Depth perception

Images removed due to copyright restrictions.

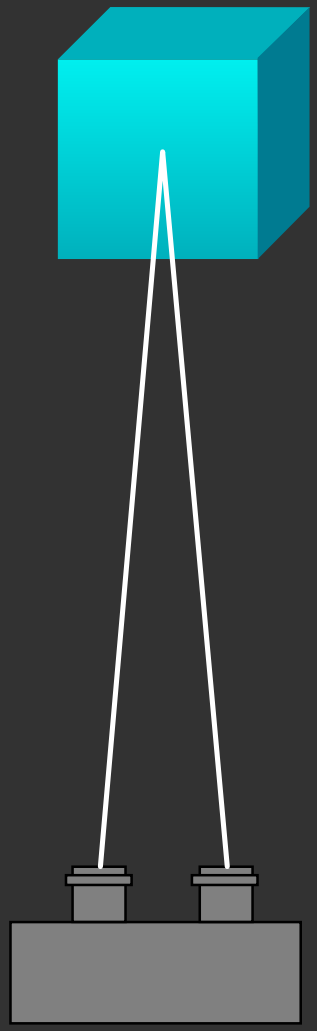
Please refer to lecture video

Cues used for coding depth in the brain

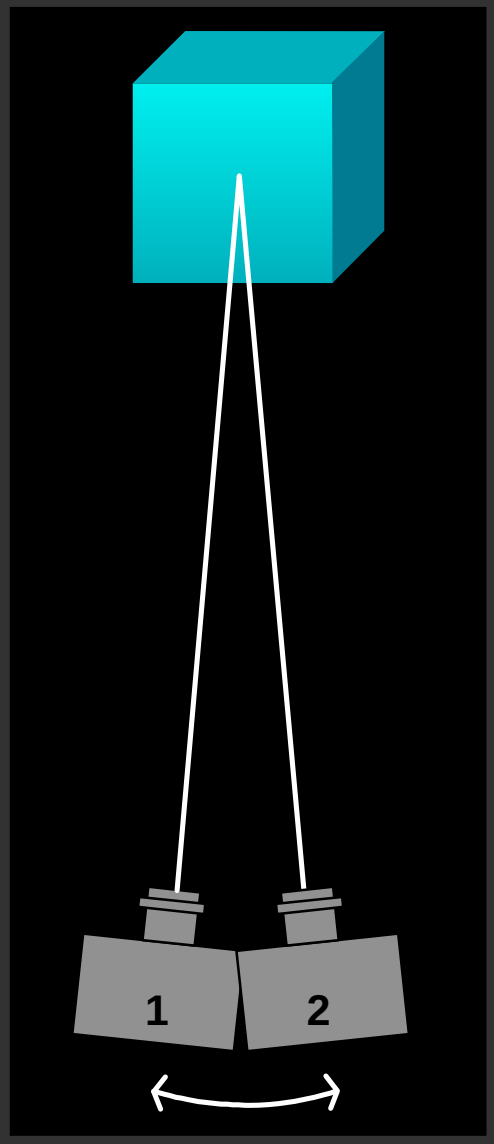
Oculomotor cues	Visual cues
accommodation vergence	*Binocular* stereopsis
	Monocular motion parallax shading interposition size perspective

Stereopsis, basic facts and demos

Two simple methods for creating stereo images



stereo camera



swiveled regular camera

Image is in public domain.

Demos, page 1

Images removed due to copyright restrictions.

Please see lecture video or Figure 1 of Schiller, Peter H., Geoffrey L. Kendall, et al. "Depth Perception, Binocular Integration and Hand-Eye Coordination in Intact and Stereo Impaired Human Subjects." *Journal of Clinical & Experimental Ophthalmology* 3, (210).

Demos, page 1 & 2

Autostereogram from Magic Eye

Images removed due to copyright restrictions.

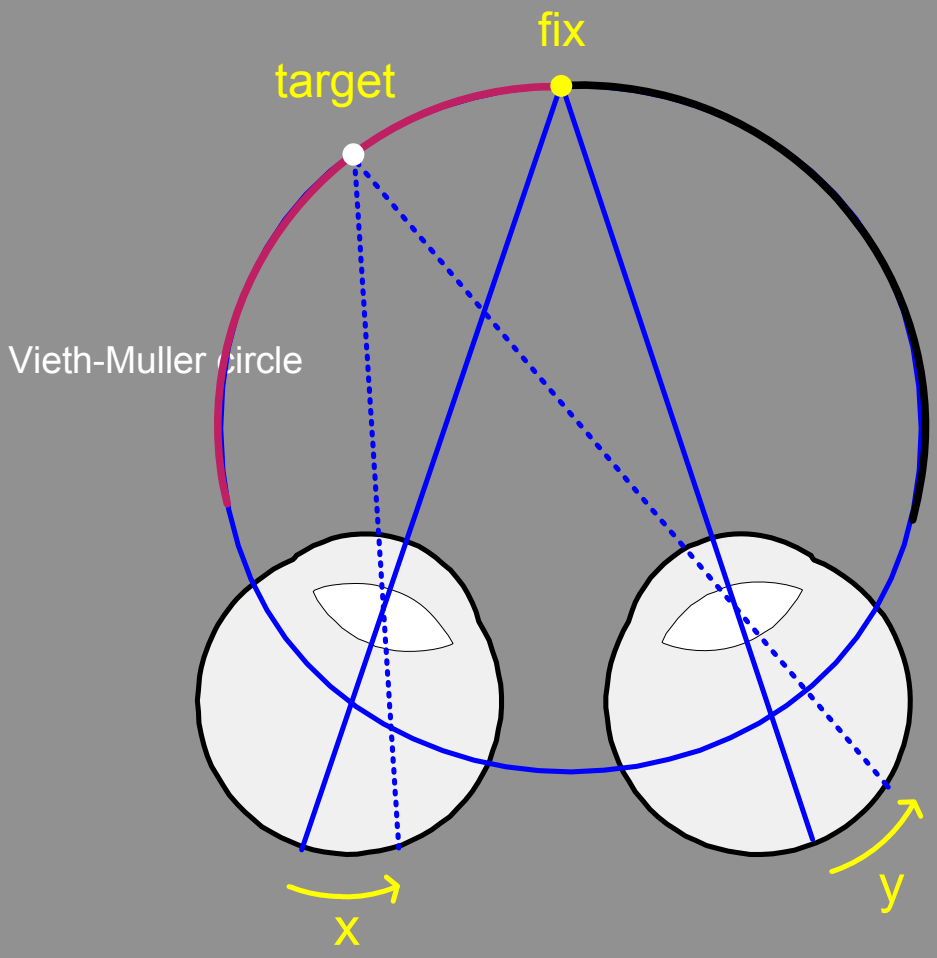
Please see lecture video or the autostereogram from The Magic Eye, Volume I: A New Way of Looking at the World. Andrews McMeel Publishing, 1993.

Autostereograms: see Howard and Rogers, Depth Perception, Vol 2, pp. 549-556.

Demos, page 3

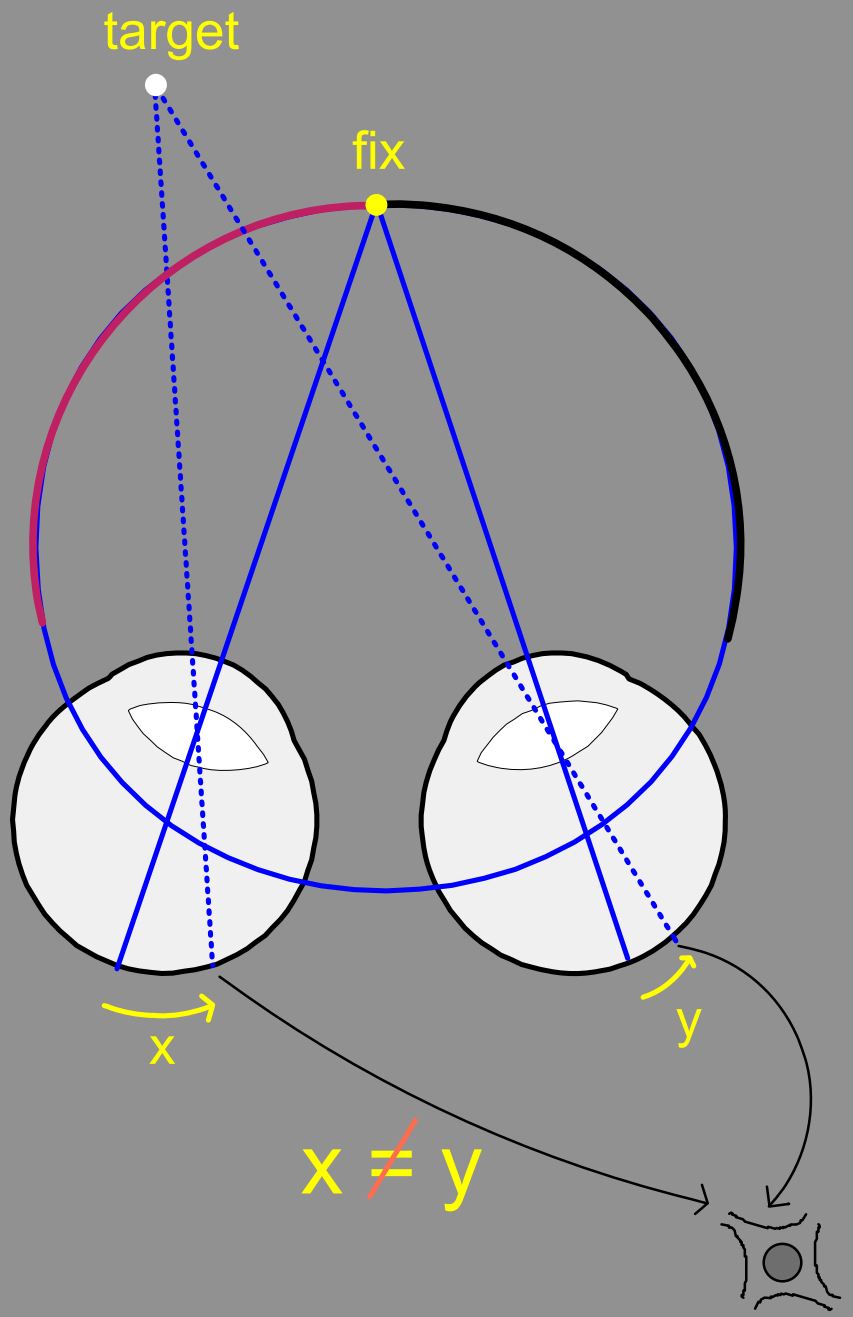
Retinal disparity utilized for stereopsis

Target hits corresponding retinal points



x = y

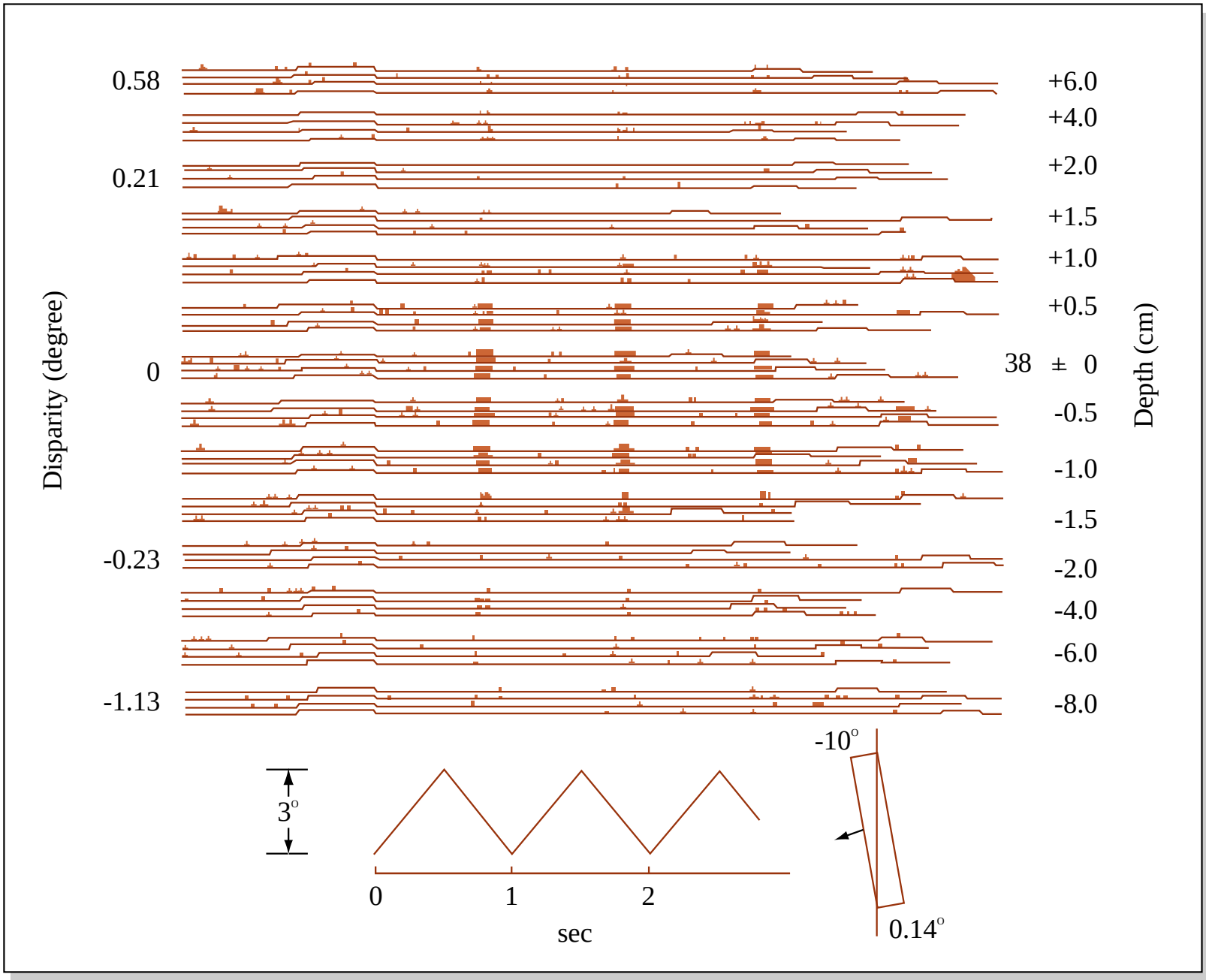
Target hits non-corresponding retinal points



