2018-02-05 Depth Perception

PSY 525.001 • Vision Science • 2018 Spring

Rick Gilmore

2018-02-05 08:53:13

But what is the Fourier Transform? A visual introduction.

Today's topics

Today's topics

Discuss project proposal

Today's topics

Discuss project proposal

Depth perception

Today's topics

Discuss project proposal

Depth perception

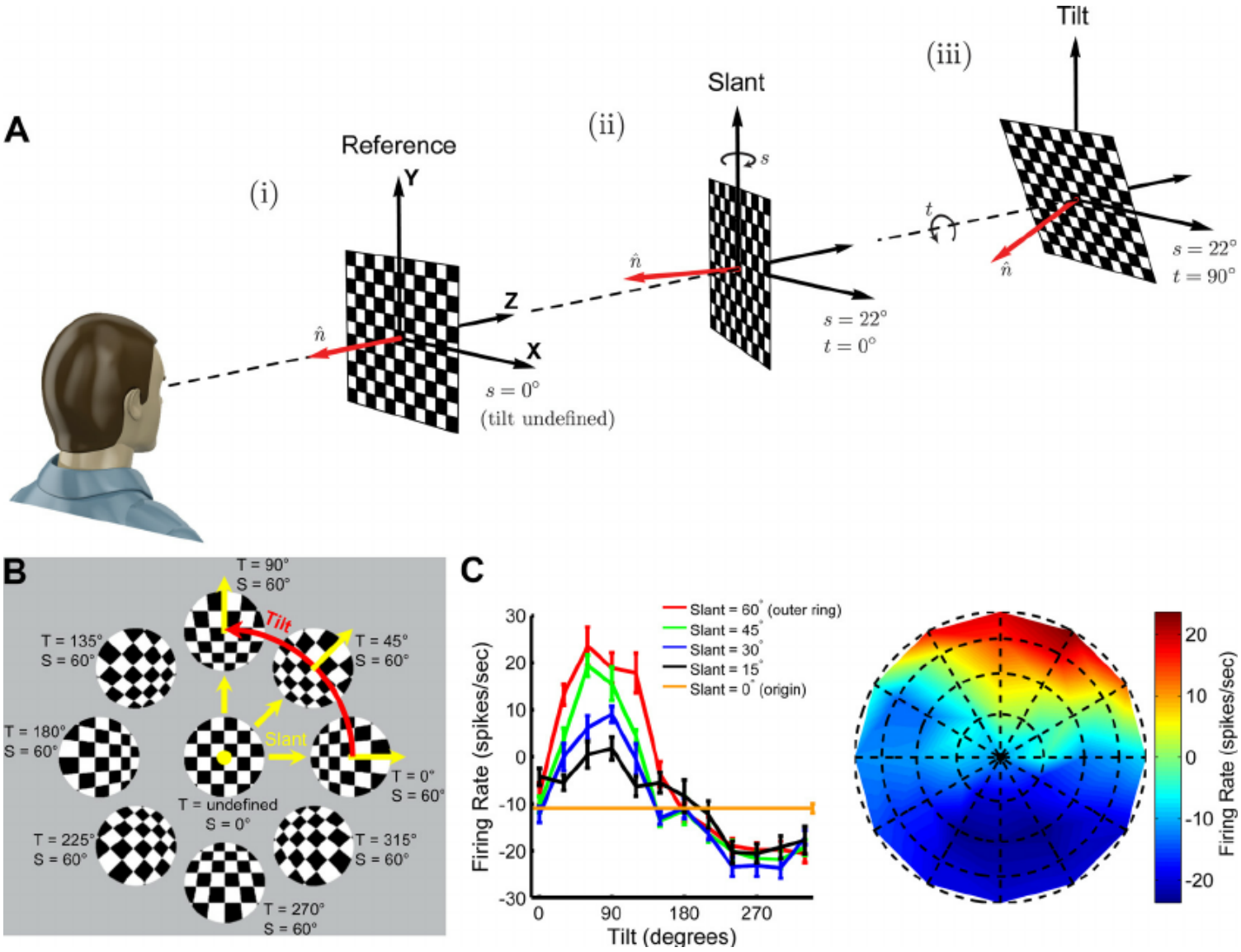
Discuss Leopold & Logothetis, N. K. (1996).

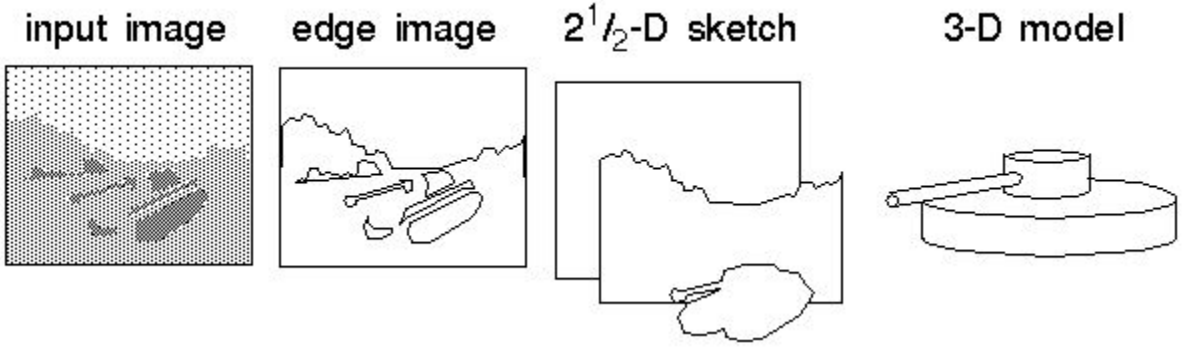
Term project

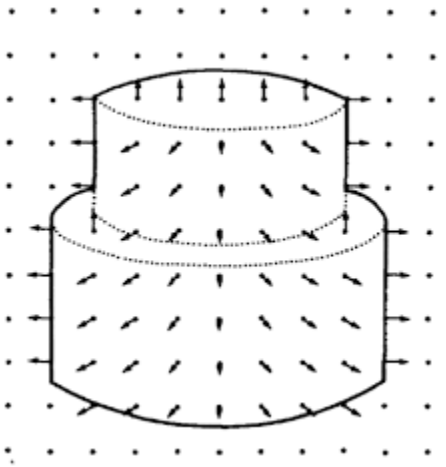
http://psu-psychology.github.io/psy-525-vision-spring-2018/project-proposal.html

Perceiving surfaces orientation (spatial layout)

Slant, tilt, distance


A
(i)
Reference
Y
Z
X
$\hat{n}$
$s = 0°$
(tilt undefined)
(ii)
Slant
s
$\hat{n}$
$s = 22°$
$t = 0°$
(iii)
Tilt
t
$\hat{n}$
$s = 22°$
$t = 90°$
B
T = 90°
S = 60°
Tilt
T = 135°
S = 60°
T = 45°
S = 60°
T = 180°
S = 60°
Slant
T = 0°
S = 60°
T = undefined
S = 0°
T = 225°
S = 60°
T = 315°
S = 60°
T = 270°
S = 60°
C
Slant = 60° (outer ring)
Slant = 45°
Slant = 30°
Slant = 15°
Slant = 0° (origin)
Firing Rate (spikes/sec)
Tilt (degrees)
Firing Rate (spikes/sec)





Marr's 2.5 D sketch

VISION

David Marr

FOREWORD BY
Shimon Ullman

AFTERWORD BY
Tomaso Poggio

Depth perception

> *"For those of a creationist bent, one could note that God must have loved depth cues, for He made so many of them"*

Yonas & Granrud, 1985, p. 45

Kinetic

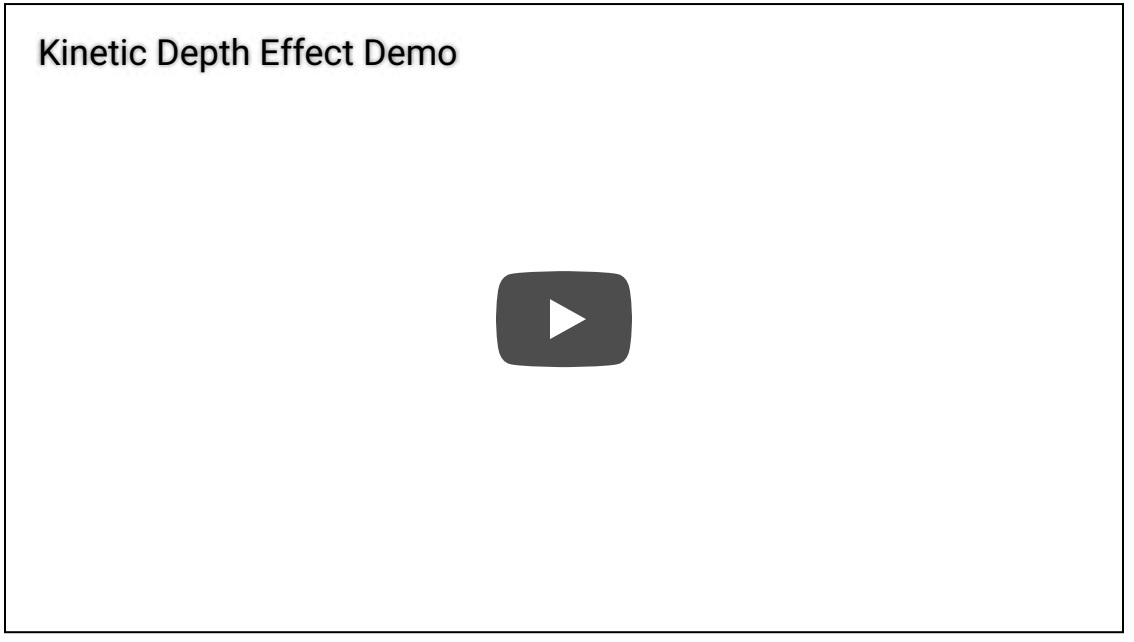
Binocular

Static (pictoral)

