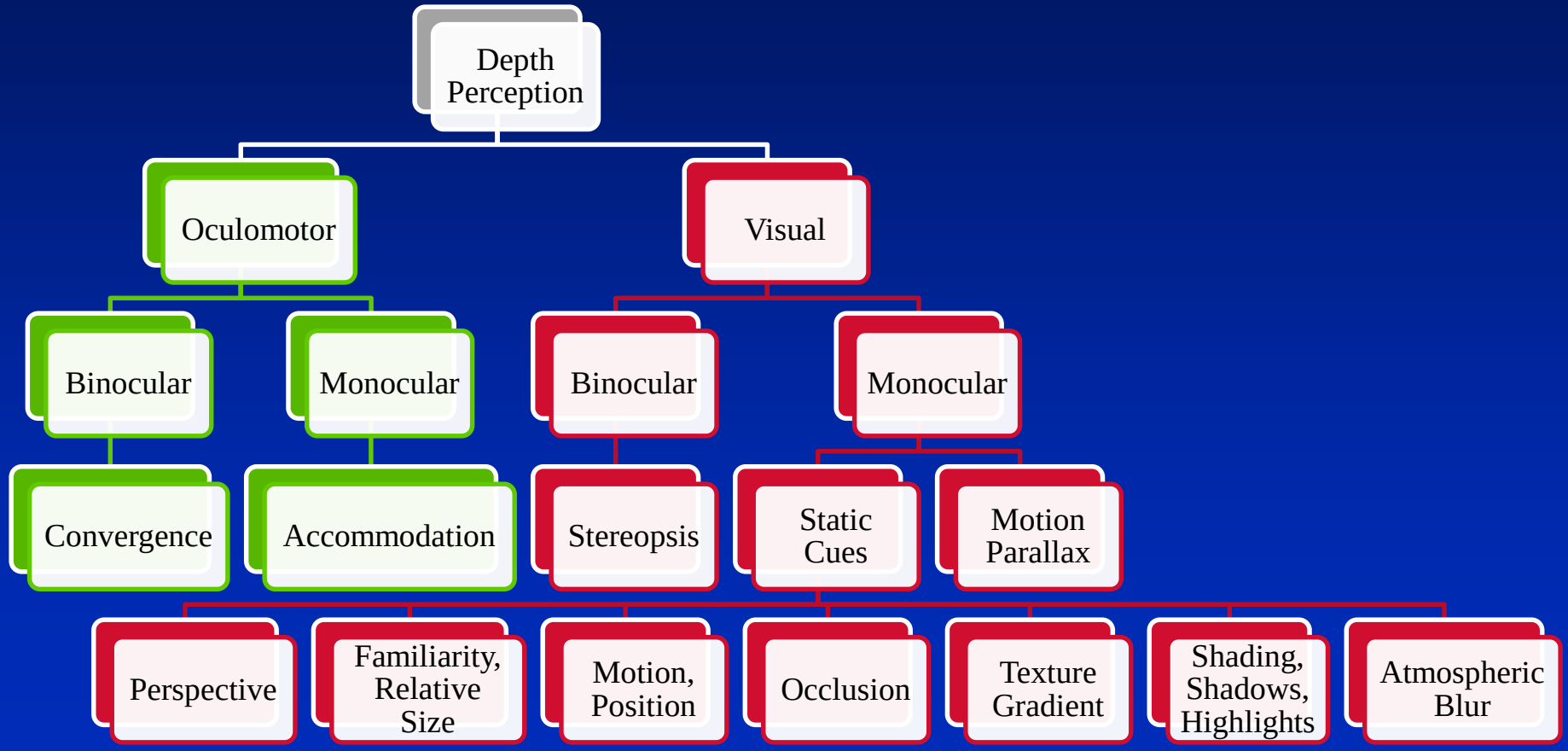
Depth Perception from 2-D Images

Monoscopic

Stereoscopic

Paris Street, Rainy Day 1877
Caillebotte

Human Depth Perception



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative Size,
Position, Familiarity