x ≠ y

Stereopsis, neuronal responses

V1 cell response to drifting bars at varied stereo depths



V1 cell response to drifting bars at varied stereo depths

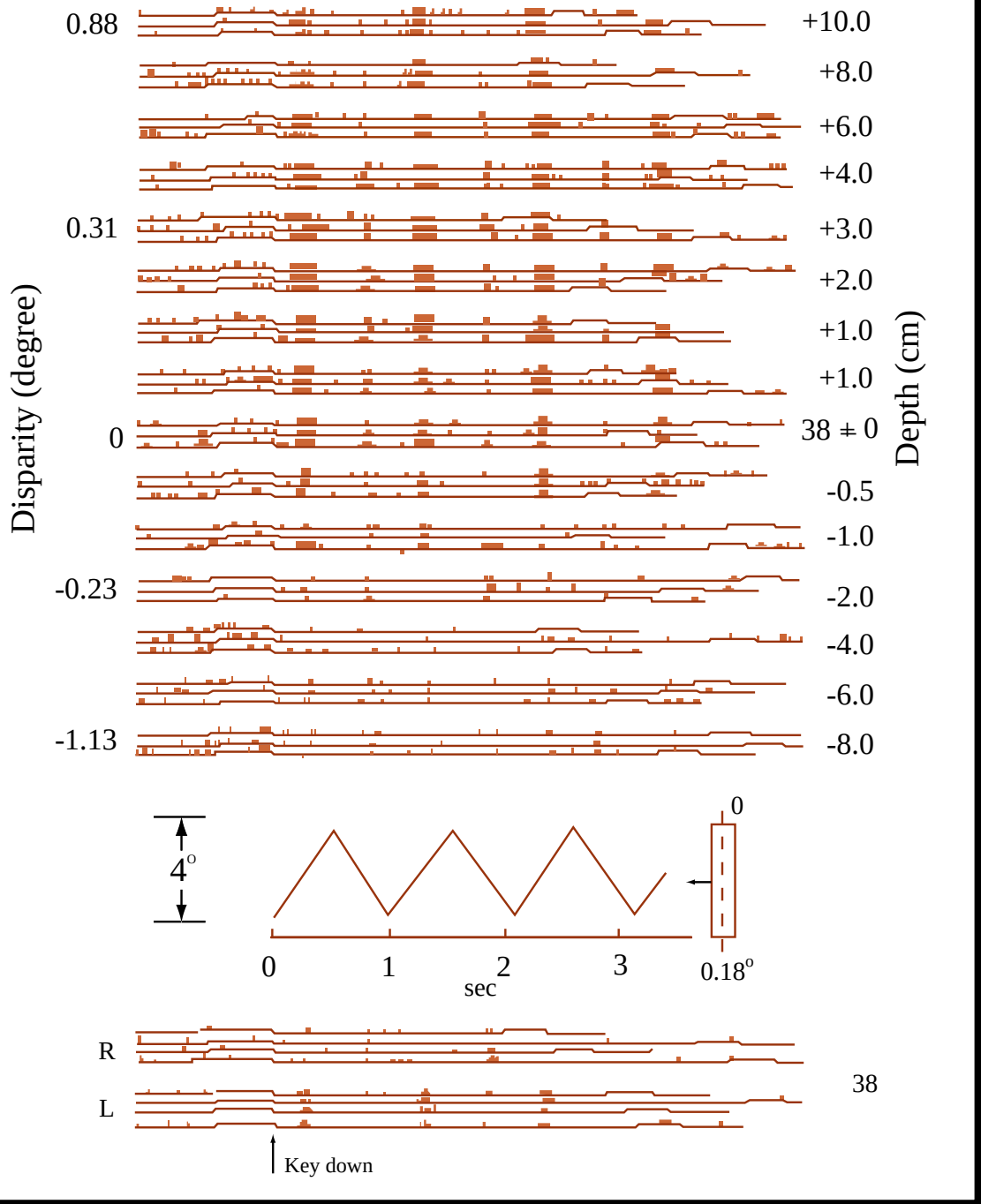
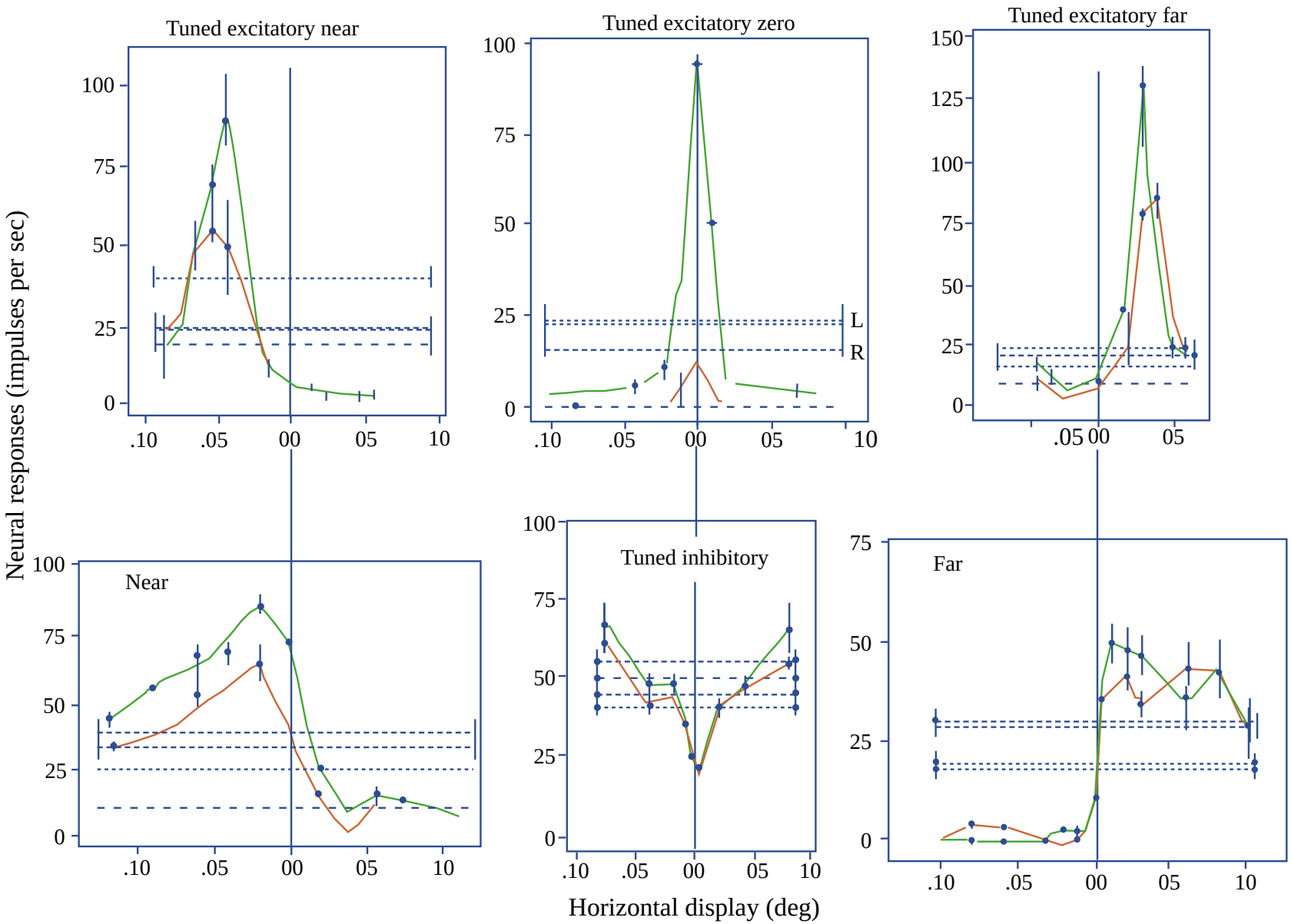


Image by MIT OpenCourseWare.

Basic cell types for stereo



Basic cell types for stereo

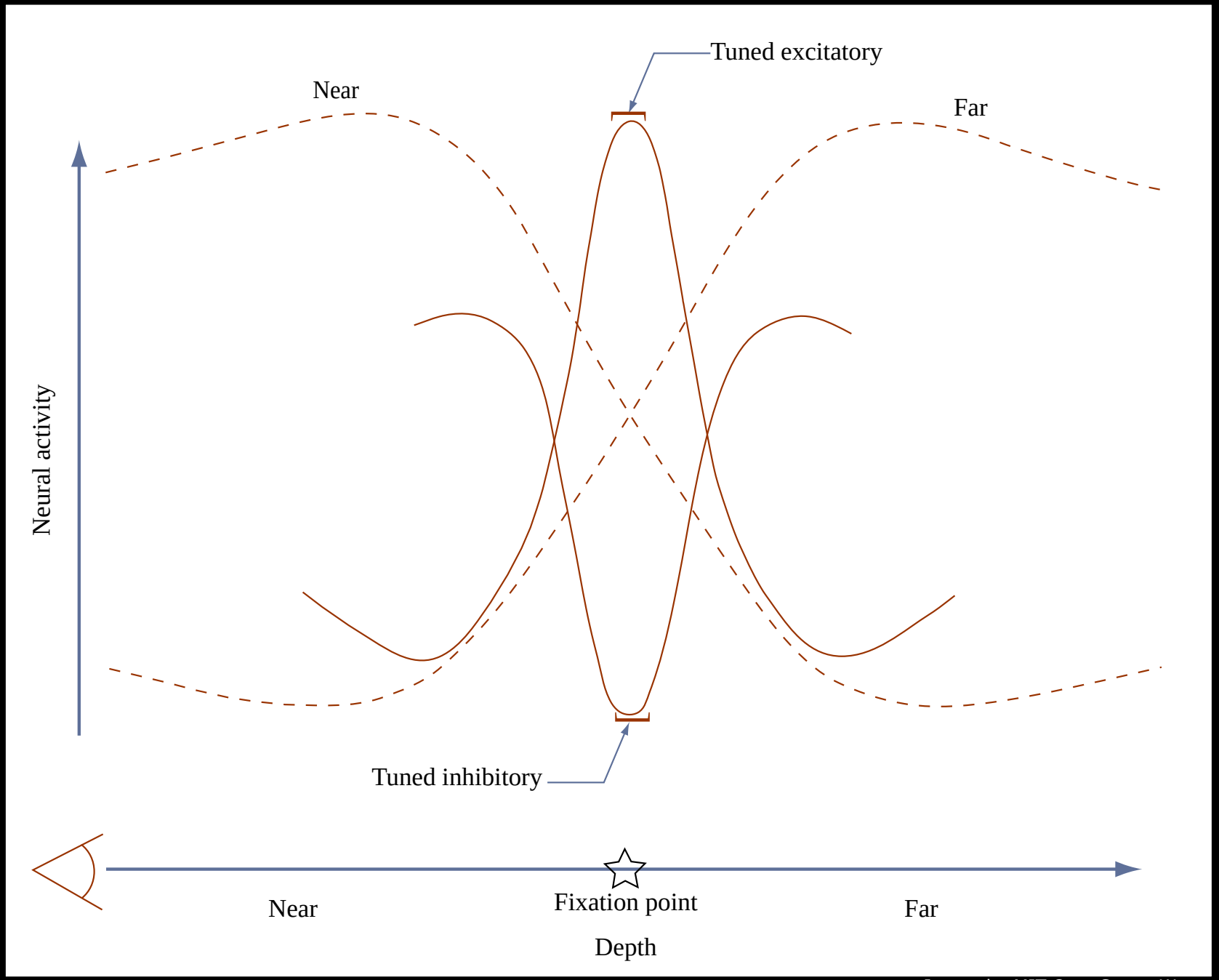


Image by MIT OpenCourseWare.

The effects of V4 and MT lesions on stereoscopic depth perception

Images removed due to copyright restrictions.

Please see lecture video or Figure 1 of Schiller, Peter H., Geoffrey L. Kendall, et al. "Depth Perception, Binocular Integration and Hand-Eye Coordination in Intact and Stereo Impaired Human Subjects. "*Journal of Clinical & Experimental Ophthalmology* 3, (210).

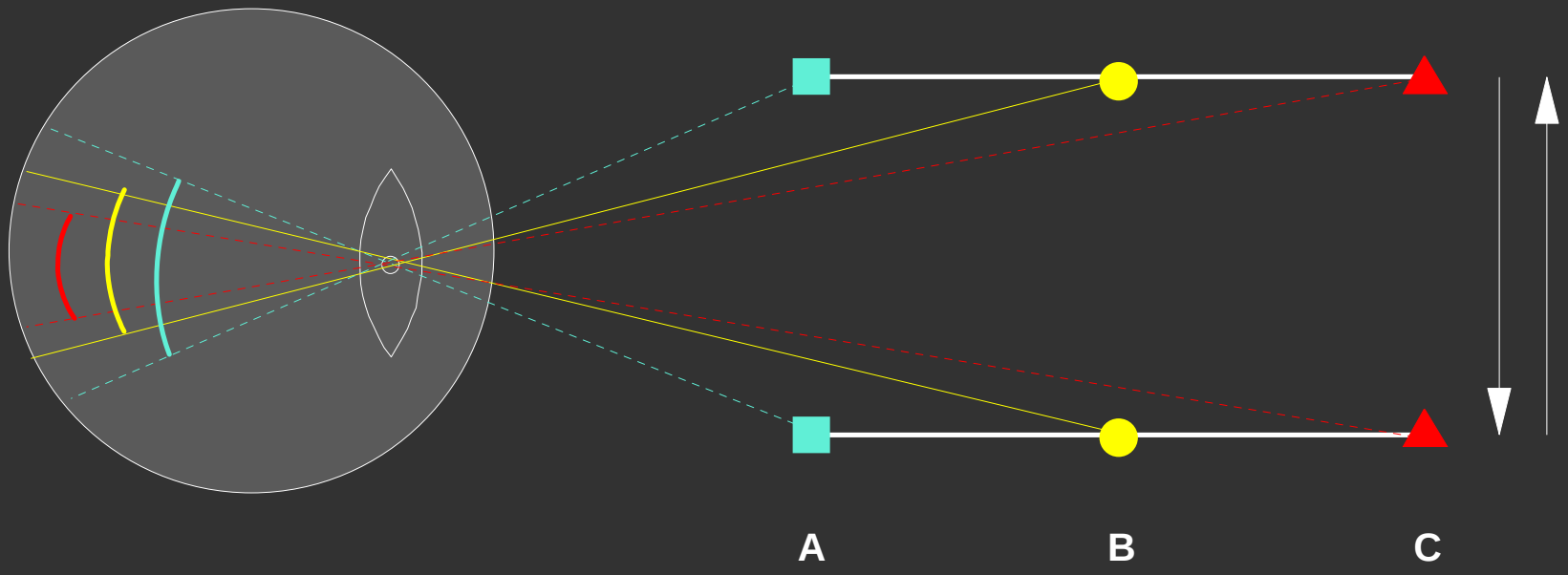
Stereopsis

Graphs removed due to copyright restrictions.

Please see lecture video or Schiller, Peter H. "The Effects of V4 and Middle Temporal (MT) Area Lesions on Visual Performance in the Rhesus Monkey." *Visual Neuroscience* 10, no. 4 (1993): 717-46.

Motion parallax

MOTION PARALLAX, the eye is stationary

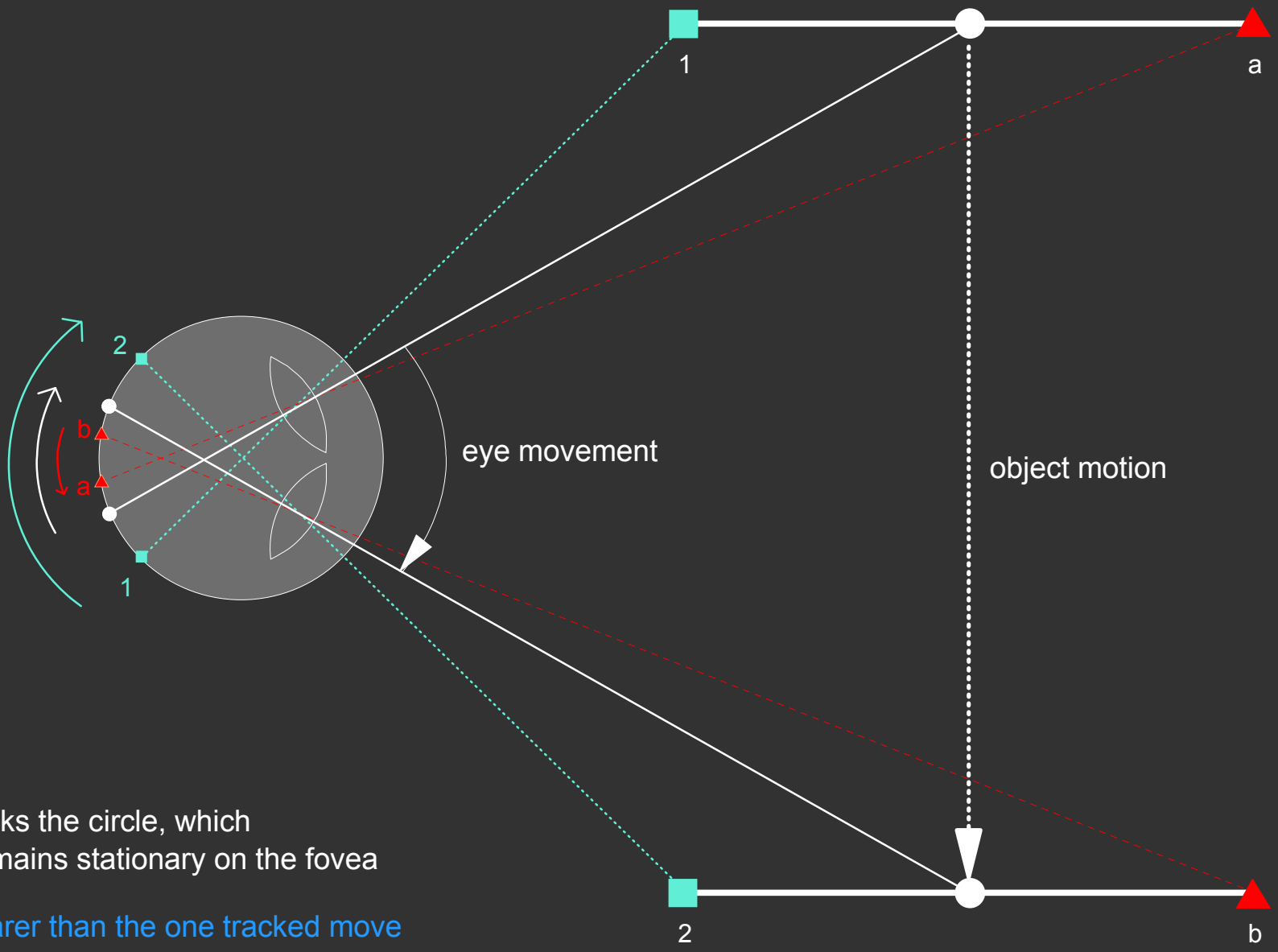


Velocity of motion:

A fastest, C slowest, creating velocity gradient

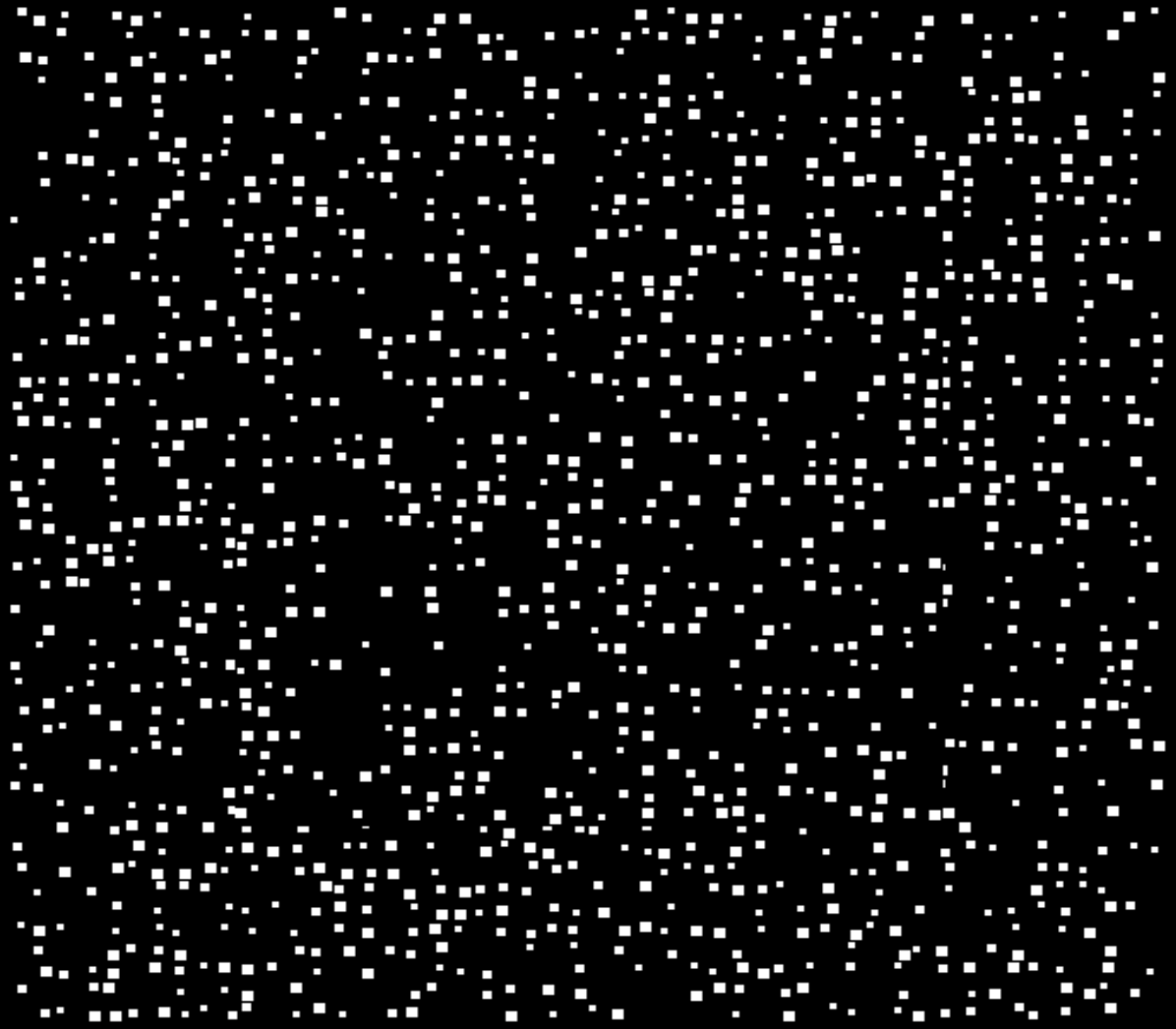
With rigidity constraint highest relative velocity is judged to be closest

MOTION PARALLAX, the eye tracks



The eye tracks the circle, which therefore remains stationary on the fovea

Objects nearer than the one tracked move at greater velocities on the retinal surface than objects further; the further objects actually move in the opposite direction on the retina.