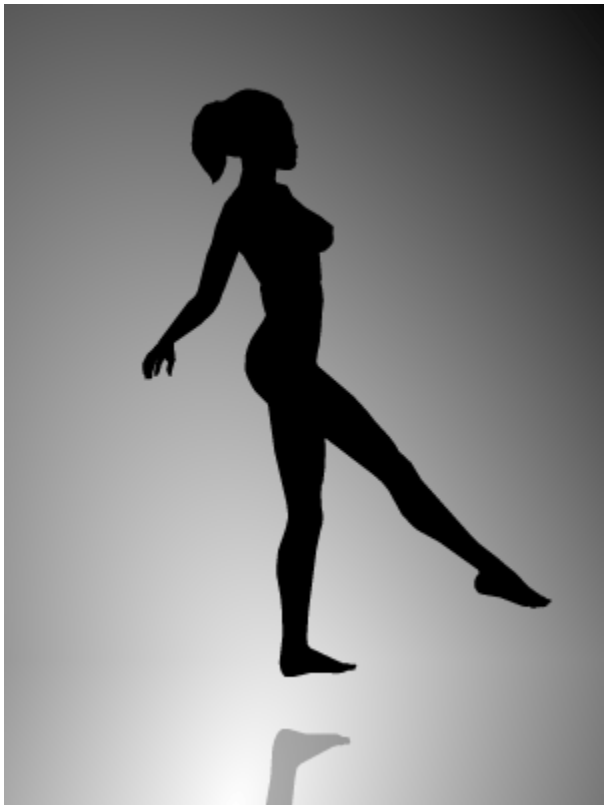
Sensorimotor

Monocular (kinetic, static, some sensorimotor) vs. binocular cues

Kinetic cues to depth



Kinetic depth effect (KDE)



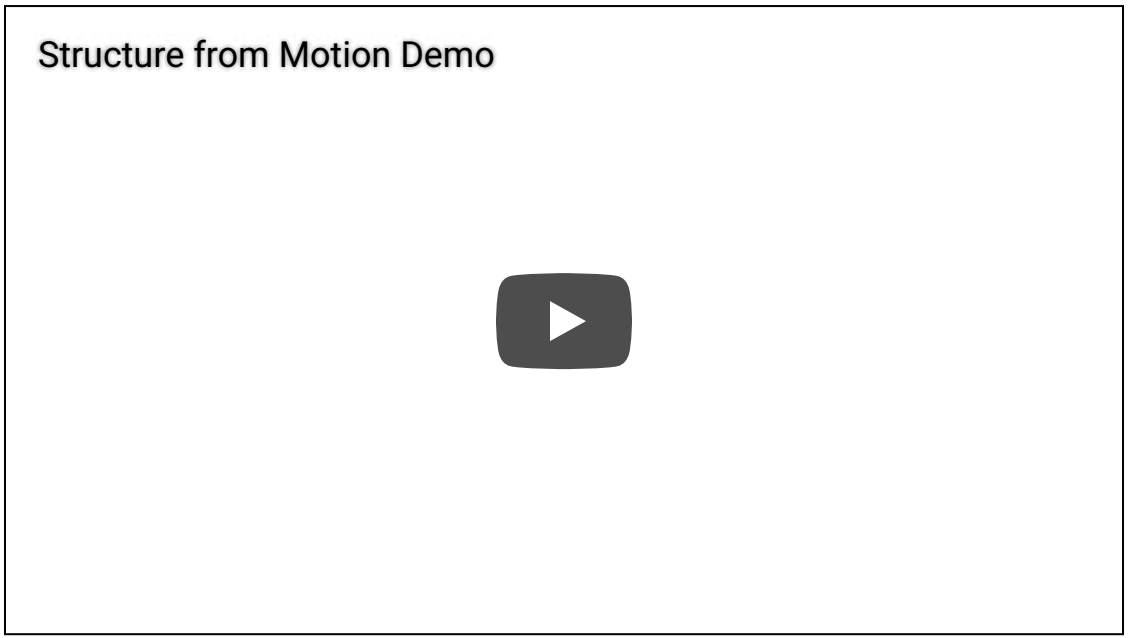
By Nobuyuki Kayahara - Procreo Flash Design Laboratory, CC BY-SA 3.0, Link

This one is also bistable

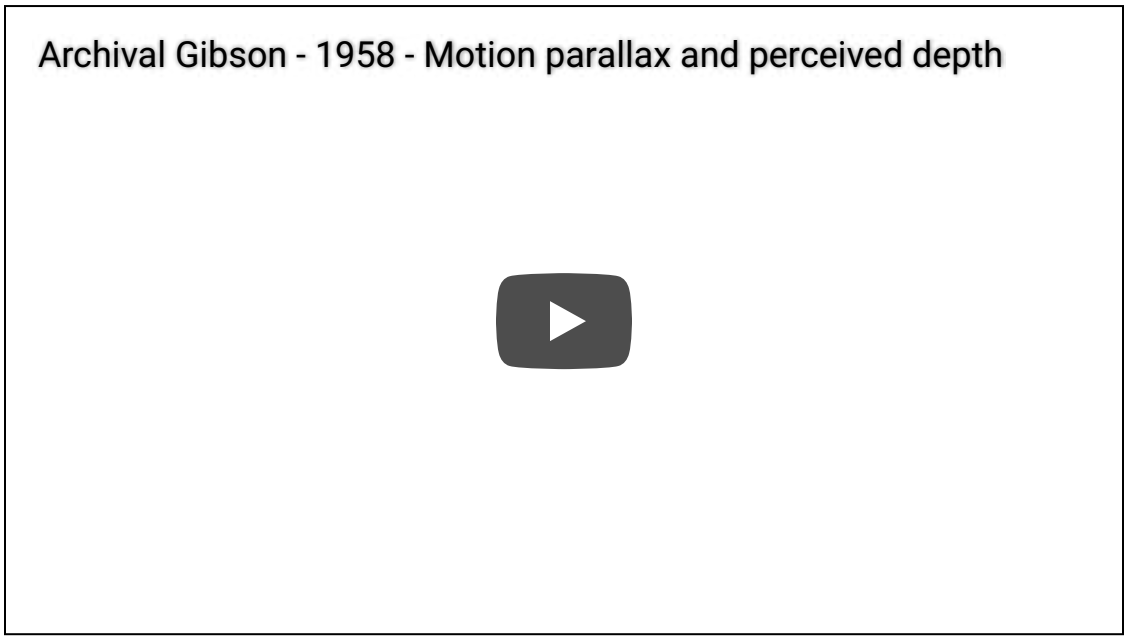
Kinetic depth effect

3D structure perceived from temporal sequence of 2D (outline-only) views.

Reported in Wallach, H., & O'Connell, D. N. (1953). The Kinetic Depth Effect. *Journal of Experimental Psychology*, *45*(4), 205.

