University of Colorado
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Introduction to Virtual Reality

Depth Perception

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Depth Perception

Lots of research!

Still not entirely understood

Visual Cliff: Gibson and Walk (1960) – Learned or innate?

Binocular and Monocular cues

Depth Perception

Innate

Binocular Cues

- Stereopsis (Disparity, Binocular Parallax)
- Convergence

Learned?

Monocular Cues

- Size
- Interposition
- Grain / Texture
- Motion parallax
- Linear perspective
- Aerial perspective
- Light and shade
- Relative Height
- Accommodation

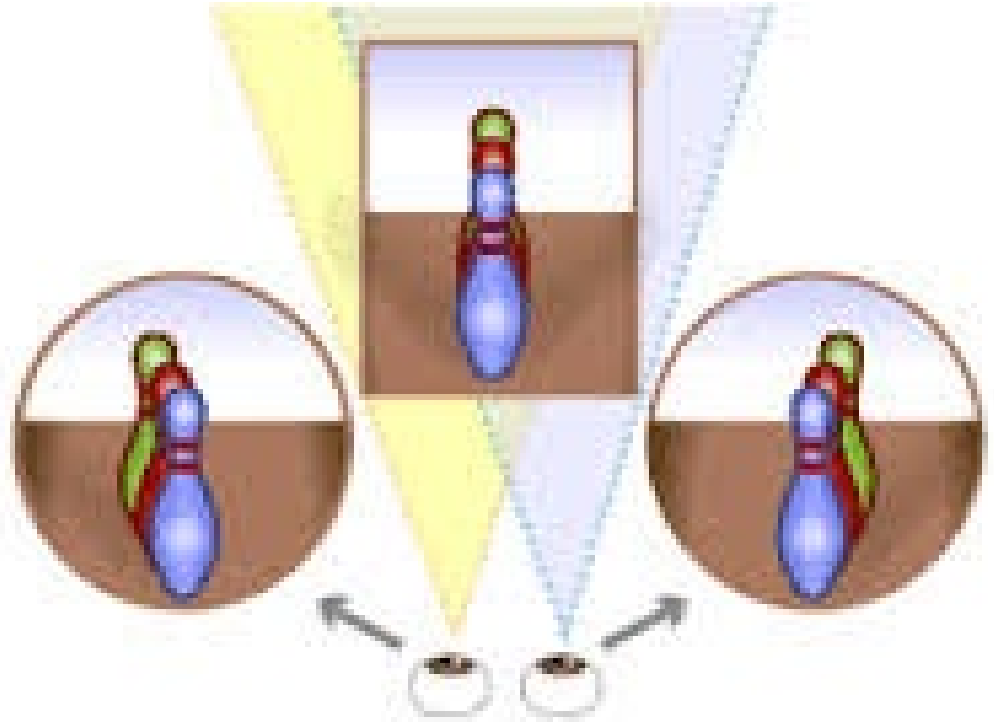
Binocular Cues

Stereopsis

(retinal / binocular disparity)

Brain fuses images from both eyes

As horizontal distance between eyes is fixed, can triangulate to determine distance



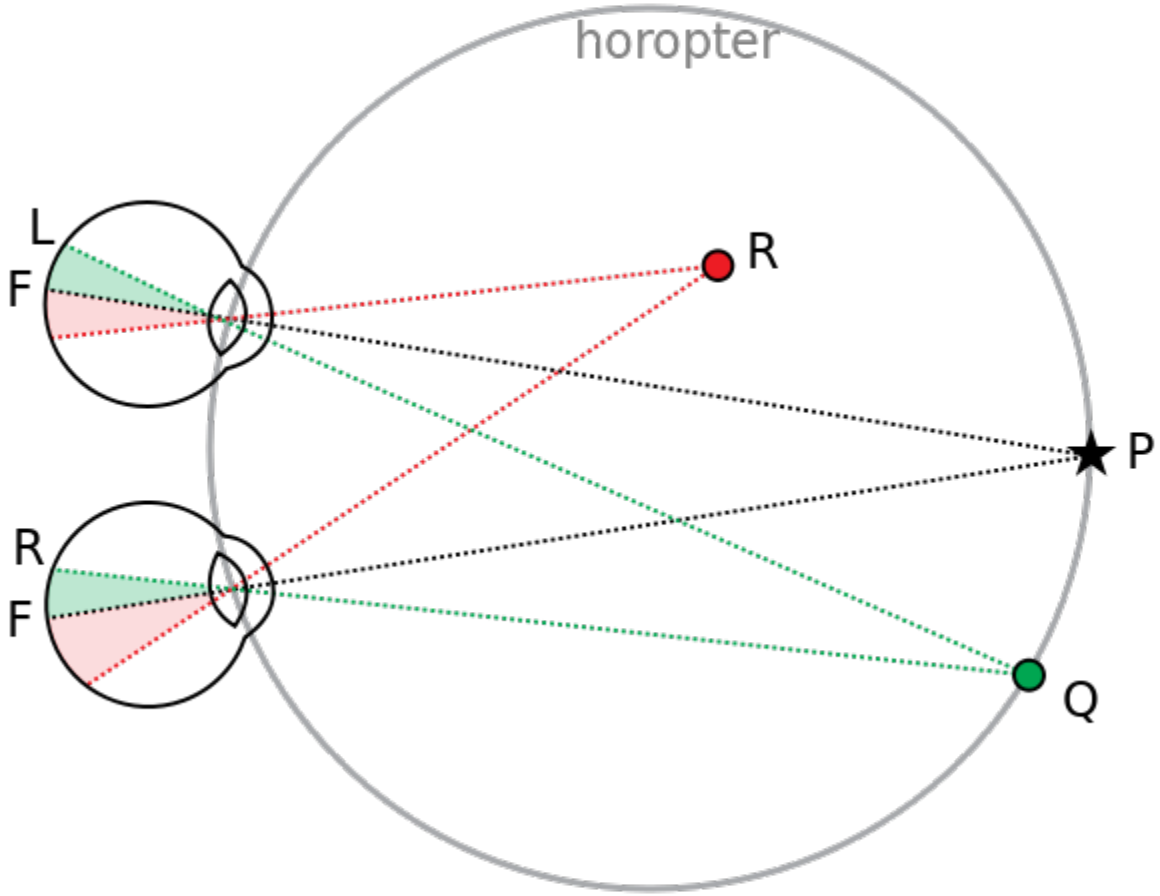
Stereopsis (cont.)

