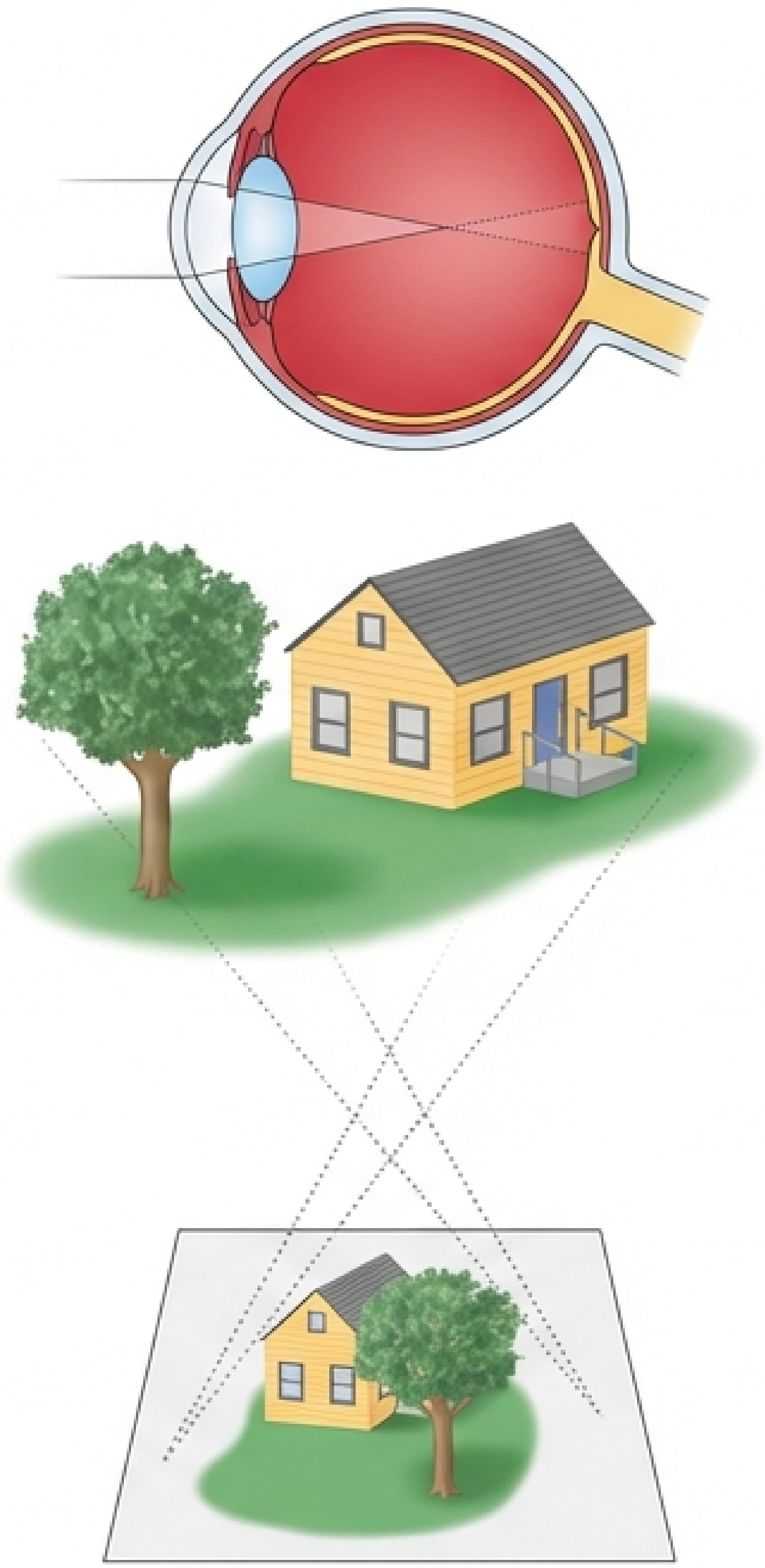
Perceiving Depth and Size

Reconstructing Reality from Retinal Images

The Fundamental Challenge

We experience the world in three dimensions, but the input we receive is strictly two-dimensional. Light reflected from objects falls onto the retina—a flat surface at the back of the eye. Notice points T’ and H’ on the retinal image diagram. On their own, these flat points cannot tell us that the house is farther away than the tree.

The brain must reconstruct this missing dimension.



The Link Between Depth and Size

Depth perception is not just about navigation; it creates our understanding of scale. When depth cues are manipulated, our brain fails to calculate size correctly. We don't see the man as 'far away'; we see him as 'small'.

