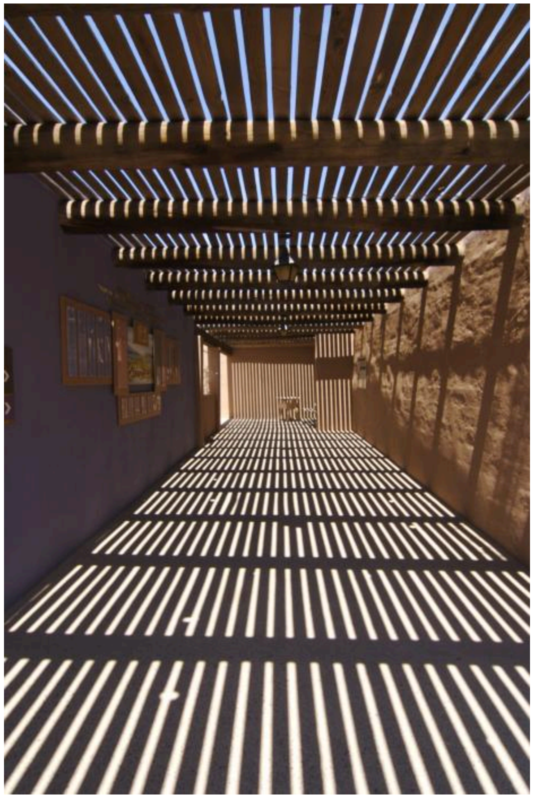
Depth Perception, part II

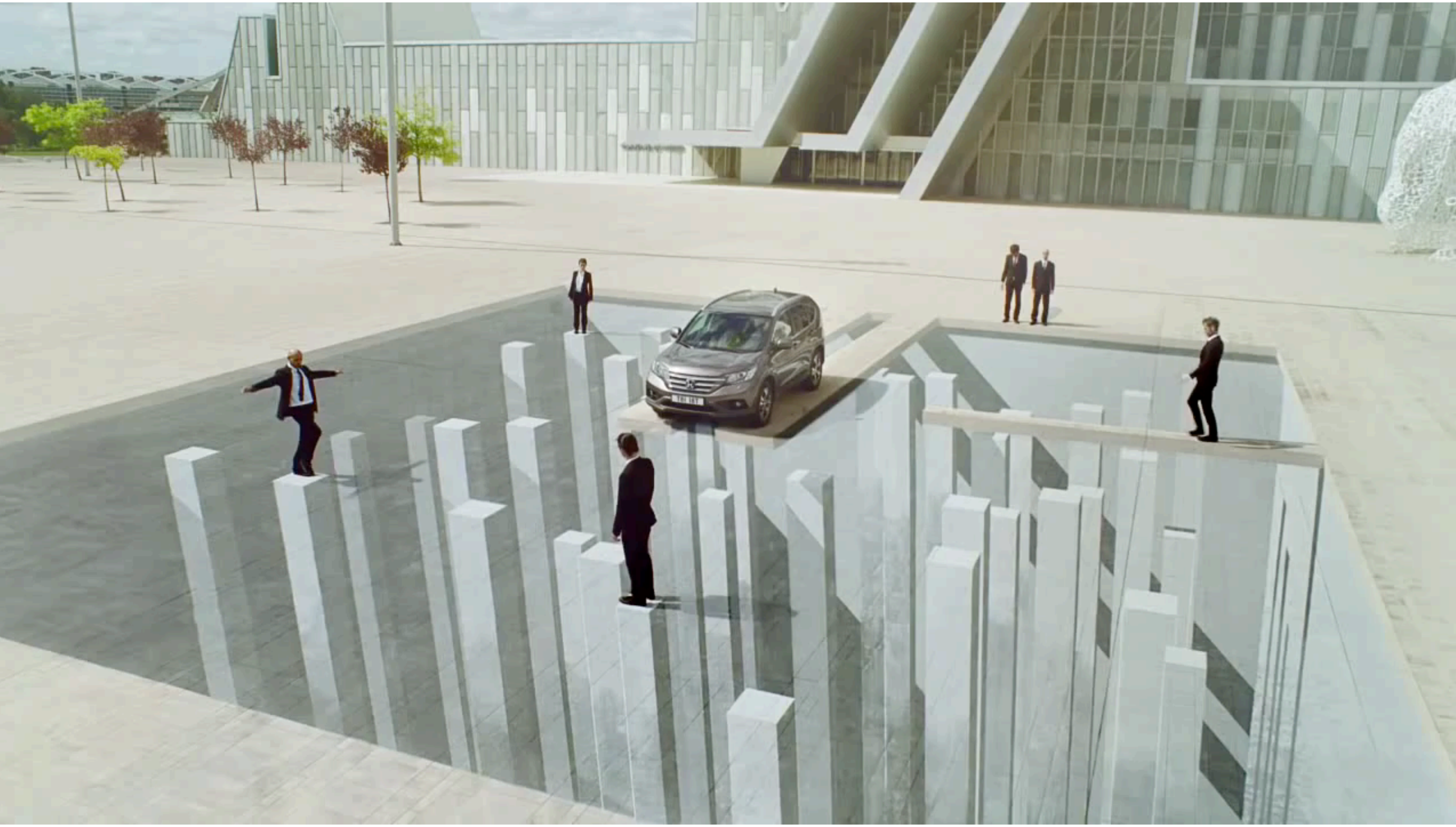


Lecture 12
(Chapter 6)

Jonathan Pillow
Sensation & Perception (PSY 345 / NEU 325)
Spring 2019

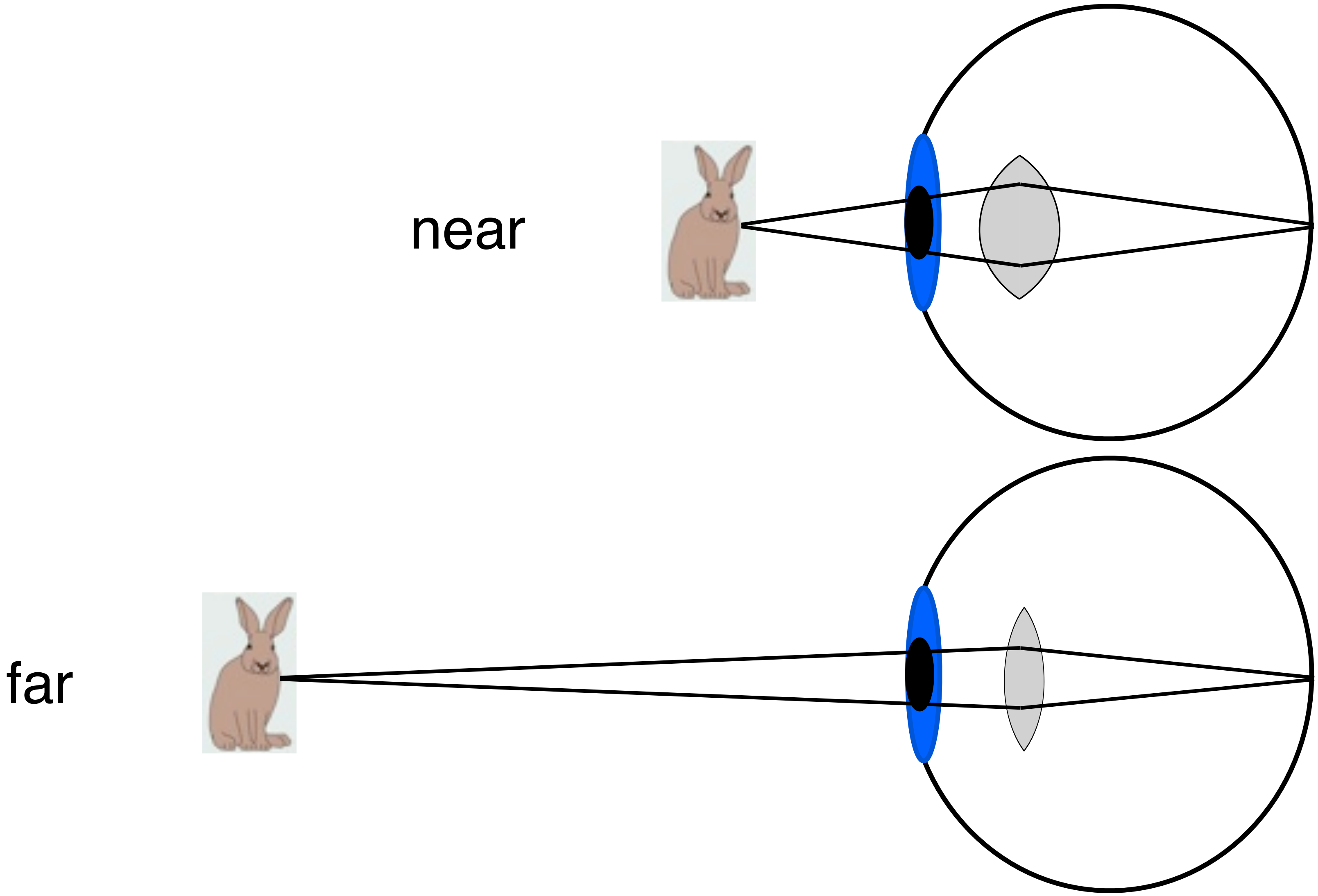
nice illusions video - car ad (2013)

(anamorphosis, linear perspective, accidental viewpoints, shadows, depth/size illusions)



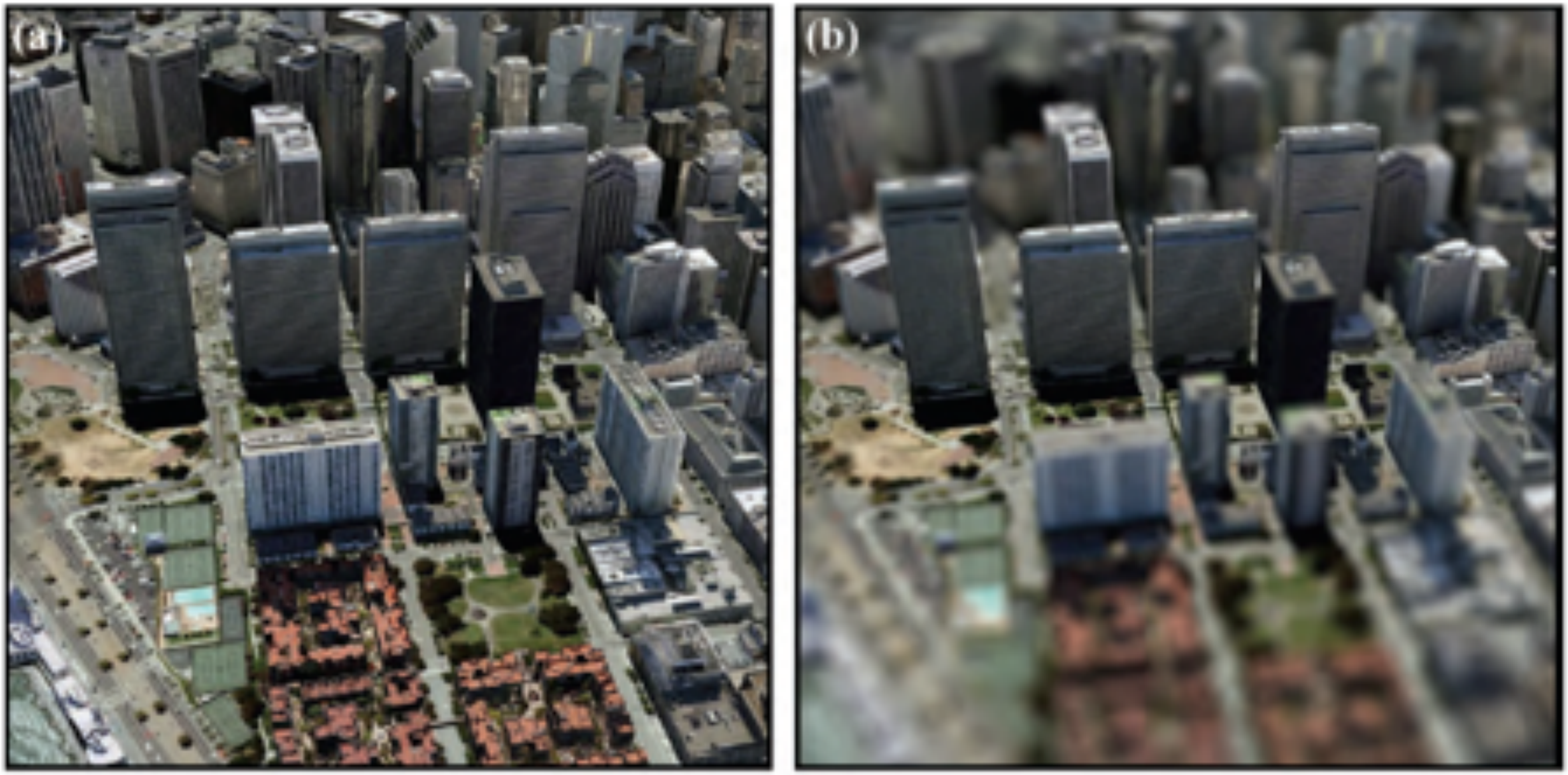
https://www.youtube.com/watch?v=dNC0X76-QRI

Accommodation - “depth from focus”



Depth and scale estimation from accommodation

“tilt shift photography”



Depth and scale estimation from accommodation

“tilt shift photography”

Depth and scale estimation from accommodation

"tilt shift photography"

Depth and scale estimation from accommodation

“tilt shift photography”