Correspondence points vs retinal disparity

Panum's Fusional area: area on retina that corresponds to binocular fusion

Diplopia: images fall far apart causing double vision

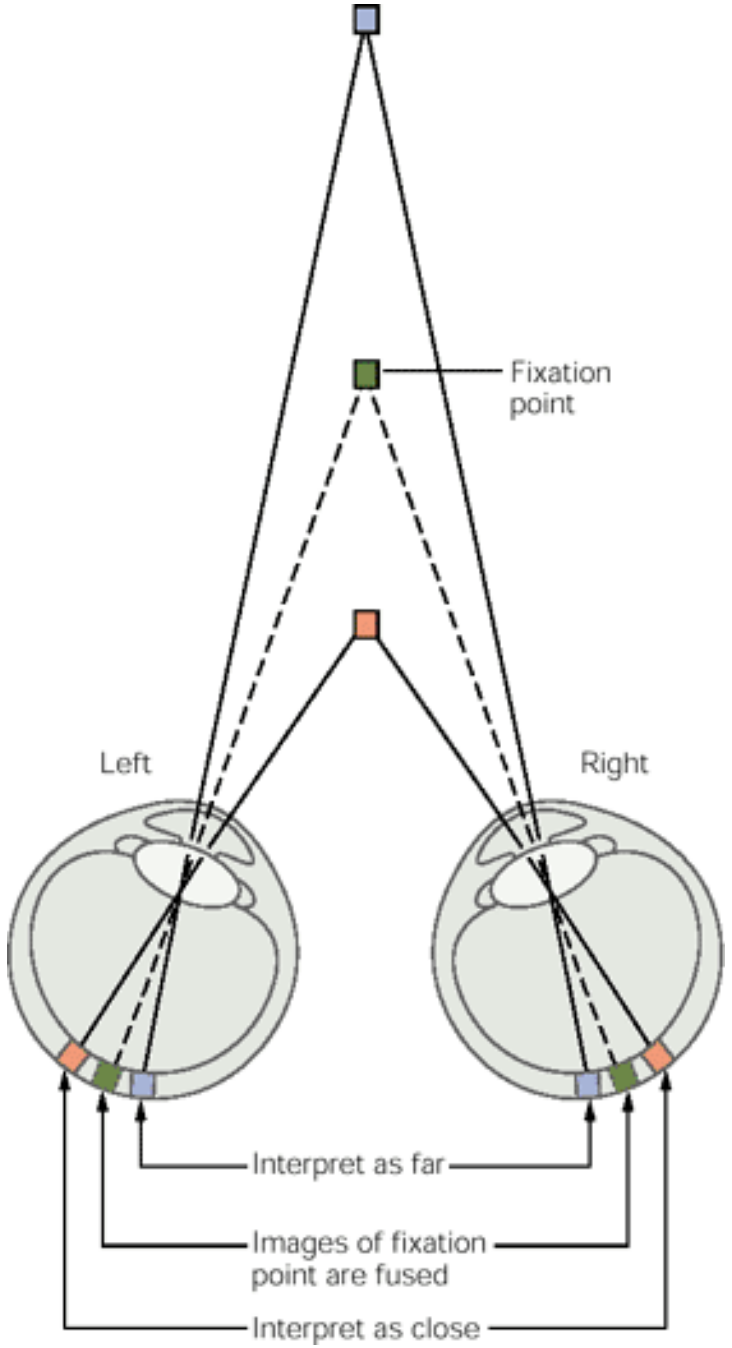
Horopter: plot of correspondence points for given distance



Convergence

Muscles and nerves send signals as object is tracked

Inward turn of ocular muscles indicates object is close



Monocular Cues

Relative Size

Objects that cast a smaller retinal image tend to be perceived as farther away (if relatively the same size)

BaMbuti Pygmies

1950's and 1960's study by Colin Turnbull

Pygmies environment did not require relative size depth cues and thus they were not able to utilize relative size to determine depth

Demonstrated certain depth cues are learned

Interposition / Overlap / Occlusion

Objects that block out the view of another object are perceived to be nearer

Grain / Texture Gradient

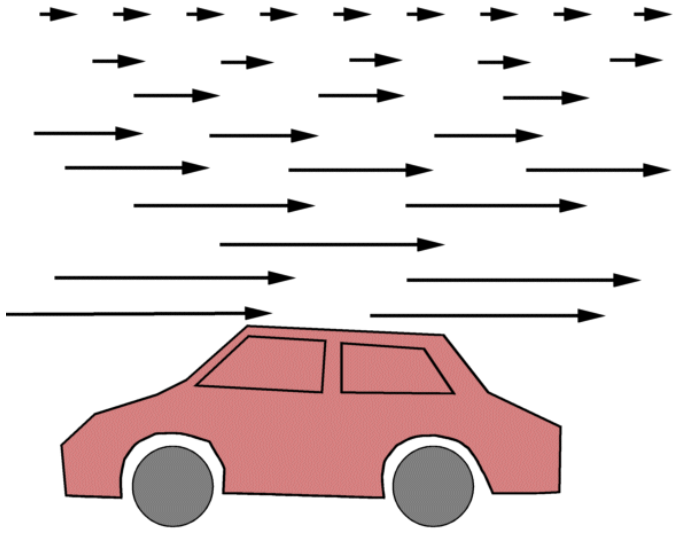
The clearer the texture of an object is the closer we perceive it to be