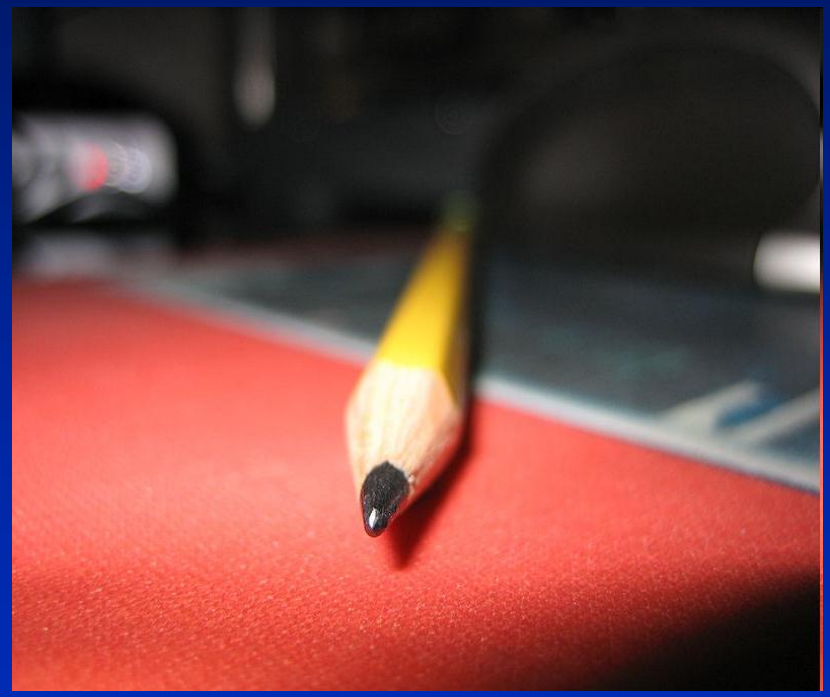
Occlusion

Texture Gradient

Parallax from Motion

Shadows and Specular Highlights

Atmospheric Blur



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative
    Size, Position, Familiarity

