Visual Processing

Andrew Stockman

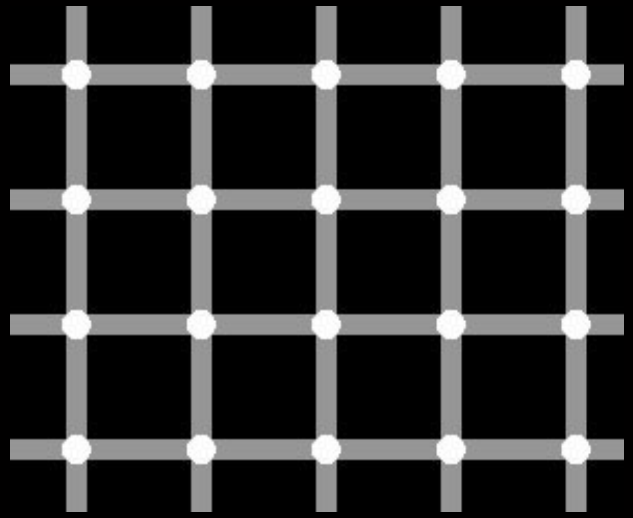
NEUR 0017
Visual Neuroscience

Part 1:

Depth perception and stereopsis

Part 2:

Visual Illusions



1. DEPTH PERCEPTION AND STEREOPSIS

Monocular depth

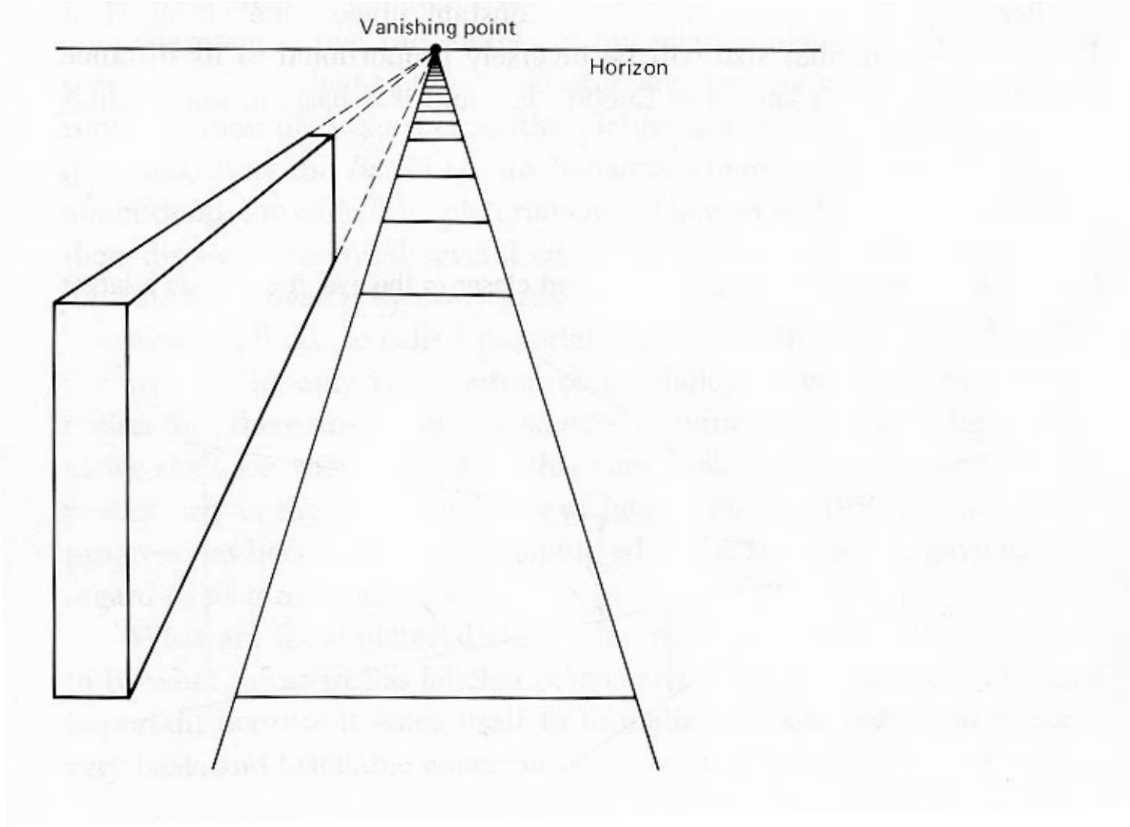
You don’t need two eyes to perceive depth…

Which monocular depth cues can you see in this picture?

MONOCULAR DEPTH CUES

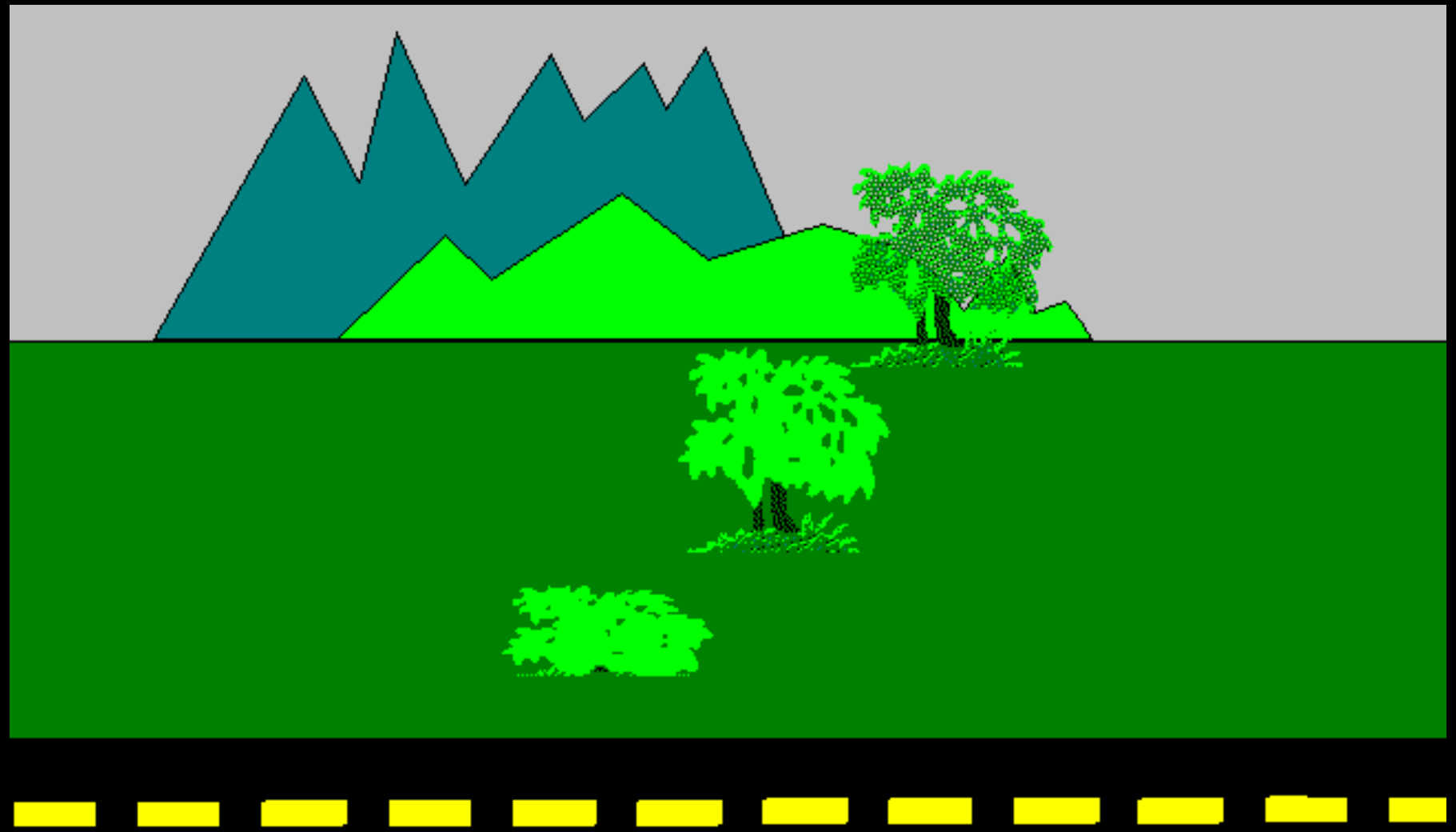
- Linear perspective
- Motion parallax
- Interposition
- Shading
- Relative size
- Relative height
- Aerial perspective
- Texture
- 3D Structure from motion

Linear perspective



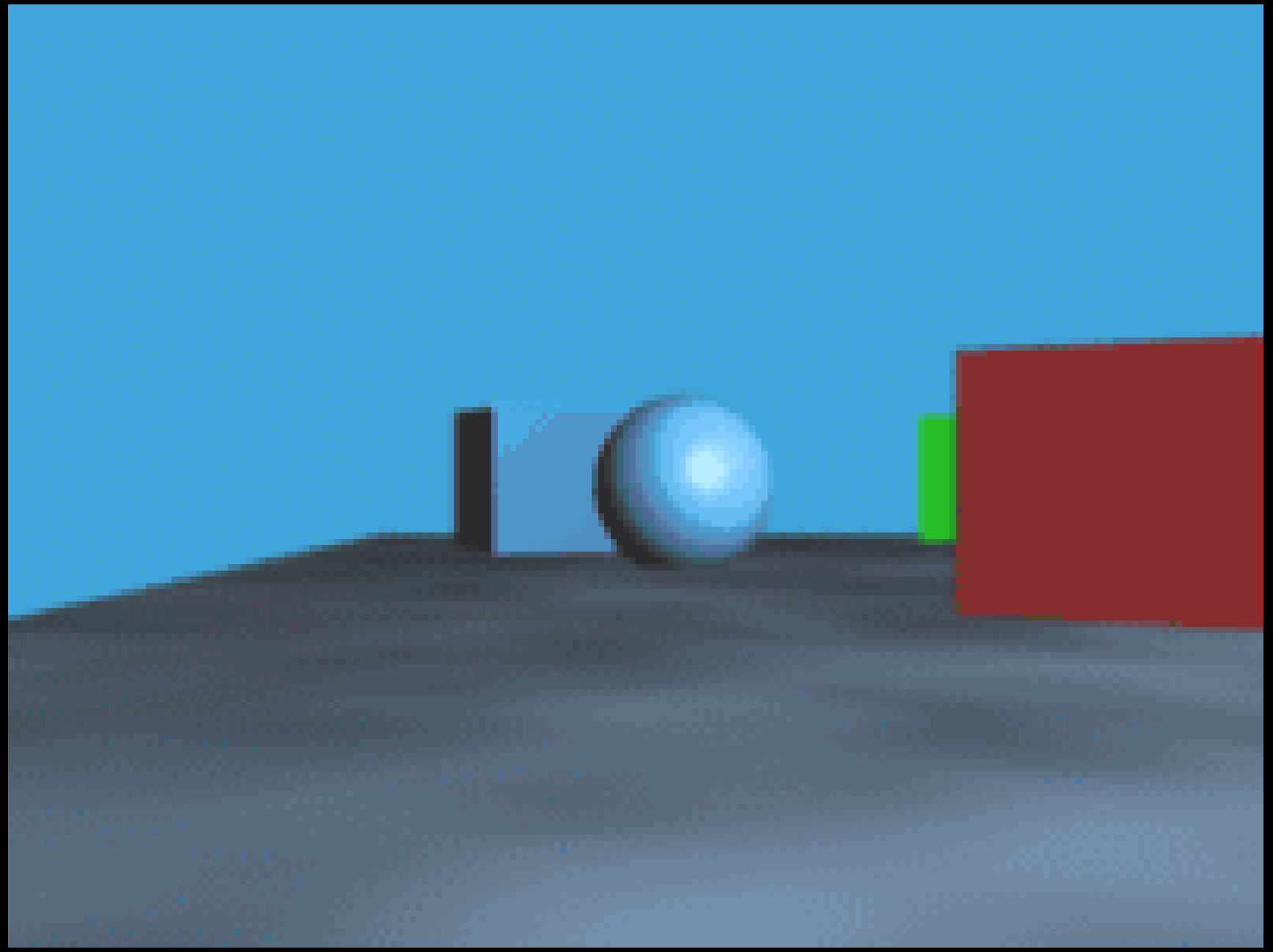
Motion parallax

Fixation point determines plane in the scene that doesn't move.

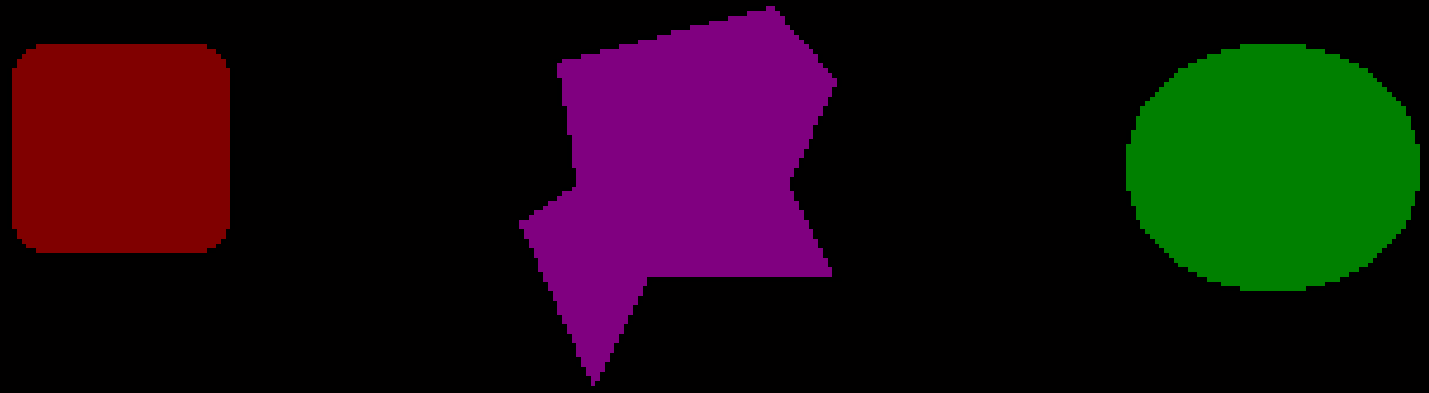


Credit: John Krantz

Motion parallax

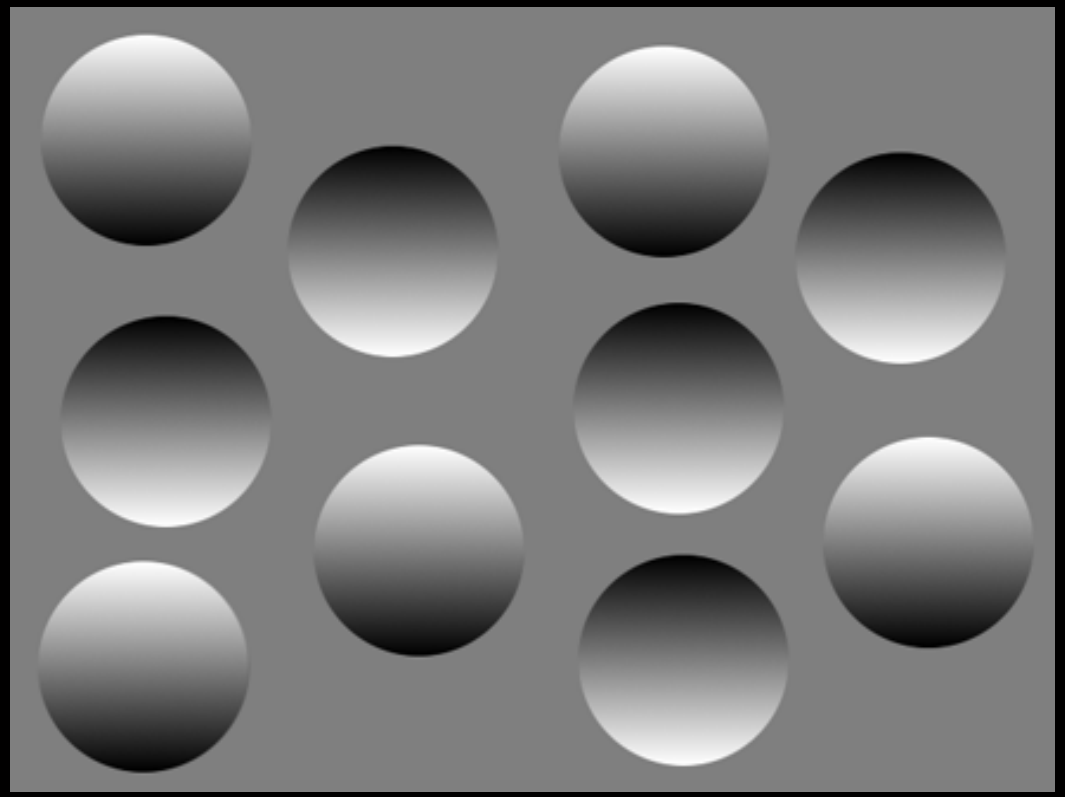


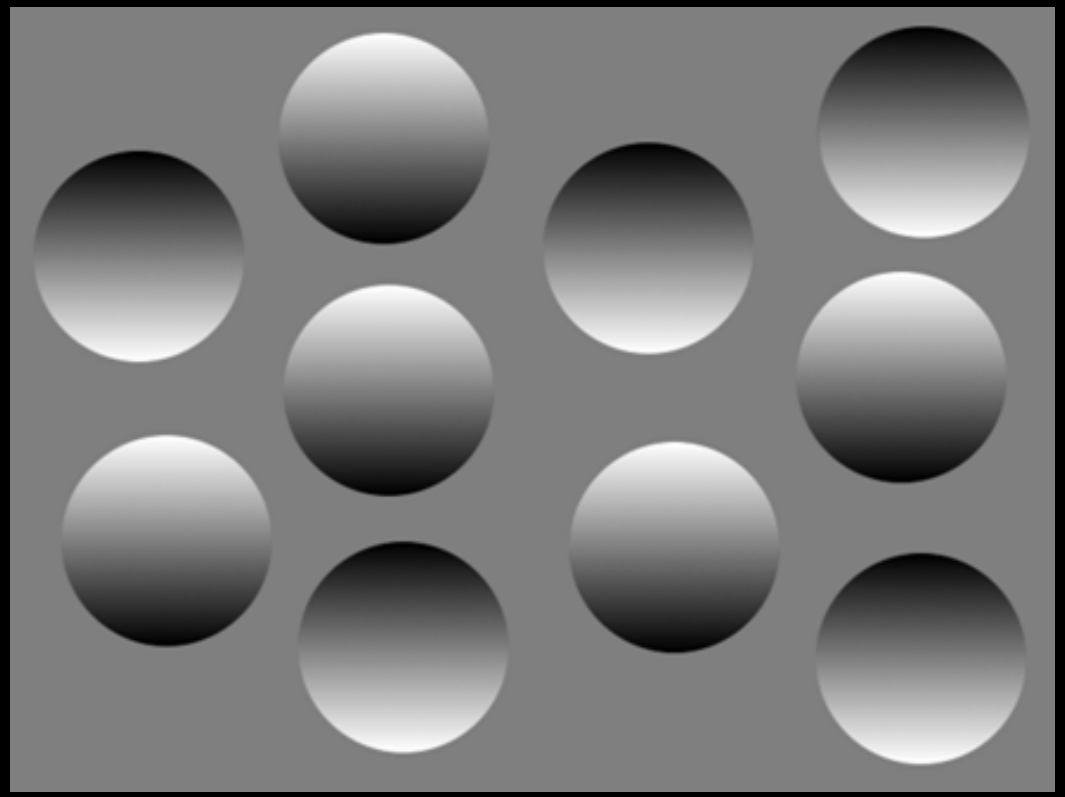
Interposition



Credit: John Krantz

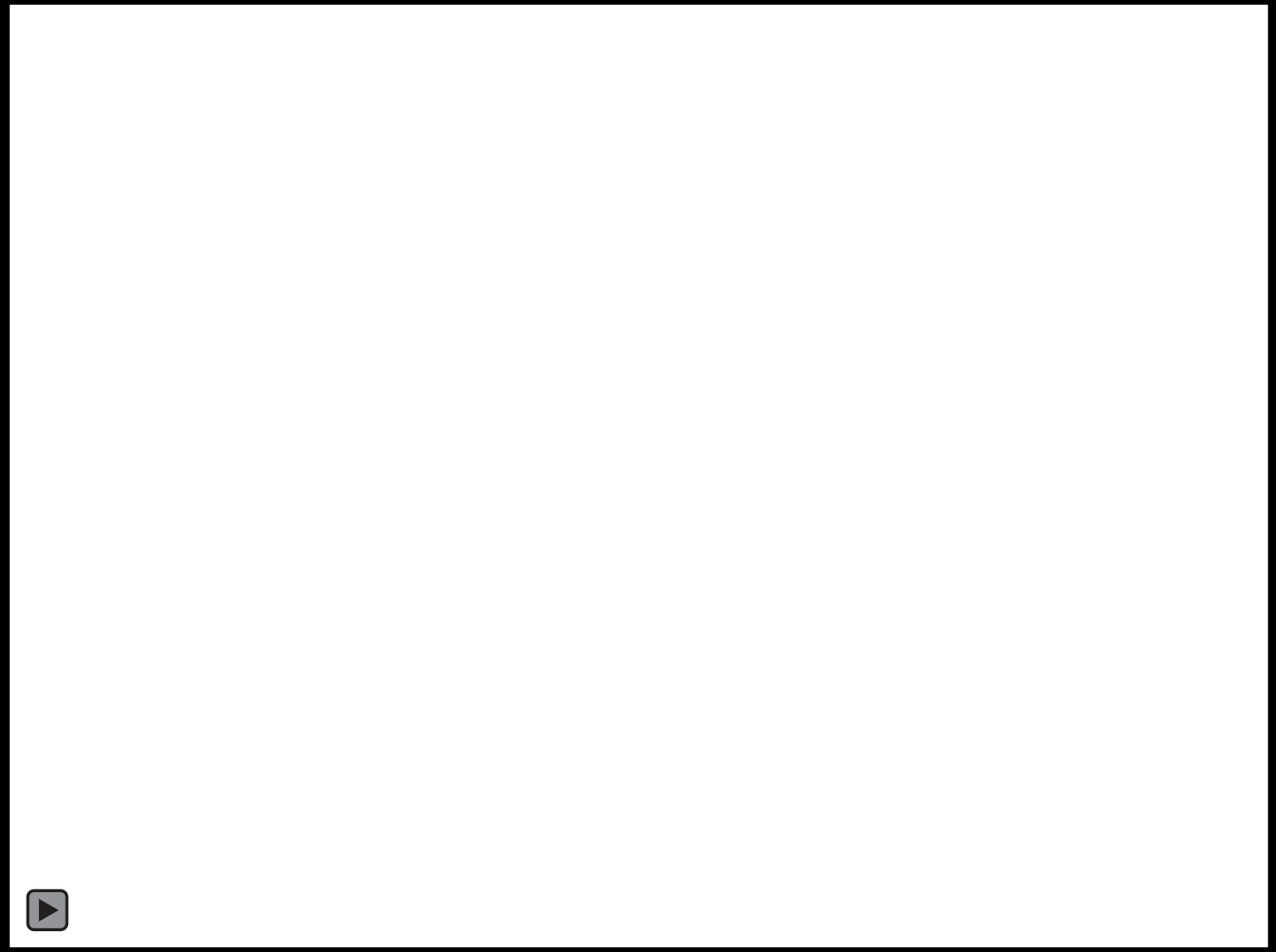
Depth from shading



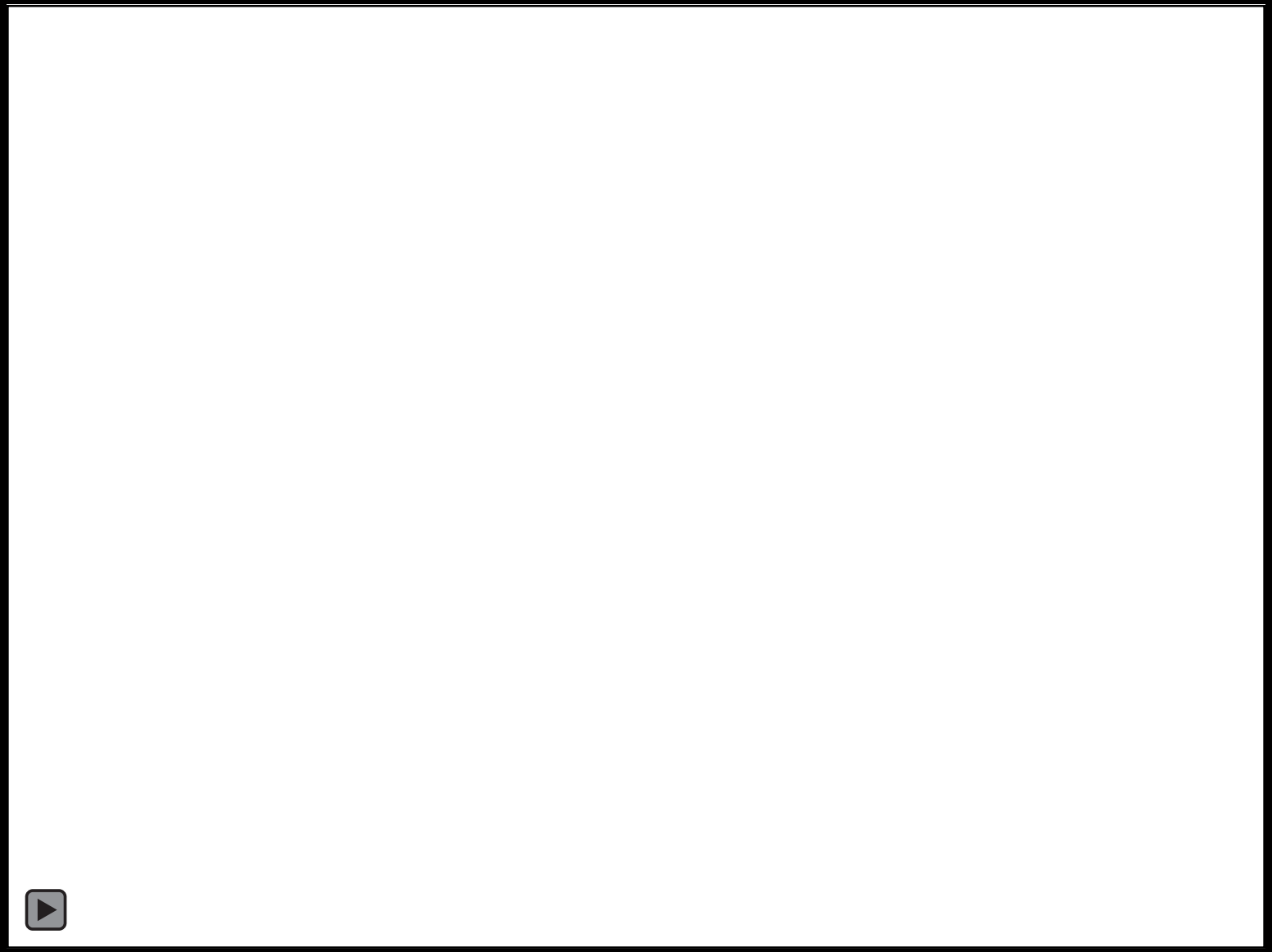


What assumption about the light source is made?

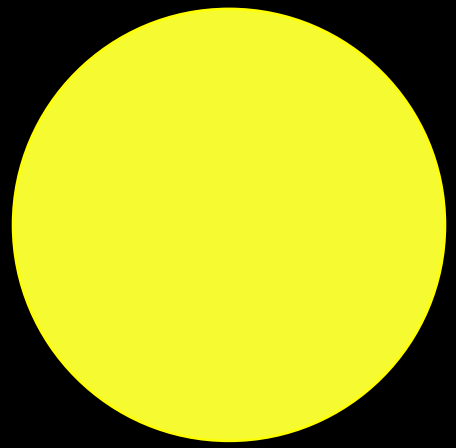
Inverted face illusion



Ball-in-a-box



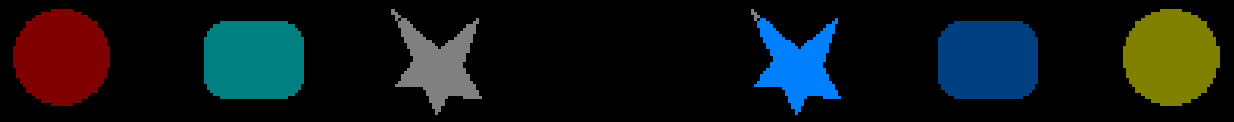
Relative size



Credit: John Krantz

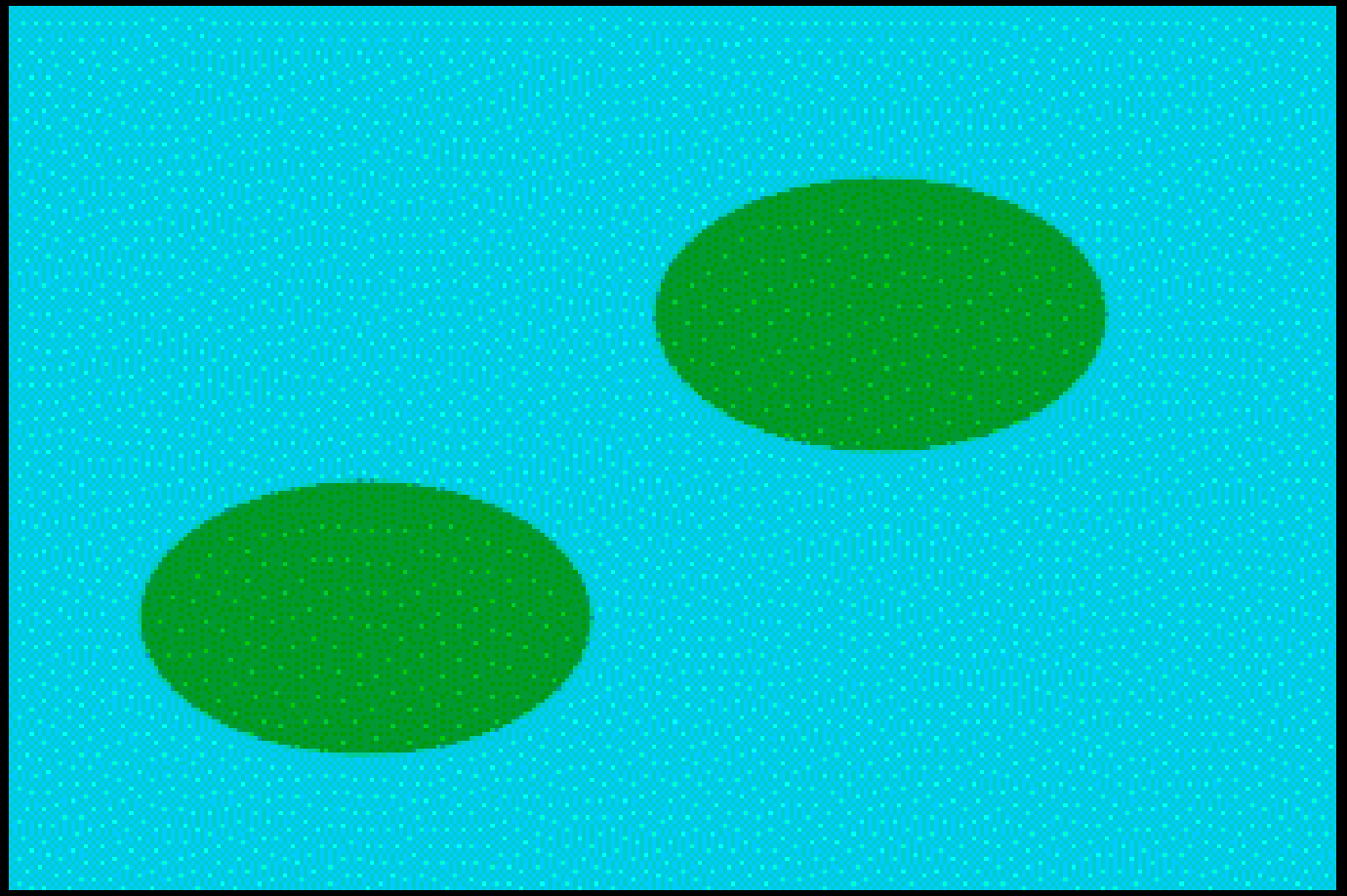
Relative size

Relative height



Credit: John Krantz

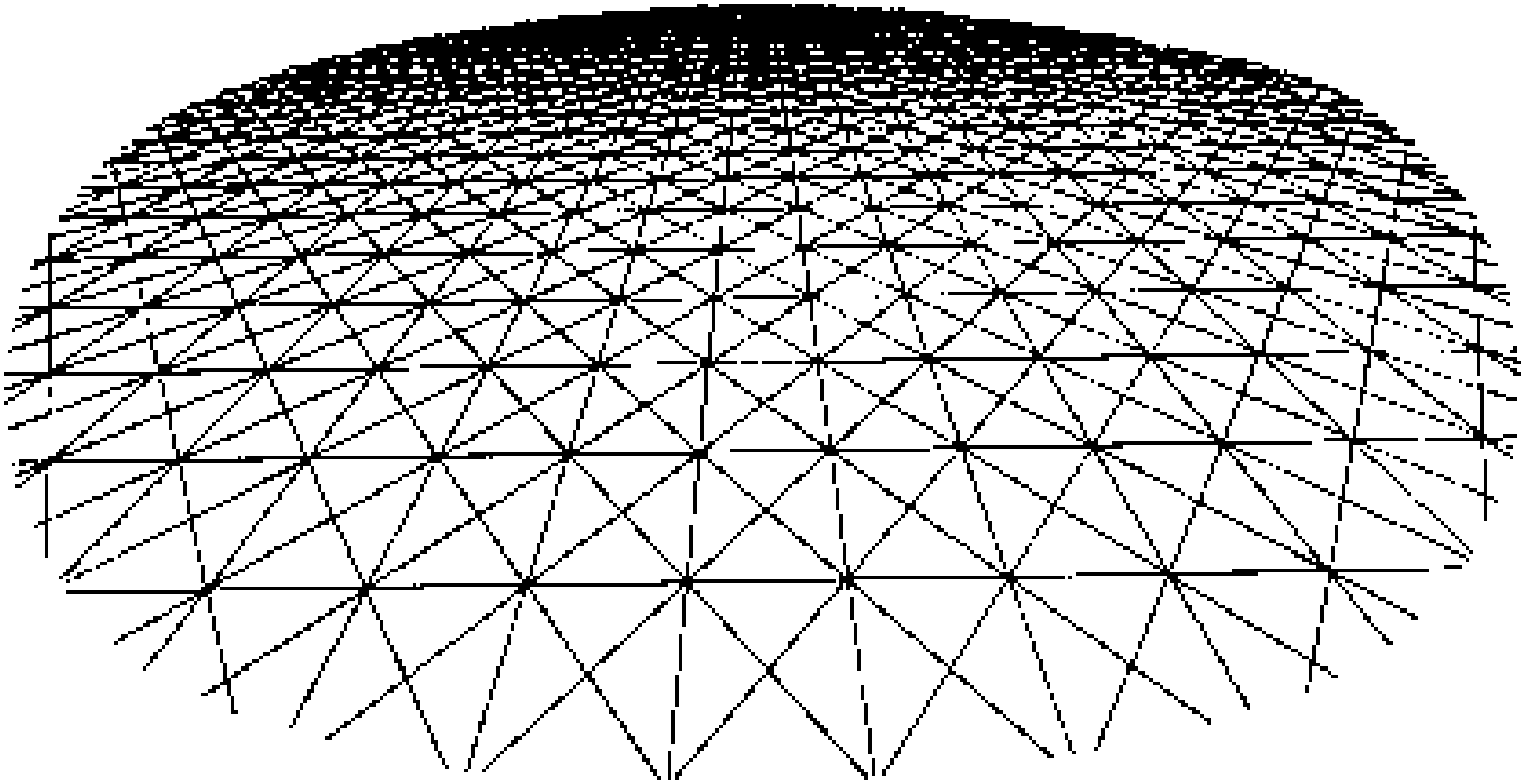
Aerial perspective



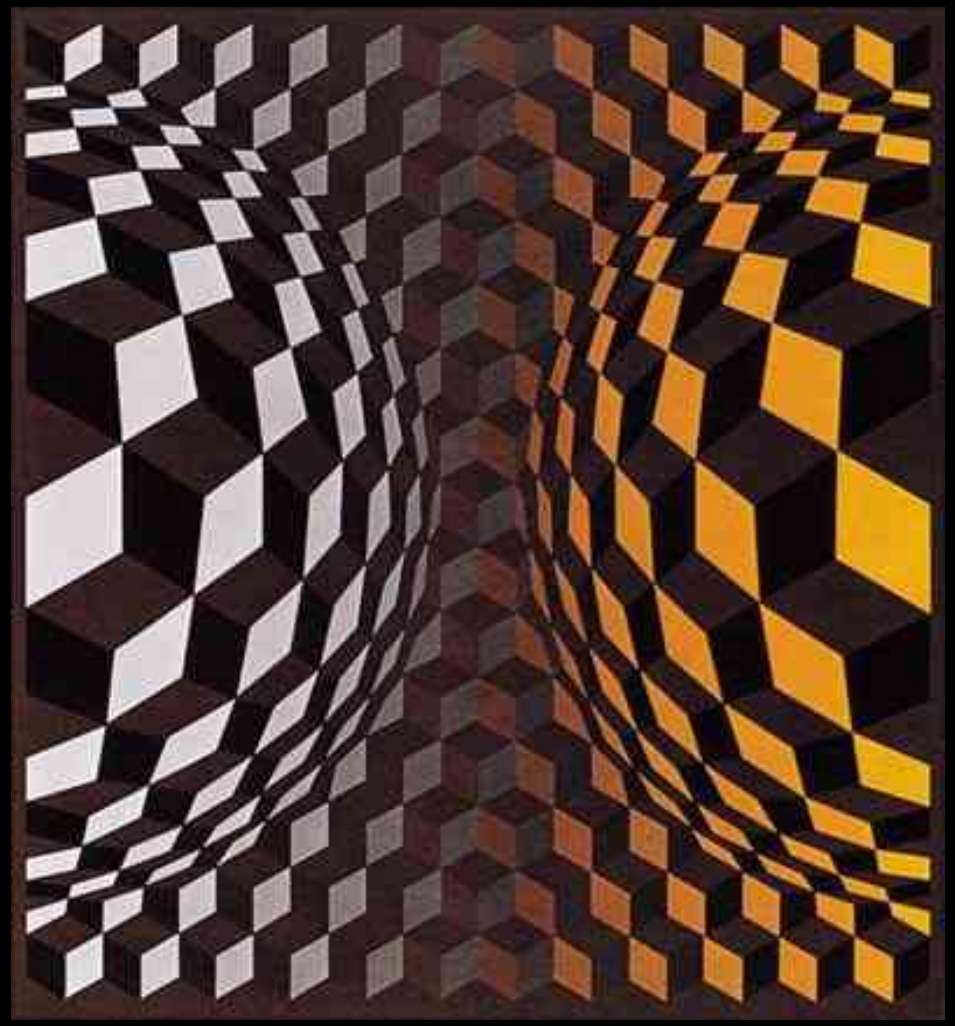
Credit: John Krantz

Aerial perspective

Texture



Texture



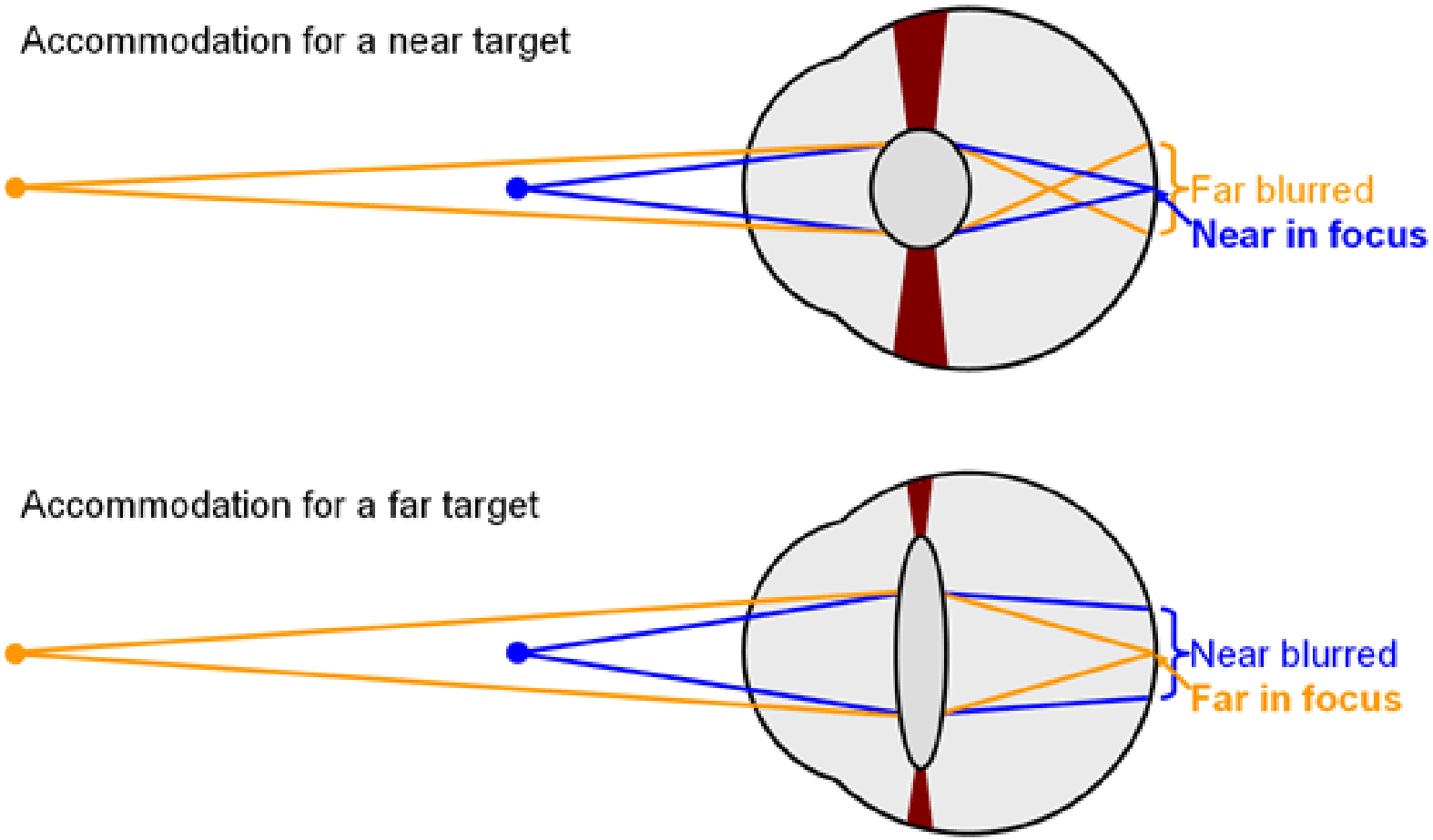
3D structure from motion

Myron L. Braunstein

What cues are in this picture?

