#5 Sensation and Perception

[Adapted from Crash Course Psychology with Hank Green, written by Kathleen Yale,
edited by Blake de Pastino, with psychology consultant Dr. Ranjit Bhagwat]

Let me tell you about Oliver Sacks, the famous physician, professor and author of unusual neurological case studies. We'll be looking at some of his fascinating research in future lessons, but for now, I just want to talk about Sacks himself. Although he possesses a brilliant and inquisitive mind, Dr. Sacks cannot do a simple thing that your average toddler can. He can't recognize his own face in the mirror. *Sacks has a form of prosopagnosia, a neurological disorder that impairs a person's ability to perceive or recognize faces, also known as face blindness.*

Last week we talked about how brain function is localized, and this is another peculiarly excellent example of that. Sacks can recognize his coffee cup on the shelf, but he can't pick out his oldest friend from a crowd, because the specific sliver of his brain responsible for facial recognition is malfunctioning. *There's nothing wrong with his vision. The sense is intact. The problem is with his perception, at least when it comes to recognizing faces.* Prosopagnosia is a good example of how sensing and perceiving are connected, but different.

Sensation *is the bottom-up process by which our senses, like vision, hearing and smell, receive and relay outside stimuli.* And then we have Perception*, on the other hand, is the top-down way our brains organize and interpret that information and put it into context*. So right now at this very moment, you're probably receiving light from your screen through your eyes, which will send the data of that sensation to your brain. Perception meanwhile is your brain telling you that what you're struggling with a method of explaining the difference between sensation and perception. We are constantly bombarded by stimuli even though we're only aware of what our own senses can pick up.

The Absolute Threshold of Sensation *is the minimum stimulation needed to register a particular stimulus, 50% of the time.* So if I play a tiny little beep in your ear and you tell me that you hear it fifty percent of the times that I play it, that's your absolute threshold of sensation. We have to use a percentage because sometimes I'll play the beep and you'll hear it and sometimes you won't even though it's the exact same volume. Why? Detecting a weak sensory signal isn't only about the strength of the stimulus. It's also about your psychological state; your alertness and expectations in the moment.

Students playing with their smart phones in class may hear only 5% of a teacher's lecture, even though it was a riveting presentation. The Smart phone distraction allows them to miss the world. Exhausted new parents, on the other hand, might hear their baby's tiniest whimper, but not even register the bellow of a passing train. Their paranoid parent brains are so trained on their baby, it gives their senses a sort of boosted ability, but only in relation to the subject of their attention.

Conversely, if you're experiencing constant stimulation, your senses will adjust in a process called *sensory adaptation*. You enter a classroom and are annoyed by the smell. After being in the room for 30 minutes, you may no longer notice the smell. You move into a dorm room and are annoyed by the noise of people coming and going in the hallway. But after living there for a month, you may not notice these noises at all.

Weber's Law says that we perceive differences on a logarithmic, not a linear scale. If you are exercising with a 10 pound weight, and you increase the weight to 10.5 pounds, you may not notice the change. But if you are exercising with a 1 pound weight, and you increase it to 1.5 pounds, you will definitely notice. A 5% change may not be not be perceived, but a 50% change will definitely be noticeable. *According to Weber's Law, it's not the amount of change. It's the percentage of change that matters.*

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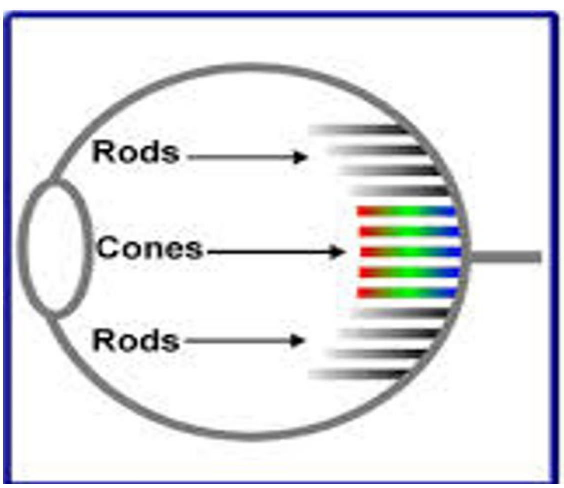
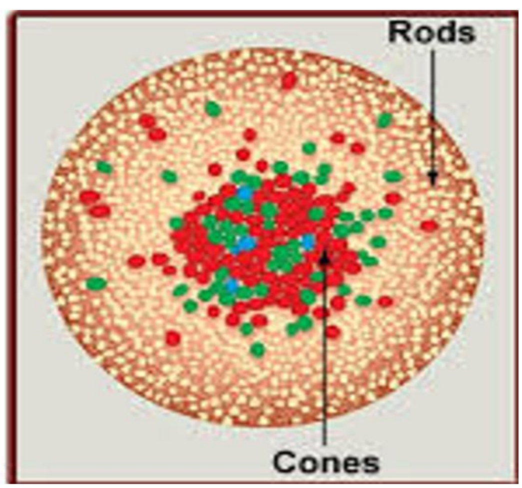
Vision

How about now we take a more in depth look at how one of our most powerful senses works? *Vision*. *Your ability to see your face in the mirror is the result of a long but lightning quick sequence of events. Light bounces off your face and then off the mirror and then into your eyes*, which take in all that varied energy and transforms it into neural messages that your brain processes and organizes into what you actually see, which is your face. So how do we transform light waves into meaningful information? *After the eye takes this light in through the cornea and the pupil, it hits the transparent disc behind the pupil - the lens - which focuses the light rays into specific images.* And just as you'd expect the lens to do, it projects these images onto the retina, the inner surface of the eyeball that contains all the receptor cells that begin sensing all that visual information.