Depth and scale estimation from accommodation

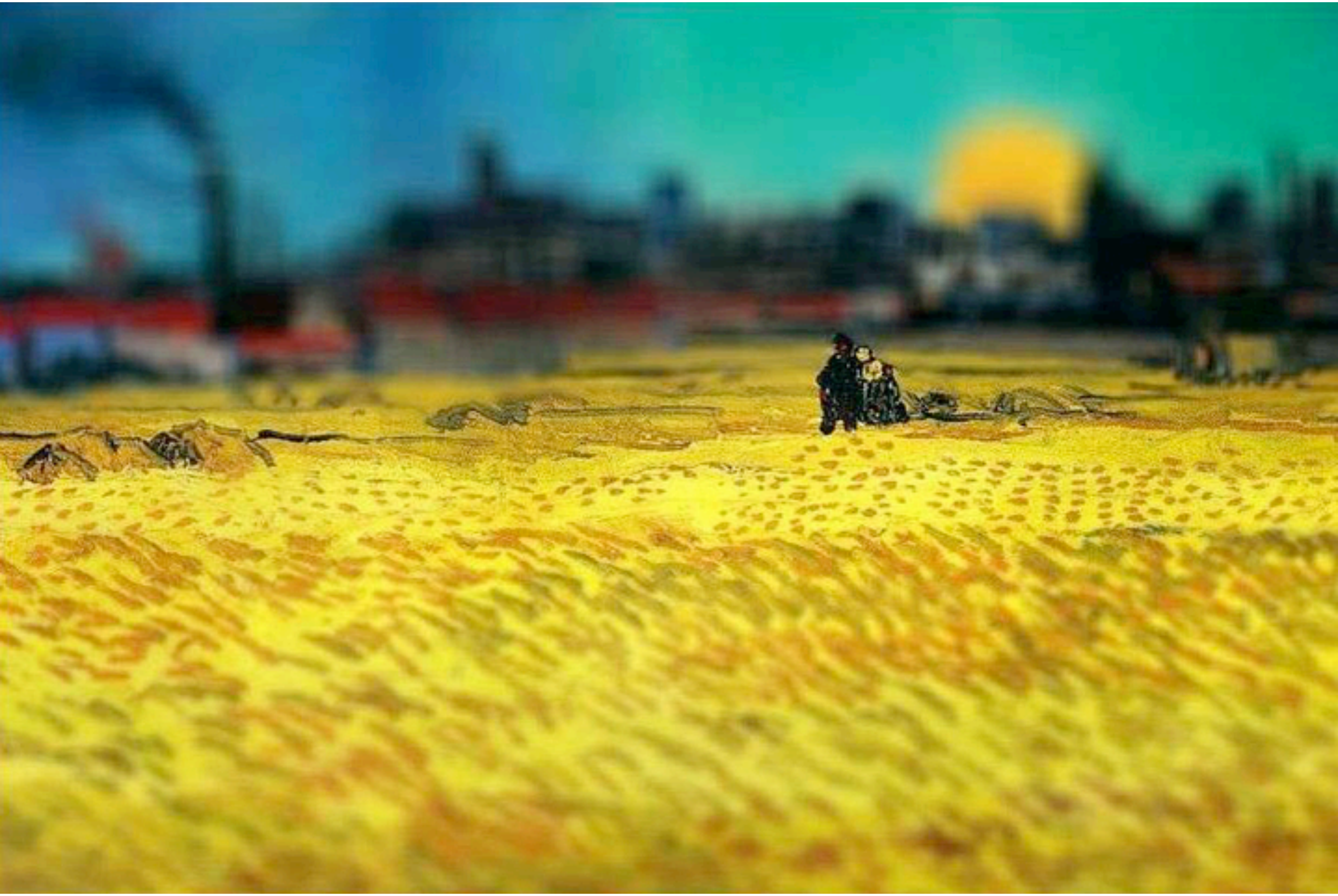
“tilt shift photography”

more on tilt shift: Van Gogh

http://www.mymodernmet.com/profiles/blogs/van-goghs-paintings-get

Tilt shift on Van Gogh paintings

http://www.mymodernmet.com/profiles/blogs/van-goghs-paintings-get



countering the depth-from-focus cue

Monocular depth cues:

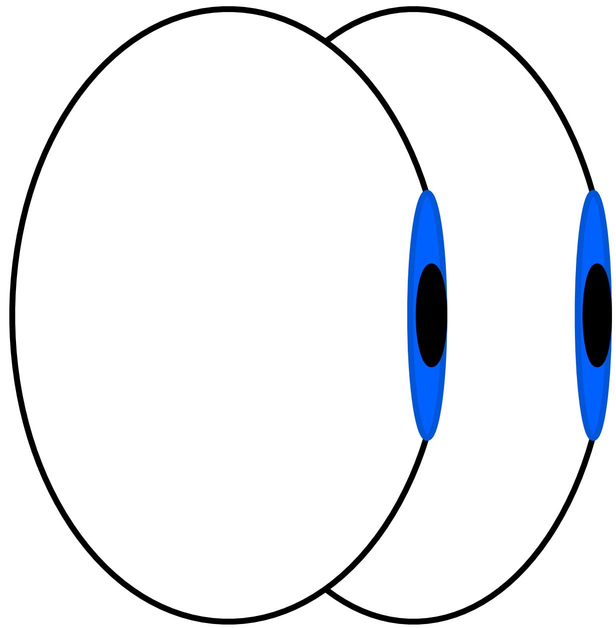
Pictorial

- occlusion
- relative size
- shadow
- texture gradient
- height in plane
- linear perspective

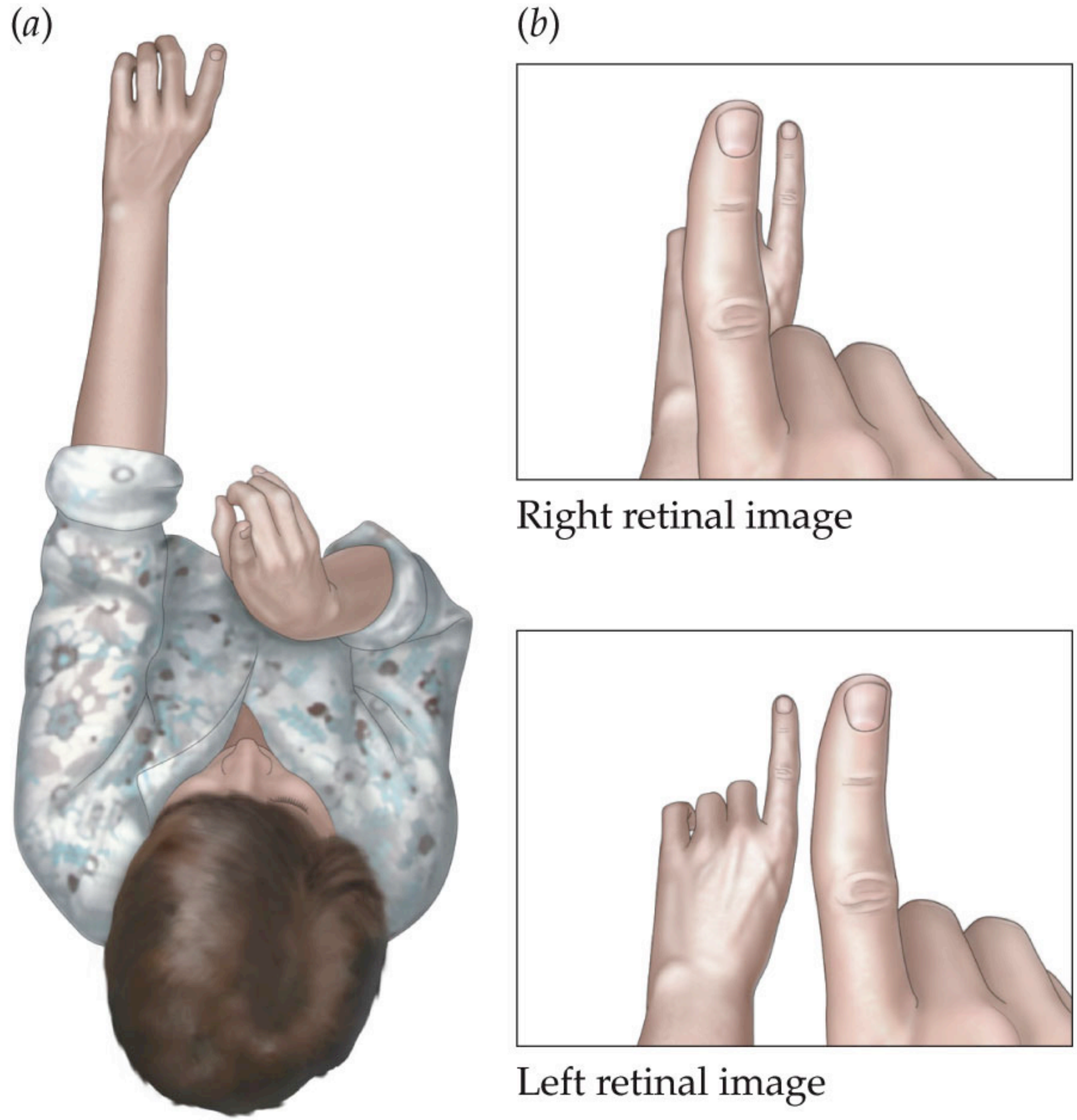
Non-Pictorial

- motion parallax
- accommodation ("depth from focus")

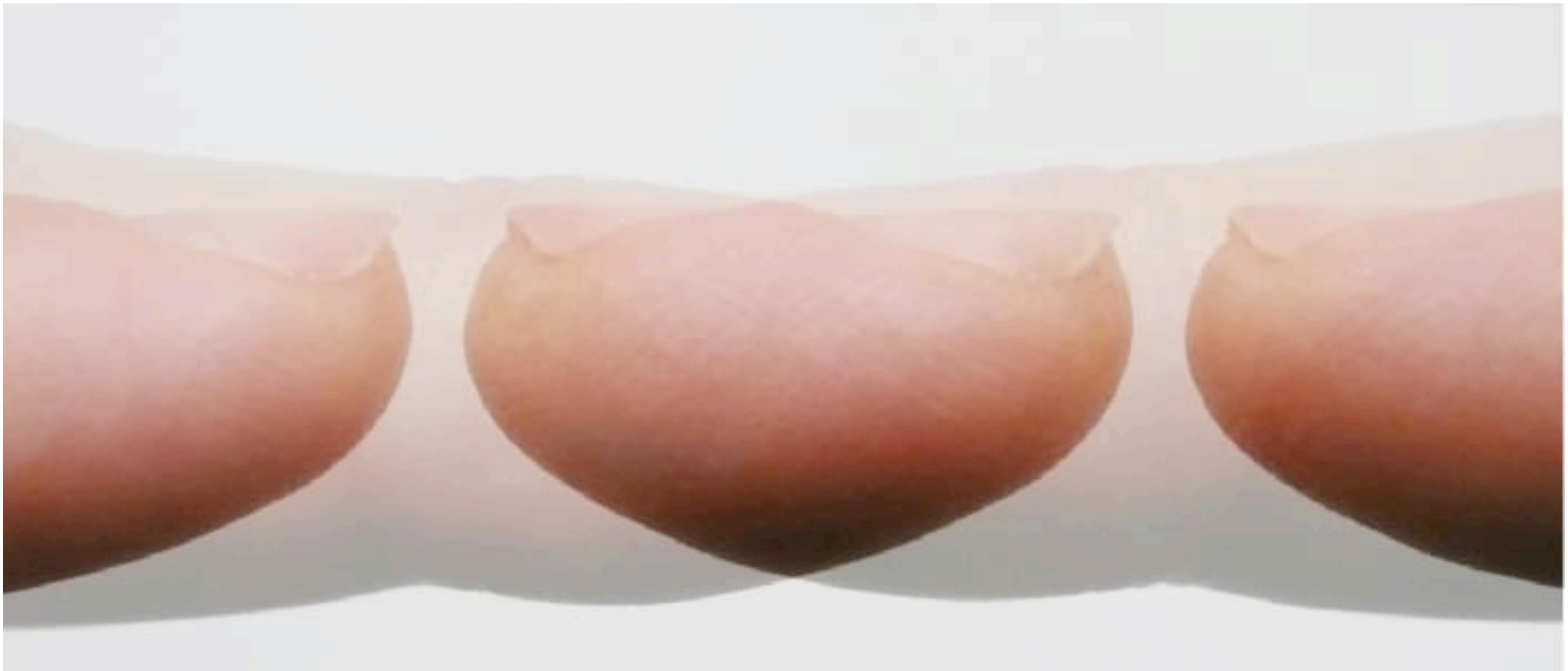
- **Binocular depth cue:** A depth cue that relies on information from both eyes



Two Retinas Capture Different images



Finger-Sausage Illusion:



Pen Test:

Hold a pen out at half arm's length

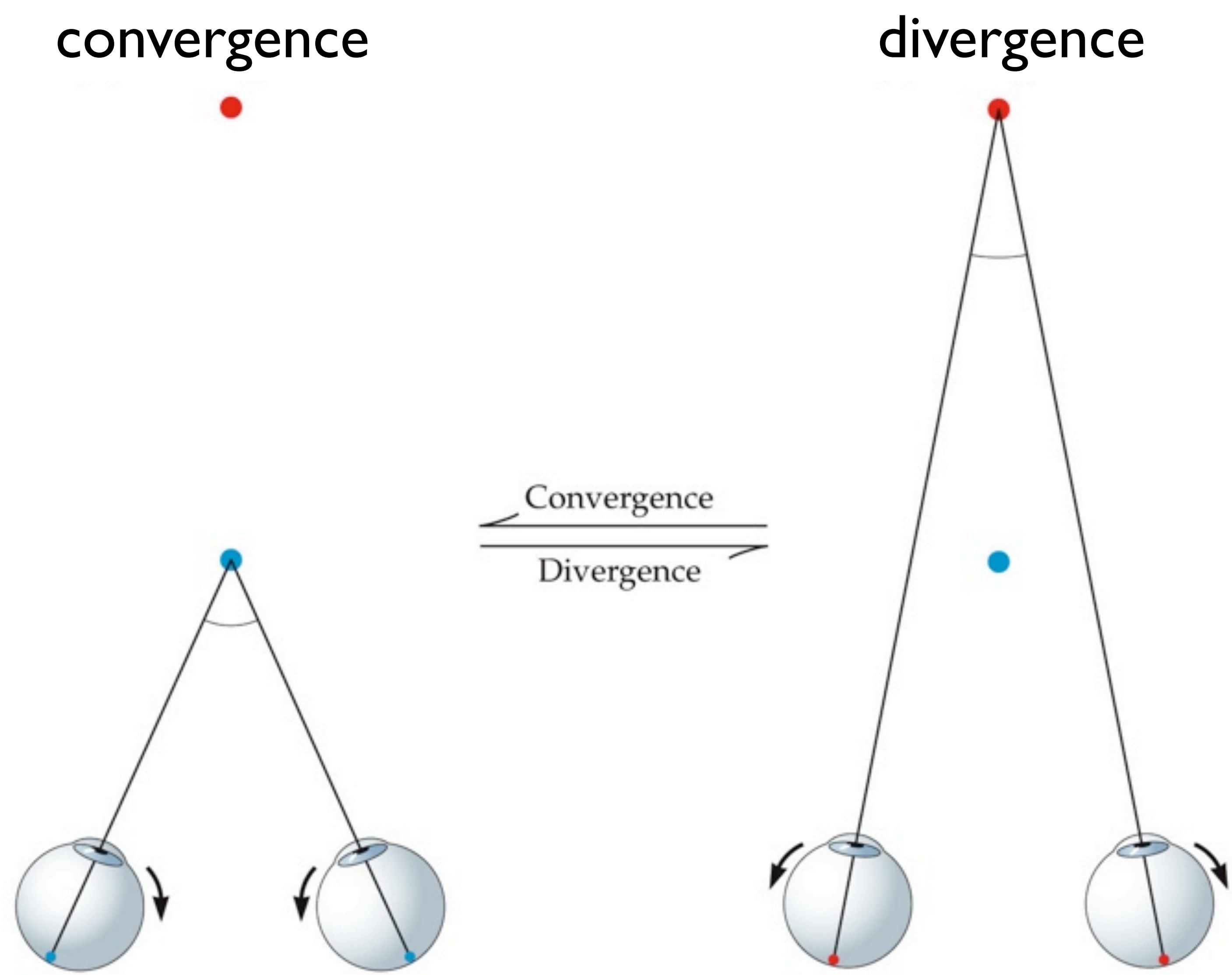
With the other hand, see how rapidly you can place the cap on the pen.