- Linear perspective
- Motion parallax **X**
- Interposition
- Shading
- Relative size
- Relative height
- Aerial perspective
- Texture
- 3D Structure from motion **X**

Accommodation

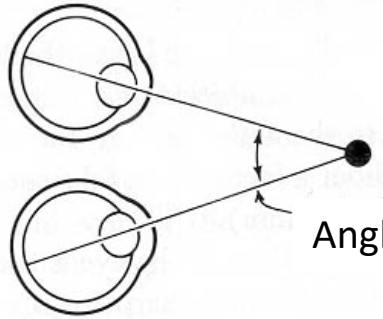


STEREO DEPTH CUES

- Convergence
- Binocular disparity

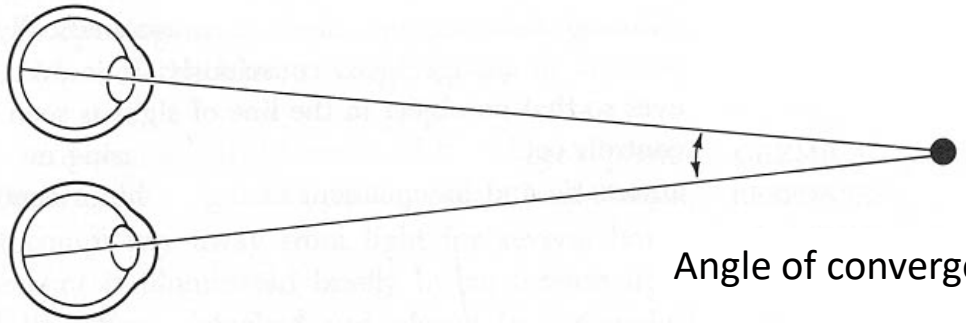
Convergence

Thick lens and large angle of convergence when the object is close (pupil size decreases to increase depth of field)



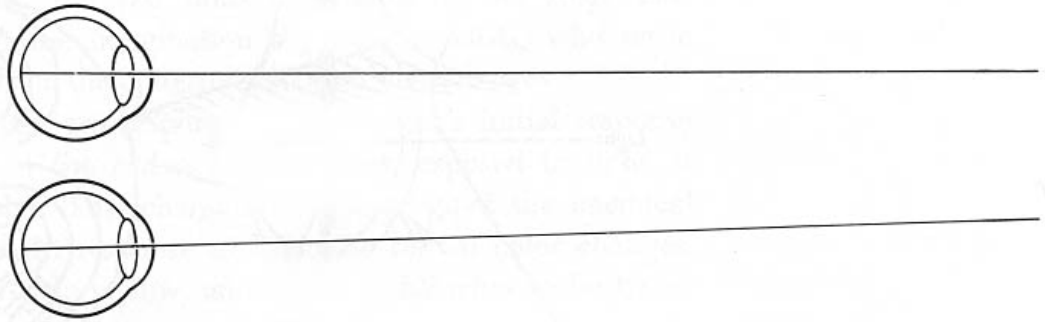
Angle of convergence

Thinner lens and small angle of convergence when the object is farther away



Angle of convergence

Very thin lens and negligible angle of convergence when the object is very far away



Credit: Lindsay and Norman

Binocular disparity

A and B are at the same depth and thus have the same disparity (of zero since it is A which is being fixated)

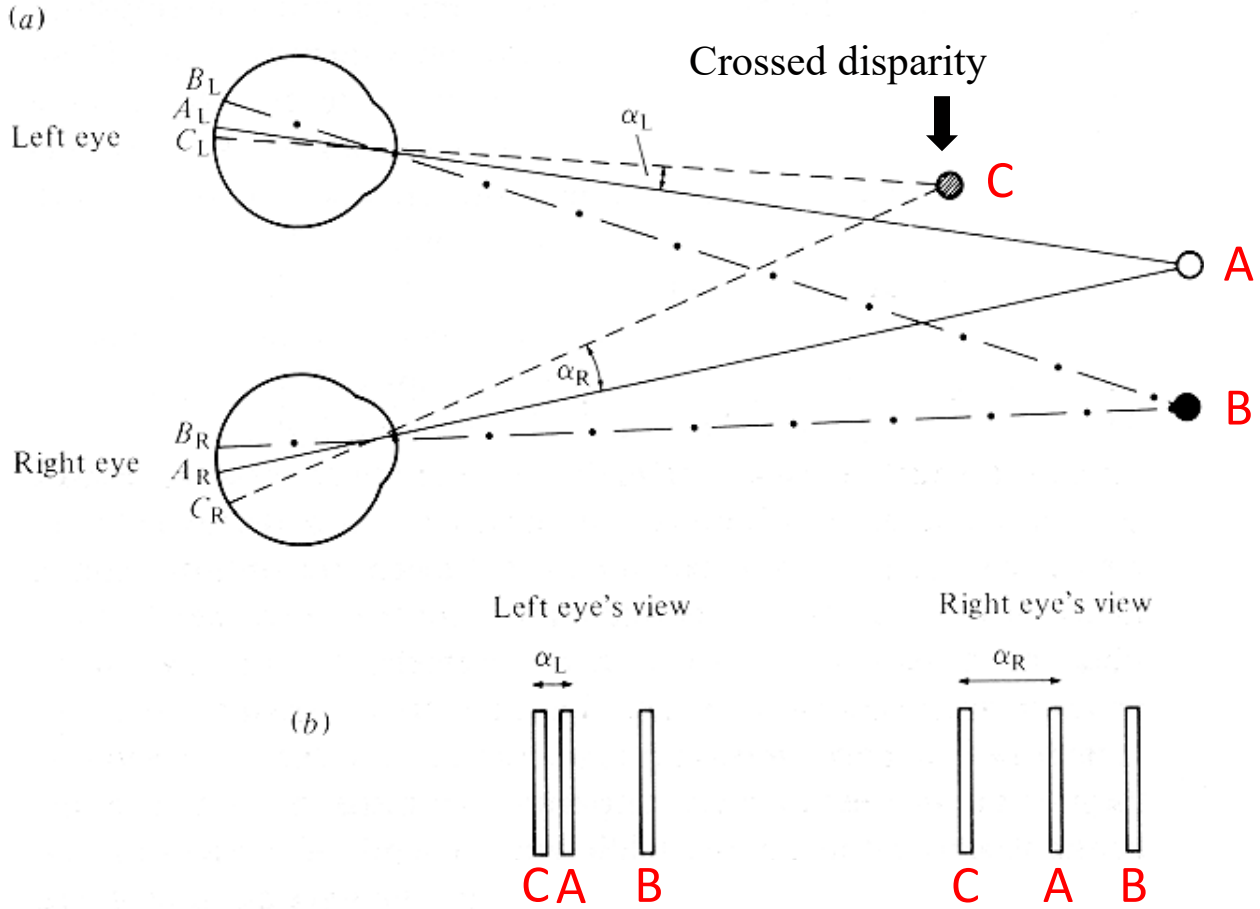
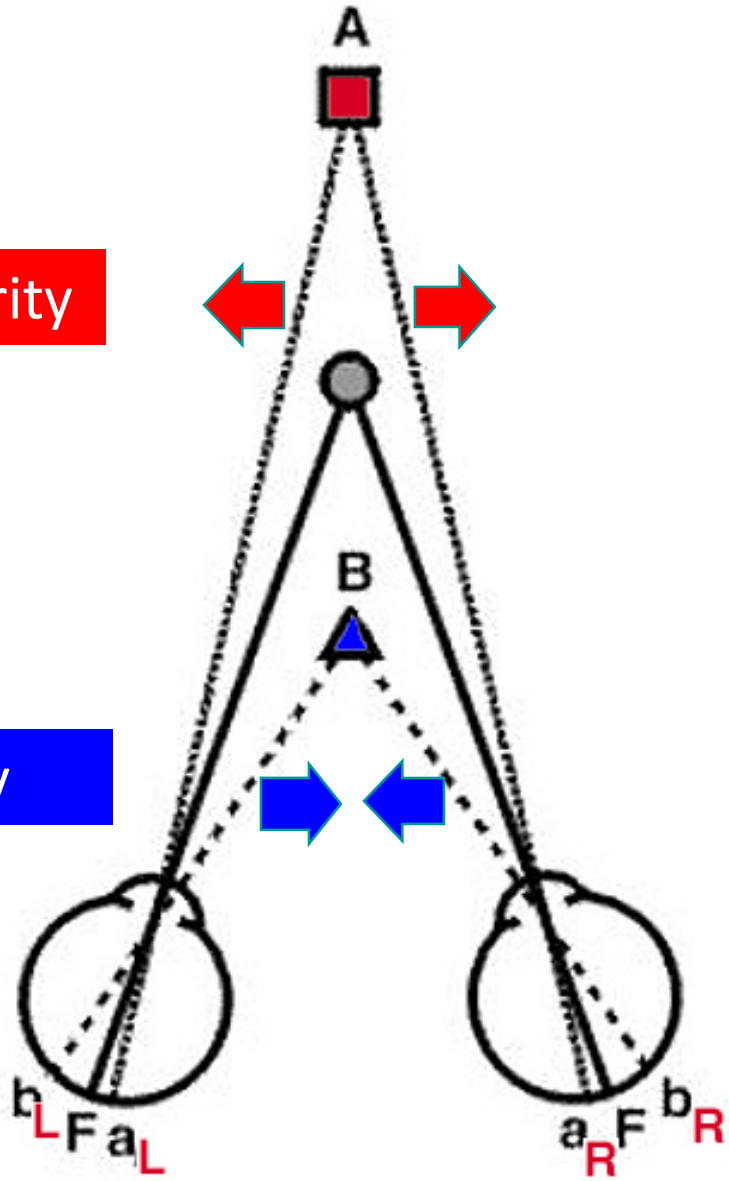


Fig. 10.1. (*a*) Projections of three objects on to the two retinae. A_L B_L C_L are the positions of the retinal images of *A B C* in the left eye, and A_R B_R C_R the positions of their retinal images in the right. Since *A* is fixated, A_L and A_R are the central foveas of each eye. The angular difference $(\alpha_R - \alpha_L)$ is the disparity of the images of *C*. *A* and *B* have zero disparity. (*b*) The spatial relationship of *A*, *B* and *C* as viewed by each eye, showing the disparity between the two eyes' views. This pair of pictures, displayed in a stereoscope, would give the same retinal patterns as the objects in space and would lead to the same perception of stereoscopic depth.

Binocular disparity

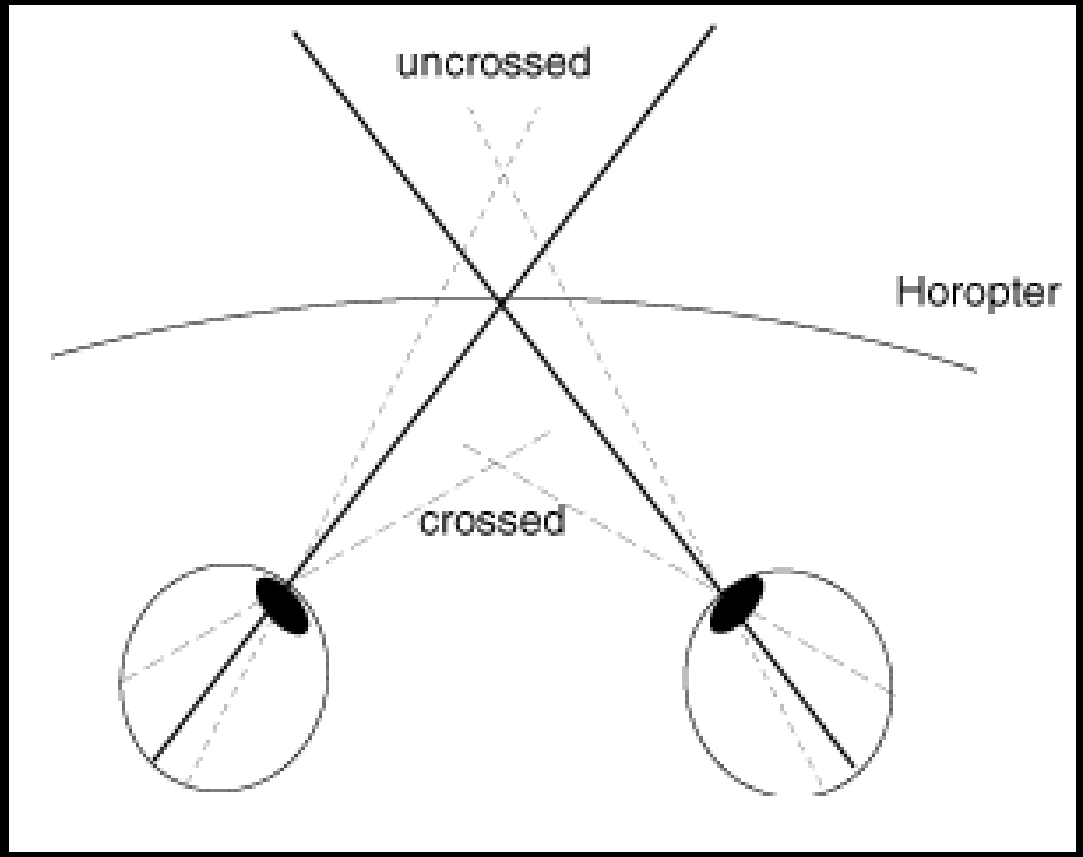
(A) Uncrossed disparity

(B) Crossed disparity

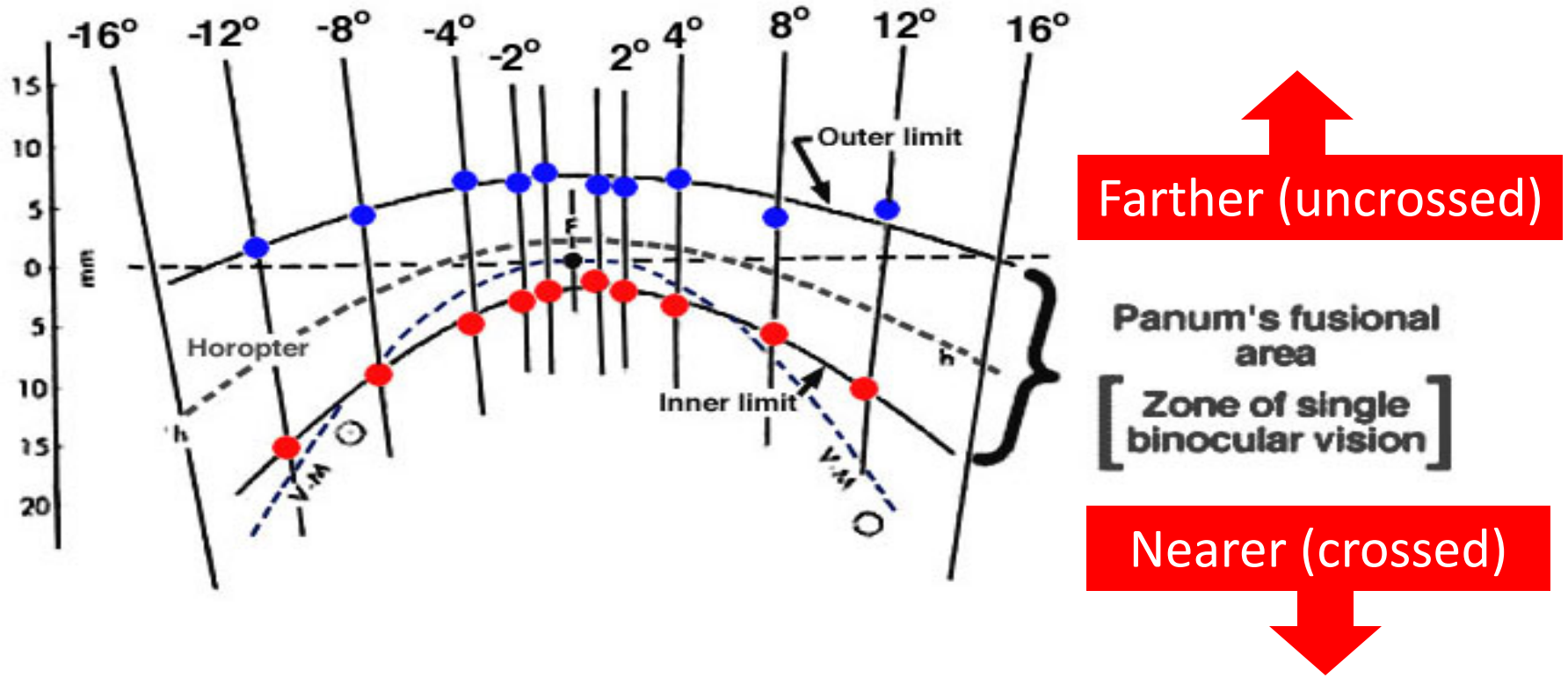


Credit: Webvision

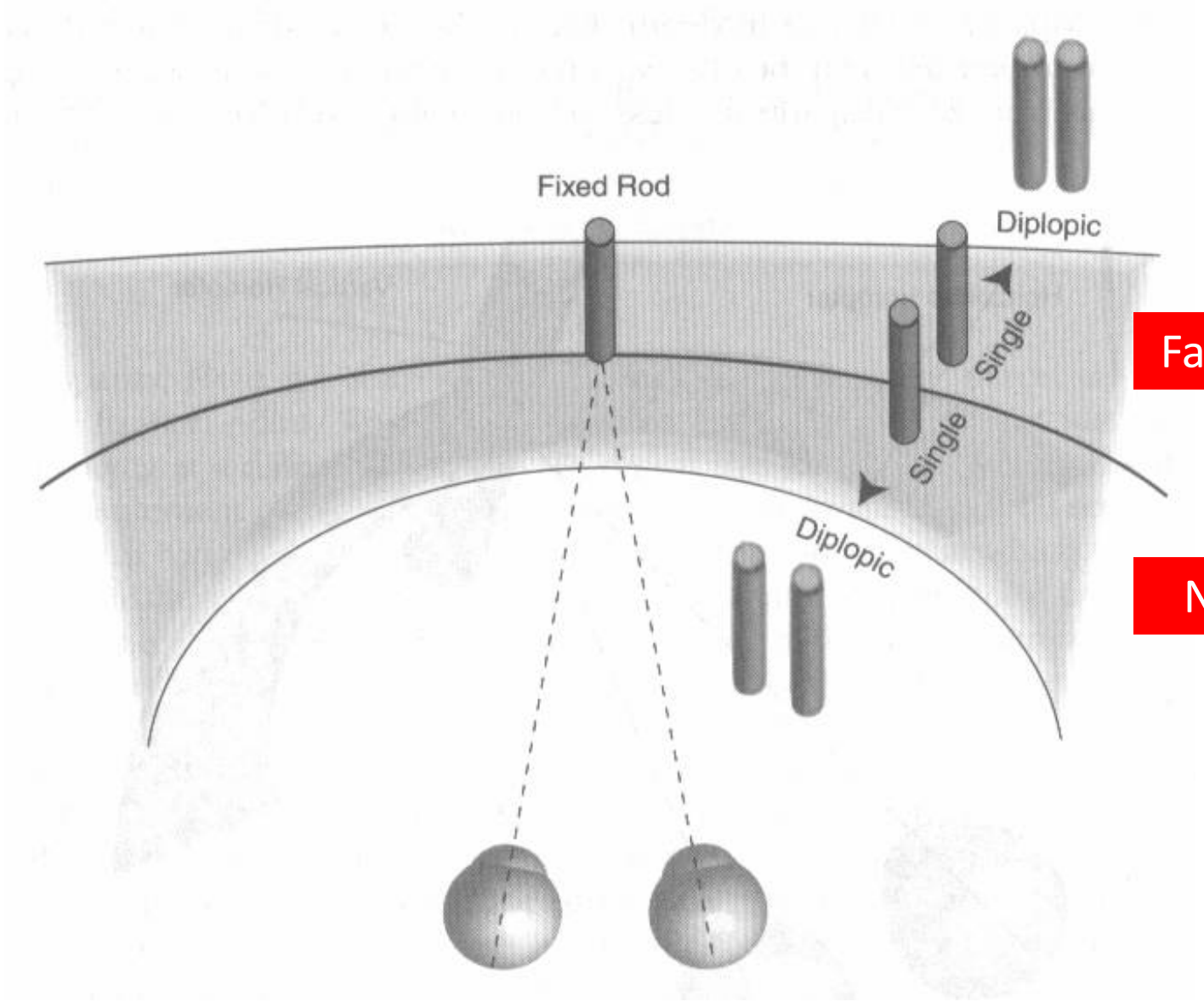
Uncrossed disparity: An object farther away than the horopter has uncrossed disparities. You must 'uncross' your eyes to fixate on it.



Crossed disparity: An object closer than the horopter has crossed disparity. You must 'cross' your eyes to fixate on it.



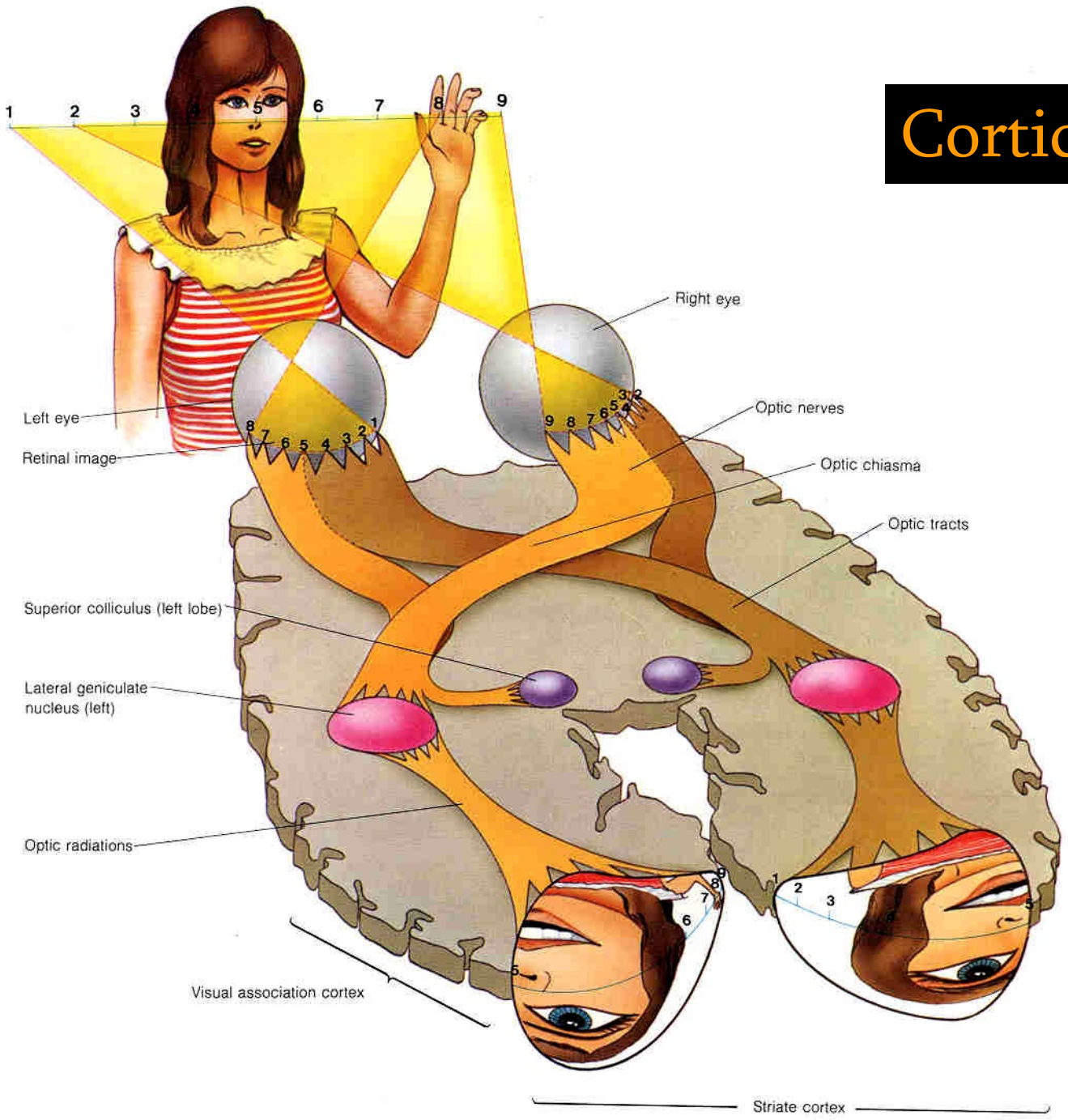
You get diplopia (double vision) outside Panums's fusional area.



Farther (uncrossed)

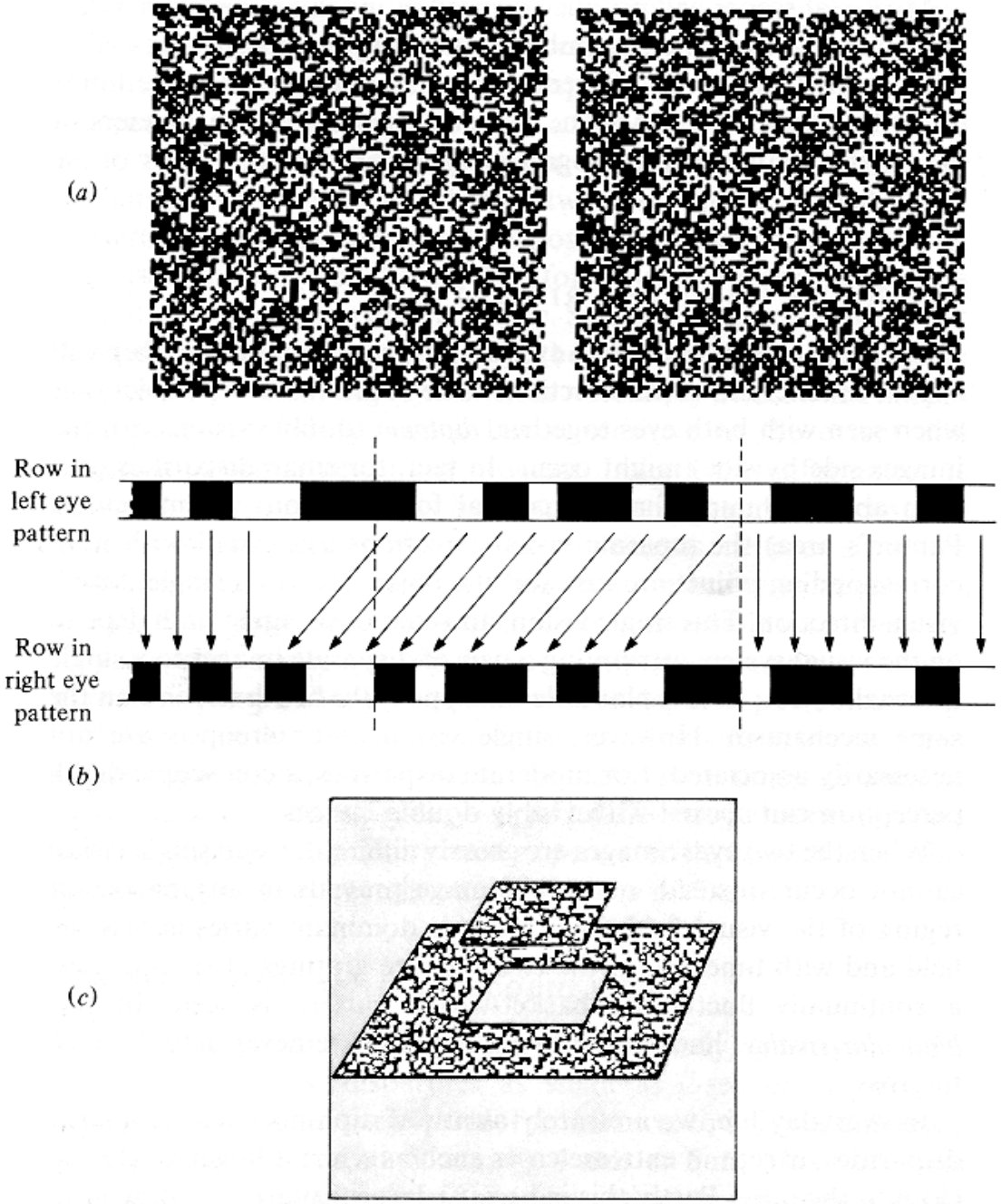
Nearer (crossed)