As textures blend together, we perceive the object to be further away

Relative Motion / Motion Parallax

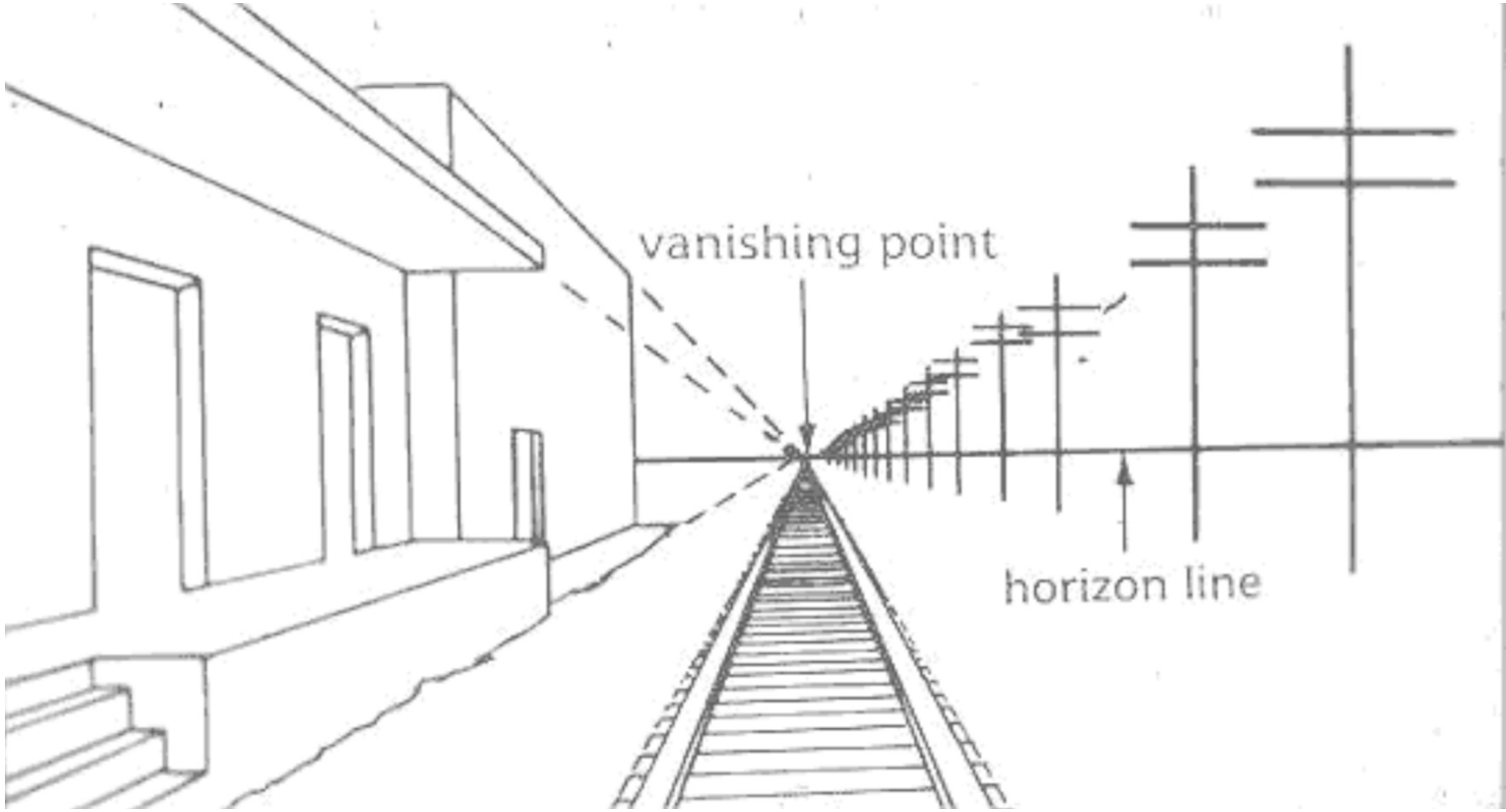
As we move forward, nearby objects appear to move out of our field of vision more quickly

Objects that move slower or appear to move with us are perceived to be further away



Linear Perspective

As assumed parallel edges (e.g., road, railroad tracks) appear to get closer together they are perceived to be farther away from us