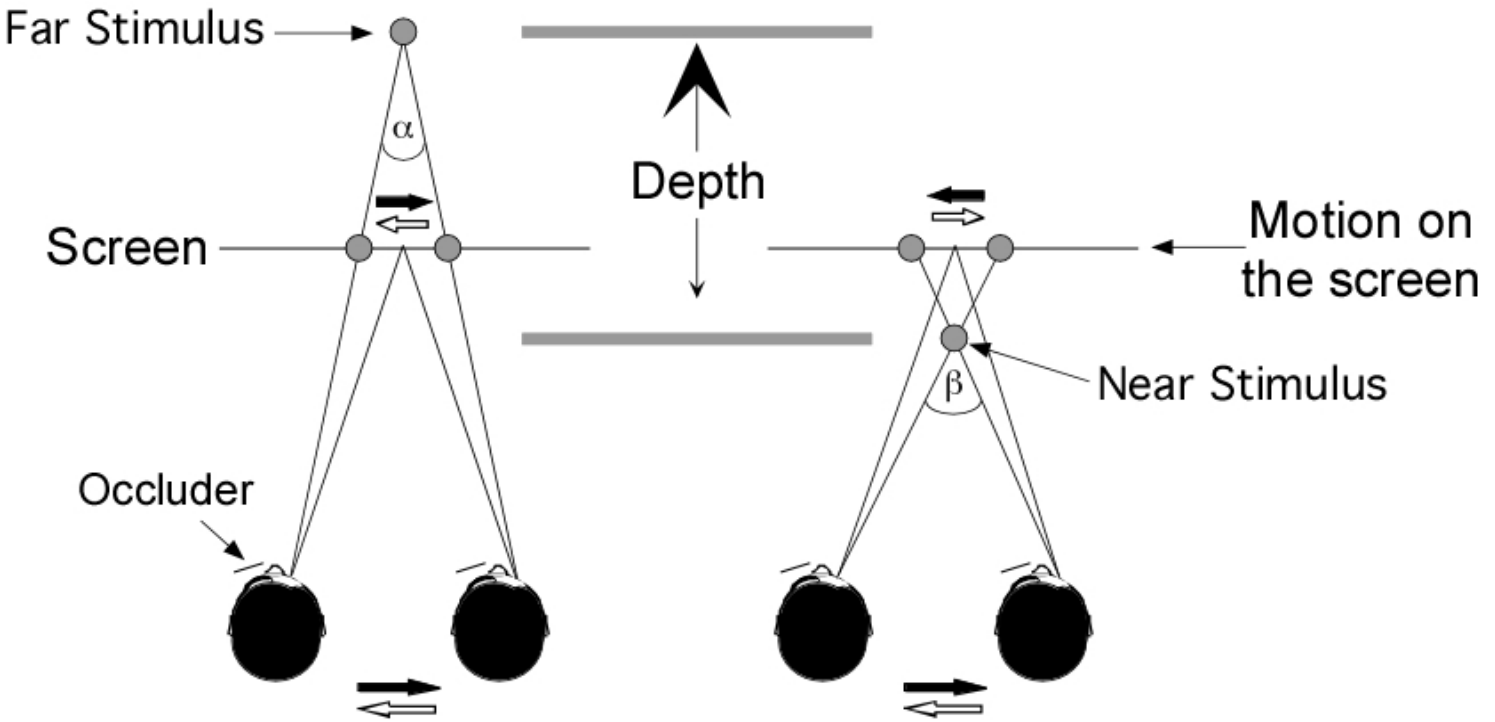


Structure from motion



Motion parallax

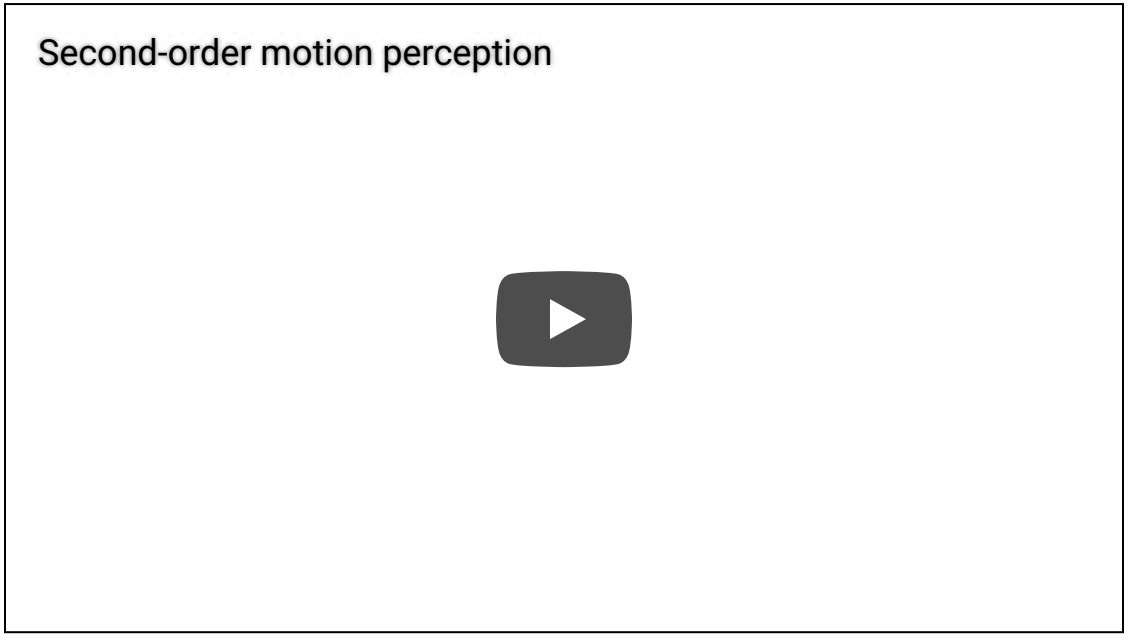
City motion parallax



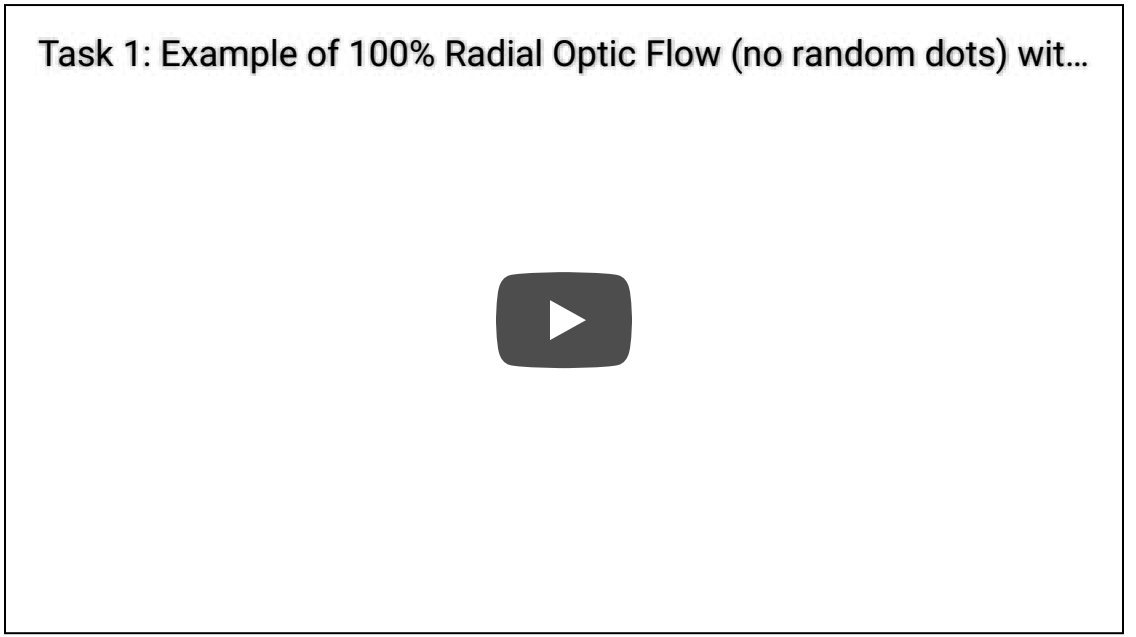
The geometry of motion parallax

Where is fixation? What is the direction of motion?