Cortical projections

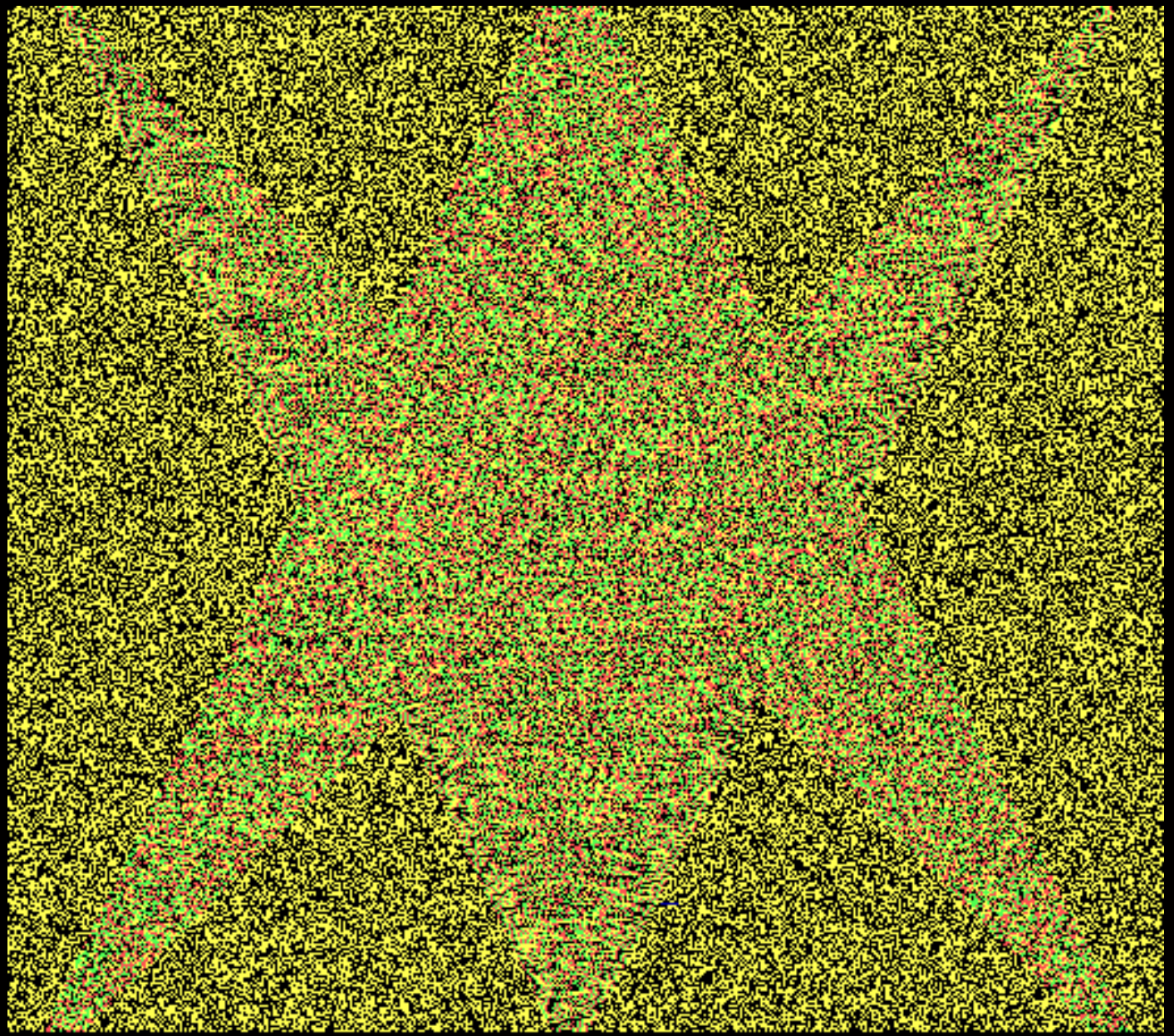


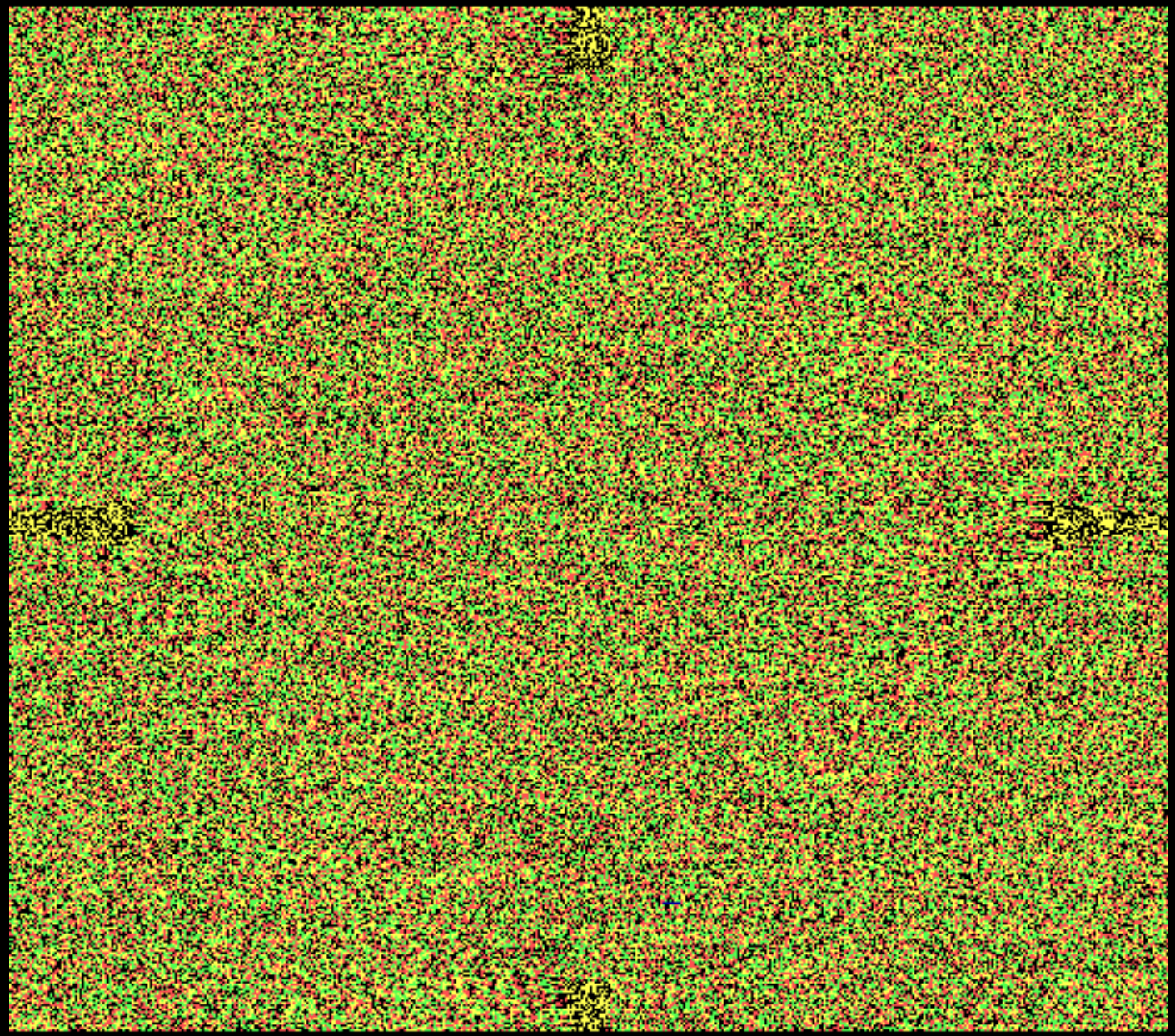
Dave Pape,
Wikipedia

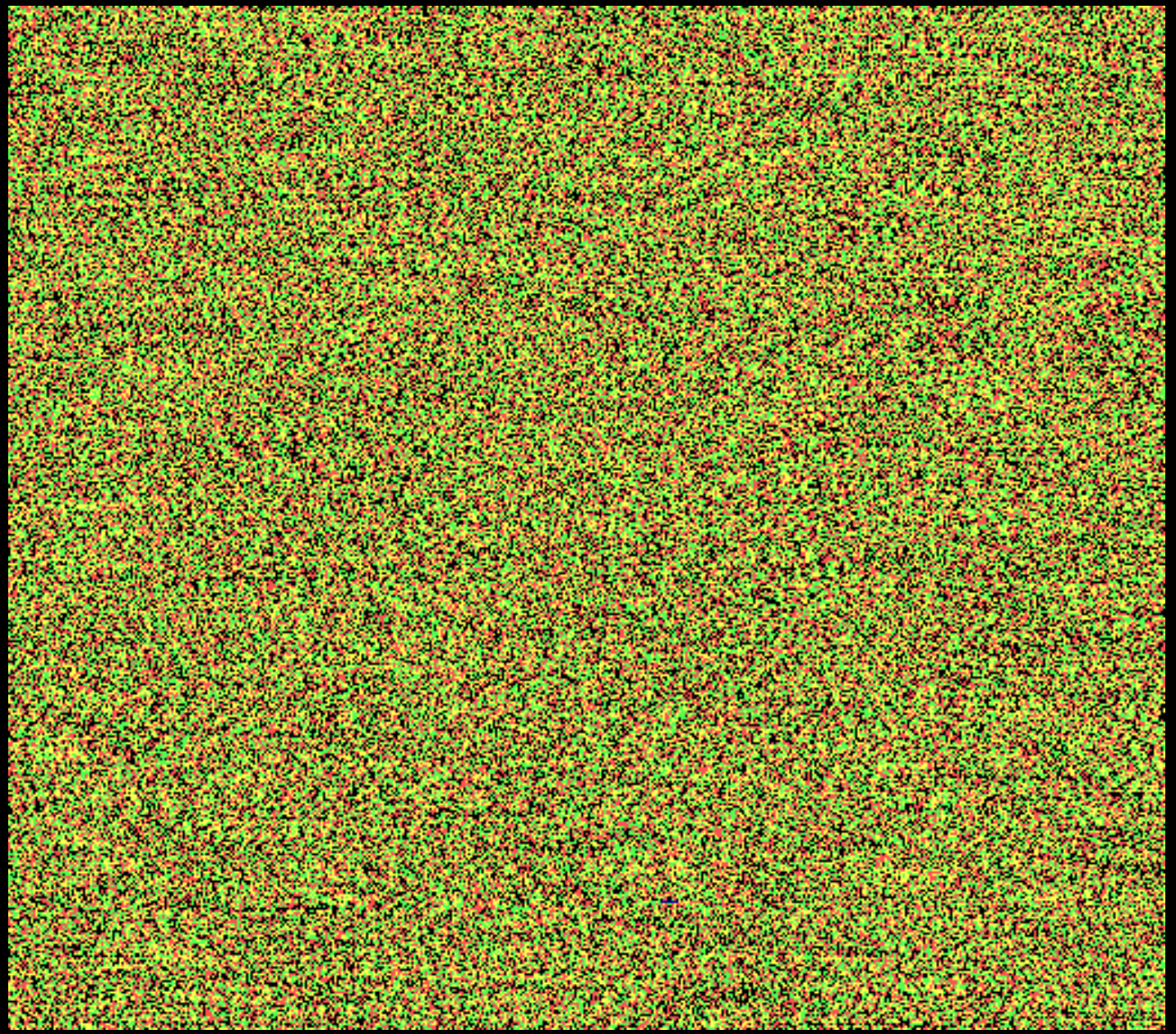
Principal of stereograms

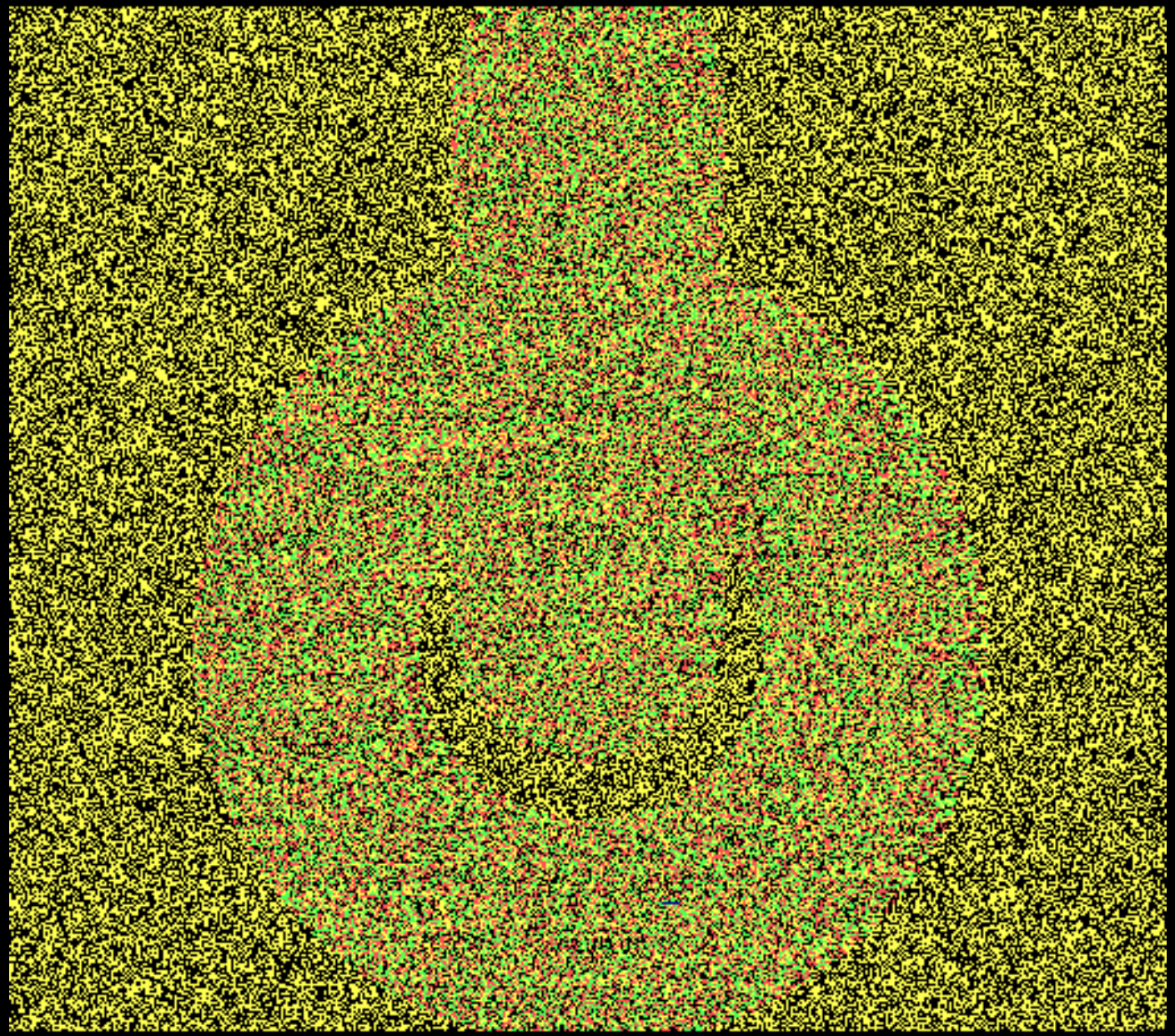


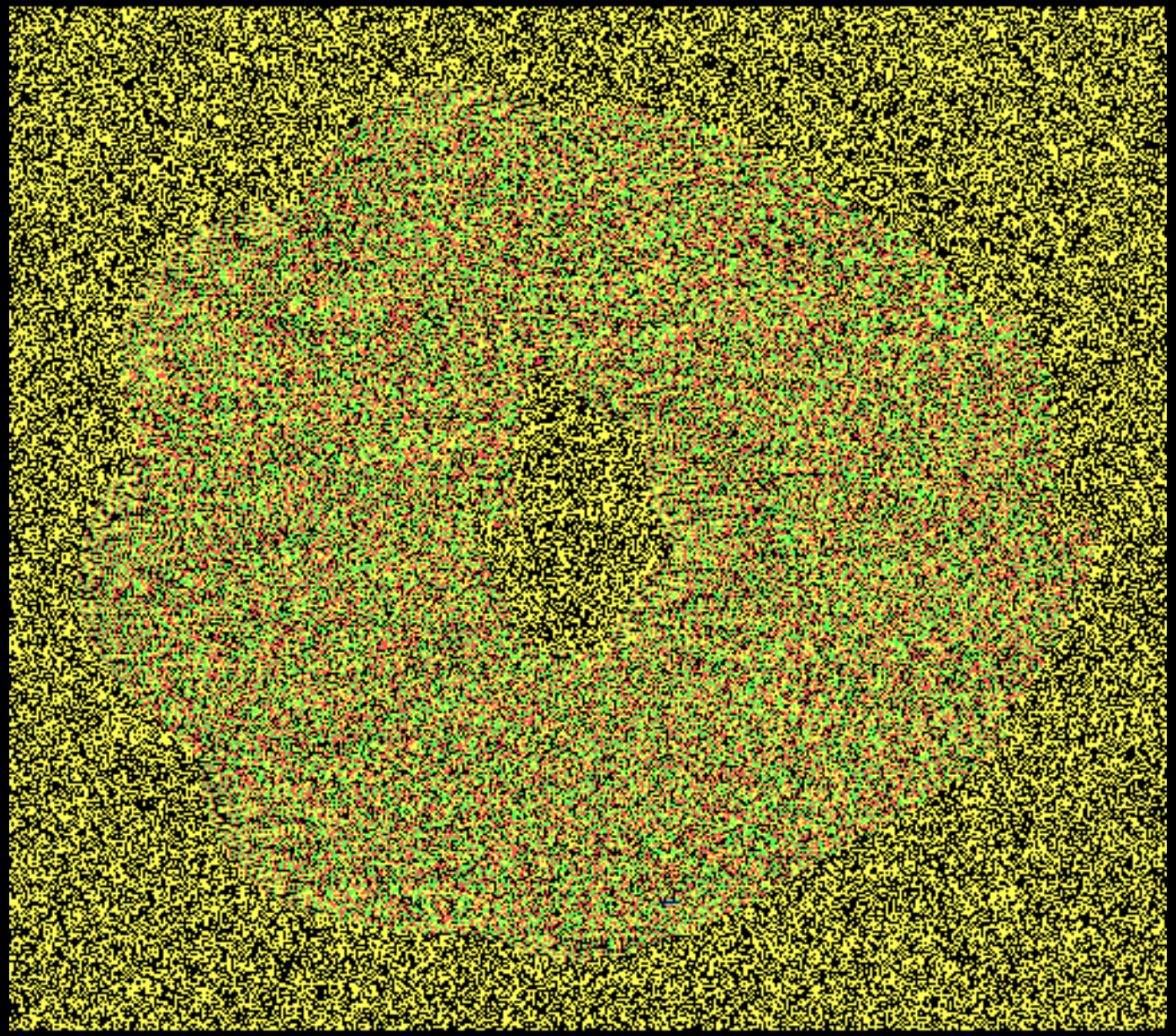
Credit: Braddick

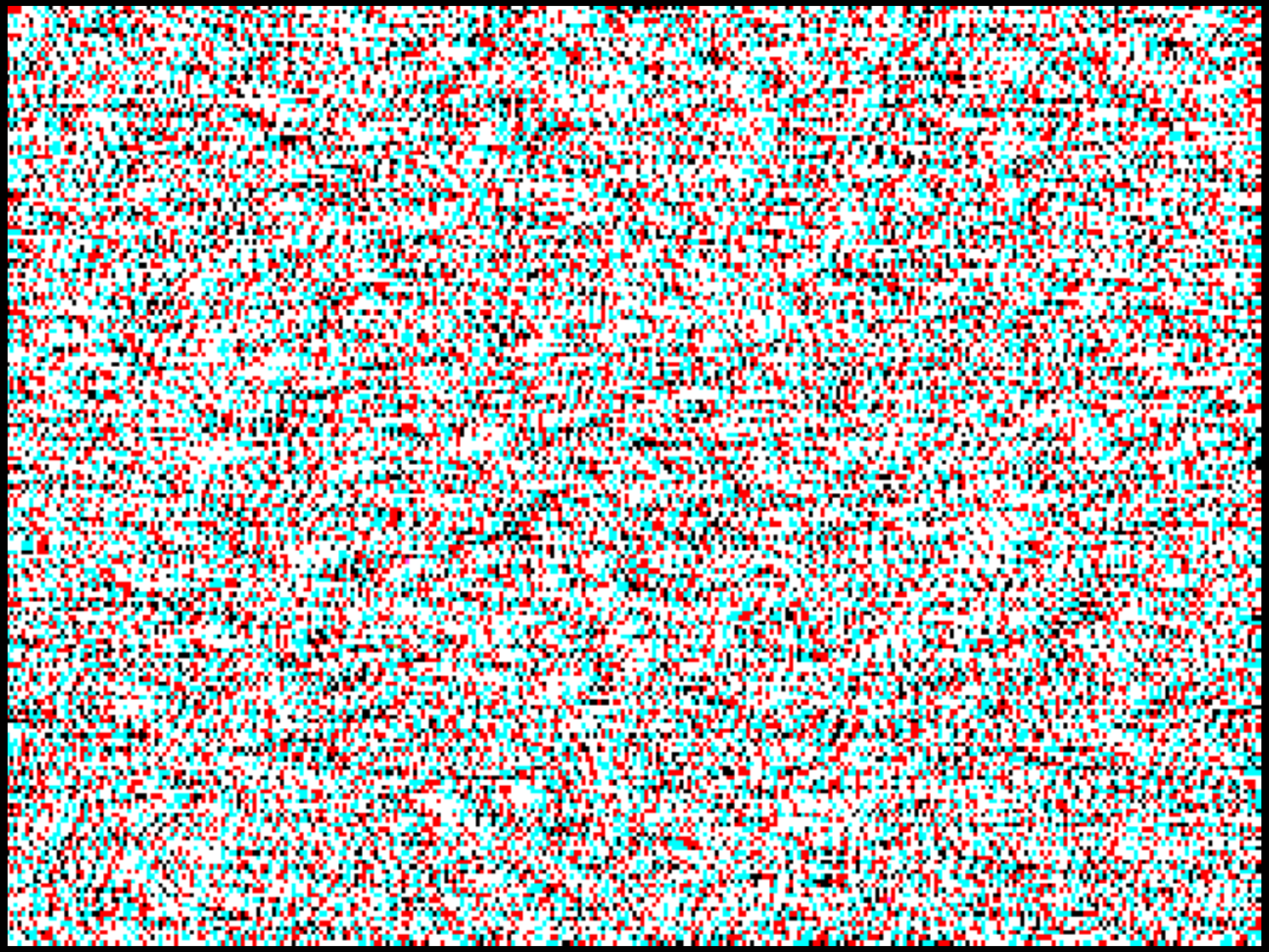


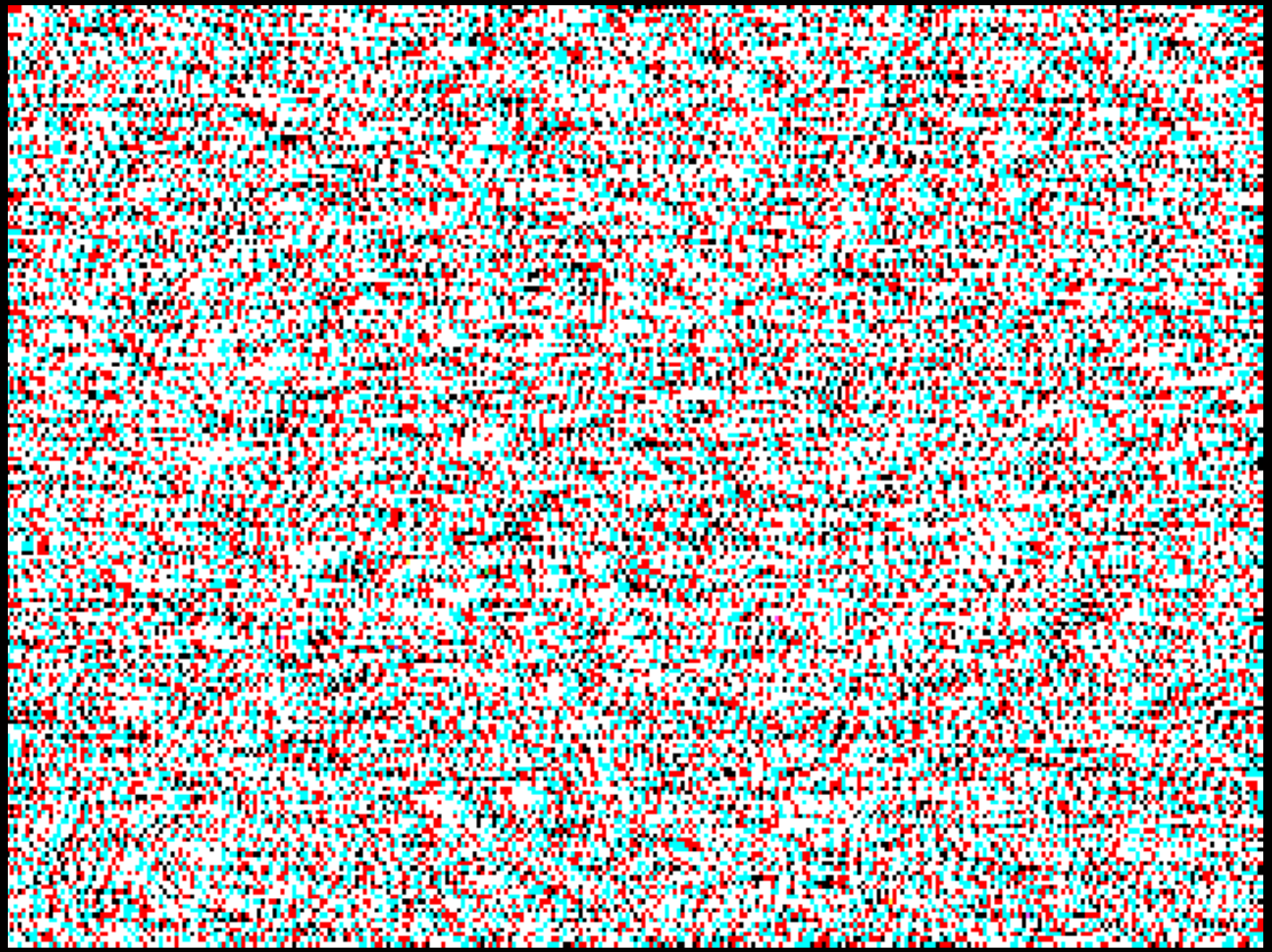


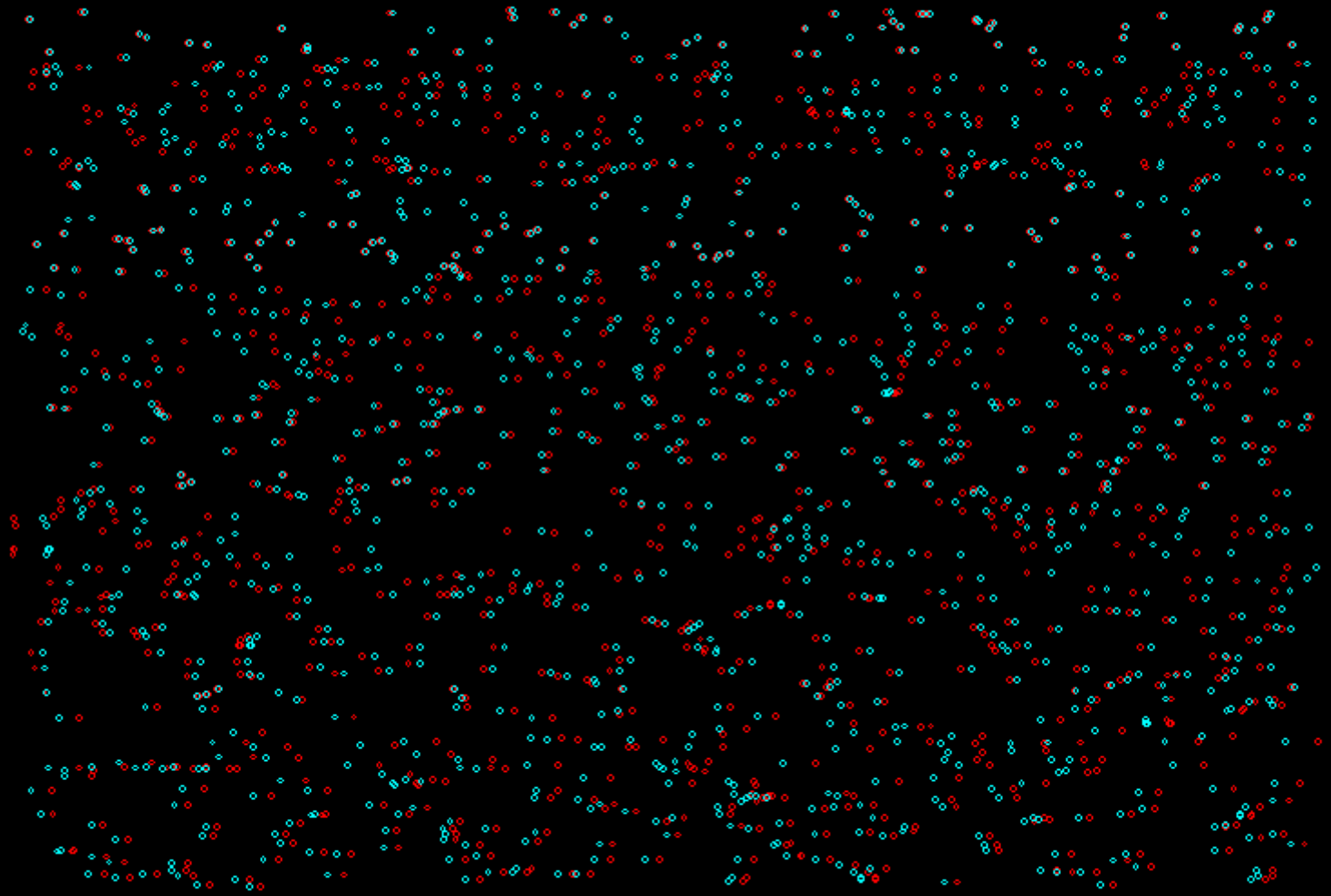




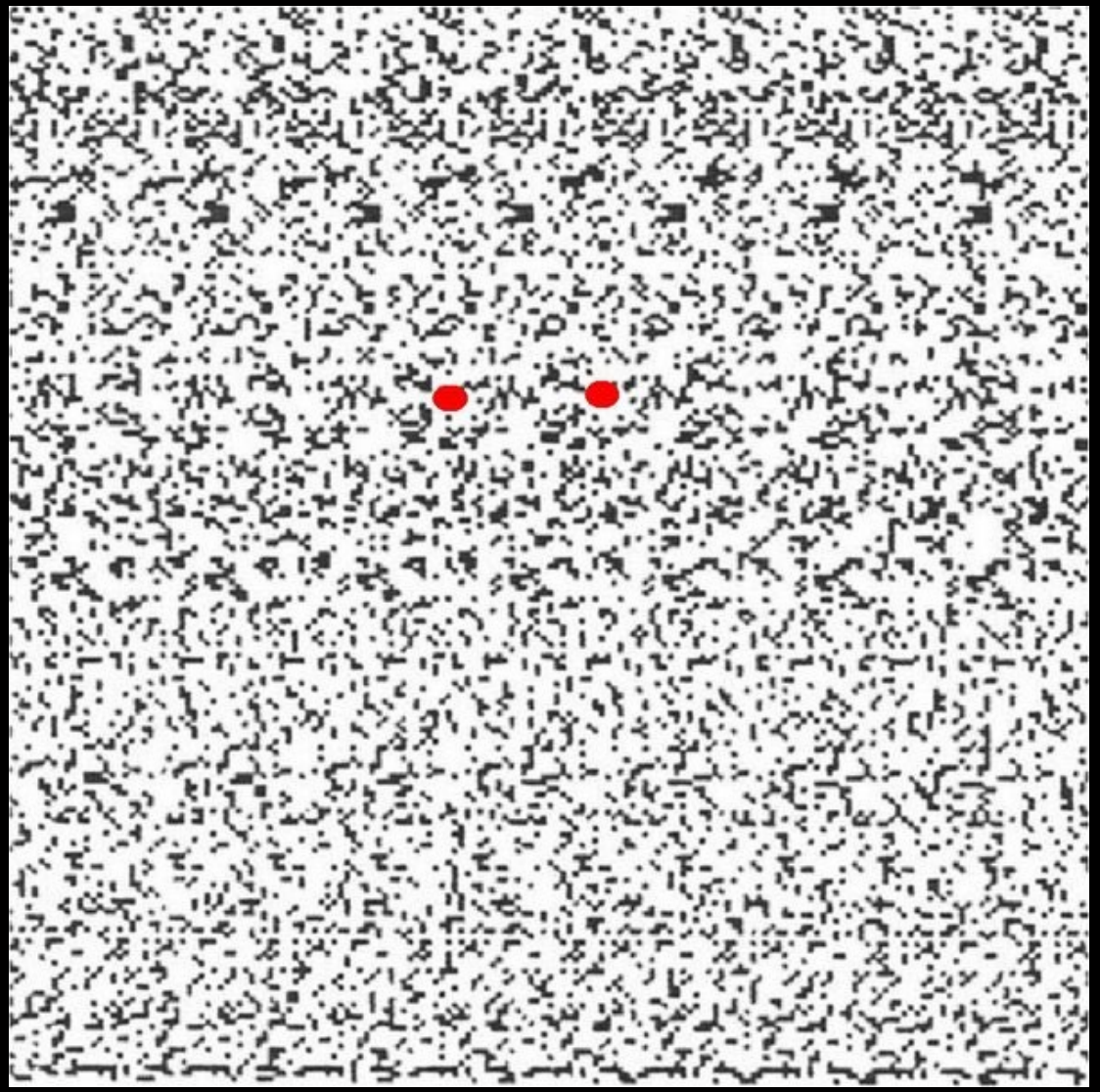








Autostereograms



'Furrows' (1979). One of the first random-dot autostereograms (from Tyler, 1994).
Converge or diverge the eyes so as to see a triplet of three red dots

DEPTH CUES: Summary

Monocular

- Linear perspective
- Motion parallax
- Interposition
- Shading
- Relative size
- Relative height
- Aerial perspective
- Texture
- 3D Structure from motion
- Accommodation

Binocular

- Convergence
- Binocular disparity

2. VISUAL ILLUSIONS

Why study illusions?

- Seeing is not always believing
- Failures can provide an insight into how the visual system works
- They are fun
- Usually “perception” rather than “sensation”

Try to come up with your own explanations as we go through them…

Illusions of colour and luminance

We've already encountered many illusions in the colour and luminance (and other) lectures.

Used by lecturers in vision for the wow factor!

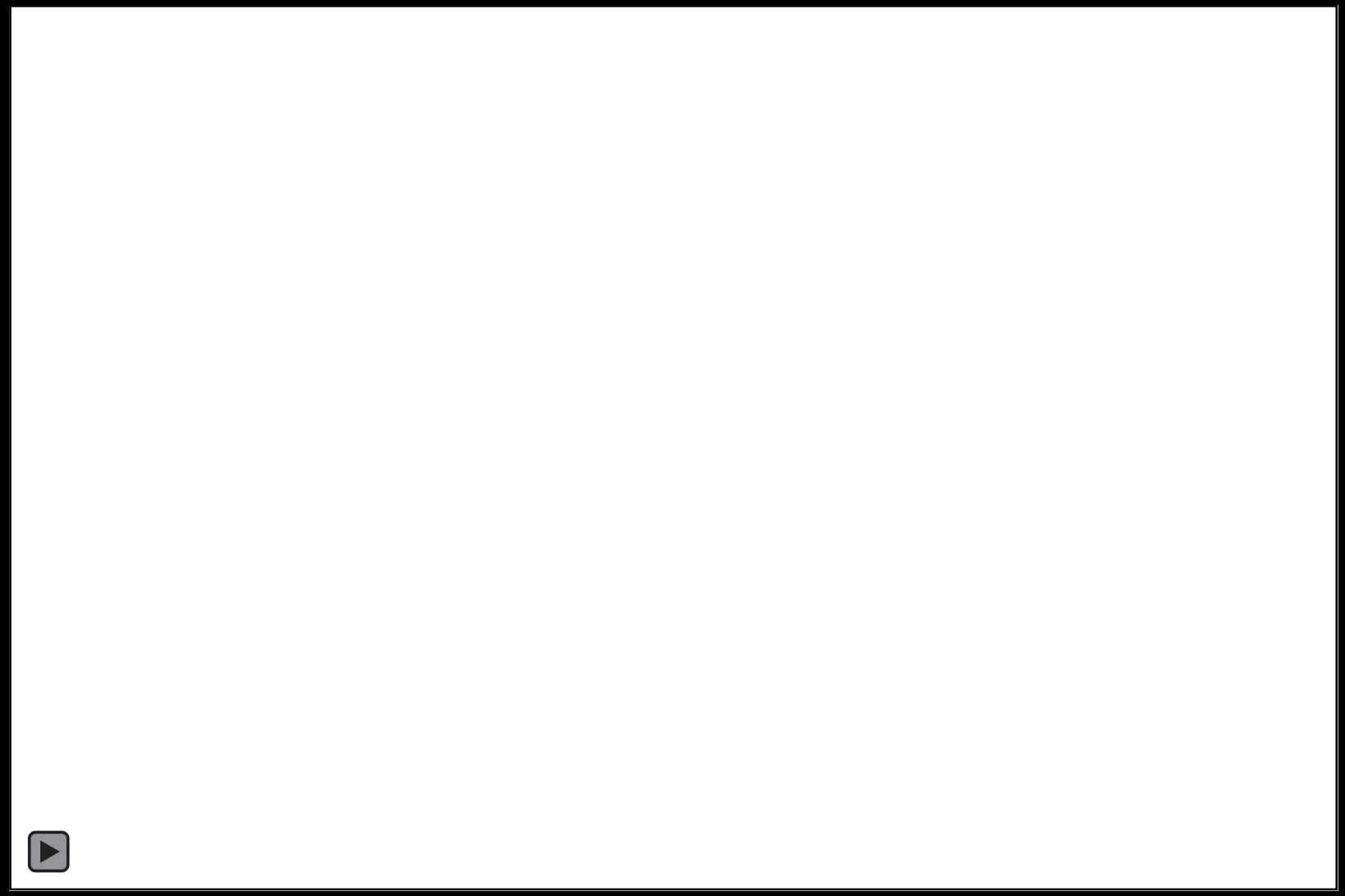
Even something as simple as a mixture of red and green spectral lights appearing identical to a yellow spectral light is an illusion.

However, once the biological basis of an effect becomes well understood, it is less likely to be thought of as an illusion.

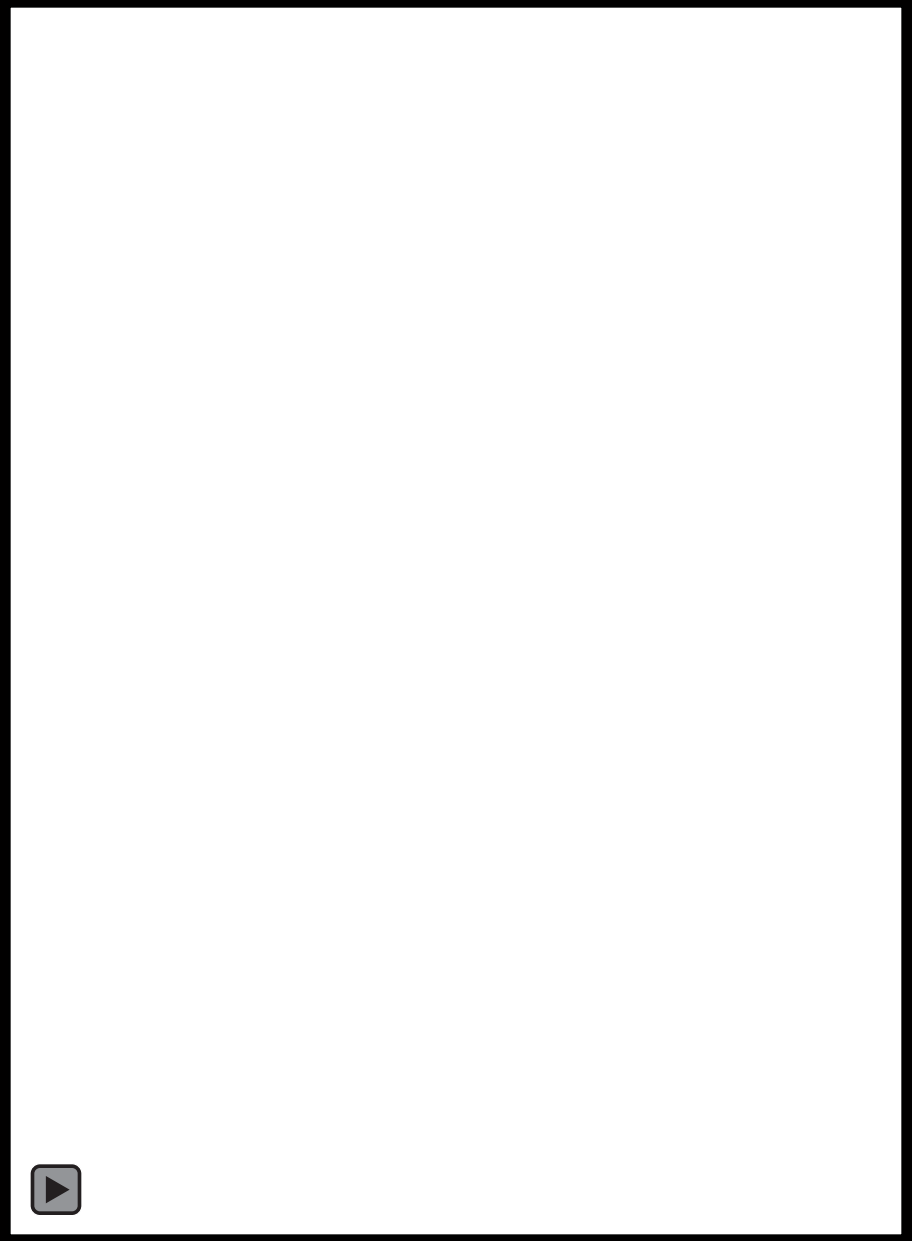
ILLUSIONS OF COLOUR

You’ve already seen many examples of these!

Colour and the illuminant

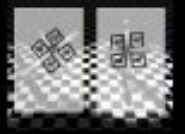


Colour and brightness



This image combines illusions of form and colour. The central element of the two 'X' objects appear very different in colour (dark blue on the left and light yellow on the right). What's more, the angles of each 'X' appear either smaller or larger than 90 degrees.

'MASK'



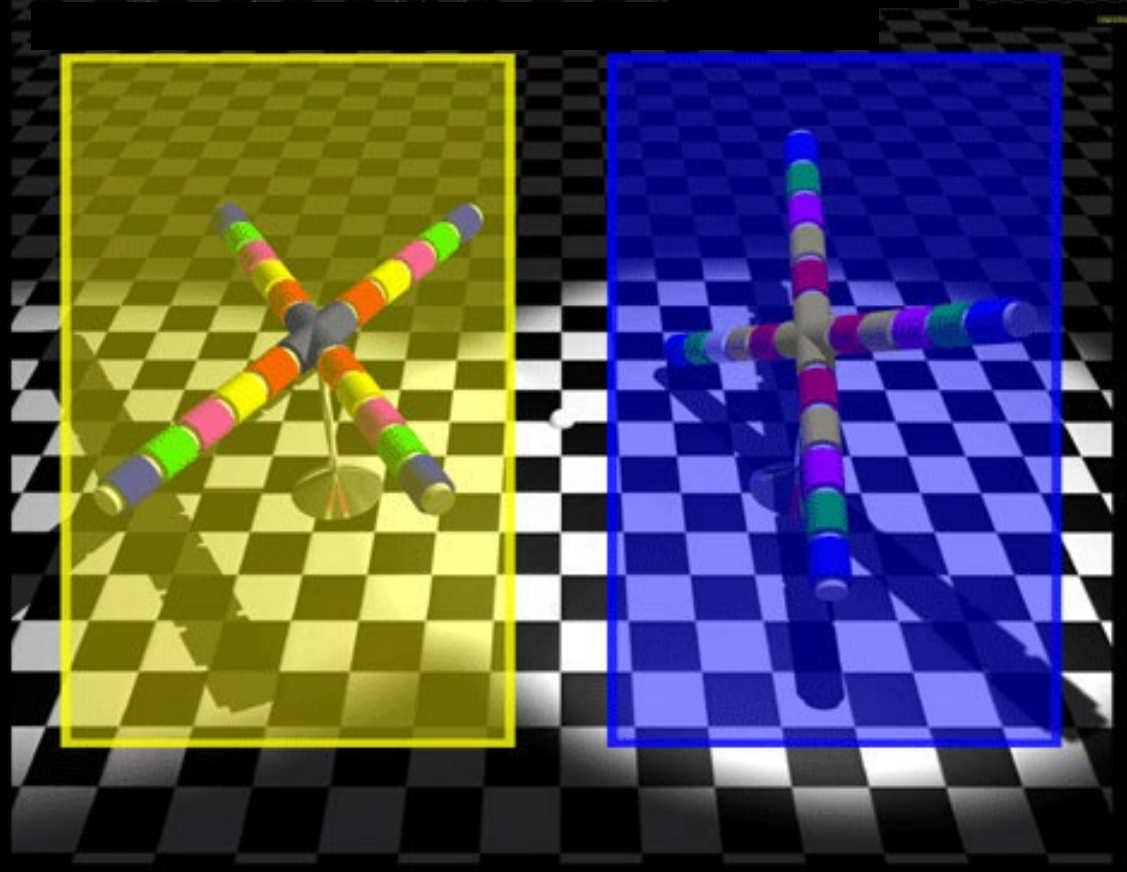
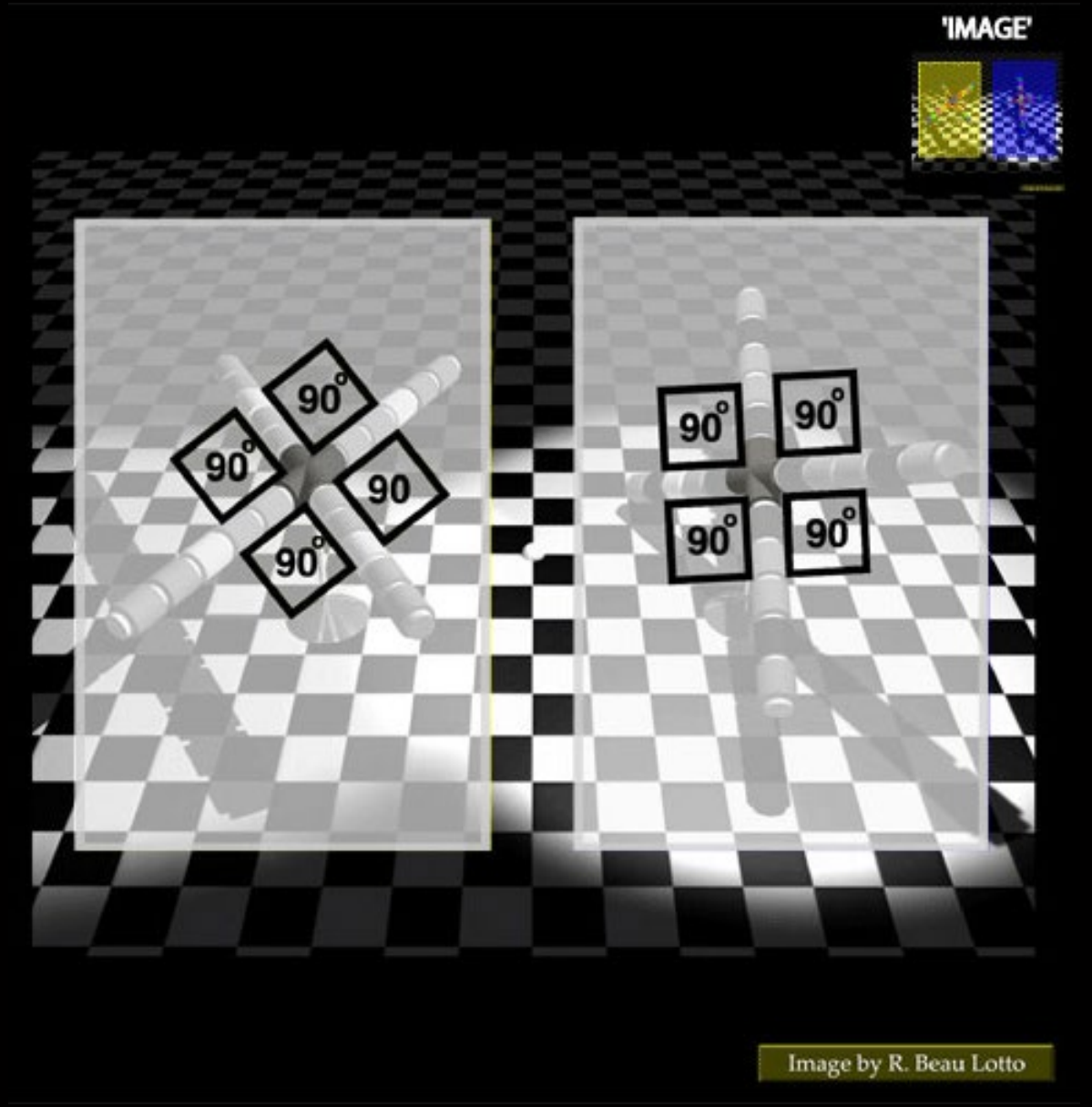


Image by R. Beau Lotto


'IMAGE'
90°
90°
90
90°
90°
90°
90°
90°
Image by R. Beau Lotto

ILLUSIONS OF BRIGHTNESS

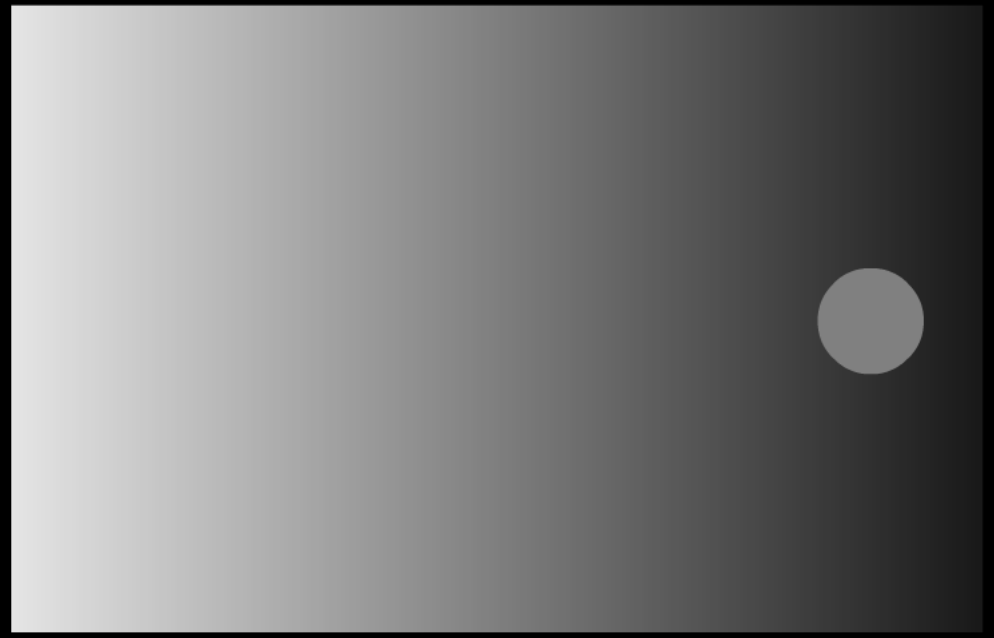
BRIGHTNESS
CONTRAST EFFECTS

The brightness of a patch depends on the brightnesses of things that surround it…

You've also seen some examples of these in other lectures…

Simultaneous brightness contr

SIMULTANEOUS BRIGHTNESS CONTRAST

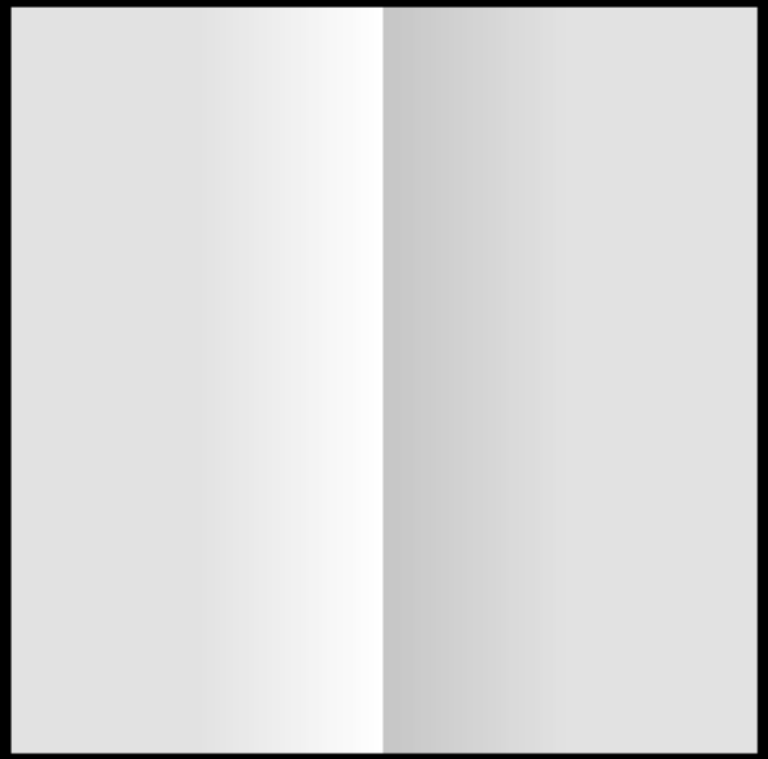


In this example of simultaneuos brightness contrast, the brightness of the circle is perceived to *increase* as it moves to the darker side (right) of the gradient and to *decrease* as it moves to the left side. Click on the "Move mask" button (bottom) to position a mask over the gradient and convince yourself that that the luminance of the circle remains constant.