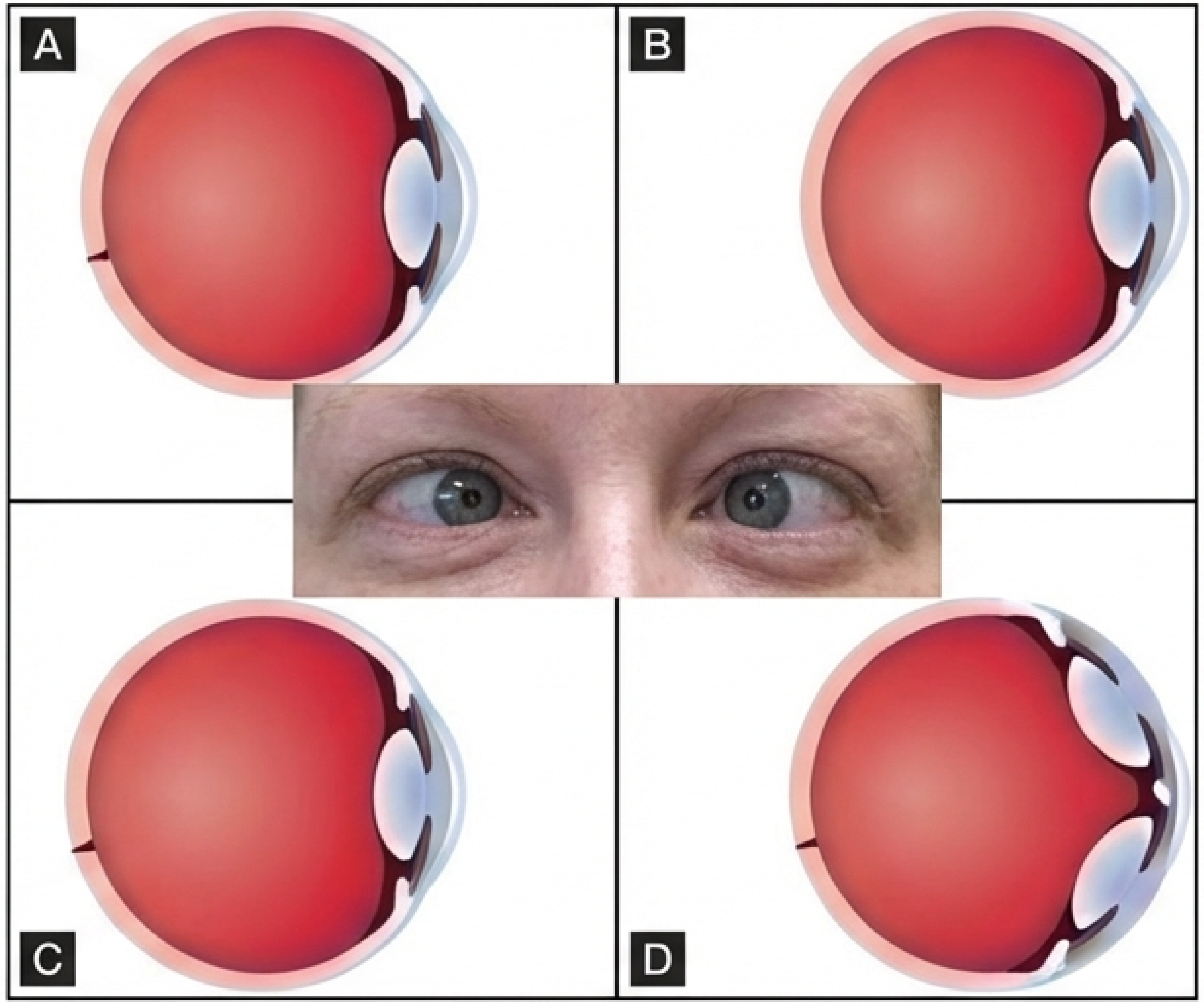
THE PERCEPTION

THE REALITY

Hardware Solutions: Oculomotor Cues

1. Convergence: The inward movement of the eyes when looking at nearby objects.
2. Accommodation: The tightening of eye muscles to change the lens shape for focus.

Note: Only effective up to arm's length.



Pictorial Cues: Reading the Landscape

When muscle cues fail at distance, the brain analyzes 2D patterns.

Texture Gradient: Elements appear packed closer together as they recede.

Atmospheric Perspective: Distant objects lose sharpness and gain a blue tint due to air particles.

Pictorial Cues: Light and Shadow

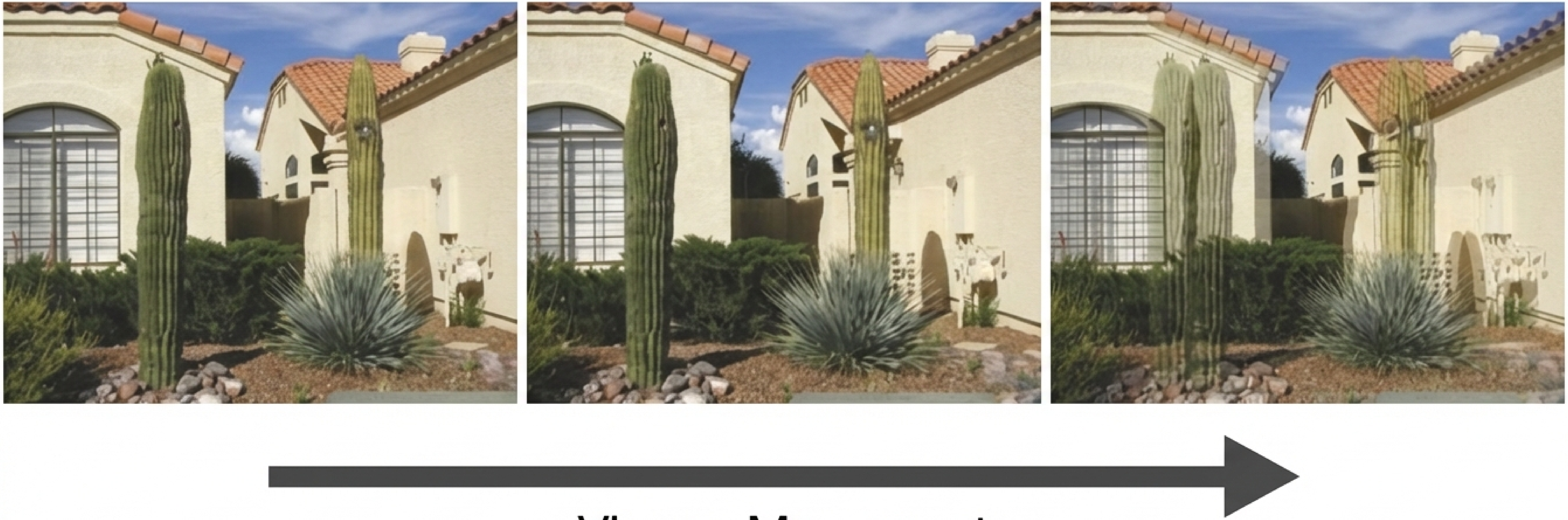
Shadows anchor objects in space and define their volume.

