

MERI Optical Illusions Exploration

Station - Can you believe your eyes?

Purpose: While the eye is the sensory organ that collects light, the brain is actually responsible for converting, processing and interpreting the data embedded in those collected photons into usable information that we experience as visual perception. The brain relies on neurons to convert signals from the environment and process the data from sensory organs to create our lived experiences. Interpreting all this sensory data requires a lot of computing power, and the brain relies on context, known inferences, and bias to make make sense of the sensory sensory data, including light, as quickly as possible. It is thus vulnerable to being tricked when the environment provides situations that play into these biases and context cue usage, for example by over-stimulating different kinds of processing neurons (physiological), triggering biased inferences during interpretation of the environment (cognitive), or manipulating the link between the motor and visual perception of the world (cognitive-motor illusions). These tricks result in the experience of optical illusions where perception differs from reality. In this exploration station we will examine physiological illusions and cognitive illusions to help visitors learn about visual perception and the brain.

Anatomical Illusions

Find your blind-spot

The blind spot is the area on the retina without receptors that respond to light. Therefore an image that falls on this region will NOT be seen. It is in this region that the optic nerve exits the eye on its way to the brain. To find your blind spot, look at the image below or draw it on a piece of paper:



Close or cover your right eye. Hold the image (or place your head from the computer monitor) about 20 inches away. With your left eye, look at the +. Slowly bring the image (or move your head) closer while looking at the +. At a certain distance, the dot will disappear from sight...this is when the dot falls on the blind spot of your retina. Reverse the process. Close or cover your left eye and look at the dot with your right eye. Move the image slowly closer to you and the + should disappear. As you can see, you have a blind spot at least as big as the spot in the diagram. What's particularly interesting though is that you don't SEE it. When the spot disappears you still don't SEE a hole. What you see instead is a continuous white field (remember not to LOOK at it. If you do, you'll see the spot instead). What you see is something the brain is making up, since the eye isn't actually telling the brain anything at all about that particular part of the picture. This is an anatomical illusion.

Physiological Illusions

Cone Fatigue

Stare at the image on the other side of this page for 20 seconds and then look at a blank white area.

The after image you see has the opposite colors of the picture you just stared at due to “cone fatigue.” The eye contains special cells called photoreceptors that detect light. We have two types of photoreceptors – rods and cones. Rods can detect light and dark while cones are good at detecting colors such as red, green and blue. When you stare at a specific color for too long, the cells that detect that color will get tired, or fatigued. The after image is a result of all your photoreceptors not being in balance. As the photoreceptors become less tired, which takes between ten and thirty seconds, the balance is recovered and the after image disappears. When red, green and blue are added together we see white (see picture below). If you stare at something red, your red cones will get tired. If you then look at something white, you will see an afterimage that is cyan, the complementary color of red. If you stare at something green, the afterimage will be magenta. Once the cones recover from fatigue and become active again, the after image disappears. This is a physiological illusion.

Color Adaptation

Stare at the inverse color castle image on the screen for 20 seconds then click to advance the slide. For a few seconds the black and white image will appear to be not only in color, but the correct colors. In very general terms, the explanation is that we do not perceive things as they really are, but as they are relative to other things. More specifically, in color perception this means that we do not perceive, say, the amount of red, but the amount of red relative to the amount of green. This principle is called color opponency, and can be traced back to specific types of neurons. Neurons that respond to green are inhibited by red, and vice versa. Let's say that you are exposed for some time to a red dot. Your eyes will adapt to the color red, effectively perceiving less red than there actually is, just like you will adapt to increased levels of light. If the red dot subsequently disappears, your eyes will not immediately recover, because adaptation is slow, and for some time you will still perceive less red than there is. Following the principle of color opponency, perceiving less red is the same as perceiving more green. Together, this explains why perception of a red dot gives an after effect in the form of an illusory green(ish) dot. Thus, when the inverse colors are removed from the castle image, you see the correct colors briefly. This is a physiological illusion.