BRIGHTNESS EDGE EFFECTS

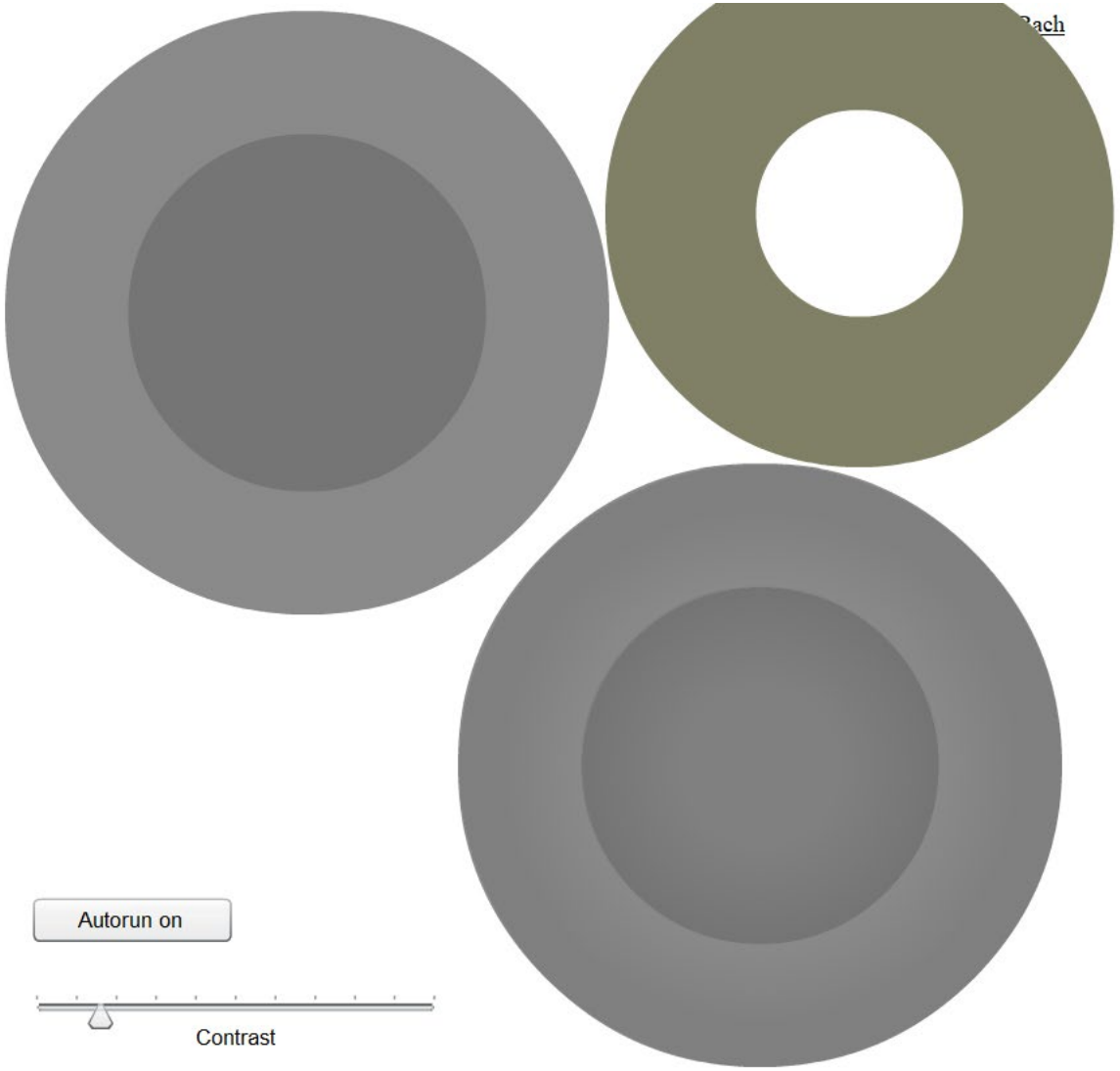
The edge between two patches affects their relative brightnesses…

Craik-O'Brien-Cornsweet illusion



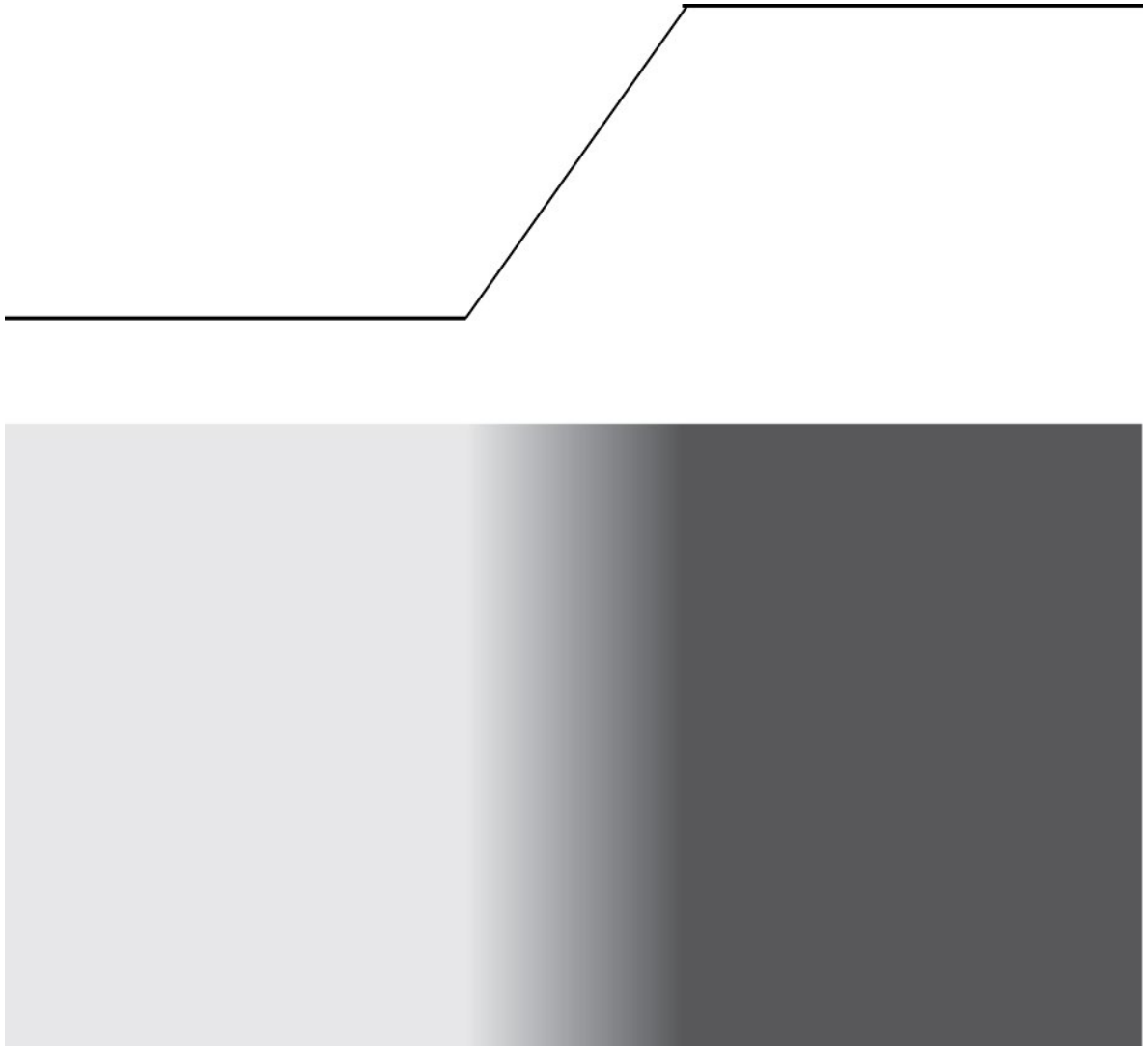
Credit: Thomas Wachtler and Christian Wehrhahn

Craik-O'Brien-Cornsweet illusion

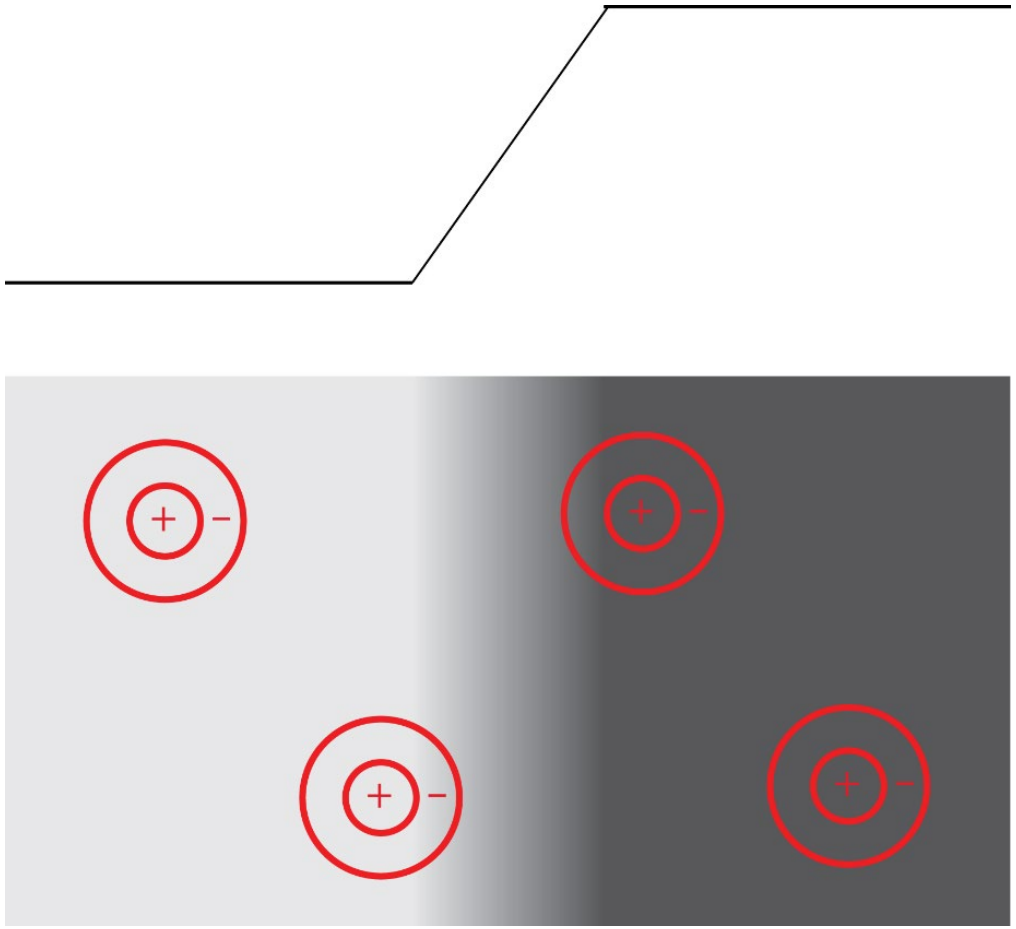


Michael Bach

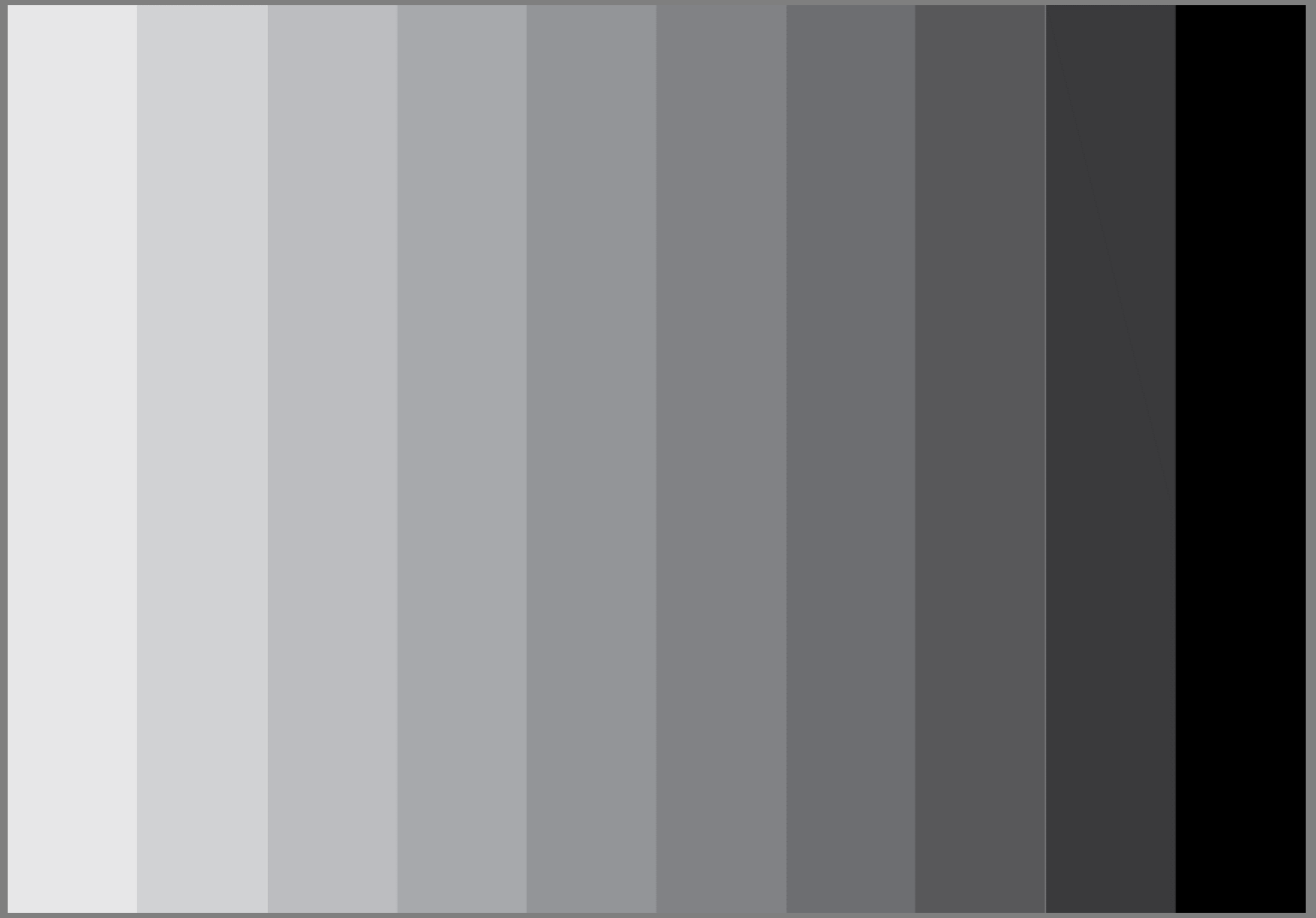
Mach bands



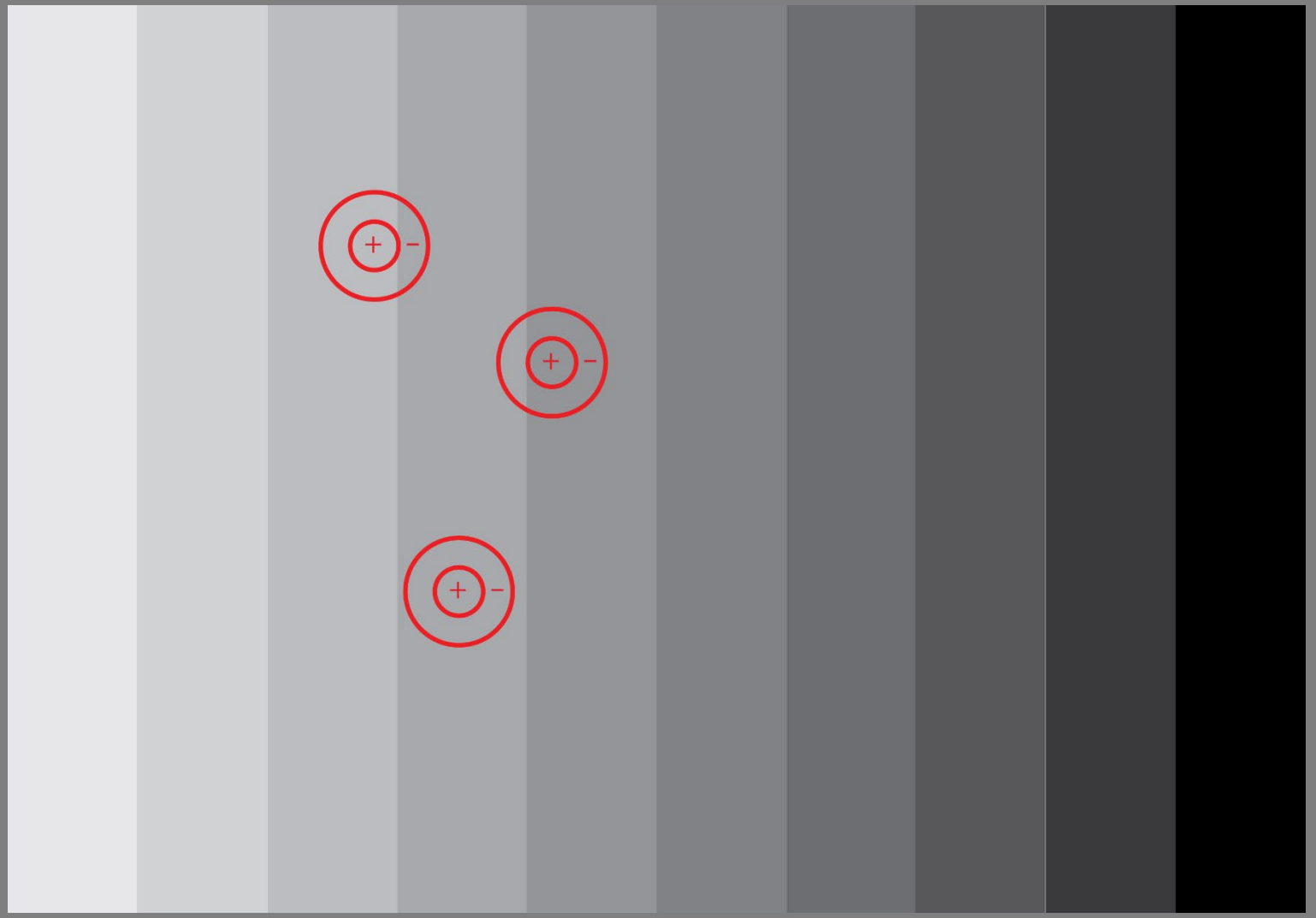
Mach bands



Mach band steps



Mach band steps

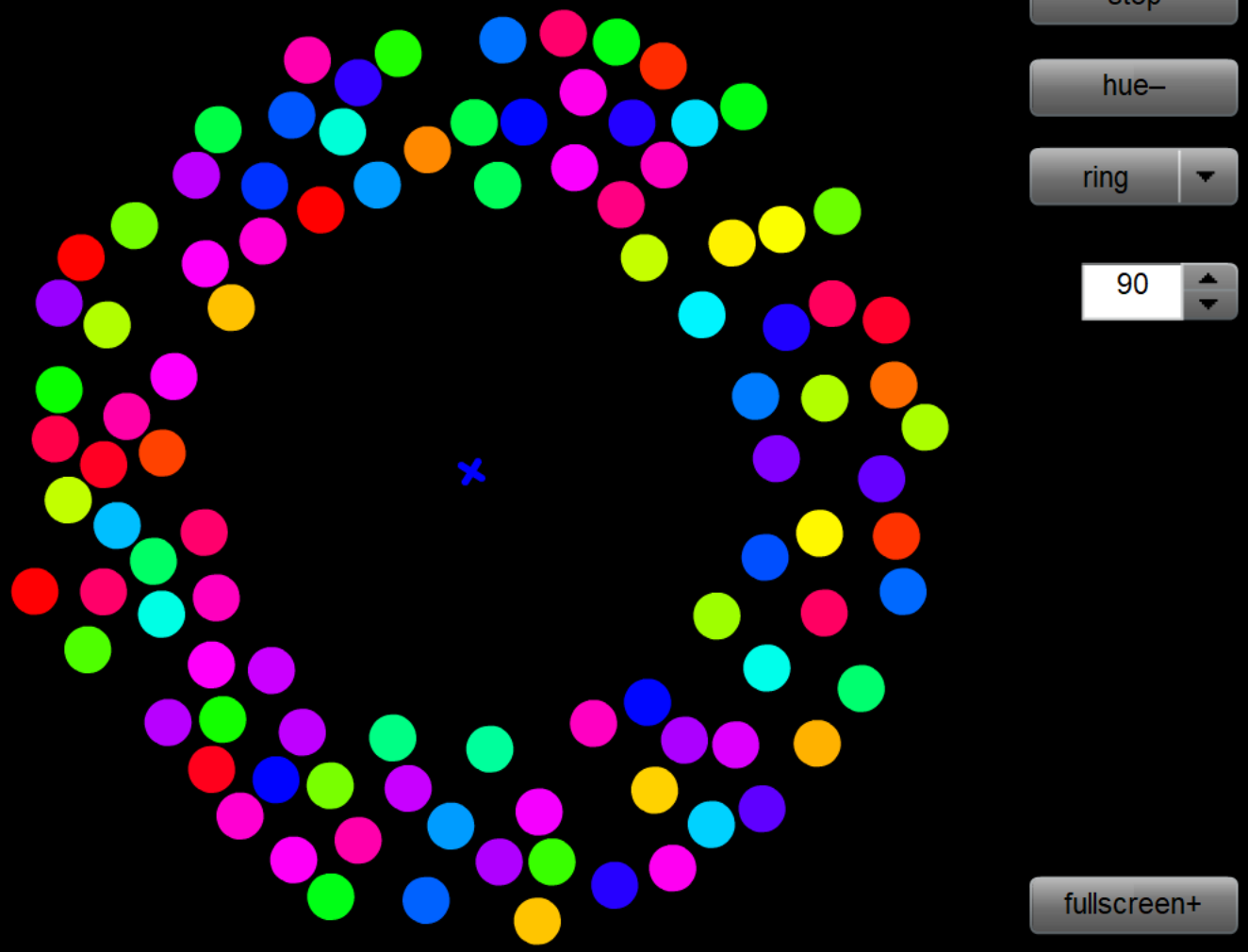


The Koffka Ring

Perceptual science group MIT

ILLUSIONS OF MOTION

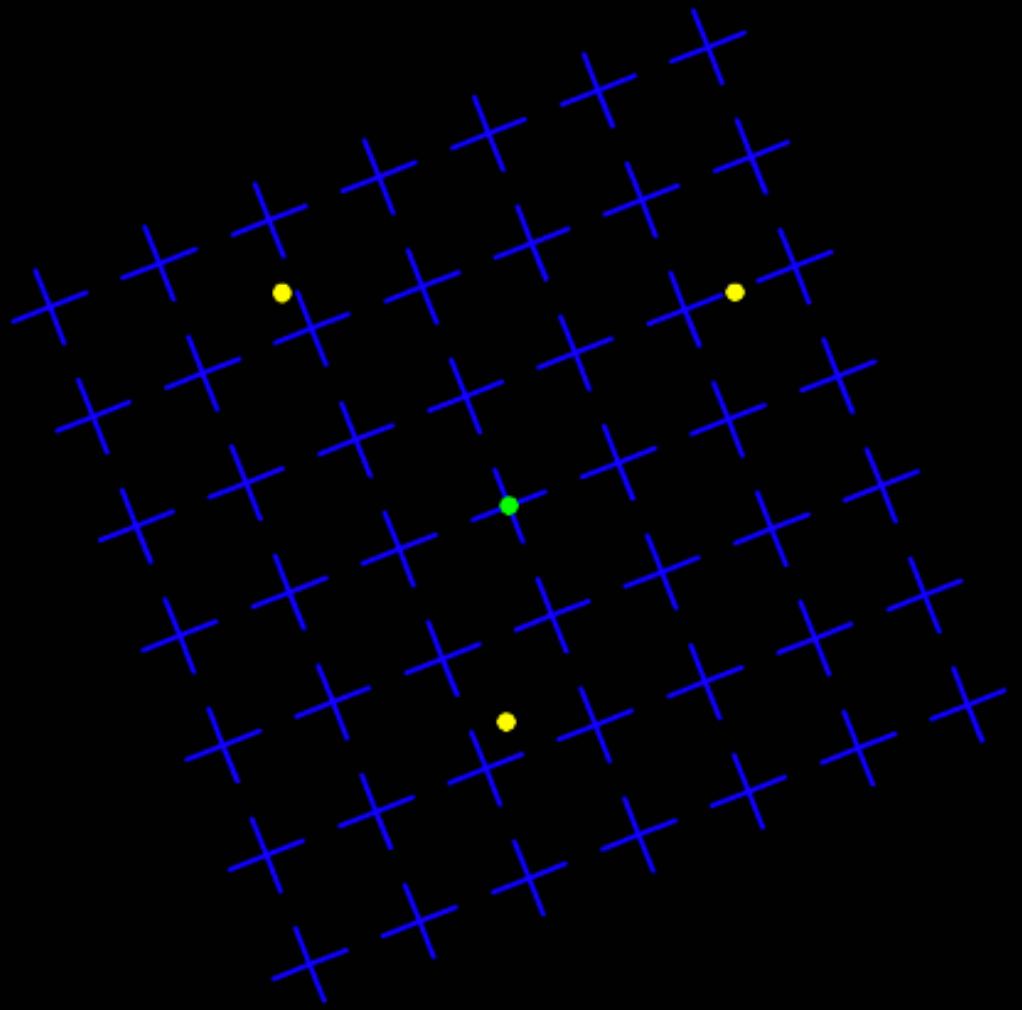
Silencing by Motion



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

Michael Bach after Suchow & Alvarez

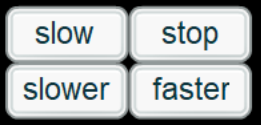
Motion Induced Blindness

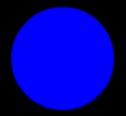


http://michaelbach.de/ot/index.html

Michael Bach

Flash-Lag Effect

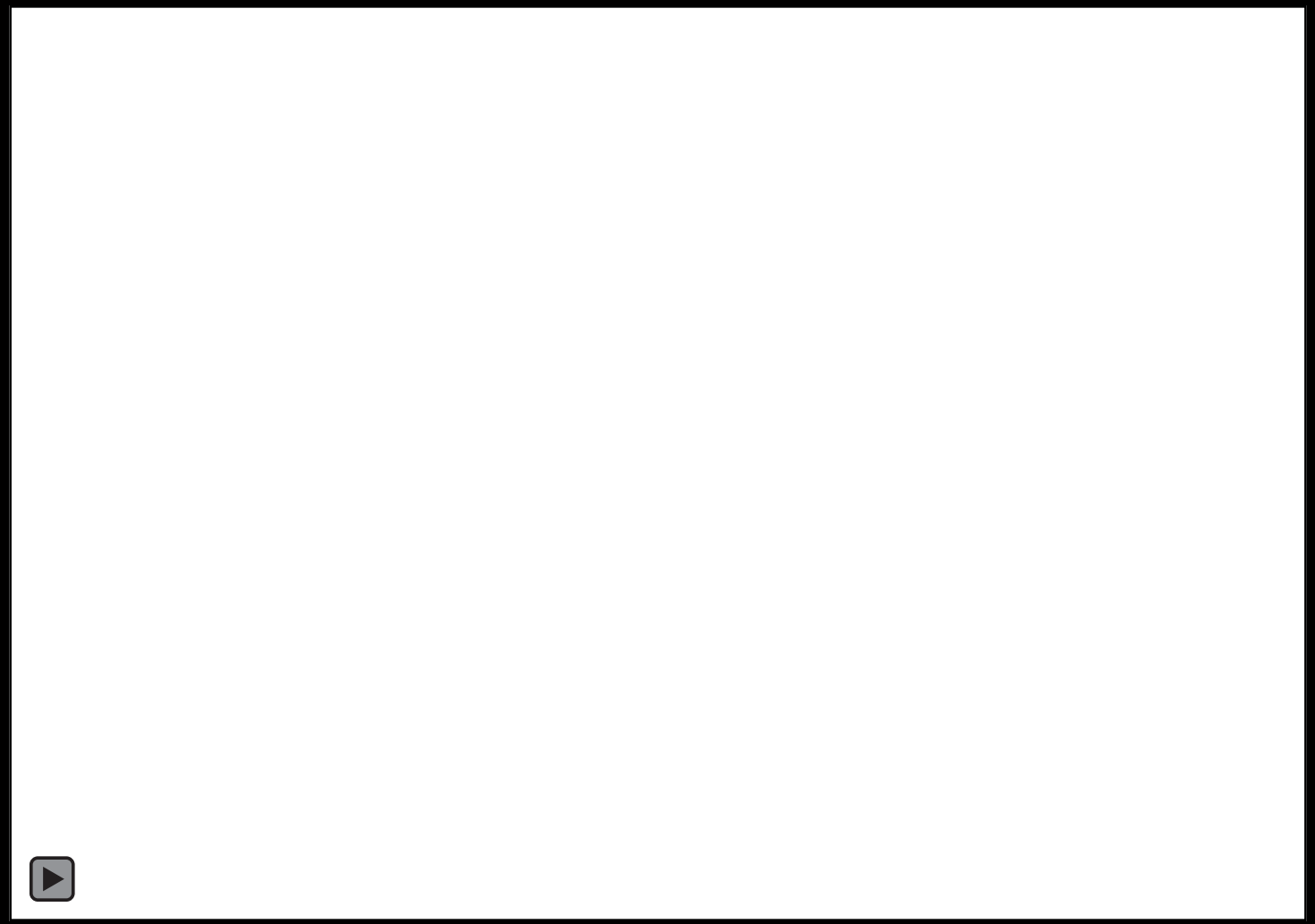




http://michaelbach.de/ot/index.html

Michael Bach after R. Nijhawan

“Stepping feet” illusion



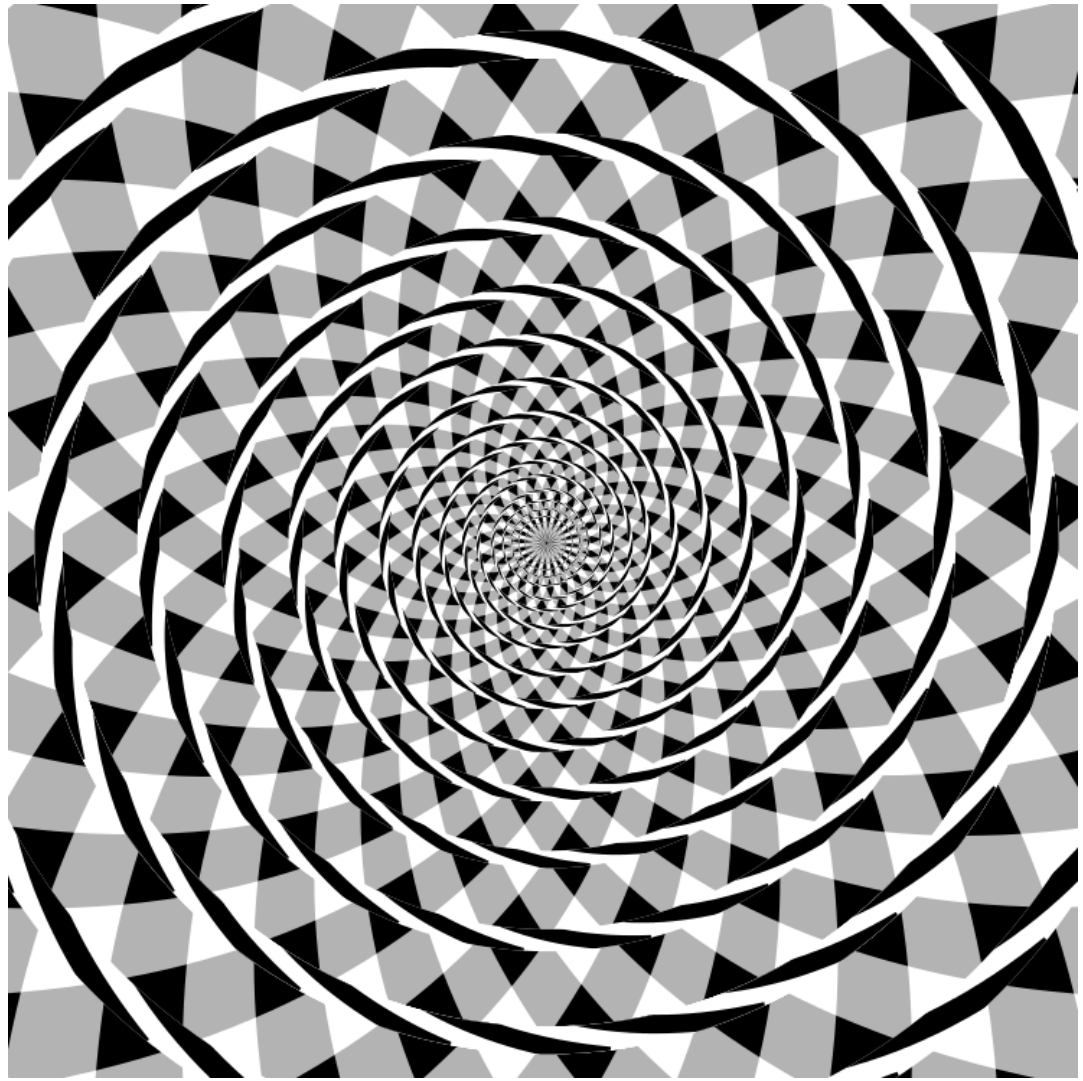
After Stuart Anstis, drawn by Michael Bach