Object Location

Object Shape

Motion-Produced Cues

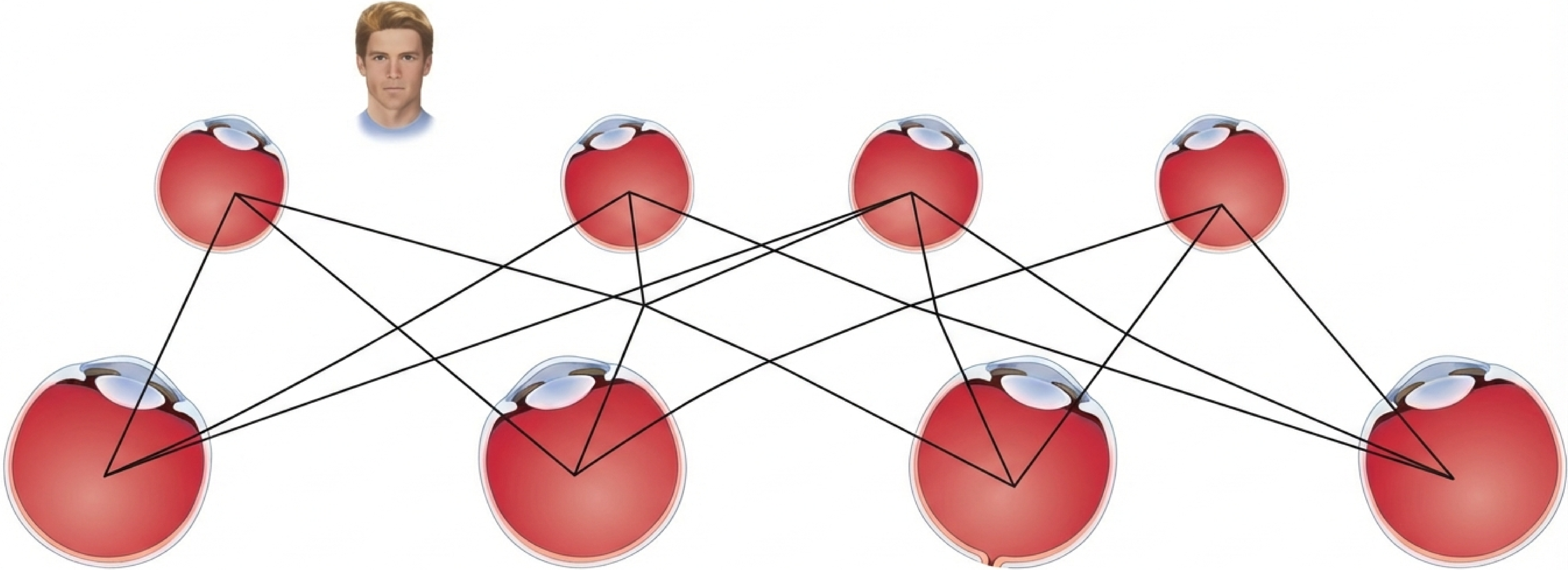
Deletion and Accretion: As we move, near objects cover (delete) and uncover (accrete) far objects. This relative movement confirms depth.



Viewer Movement

Binocular Vision: The Geometry of Two Eyes

Corresponding Points: Locations on each retina that would overlap if one eye were slid over the other.