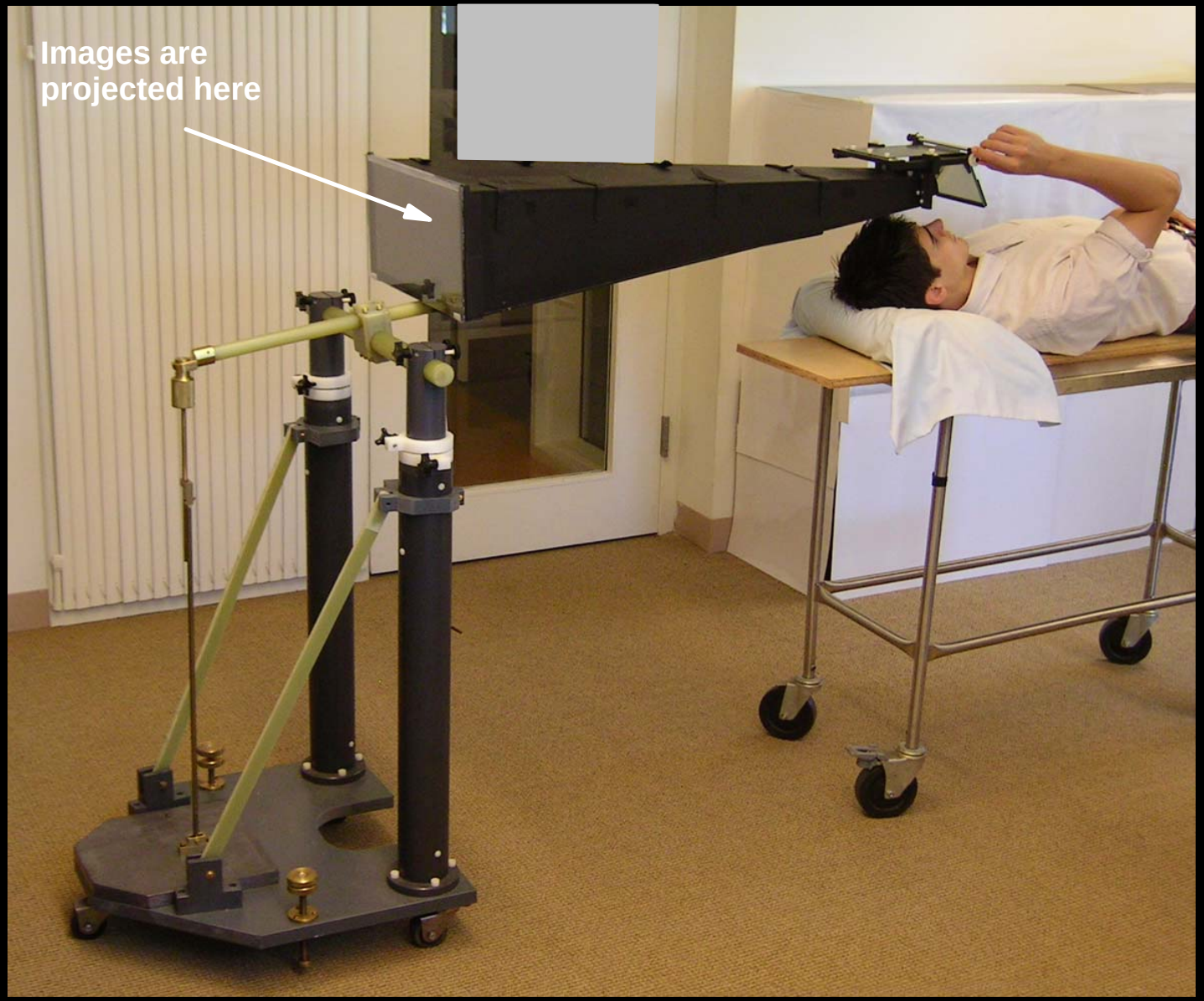
Motion parallax

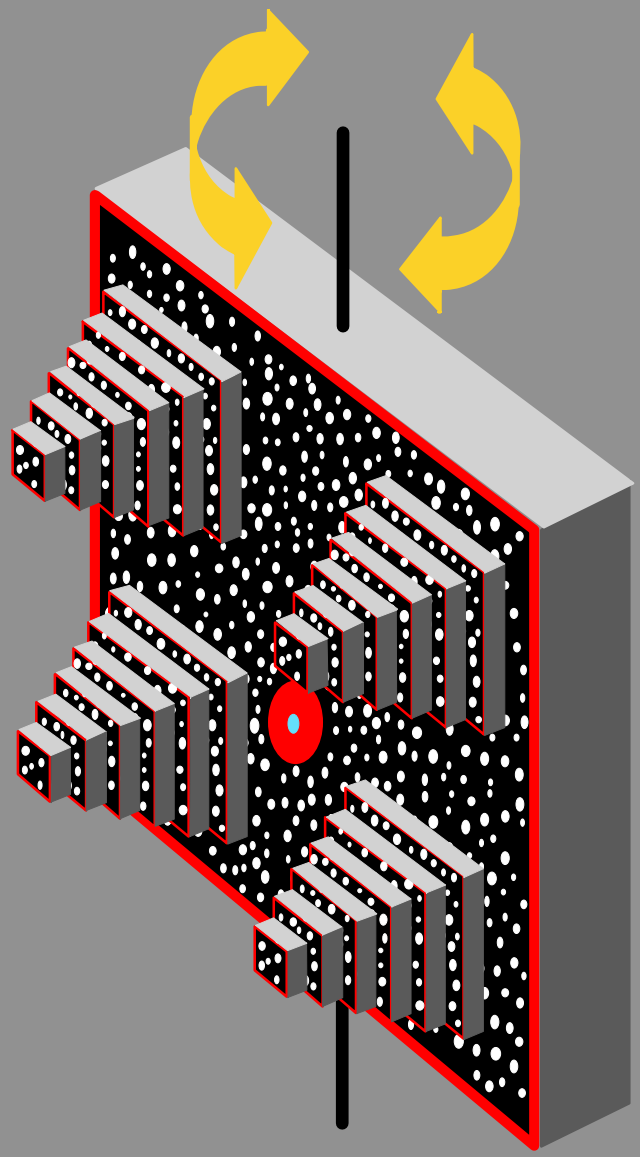
To derive depth information from motion parallax neurons are needed that provide information about velocity and direction of motion and perhaps also about differential motion.

The majority of cells in V1 are direction and velocity selective. Some appear also to be selective for differential motion.

Cells that process motion parallax have also been found in MT.

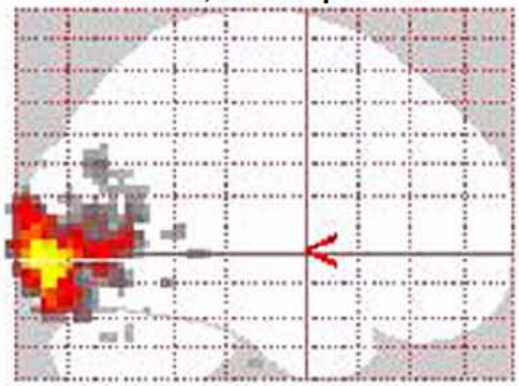
Brain activation by stereopsis and motion parallax in normal and stereoblind subjects with fMRI


Images are
projected here

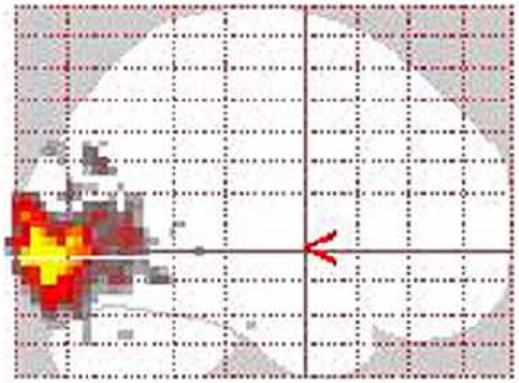


Normal subject

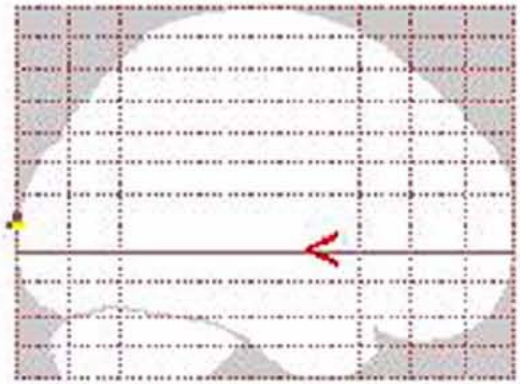
Binocular, motion parallax



Binocular, stereo

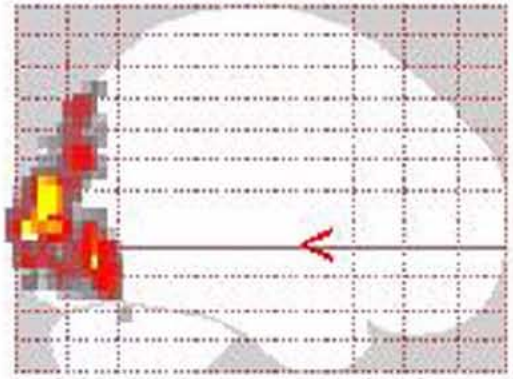


Monocular, stereo

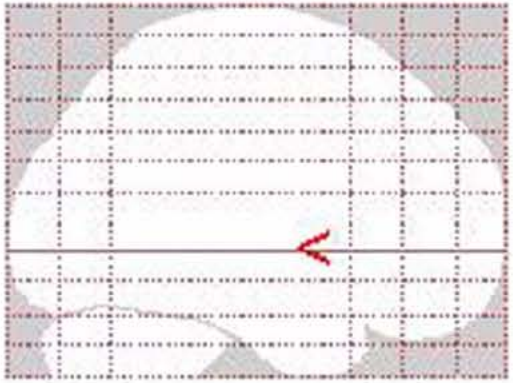


Stereoblind subject

Binocular, motion parallax



Binocular, stereo

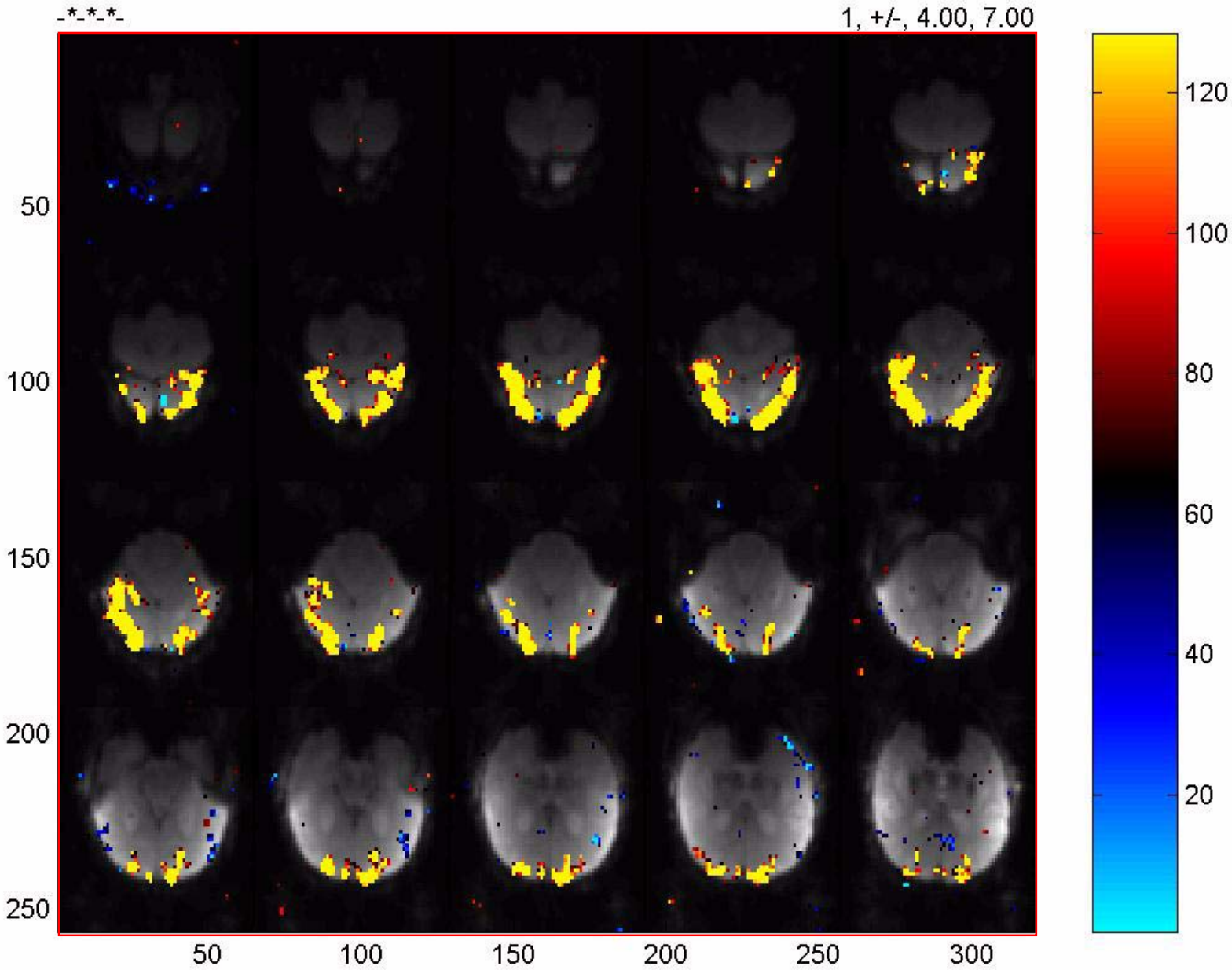


Four conditions:

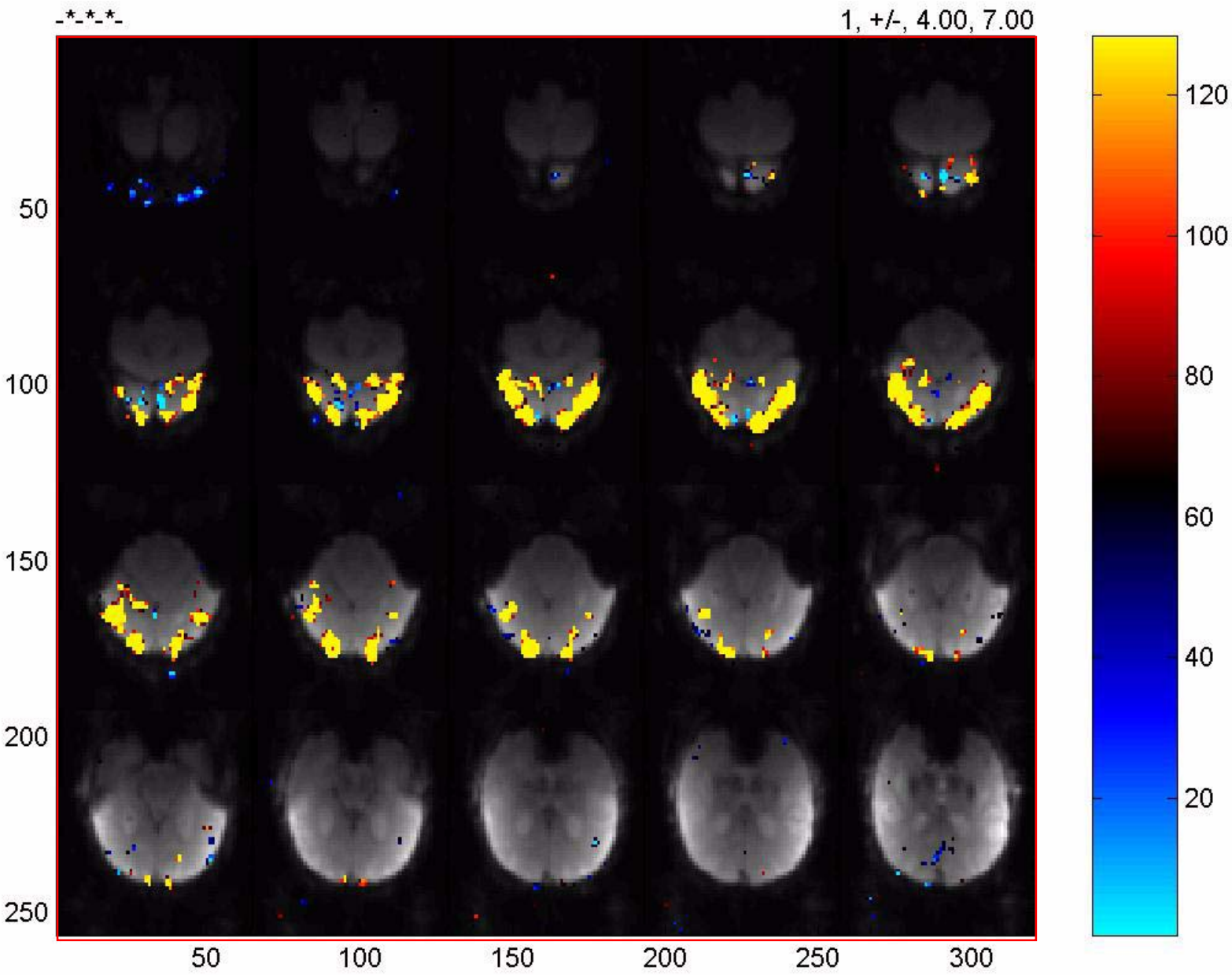
1. No depth cues
2. Stereo only
3. Parallax only
4. Stereo and parallax

50 and 60 trials each

A: Stereo


-*-*-*-
1, +/-, 4.00, 7.00
50
100
150
200
250
50
100
150
200
250
300
120
100
80
60
40
20

B: Parallax


-*-*-*-
1, +/-, 4.00, 7.00
50
100
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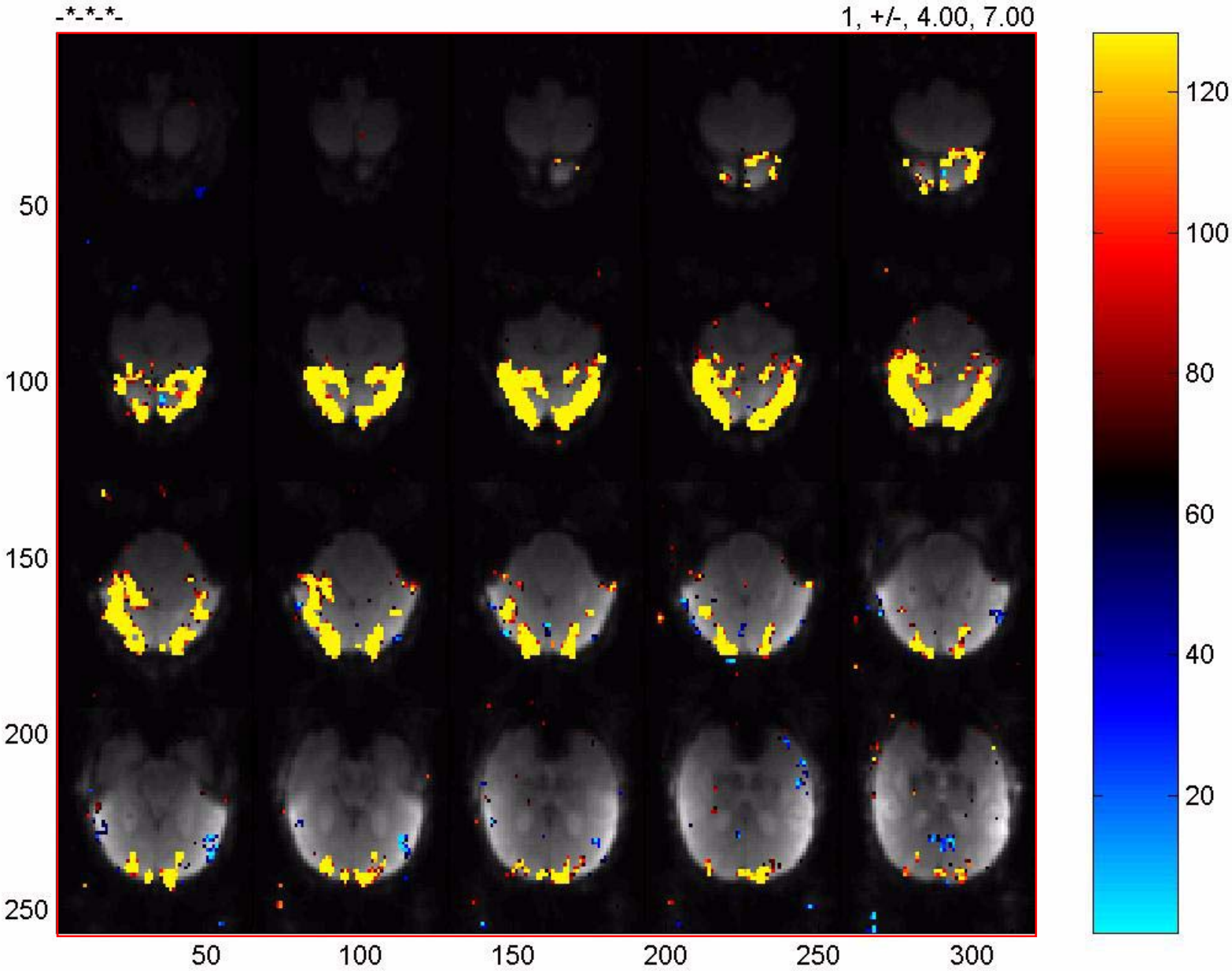
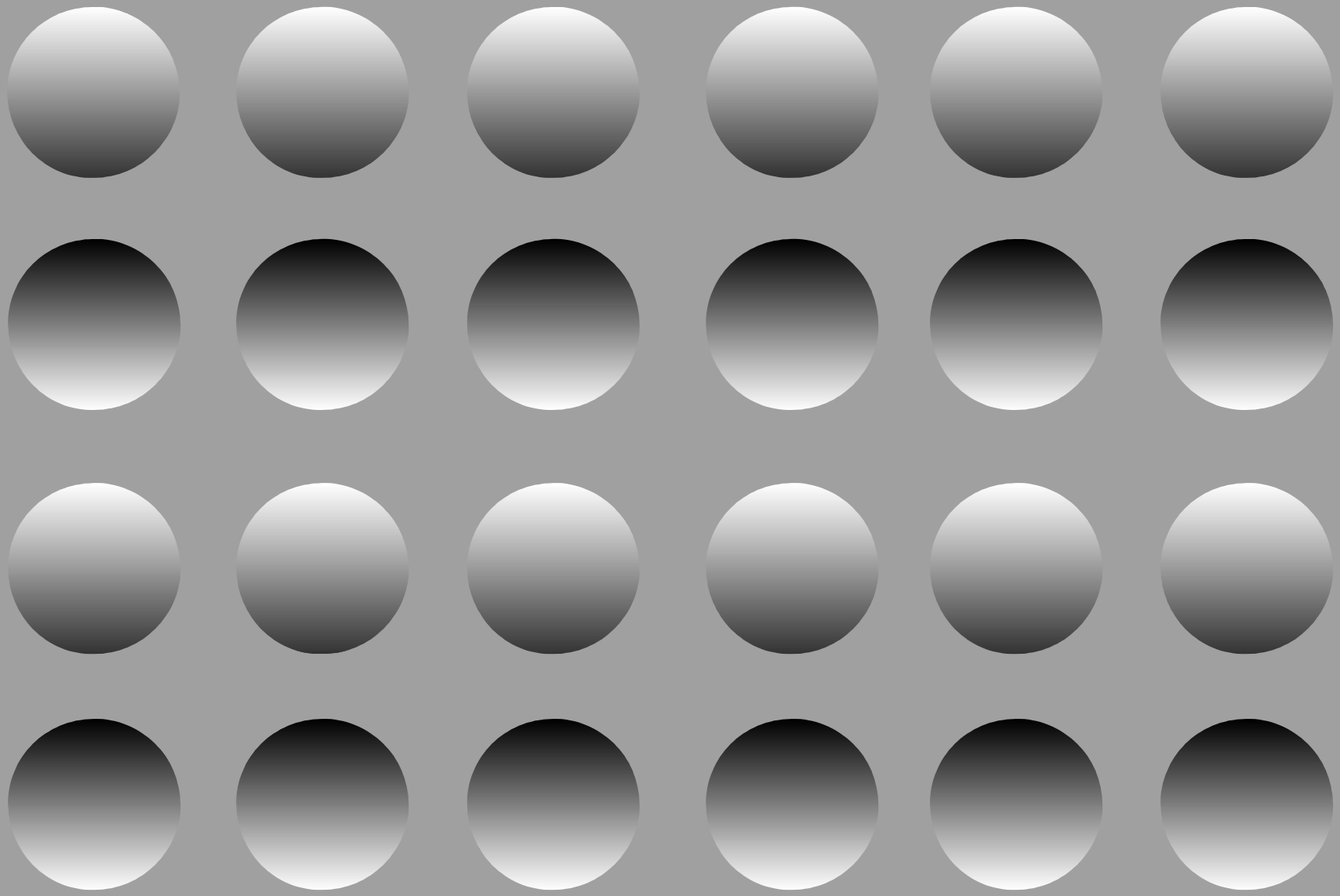
200
250
50
100
150
200
250
300
120
100
80
60
40
20