Occlusion

Texture Gradient

Parallax from Motion

Shadows and Specular Highlights

Atmospheric Blur

Monoscopic Depth Cues

Perspective

Depth from Motion, Relative

Size, Position, Familiarity

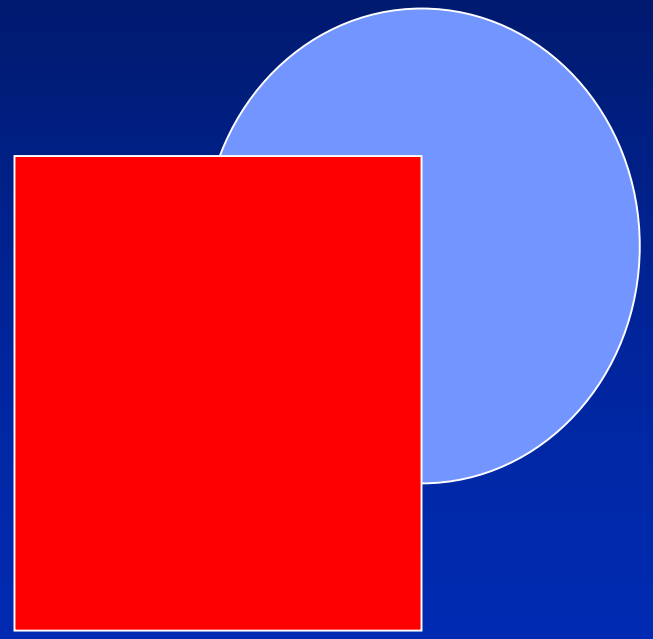
Occlusion

Texture Gradient

Parallax from Motion

Shadows and Specular Highlights

Atmospheric Blur



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative

Size, Position, Familiarity

Occlusion

Texture Gradient

Parallax from Motion

Shadows and Specular Highlights

Atmospheric Blur

Monoscopic Depth Cues

Perspective

Depth from Motion, Relative Size, Position, Familiarity

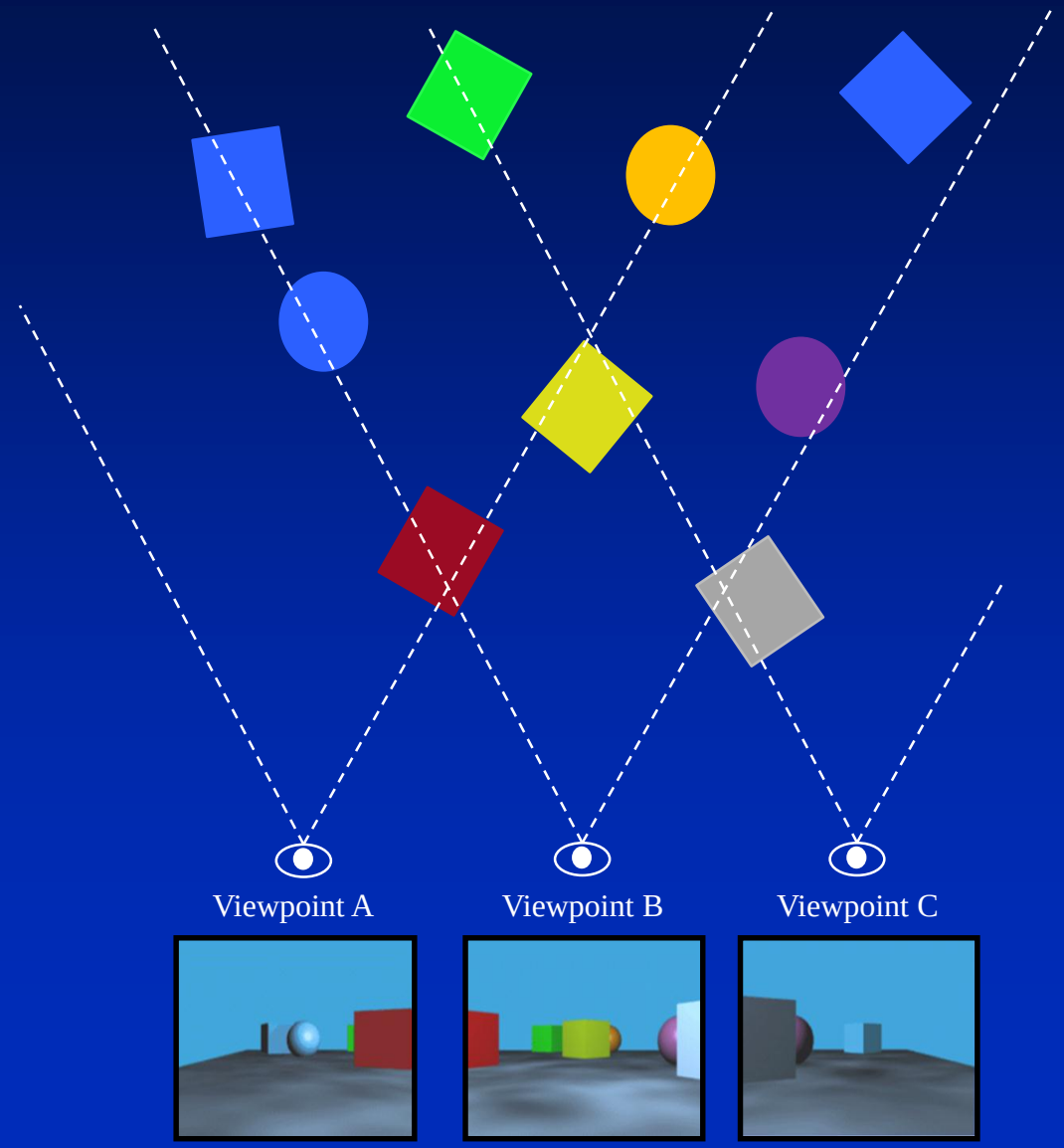
Occlusion

Texture Gradient

Parallax from Motion

Shading, Shadows, and Specular Highlights

Atmospheric Blur



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative Size, Position, Familiarity

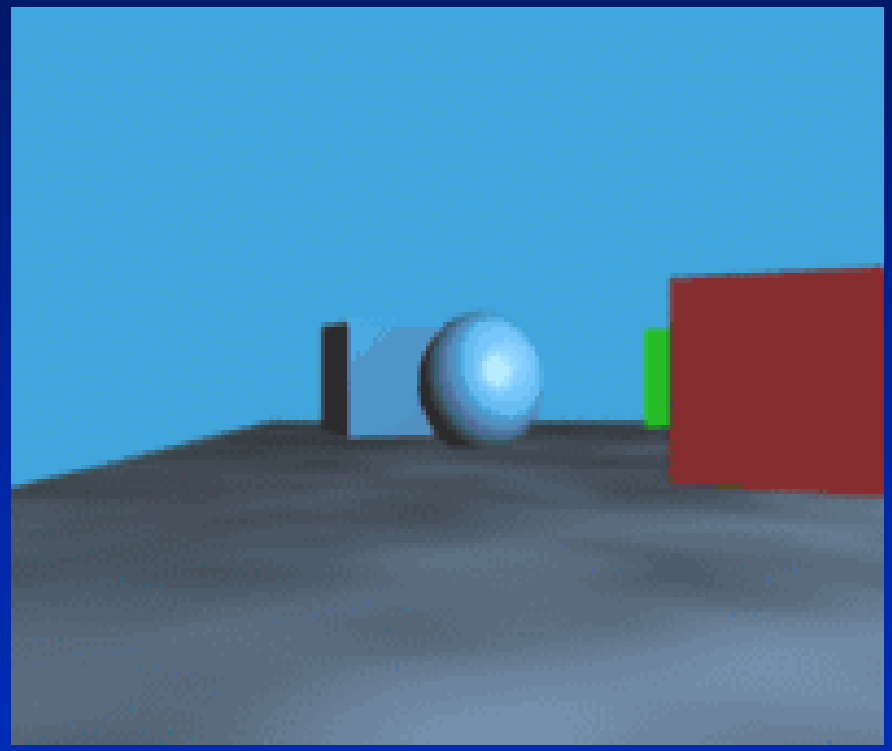
Occlusion

Texture Gradient

Parallax from Motion

Shading, Shadows, and Specular Highlights

Atmospheric Blur



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative Size, Position, Familiarity