First using two eyes, then with one eye closed

Binocular depth cues:

1. **Vergence angle** - angle between the eyes

If you know the angles, you can deduce the distance



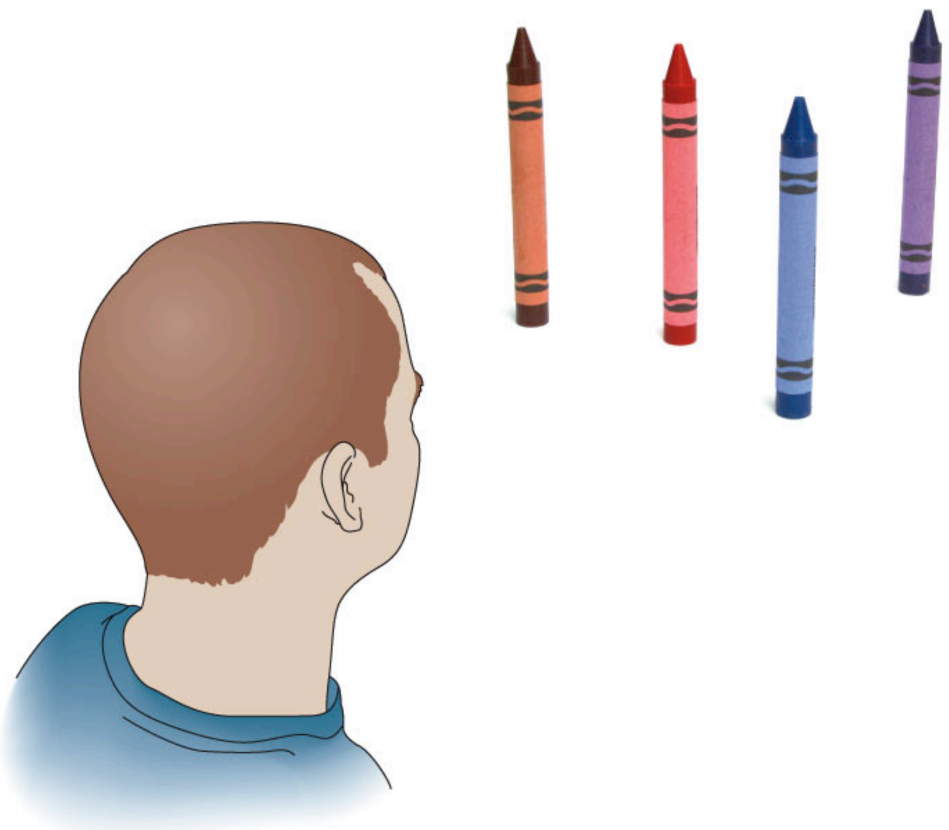
Binocular depth cues:

2. **Binocular Disparity** - difference between two retinal images

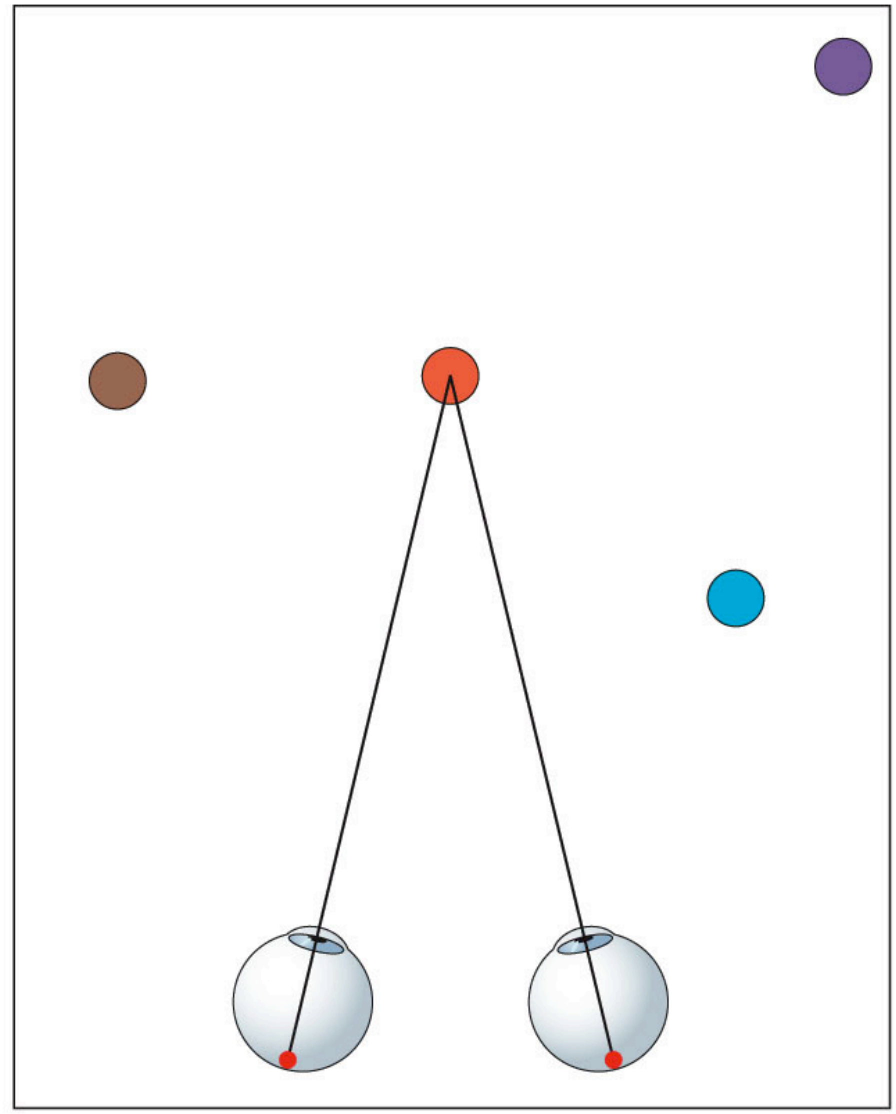
Stereopsis - depth perception that results from binocular disparity information

(This is what they're offering in 3D movies…)

(*a*)



(*b*)

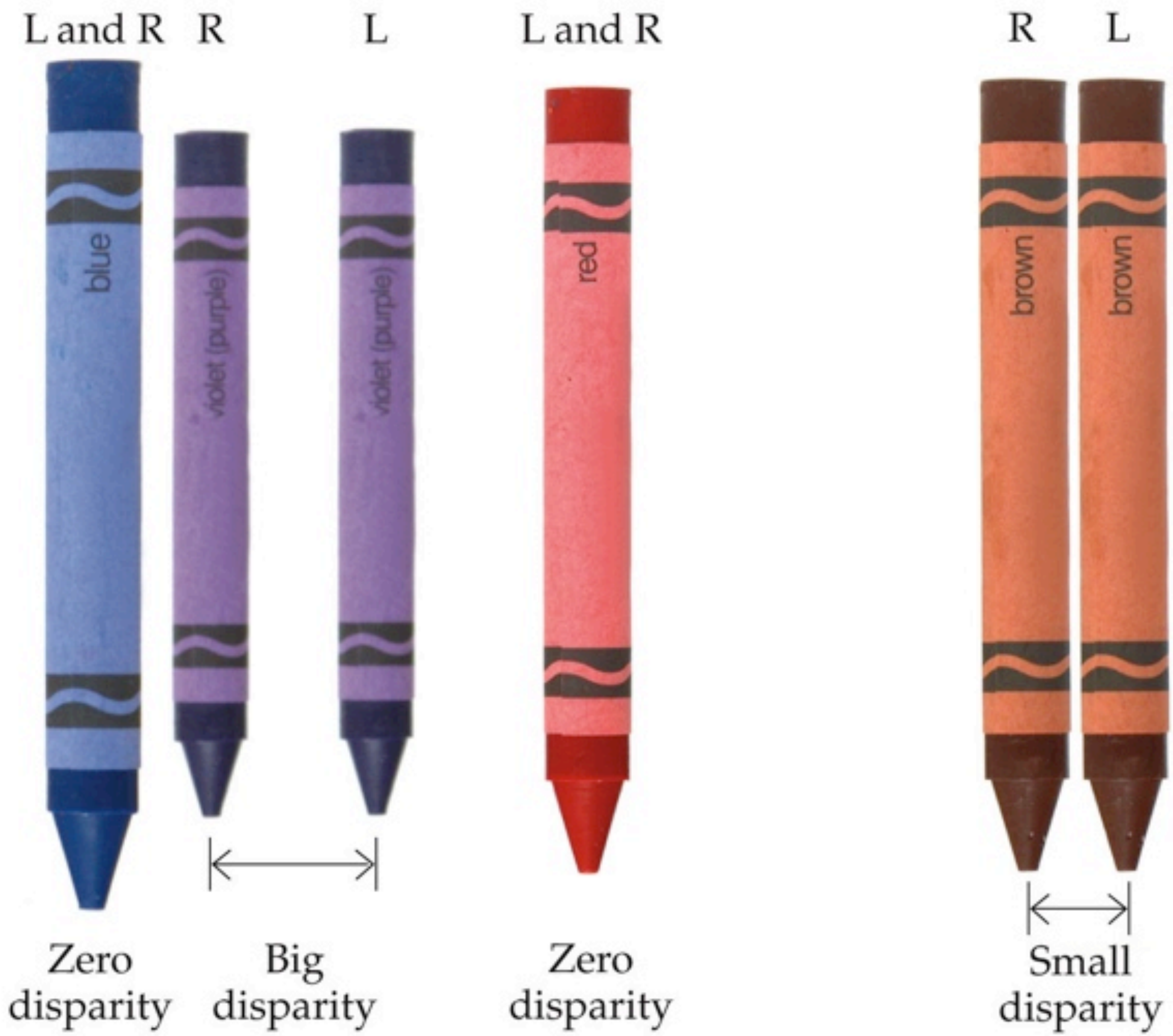


Retinal images in left & right eyes

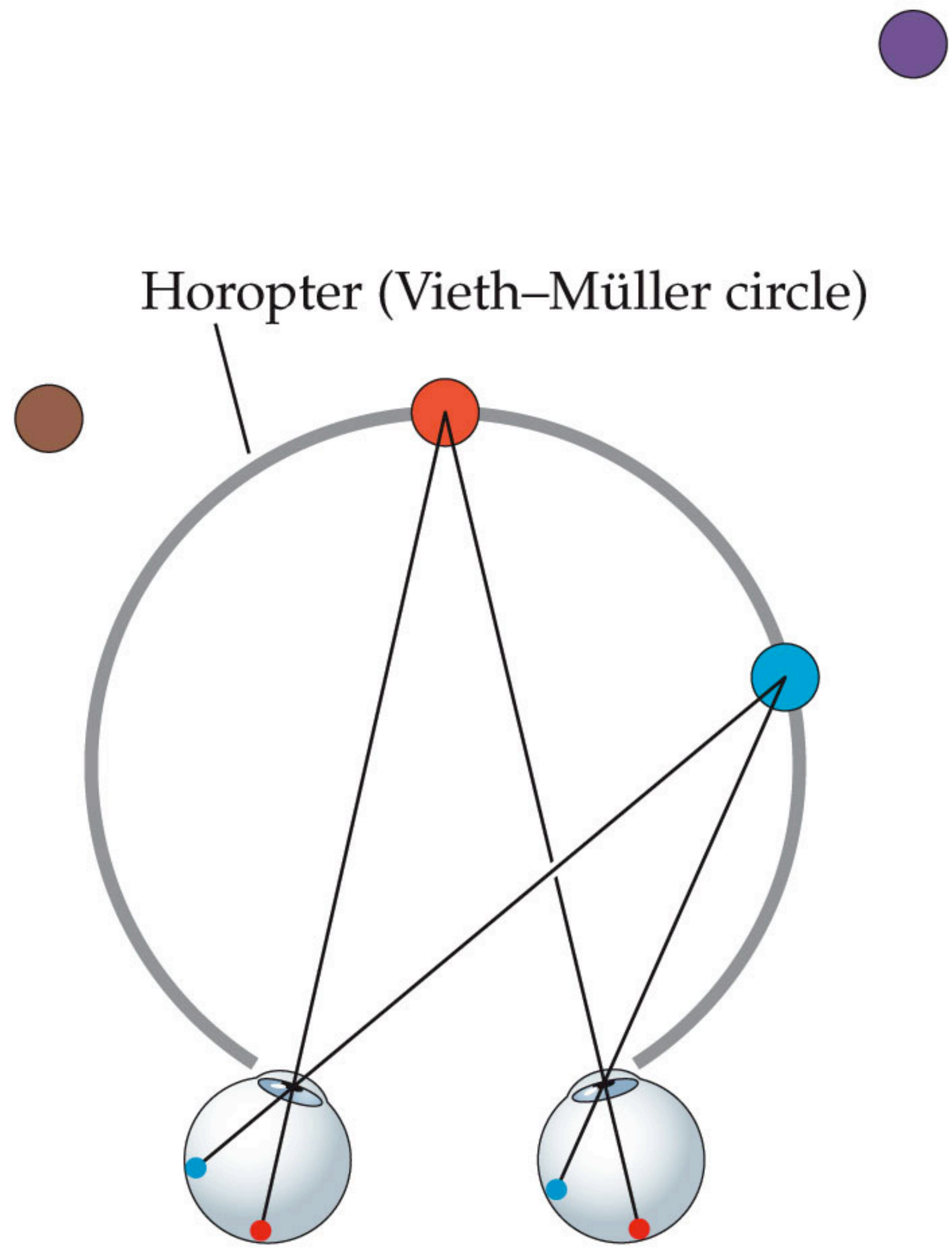
Left retinal image Right retinal image

Figuring out the depth from these two images is a challenging computational problem. (Can you reason it out?)