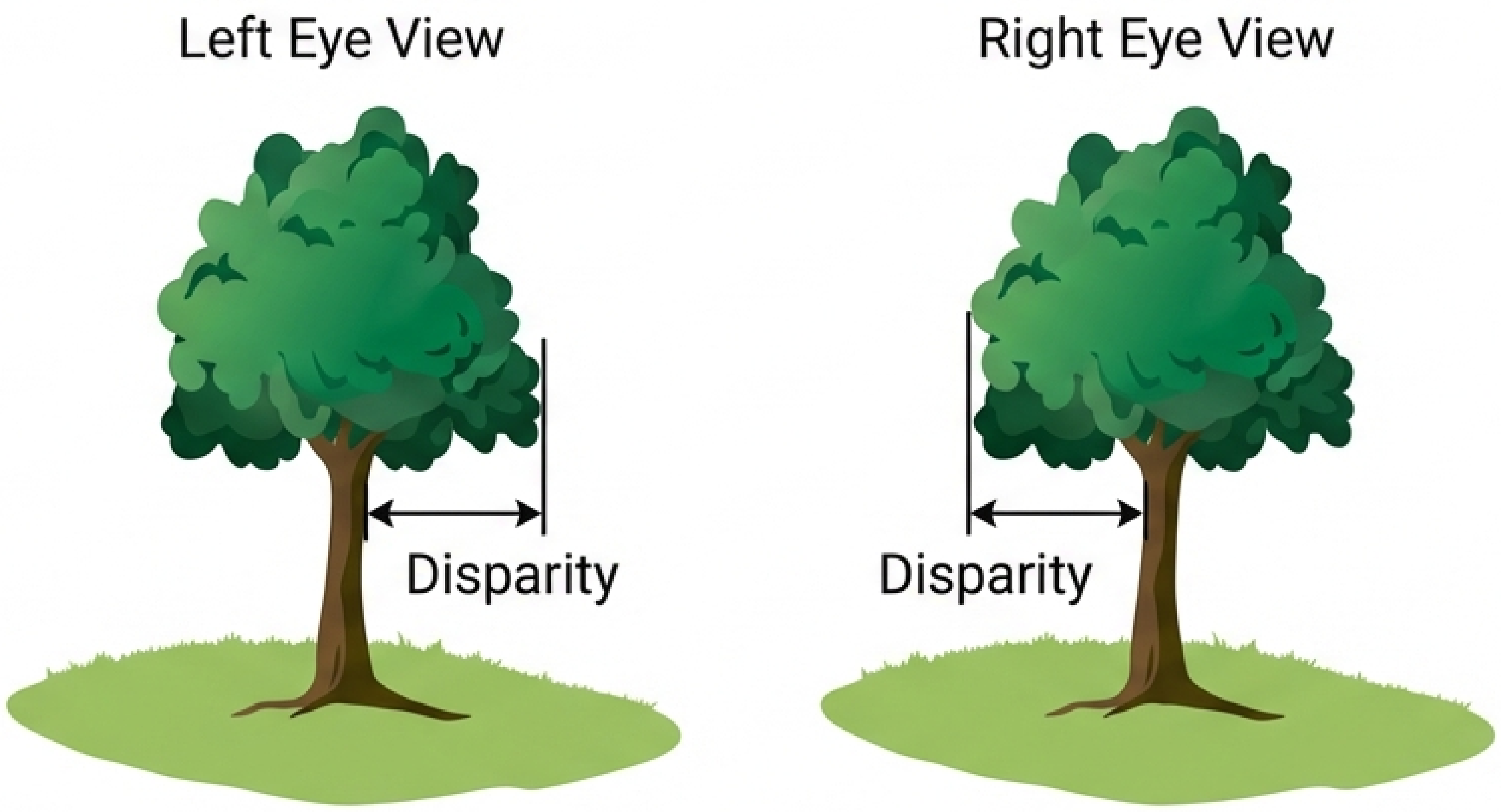
The Horopter

The ‘sweet spot’ of fusion. Objects on this imaginary line fall on corresponding retinal points. Objects off this line create disparity.

Subjects at different focal depths.

Calculating Depth from Disparity

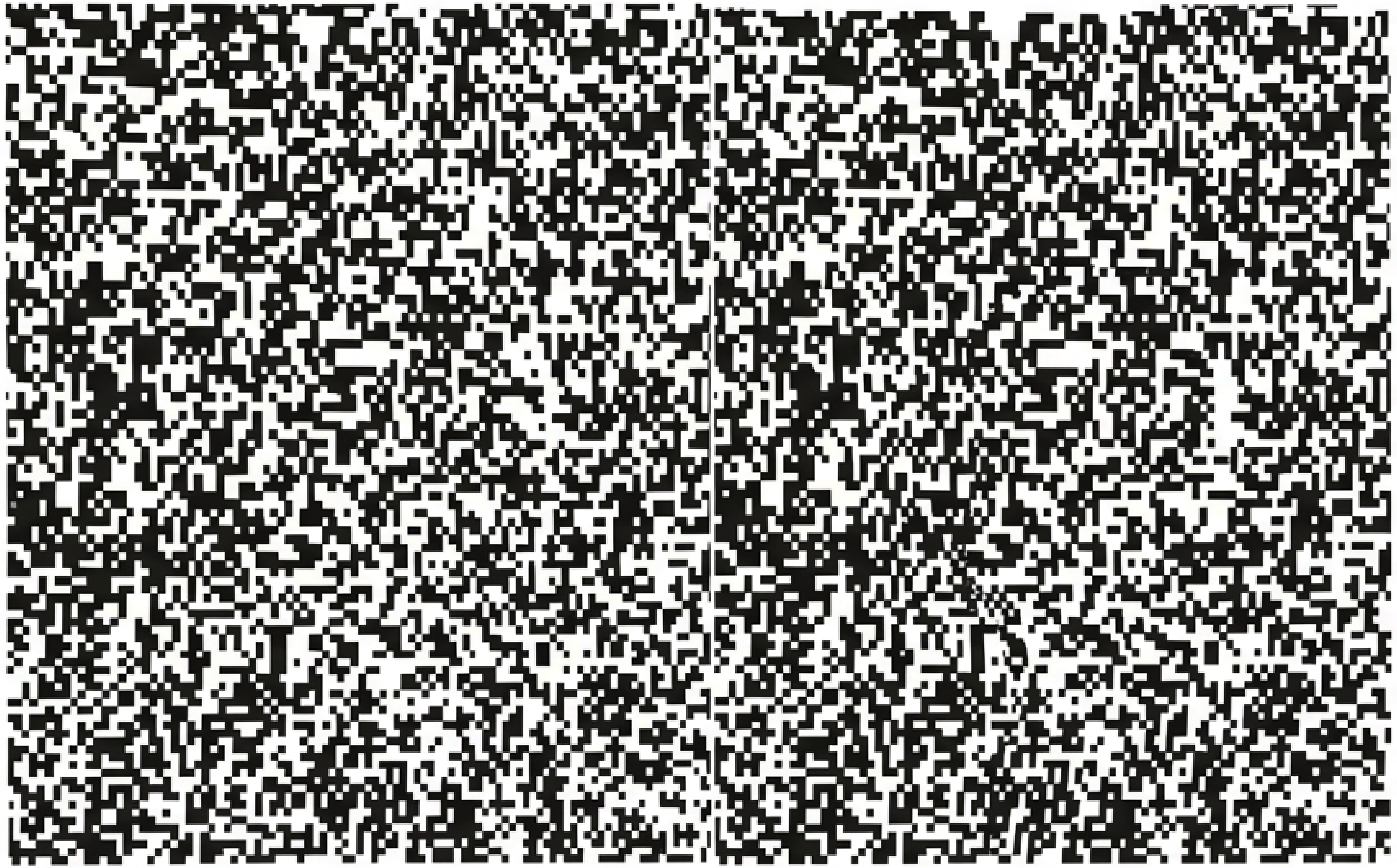
The brain uses the angle of disparity to calculate precise distance from the horopter.