Rotating Wheels

The wheels on the other side of this page appear to move – even though in reality they are utterly stationary. The illusion is so strong that many people feel nauseous if they look at the image for more than a few moments –and may feel ill

for some time afterwards. Notice that only those wheels in your peripheral vision appear to rotate. When you look directly at one of the wheels, you can't 'catch' it moving! Each wheel in the illusion is made up of four colored elements: black, blue, white and yellow – in that order. The critical feature for making the wheels rotate is the differences in the levels of luminance (light) between adjacent elements. This means that the illusion also works well when printed in black and white.

For many years scientists have known we have specific cells in our brains that fire when we look at something moving in a particular direction. These cells are called direction-selective neurons. When scientists examined this illusion they found something quite remarkable. Direction-selective neurons begin firing when looking at this illusion. This is particularly exciting because up until now, scientists thought this type of brain neuron could only be activated by seeing something that was really moving (either on-screen or in the real world). Vision scientists think the cells that detect motion actually interpret the rollers as if they were really moving. This is a physiological illusion.

Cognitive Illusions

Albert Einstein - Marilyn Monroe Hybrid Image

Proposed in 1994 and improved by Aude Olivia and Philippe G. Schyns. Stand ~ 6 feet away from the image and walk slowly forward – who do you see? This illusion shows the finer details of Albert Einstein on a blurry background, but an underlying image of Marilyn Monroe when viewed at a greater distance. The explanation for this illusion relates to how the brain processes a combination of the lower number of pixels in Monroe's image and the larger number of dense pixels in Einstein's image.

Thatcher illusion

Look at the two upside down photos – is the person smiling or frowning in each? Rotate the photos to reveal one photo of a normal smiling face and the one photo where the lips and eyes have been inverted. Upside down it appears that the person was smiling in both photos, while right-side up it is obvious that the person was smiling in one and frowning in the other. Faces seem unique despite the fact that they are very similar. It has been hypothesized that we develop specific processes to differentiate between faces that rely as much on the configuration (the structural relationship between individual features on the face) as the details of individual face features, such as the eyes, nose and mouth. As Lewis and Johnston demonstrated, when a face is upside down, the configural processing cannot take place, and so relational differences that are obvious when upright are difficult to detect when inverted.

Spinning Dancer

The spinning dancer does not necessarily spin the same direction for everyone because there are no clear reference points to help the brain decide which way the dancer is spinning. Usually, with enough concentration, one can view the dancer spinning in either direction, sometimes flipping rather quickly back and forth between the two directions. It had been incorrectly suggested that those who see the dancer spinning clockwise *versus* counter clockwise are using the right, creative *versus* the left, logic side of the brain. However, this is not supported by any credible evidence.

Hollow Face Dragon

Look straight on at the little paper dragon – is it's face concave, convex or flat? Do it's eyes appear to follow you? How does it work? If we move around when viewing a solid object, our brain knows how the object we are looking at should behave. However the dragon gives us the wrong clues, because we mis-interpret what its shape is. We assume that the nose of the dragon is pointing out towards us, but in fact the dragon's head is concave.

Checker Shadow Illusion

Look at the picture, are the A and B squares the same? And what if we cover everything except for these two squares?

The illusion that the B square (the square in the shadow) is lighter than the A square (the square in the light) is due to our brain's use of context to infer the color of objects in the environment. In this case, the perception of the squares' colors is based on how your brain interprets the surrounding color and shadow information, namely that objects in the shadow will appear darker than when they are in the light. As such, if two objects have the same *perceptual* color, but one is in the light and one in the shade, then it means that the object in shade must a lighter color than the one in the light. When the contextual clues are removed (or when a hint is provided), you can easily see that the squares are the same color.

Ames' Room

Look through the peephole on the side of the room. Which of the two ninja turtles is bigger than the other? And what happens when we move one of the ninja turtles from one of the back corners to the other corner where the other turtle is? The illusion that one of the ninja turtle is bigger than the other one is because the room is not a square, but a special shape that was specially designed to give the illusion of an ordinary room. This illusion works because most information about the true shape of the room does not reach the observer's eye. The geometry of the room is carefully designed, using perspective, so that, from the peephole, the image projected onto the retina of the observer's eye is the same as that of an ordinary room. By preventing the observer from changing their perspective of the room, the brain cannot use its strategies to figure the depth in a scene, such as getting information from both eyes instead of one (stereopsis) or moving to figure out how elements of the scene move with respect to each other (parallax).