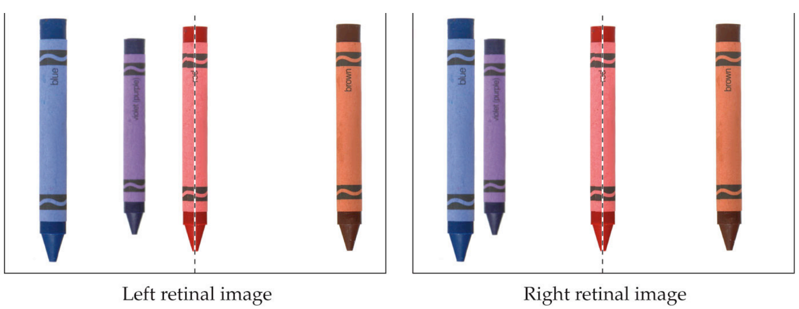
Disparity: difference between points in L and R eye images

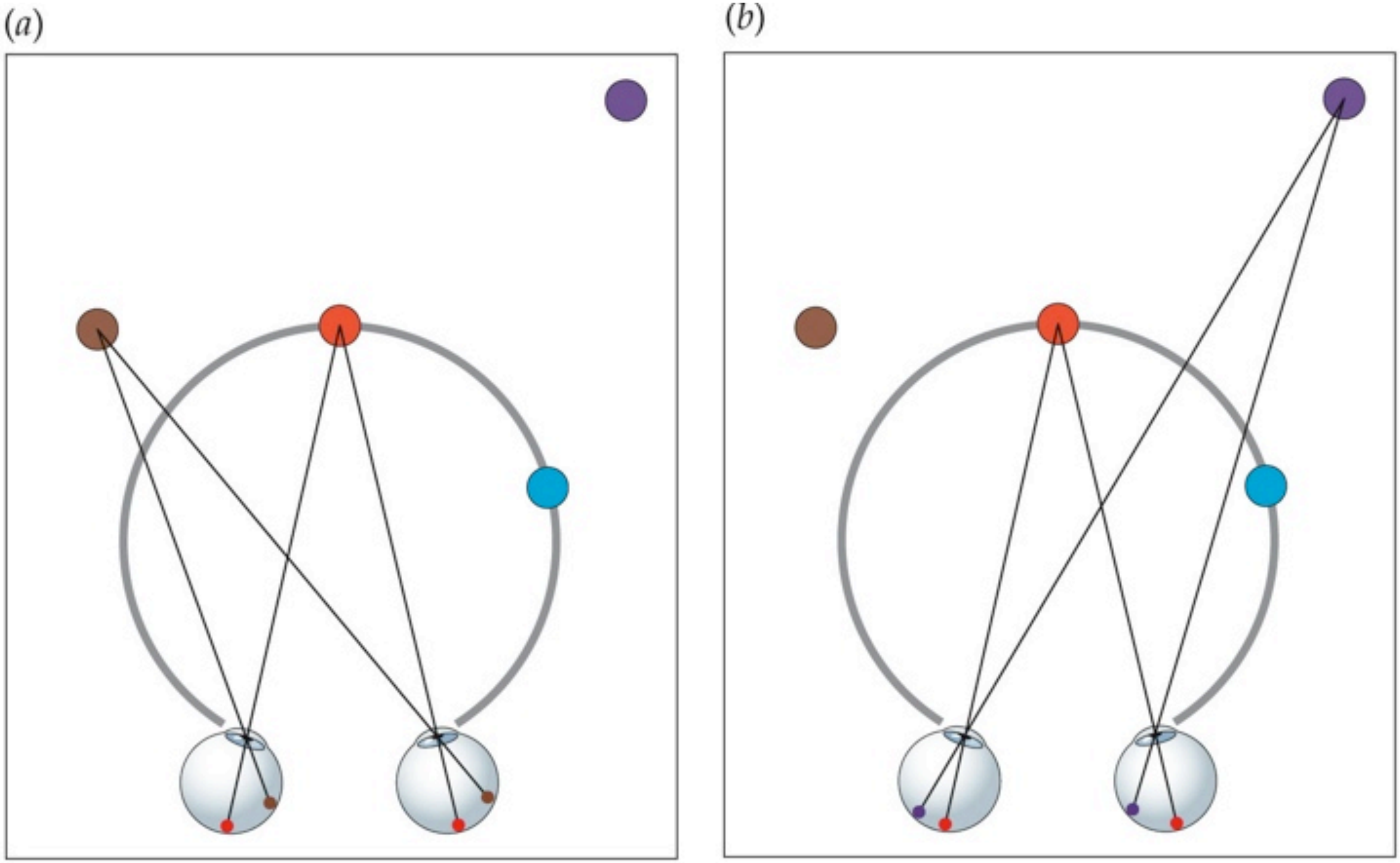


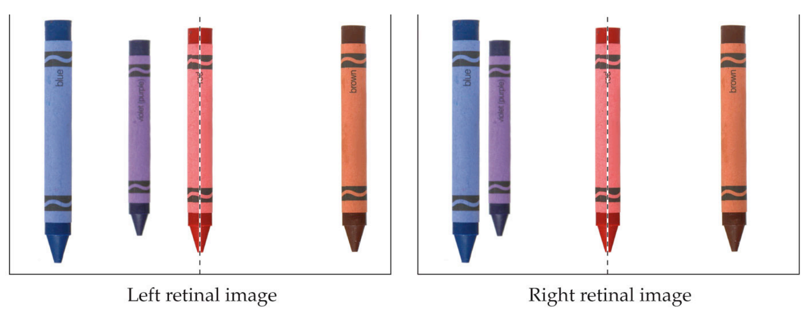
Horopter: circle of points that fall at zero disparity (i.e., they land on corresponding parts of the two retinas)

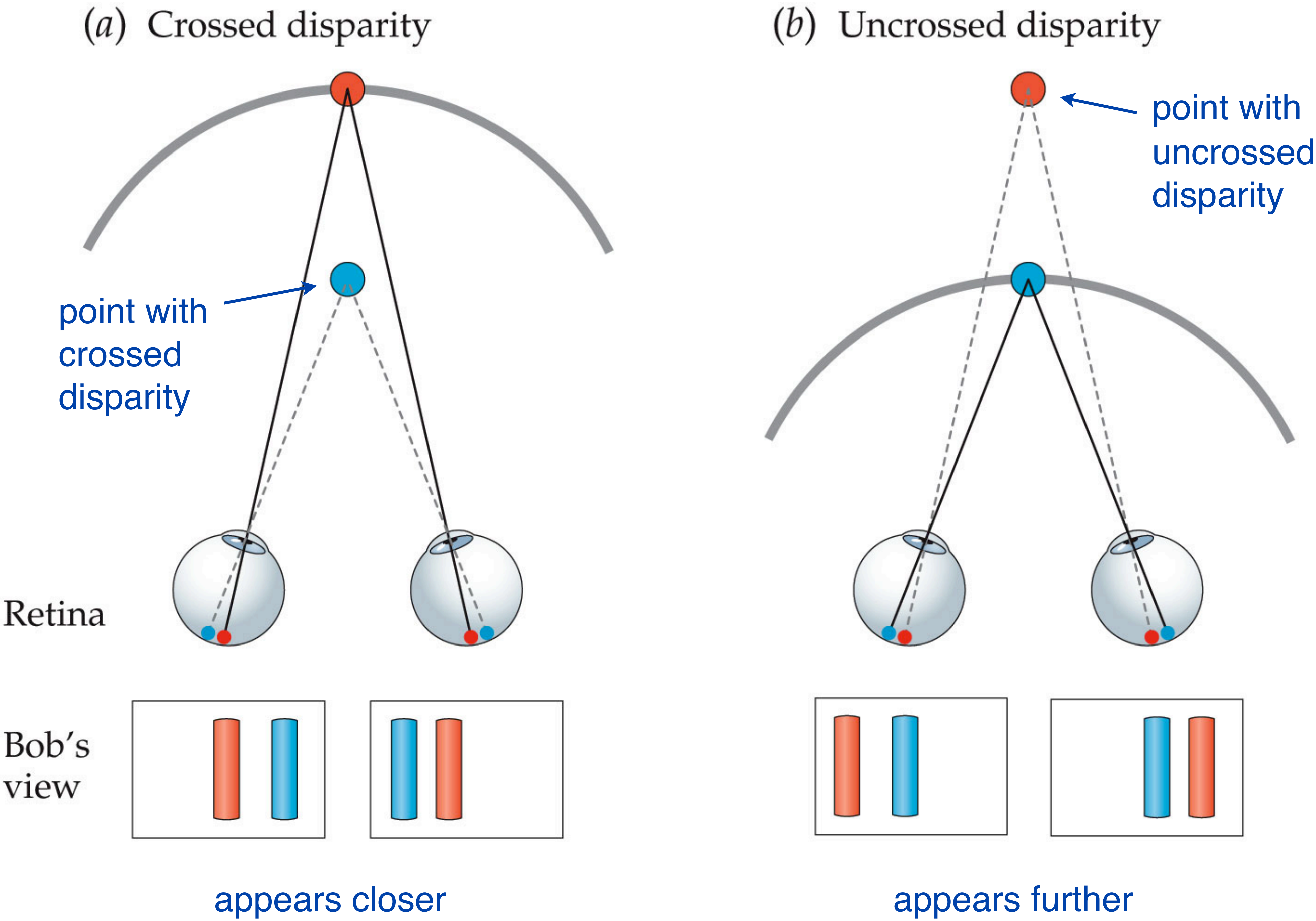


A bit of geometric reasoning will convince you that this surface is a circle containing the fixation point and the two eyes

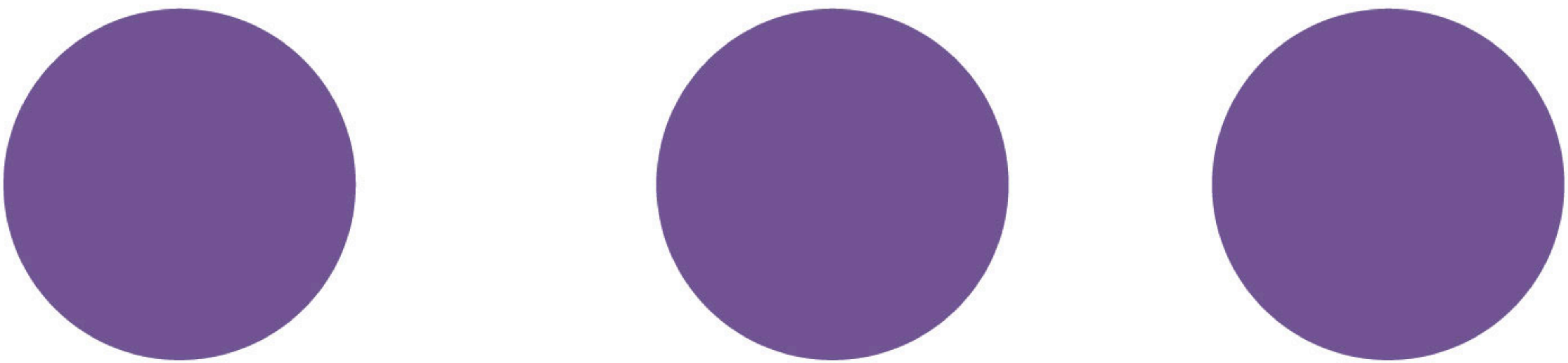



(a)
(b)


Left retinal image
Right retinal image

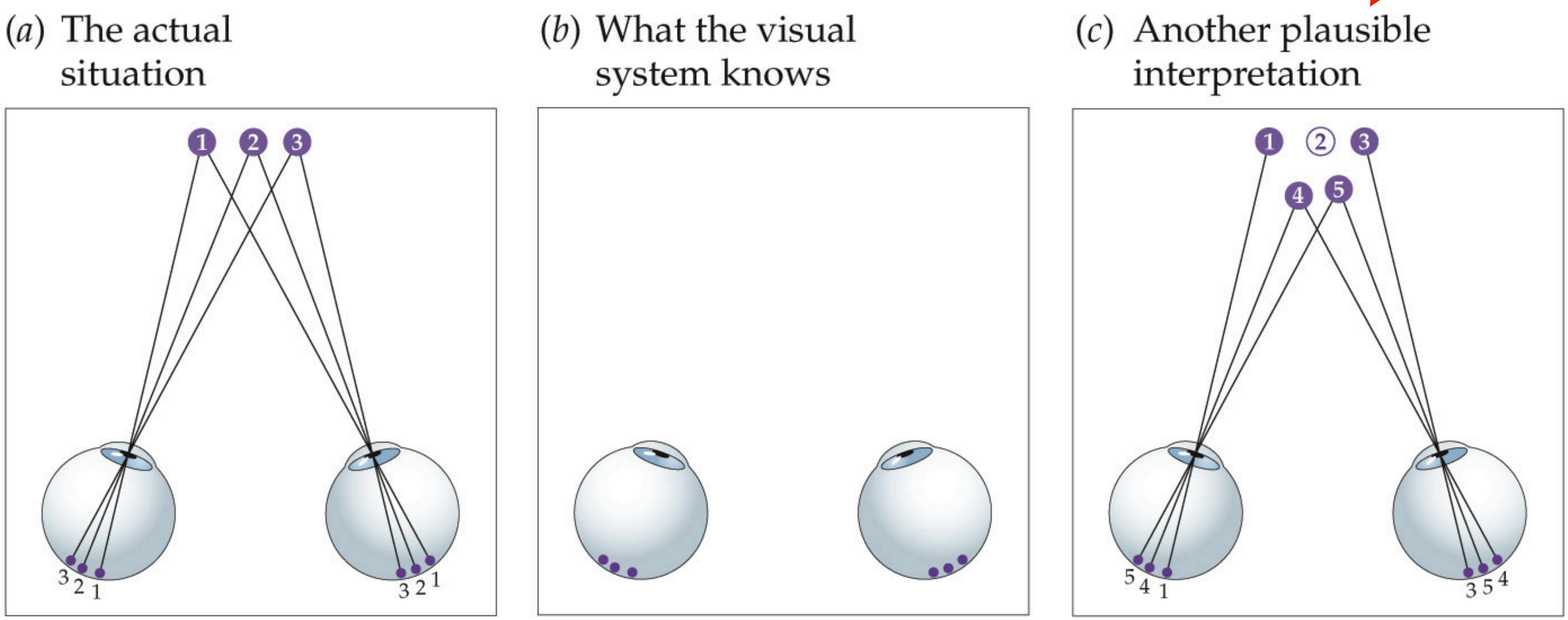

(a) Crossed disparity
(b) Uncrossed disparity
point with uncrossed disparity
point with crossed disparity
Retina
Bob's view
appears closer
appears further

Is this a simple picture or a complicated computational problem?



Interpreting the visual information from three circles

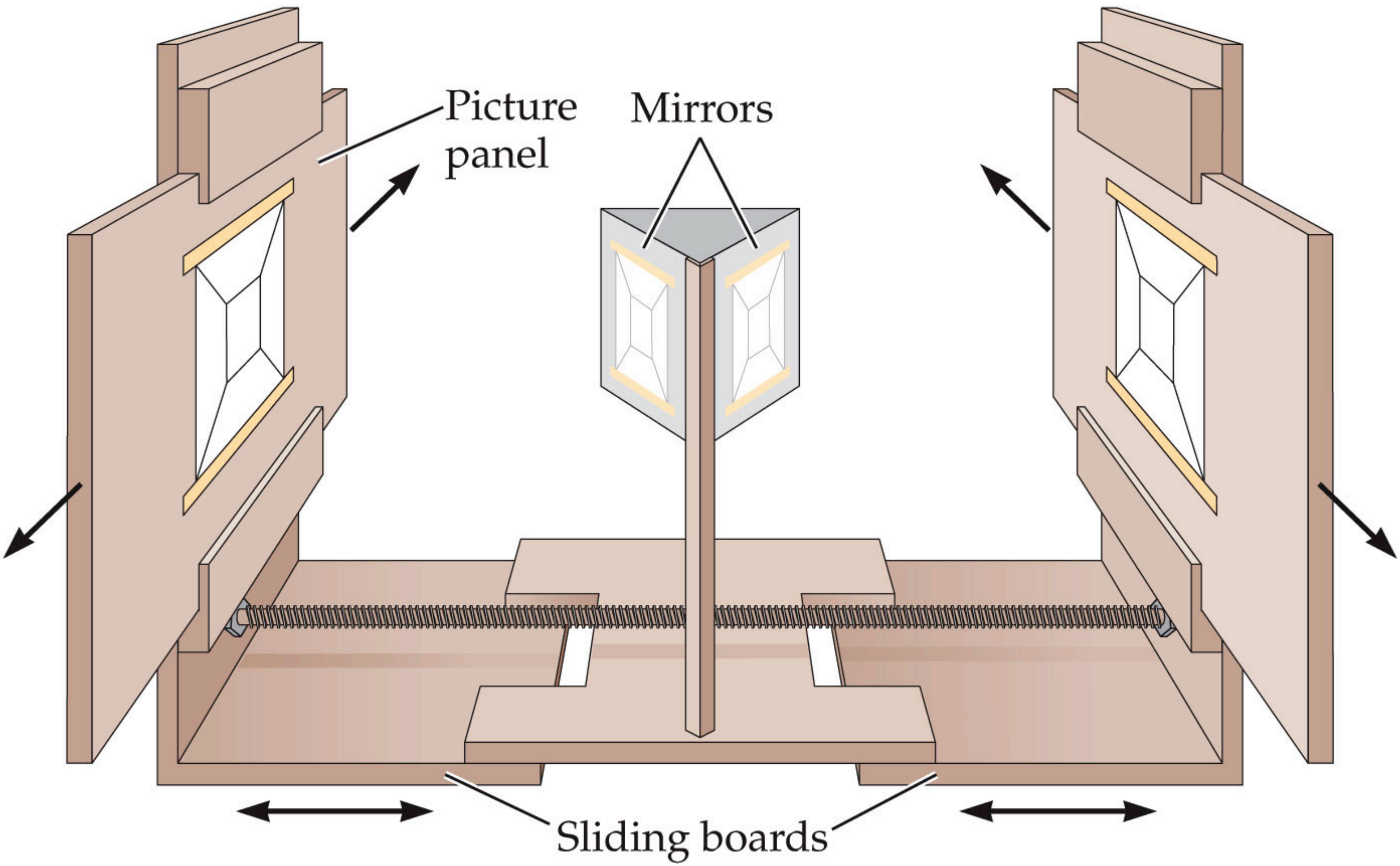
This one requires an accidental viewpoint