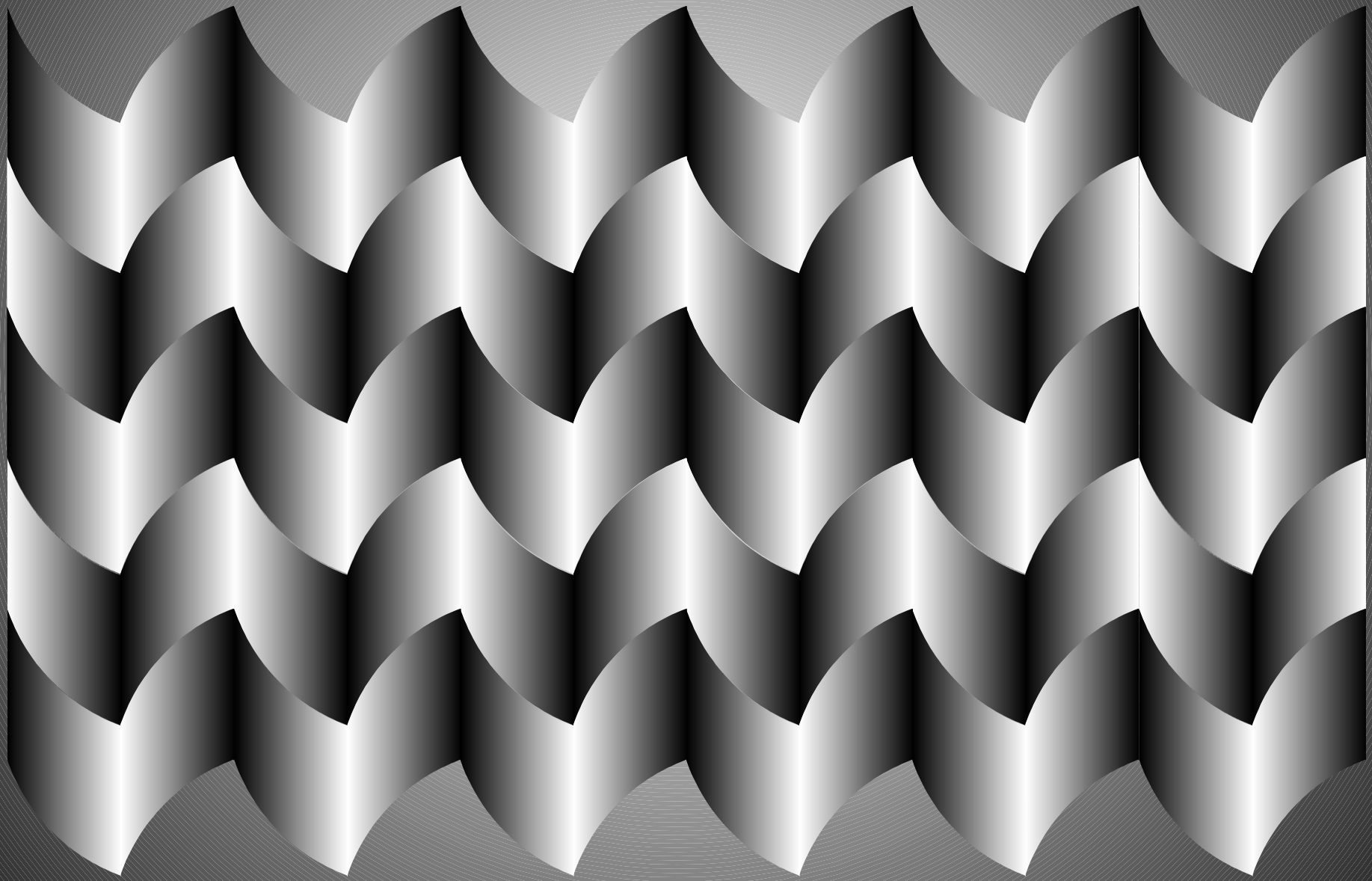
C: Stereo + Parallax

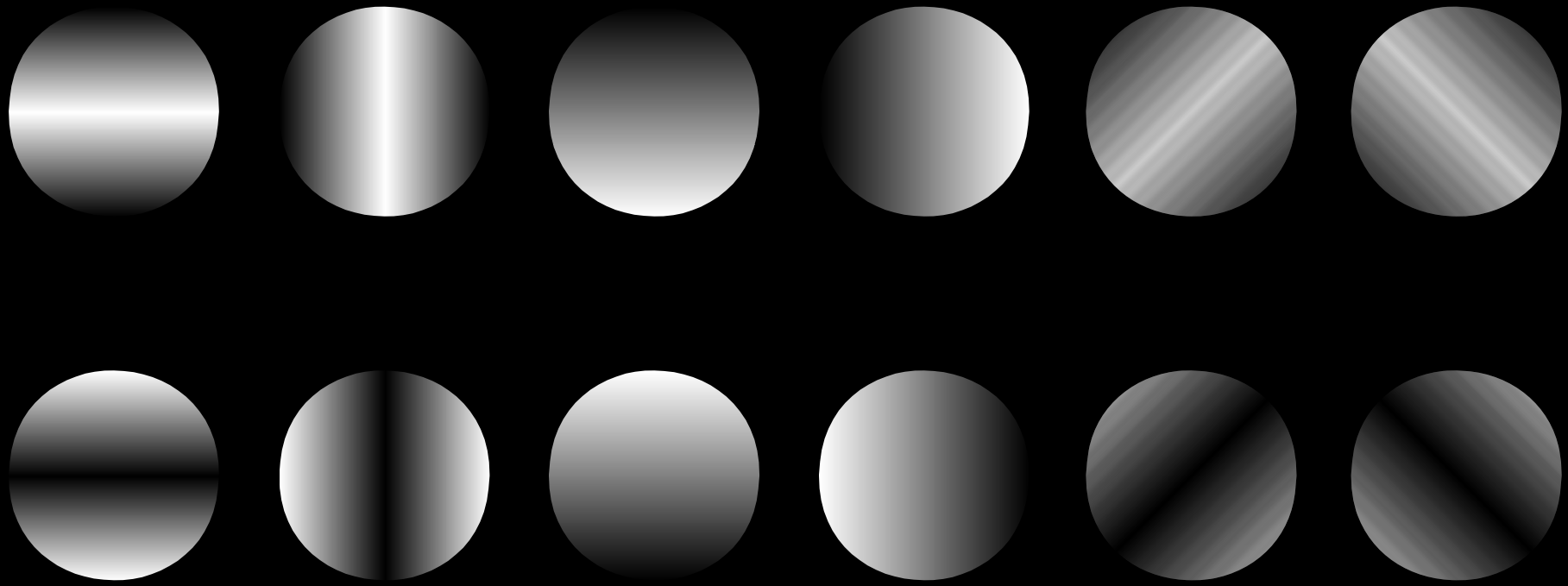


Shading



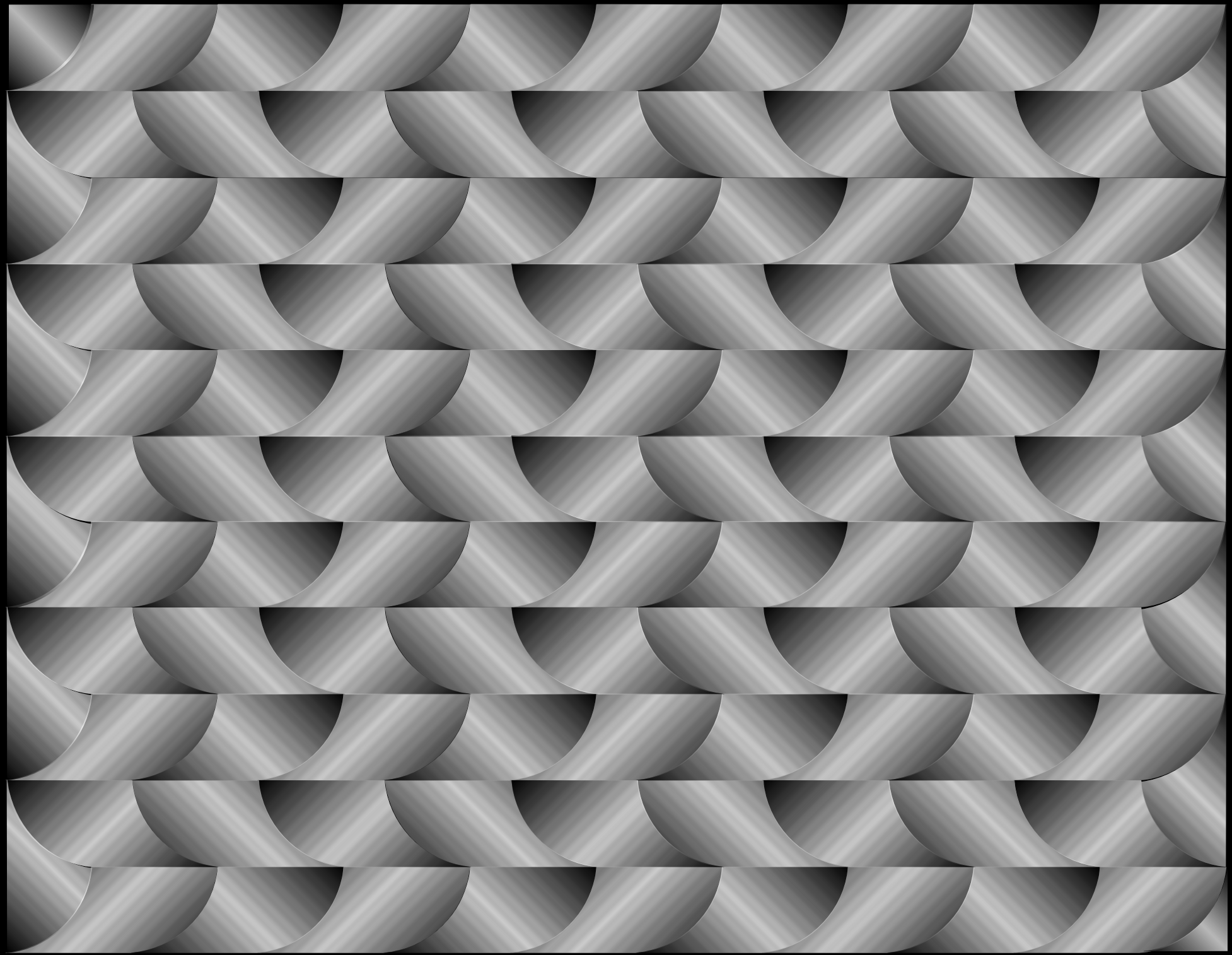
The power of shading for depth perception

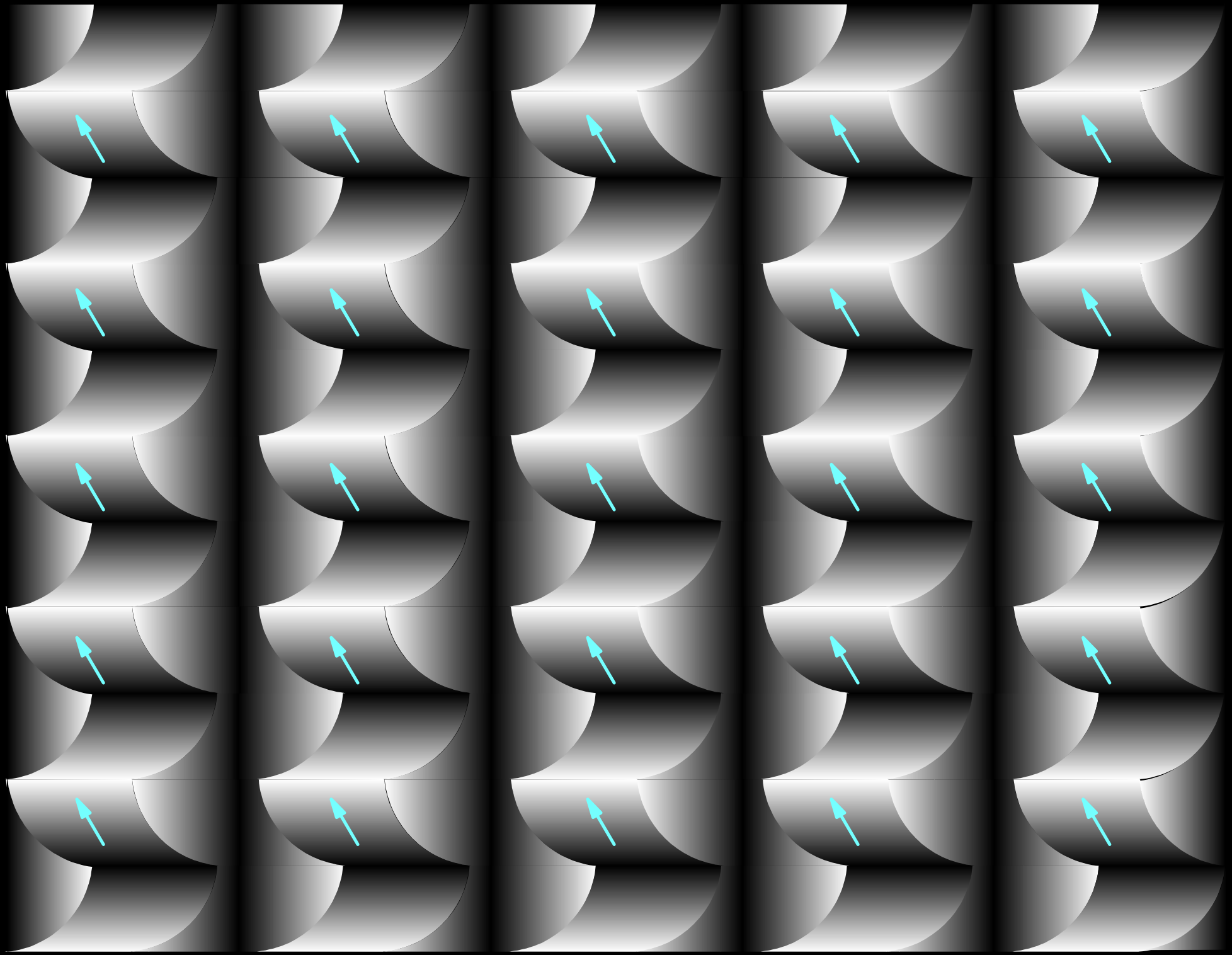


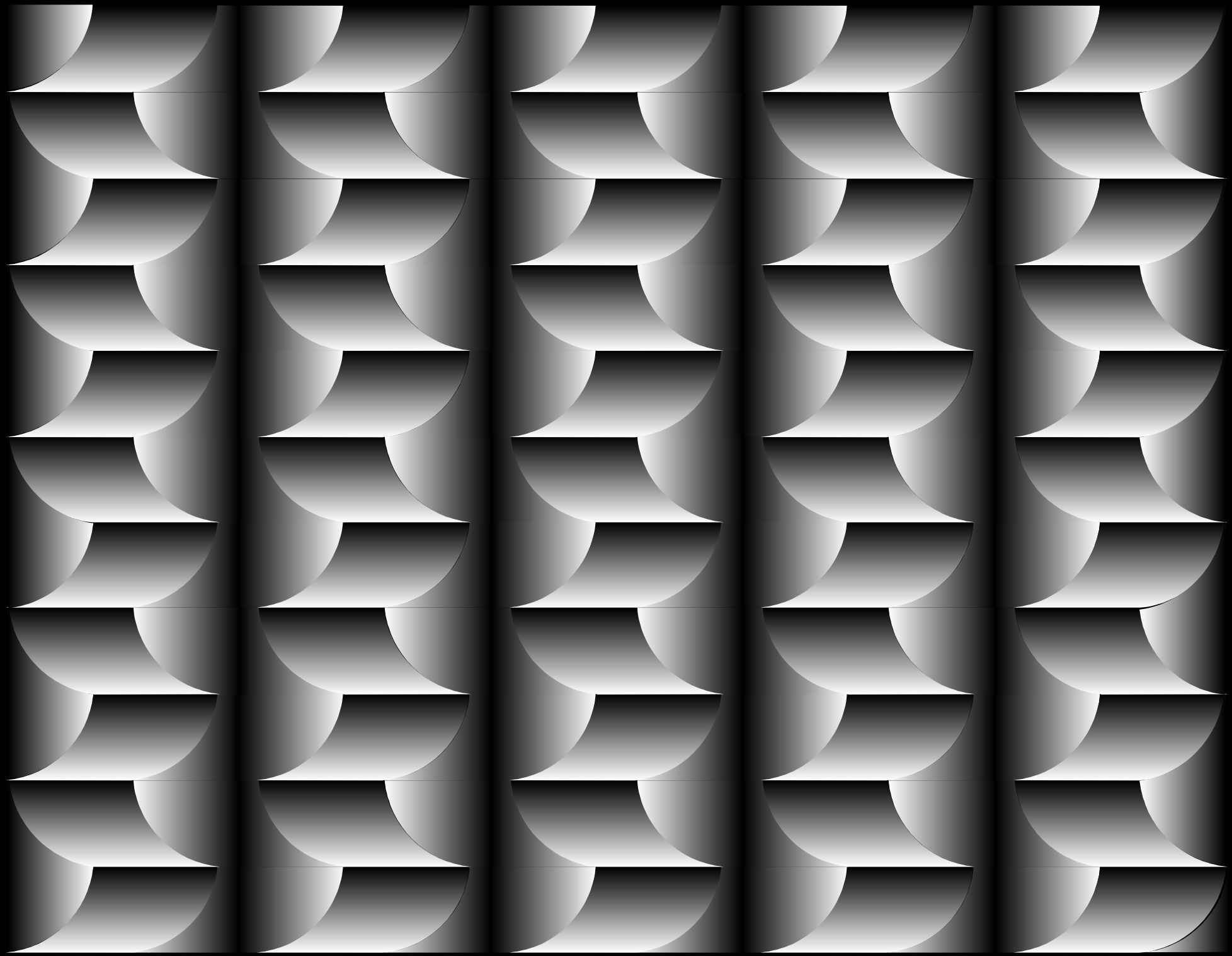


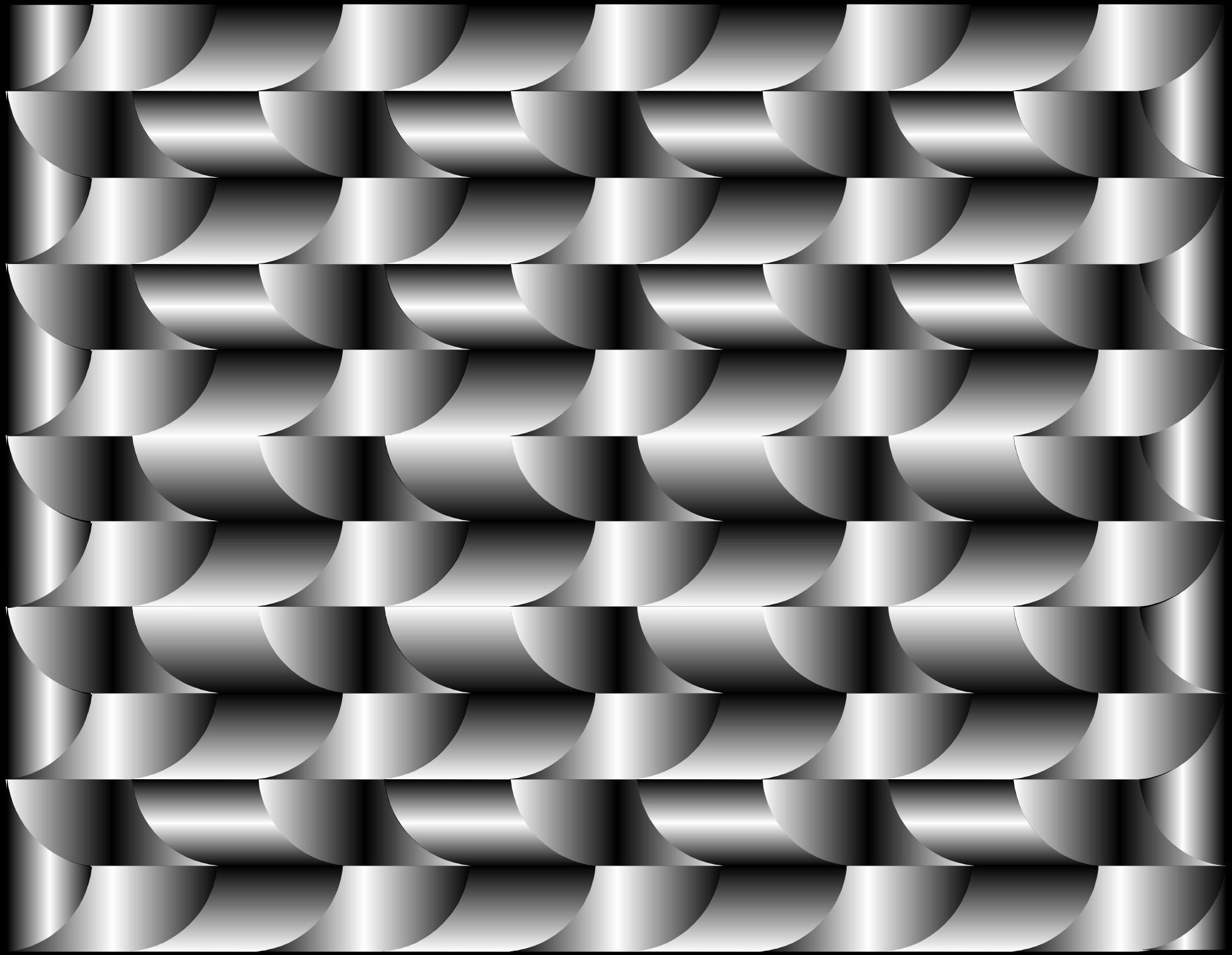
Examples of the 12 different shadings used

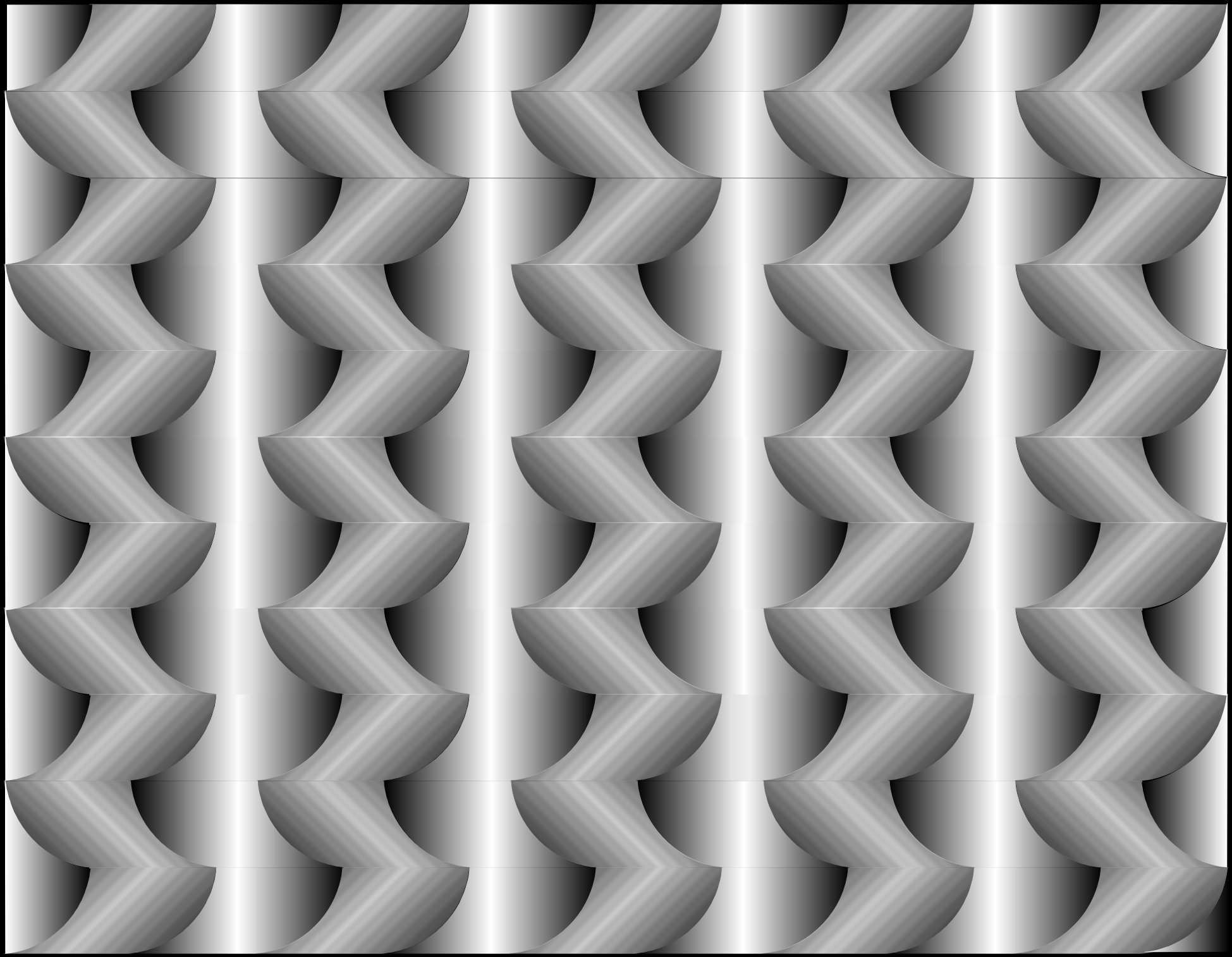
The next five displays have identical, repeating elements which are shaded differently in each set yielding a variety of stable and conflicting percepts