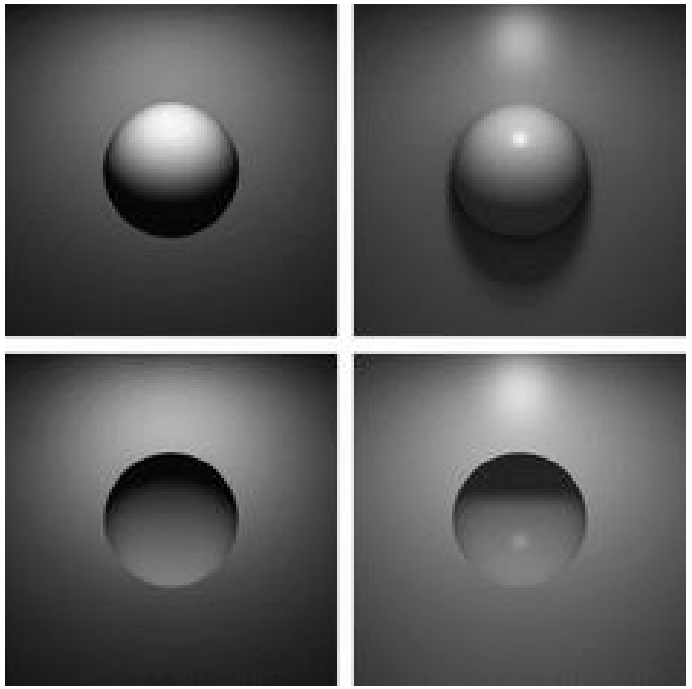
Aerial Perspective / Atmospheric Perspective

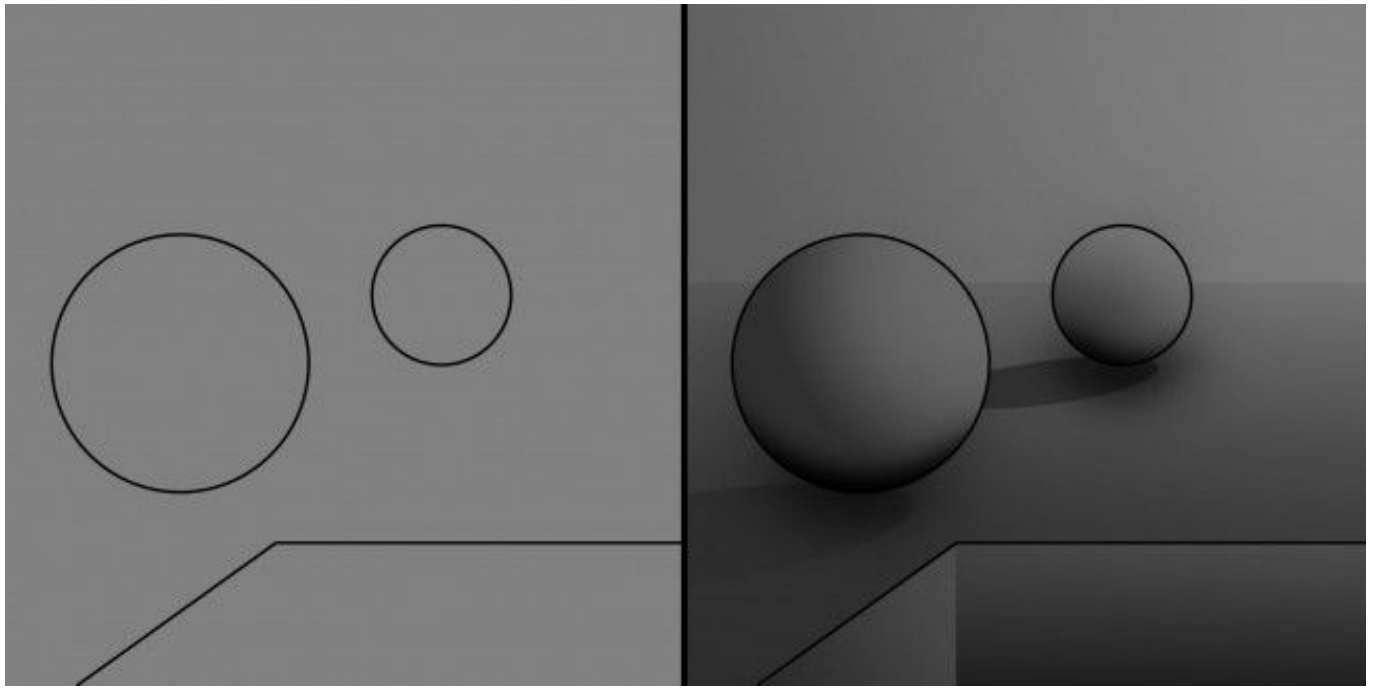
Objects that appear less clear are perceived as being farther away (environmental effect)

Farther away objects have less saturated colors and shift towards the background color

Light and Shading

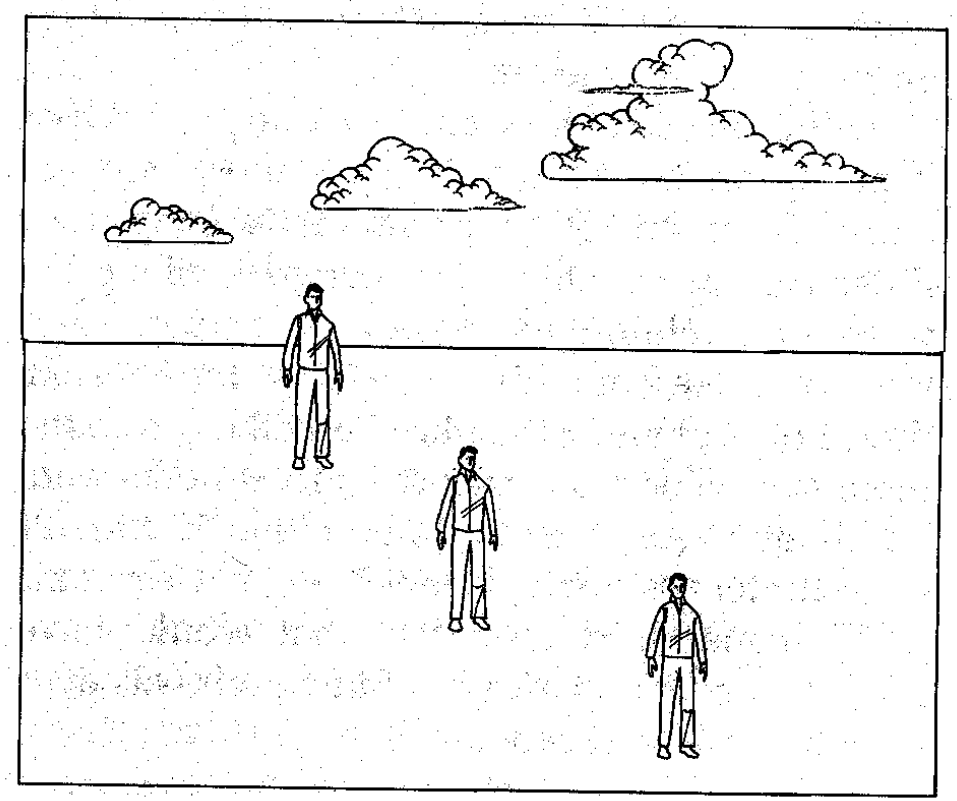
Objects that are seen as brighter are perceived as nearer