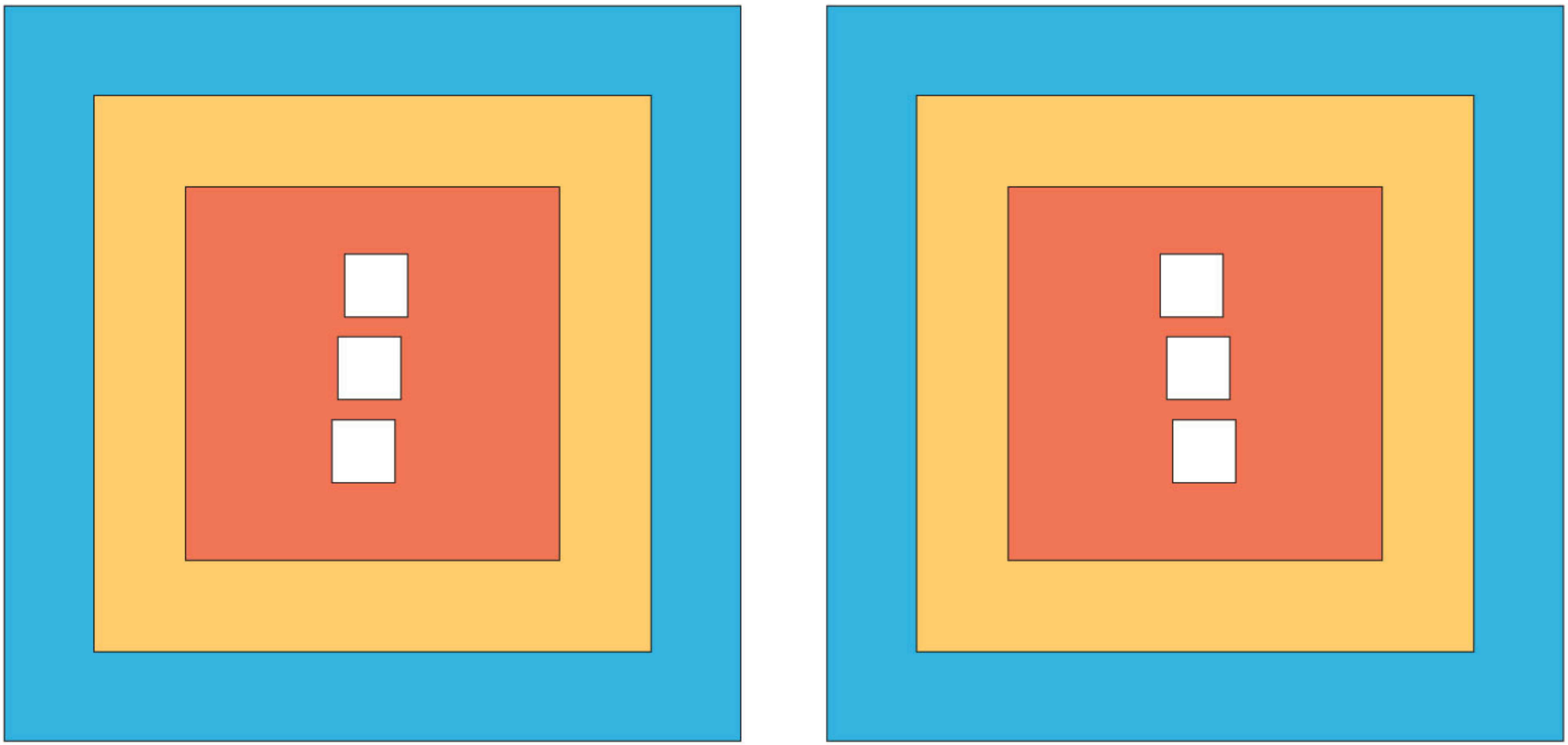
Known as the “**correspondence problem**” - which points in the left eye go with which points in the right eye?

Wheatstone’s stereoscope

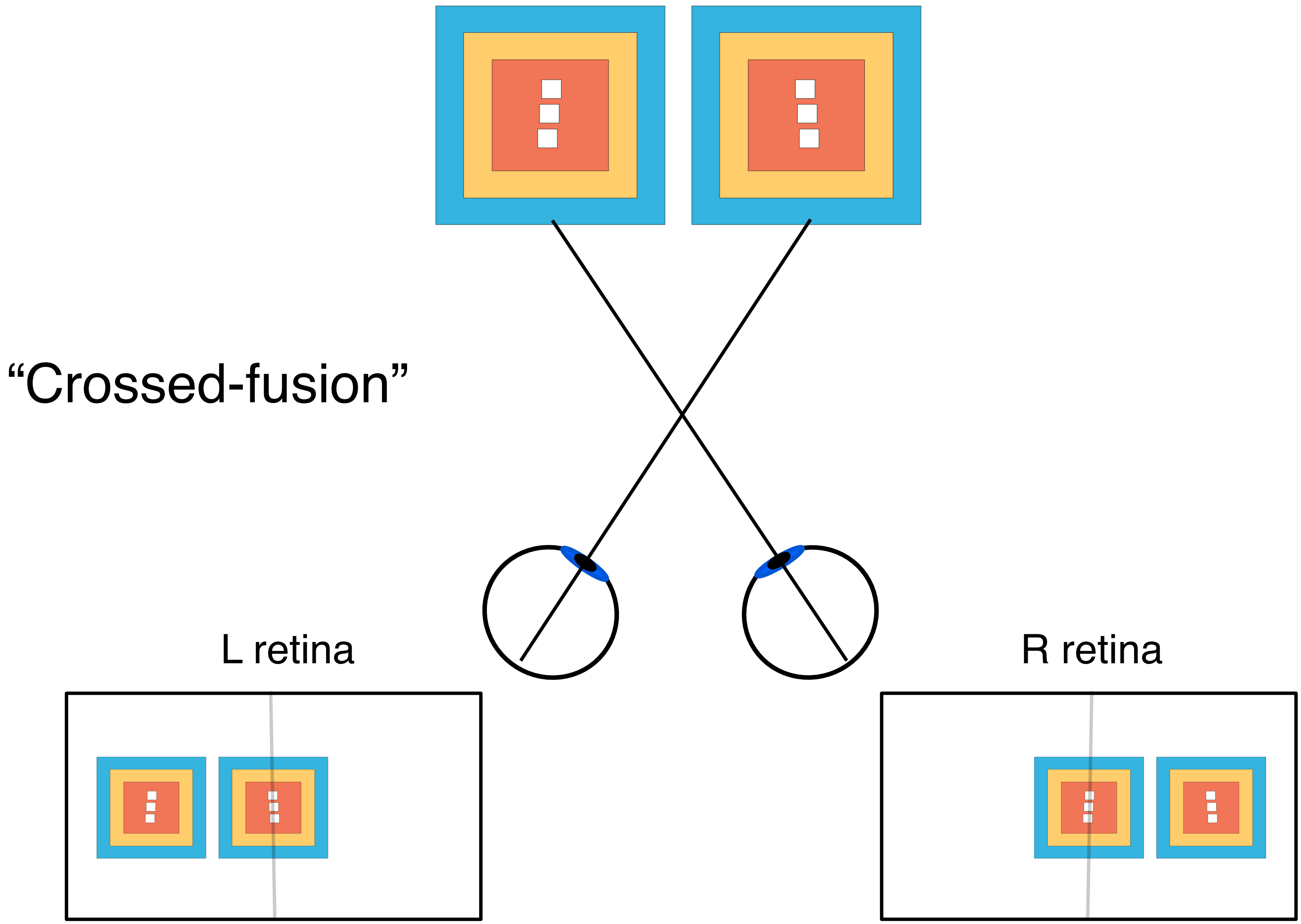
- device for presenting one different images to the two eyes



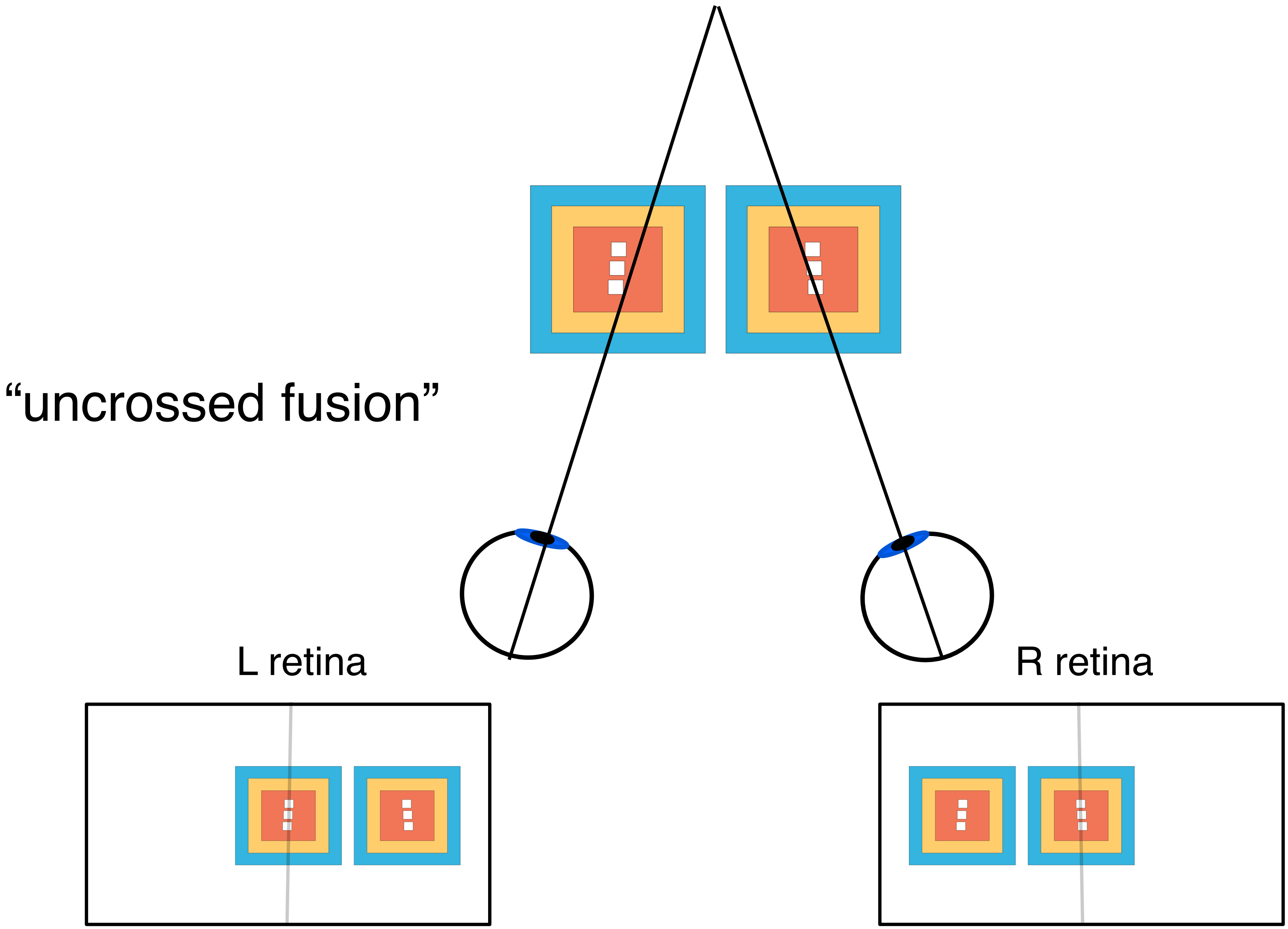
Free fusing - focusing the eyes either nearer or farther than this image so that each eye sees a different image



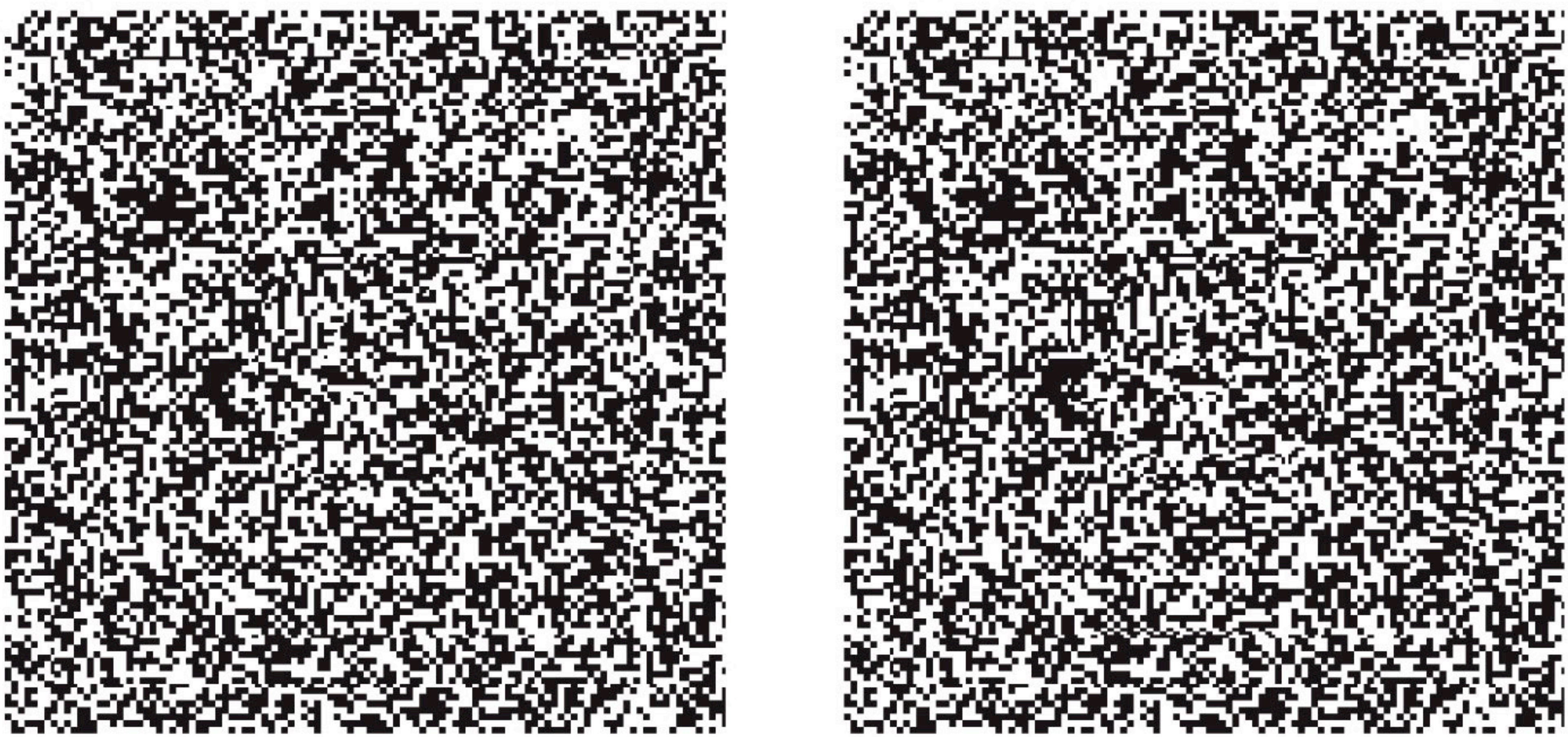
Free fusing - focusing the eyes either nearer or farther than this image so that each eye sees a different image