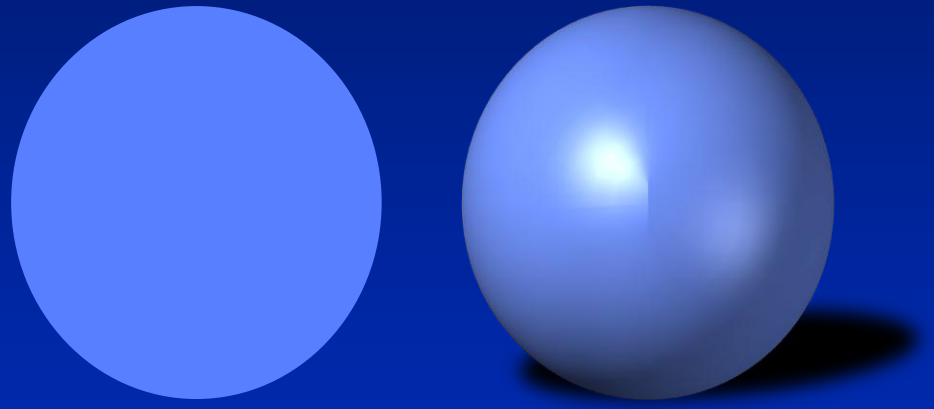
Occlusion

Texture Gradient

Parallax from Motion

Shading, Shadows, and Specular Highlights

Atmospheric Blur



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative

Size, Position, Familiarity

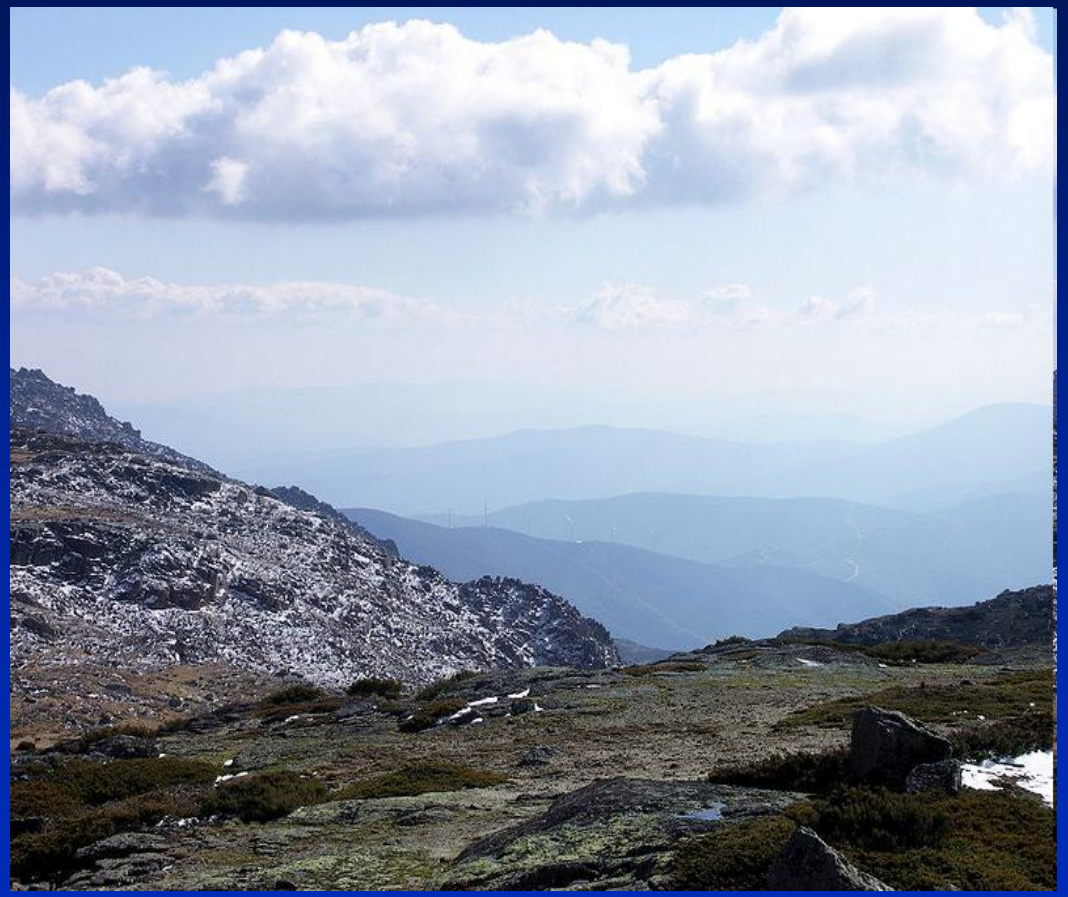
Occlusion

Texture Gradient

Parallax from Motion

Shadows and Specular Highlights

Atmospheric Blur



Monoscopic Depth Cues

Perspective

