1. Depth perception and stereopsis
You don’t need two eyes to perceive depth…

What 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**

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

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**Motion parallax**

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

Interposition

Credit: John Krantz
Depth from shading

What assumption about the light source is being 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
What cues are in this picture?

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

- Convergence
- Binocular disparity
A and B are at the same depth and thus have the same disparity (of zero since it is A that is 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 \((\alpha_L - \alpha_R)\) 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.
(A) Uncrossed disparity
(B) Crossed disparity

**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.
Principal of stereograms

Credit: Braddick
Andrew Stockman

*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.

**Autostereograms**
## DEPTH CUES: Summary

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### 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.

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

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

Colour after-effects
Andrew Stockman

Lilac chaser or Pac-Man illusion

Jeremy Hinton
Lilac chaser or Pac-Man illusion

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

Michael Bach and Jeremy Hinton
ILLUSIONS OF BRIGHTNESS

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

You've seen examples of these in other lectures...
Simultaneous brightness contrast

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 (2)

Michael Bach
Mach band steps

Mach band steps
The Koffka Ring

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

Spiral after effect
The grating is simply contrast reversing. Move your finger along it from left to right with a speed such that you travel the distance in about 2 seconds, while following the finger with your gaze. At the right speed, you should perceive a smooth rightwards motion of the stripes. Now move your finger back. If you follow it again with your eyes, you will see smooth leftwards motion of the stripes.
Motion-Bounce illusion

ILLUSIONS OF DEPTH
Size distortion

Shepard’s Table illusion

Version by Akiyoshi Kitaoka
Shepard’s “Turning the Tables” illusion

Ames Room
Andrew Stockman

**Ames Room (2)**

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 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.

“Carpentered world” hypothesis

Credit: Richard Gregory
Ponzo

Ponzo scene
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
"Communication among eggs"

Credit: Akiyoshi Kitaoka

Coal mine

Credit: Akiyoshi Kitaoka
Frazer spiral

Frazer spiral in motion
Men with sunglasses

Midorigame (Green turtle)
An explanation?
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
Andrew Stockman

Father son

Rabbit duck
Eskimo

UNSTABLE FIGURES
Hermann’s grid

Hermann grid: you see illusory spots

Streched grid: you do not see illusory spots

János Geier
Scintillating grid illusion

Lingelbach (1994)

Janos Geier
Rotating spiral snakes

Credit: A. Kitaoka
“The Enigma”

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

Thatcher illusion (1)

Credit: Peter Thompson
Say to yourself the colours of the ink in which the following words are written -- as fast as you can.

So, for RED, say “red”.

But for RED, say “green”

Ready, steady…

TEST 1

RED GREEN BLUE YELLOW PINK
ORANGE BLUE GREEN BROWN WHITE
GREEN YELLOW PINK RED ORANGE
BROWN RED WHITE BLUE YELLOW
WHITE ORANGE GREEN BROWN RED

How long?
How long?