Slight lateral shift (disparity) between views.

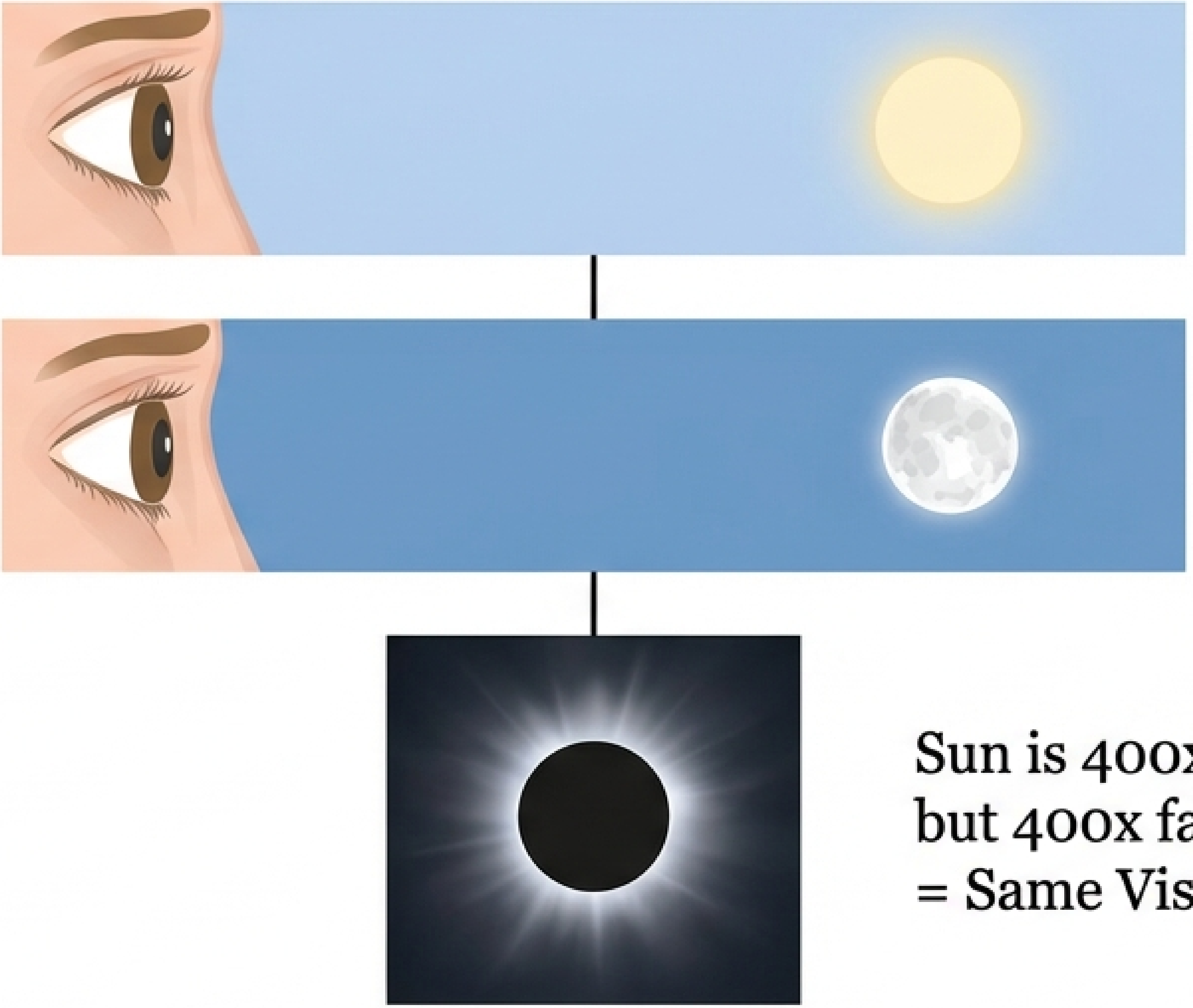
Stereopsis: Depth from Disparity Alone

Bela Julesz's Random-Dot Stereogram proved that the brain does not need outlines or shadows to see depth—only disparity.