Motion binding illusion

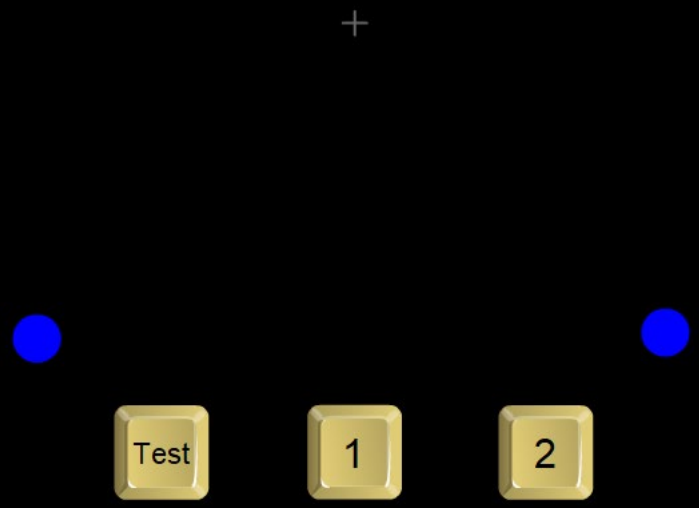
Michael Bach

Spiral after effect

Michael Bach

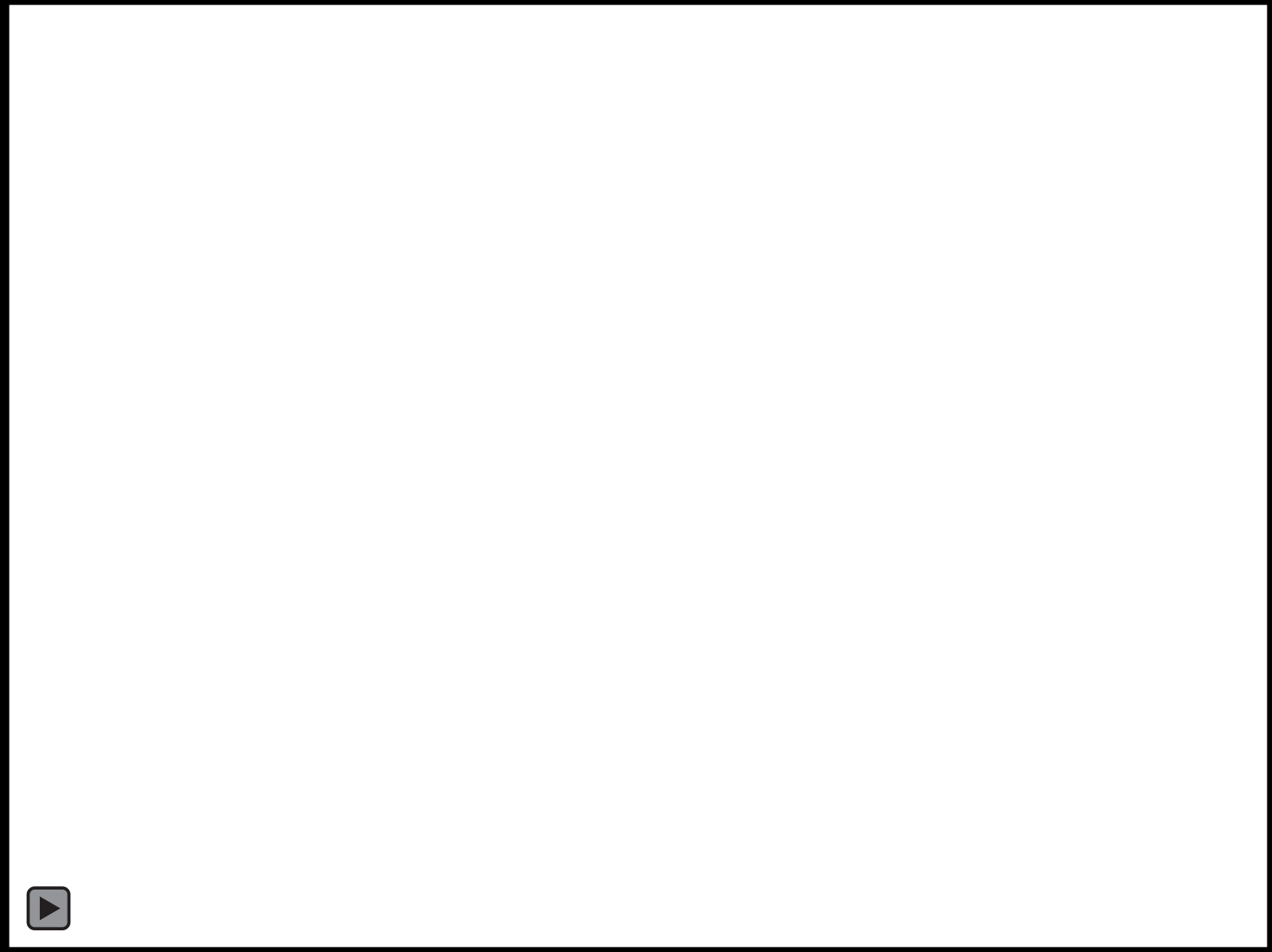


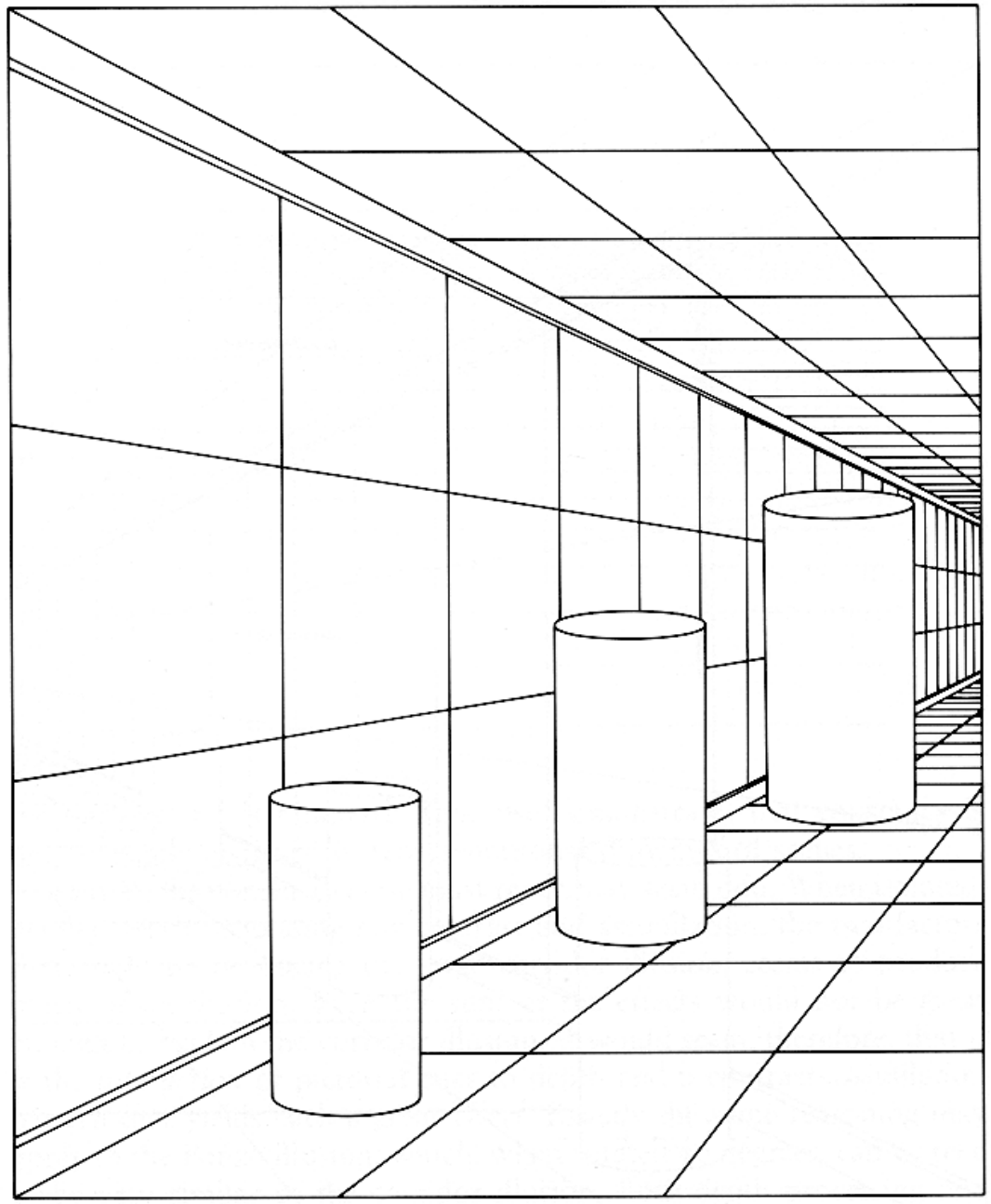
Motion-Bounce illusion



Michael Bach

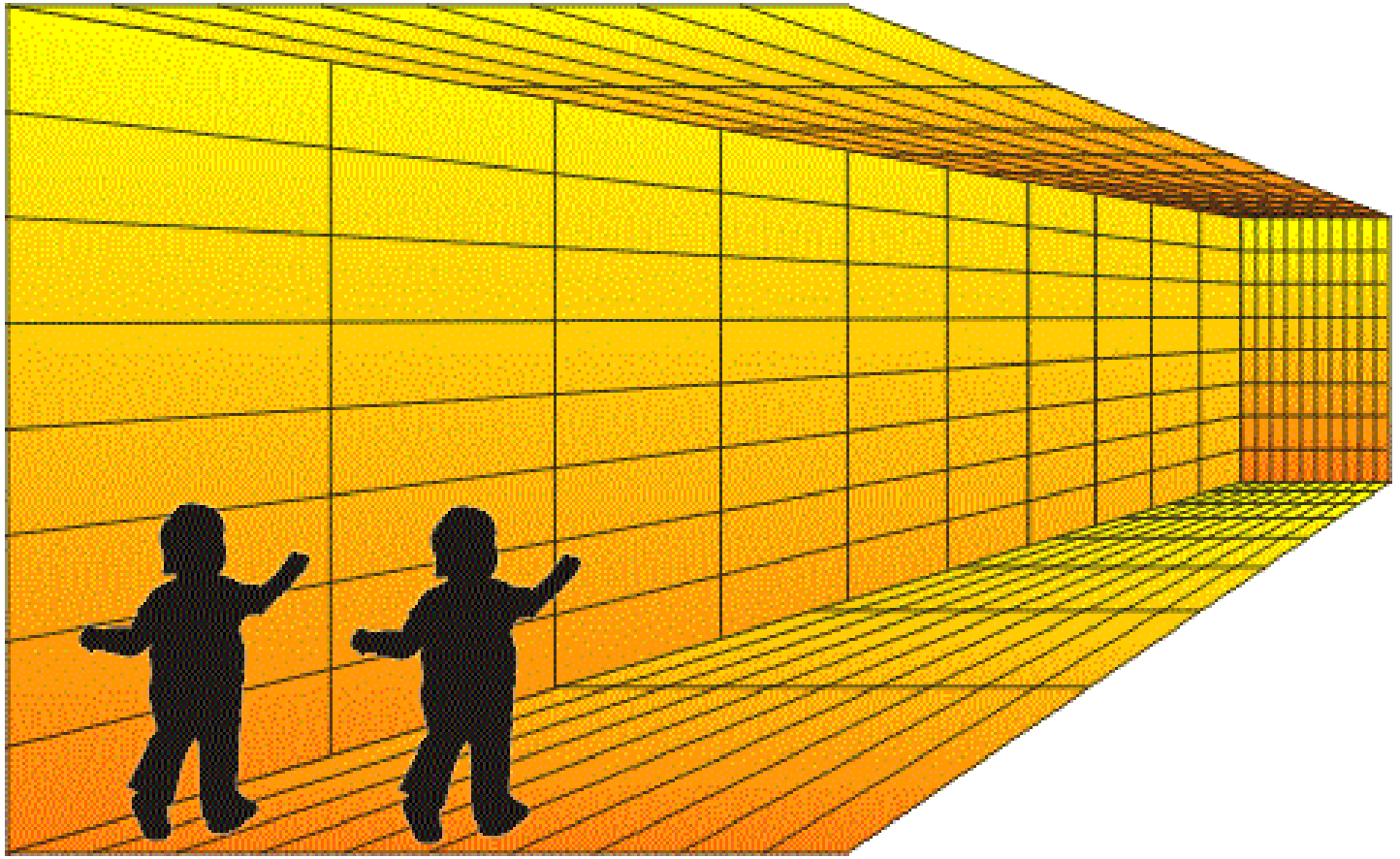
ILLUSIONS OF DEPTH



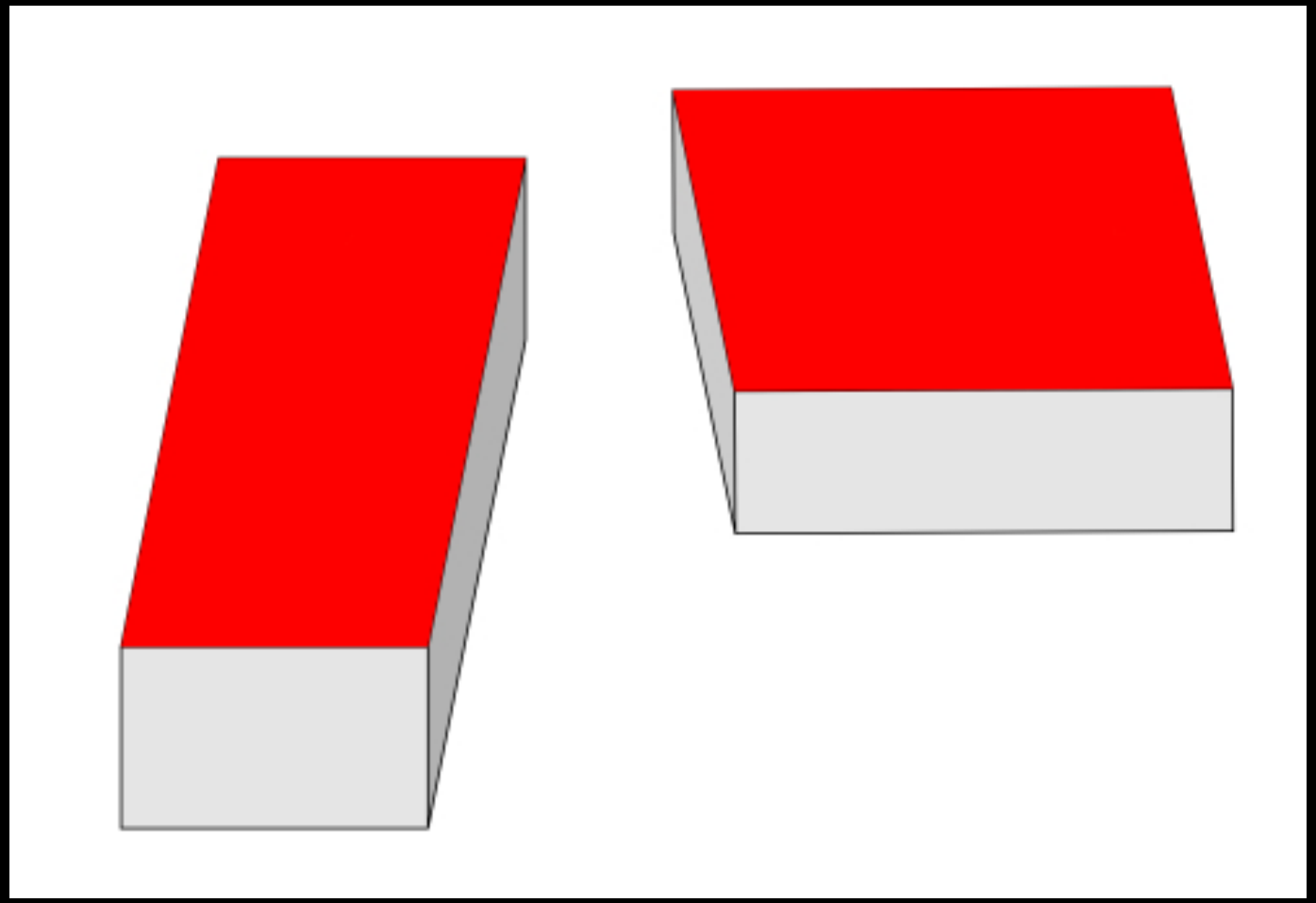


Corridor

Size distortion

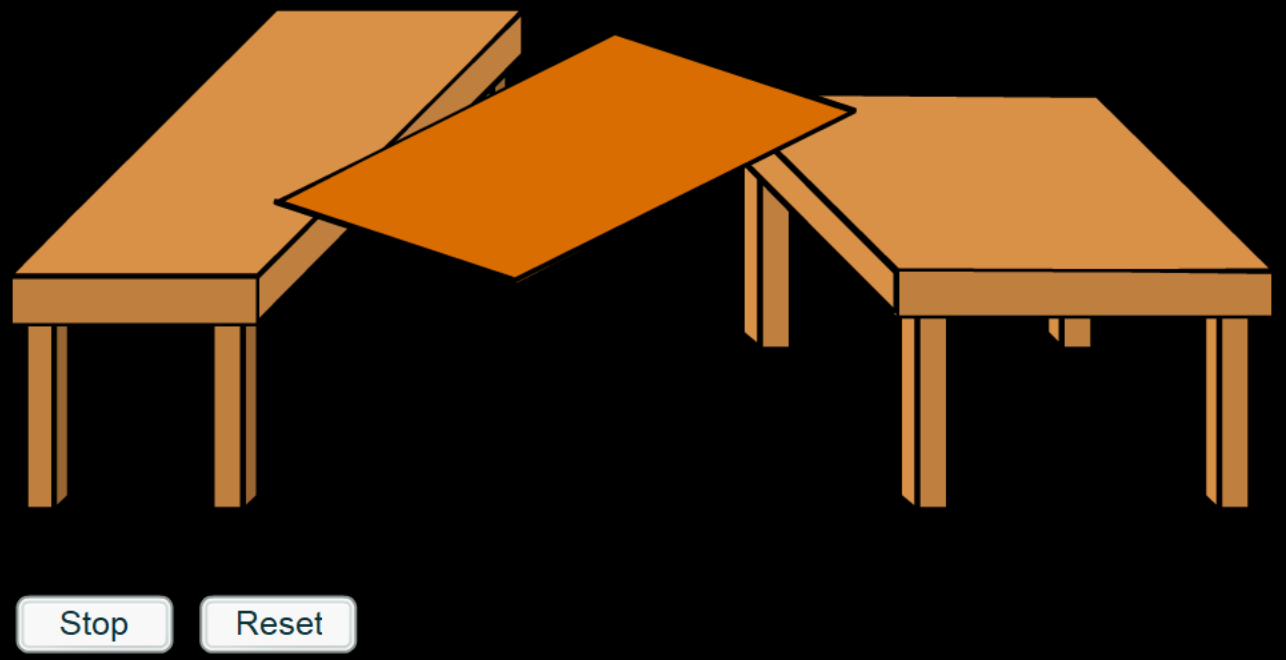


Shepard's Table illusion



Version by Akiyoshi Kitaoka

Shepard's "Turning the Tables" illusion

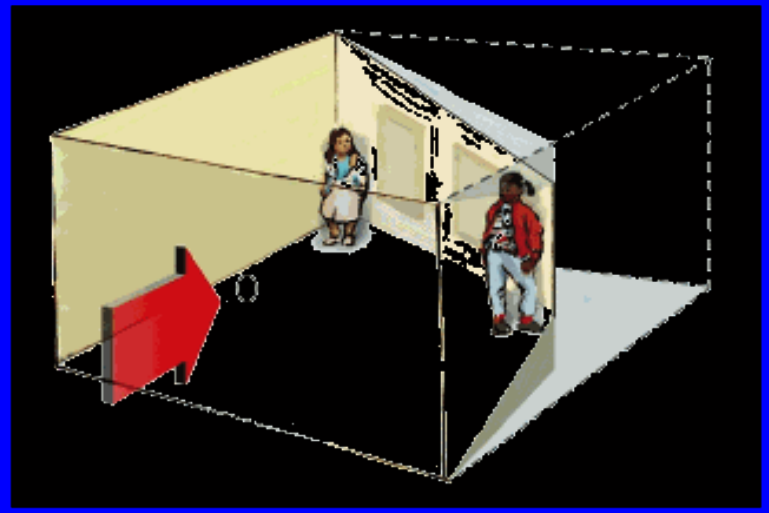


http://michaelbach.de/ot/index.html

Michael Bach

Ames Room

Ames Room (2)

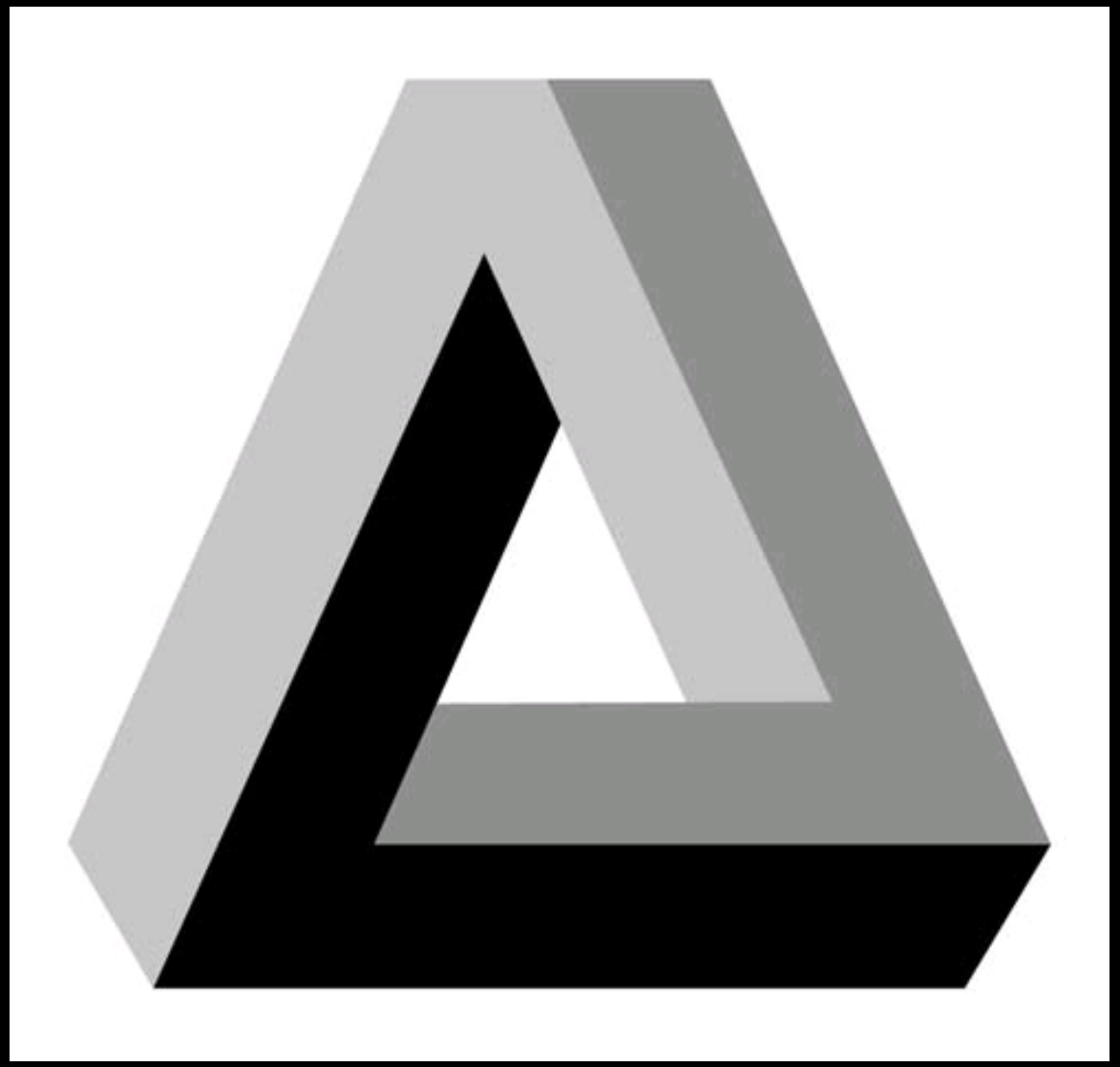


Impossible staircase

These figures can only exist in 2D

Credit: Sandlot Science

Impossible triangle

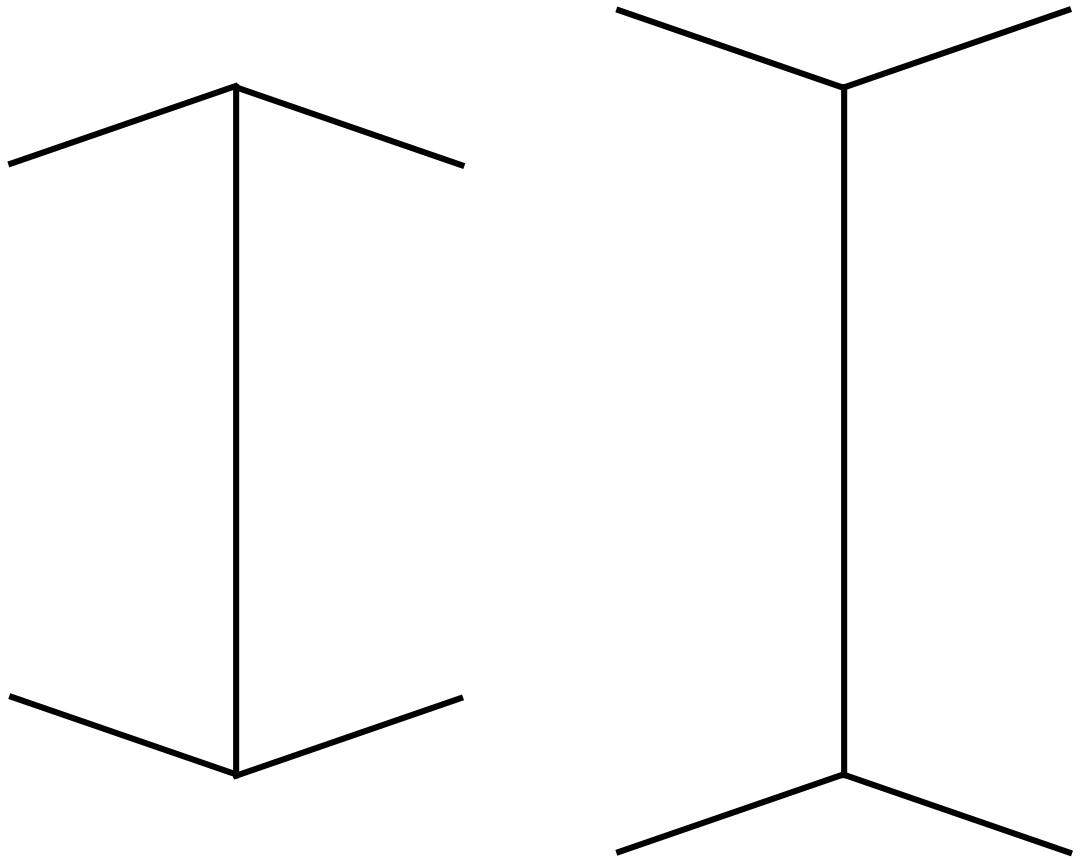


Impossible waterfall

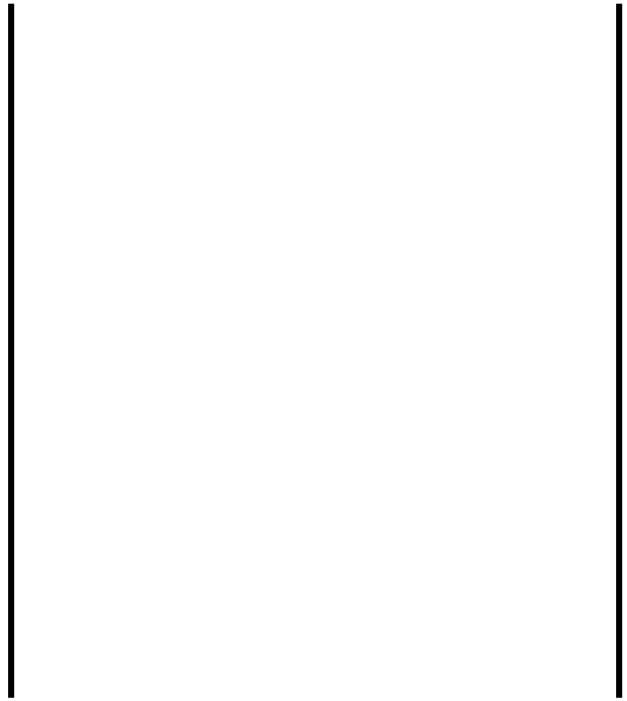
Escher and Cordon Art B.V.

GEOMETRICAL ILLUSIONS

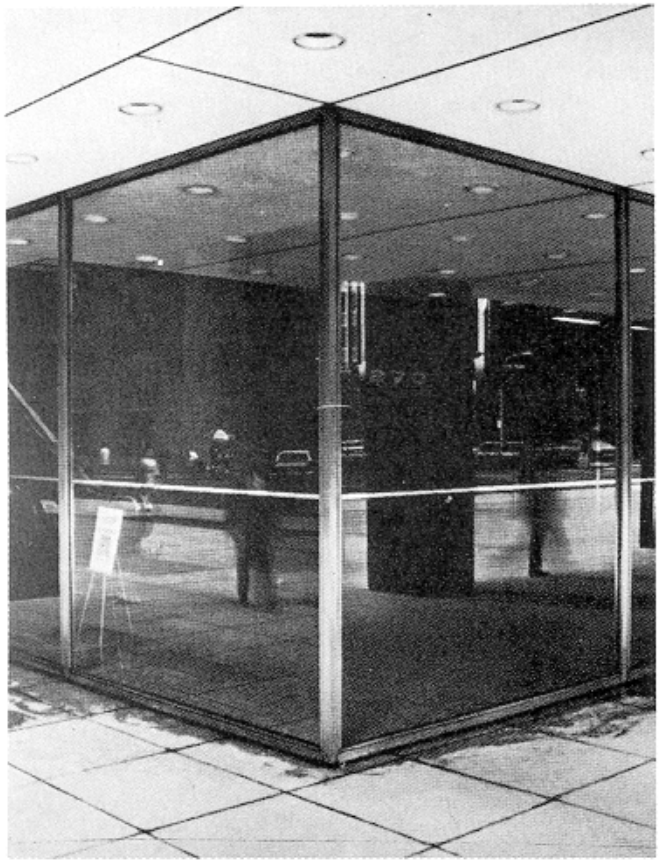
Müller-Lyer

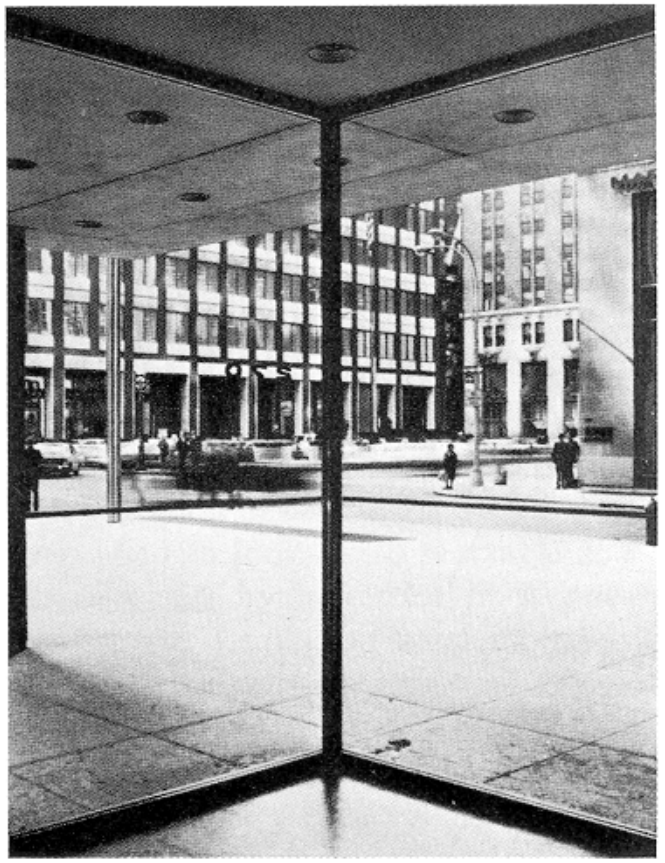


Müller-Lyer



Müller-Lyer explanation



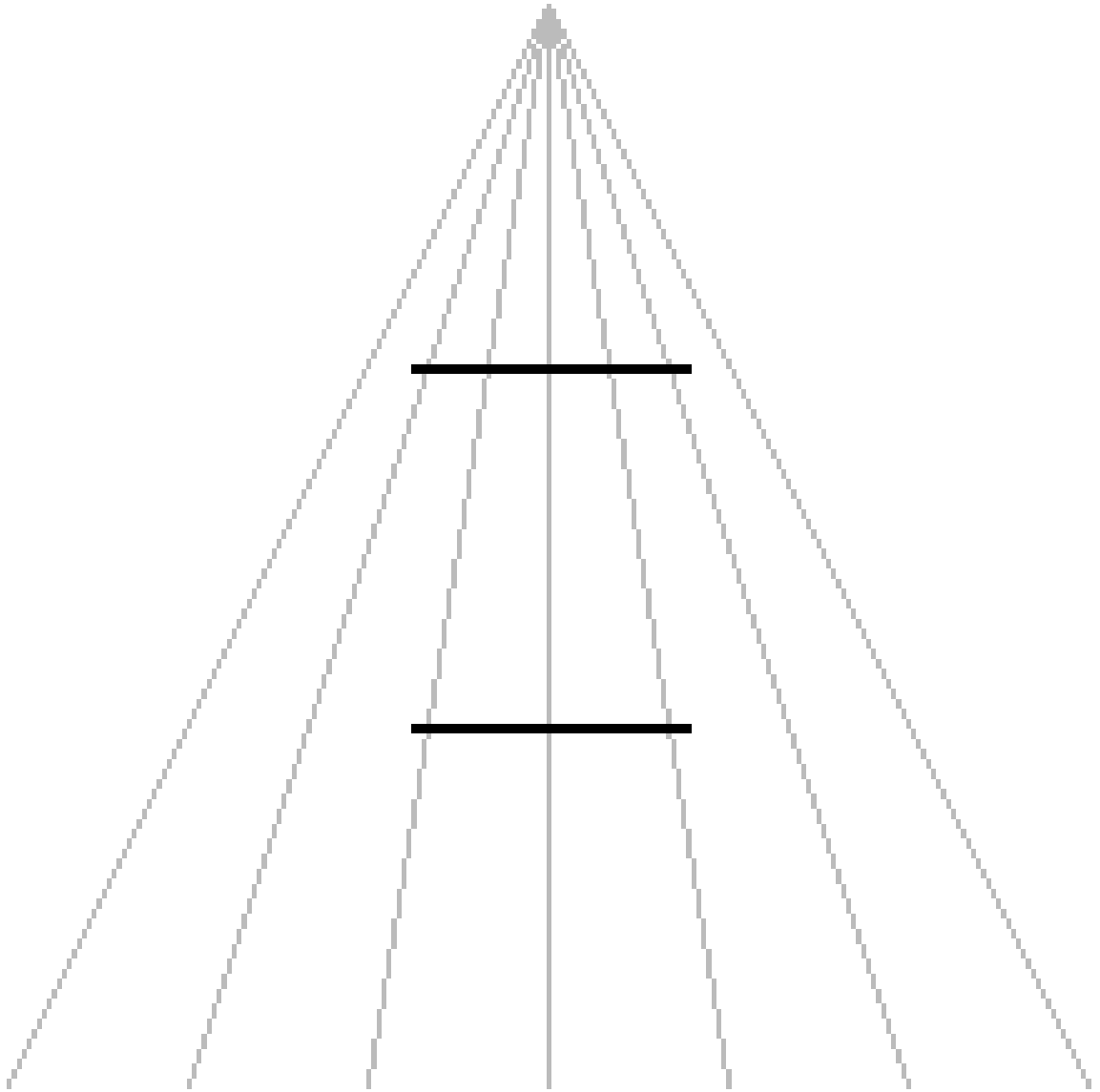


A depth-processing explanation of the Müller-Lyer illusion suggested by Richard Gregory. The test line in the photograph on the left is processed as the edge of a convex corner and the one in the photograph on the right as the edge of a concave corner.