Relative Height / Elevation

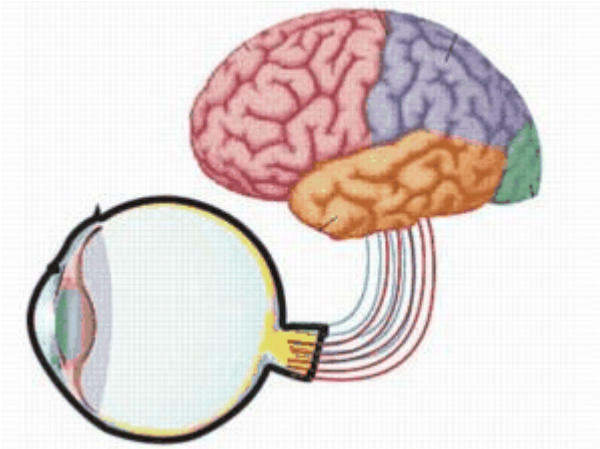
Objects that appear higher in our field of vision are perceived to be farther away (below vs above horizon)

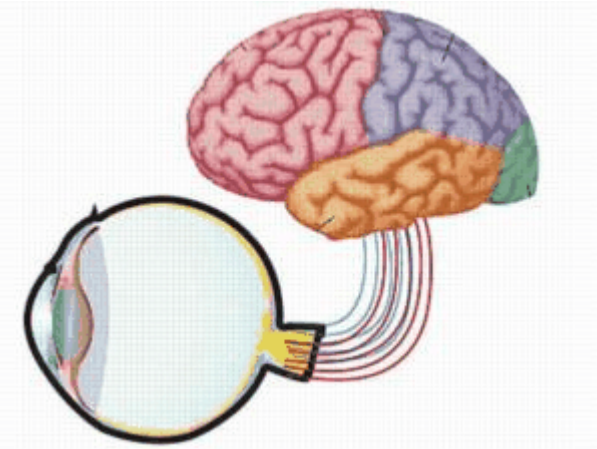


Accommodation

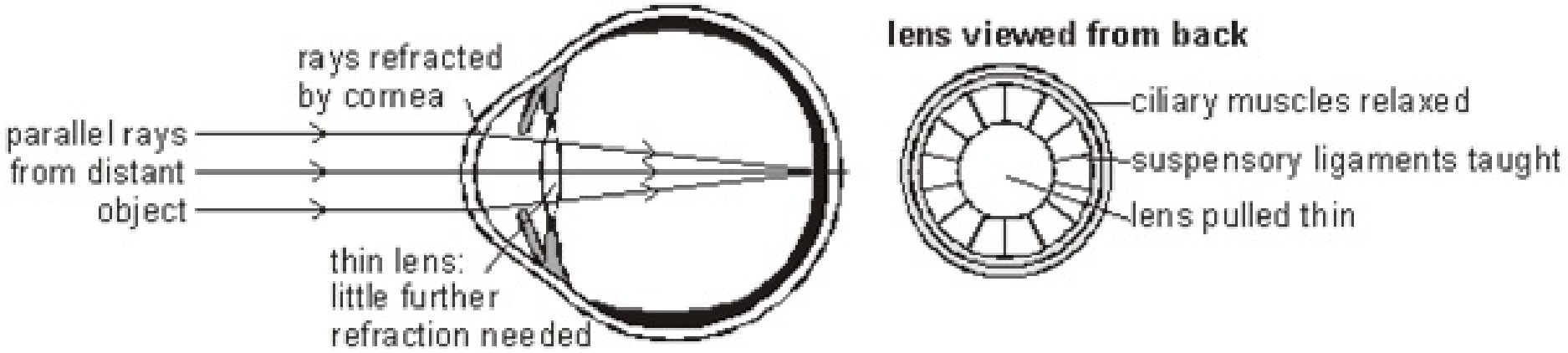
Process of how the eye controls the focus to see an object at different distances by changing the shape of the eye lens