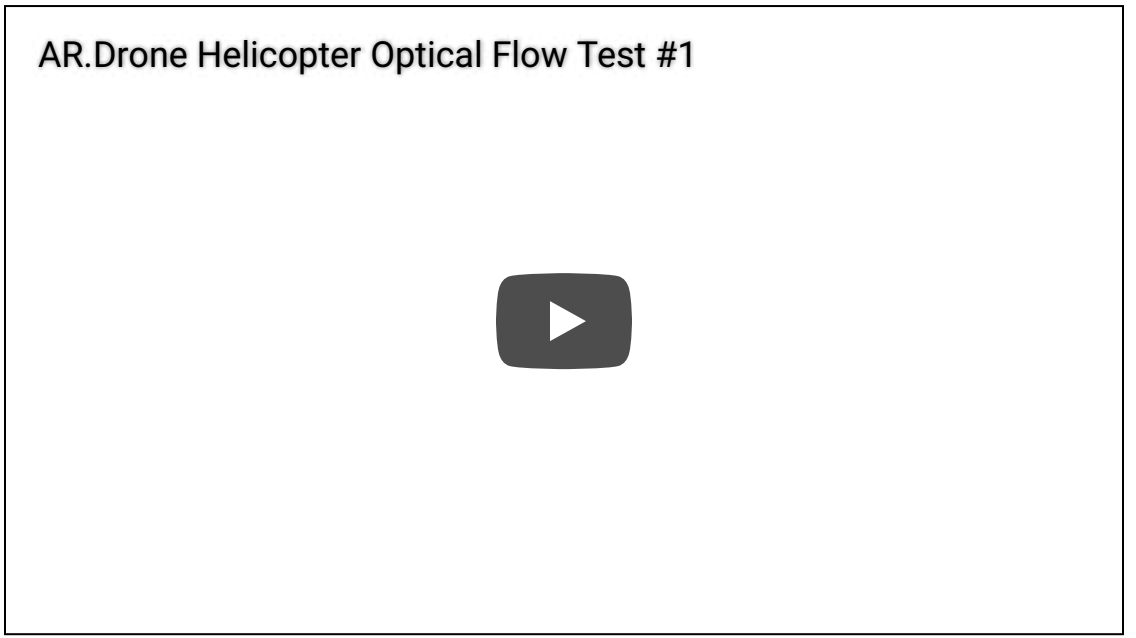
Texture accretion & deletion



Texture accretion & deletion



Optic flow

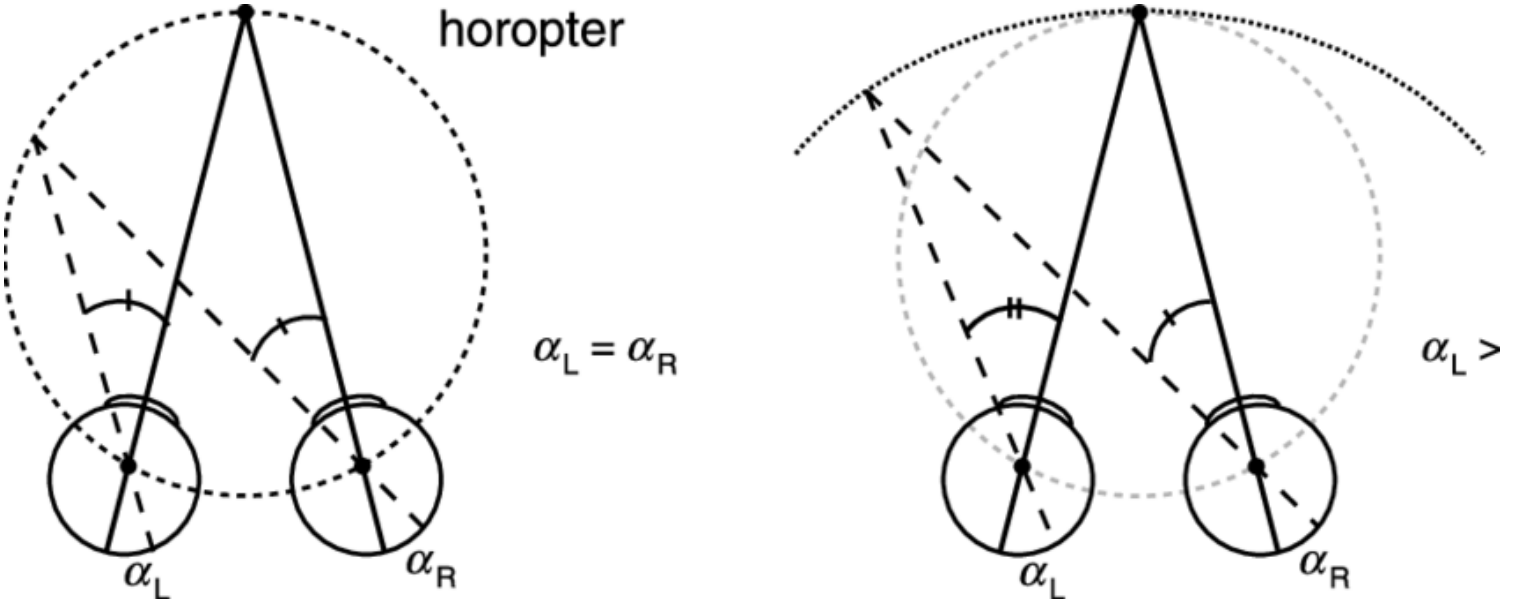


Optic flow and autonomous flight

Binocular cues to depth

Stereopsis

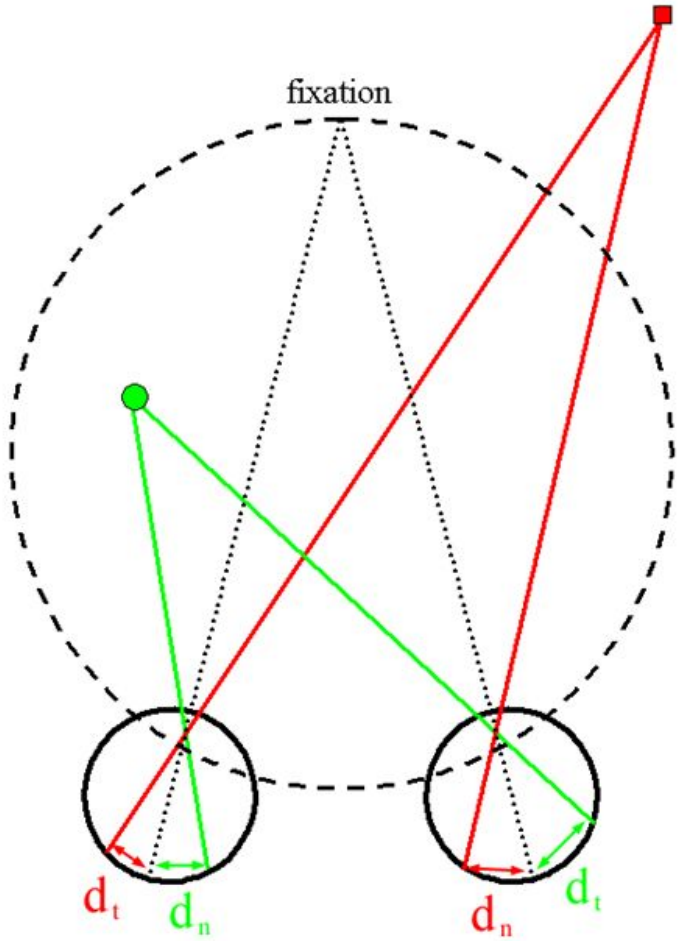
Perception of depth and 3D structure from stimulation of both eyes



Horopter

a line or surface containing all those points in space whose images fall on corresponding points of the retinas of the two eyes.

"Crossed" and Uncrossed" Retinal Disparity



The corresponding locations for the "closer" green stimulus exhibits positive retinal disparity

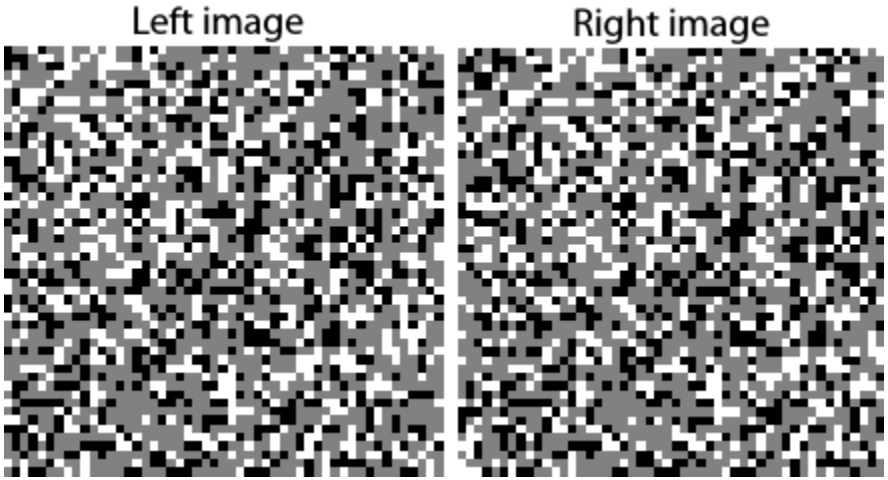
$D = d_{temporal} - d_{nasal} > 0$
(or "crossed" disparity)

The corresponding locations for the "farther" red stimulus exhibits negative retinal disparity

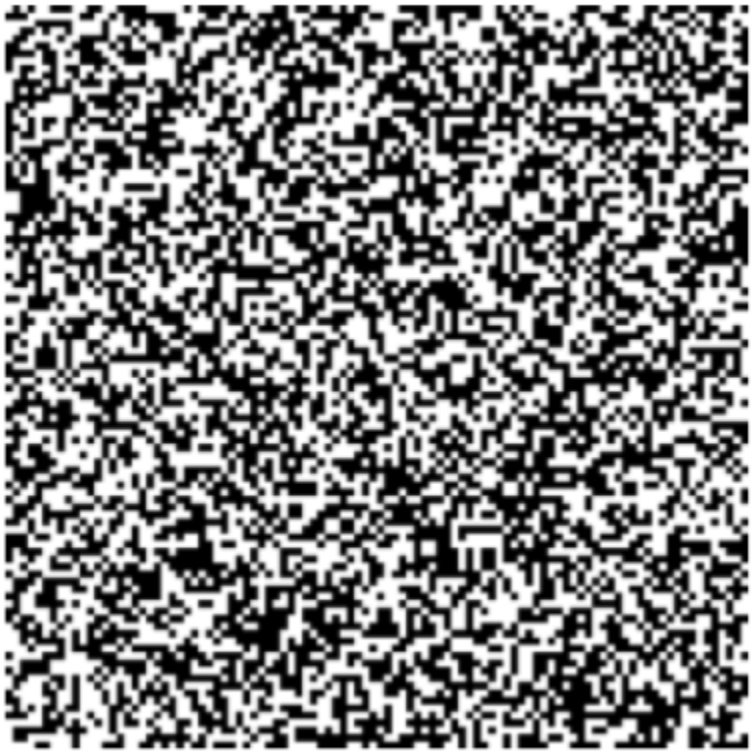
$D = d_{temporal} - d_{nasal} < 0$
(or "uncrossed" disparity)

Random-dot stereograms

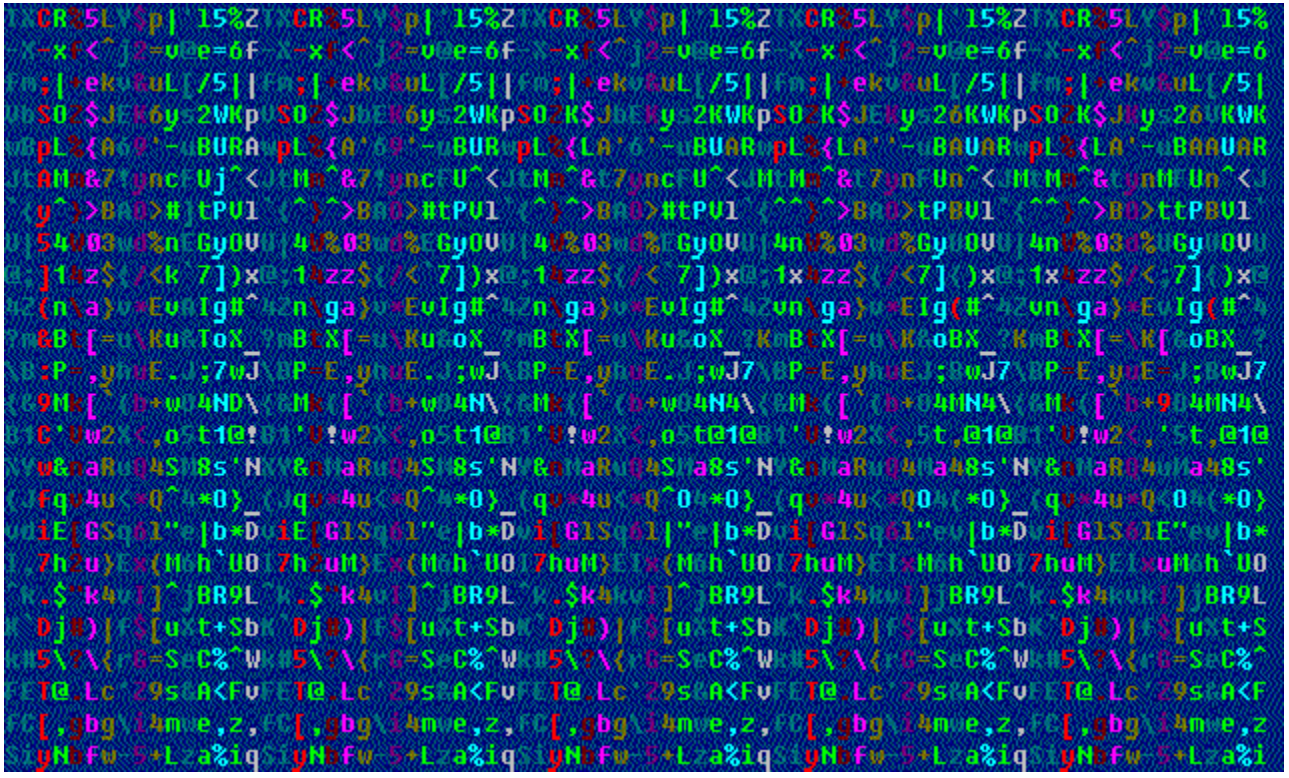
Invented by Béla Julesz


Left image
Right image

```
library(imager)
n_pts <- 100
left_img <- array(round(runif(n=n_pts^2),0), dim = c(n_pts, n_pts))
plot(as.cimg(left_img), axes=FALSE)
```