The Geometry of Size: Visual Angle

Visual Angle depends on two variables: physical size and distance.
The Sun and Moon have the same visual angle (0.5°).

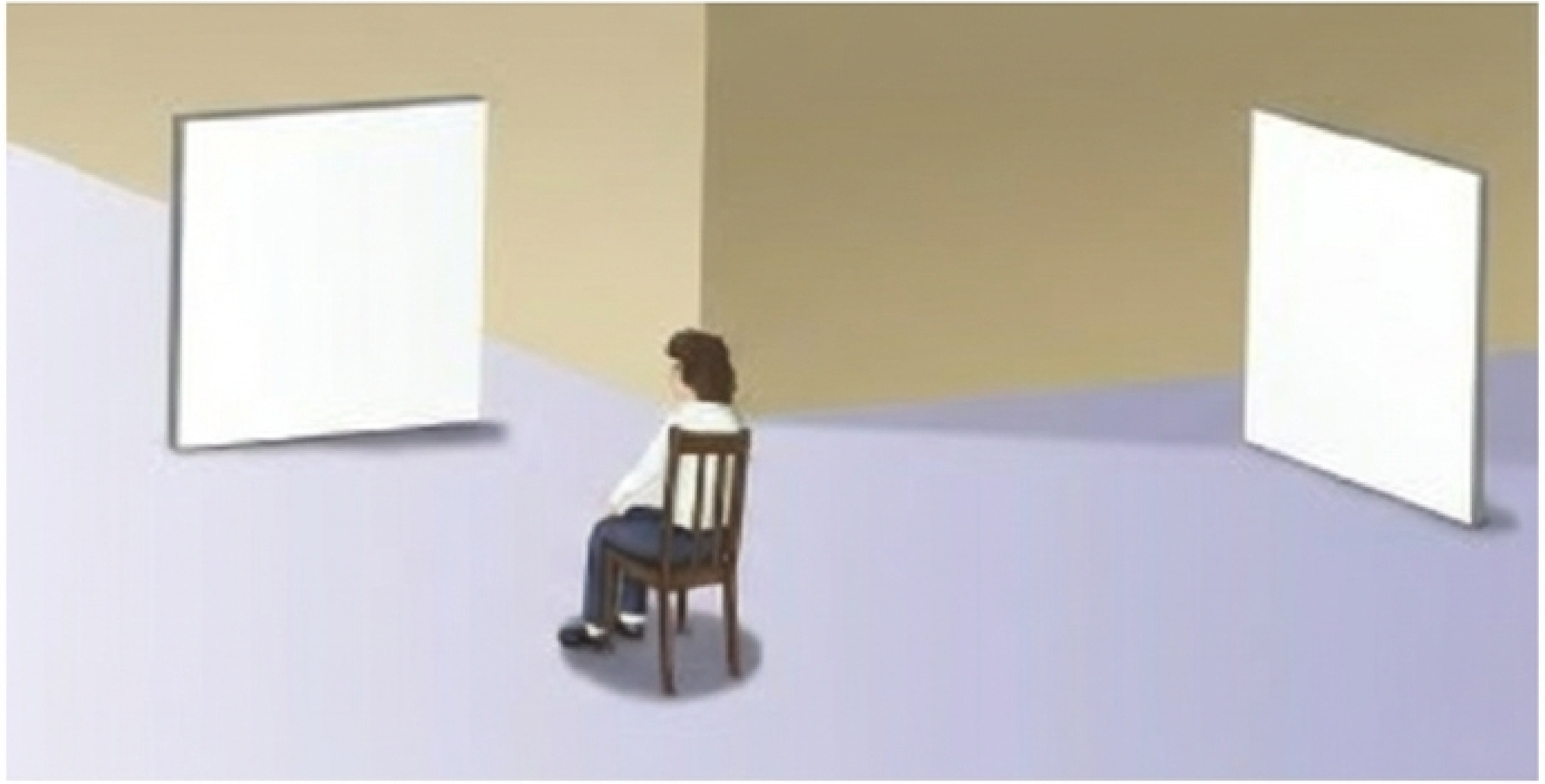


Sun is 400x larger,
but 400x farther away
= Same Visual Angle.

The Holway & Boring Experiment (1941)

Experiment Setup: An observer sits at the intersection of two hallways. They must match the size of a Comparison Circle (nearby) to a Test Circle (distant).

When depth cues (shadows, binocular vision) were removed, observers failed to judge size, relying only on visual angle.