Depth from Motion, Relative
Size, Position, Familiarity

Occlusion

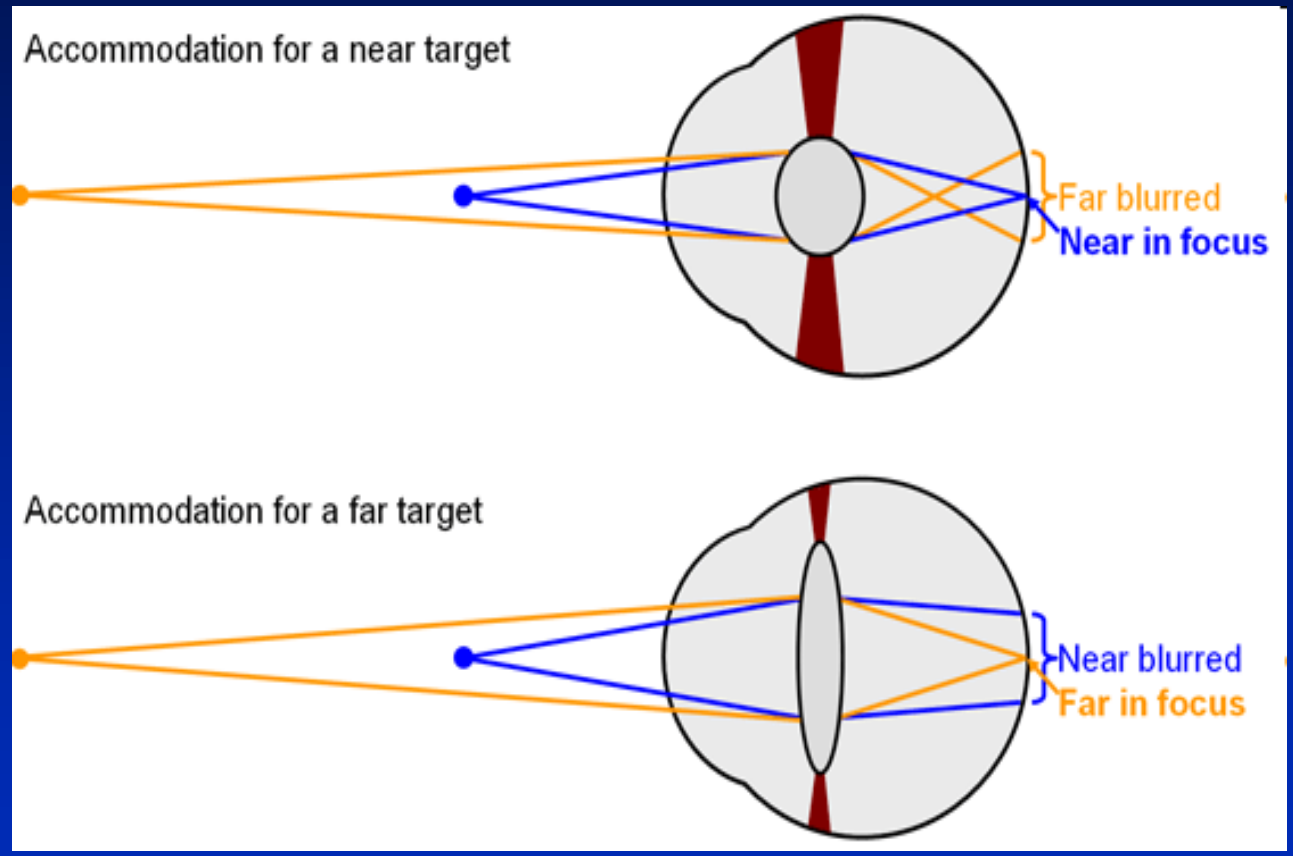
Texture Gradient

Parallax from Motion

Shadows and Specular Highlights

Atmospheric Blur

Accommodation

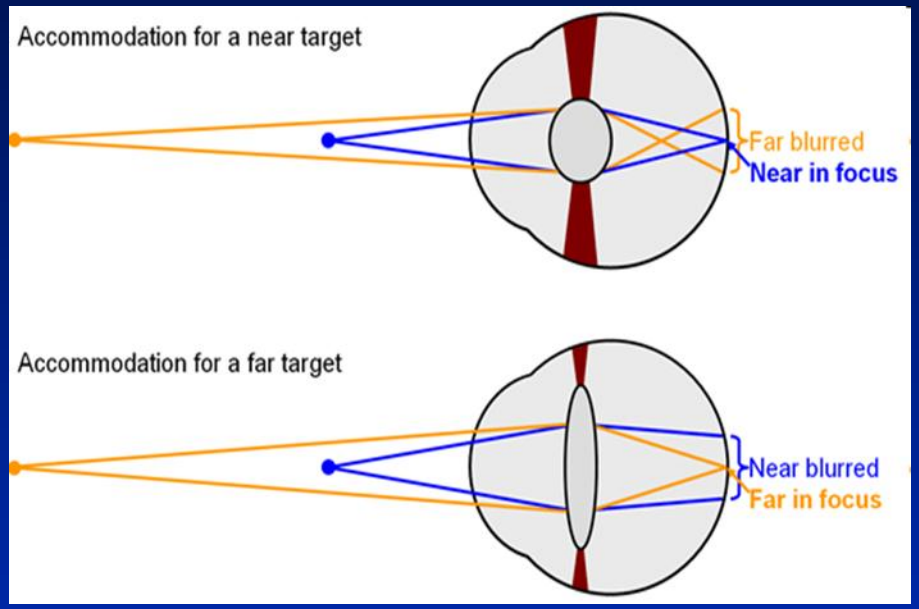


Note change in lens shape

Accommodation

This is the process by which the vertebrate eye changes optical power to maintain a clear image or focus on an object as its distance varies.