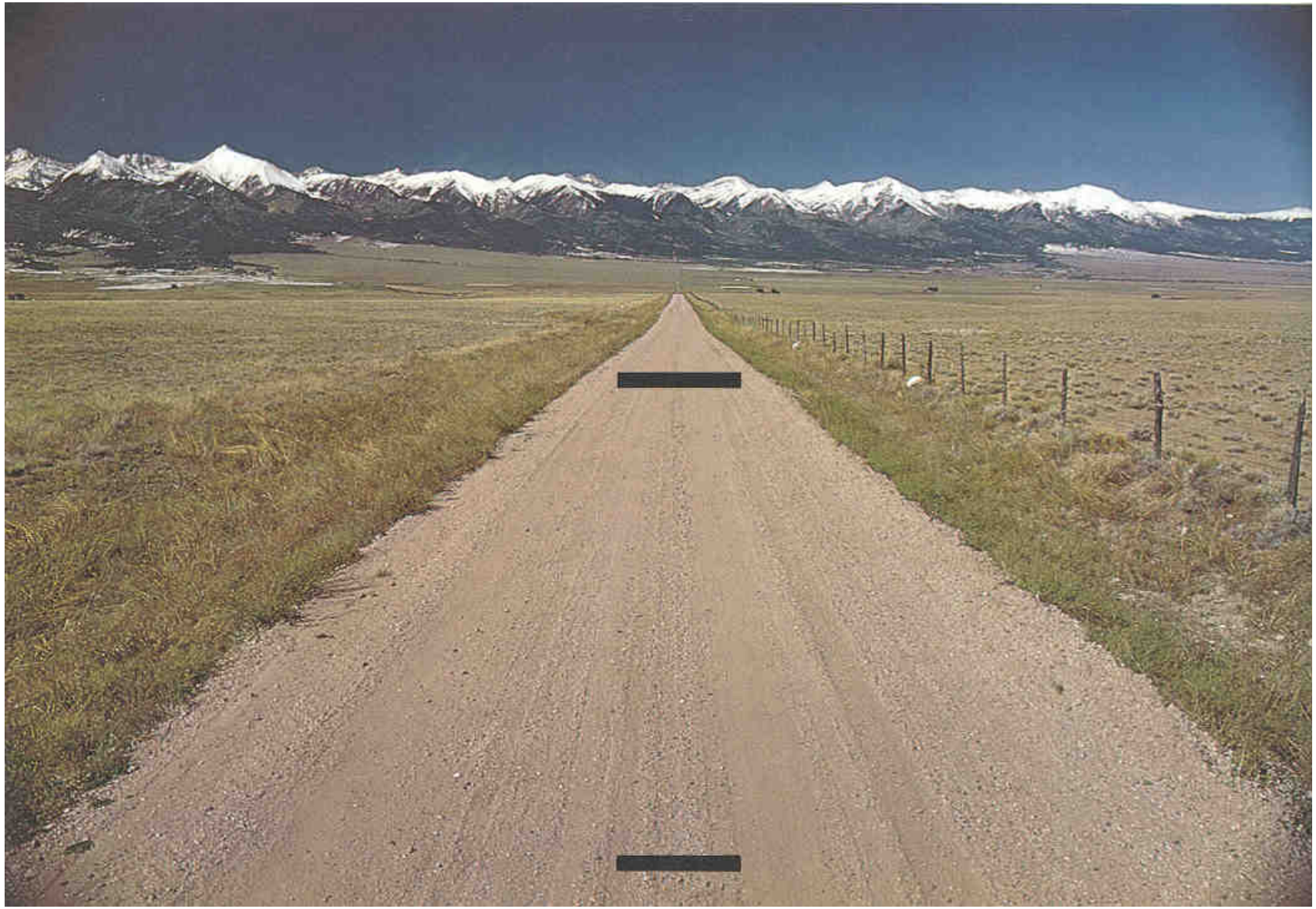
Credit: Richard Gregory

"Carpentered world" hypothesis

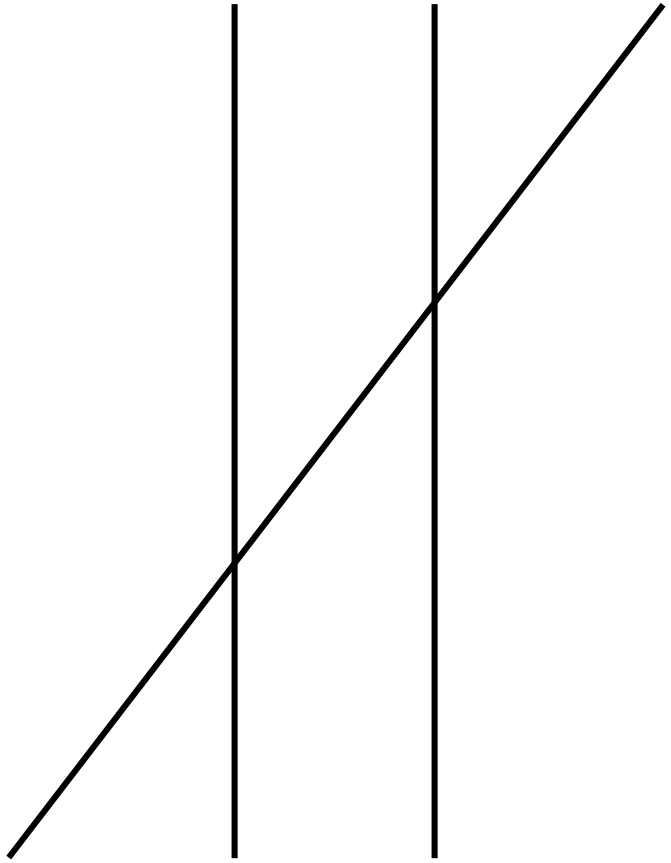
Ponzo



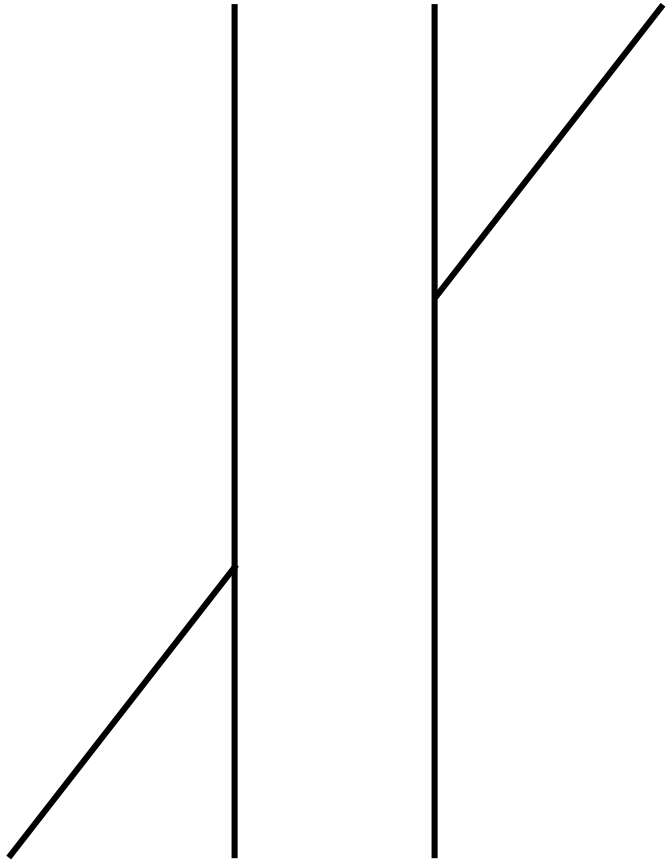
Ponzo scene



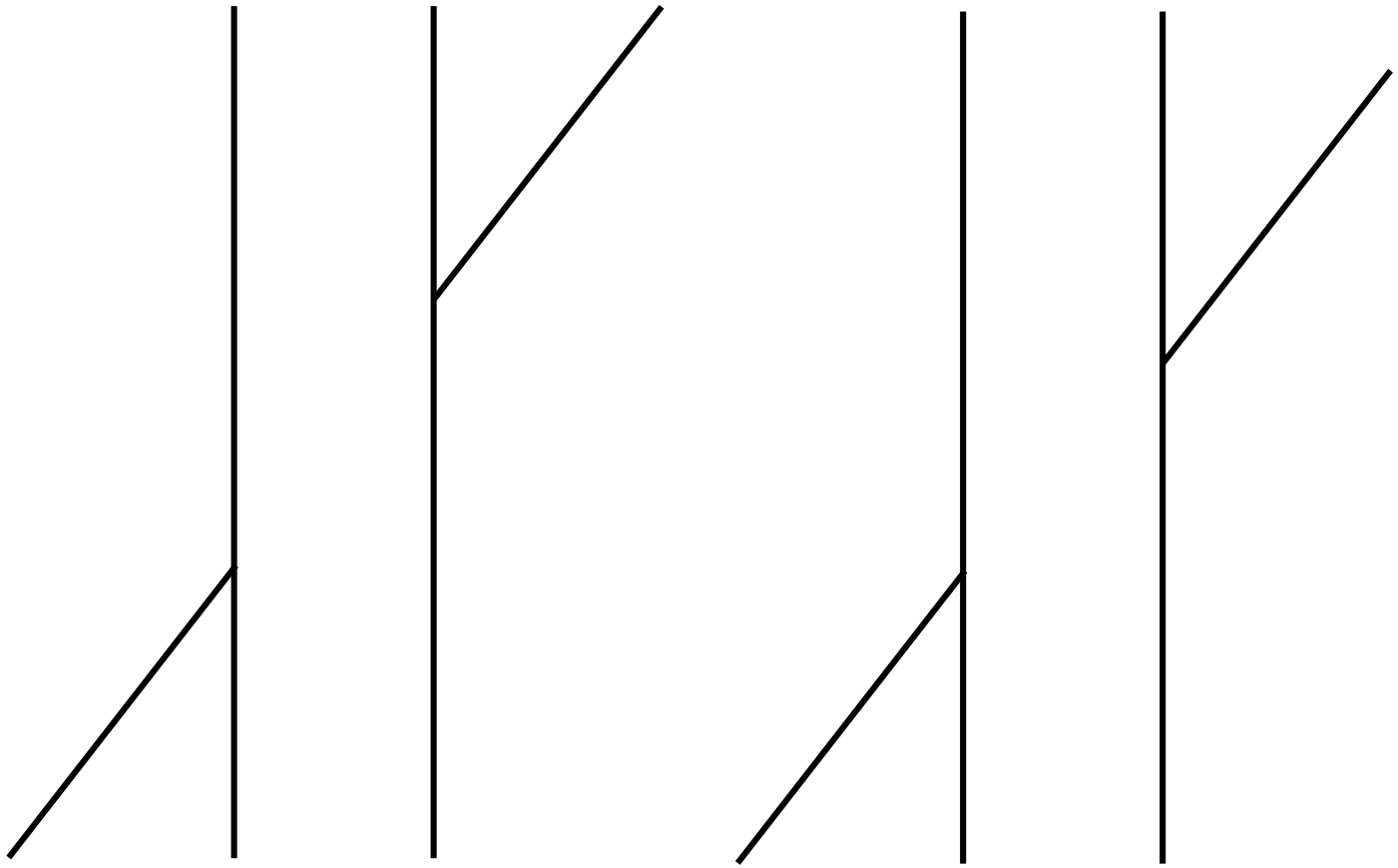
Poggendorf



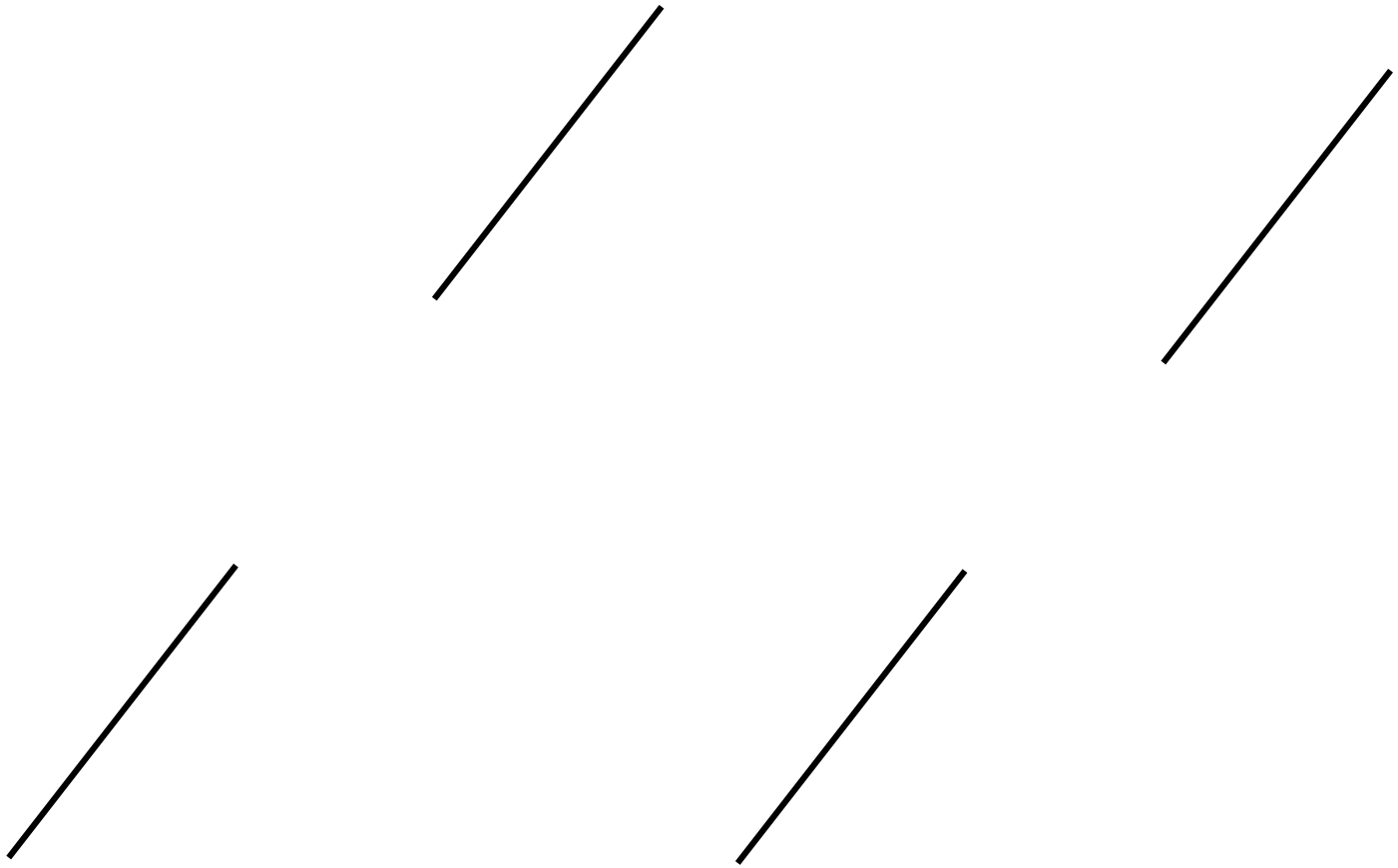
Poggendorf



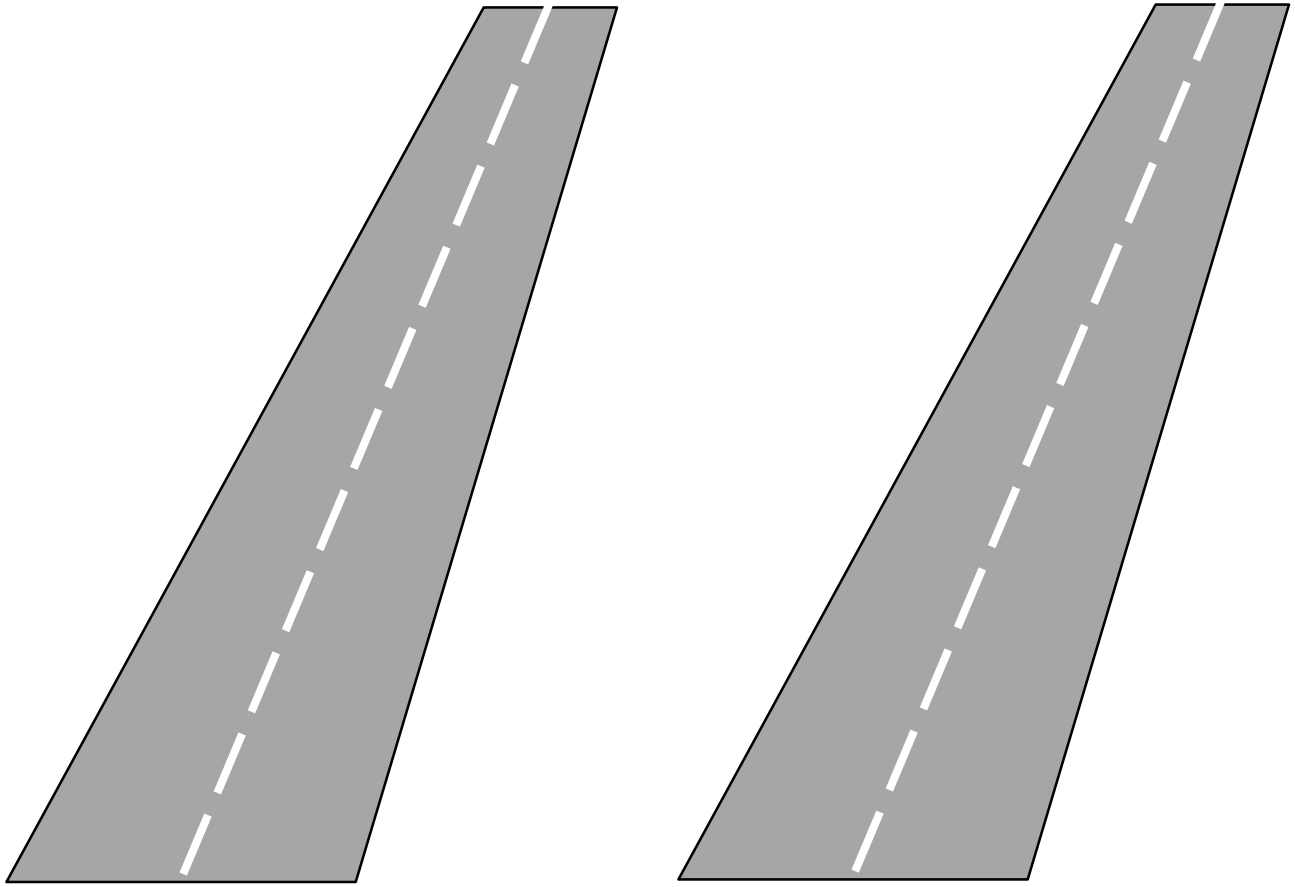
Poggendorf



Poggendorf

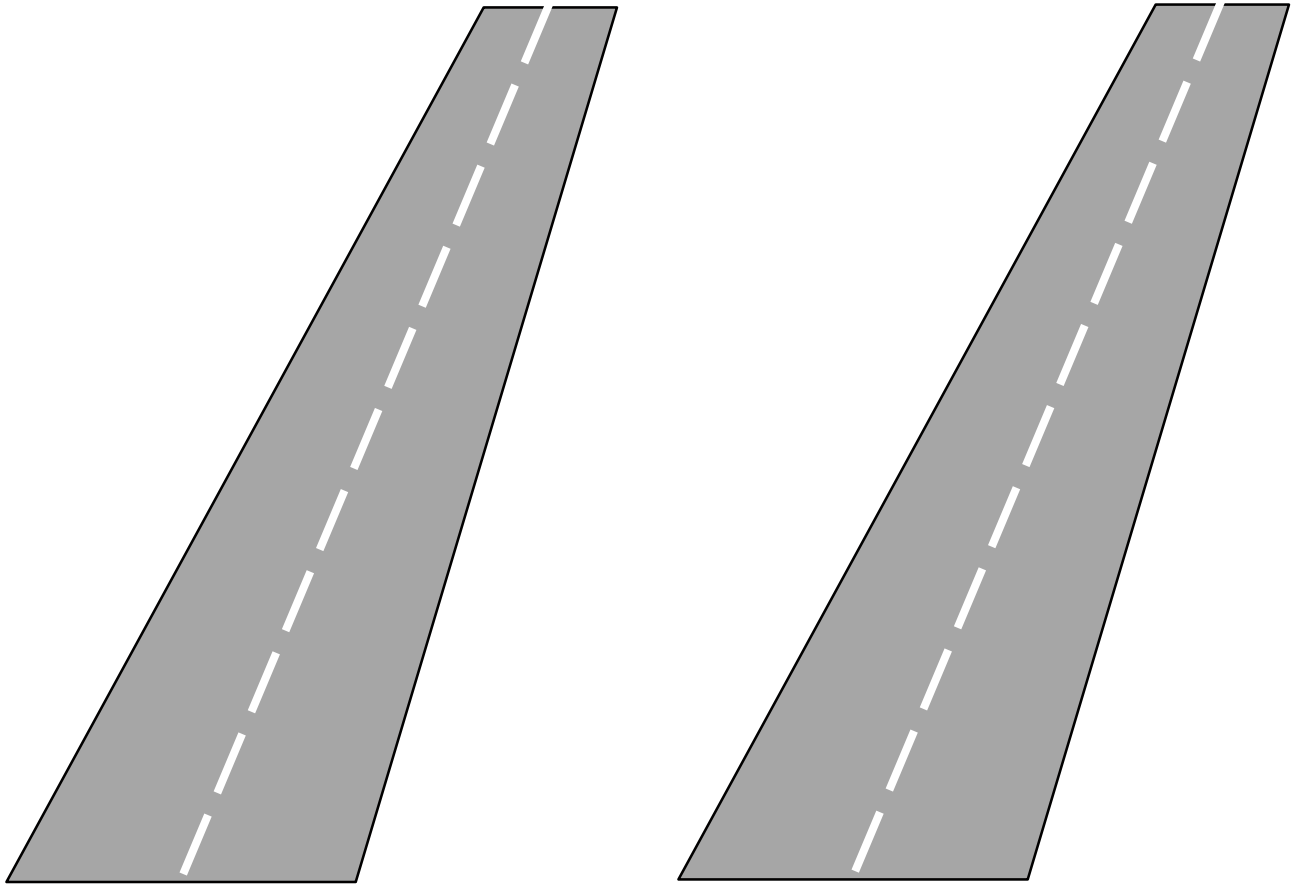


“Runways”



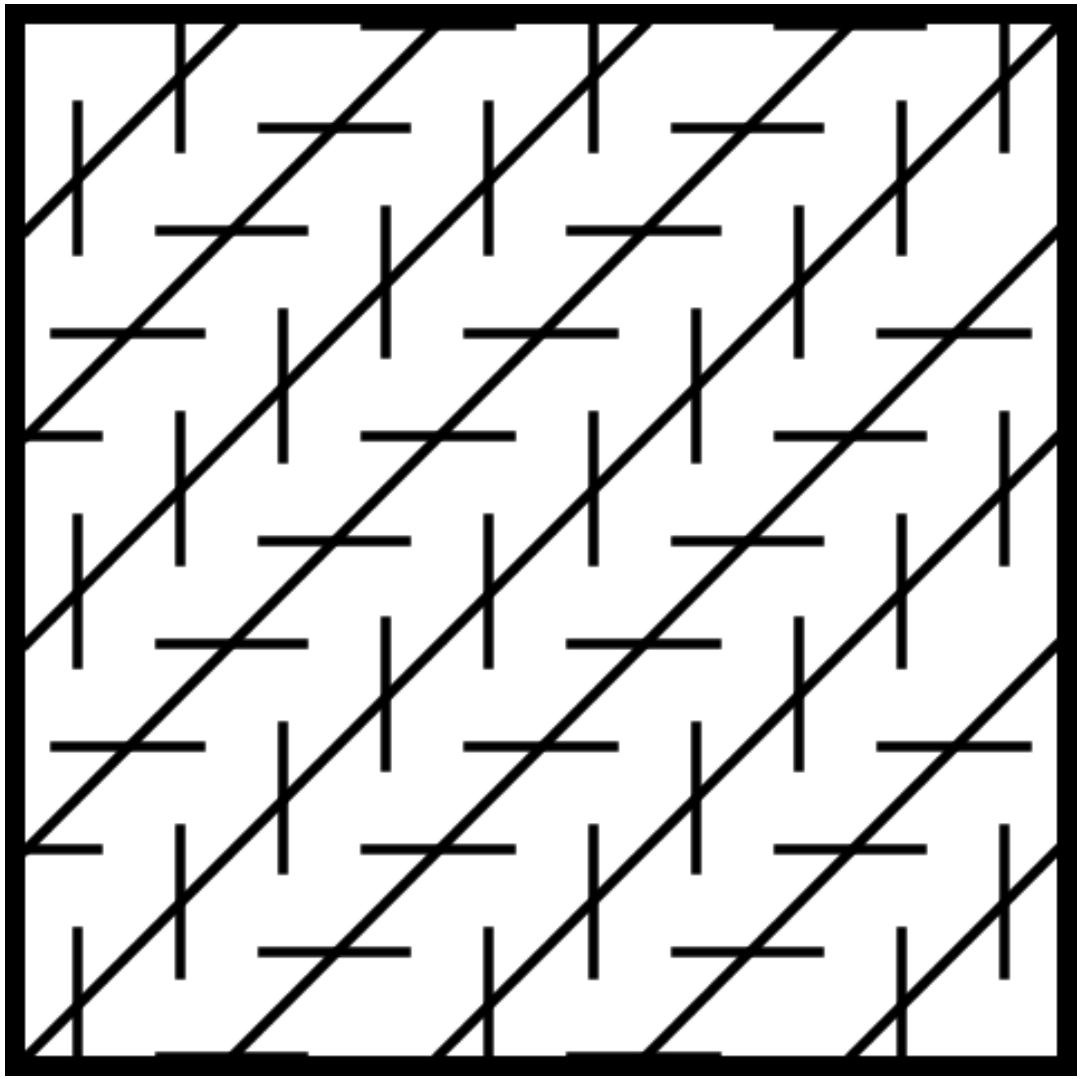
Credit: Akiyoshi Kitaoka

“Runways”

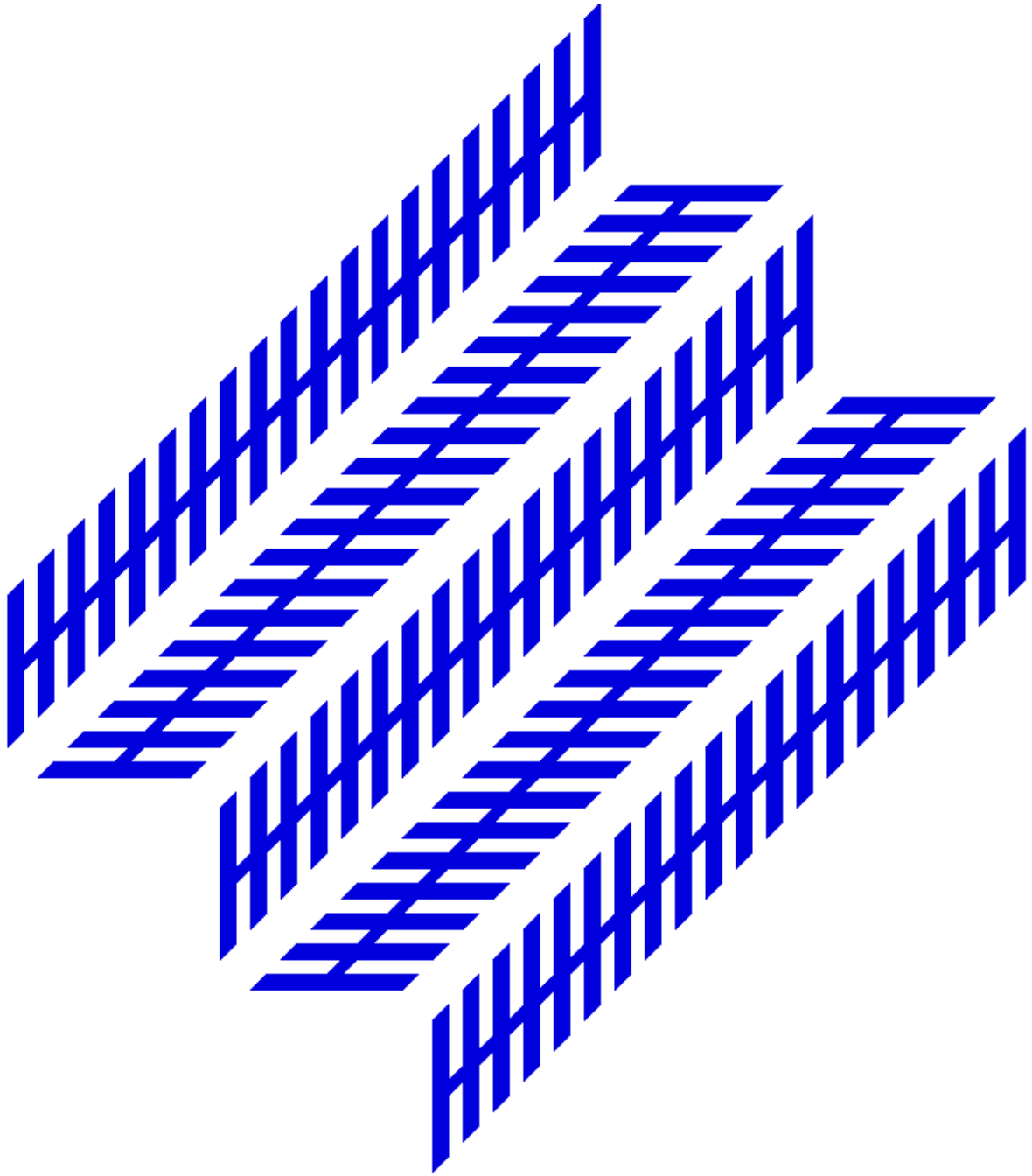


Credit: Akiyoshi Kitaoka

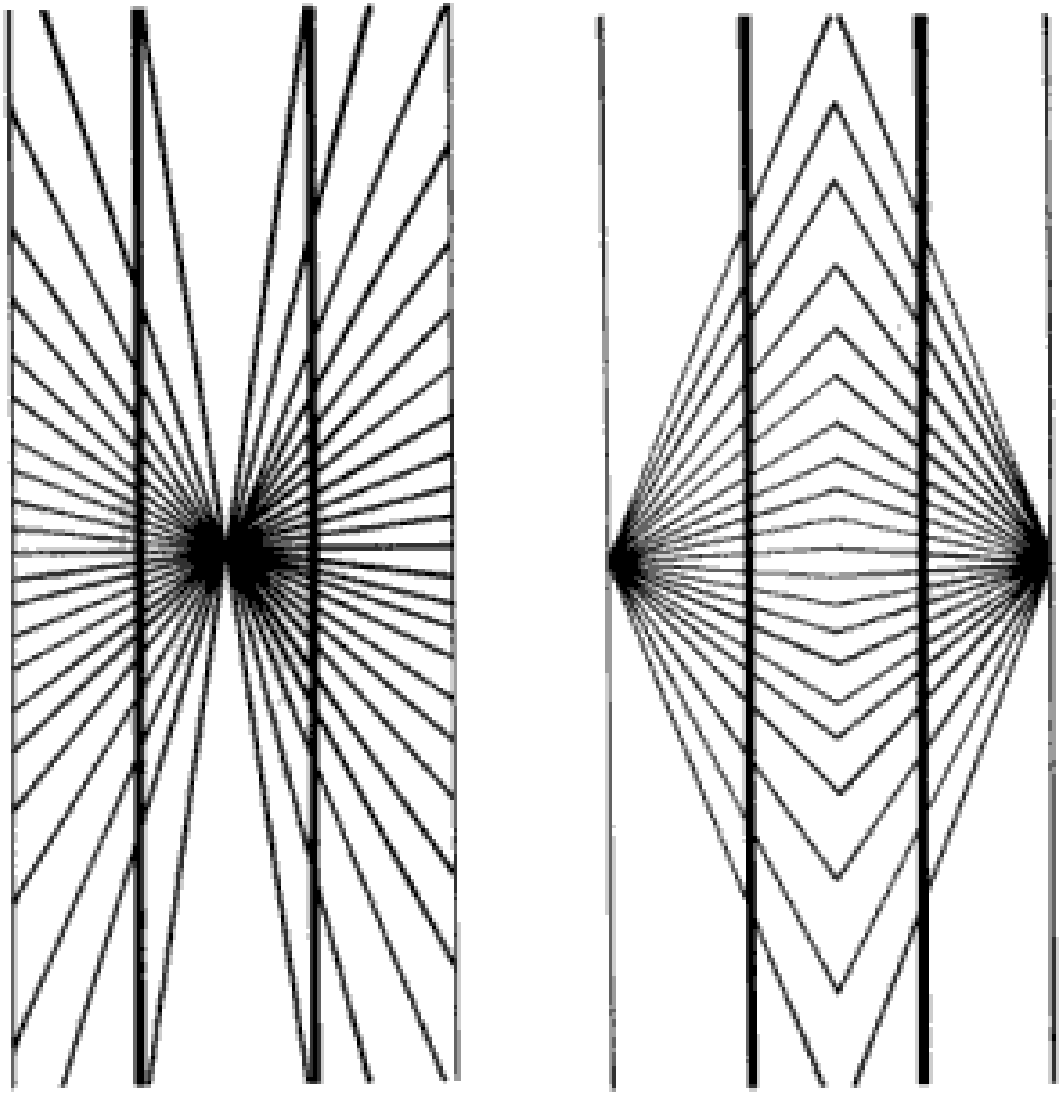
Zöllner



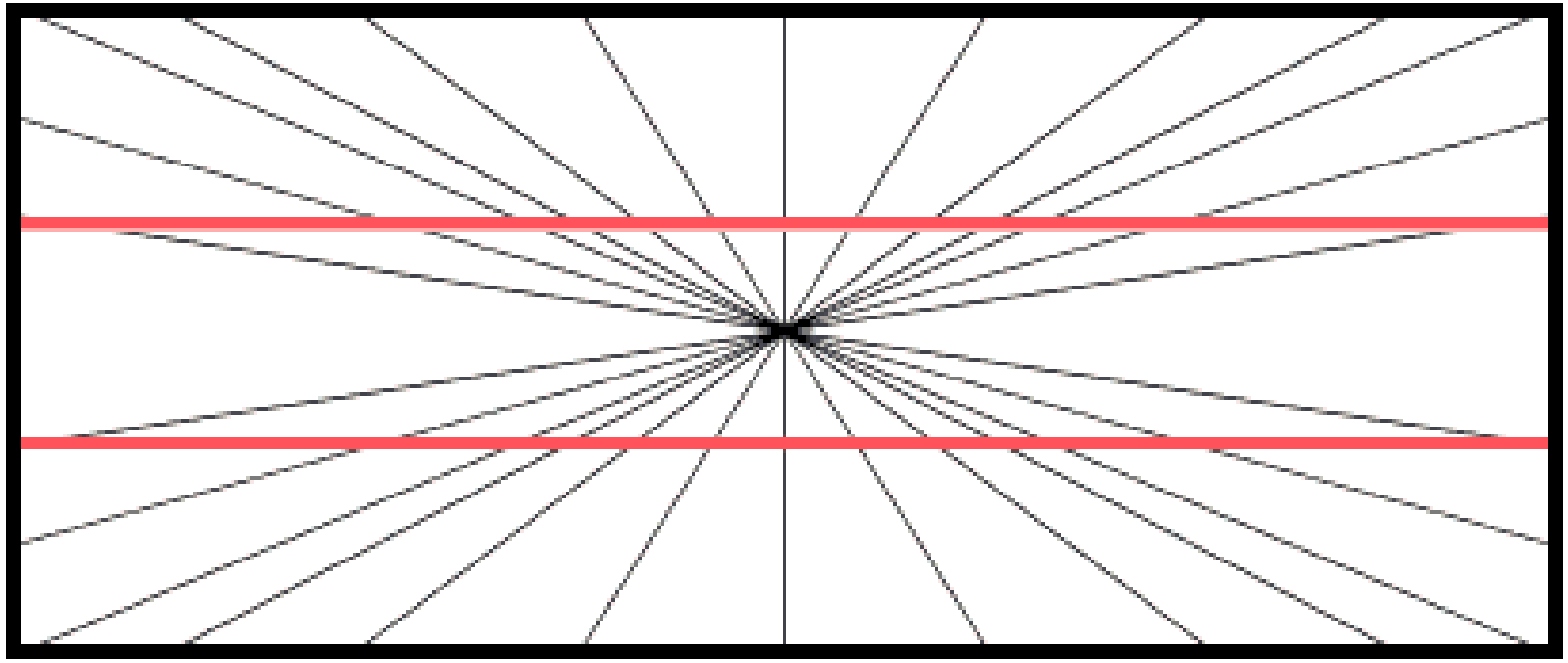
Zöllner (2)



Hering

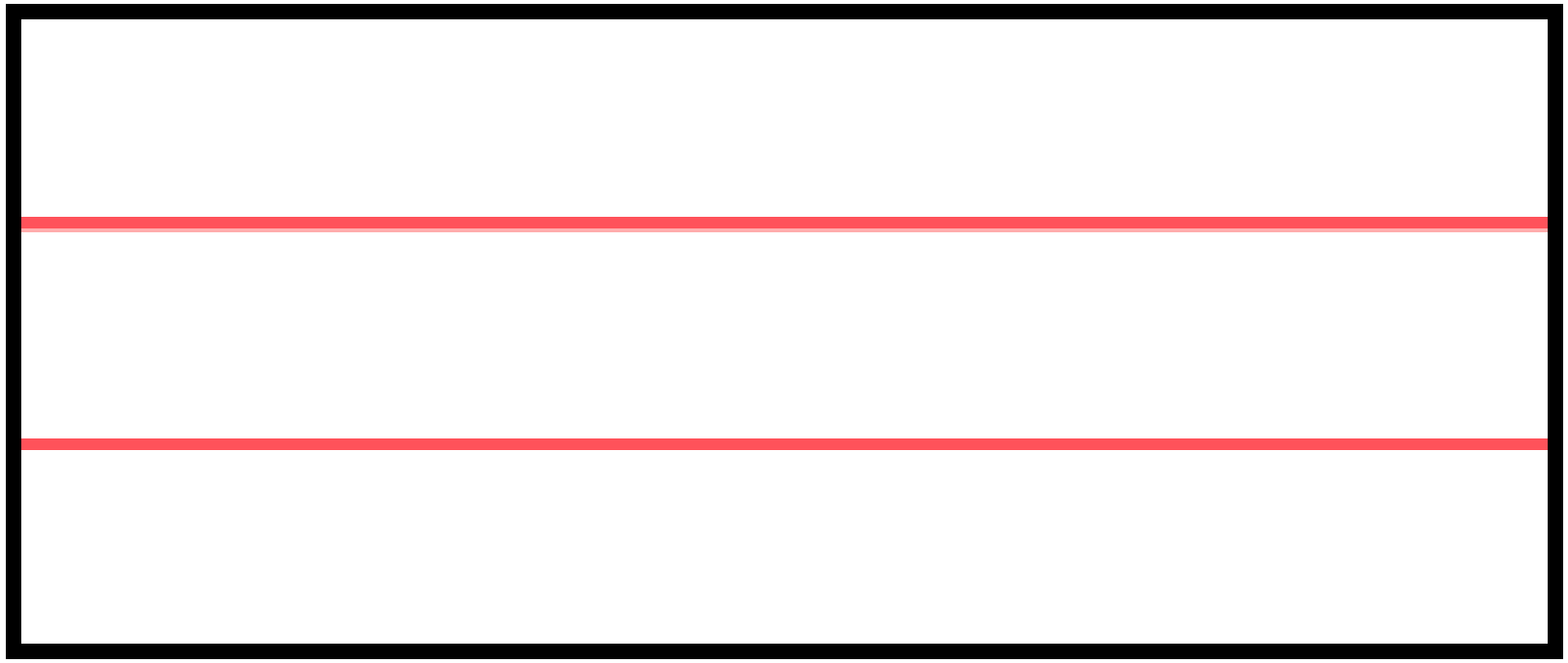


Hering



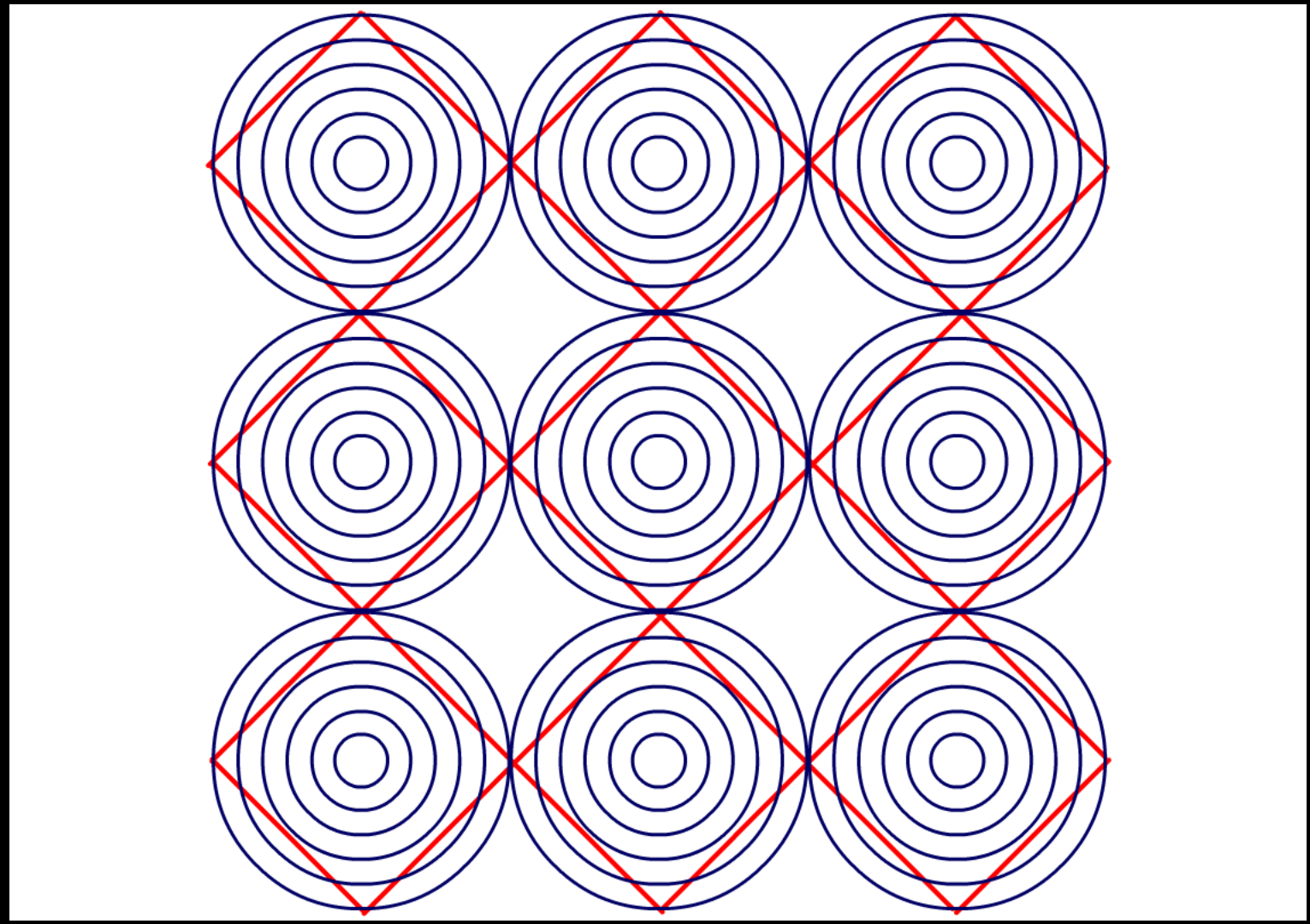
Credit: Michael Bach

Hering



Credit: Michael Bach

Hering / Zöllner



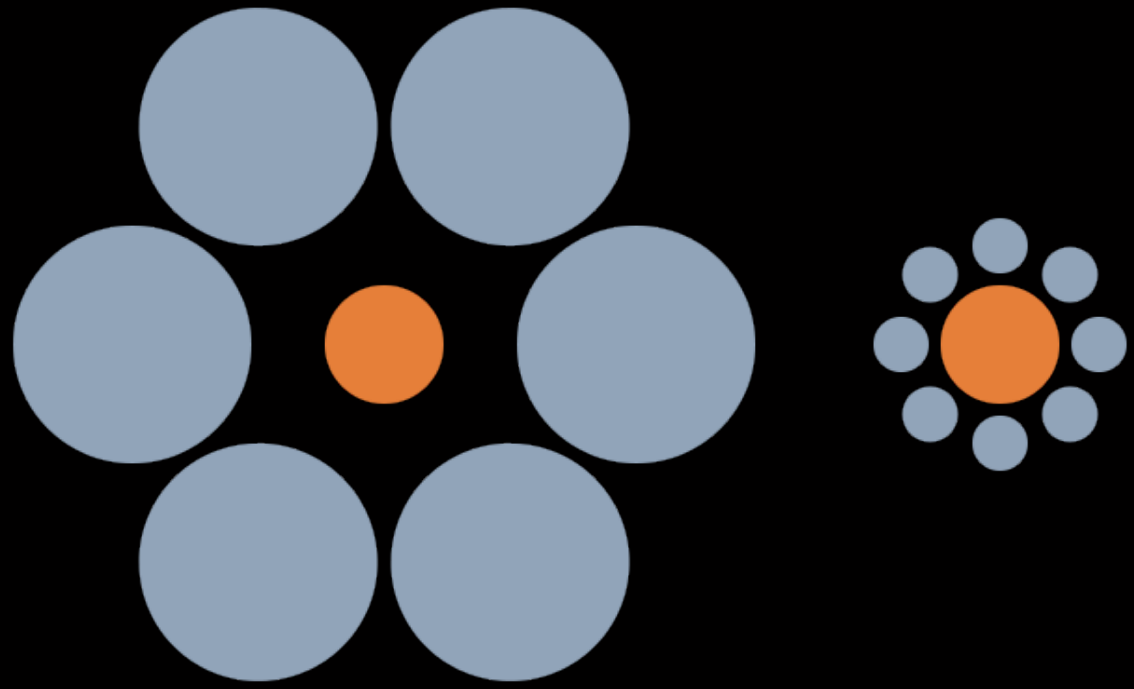
Credit: Michael Bach

Typical explanations

- Impressions of depth: the shorter lines are at an angle to the longer lines. This angle helps to create the impression that one end of the longer lines is nearer to us than the other end.

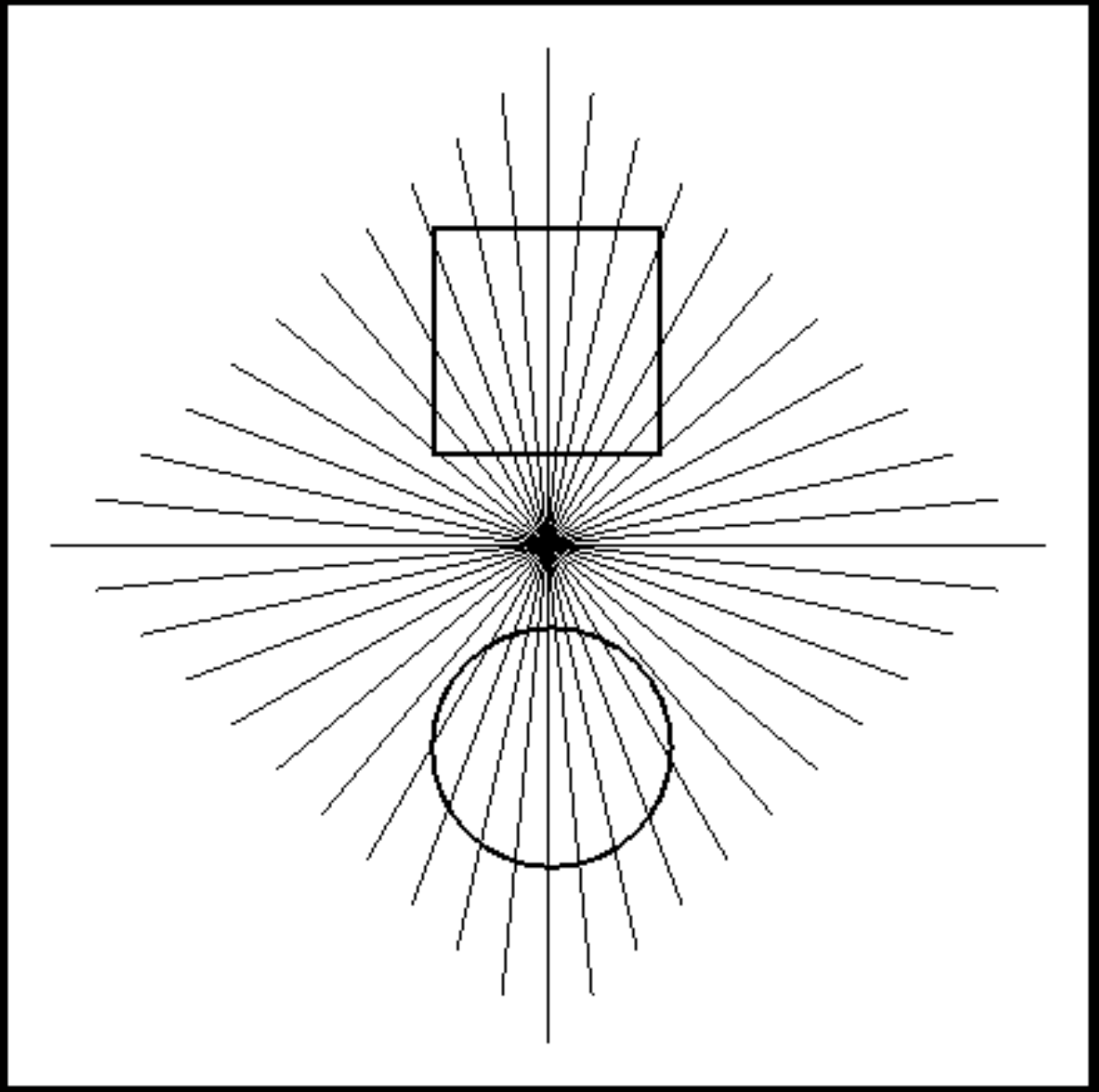
- Apparent changes in angle: the brain increases the angle between the long line and the shorter lines that cross it. As a result, the brain bends the longer lines towards or away from each other

Ebbinghaus

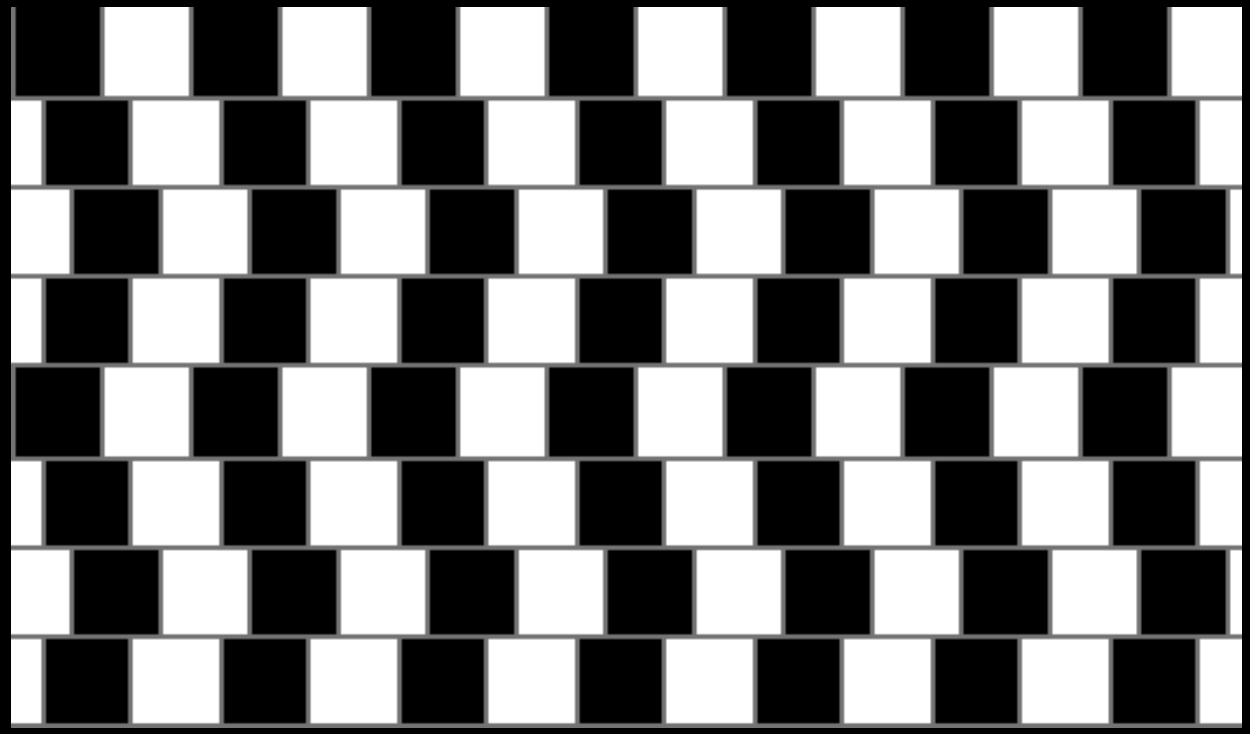


Relatively Interesting.com

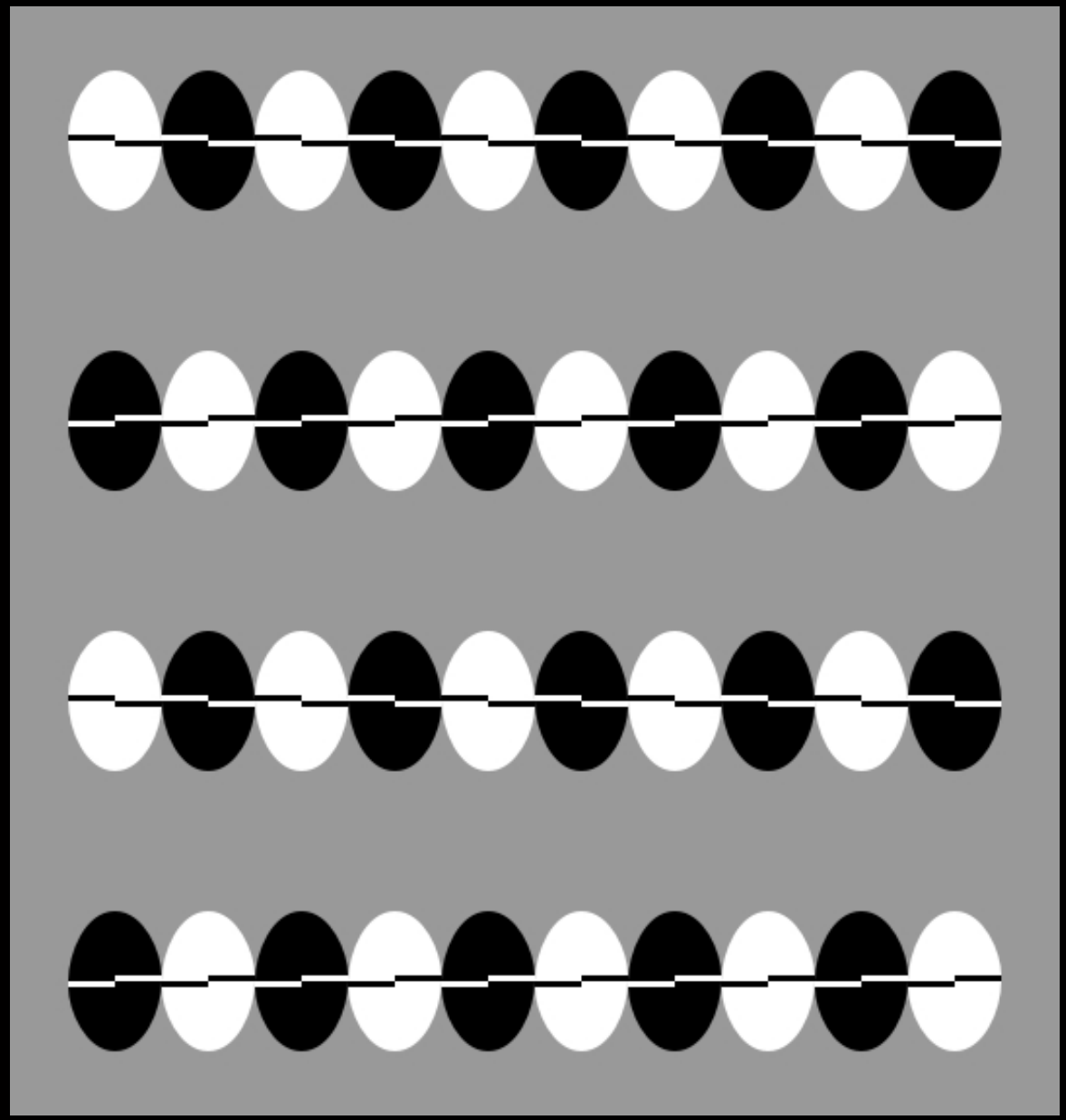
Ehrenstein



Café-wall illusion

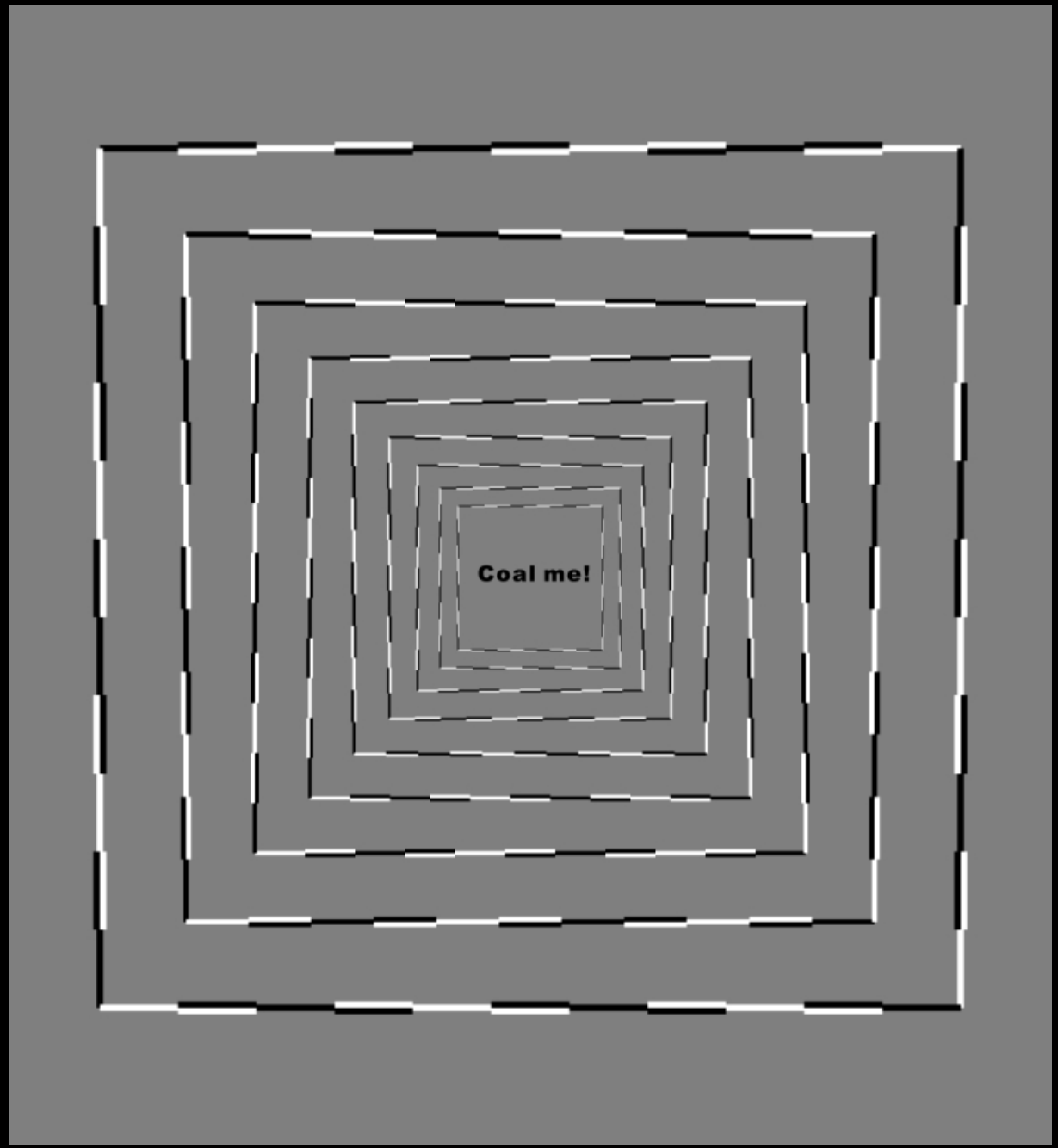


"Communication among eggs"