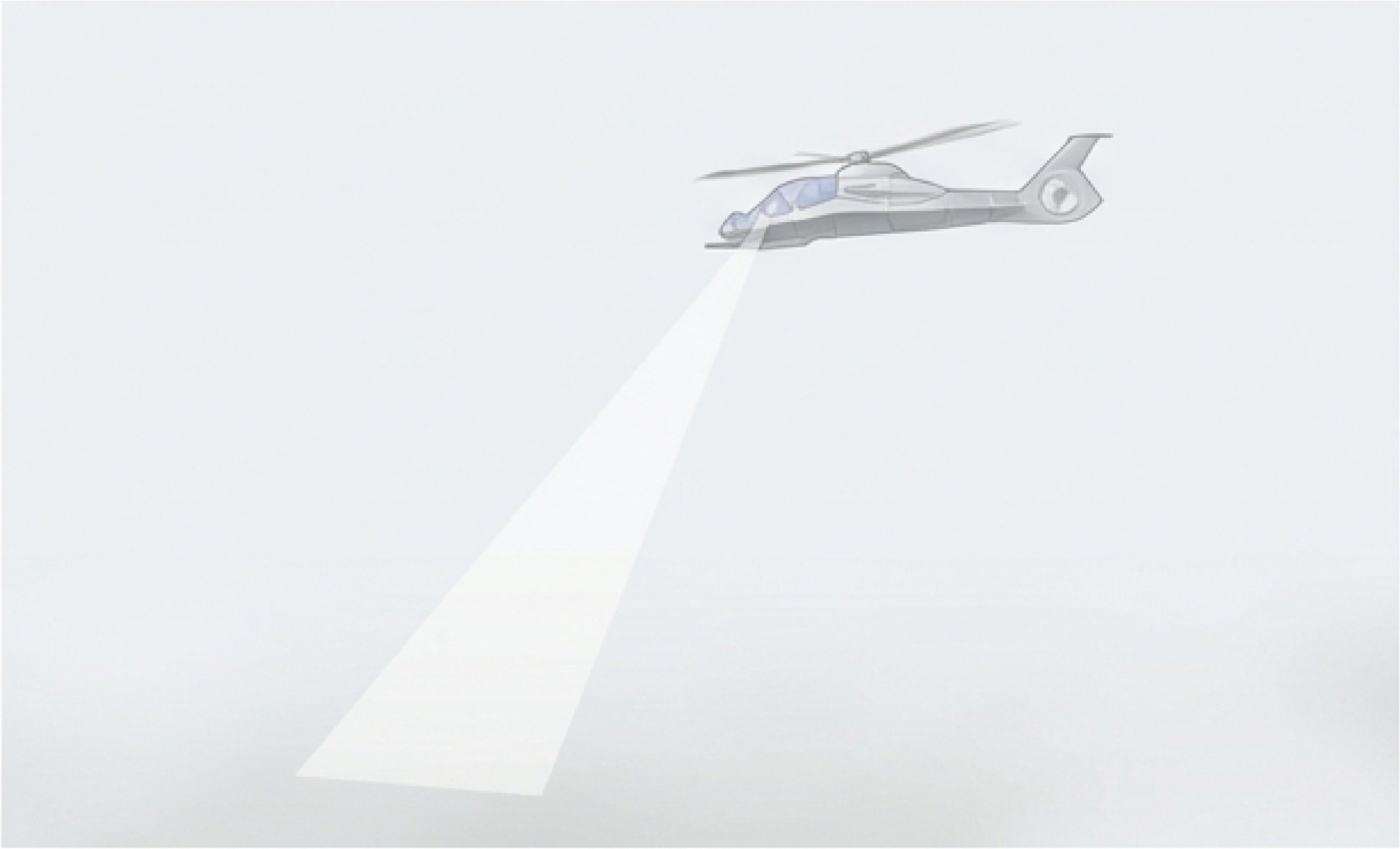
Size Constancy in Action

Perceived Size = Retinal Image × Distance

Constancy Works

Texture gradients allow us to scale objects correctly.

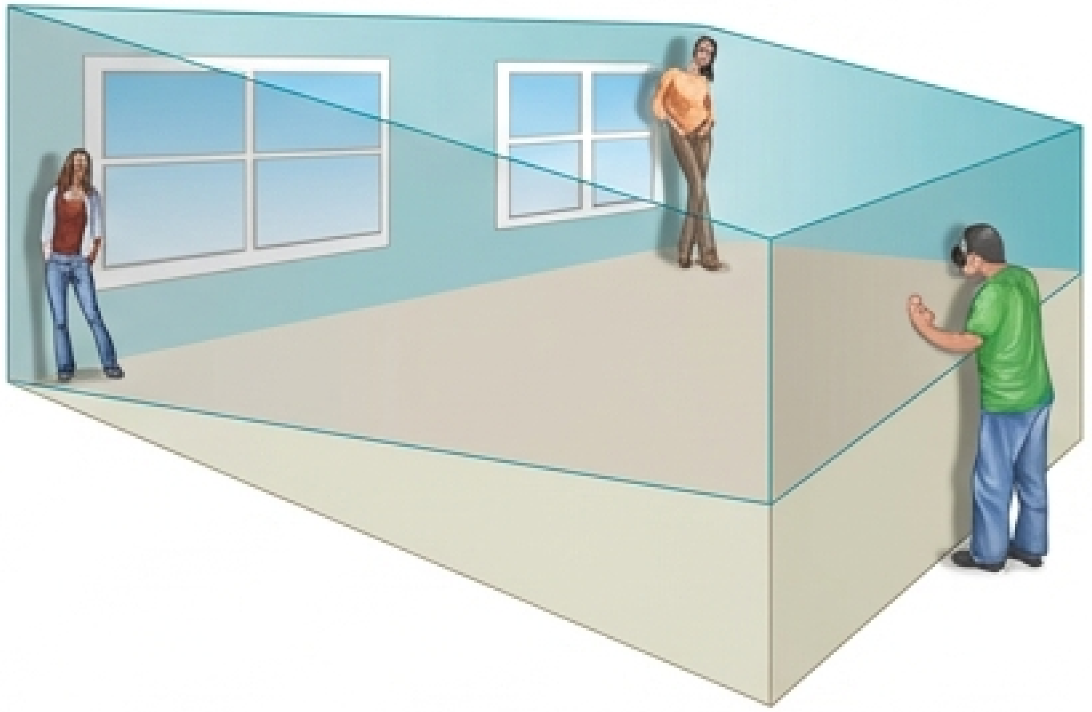
Constancy Fails



In a whiteout, Distance (D) is unknown, causing errors in perceived Size (S).

