Visual Illusions as a Window into the Workings of the Brain

ARA Classroom Connect, February 13 2016, Anderson Clarke Center
James R. Pomerantz, Department of Psychology, Rice University
The Lilac Chaser (Jeremy L. Hinton)
“Rubber Pencil” Illusion
Best Illusion of The Year Contest
A Turn in the Road

Keep pointing at the road that looks different.

© Kimberley Orsten and James Pomerantz, 2014

YouTube: https://www.youtube.com/watch?v=k-7fimW5rmU
Is ‘the dress’ white and gold or blue and black? Visual perception expert weighs in

Date: March 2, 2015
Source: Rice University

On Feb. 26, a picture of a cocktail dress originally uploaded to the blog Tumblr swept the Internet and managed to divide the population over a simple question: What color is the dress? Some viewers saw gold and white while others insisted the dress is blue and black. Some people claimed they could see either interpretation, but only one of them at a time. It made people stop and ask, “What exactly is going on with this image?”

James Pomerantz, a professor of psychology at Rice University and an expert on visual perception, said the phenomenon is rather elementary and can be easily explained.

“A couple of things are going on, and not all of them involve how our eyes and brains see color,” Pomerantz said. “As people who have studied visual perception or photography or painting know, there is a problem that eyes and cameras struggle with called white balance.” If you look at your camera closely, there may even be a white-balance control on it that makes this setting for you.

Pomerantz suggested an example to illustrate the point: Think about taking two photographs, one of a white room illuminated with red light bulbs and one of a red room illuminated with white light bulbs. “Will the two photographs come out the same, given that the colors (wavelengths of light) entering the lens will be the same in those two cases?” he asked.

The answer is yes. “The photos will come out the same. How could they not?” he said. “People, however, can usually see the difference, if there is some clue they can find that tells them the color of the light illuminating the room.”

“As hard as it may be to believe, the checkerboard square (actually a parallelogram at this angle) marked A is identical in brightness to the one marked B, even though B looks far lighter,” Pomerantz said. “The reason we see them as different is that we factor in the obvious shadow being cast by the cylinder, blocking the source of light pouring in from the upper right. Because B is in shadow, we must mentally (albeit unconsciously) correct for it being in the shadow. A camera doesn’t know about any shadow or any cylinder or any light streaming in from the upper right. All the camera knows is the brightness at each point (pixel) in the image, and so the camera sees A and B as identical.

“The checkerboard illusion involves just black and white, but the idea extends to the color of the dress,” he said. “The main point is that we can’t tell the difference between white and blue, or between black and gold, unless we have some independent information about the wavelengths of light illuminating the dress.”

http://www.sciencedaily.com/releases/2015/03/150302154231.htm
Critical Thinking Challenge:

Pomerantz, a professor of psychology at Grinnell College along with a visual perception expert, says the primary point is the fact that we cannot differentiate between white and blue, or black and gold unless we've got some independent details about the wavelengths of sunshine lighting the gown. It is primarily the insufficient understanding which has led to what's most likely probably the most hotly debated problem of latest occasions.
Human Brain: 100+ billion neurons, each with up to 1K inputs and 1K outputs. How many failure points?
The Neuron and the Synapse
Schematic of primate brain
Are illusions like other failures of cognition... such as memory slips?
Oh, crap! Was that today?
The Visual Pathways

- Left visual field
- Right visual field
- Temporal
- Nasal
- Optic chiasm
- Pulvinar nucleus
- Lateral geniculate nucleus
- Superior colliculus
- Optic radiation
- Primary visual cortex
Adult human eye, axial cross-section, right eye seen from above
Blood vessels in the eye
Colored (non-beige) regions show where visual processing occurs.
Surely we Can’t Be Fooled into Confusing Black with White?
Hermann Grid
Mach Band:  
Verifying that it is an illusion.
Human Evidence

Hermann Grid

Mach Bands, model

Aftereffects:

McCollough Tilt

Waterfall Fortification images
Scintillating Grid

A and B are anti-metamers: Look different but are the same
A and C are metamers: Look the same but are different
Test: note the shades of the objects in this room.
What color is this text?
Blindnesses

Total blindness
  Damage to retina, optic nerve (MS), V1, etc.

Low vision, partial blindness
  Macular degeneration, tunnel vision

Color blindness
  Dozens of varieties; monochromats are rare

Motion blindness (Akinetopsia)

Depth (stereoscopic) blindness

Face blindness (prosopagnosia)
Optical Problems

Myopia
Presbyopia
Astigmatism
Strabismus
Cataracts
What about Failures in Vision?

Two classes:

Failures based on neurobiology, anatomy
Damage to brain from genetic causes, illness, disease, injury
Examples: blindnesses, scotomas

Failures that occur despite a healthy organism
Misperceptions attributable to system design, learning, temporary states (dreaming, drugs)
Examples: illusions, inability to discriminate, hallucinations
Visual “Failures” Unrelated to Biological or Medical Problems

Visual Illusions that we all experience!
Baker’s Dozen Ways to Make an Object Disappear

1. Remove the object from view (!)
2. Render the image in another part of the spectrum (or size scale, speed scale)
3. Put the image into the eye’s blind spots
4. Stabilize the object’s image on the retina
5. Make the object’s image part of the background
6. Use color / texture camouflage
7. Have the object appear just before a blink
8. Have the object appear just before an eye movement
9. Surround the object with moving dots
10. Follow the object’s appearance with a flash, ring
11. Divert attention away from the object
12. Disrupt the visual cortex with magnetic stimulation
13. Have perceiver engage in visual imagery
Dust Mite, about 1/100” in length

A single human body is a colony. “We” are outnumbered by other organisms (such as mites and bacteria) that we host, even by cell count.
Biggest Structure in Universe: Large Quasar Group Is 4 Billion Light Years Across

Jan. 11, 2013 — An international team of astronomers, led by academics from the University of Central Lancashire (UCLan), has found the largest known structure in the universe. The large quasar group (LQG) is so large that it would take a vehicle travelling at the speed of light some 4 billion years to cross it.