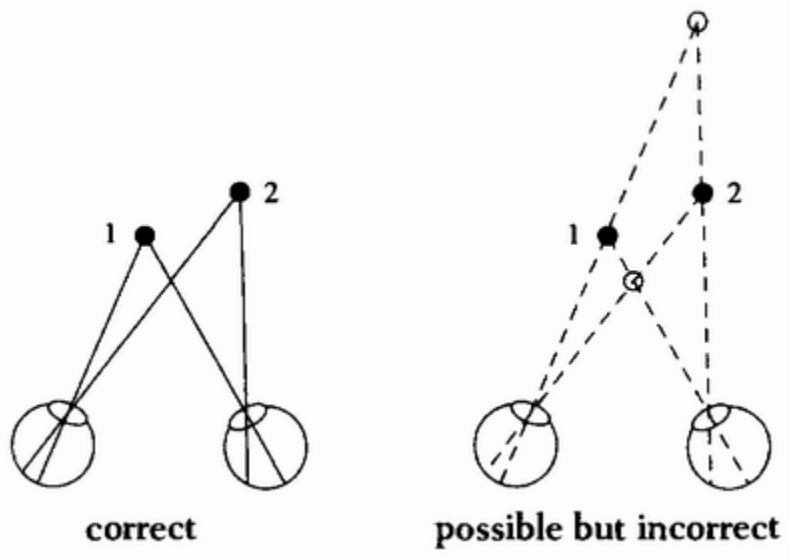


```
right_img <- left_img
square_pix <- 20
center_square <- right_img[floor(n_pts/2-square_pix/2):floor(n_pts/2-
plot(as.cimg(center_square), axes=FALSE)
```



Auto-stereogram

Can't really fuse these from *projected* image. Why?



The "correspondence" problem

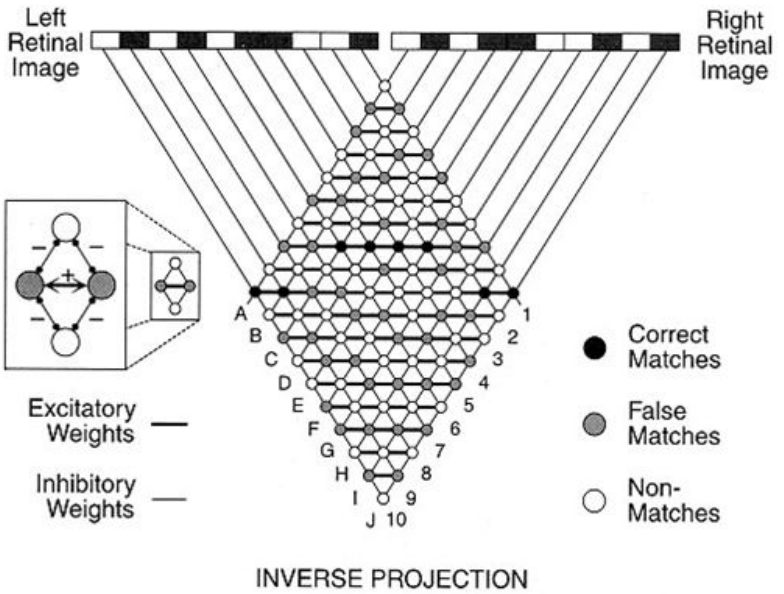
How do retinal image points/edges correspond to object points/edges?

Why can it take time to "fuse" stereograms?

Marr-Poggio's network-based formulation of the problem:

Assumptions:

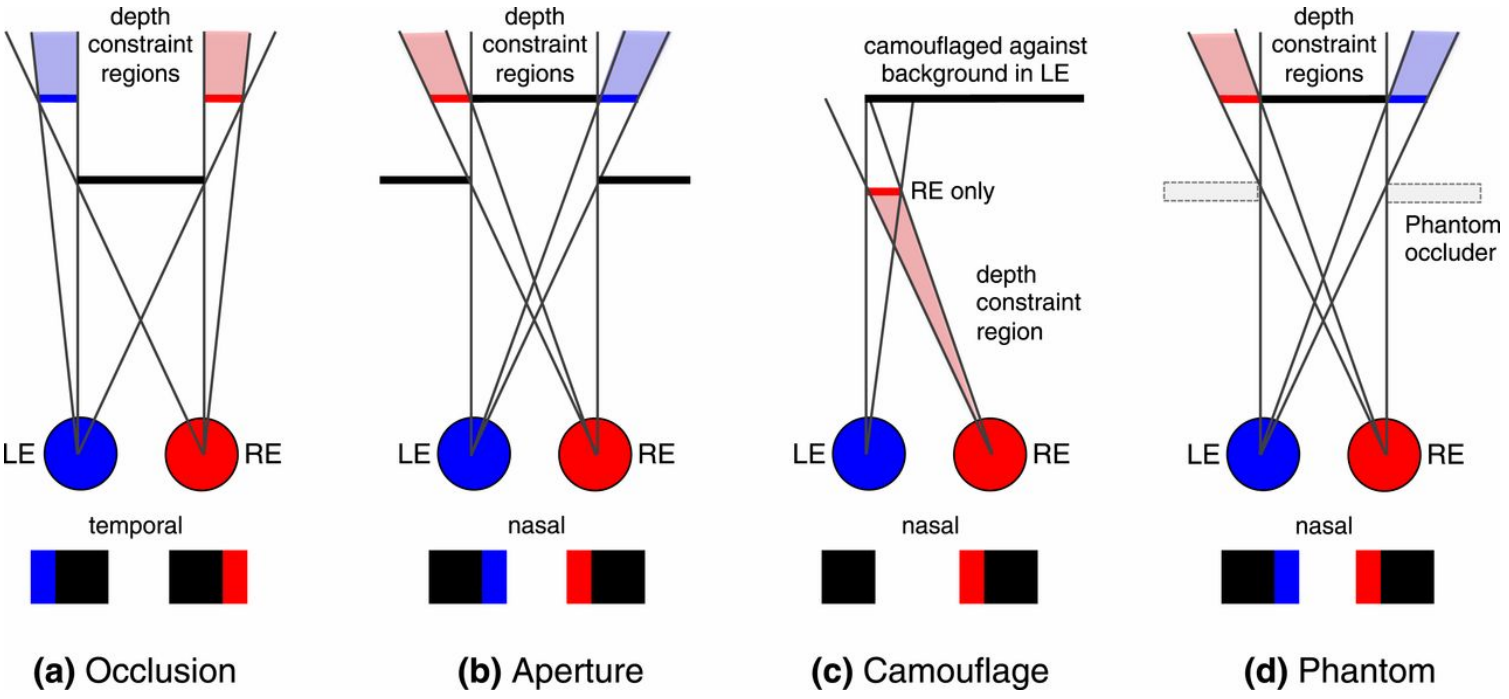
1. Surface opacity / match uniqueness
2. Surface continuity
3. Match compatibility



Marr-Poggio algorithm for solving

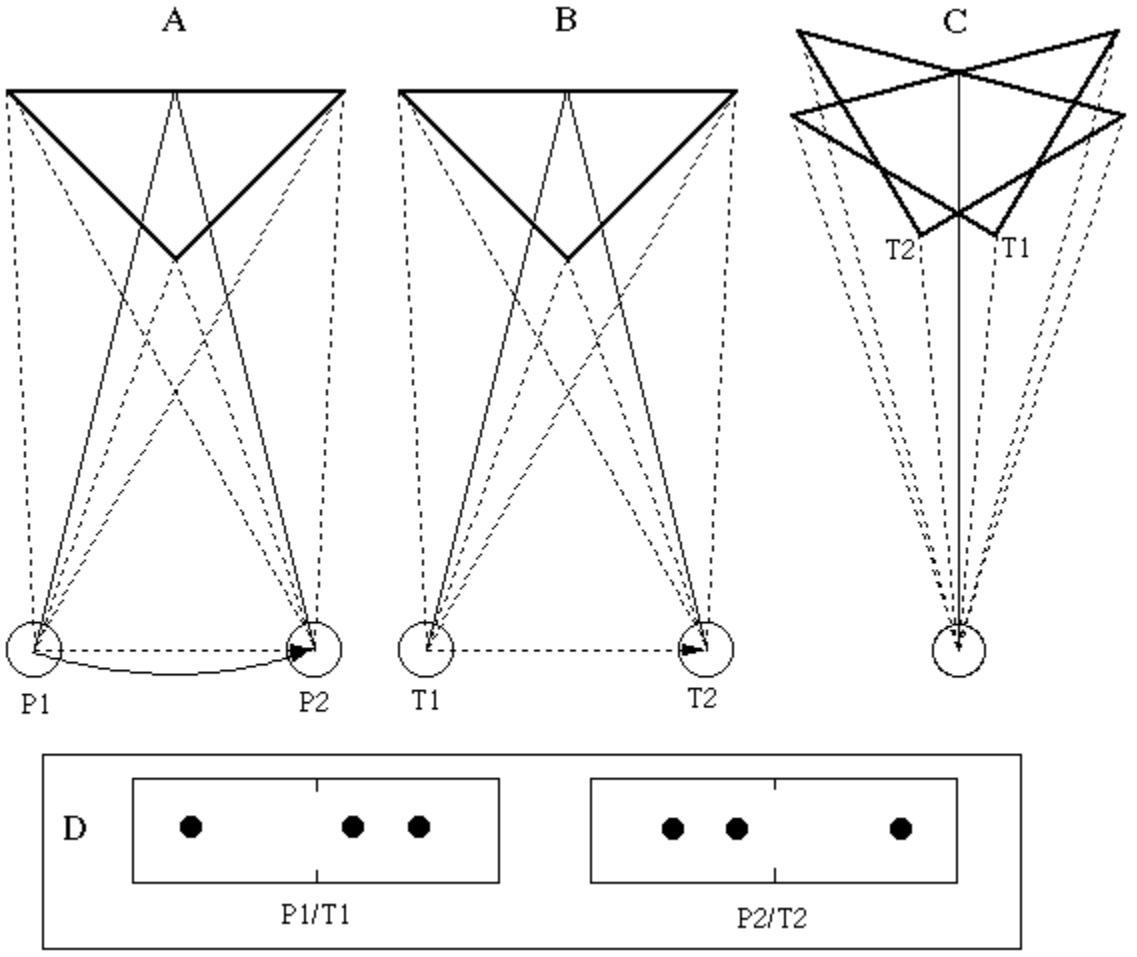
Use: surface opacity & surface continuity heuristics