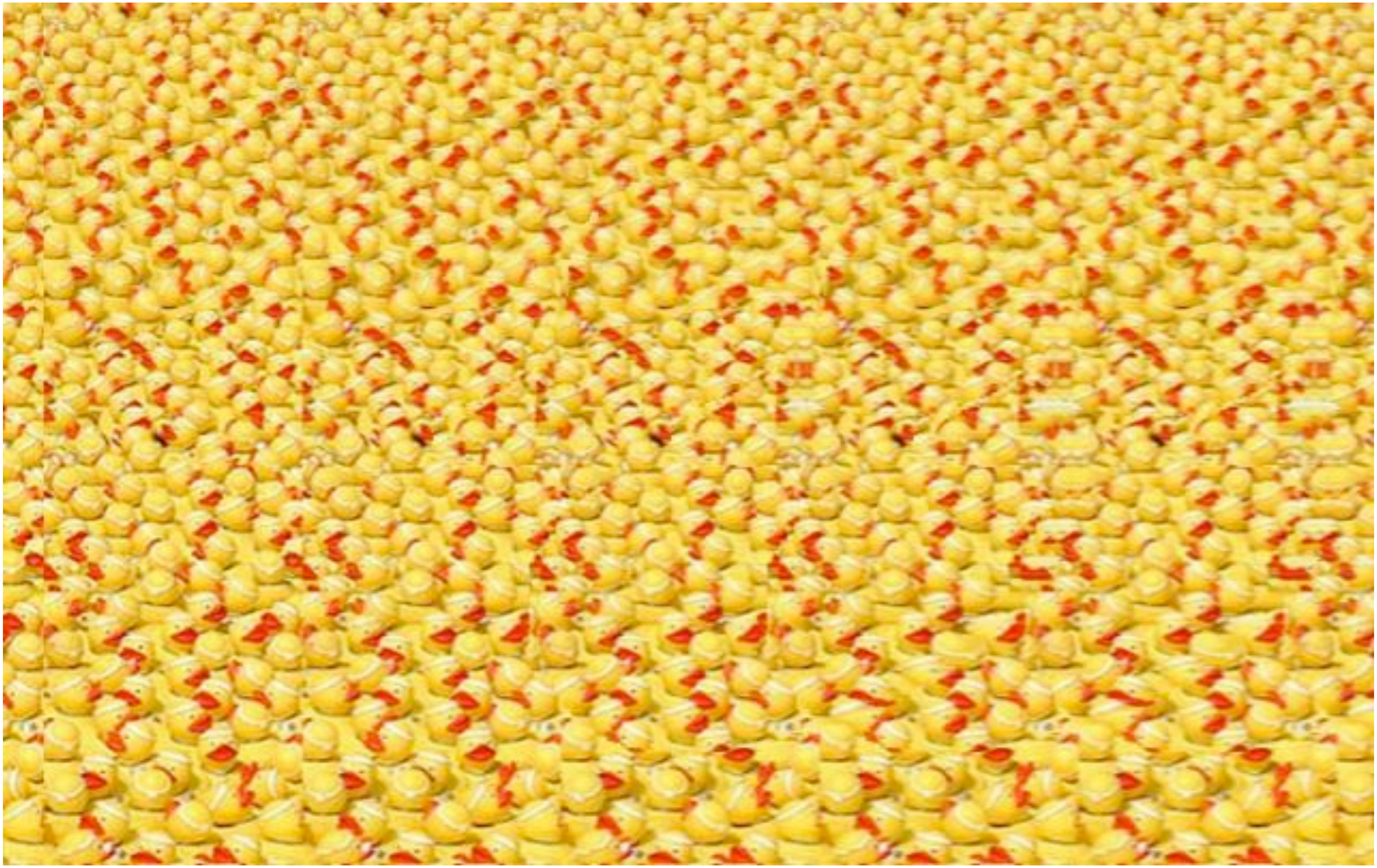
Free fusing - focusing the eyes either nearer or farther than this image so that each eye sees a different image



Random Dot Stereogram - same concept, but no detectable “features” in either image. Details of dot pattern allow brain to solve the correspondence problem

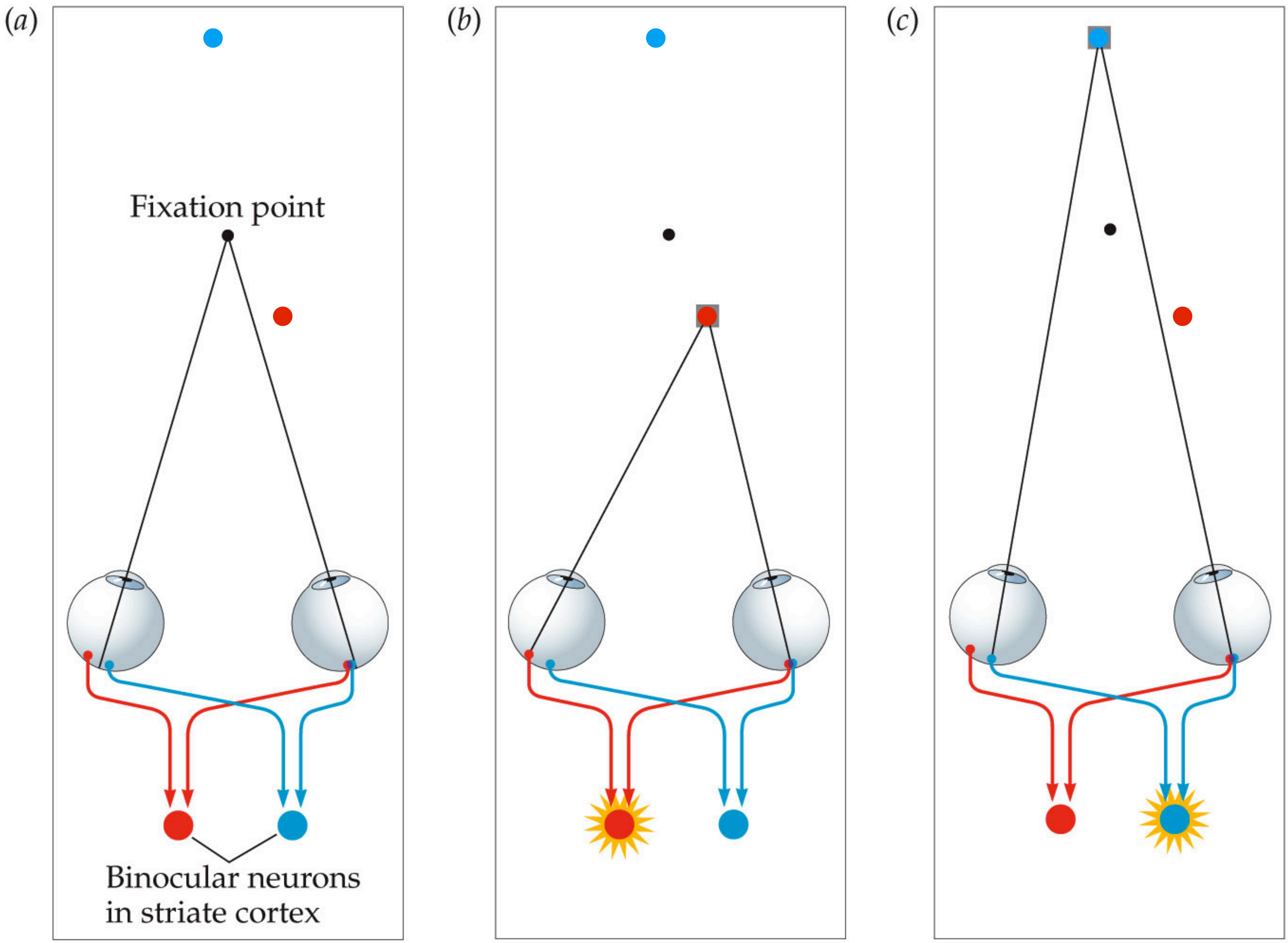


“Magic Eye” images use same principle



If you were designing a visual system, how might you go about designing neurons tuned for different disparity?

The brain solves this problem with disparity-tuned neurons

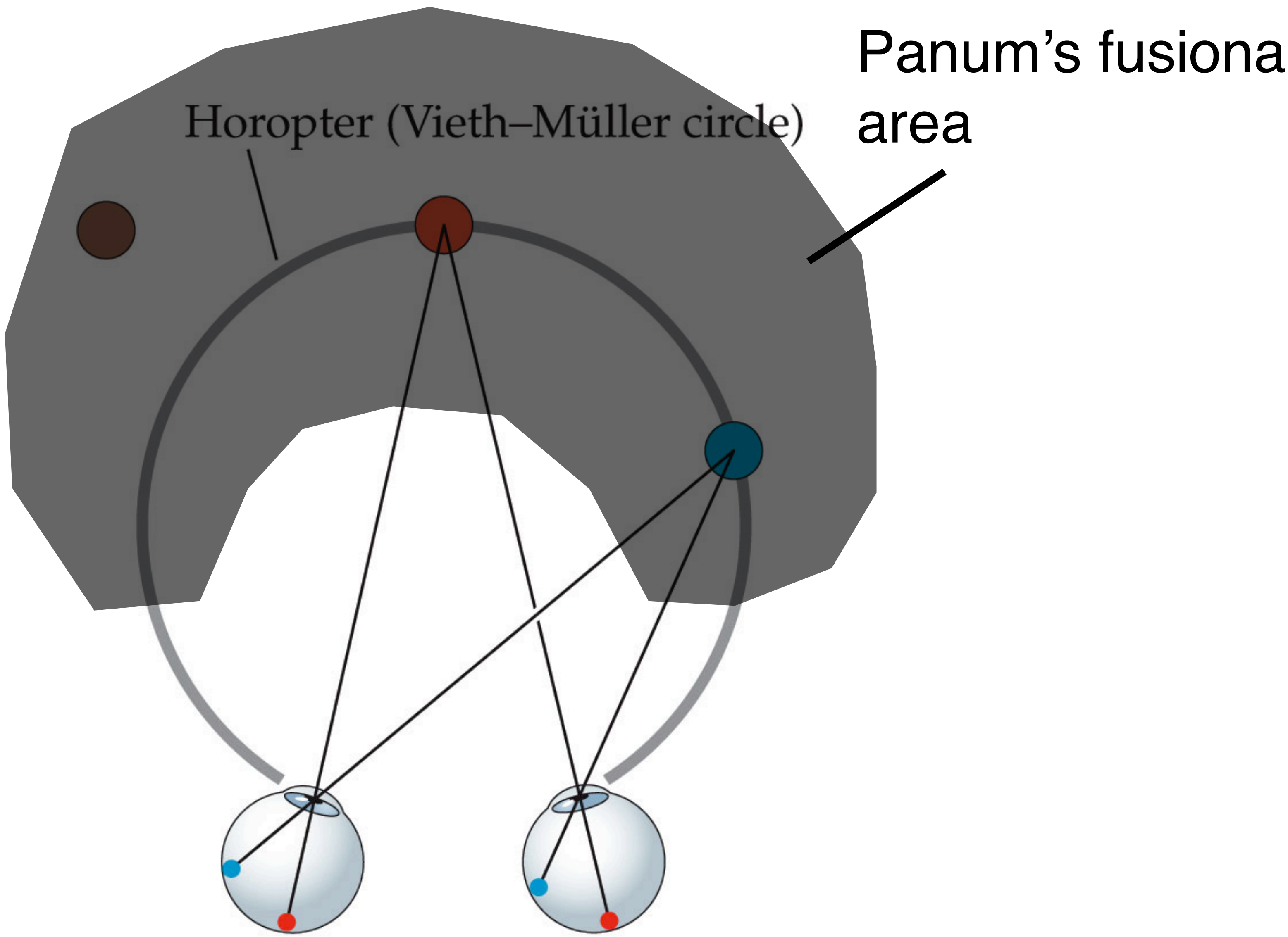


How is stereopsis implemented in the human brain?