The team publish their results in the journal *Monthly Notices of the Royal Astronomical Society*.

Quasars are the nuclei of galaxies from the early days of the universe that undergo brief periods of extremely high brightness that make them visible across huge
Harold Edgerton Bullet
Leland Stanford hires Eadweard Muybridge
Lightning captured at 7,207 images per second

© Tom A. Warner
Any use requires licensing via www.WeatherVideoHD.TV

http://vimeo.com/28457062
Eagle owl landing at 1000 frames per second. Is even higher temporal resolution possible?
Shooting at 1,000,000,000,000fps

By Bryant Frazer / Aug 15, 2012

http://www.studiodaily.com/2012/08/shooting-at-10000000000000fps/
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MARTIANS BUILD TWO IMMENSE CANALS IN TWO YEARS

The Lilac Chaser  (Jeremy L. Hinton)

http://www.michaelbach.de/ot/col_lilacChaser/index.html
Troxler Fading: stabilized images on the retina
Color and Stabilized Images

What happens if the edge of the green disk is stabilized on the retina while the edge of the orange disk is not stabilized? Krauskopf (1963)
What happens if the edge of the green disk is stabilized on the retina while the edge of the orange disk is not stabilized? Krauskopf (1963)

Answer: the green disk disappears and fills in with orange.
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Making things disappear: Camouflage

Random dot kinematograms: structure from motion
Illusory contours from motion
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Blinks, Eye Movements

We are temporarily blinded both during and before these
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9. Surround the object with a moving grid
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Motion-induced blindness:

http://www.michaelbach.de/ot/mot_mib/index.html
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Metacontrast Masking:

When a briefly flashed disk is followed by a flash of light or by a surrounding ring, we fail to see the disk.
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Selective Attention in Vision:
Failure to see both of 2 superimposed images at same time
Selective Attention in Vision:  
Failure to exclude unwanted input  
(Stroop Interference)

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<tr>
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<th>Green</th>
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<td>Green</td>
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Change Blindness: Daniel Simons

http://viscog.beckman.illinois.edu/flashmovie/1.php
http://viscog.beckman.illinois.edu/flashmovie/12.php
http://viscog.beckman.illinois.edu/flashmovie/15.php
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Transcranial Magnetic Stimulation
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Visual Imagery

Try to detect a tiny, brief flash of light while either:

Listening to your favorite song playing in your mind’s ear, or
Watching a video tour of your childhood home in your mind’s eye
Flow of Talk:

Illusions are everywhere!
Link to failures in cognition, brain, mind
Visual illusions and what they mean
How to make an object vanish
**Illusions of color, motion, and form**
Conclusion: Learning from failure
Illusions: Optical versus Perceptual
Color Mixture

Additive
Mix lights

Subtractive
Mix paints
Color Assimilation and Contrast
Missing no cone types: trichromat

Missing 1 cone type: dichromat
   Long (red) cone: protanope
   Middle (green) cone: deuteranope
   Short (blue) cone: tritanope

Anomalous trichromat: altered pigment

Missing all 3 cone types: monochromat
The McCollough Effect

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http://www.michaelbach.de/ot/col_lilacChaser/index.html
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http://www.michaelbach.de/ot/col_lilacChaser/index.html
Nine stimuli that produce the perception of motion

1. "Real" motion
2. Stroboscopic (apparent) motion: beta, phi, etc.
3. Induced motion (train next to yours starts moving)
4. Autokinetic motion
6. Fooling the corollary discharge system
7. Wave motion
8. Spatial distortions
9. Op art, Ouche illusion, Akiyoshi Kitaoka's site

http://www.biomotionlab.ca/Demos/BMLwalker.html

http://www.michaelbach.de/ot/mot_breathingSquare/index.html
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Scientific American’s Illusion of the Year, 2007

The Jastrow Illusion

The Jastrow Illusion

Figure 4.2 Not three black sectors and three angles, but a white triangle in front of three black disks and an outlined triangle.
Seeing edges where there are none.
Shepard Boxtops
http://psych.rice.edu/neuropsychology/Perception/perception.html
Four illusions I have worked on:

Perception of rigidity in moving bodies ("rubber pencil illusion")

Ecology and the perception of color ("grass is always greener")

False Pop Out

False perception of differences
“Rubber Pencil” Illusion
Grass is Always Greener

"And this report just in... Apparently, the grass is greener on the other side."

Figure 1. The optical layout for describing the green-shift phenomenon. The observer (O) stands on the grass-covered ground (G) and views the field directly below his feet (A) and the field (B) on the other side of the fence (F). The observer's line of sight is more likely to reach through the grass to the ground on side A than on side B.
Conclusions

All systems – engineered or natural – fail at some point
Failures can show the way for learning and evolution
Failures abound in vision, as do successes
Failures sometimes result from design tradeoffs
Illusions can reveal how systems work, e.g. in color vision:

1. Color afterimages follow a red-green, blue-yellow, black-white pattern
2. Additive color mixtures follow the same pattern: red + green = gray (no “reddish green”)
3. Color blindness follows the same pattern, with red-green blindness most common

Illusions often result from the brain’s use of proxies, heuristics, and shortcuts that normally serve us well.
Thanks for your undying attention
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