Accommodation

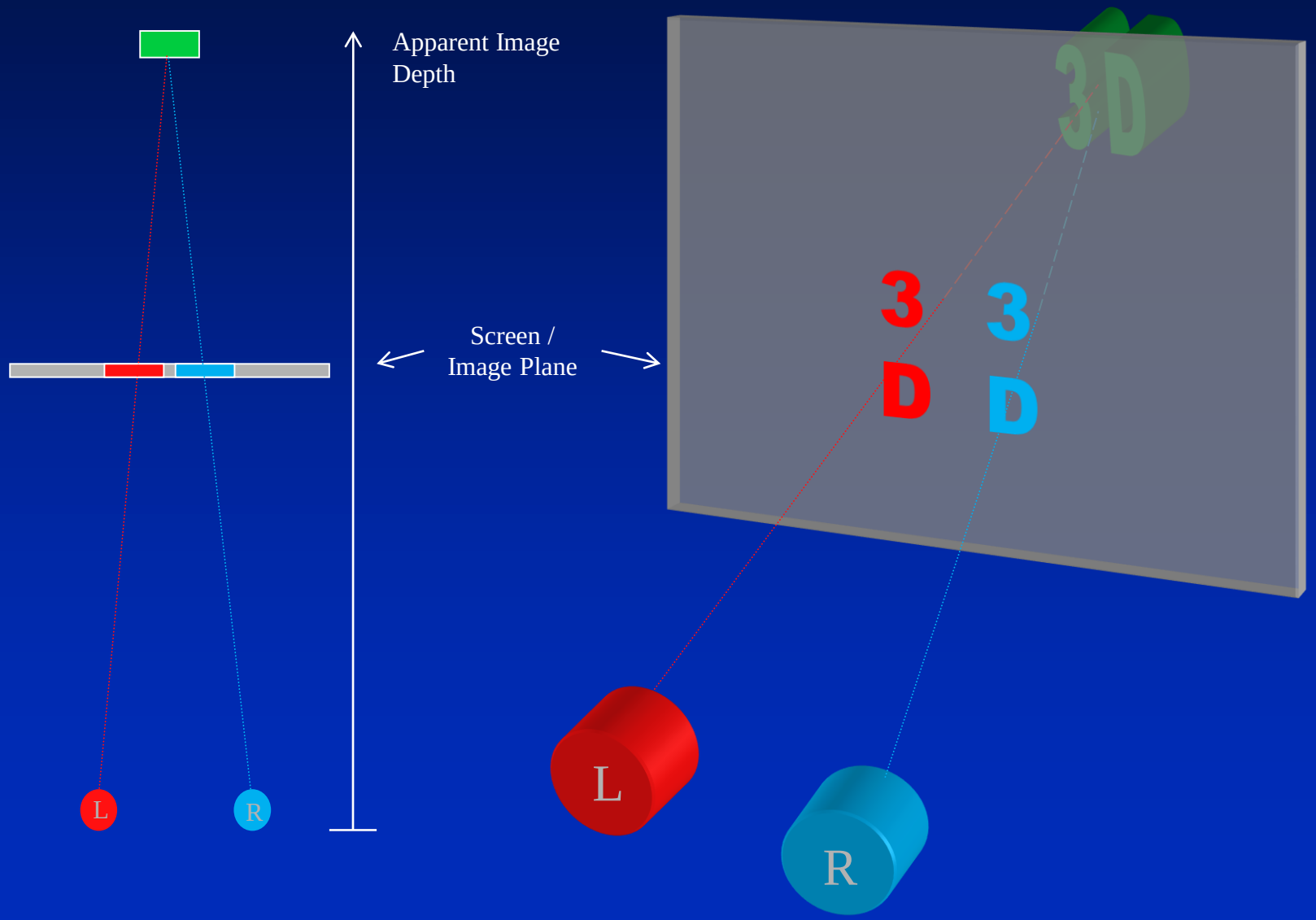


The reflex can be controlled but cannot be ‘felt’

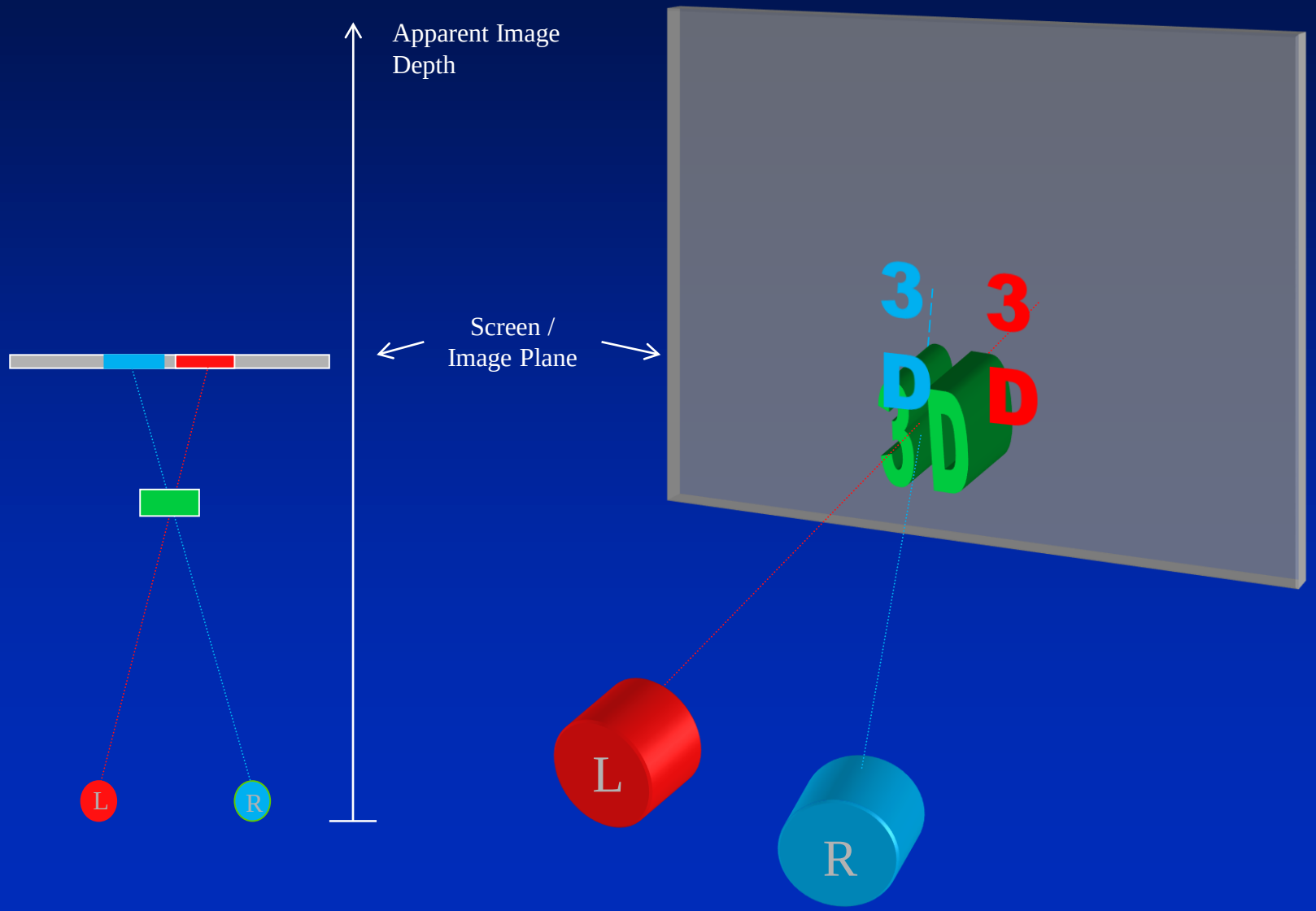
Accommodation amplitude declines with age