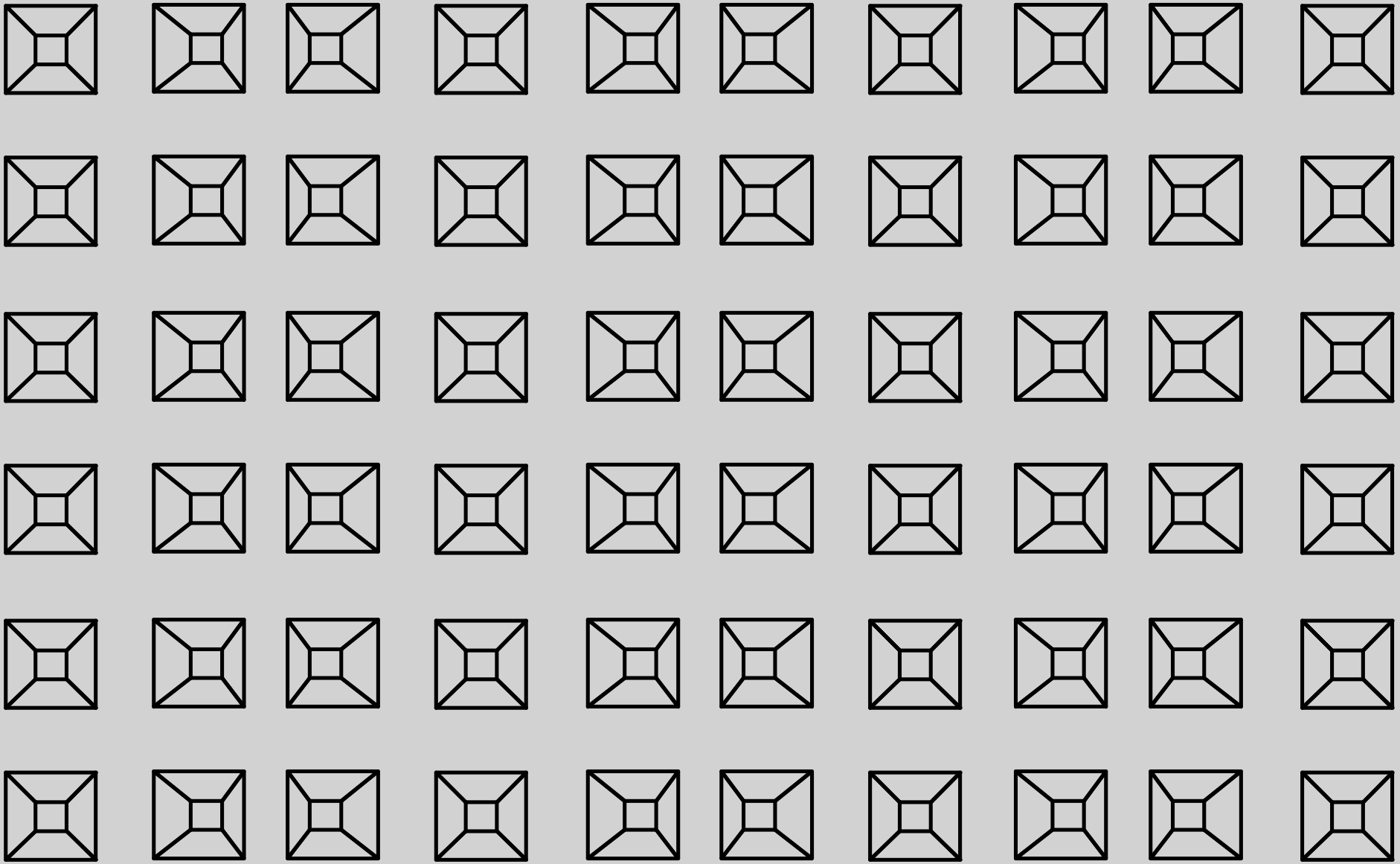


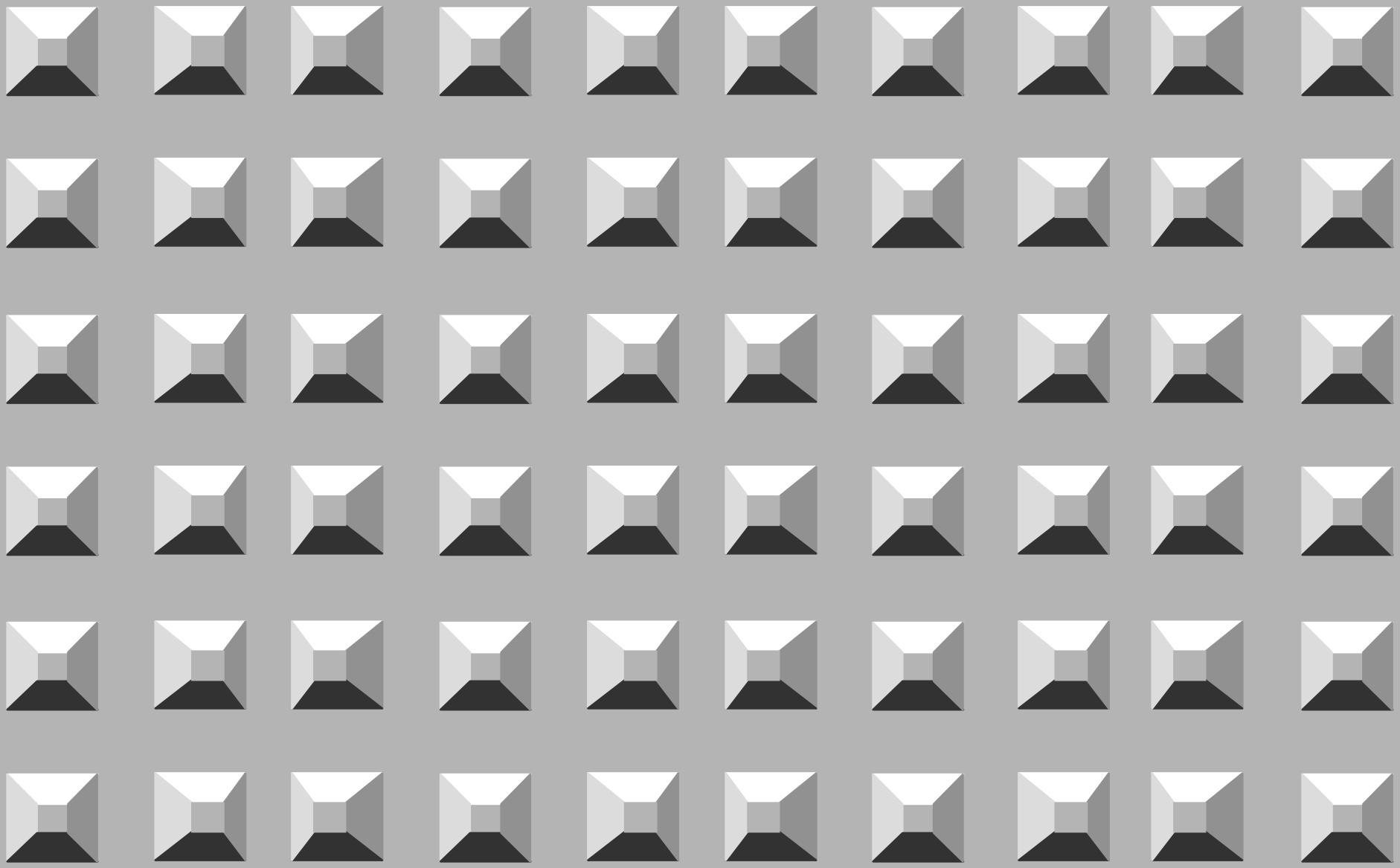


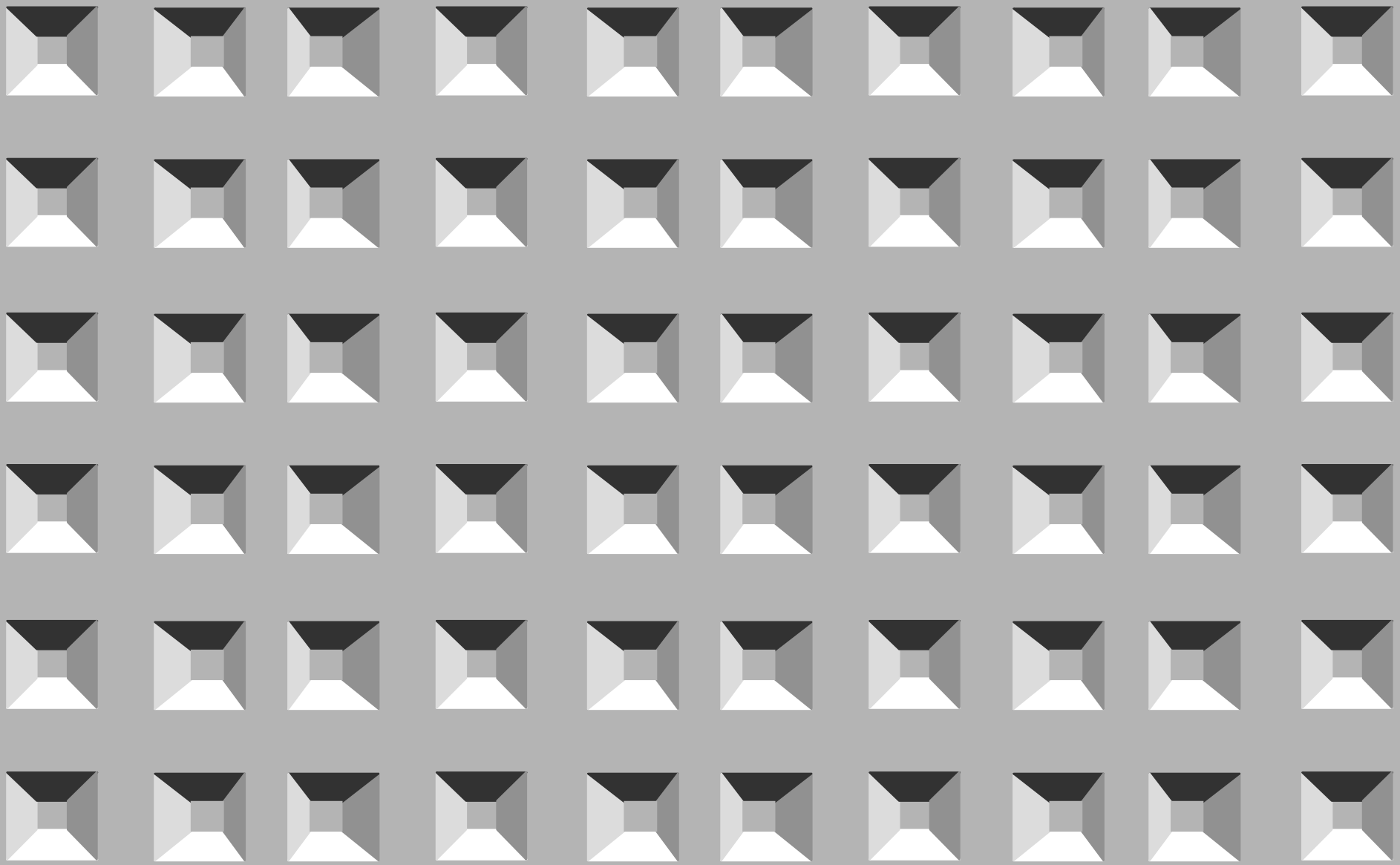
Stereo and shading in harmony and in conflict

Demos, page 4-7

f f f







Putting stereo, parallax and shading together

Image removed due to copyright restrictions.

Please see lecture video or see Display 24 of Schiller, Peter H., and Christina E. Carvey. "Demonstrations of Spatiotemporal Integration and What they Tell us About the Visual System." *Perception* 35, no. 11 (2006): 1521.

Separate and combined disparity, parallax and shading depth cues

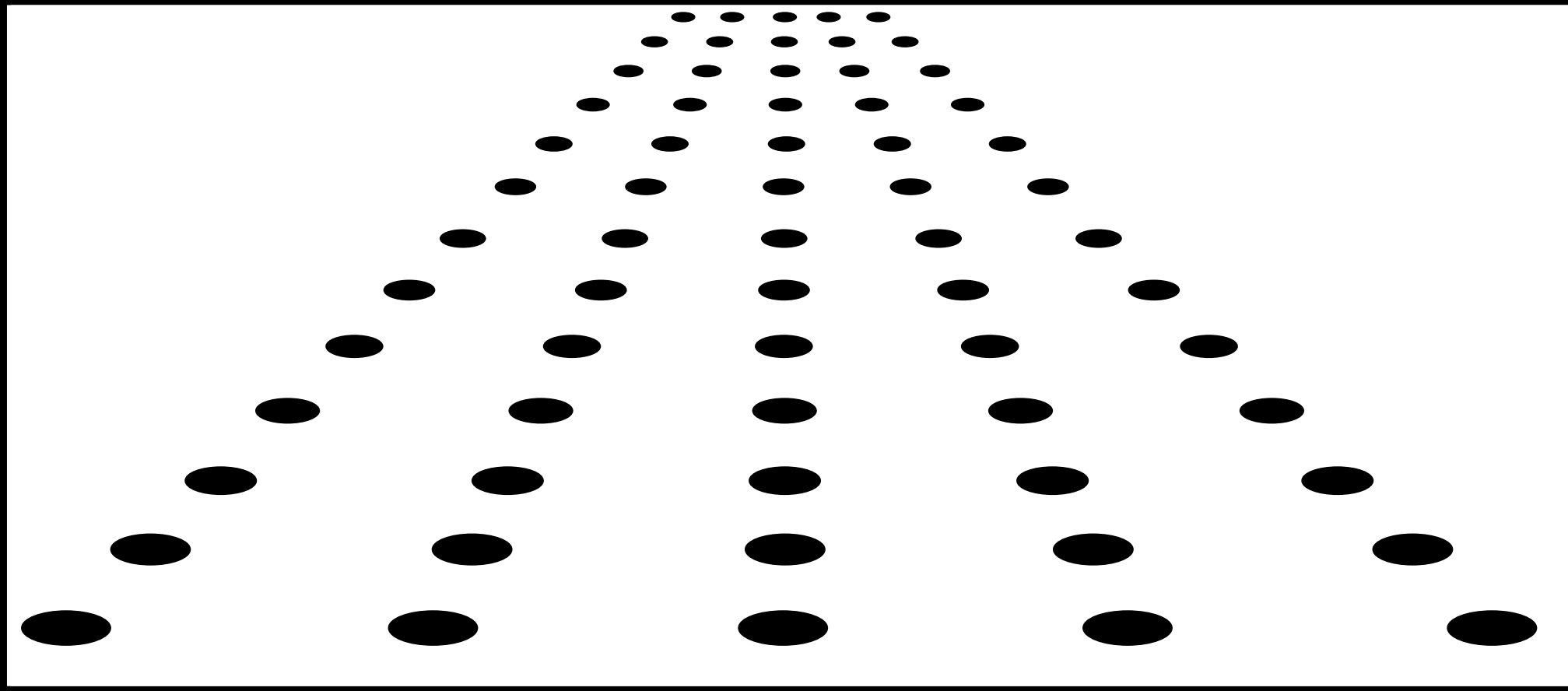
Graphs removed due to copyright restrictions.