This illusion also shows that your visual system relies on cues from the environment to figure height, depth, and distance instead of relying on cues from movable objects.

Café-Wall Illusion

Are the lines between the tiles parallel or going towards each other? What if I hide some of the tiles under one of the lines, does it still look crooked or straight? The cognitive and physiological processes behind this illusion are unfortunately not quite clear yet. One hypothesis is that this illusion is based on the fact that a light shape on a darker background will appear larger than the same dark shape on a white background. But it is not enough to explain all the variations of this illusion, and research is still ongoing to understand how our visual systems interpret borders between areas of contrasting luminance.

Hidden Frog

Try touching the frog... Where *is* the frog?

This illusion works because when you look at the frog through the hole at the right angle (which is about the angle of when you stand in front of the table), the elliptical mirrors are designed such that you see the reflection of the frog in the mirror. However, because your brain knows that the frog cannot be behind the mirror, it projects the image in front of the mirror instead, at a distance that corresponds to the distance between the mirror and the hole.

Point Light Walker

Do you see someone walk? Do you see an animal? Could you tell the gender of the person? This illusion works because when distinct elements that appear to move in a coherent manner together (e.g. following the pattern formed by someone walking), the brain will associate them together, or in other words, it will consider that they all belong to the same underlying object (in this case a person/an animal). This illusion has been shown to work especially well when the points follow the trajectory of the joints of your body when you walk, which would suggest the motion of joints are major cues used by the brain to identify someone's gait. You may also have realized that humans are really good at recognize people by the way they walk, sometimes as well as looking at them directly.

Hermann Grid Illusion

Allow your gaze to roam around the figure. Focus at one of the intersection points from time to time. How many grey dots do you see?

One explanation often cited for this illusion is lateral inhibition process, which refers to the way ganglion cells in the retina will get excited by activity in the center of their receptive field, and inhibit activity in the area at the periphery of their receptive field. This theory is however insufficient. Thus, since a point at an intersection is surrounded by more areas of higher light intensity than a point at the middle of a line, the intersection appears darker due to the increased

inhibition. This theory has been shown recently to be untenable because it does not account for all the contexts in which this illusion is perceived (e.g. different line width, wavy instead of straight lines dissipate the illusion).

Cognitive-Motor Illusions

Mirror Drawing

Time yourself while you draw the star by staying between the lines using your dominant hand and looking at the star directly, pretty quick right? Now do the same but instead look at the star through a mirror (prop a mirror in front of the star and hide the drawing hand using a sheet of paper), how fast/slow were you and how many errors did you make? While this is not exactly an illusion, this activity exemplifies how intricately linked the visual and motor systems are. To go forward for example, your visual system (looking through the mirror) tells your brain that you hand you should in one direction, however this direction is reversed compared to what your motor system should do (because of the mirror), and your motor system knows that. The conflict between these two systems, and the dominance of the visual system in such tasks leads to the difficulties encountered when trying to quickly draw something in the mirror. This is a cognitive illusion linked to the motor system.

Prismatic Goggles

Wearing the goggles, put your dominant hand next to your shoulder and point to the target on the white board *in one swift motion*. How easy/hard was it? Keep doing that 10-20 times, does it get easier? Now remove the goggles and point again to the target, how easy/hard was it? How many tries did it take to go back to “normal”? This illusion illustrates how your motor cortex and your visual systems interact when interacting with the world. The prismatic goggles shift your visual fields by 20 degrees to the left, but the map of the world from your motor cortex remained unchanged. When pointing to the target, the misalignment is the reason why your fingers pointed to the left of the target. After a few tries, your brain learned the new association between the visual map with the goggles and your internal motor map. However, this means that when you removed the goggles, both maps were now misaligned, and you had to relearn the alignment of your motor and visual maps without goggles. This is a cognitive illusion linked to the motor system.