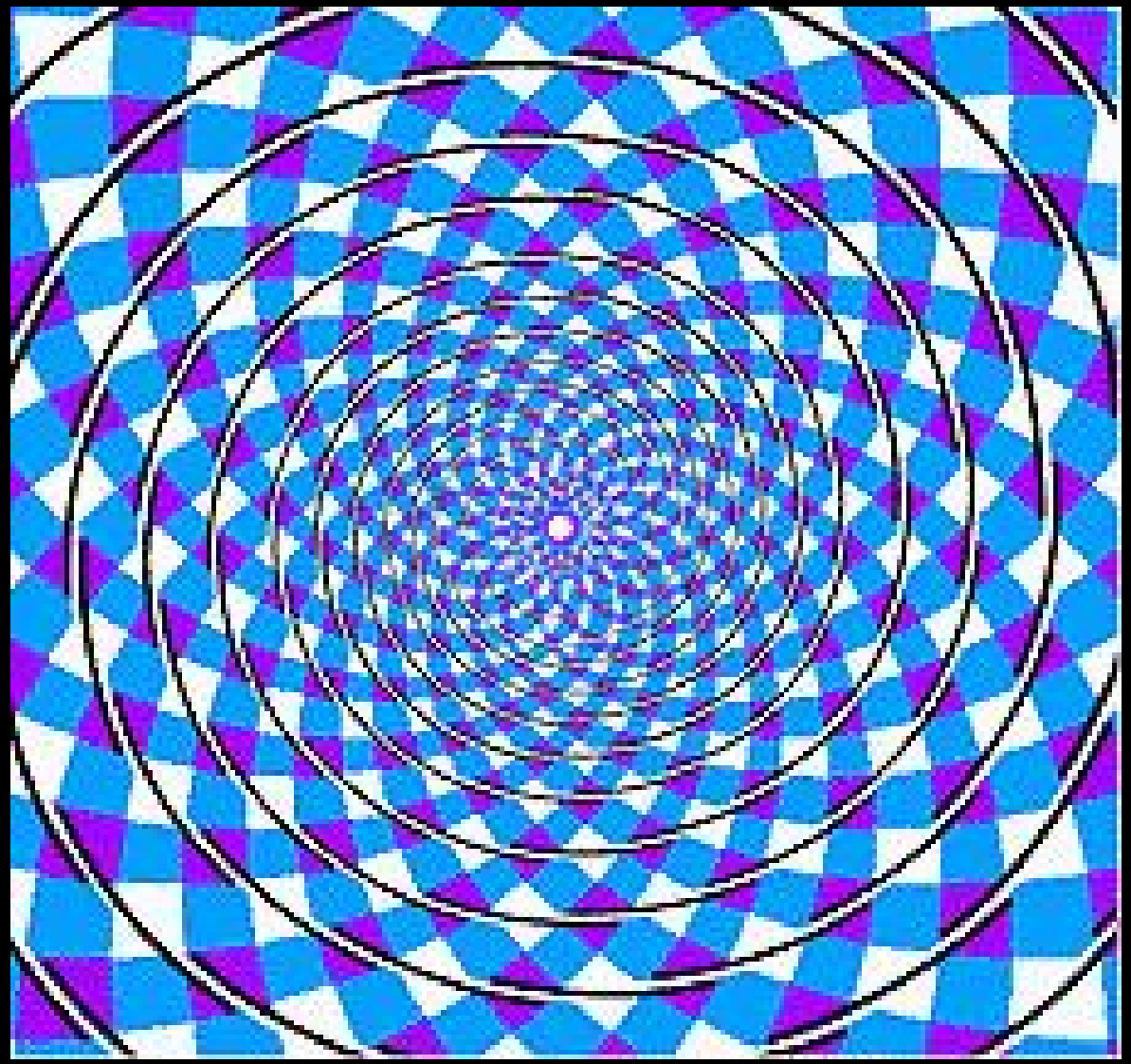
Credit: Akiyoshi Kitaoka

Coal mine

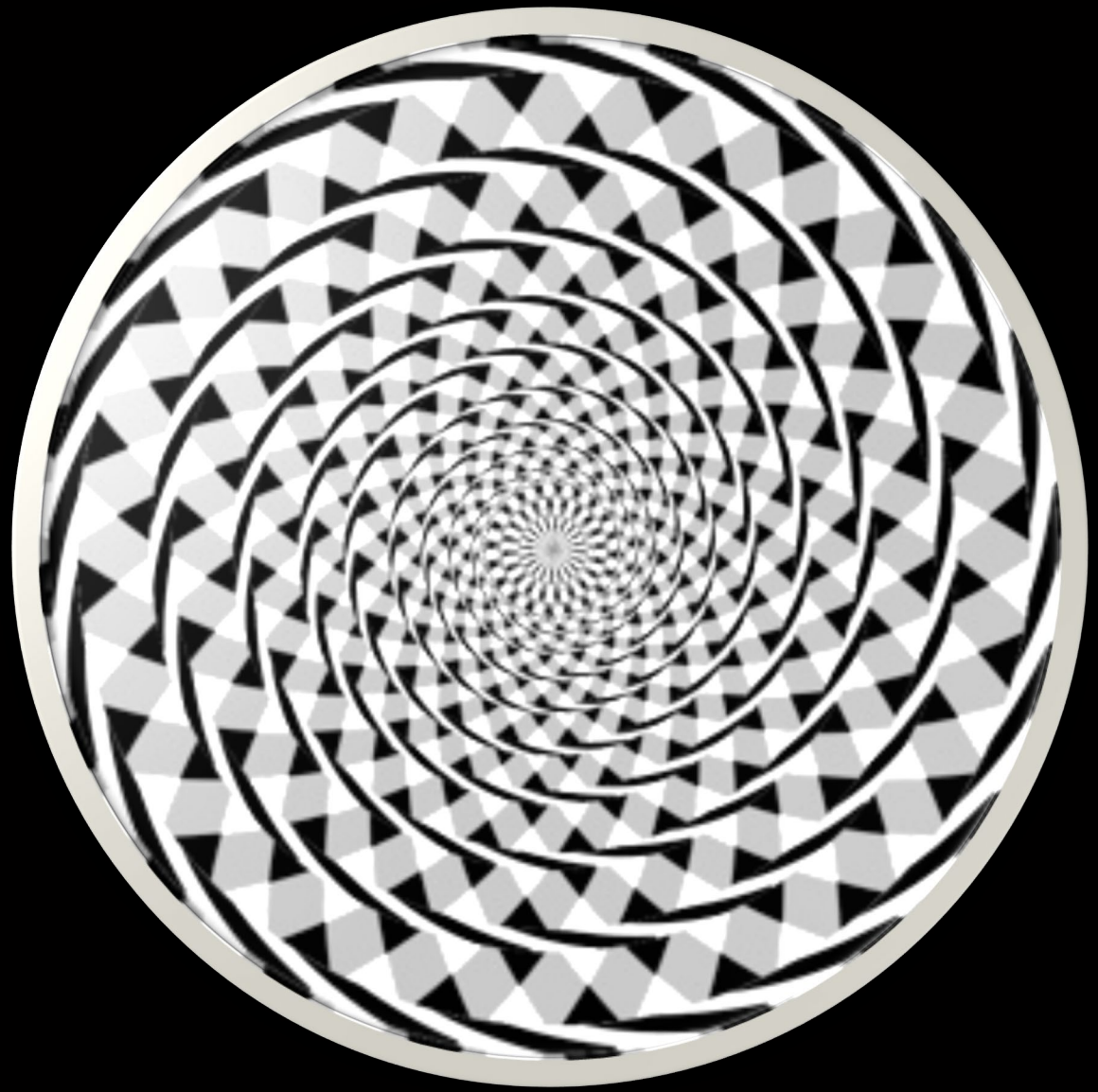


Credit: Akiyoshi Kitaoka

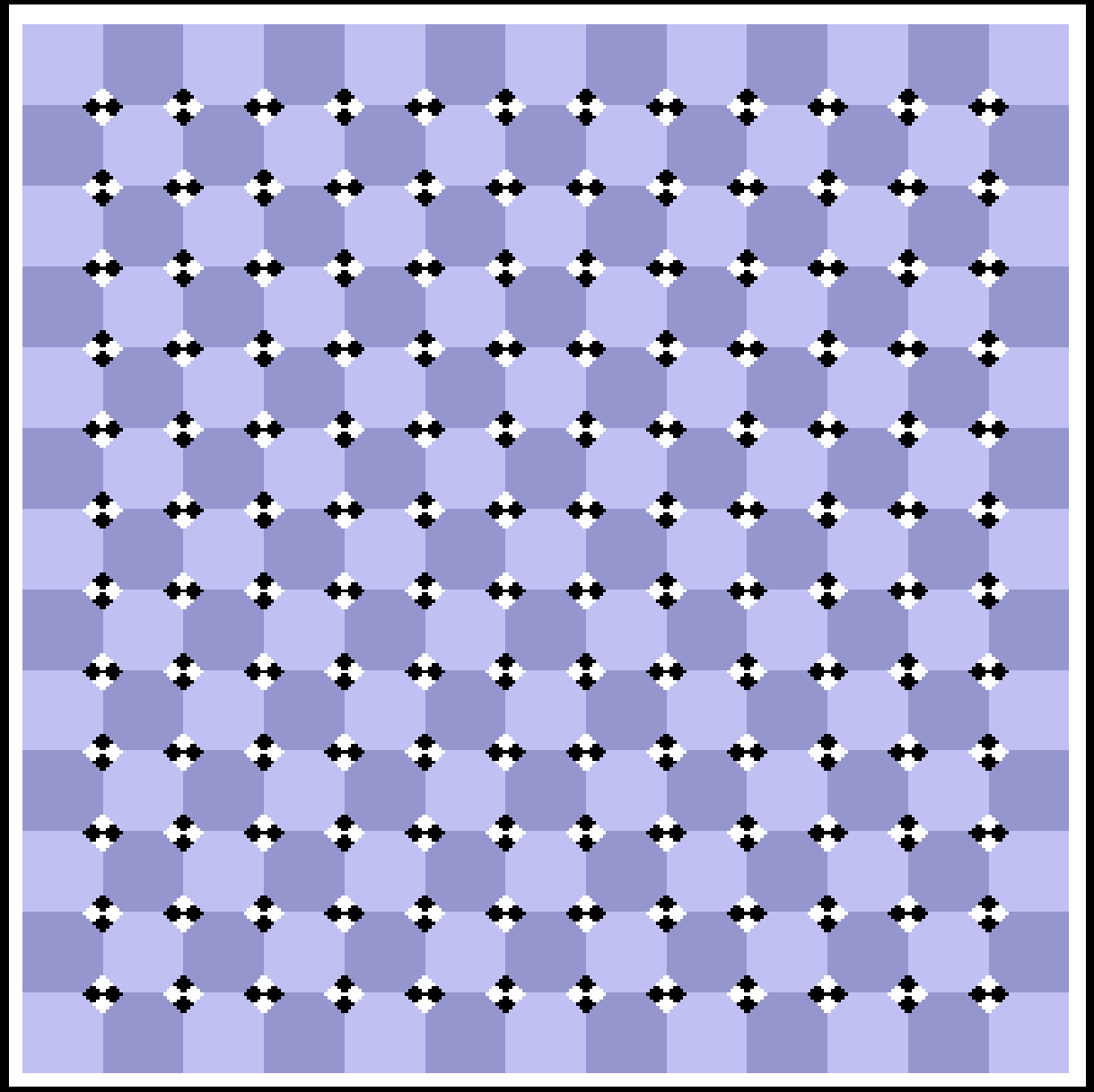
Frazer spiral



Frazer spiral
in motion

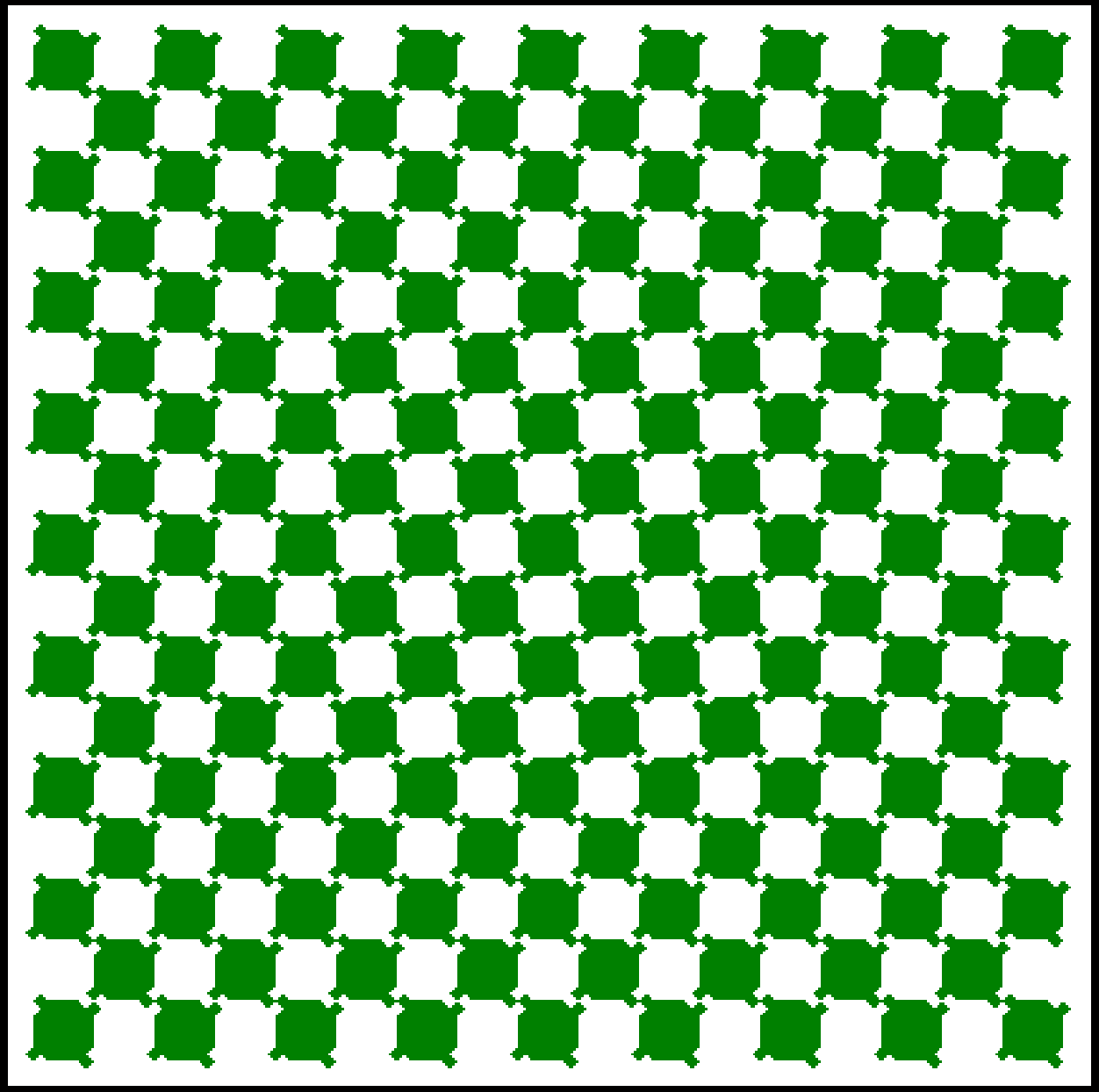


Men with sunglasses



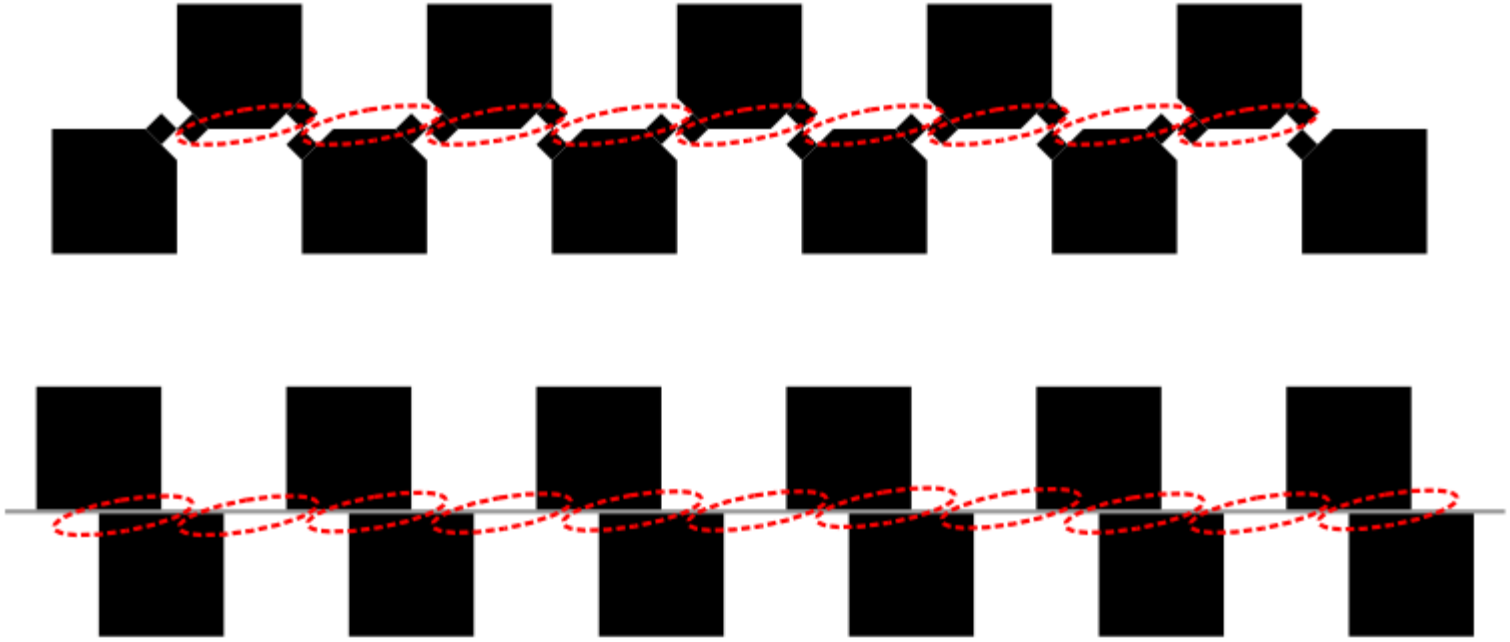
Akiyoshi Kitaoka

Midorigame
(Green turtle)



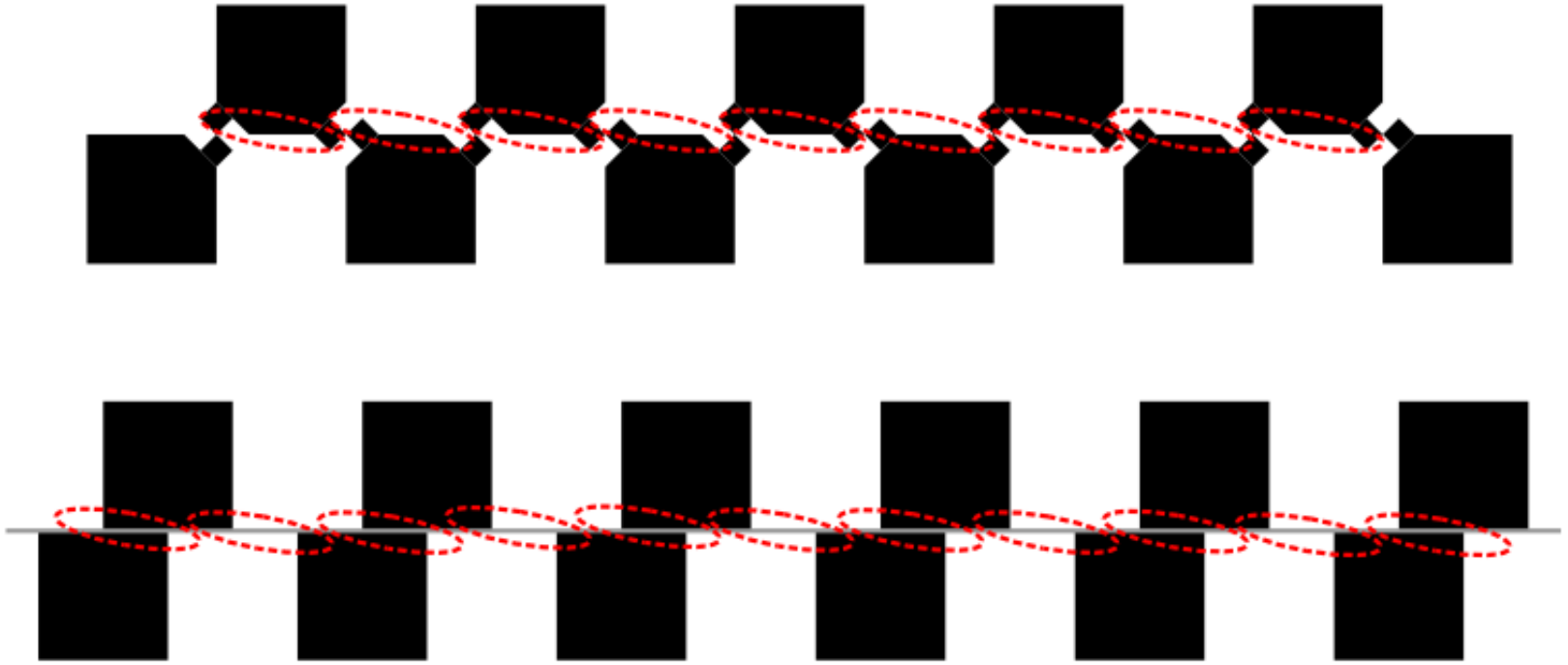
Akiyoshi Kitaoka

An explanation?



Akiyoshi Kitaoka

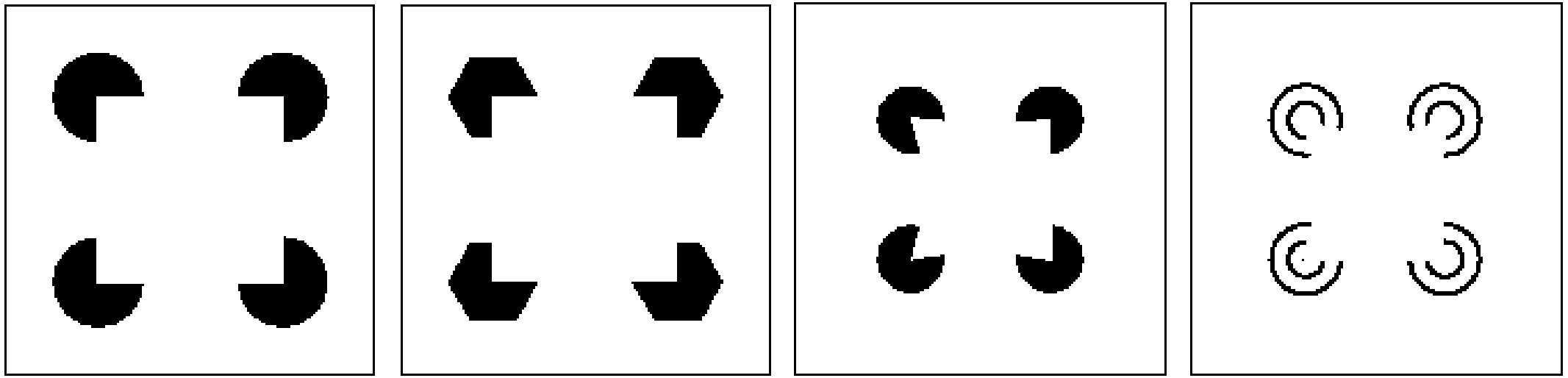
An explanation?



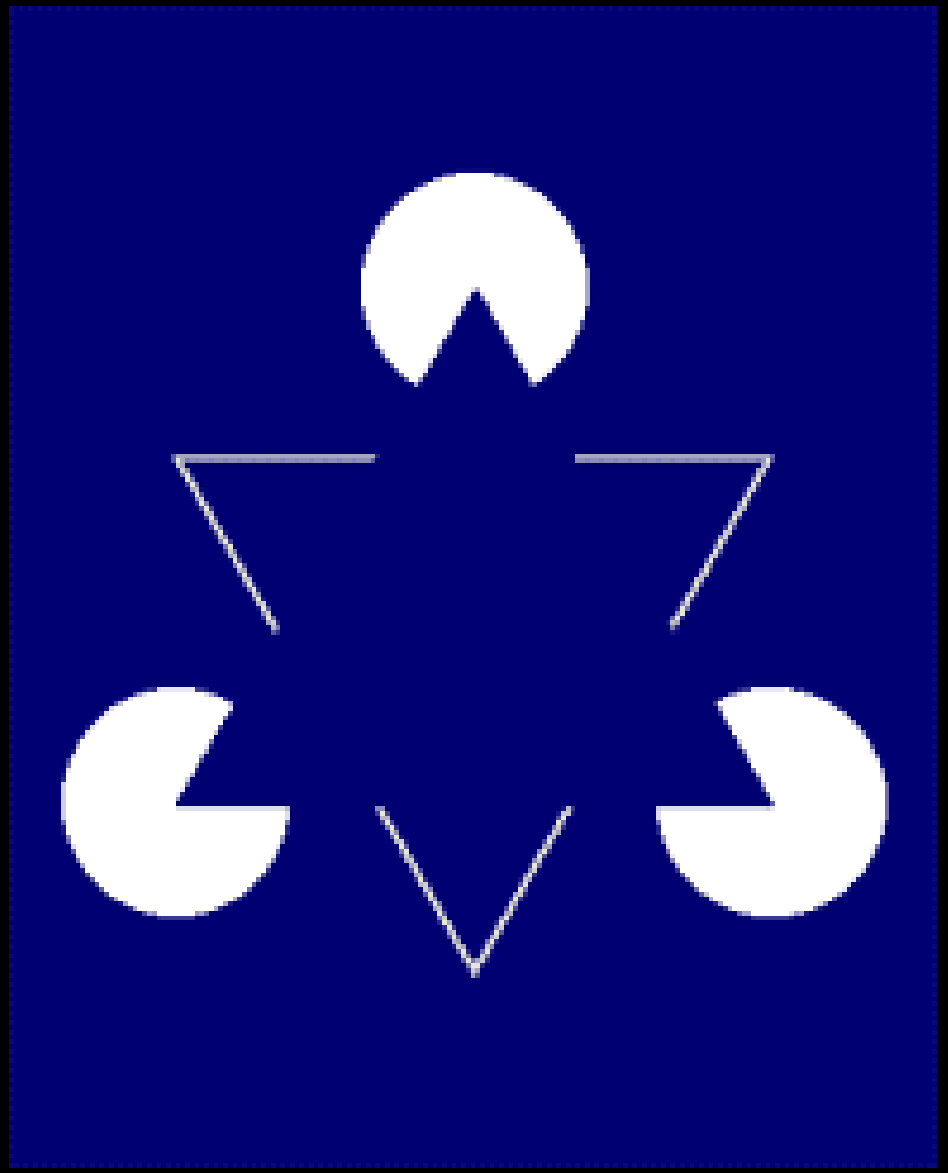
Akiyoshi Kitaoka

ILLUSORY FIGURES

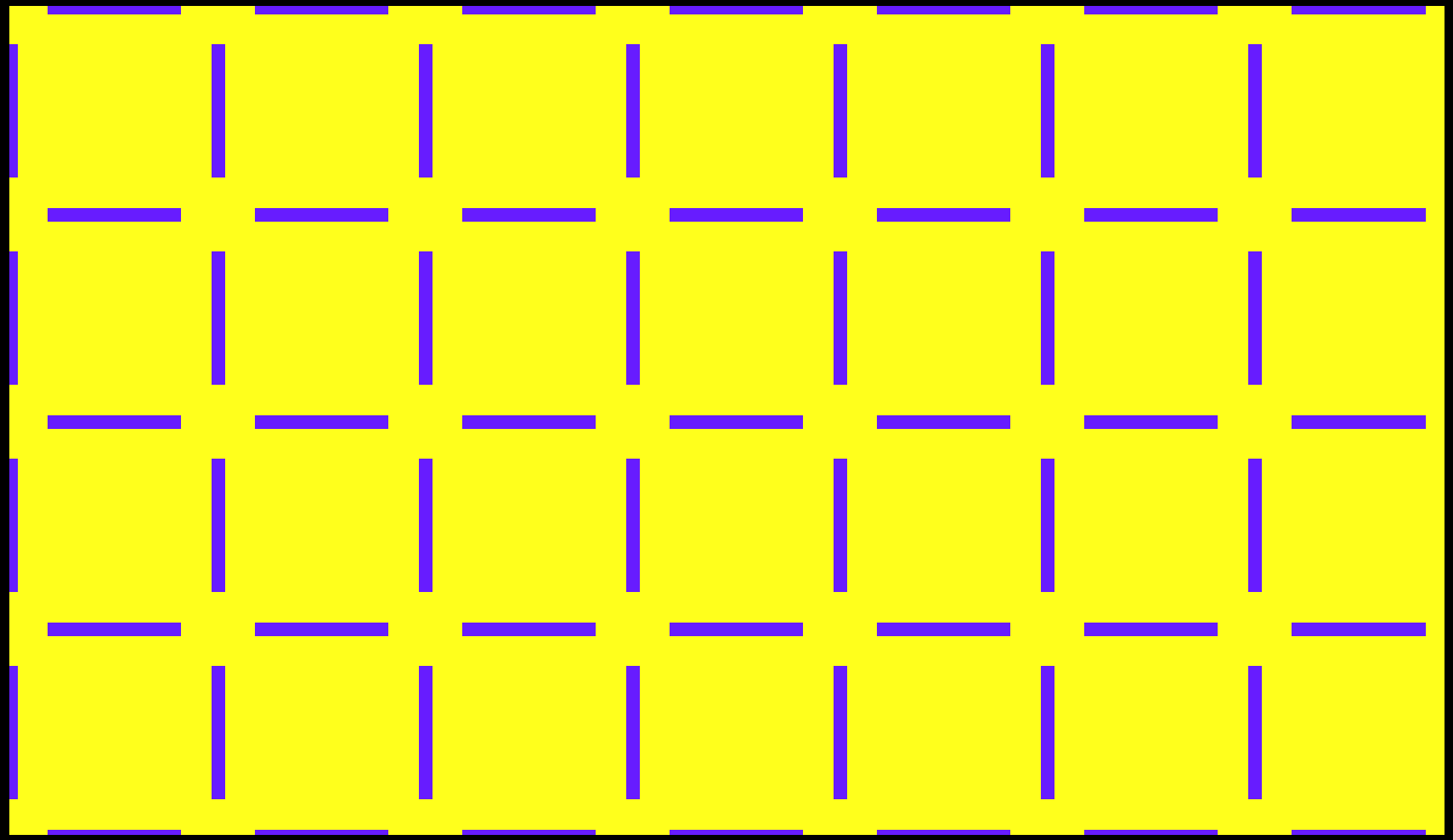
Illusory squares



Illusory triangle

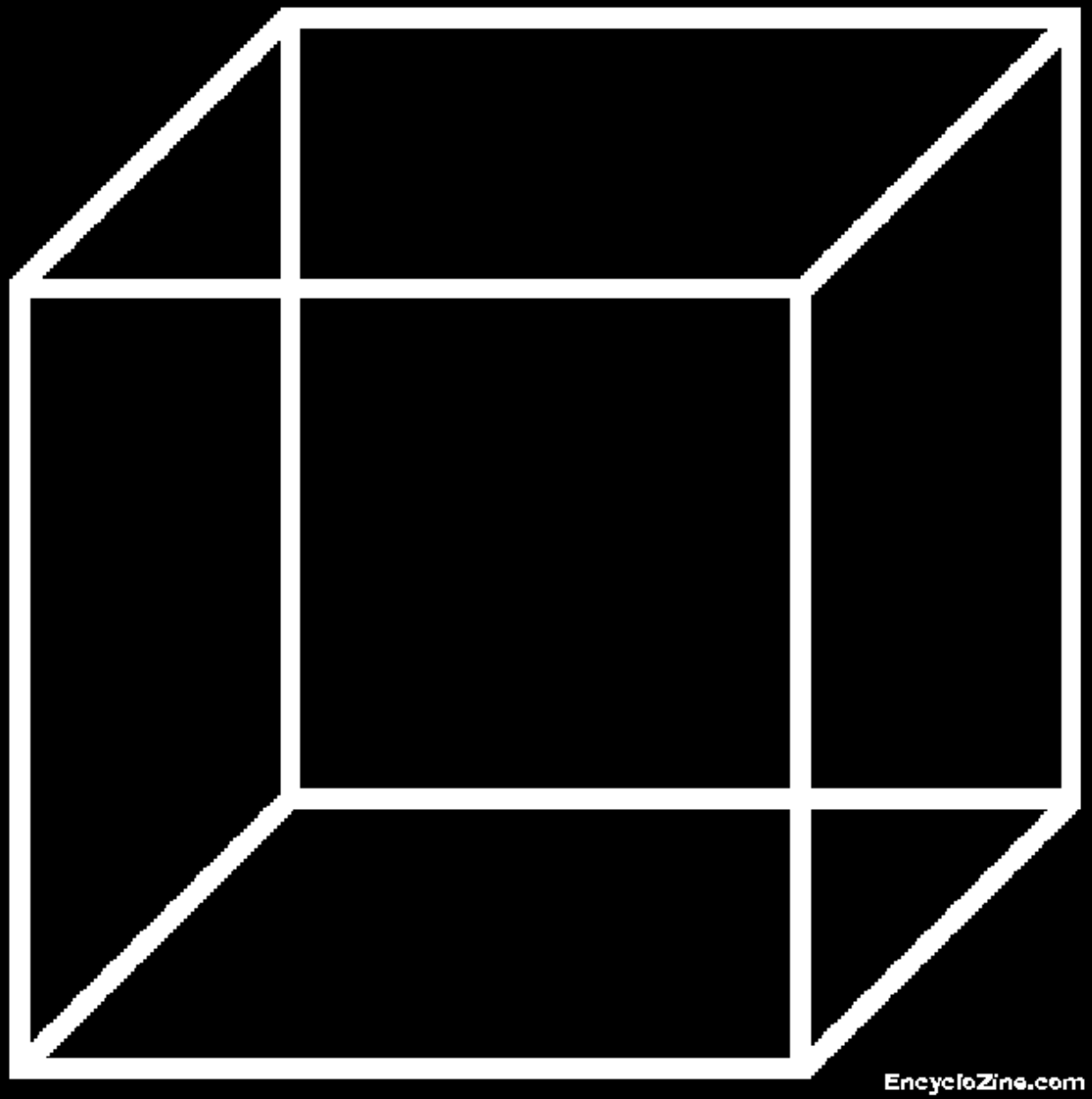


Illusory circles



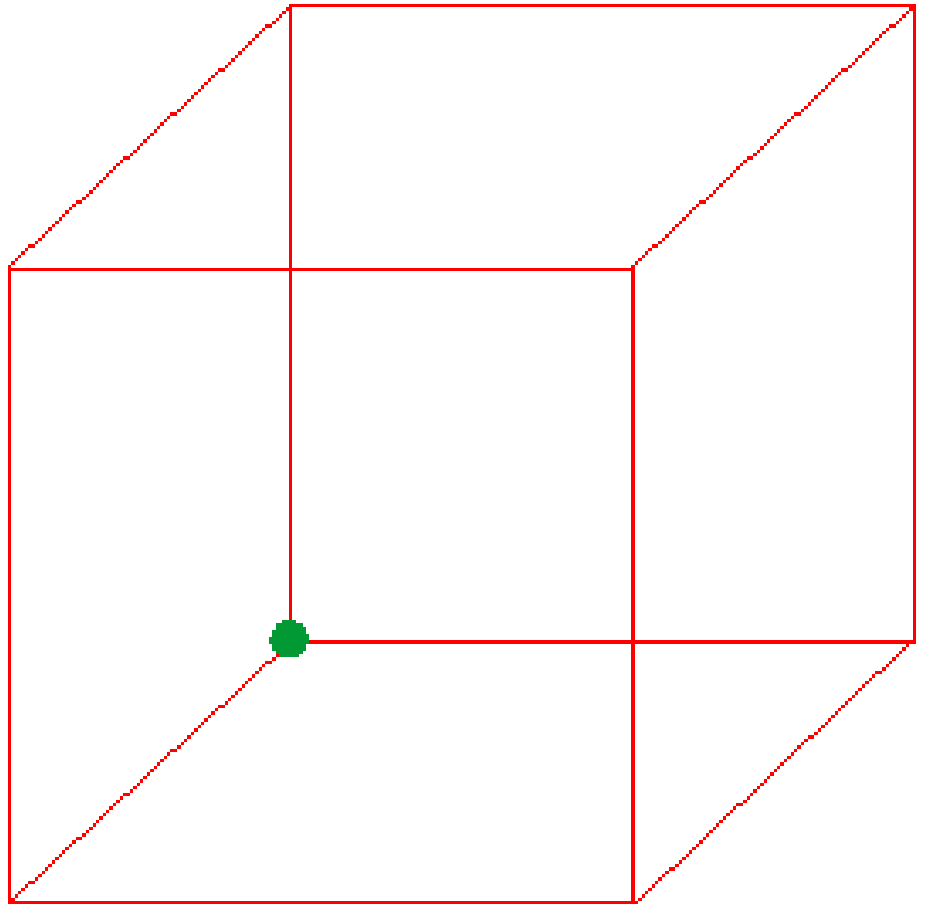
AMBIGUOUS FIGURES

Necker cube

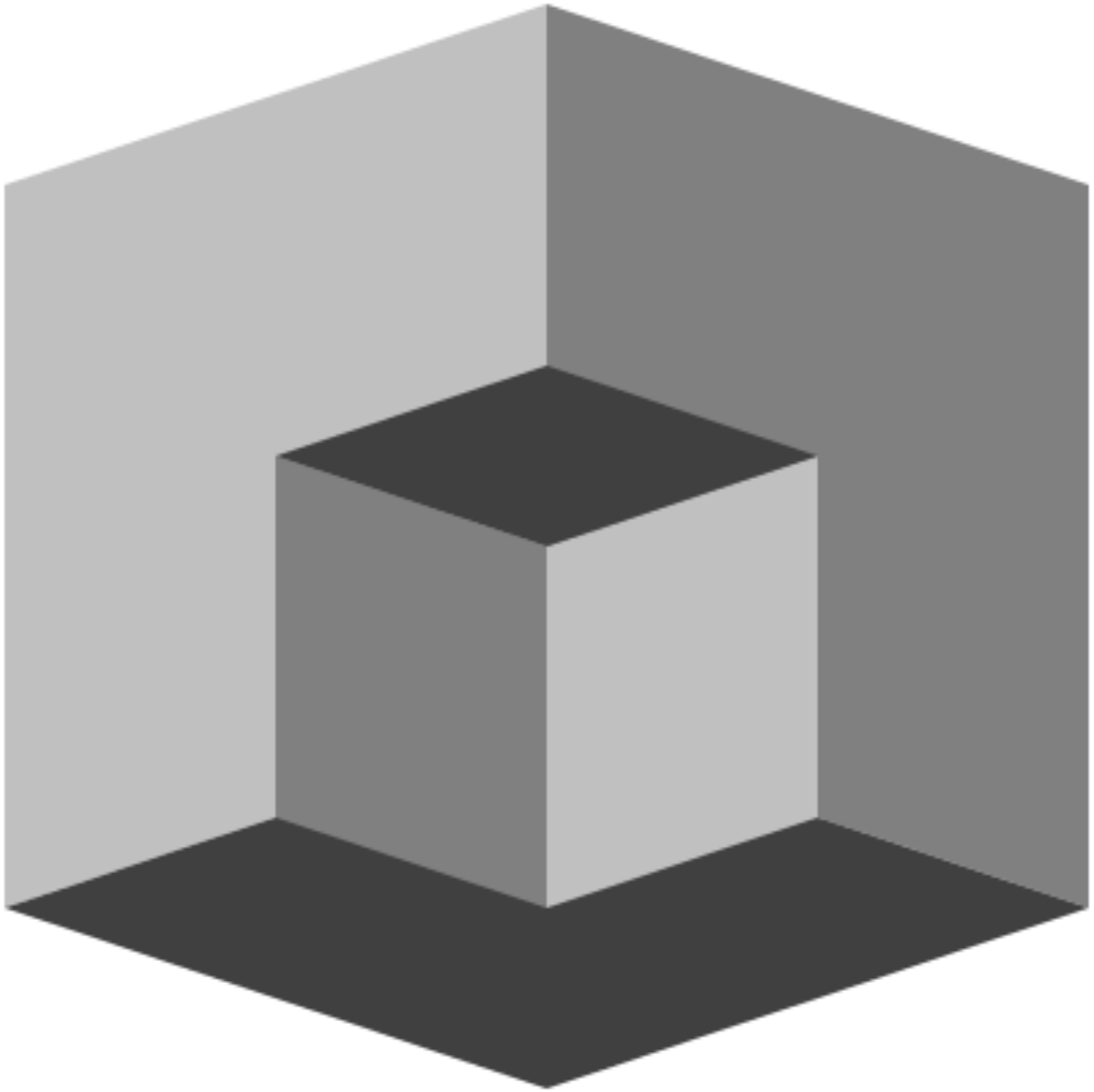


Necker cube (2)

Is the green dot in the lower left rear corner or in the lower left front corner?