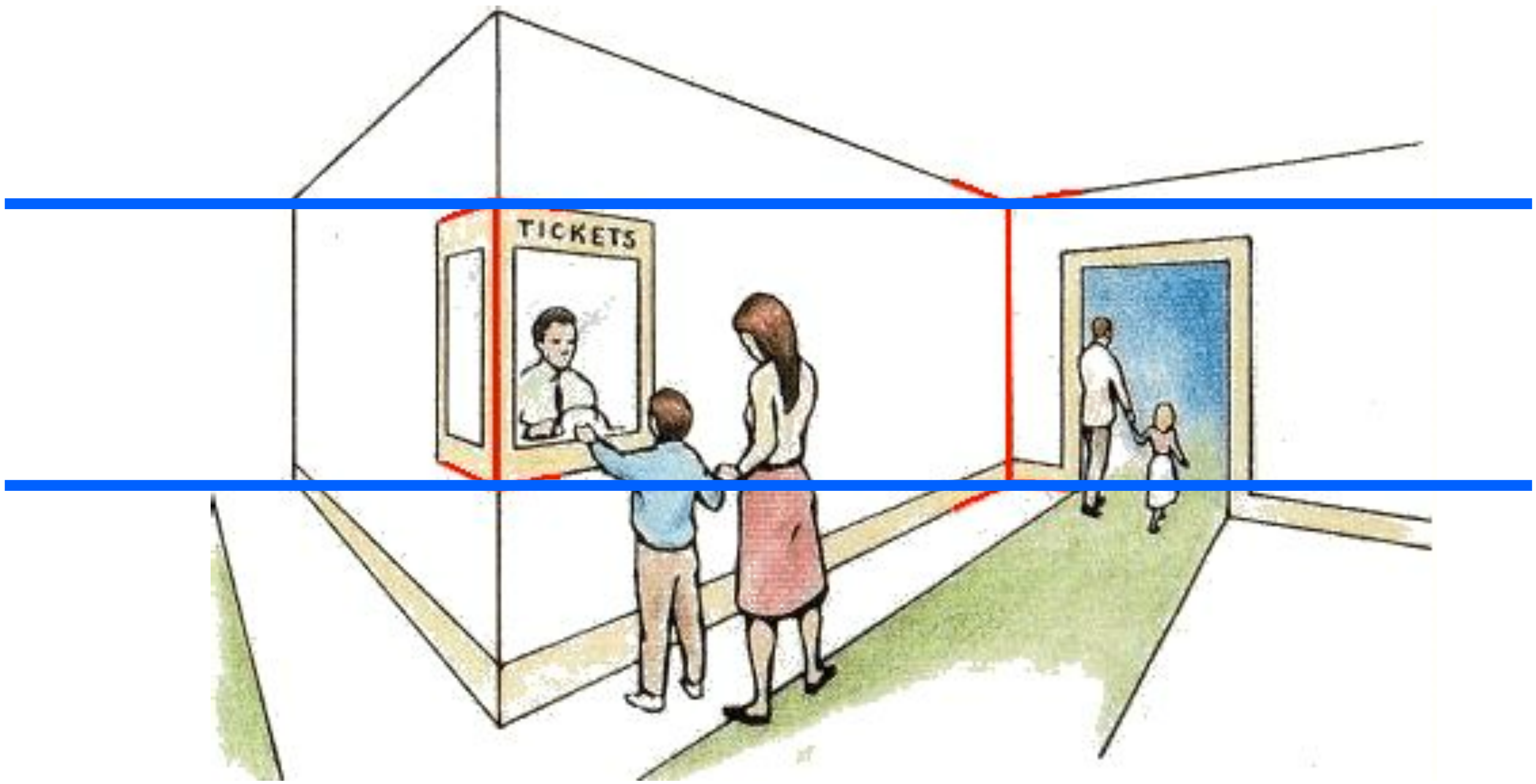
- Input from two eyes must converge onto the same cell
- Many neurons: respond best when the same image falls on *corresponding points* in the two retinas
  (this is the neural basis for the horopter)
- However: many neurons respond best when similar images occupy slightly different positions on the two retinas
- i.e., these neurons are "*tuned to a particular disparity*"

Panum's fusional area: only certain range of disparities that the brain can fuse

- comes from distribution of disparity-tuned neurons



Depth Illusions



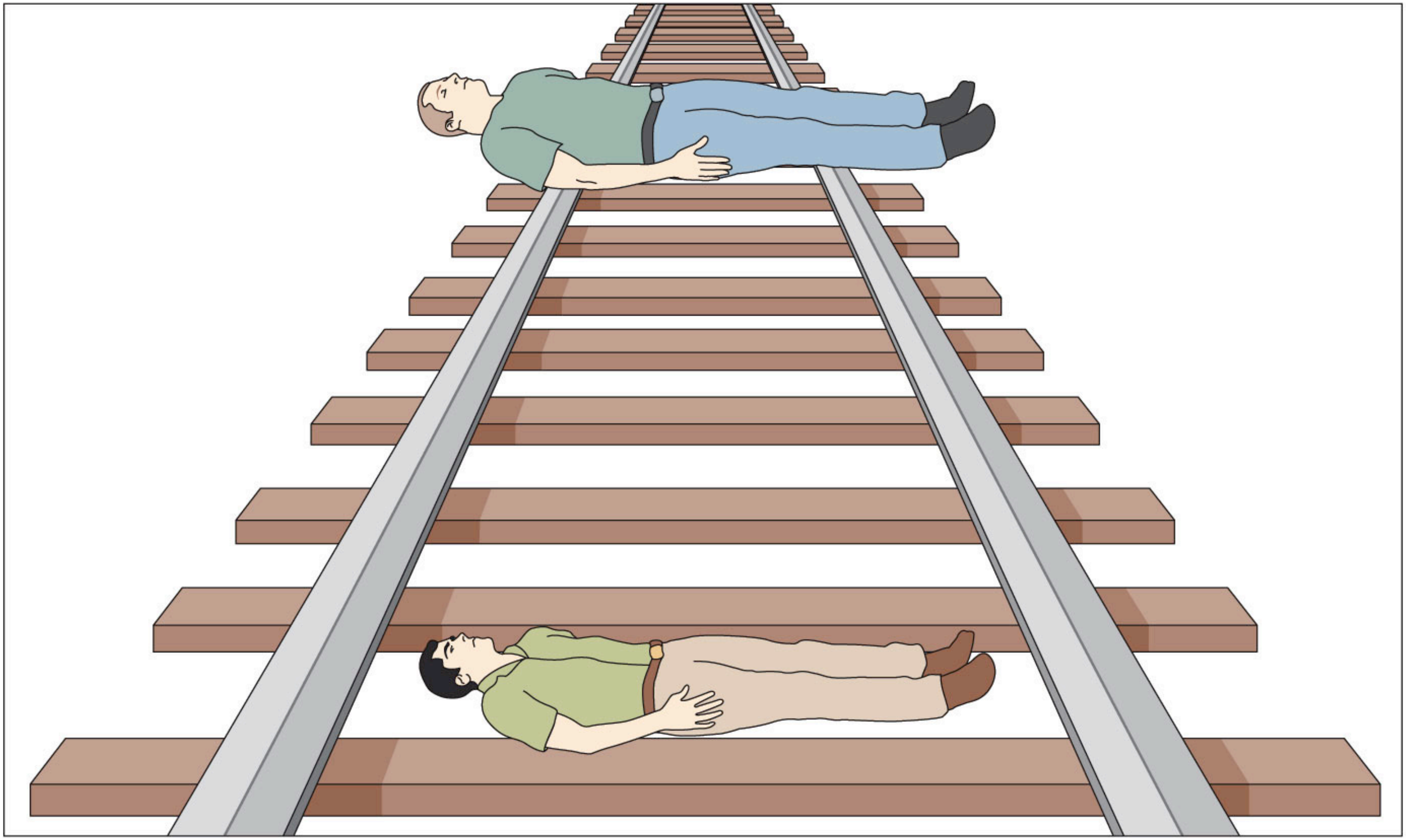
Müller-Lyer Illusion

http://www.michaelbach.de/ot/sze_muelue/index.html

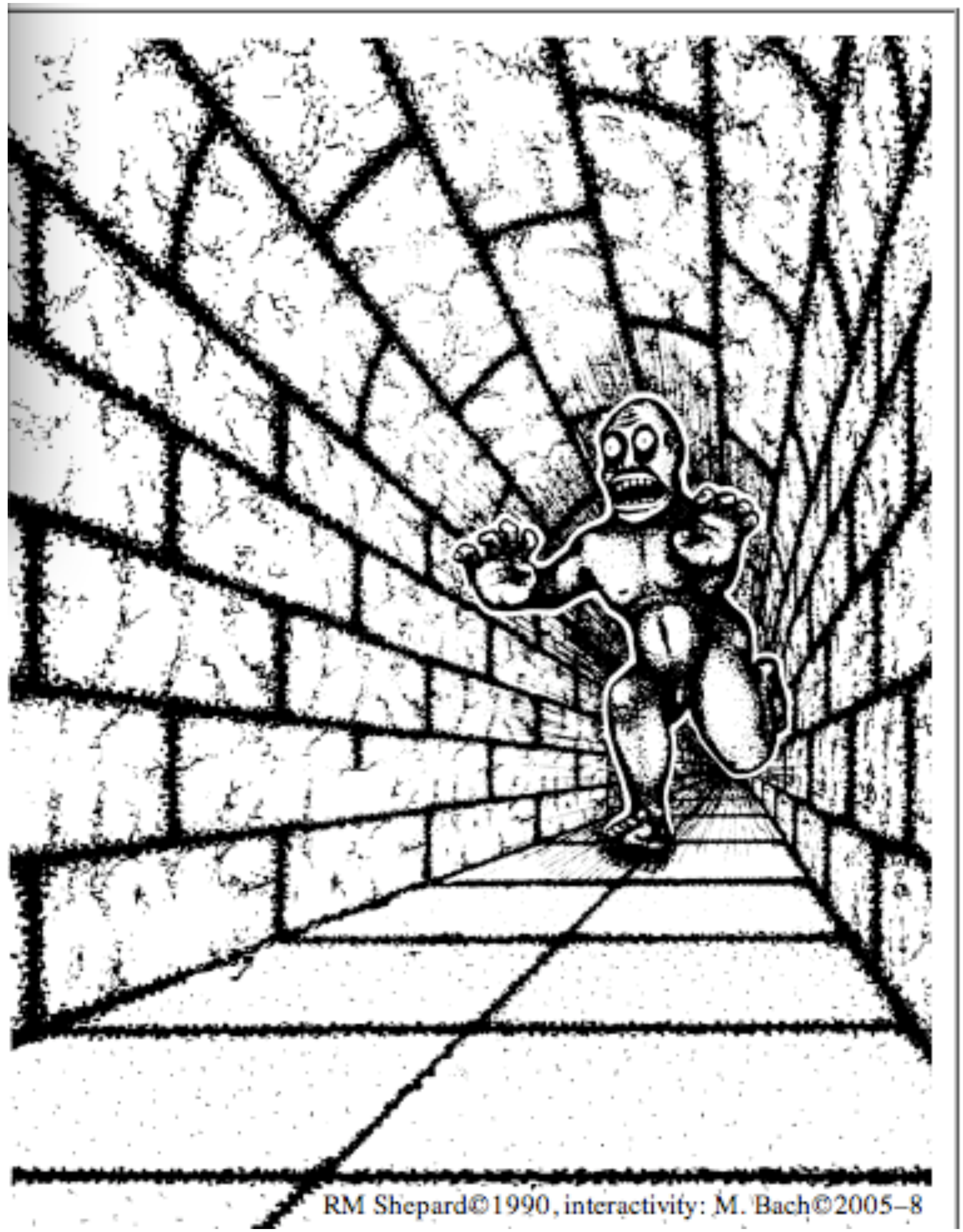
In which image are the two horizontal lines the same length?

(Ans: second from left)

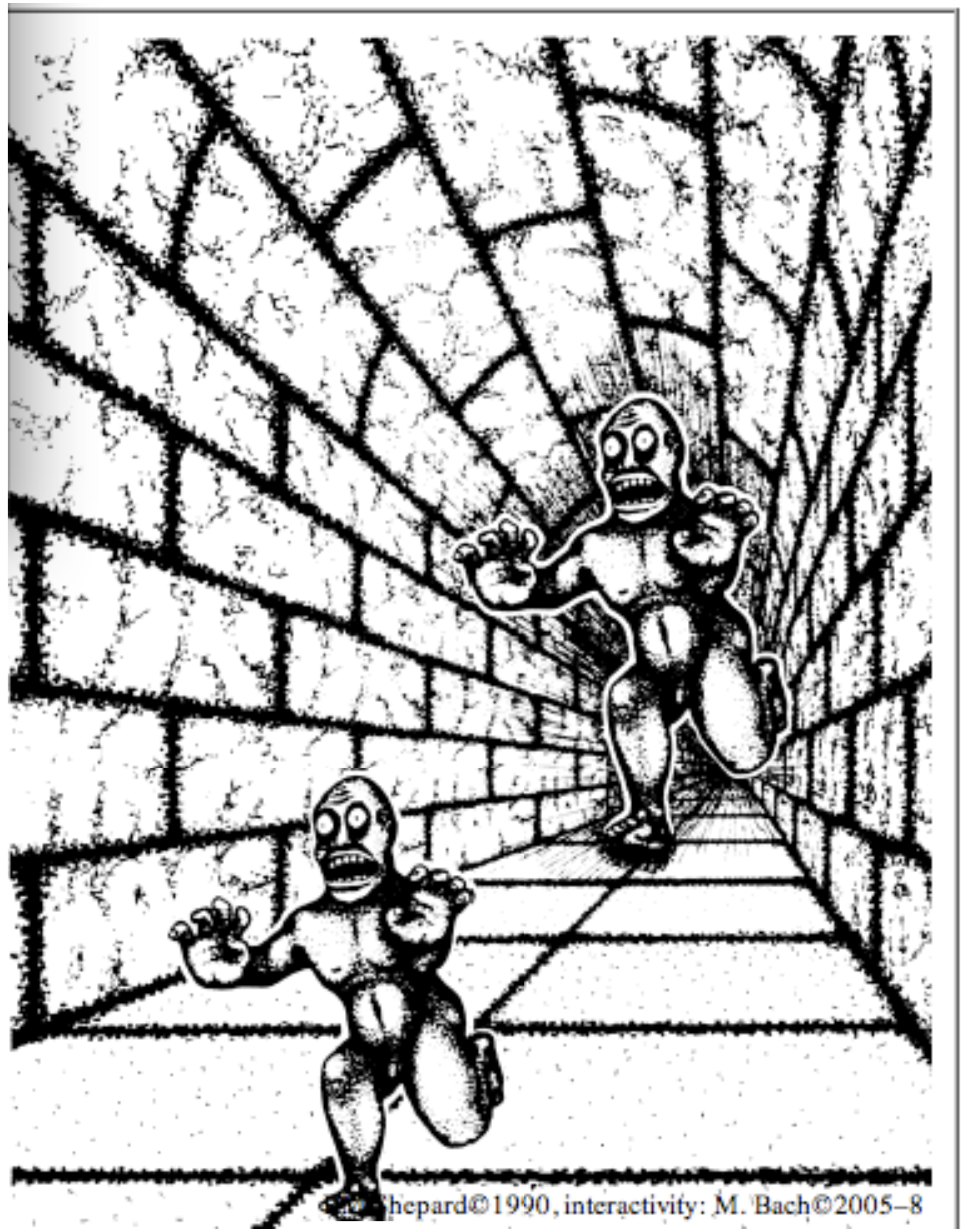
Two figures are the same size



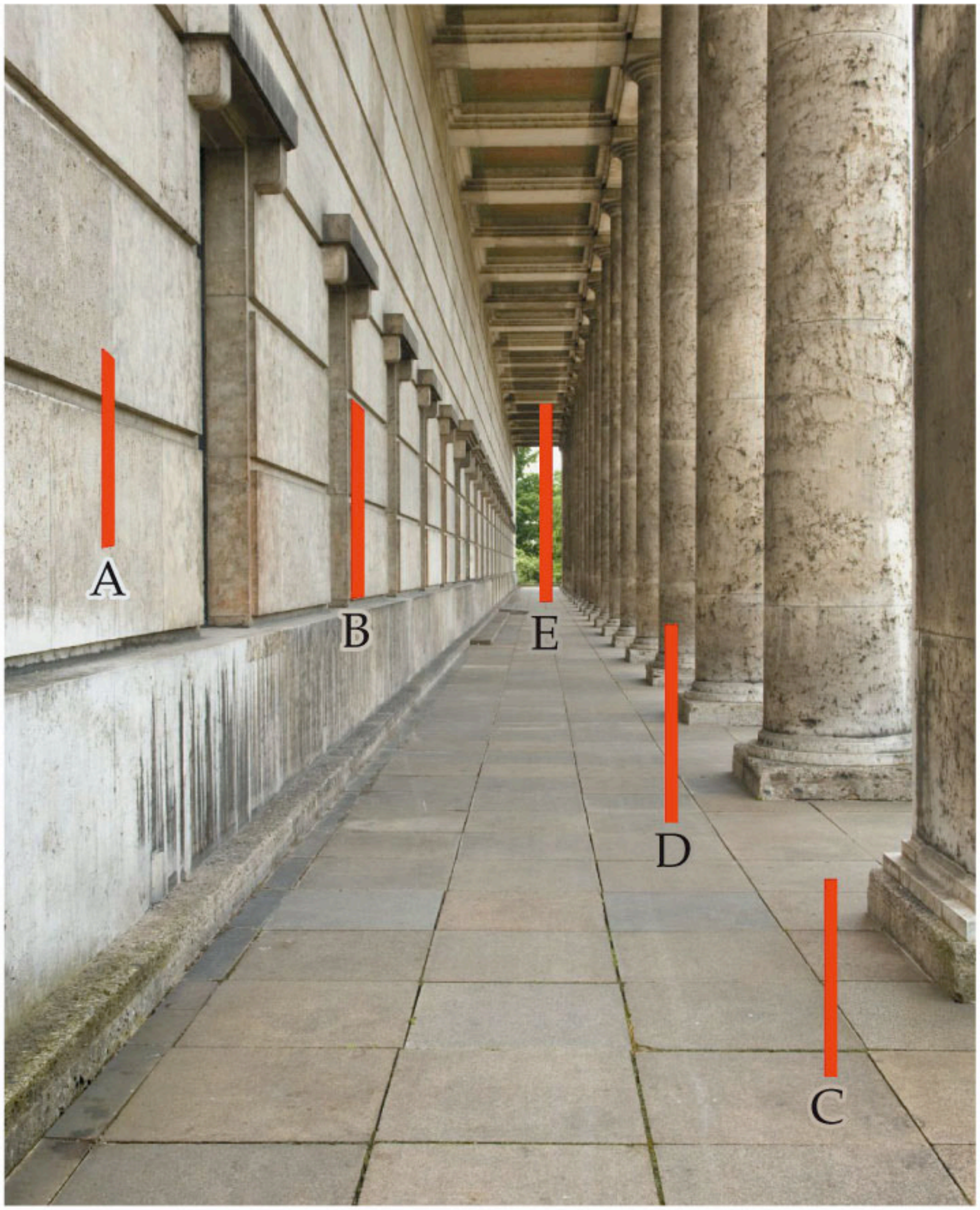
“Terror Subterra”