Ciliary muscles: contract = near, relaxed = far

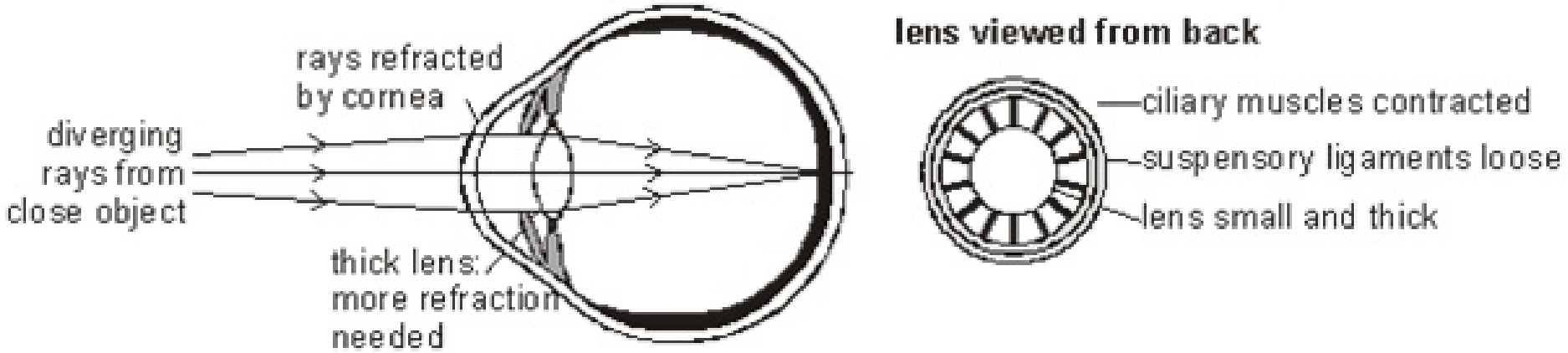




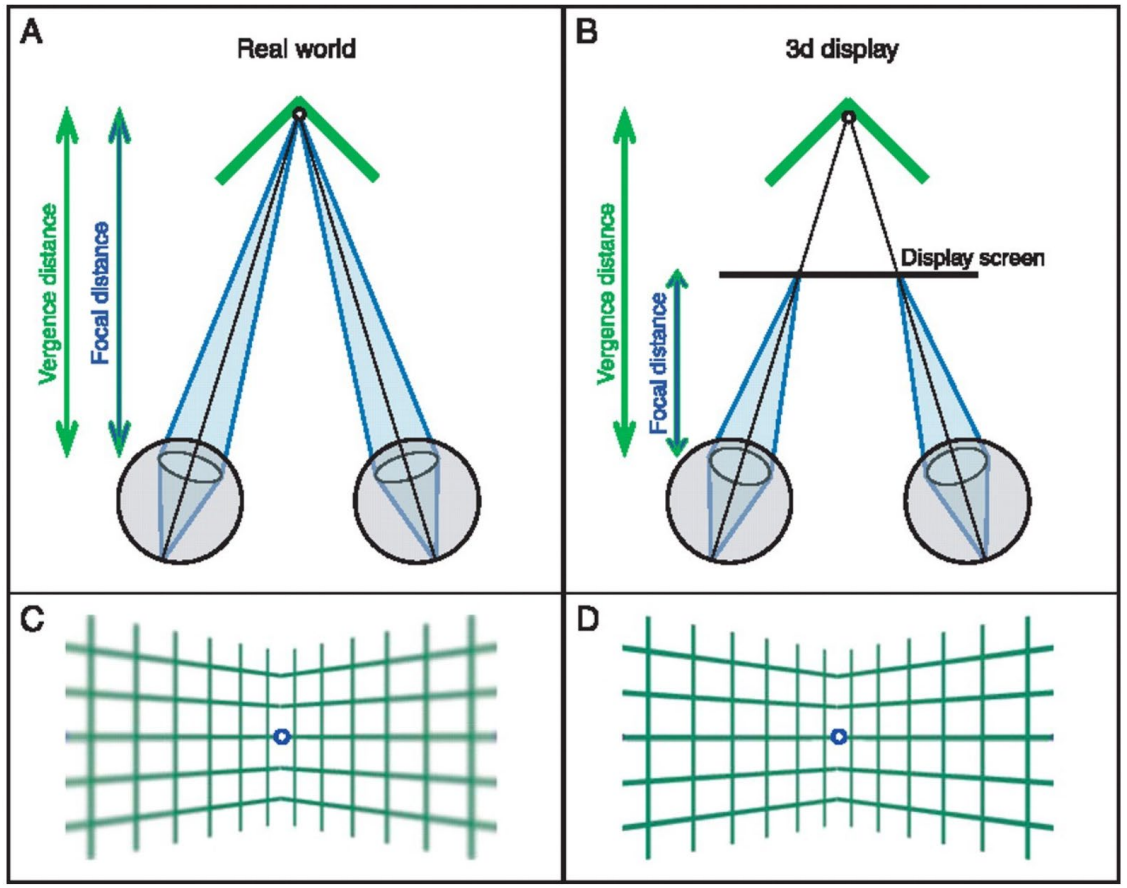
Far:

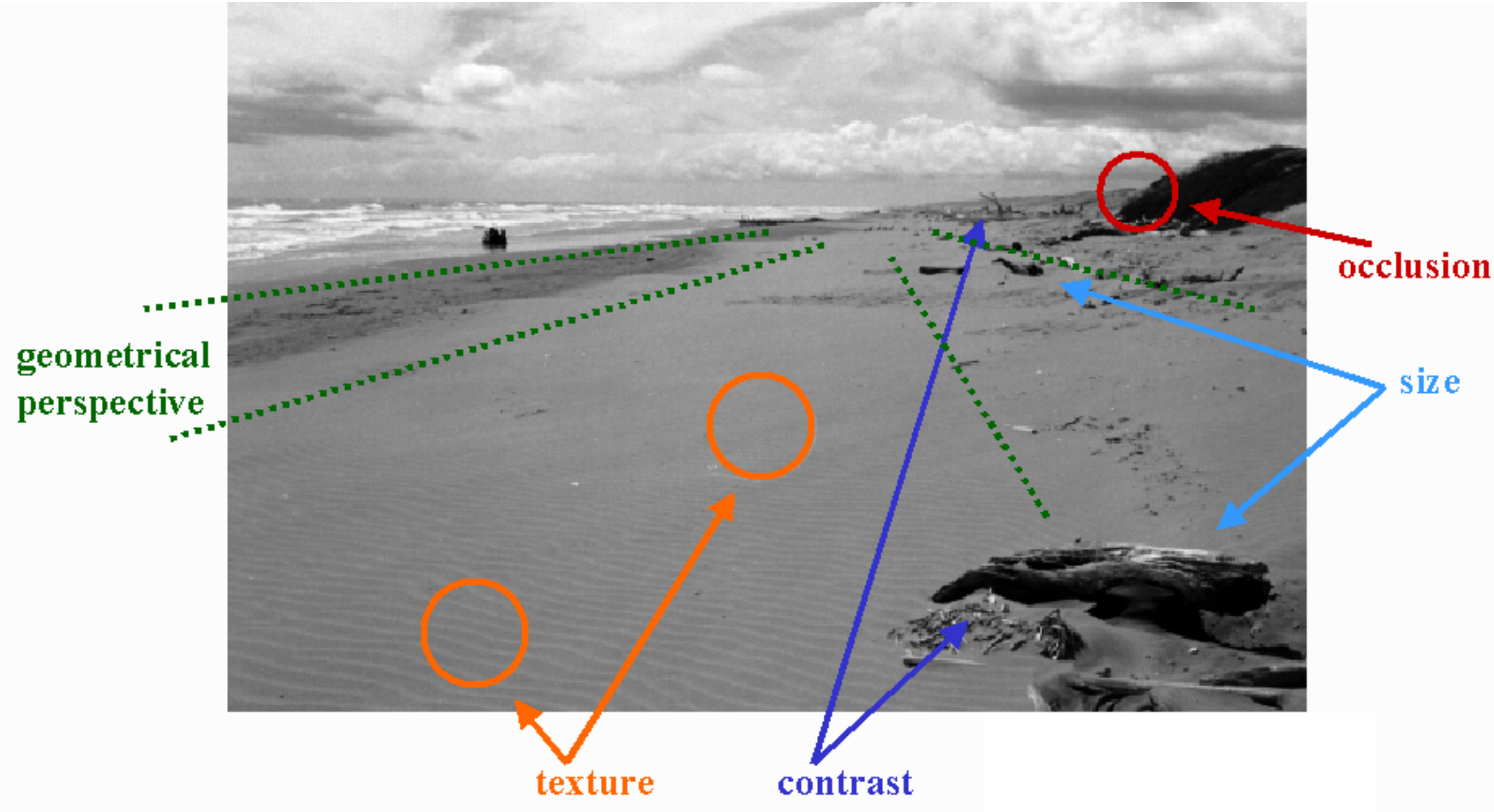

rays refracted
by cornea
parallel rays
from distant
object
thin lens:
little further
refraction needed
lens viewed from back
ciliary muscles relaxed
suspensory ligaments taught
lens pulled thin

Near:


rays refracted
by cornea
diverging
rays from
close object
thick lens:
more refraction
needed
lens viewed from back
ciliary muscles contracted
suspensory ligaments loose
lens small and thick

Accommodation-vergence conflict




occlusion
geometrical
perspective
size
texture
contrast

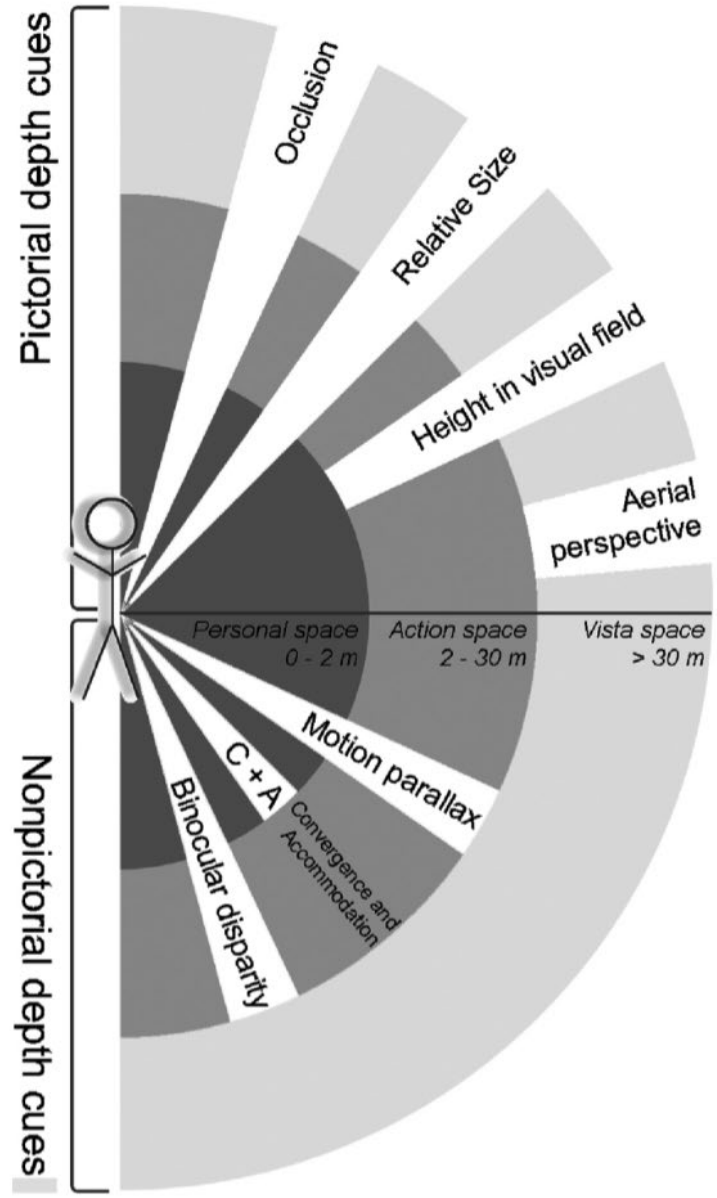


Fig. 1. Schema of effective ranges of the different depth cues (based on Cutting and Vishton [1995]).