Missing corner illusion

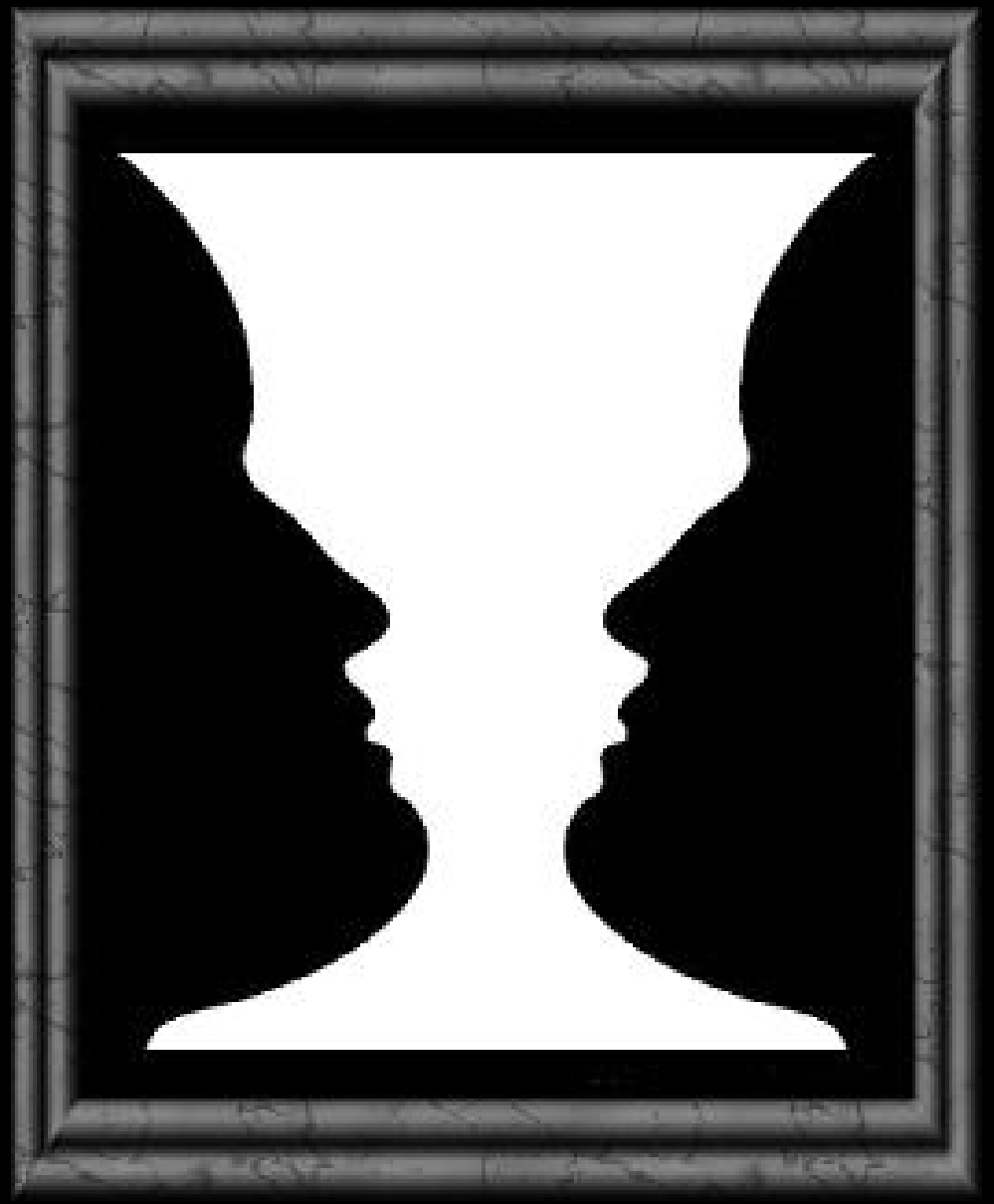


Spinning Dancer

Two women?

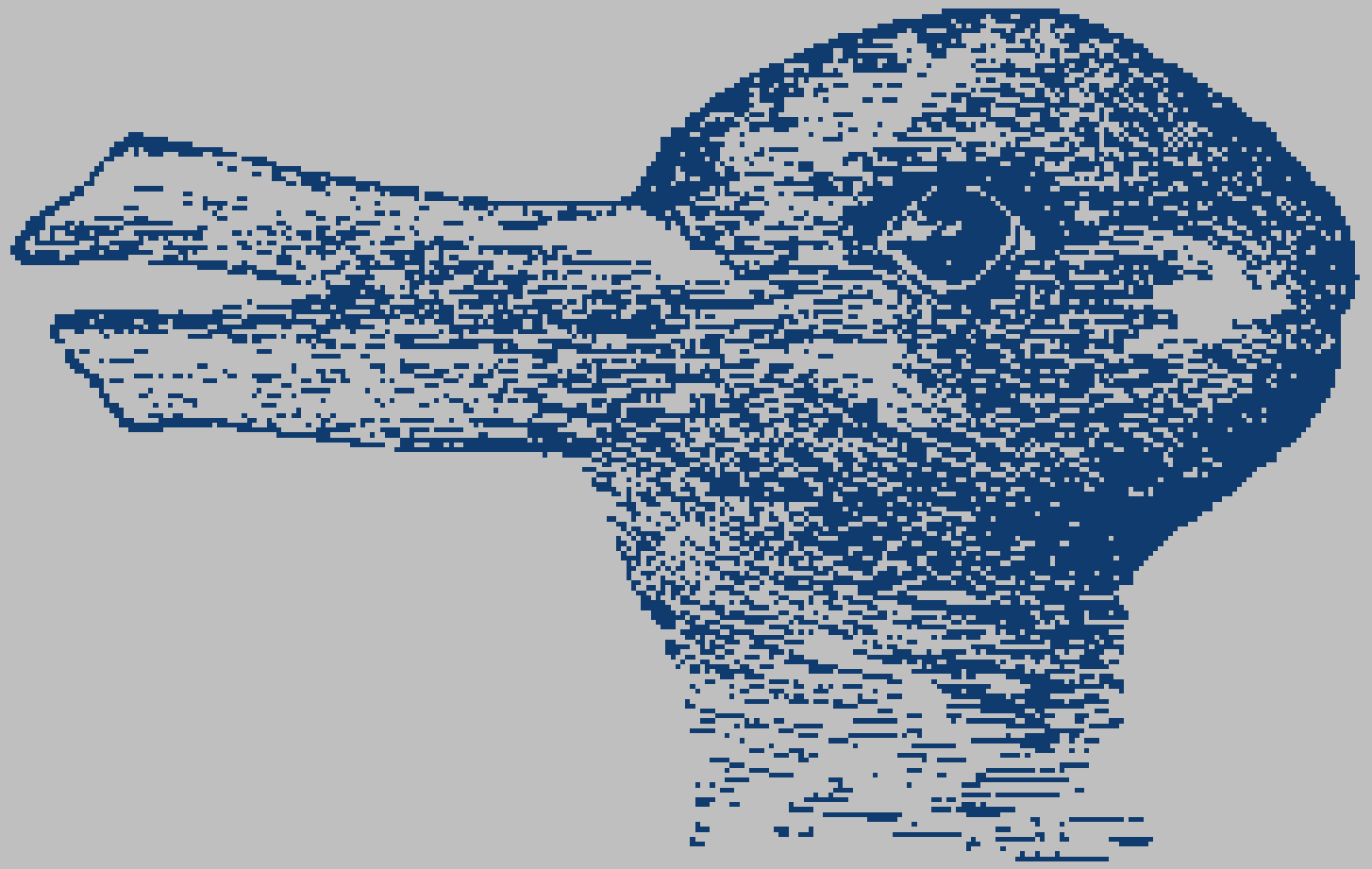
Skull?

Vase



Father son

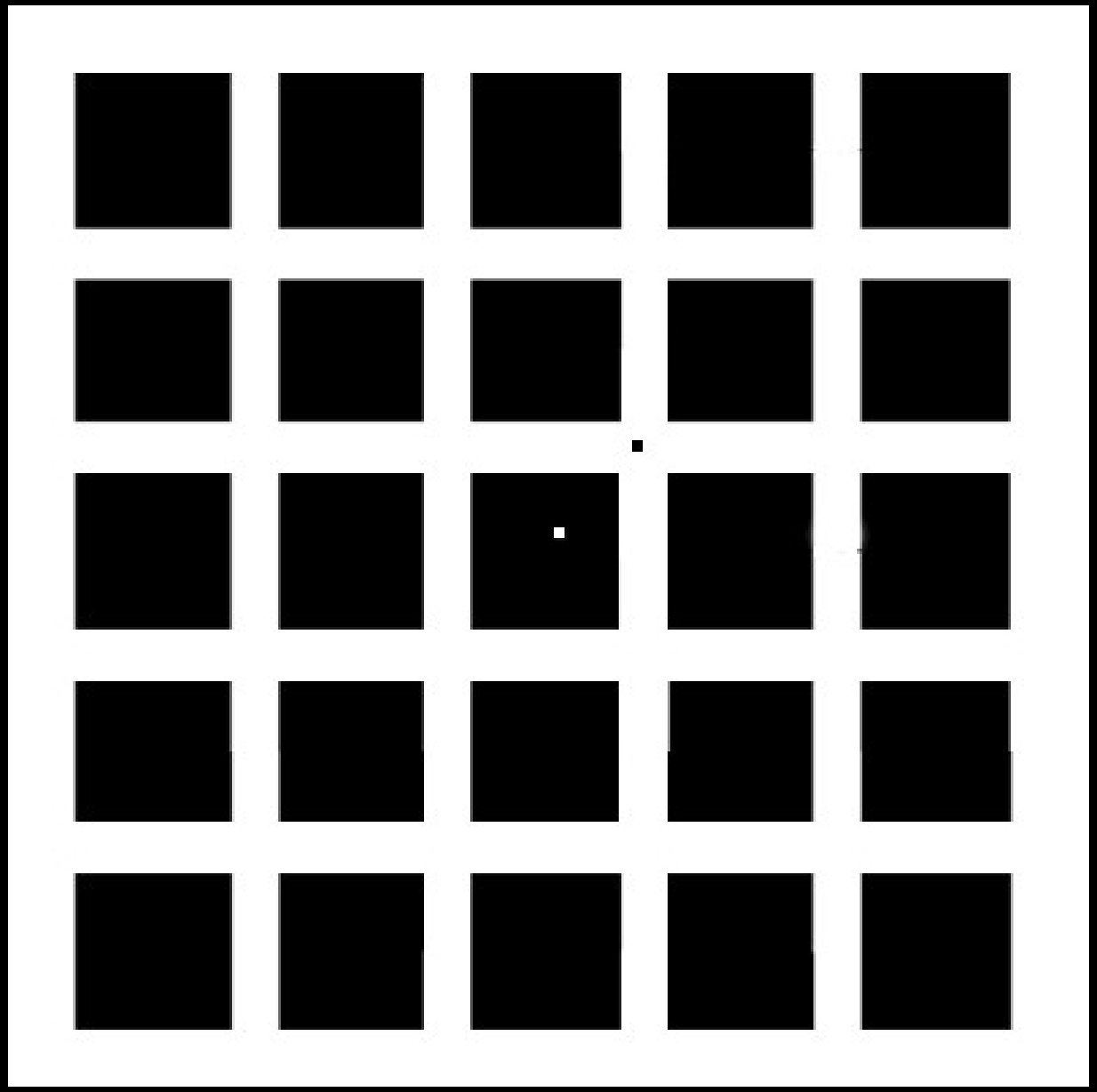
Rabbit duck

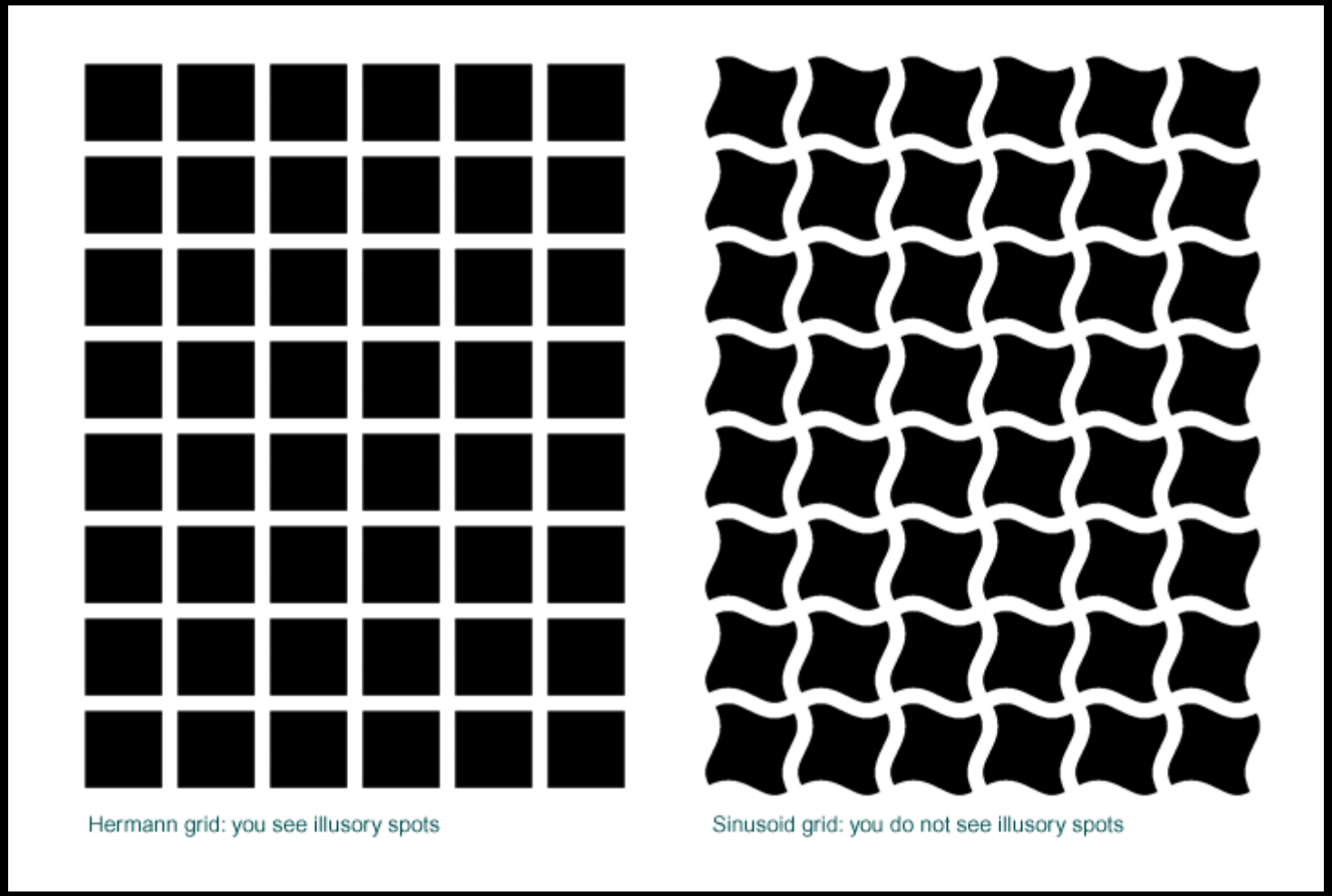


Eskimo

UNSTABLE FIGURES

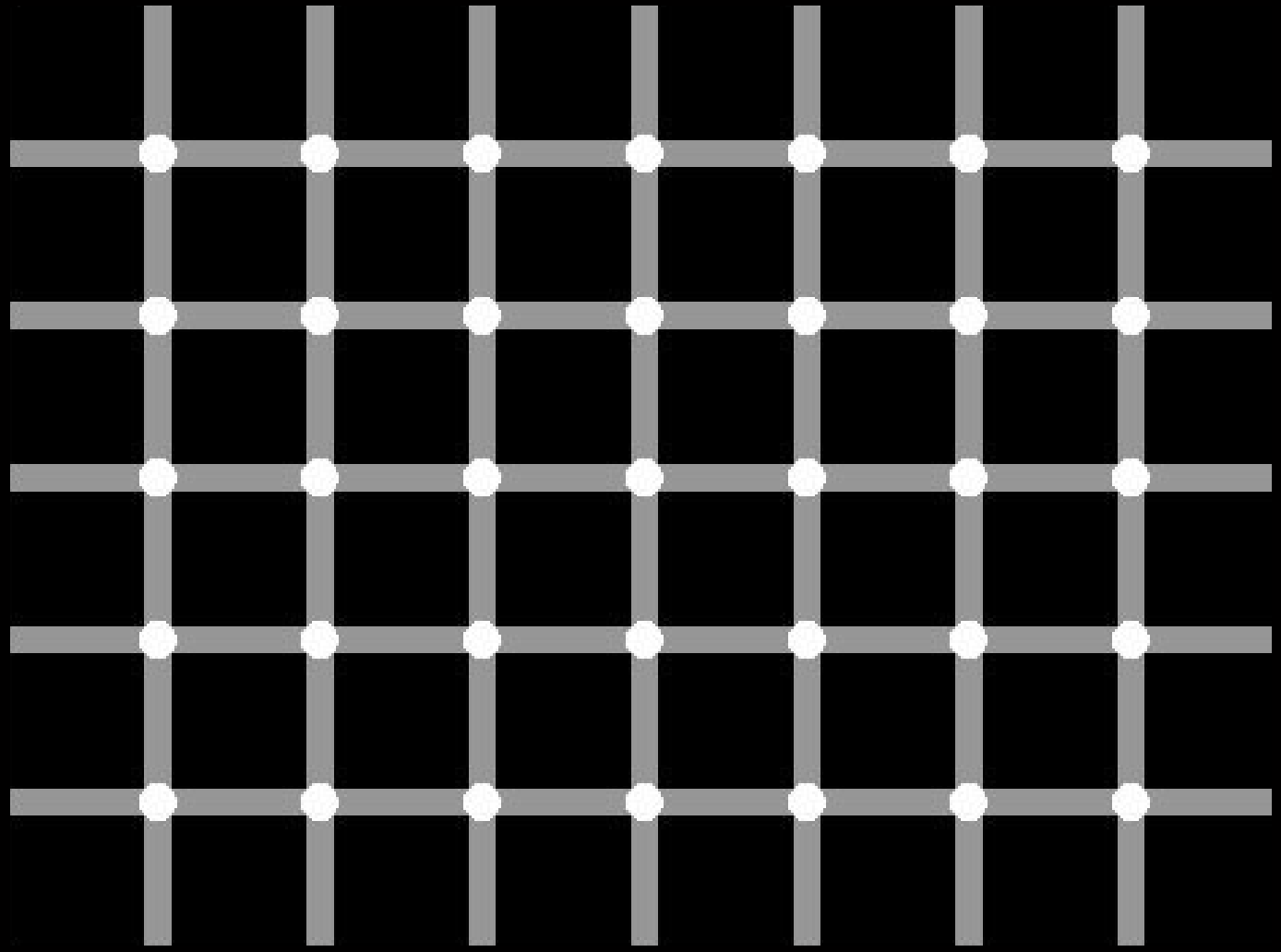
Hermann's grid



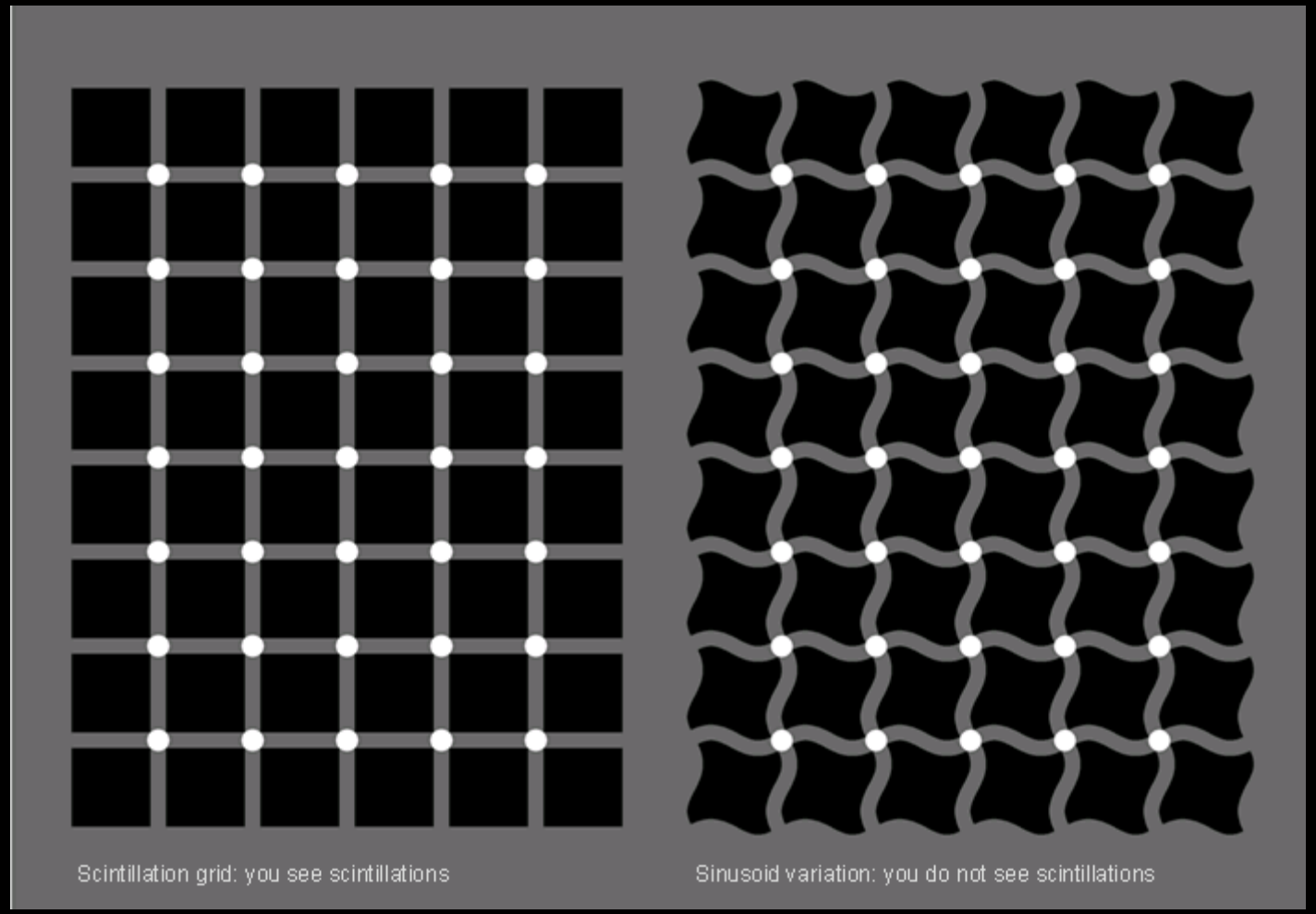

Hermann grid: you see illusory spots
Sinusoid grid: you do not see illusory spots

János Geier

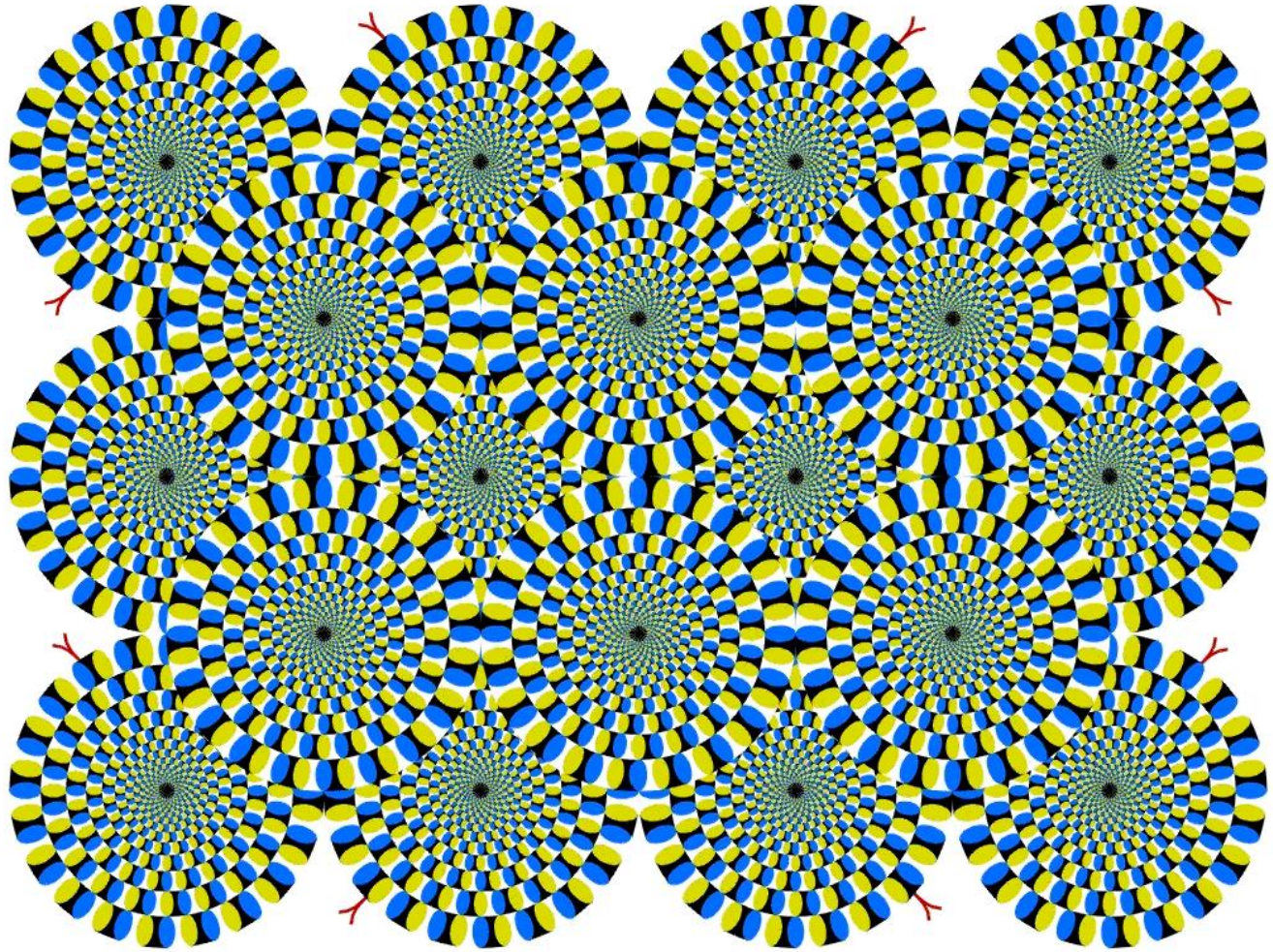
Scintillating grid illusion



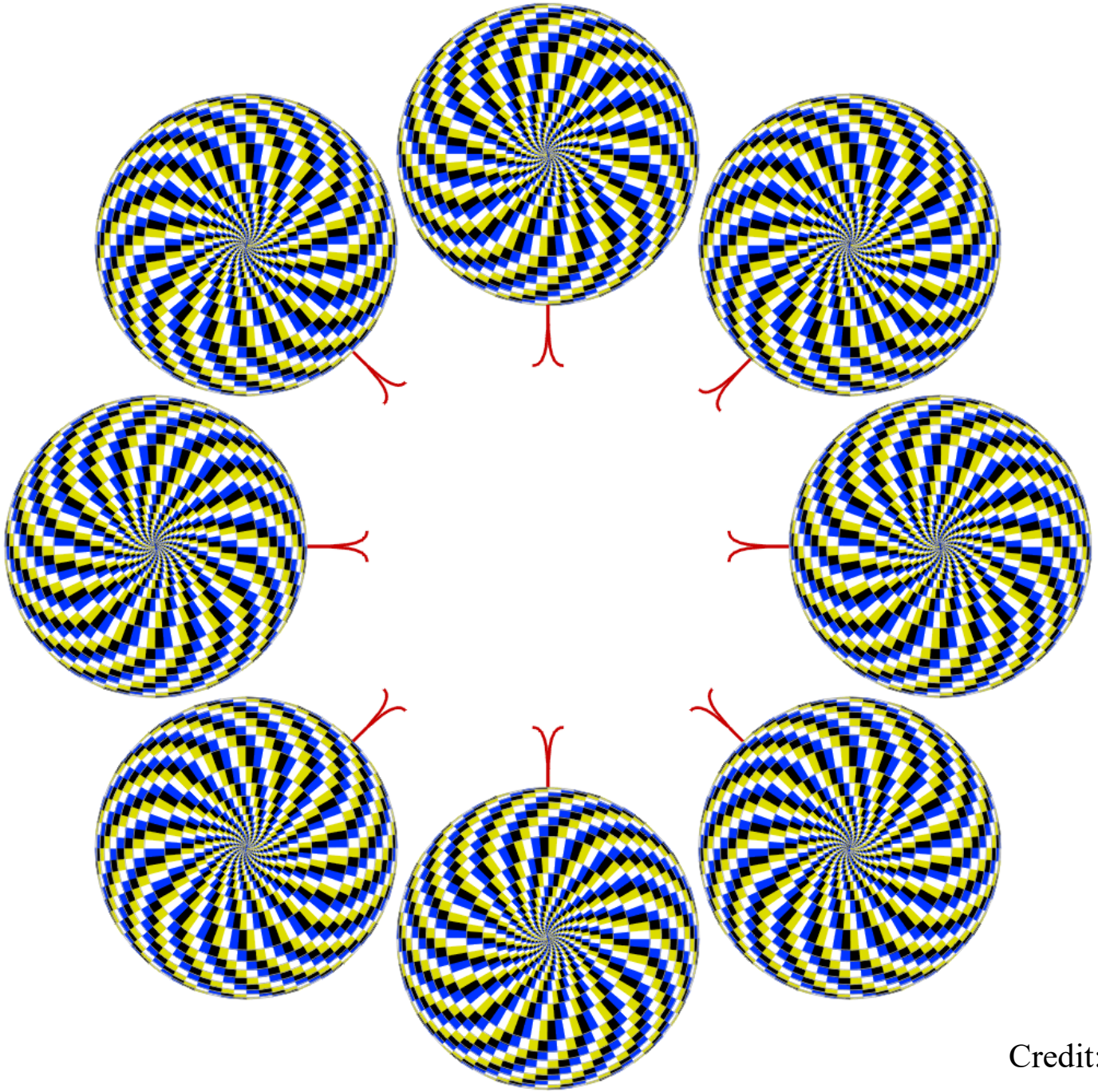
Lingelbach (1994)


Scintillation grid: you see scintillations
Sinusoid variation: you do not see scintillations

János Geier

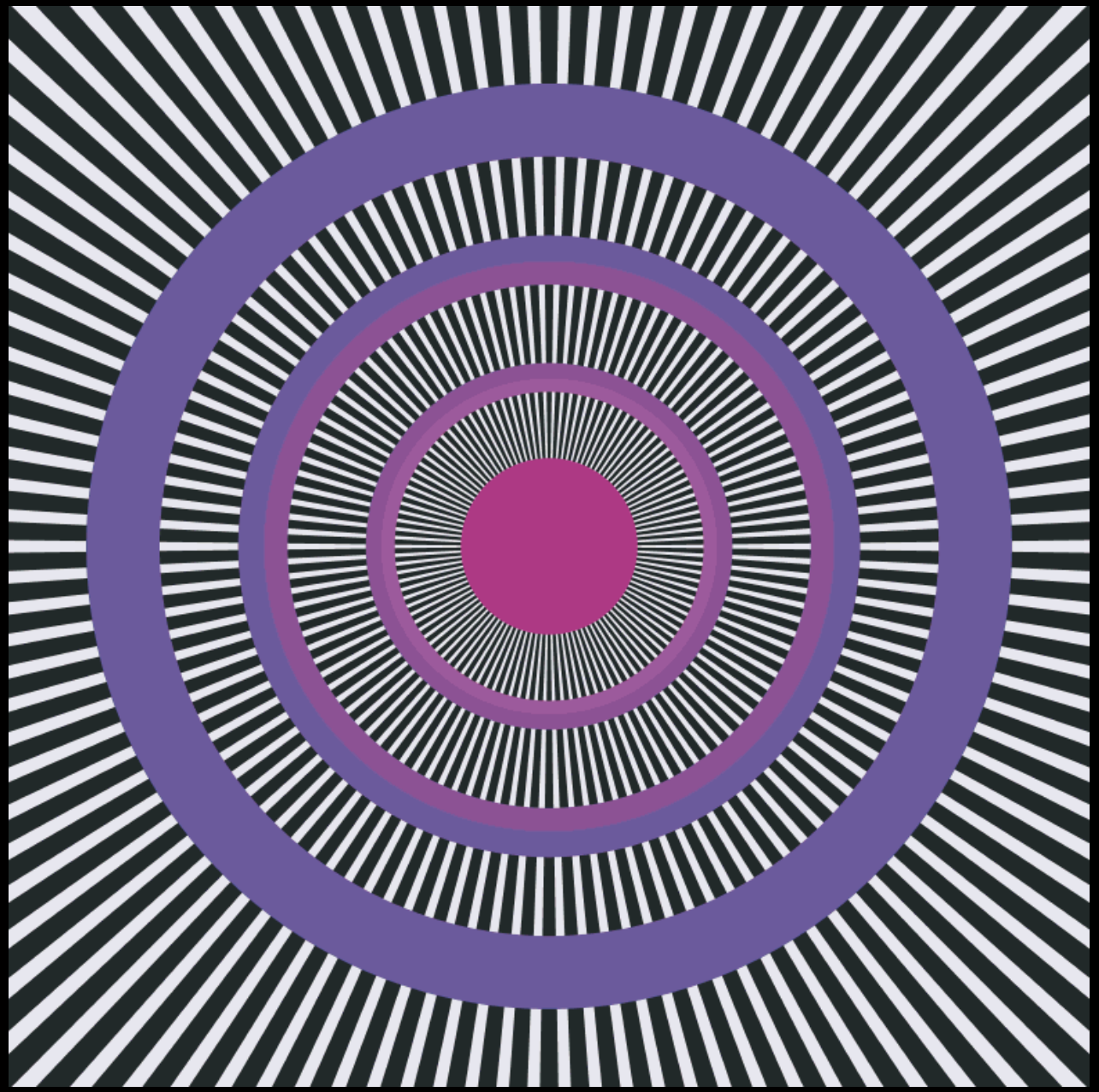


Rotating spiral snakes

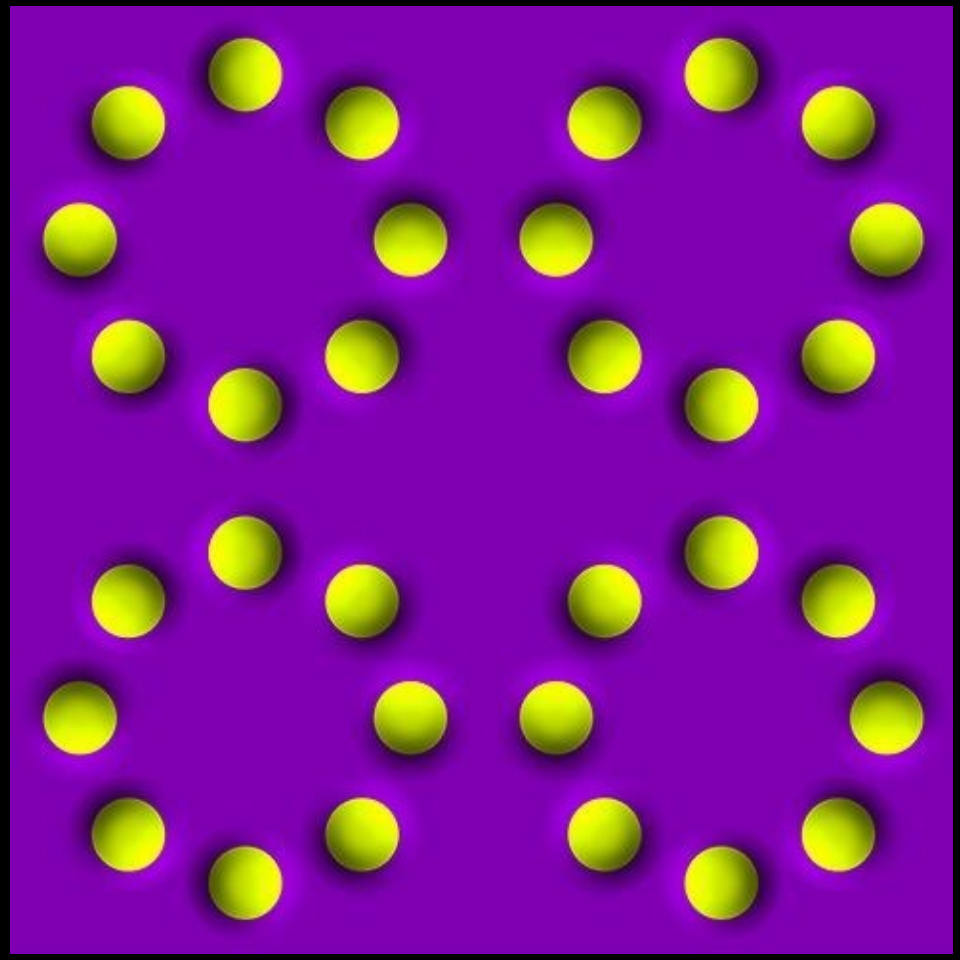


Credit: A. Kitaoka

The“Enigma”



Isia Leviant (1981), Palais de la Découverte, Paris



Thatcher illusion (1)

Credit: Peter Thompson

Thatcher illusion (2)

Credit: Peter Thompson