Hacking Perception: The Ames Room

A trapezoidal room designed to mask depth differences. The brain assumes the room is rectangular (equal distance), forcing it to perceive the people as different sizes.

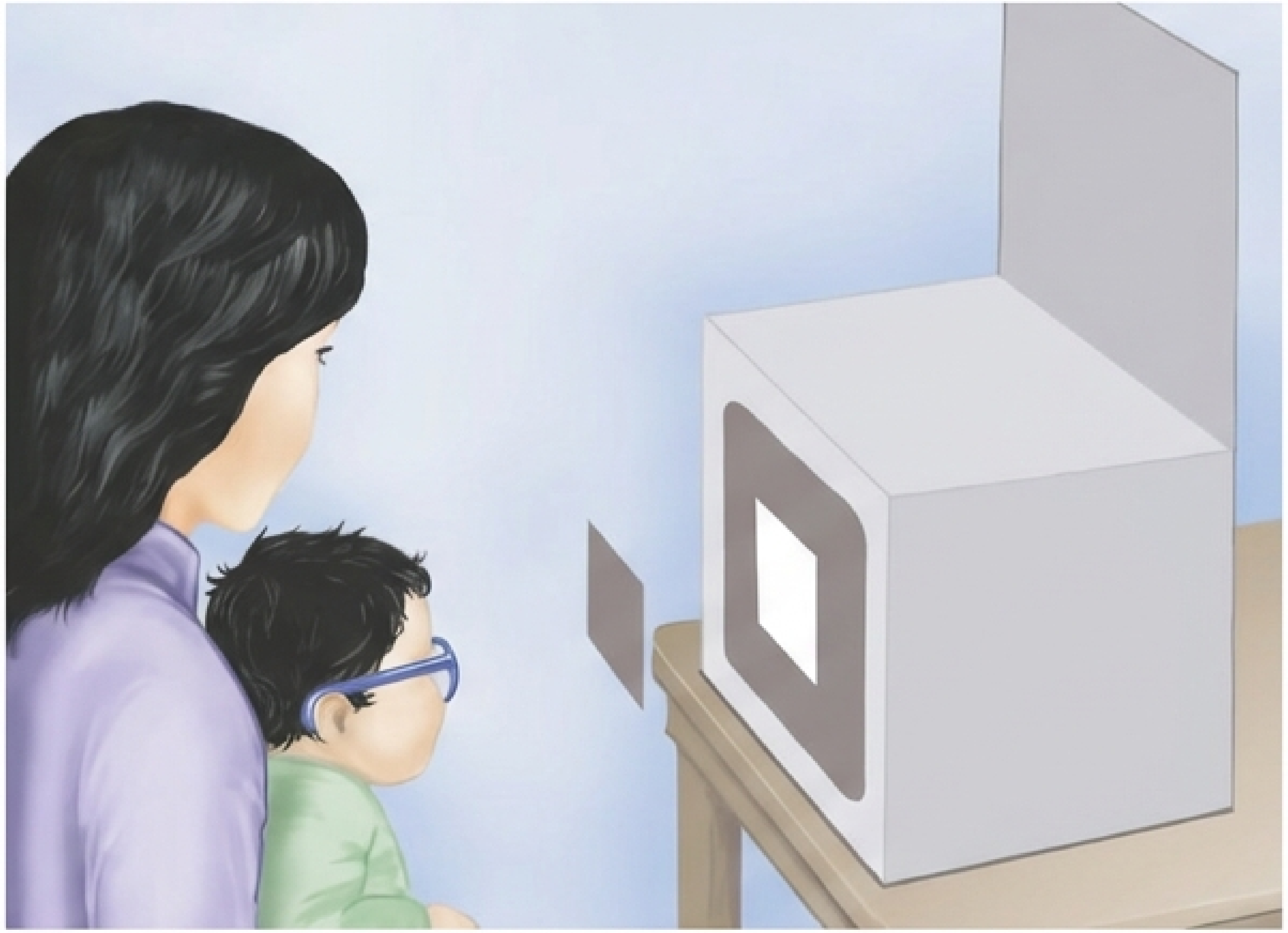


The Moon Illusion

Why does the horizon moon look huge? The “Apparent Distance Theory” suggests that horizon cues (trees, buildings) make the moon seem farther away than when it is at the zenith. If it seems farther but looks the same size on the retina, the brain concludes it must be massive.

The Origins of Perception

Is depth perception innate? Research using preferential reaching suggests infants begin to use cues like familiar size and shadows between 5 and 7 months of age.



Summary & Next Chapter

We have traced the visual path from the 2D retina to the 3D brain. Next, we explore how we process the mechanical energy of sound.