Iterate until a best-fitting solution is found



Da Vinci stereopsis

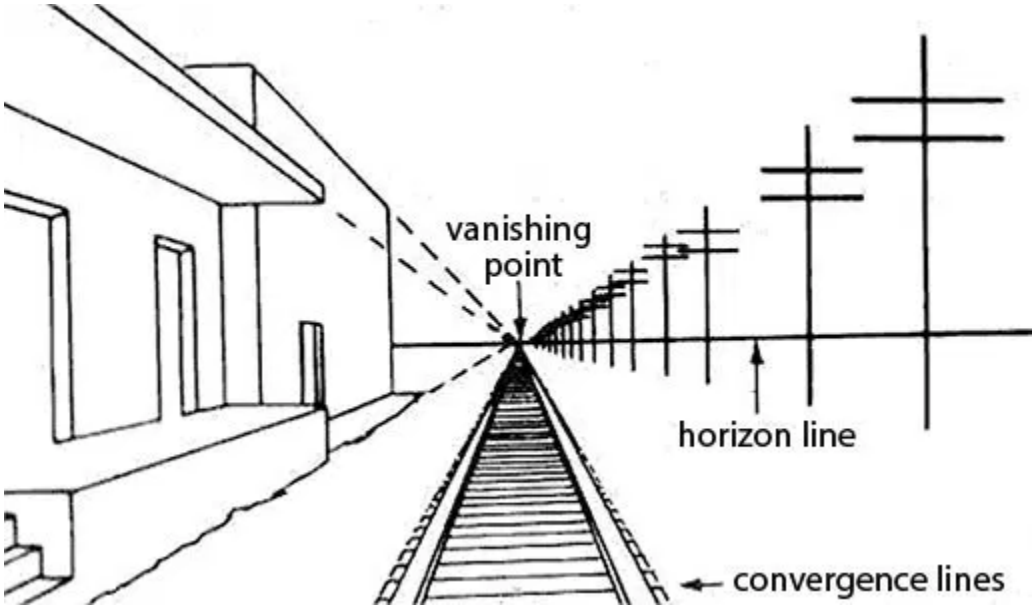
Different eyes see different portions of surfaces



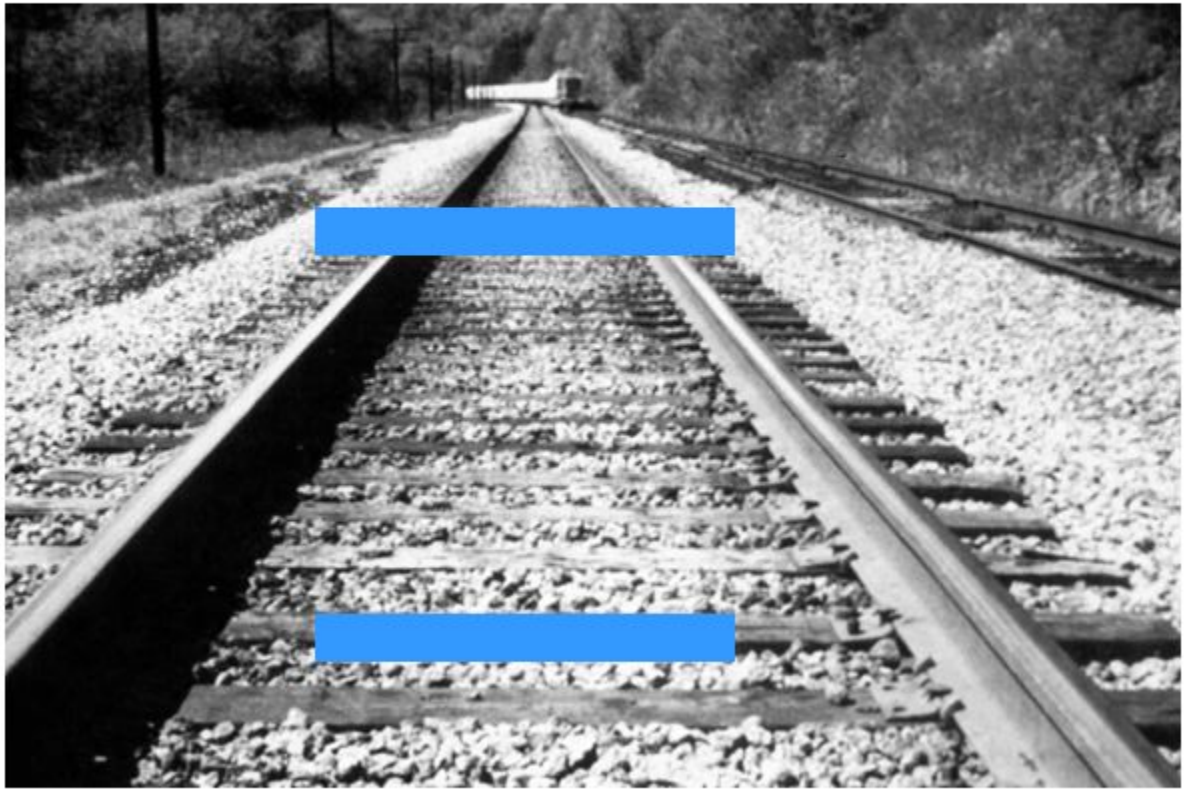
Geometry of self-motion, object-motion, and disparity

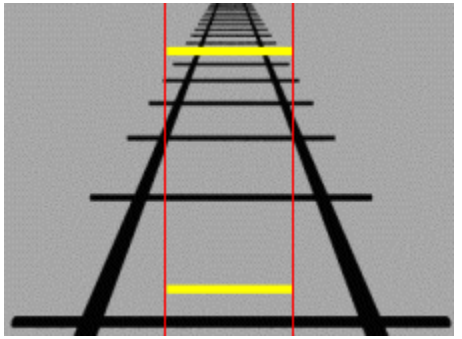
Static (pictoral) cues to depth

Linear Perspective


vanishing
point
horizon line
convergence lines

Linear perspective



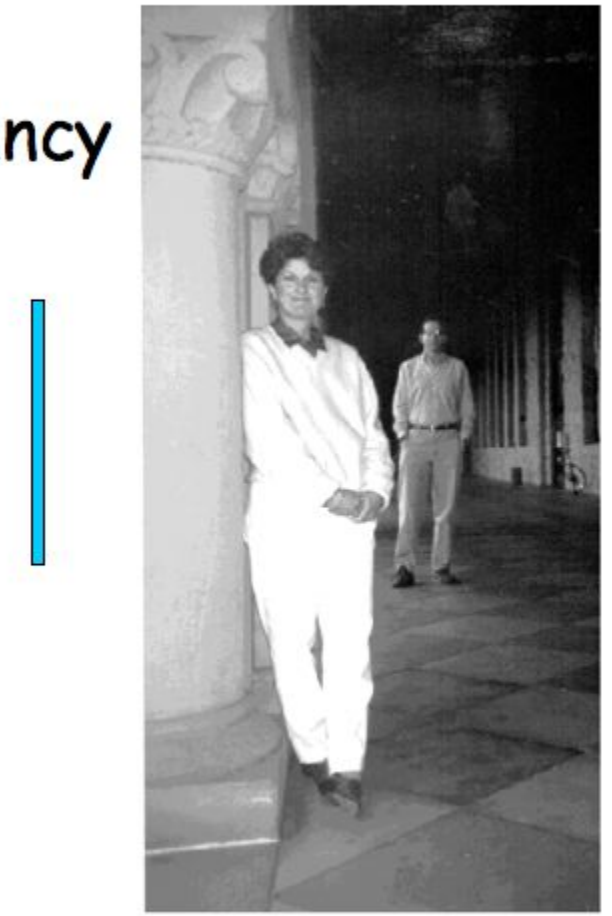


Public Domain, Link

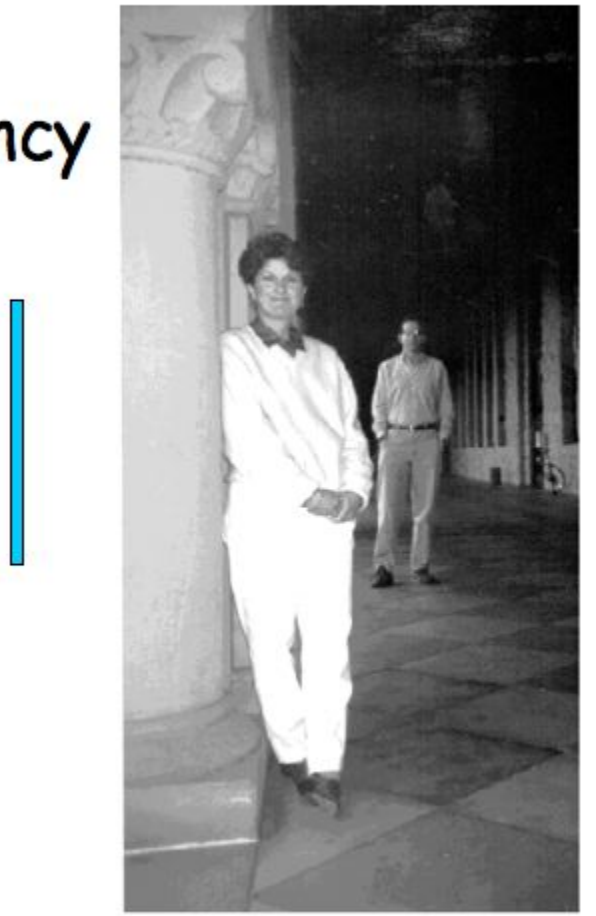
Linear perspective + elevation over horizon = Ponzo illusion

