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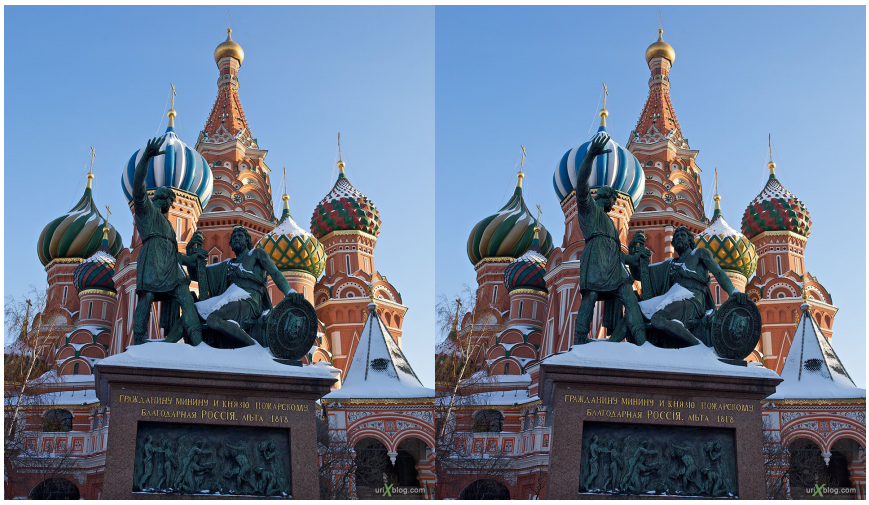
Binocular and Monocular Cues in Depth Perception

By Ellen Szubski, Ph.D., CXLT, CPSI, AHFP

Depth perception is an essential aspect of interacting with and navigating the world for people. Depth perception is the ability to perceive the world in three dimensions (3D). It allows people to judge how far away objects are, how they relate spatially to one another, and how they can successfully interact with them. Depth perception is a critical aspect of vision that enables activities like walking, driving, catching a ball, pouring a drink, eating, etc.

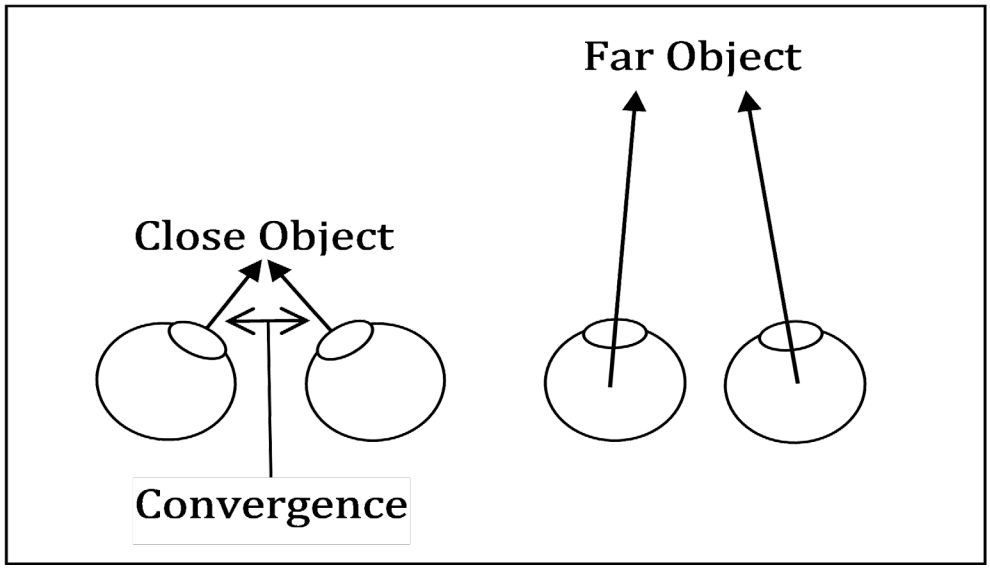
Depth perception relies on the brain combining information from both binocular cues (utilizing information from both eyes) and monocular cues (utilizing information from only one eye) to create a three-dimensional (3-D) understanding of a person's environment.

Binocular vision is the primary mechanism for depth perception. Two binocular cues used in depth perception are Retinal Disparity and Convergence. Retinal Disparity cues occur as each eye views the world from a slightly different angle. The brain merges these two slightly different images into one, allowing us to perceive depth. The greater the disparity or difference between the two images, the closer the object is to the observer. This can be demonstrated by fixating on a distant object while covering up one eye at a time. Note how the object you are



Each eye views the world from a slightly different position similar to the photographs taken above. The brain uses this retinal disparity for depth perception.

The second binocular cue is Convergence. Convergence cues occur as a person's eyes move inward or converge on an object. The brain uses the degree of convergence as a cue for that object's distance. The more the eyes converge while viewing an object, the closer the object is to the viewer. For example, hold your finger out in front of you while fixating your eyes on it. Slowly bring your finger closer to your nose while continuing to fixate on your finger. The more your eyes converge on your finger, the closer your finger is to you.



Pictorial depiction of convergence cue.