Egocentric Depth Estimation in MR

"Subjectively perceived distance from a human observer to an object"

Measured via:

- Blind walking
- Blind reaching
- Alignment tasks

Consensus: depth in VR is underestimated compared with the real world

- i.e., objects appear smaller and farther away than they should

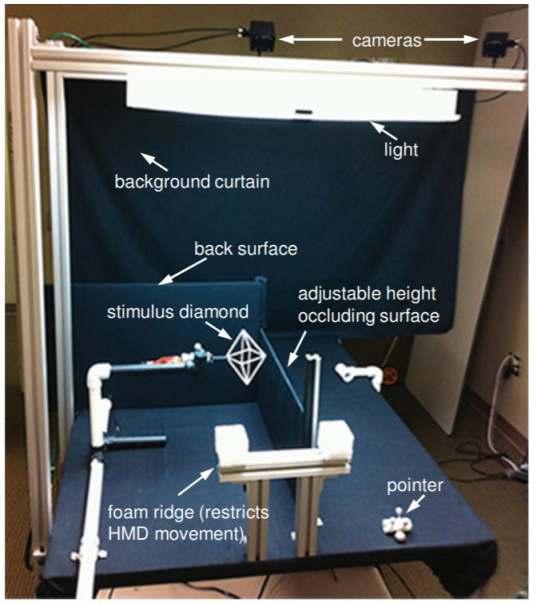


Figure 2: The experimental apparatus.

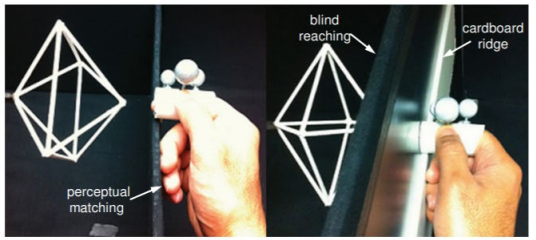
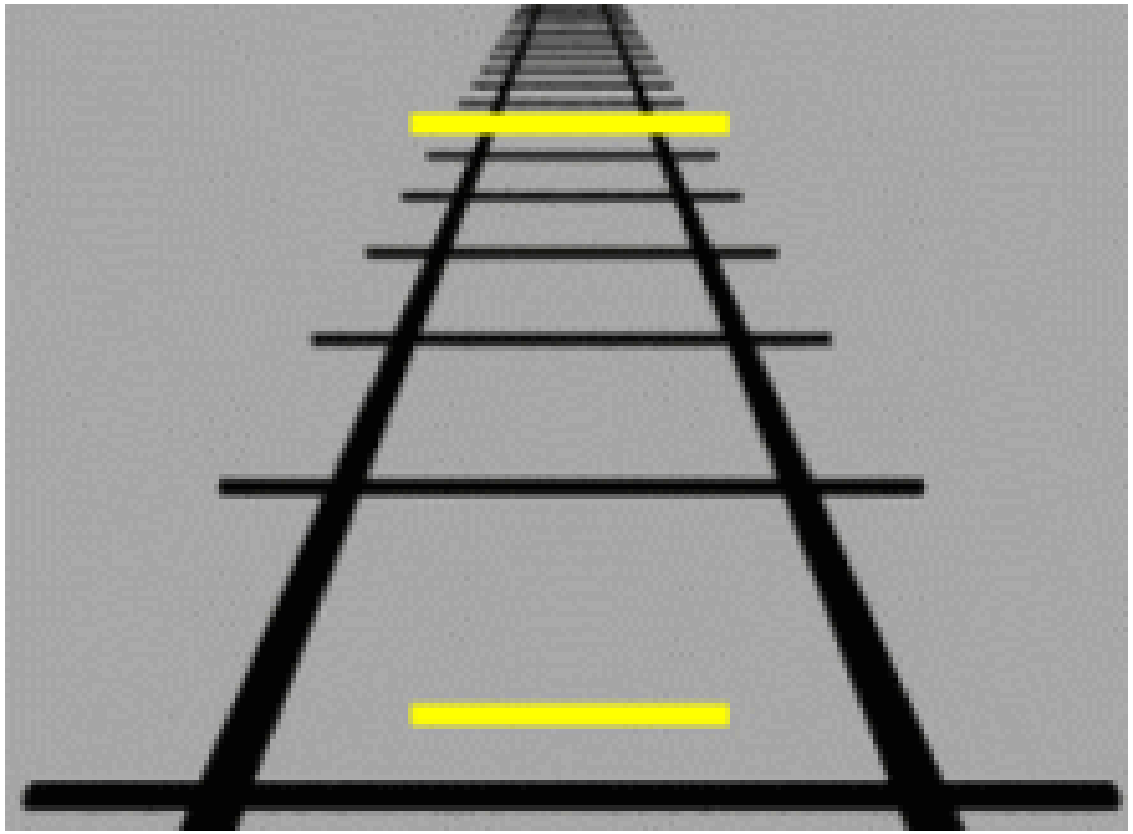


Figure 3: Perceptual matching and blind reaching tasks.

Visual Illusions




Left Click
to grab/release

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THANKS!

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