Relative size

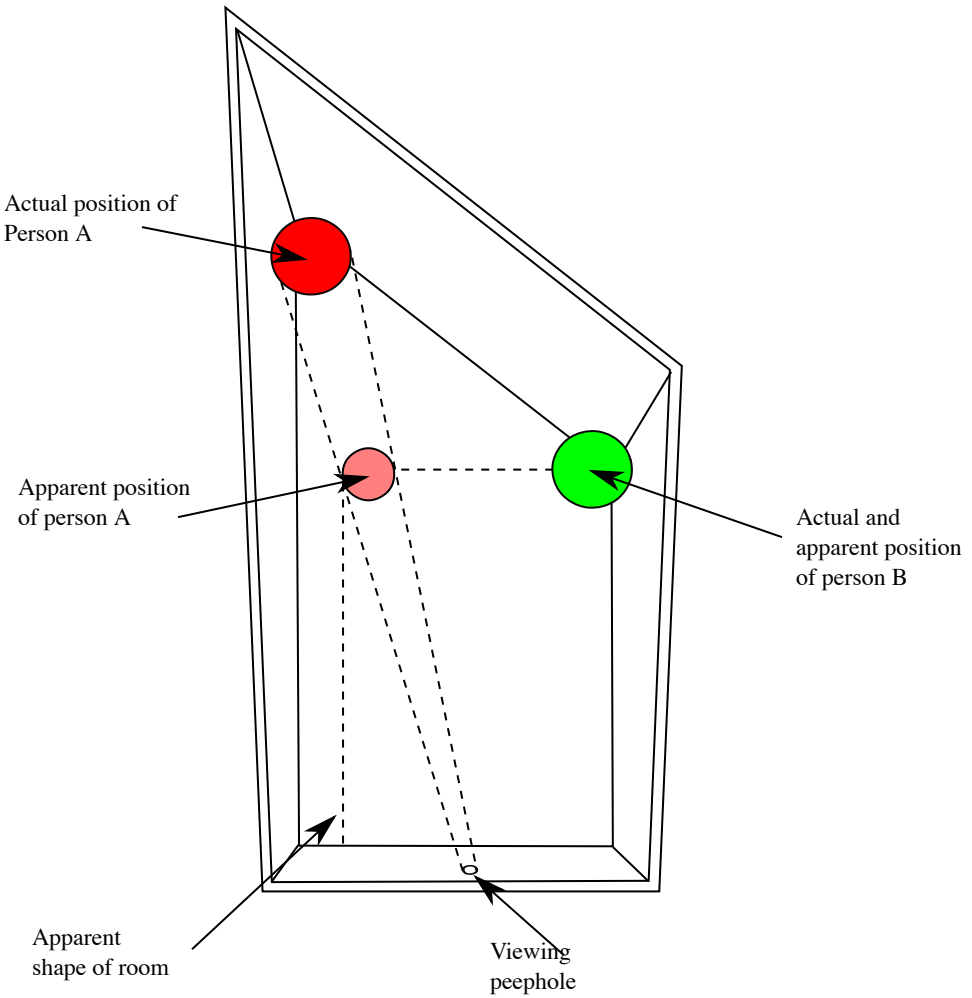
Size constancy



Size constancy



Ames room



https://en.wikipedia.org/wiki/Ames_room

Aerial perspective

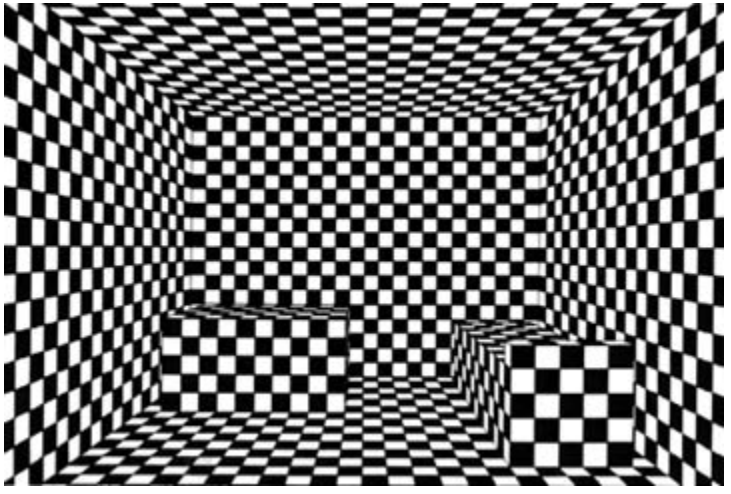
Defocus blur

By Joaquim Alves Gaspar - Own work, CC BY-SA 2.5, Link

Interposition, occultation

Texture gradients

By Gustave Caillebotte - 5wEUCOlEf-EaVQ at Google Cultural Institute maximum zoom level, Public Domain, Link



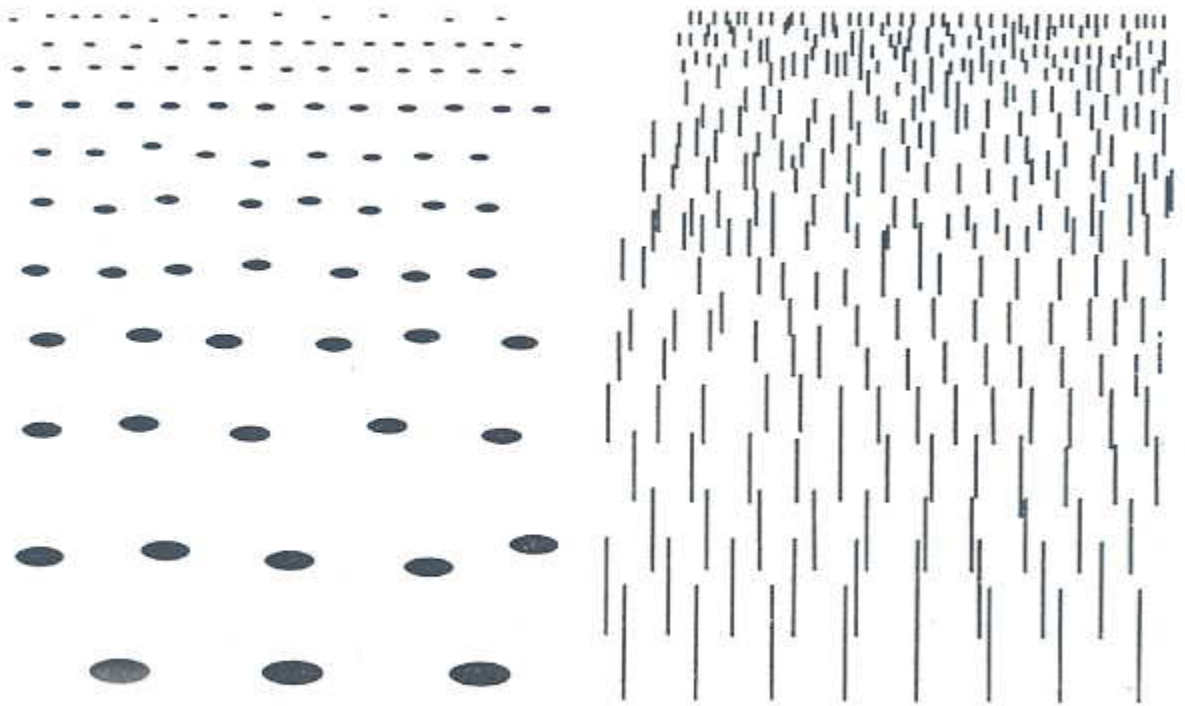
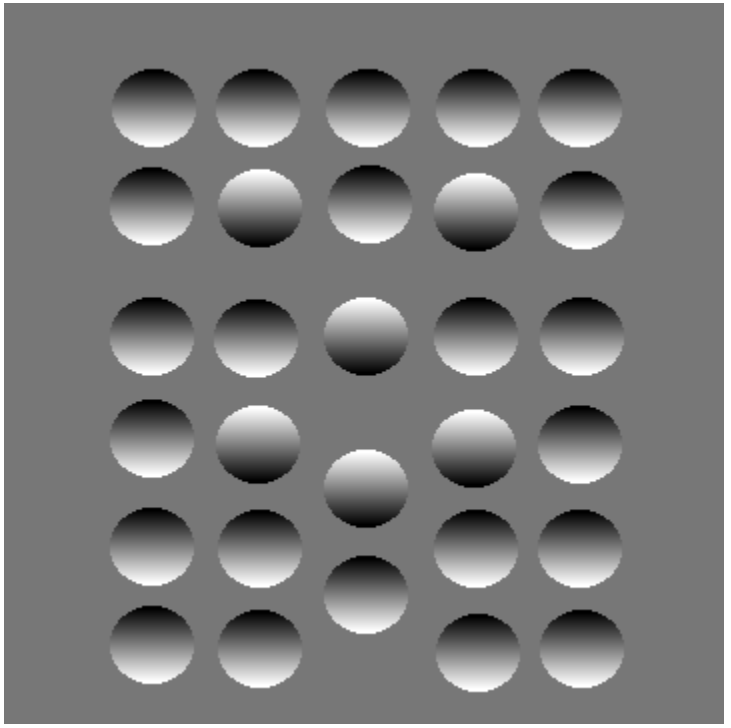


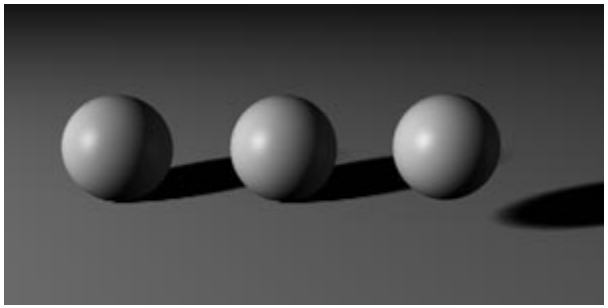
FIGURE 2.8: Examples of texture gradient. (From Gibson, 1950.)