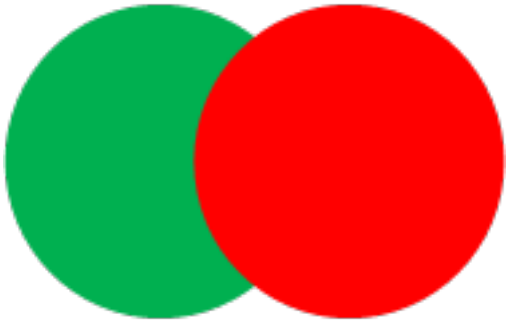
Depth perception also occurs through monocular vision cues such as relative size, interposition, texture gradient, linear perspective, and motion parallax.

Relative size cues occur when objects of known or assumed identical size are displayed at different scales and our brain interprets the smaller object as being farther away and the larger one as being closer. For example, when viewing two identical cars parked at different distances, the car that appears visually larger will be perceived as parked closer to the observer than the car that appears visually smaller.



The smaller soccer balls appear farther in the distance than the larger soccer balls displaying the relative size visual cue.

Interposition monocular cues occur when one object obscures part of another object and our brain interprets the obscured object as being farther away from the viewer. For example, if you are viewing two books. If one book is partially overlapping the other book, you will perceive that the covered book is farther away than the book that appears whole or uncovered.



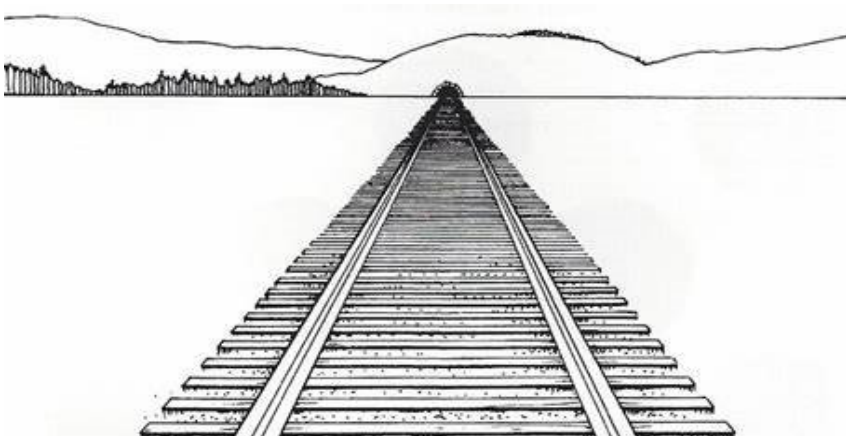
The red circle appears to be closer to the observer than the green circle due to interposition visual cues.

For texture gradient visual cues, objects with finer textures appear farther away than those with coarser textures. For example, when viewing a grass lawn, a patch of grass has sharp and defined blades of grass while another patch of grass appears smooth with indistinguishable blades of grass. Here, the observer will perceive that the patch of grass with more defined blades as closer than the smoother patch of grass as farther in the distance.



The patch of grass with defined blades appears closer to the observer than the undistinguishable blades of grass.

For linear perspective visual cues, parallel lines appearing to converge in the distance suggest a greater depth or distance. For example, when viewing a long straight road, the edges of the road appear to converge at a point in the distance. Here, the closer the parallel lines appear, the farther away the road is from the observer.



The parallel lines of the railroad appear to converge in the distance, signifying that the closer the parallel lines of the railroad are, the further away, and demonstrating linear perspective visual cues.

Lastly, motion parallax occurs when objects in an environment appear to move at different speeds and directions relative to the observer's motion. For example, when riding in a car and looking out the window, objects that are moving slower are perceived as being farther in distance than objects that are moving faster.

Depth perception is essential because it allows us to accurately understand the spatial relationships between objects in our environment and judge distances. This ability is crucial for navigating and interacting with the world effectively and safely. Accurate depth perception allows humans to avoid obstacles while walking and running. It helps humans step up or down stairs safely. Depth perception allows drivers to judge the distance between their car and other vehicles, pedestrians, or objects, as well as to estimate stopping distances and make turns safely. Depth perception aids in hand-eye coordination, allowing humans to pick up objects and accurately use tools. In addition, depth perception helps us know how far away objects are, whether we can fit through spaces, and how much effort is required to move toward or away from something. Misjudging distances can lead to tripping, falling, or collisions. Depth perception ensures safety in everyday life, especially when navigating uneven terrain or unfamiliar environments.



Ellen Szubski, Ph.D., CXLT, CPSI, AHFP, is the senior human factors consultant at The Warren Group. She earned a Doctorate of Philosophy in Human Factors Psychology and a Master of Science in Applied Psychology from Clemson University. She did her dissertation on "The Influence of Pedestrian Biological Motion on Time-To-Collision Estimates at Night". She is also a Certified XL Tribometrist, Certified Playground Safety Inspector and a Certified Associate Human Factors Professional (AHFP). Prior to entering the forensic field, Ellen planned and conducted experiments for a major bicycle manufacturer. She also conducted laser strike perception studies for the Department of Defense. Ellen applies her experience in Human Factors to the analysis of crash investigations and other personal injury matters. These matters often include collisions involving vulnerable road users and drivers, driver distraction, and slips, trips, and falls. She utilizes her knowledge of OSHA regulations, codes, and standards in her analysis of premises liability incidents and safety consulting. Ellen is a current member of the Human Factors and Ergonomics Society (HFES) and it's Forensic Professional Technical Group.