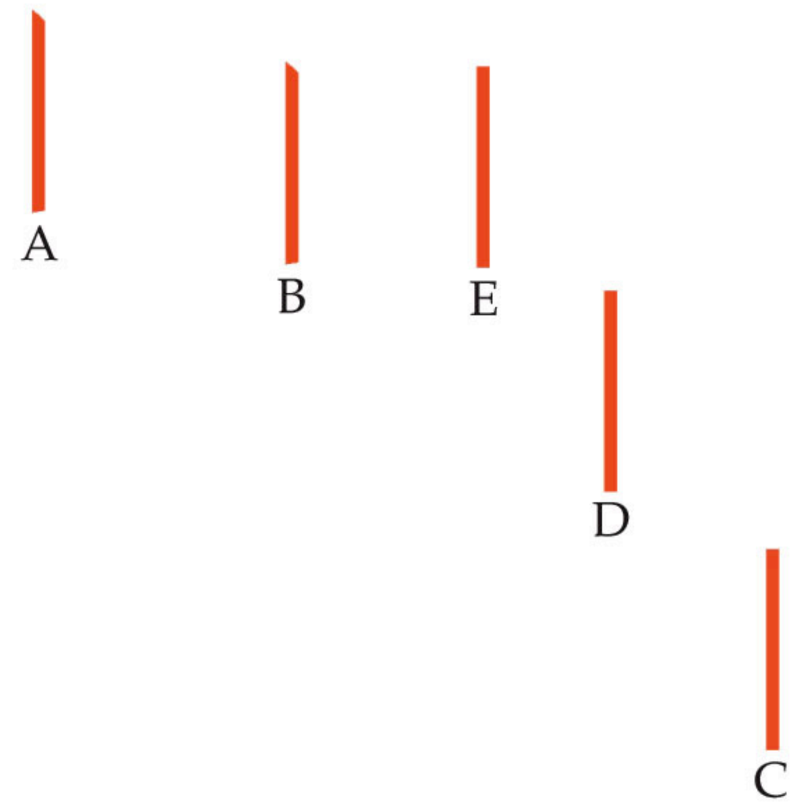


“Terror Subterra”



red lines are all the same length





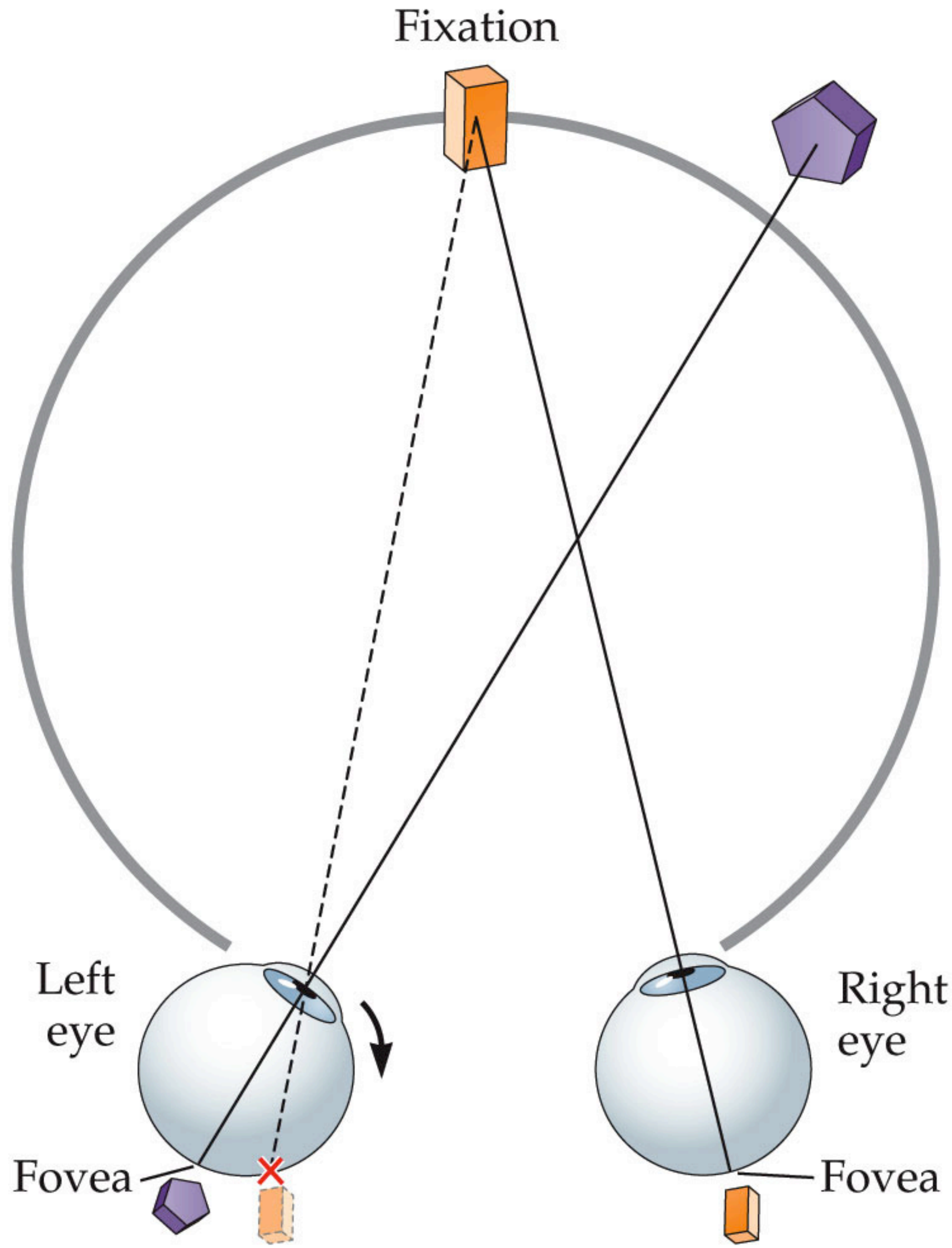
Depth / Size illusion

- all 3 cars take up the same space in the image + on your retina!

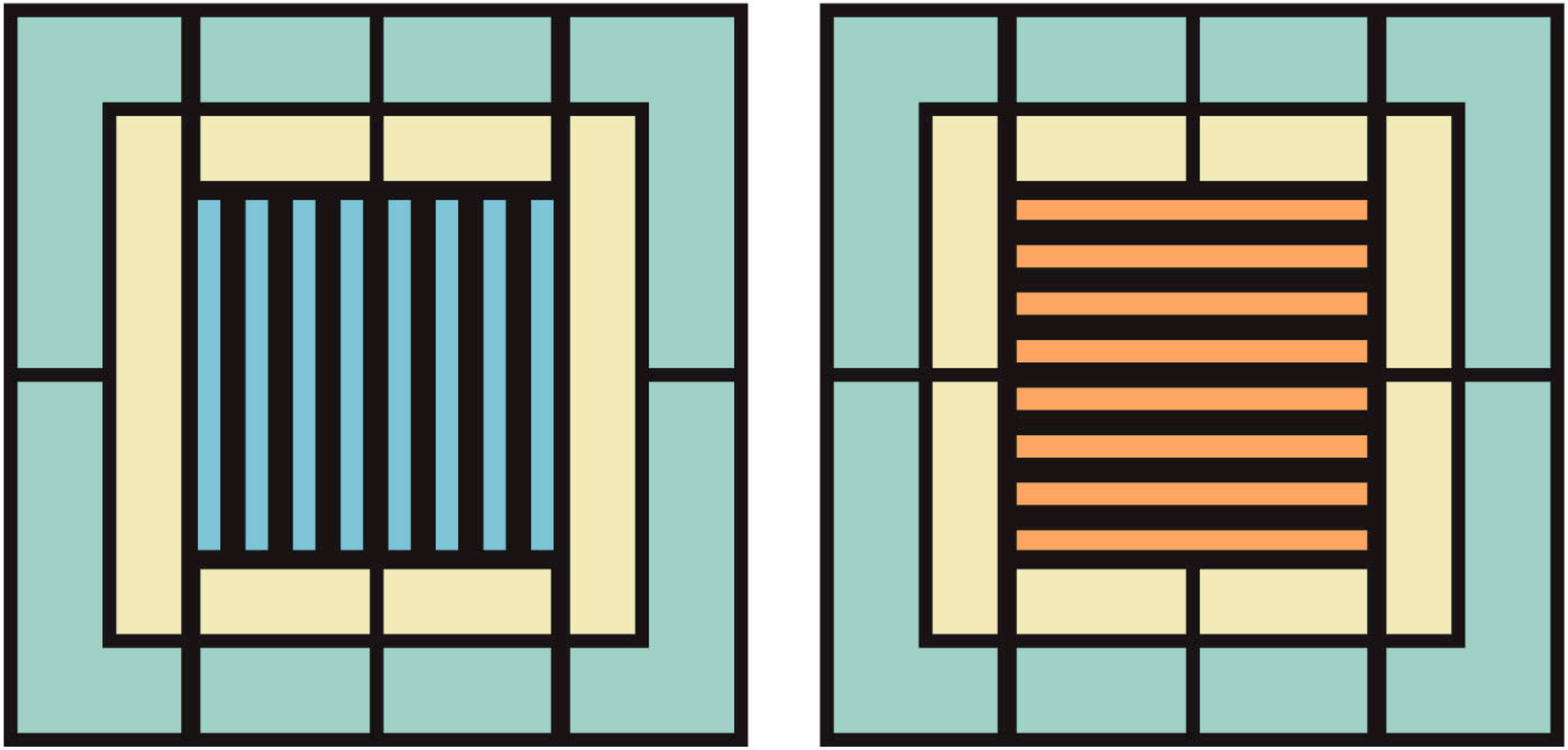
Defects in Stereopsis

Strabismus
• eyes are not aligned, so different images fall on the fovea
• If not corrected at an early age, stereopsis will not develop

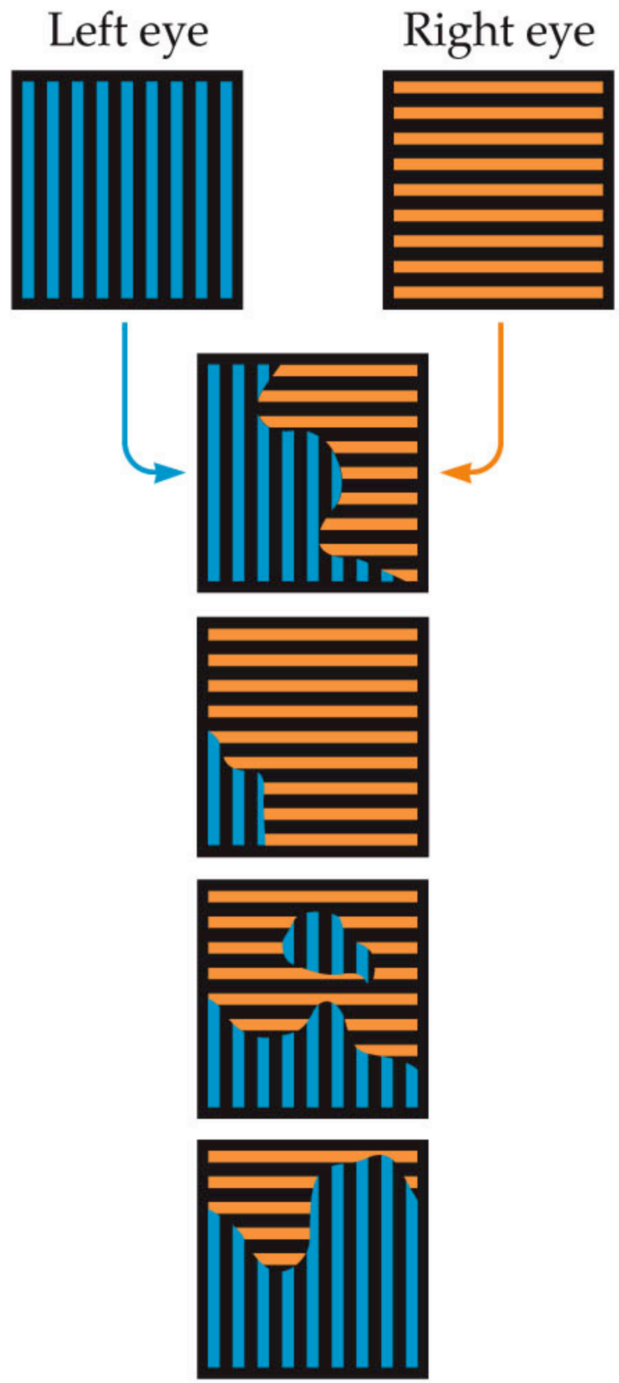
stereoblindness: inability to use binocular disparity as a depth cue.



Binocular Rivalry



Two stimuli battle for dominance of the percept



Chapter 6 Summary:

- monocular depth cues
- binocular depth cues (vergence, disparity)
- horopter
- crossed / uncrossed disparities
- free fusing
- random dot stereogram
- stereoscope
- “correspondence problem”
- panum’s fusional area
- strabismus / stereoblindness
- binocular rivalry (in book)