http://psychsciencenotes.blogspot.com/2011/08/mirrors-are-literally-windows-to.html

Lighting, shading, & shadow cues

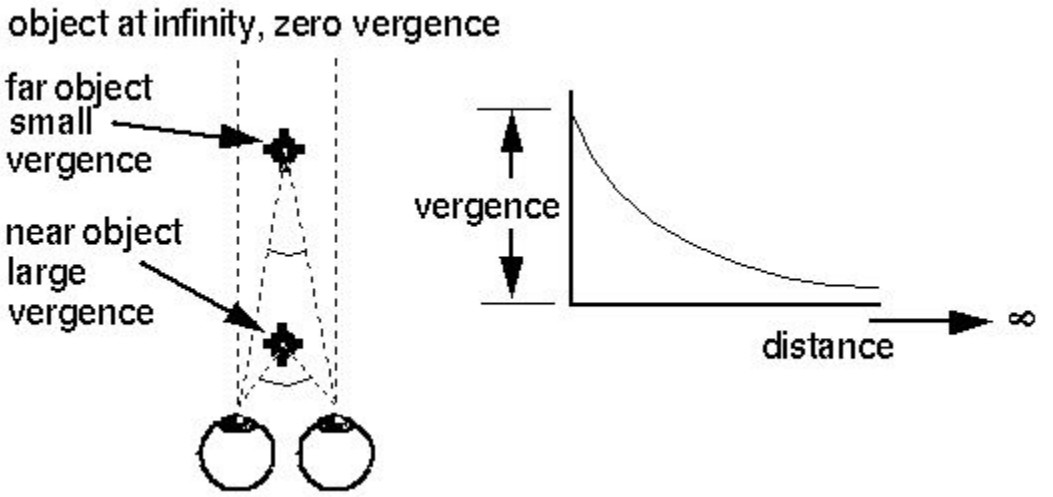
Cast Shadows





Sensorimotor cues to depth

Palmer's "ocular" cues

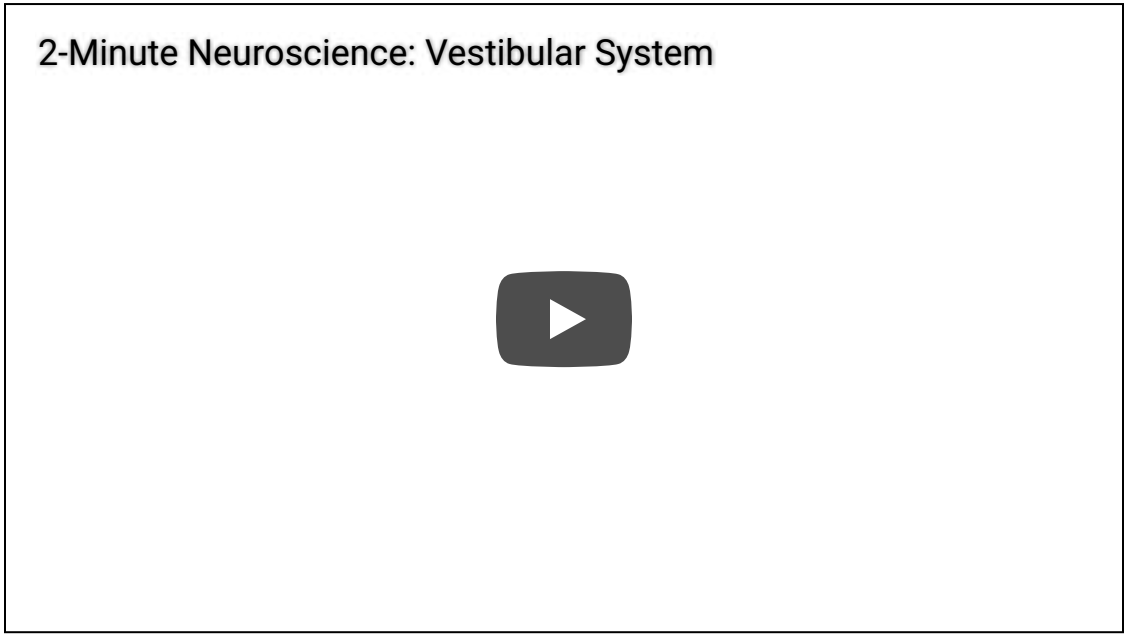


Vergence

Eyes (typically) *converge* on a 3D point. Angle of vergence related to 3D geometry.

Accommodation

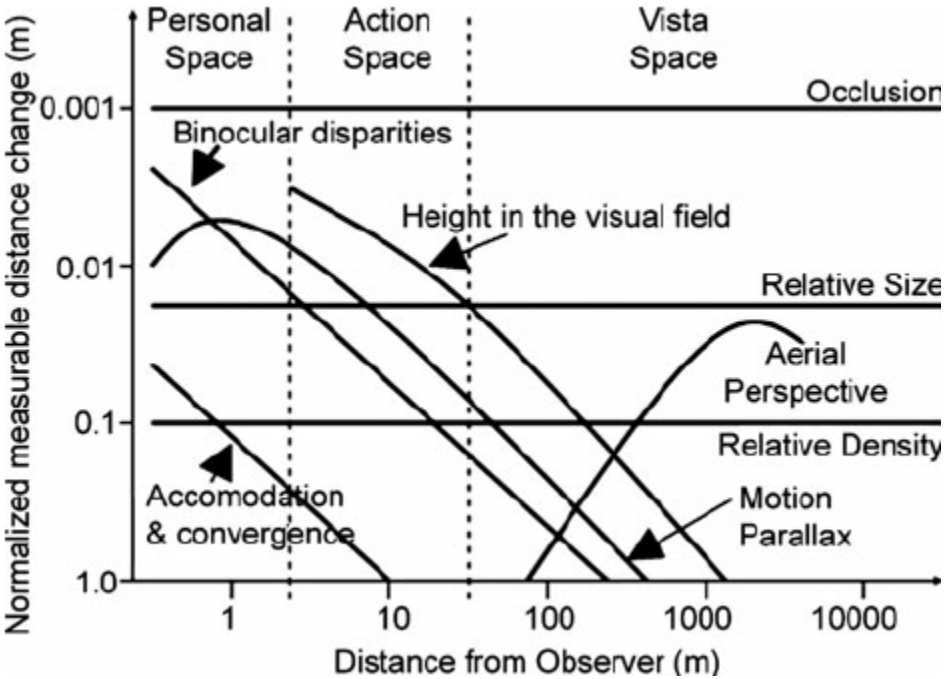
Vergence, pupil diameter change, + accommodation



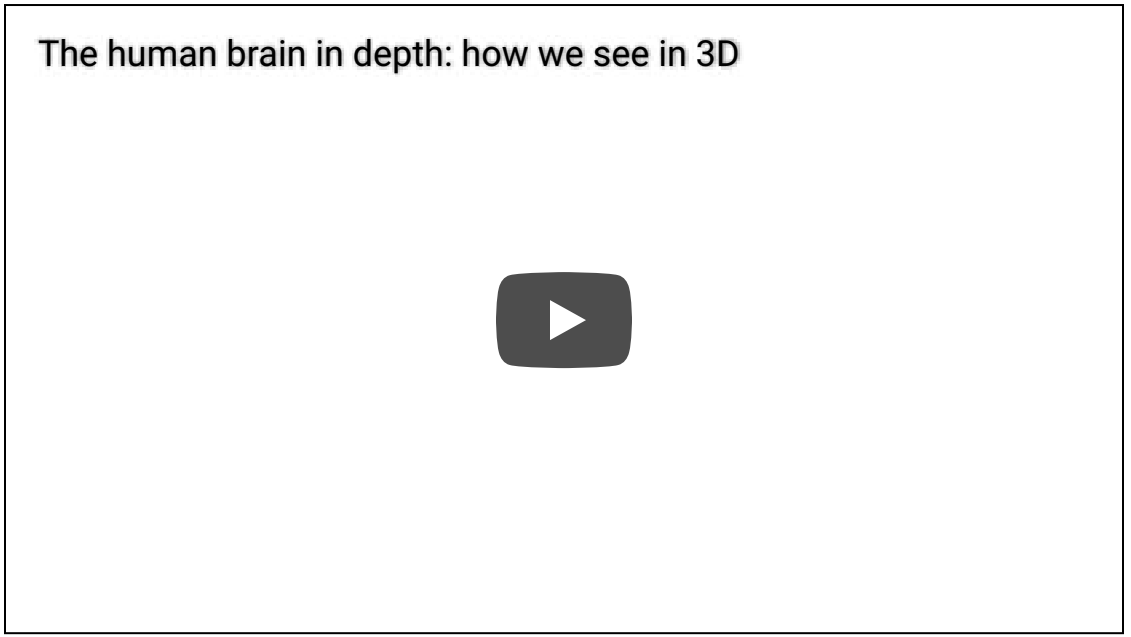
Vestibular system detects head rotation, translation

Vestibular signals speed, direction of rotation, translation

More motion parallax with head translation than rotation



Comparing the cues



Integrating the cues

Welchman, A. E. (2016). The human brain in depth: how we see in 3D. *Annual Review of Vision Science*. annualreviews.org. Retrieved from http://www.annualreviews.org/doi/abs/10.1146/annurev-vision-111815-114605

Heuristics

About world, illumination conditions

Alternative view:

These aren't cues; they are information. Animals don't "reconstruct" 3D space; they perceive it directly.

Amazing T-Rex Illusion!

Break time

Leopold & Logothetis, N. K. (1996)

Core phenomena

- Binocular rivalry
- Neural basis of binocular rivalry
- Neural basis of "conscious" visual experience

Next time...

Perceptual organization

Size, shape, orientation, & position

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