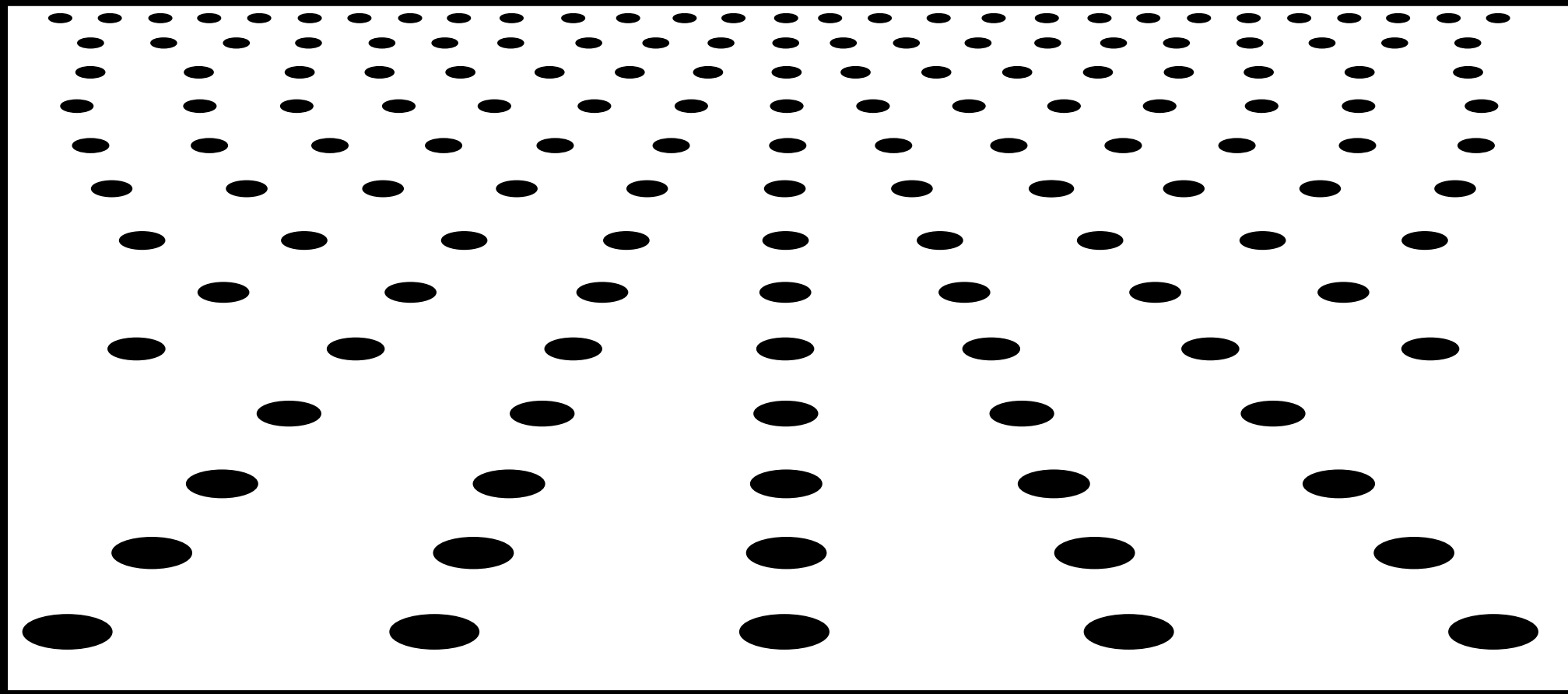
Please see lecture video or Figure 3a,b of Schiller, Peter H., Warren M. Slocum, et al. "The Integration of Disparity, Shading and Motion Parallax Cues for Depth Perception in Humans and Monkeys." *Brain Research* 1377 (2011): 67-77.

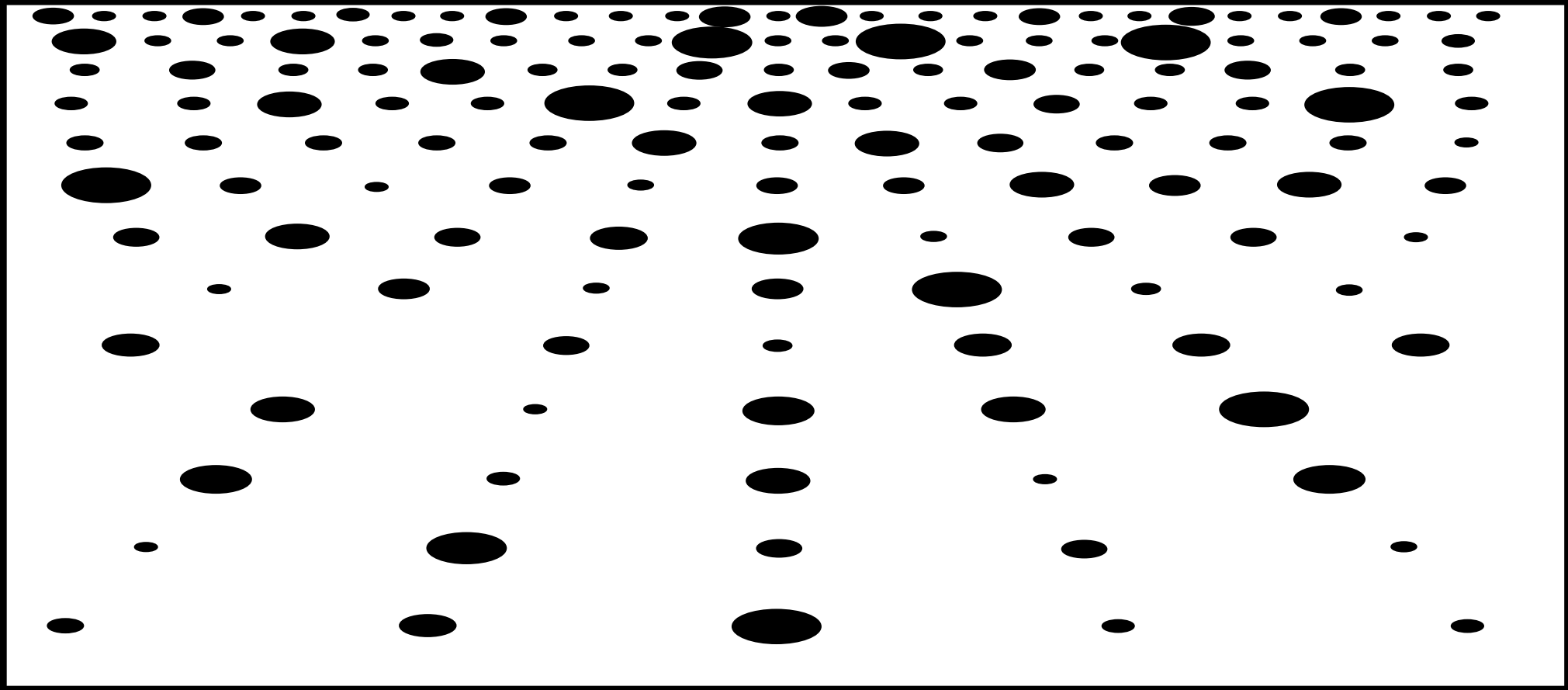
Perspective

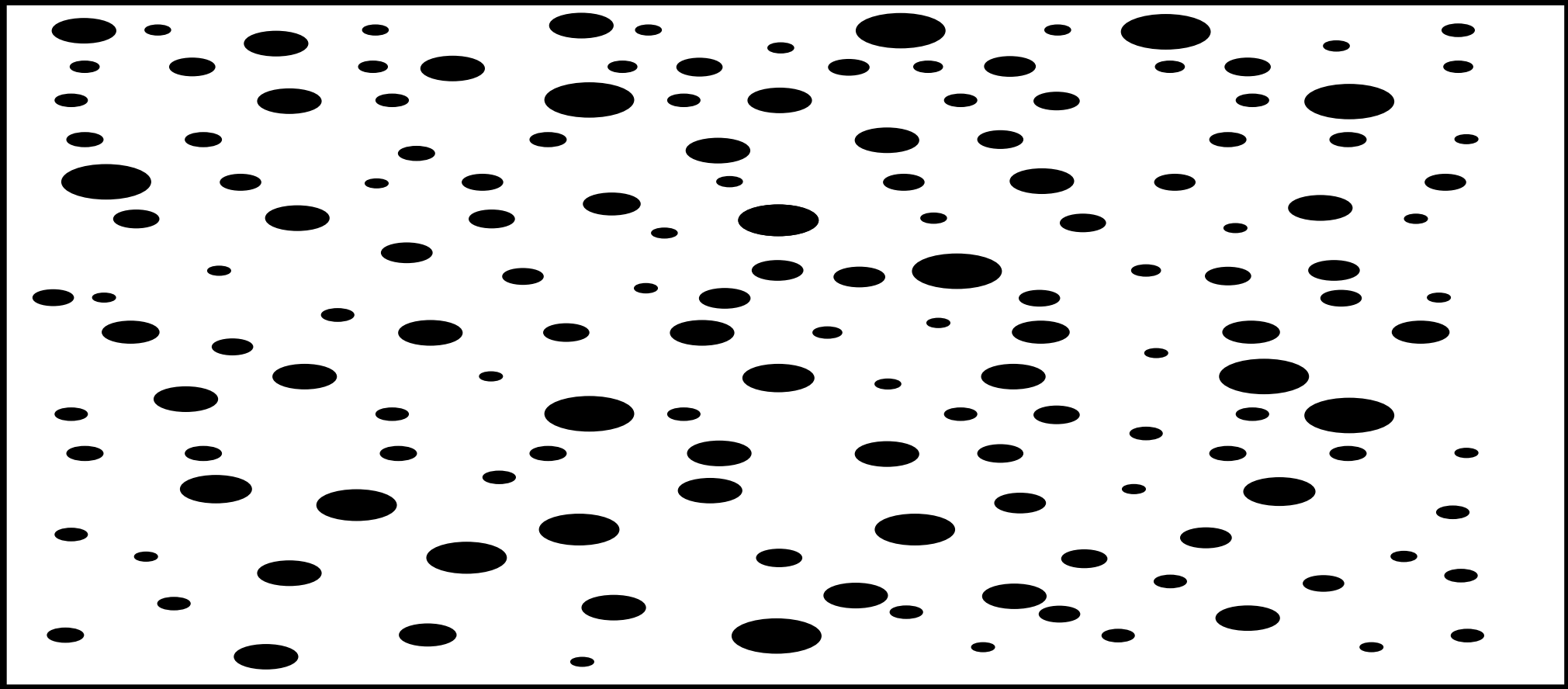
Image removed due to copyright restrictions.

Please see lecture video or see William O'Brian, "Because it's here, that's why," *New Yorker*, September 21, 1963, 42.