c
b
a

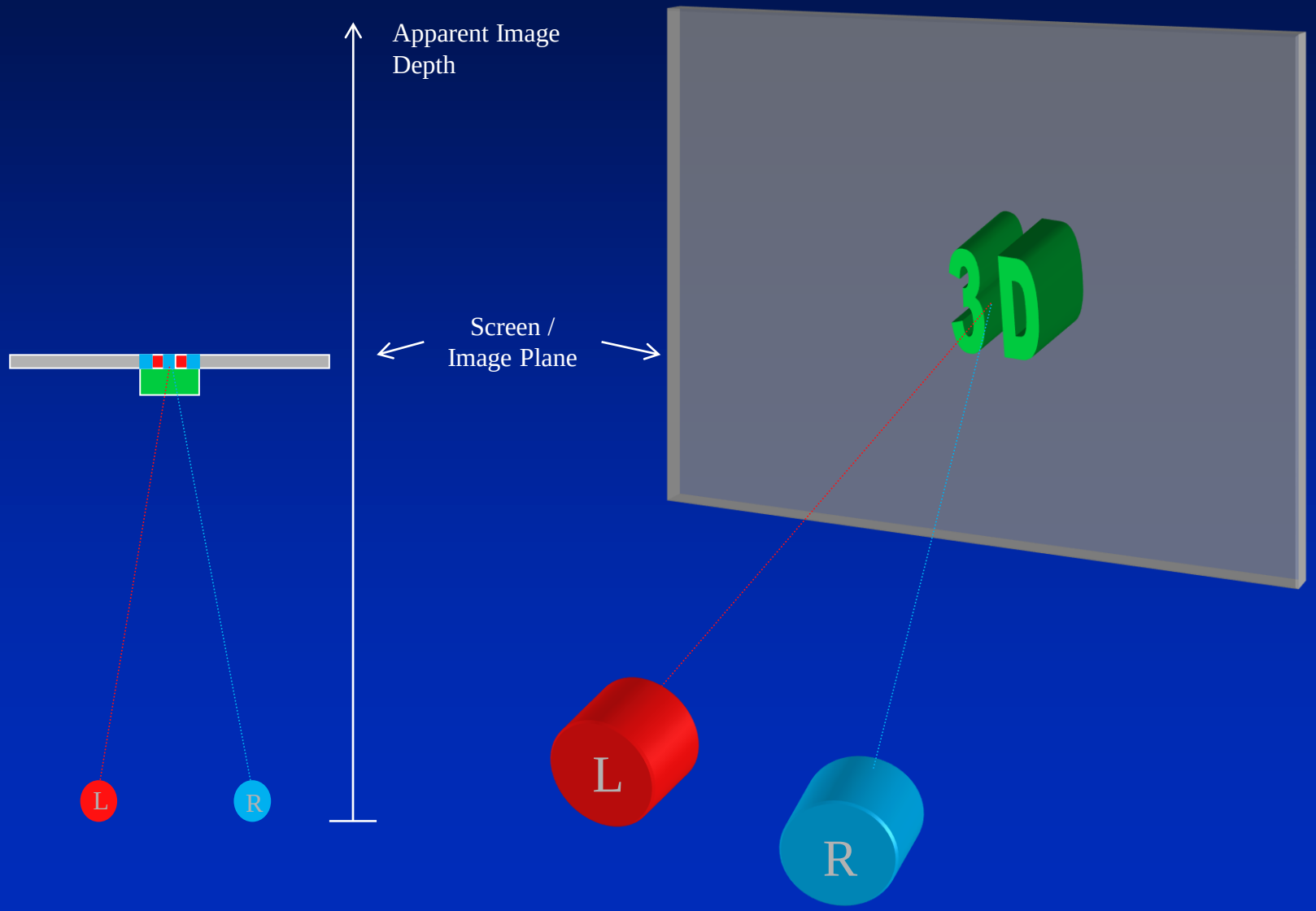
Stereoscopic Vision: Behind The Screen (Concave)



Stereoscopic Vision: In Front Of The Screen (Convex)



Stereoscopic Vision: At The Screen

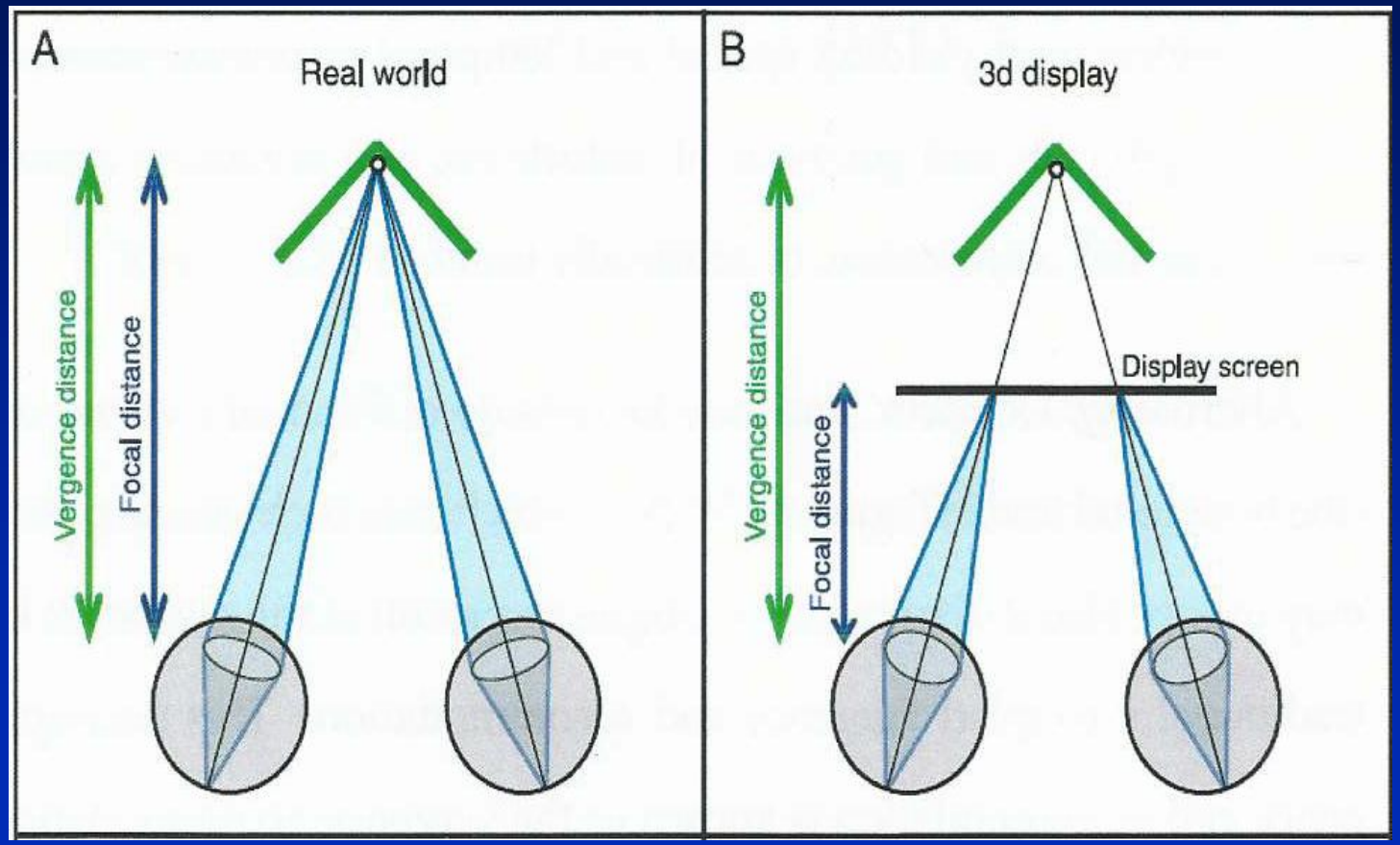


Vergence

The simultaneous movement of the pupils of the eyes toward or away from one another during focusing.

This measure of the convergence or divergence of a pair of light rays is defined as vergence.

Diagram of Vergence



Vergence Accommodation Conflict

Computer and projection displays present images on a single surface but have a focal distance (blur on the retina) which may be in front of or behind the screen

The inability to fuse the binocular stimuli causes discomfort and fatigue to the viewer

Viewers can be trained, and the discomfort can diminish with practice

David M. Hoffman, Ahna R. Girschick, Kurt Akeley, Martin S. Banks. “Vergence-accommodation conflicts hinder visual performance and cause visual fatigue, Journal of Vision, vol. 8, no. 3, article 33, March 28, 2008.

End