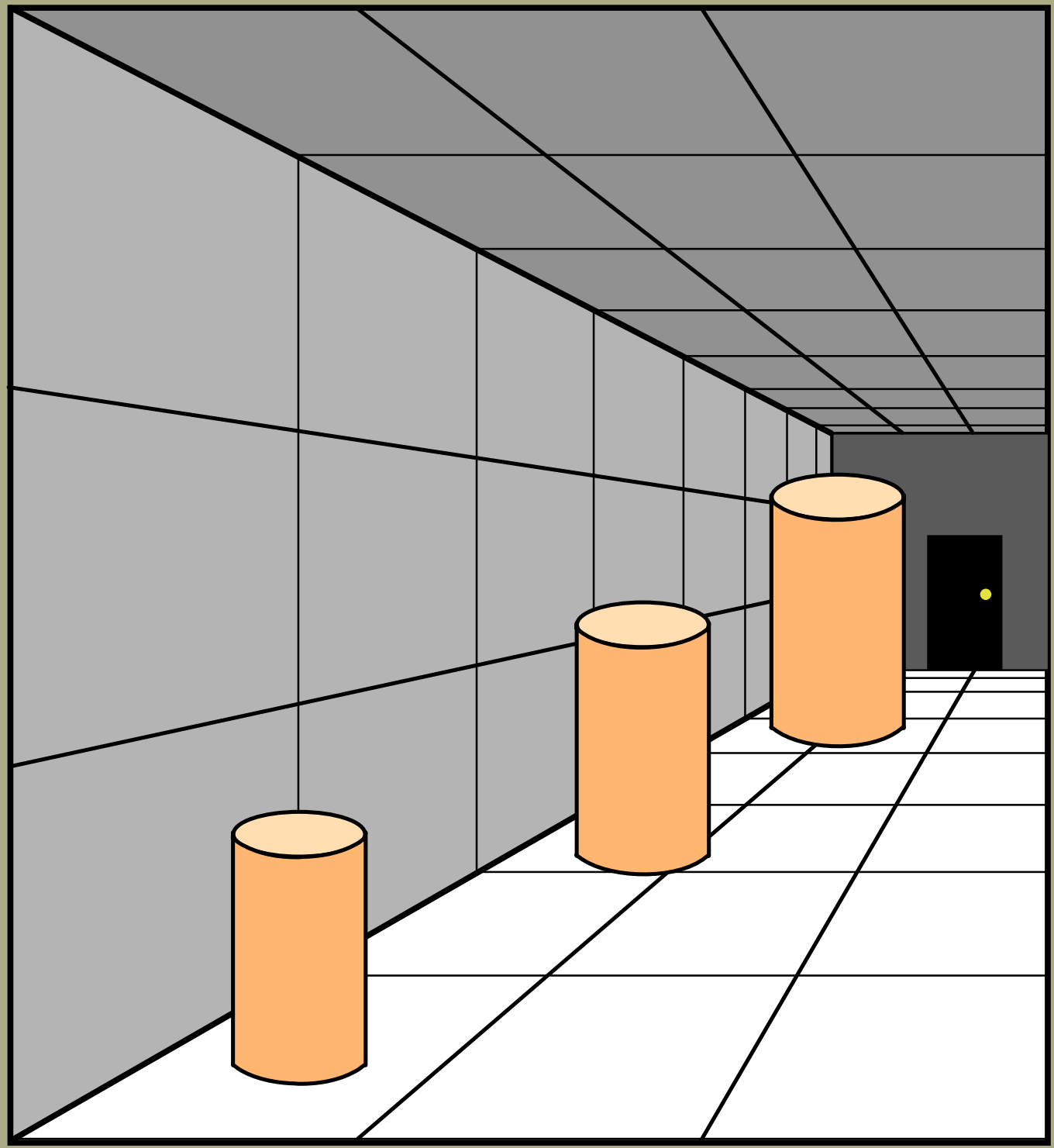


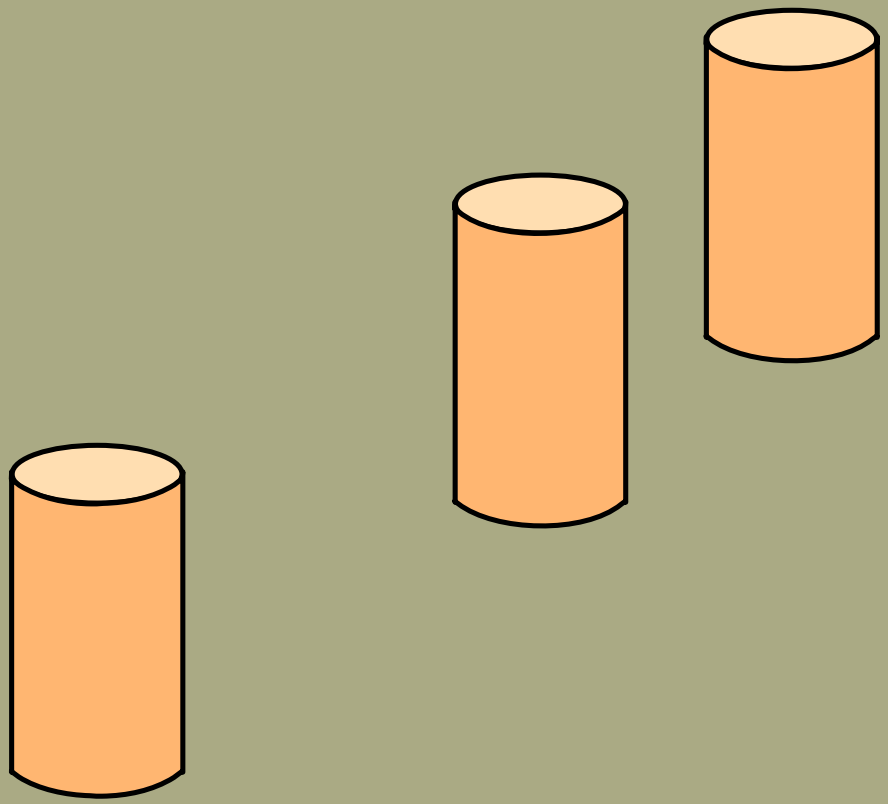




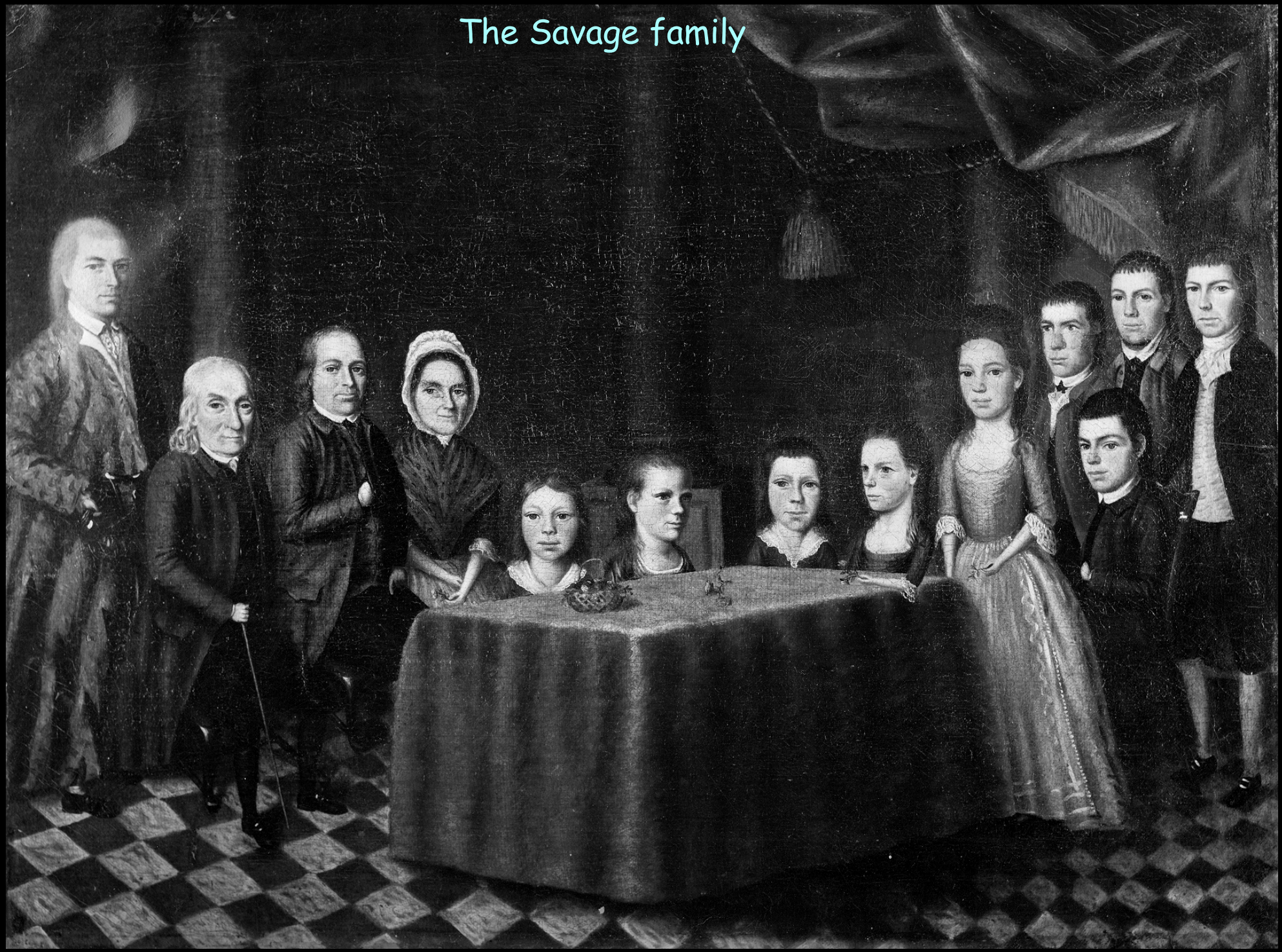


Perspective illusion





The Savage family

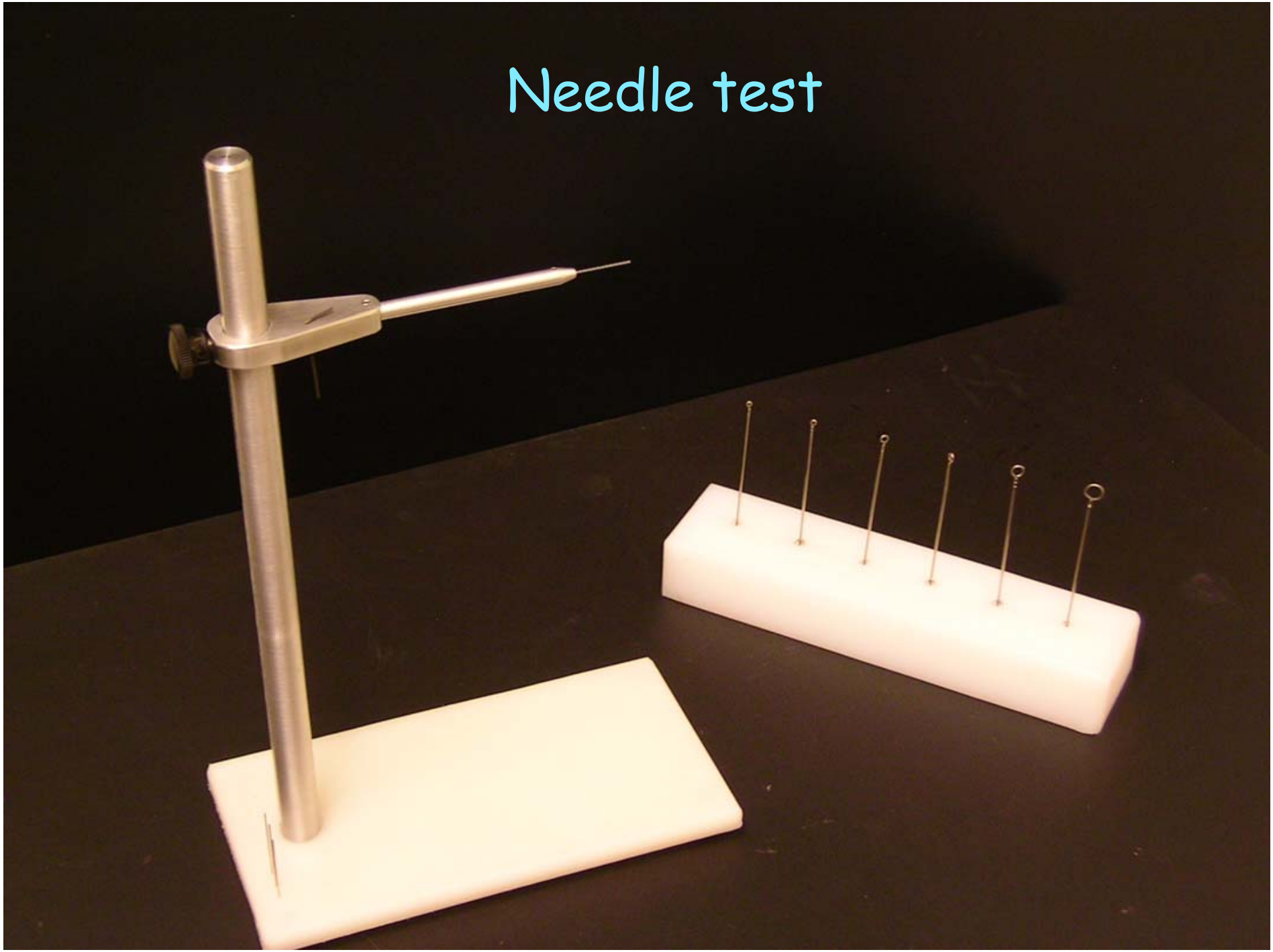


Painting is in public domain.

Edward Savage

Hand-eye coordination and Binocular integration tests

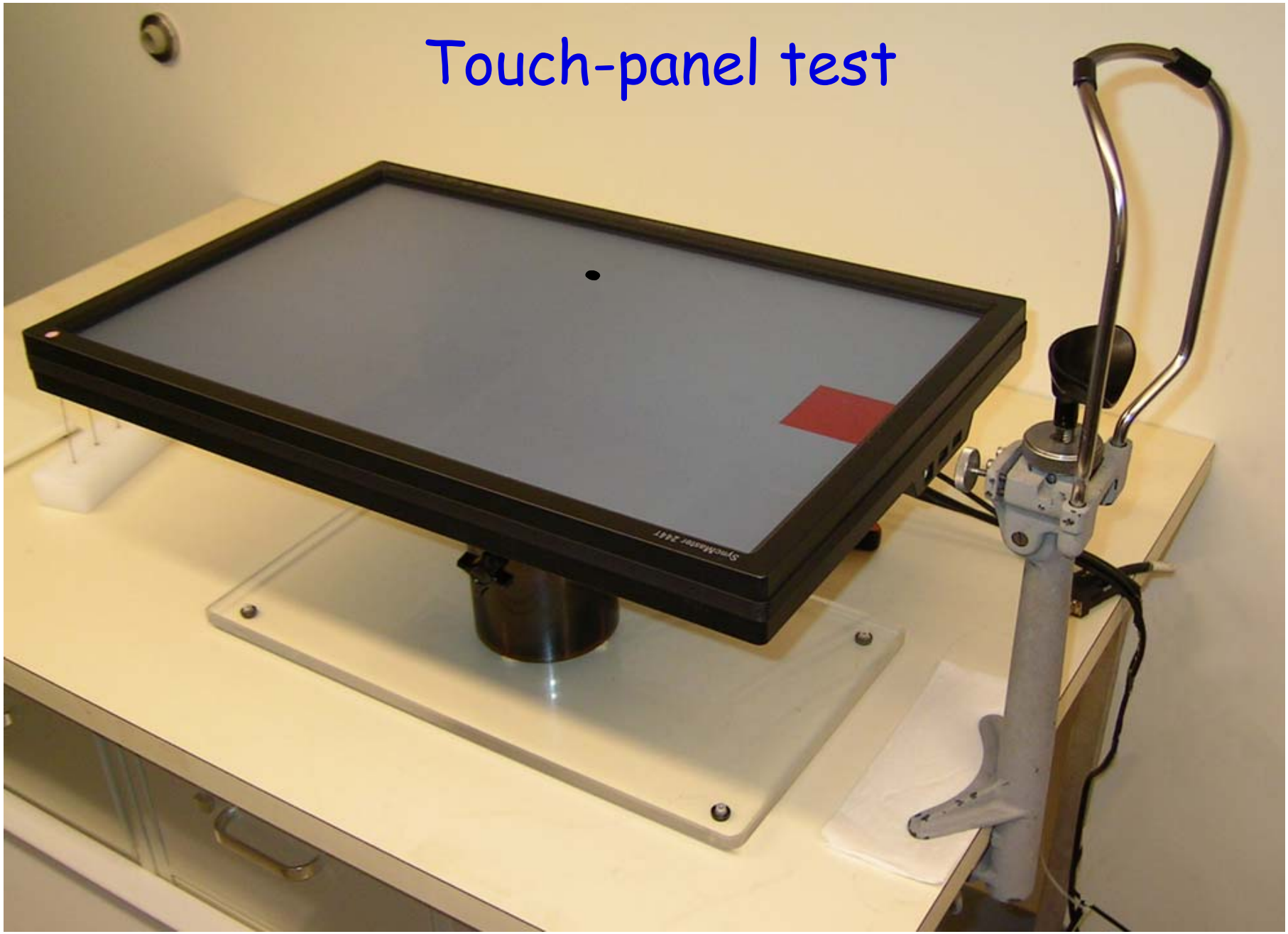
Needle test



Movie of needle test

needle_binoc
needle_monoc

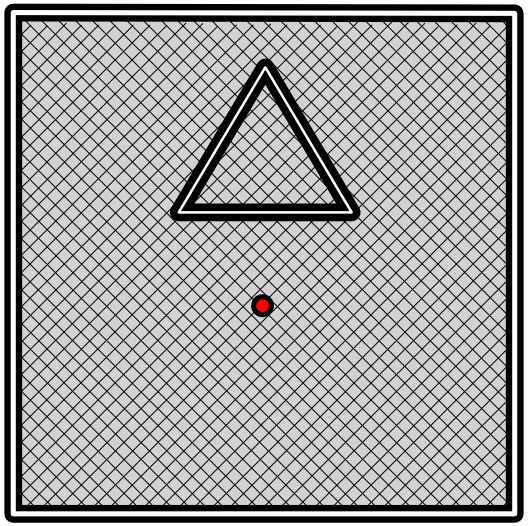
Touch-panel test

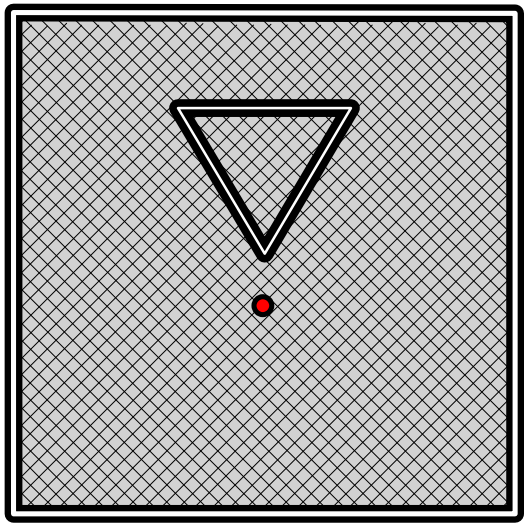


Examples of test of binocular integration

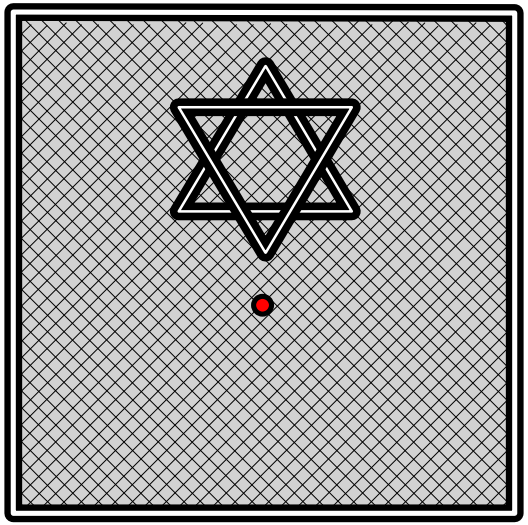
Binocular integration test, figures

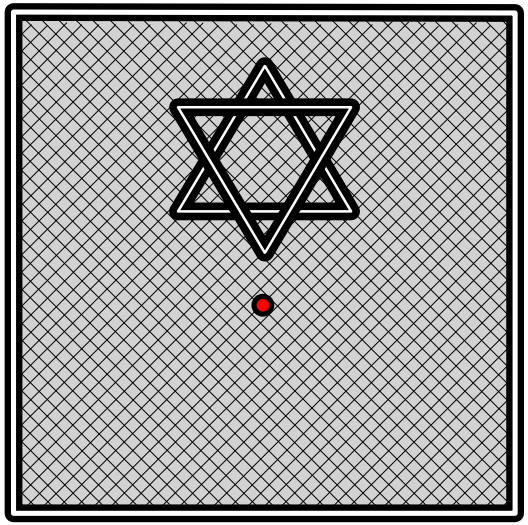
A





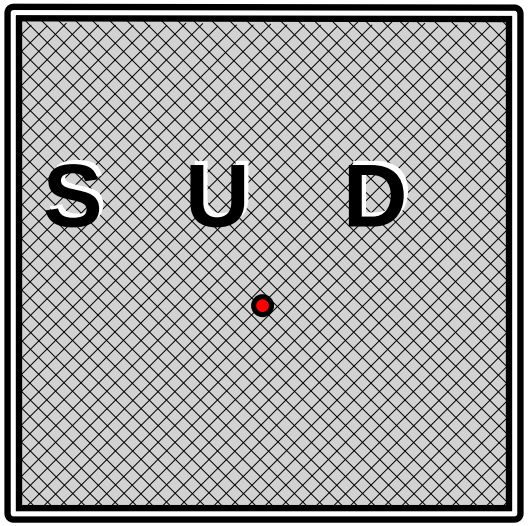
B

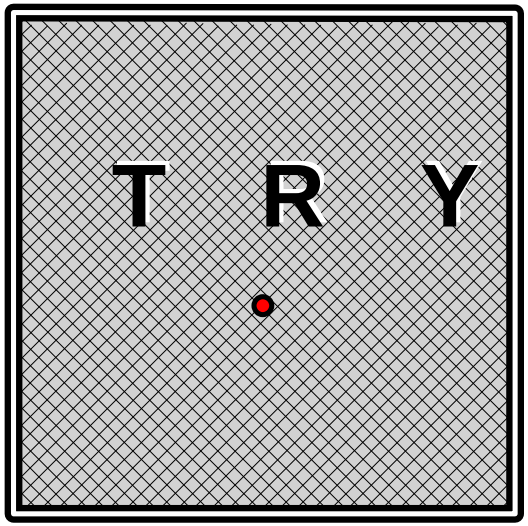




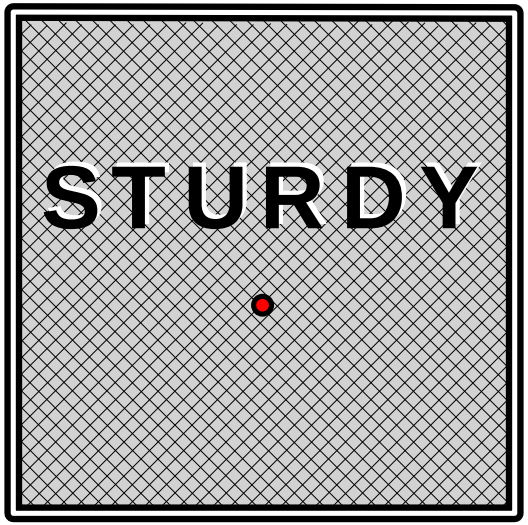
Binocular integration test, words

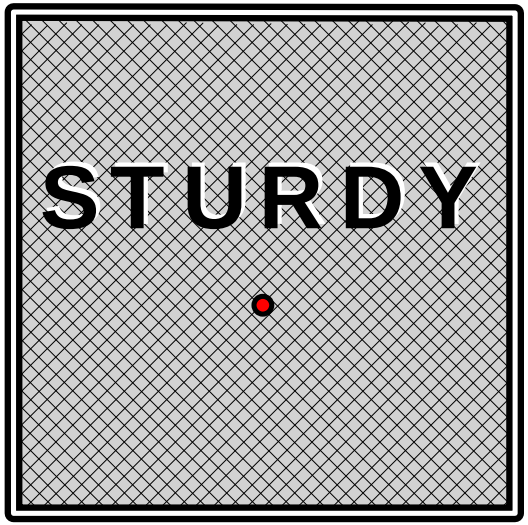
A





B





Summary, depth:

1. Numerous mechanisms for analyzing depth have been identified that include vergence and accommodation, stereopsis, parallax, shading, and perspective.

2. Several cortical structures process stereopsis utilizing disparity information; the number of disparities represented is limited as in the case of color coding.

3. Utilizing motion parallax for depth processing necessitates neurons specific for direction, velocity and differential velocity; several areas, including V1 and MT process motion parallax.

4. Area MT contributes to the analysis of motion, motion parallax, depth, and flicker; however, these analyses are also carried out by several other structures.

5. Litte is known at present about the manner in which information about shading and perspective is analyzed by the brain.

9.04 Sensory Systems

Fall 2013