Now your retinas don't receive a full image like a movie being projected onto a screen. *It's more like a bunch of pixel points of light energy that millions of receptors translate into neural impulses and zip back into the brain. These retinal receptors are called rods and cones. Our rods detect gray scale and are used in our peripheral vision* as well as to avoid stubbing our toes in twilight conditions when we can't really see in color. *Our cones detect fine detail and color*. Concentrated near the retina's central focal point called the fovea, cones function only in well-lit conditions. Two theories help us explain some of what we know. One model, called the Young-Helmholtz Trichromatic Theory suggests that the retina houses three specific color receptor cones that register red, green and blue, and when stimulated together, their combined power allows the eye to register any color. Unless, of course you're colorblind. *About one in fifty people have some level of color vision deficiency.* They're mostly dudes because the genetic defect is sex linked. The other model for color vision, known as the Opponent-Process Theory, suggests that we see color through processes that actually work against each other. So some receptor cells might be stimulated by red but inhibited by green, while others do the opposite, and those combinations allow us to register colors.





When stimulated, the rods and cones trigger chemical changes that spark neural signals which in turn activate the cells behind them called bipolar cells, whose job it is to turn on the neighboring ganglion cells. The long axon tails of these ganglions braid together to form the ropy optic nerve, which is what carries the neural impulses from the eyeball to the brain.

The visual cortex sits at the back of the brain in the occipital lobe, where the right cortex processes input from the left eye and vice versa. This cortex has specialized nerve cells, called feature detectors that respond to specific features like shapes, angles and movements. In other words different parts of your visual cortex are responsible for identifying different aspects of things. A person who can't recognize human faces may have no trouble picking out their set of keys from a pile on the counter.

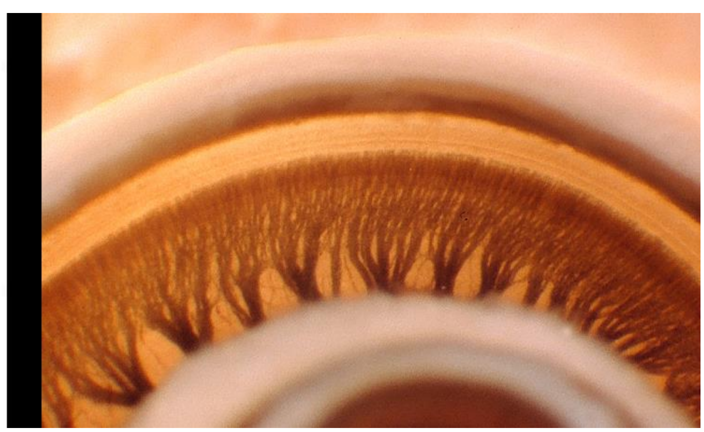
In the case of Dr. Sacks, his condition affects the region of the brain called the fusiform gyrus, which activates in response to seeing faces. Sack's face blindness is congenital (he was born with it), but it may also be acquired through disease or injury to that same region of the brain.

#6 Homunculus! The "little man" inside your brain

[Adapted from Crash Course Psychology with Hank Green, written by Kathleen Yale, edited by Blake de Pastino, with psychology consultant Dr. Ranjit Bhagwat]

We have read about the difference between sensation and perception: how *sensation is the process by which our senses and brain receive information from the outer world, while perception is how we organize and interpret that information and give it meaning.* Like, right now, my sense of sight is helping me to detect words, while my brain is processing and interpreting them, allowing me to identify and perceive the individual words and determine if they're coming from a book, a radio, or an IPad.

Sound moves in waves that vibrate through a medium, like air. They function differently, and sound waves can also vary in shape. *Short waves have a high frequency and a high pitch, like a plucky violin.* Meanwhile, *long waves have a low frequency and pitch*, like a mournful cello. *Wave height, or amplitude, determine a sound's loudness*, which we typically measure in decibels. And just as light waves become electrical impulses that we register with our sight, so too do our ears turn vibrating air into signals that our brains can decipher.



While the human ear might not be as elegant as the jackrabbit's, or as wild as the long-eared bat's, it's actually a pretty incredible organ. *Your outer ear, the part that you can see and pierce and tug on, collects sound waves that funnel through the ear canal and into the middle ear, where they cause your eardrum to vibrate.* From there, sound vibrations are amplified by the so-called 'ossicle bones', *which also happen to be the most awesomely named bones in your body: the* stirrup, *the* hammer *and the* anvil. From here, those physical vibrations travel to the inner ear, where they bump into the snail-shaped *cochlea*, and its surrounding fluids get jostled around, causing some of your 16,000 tiny cochlear hair cells to bend. This motion triggers neighboring nerve cells that convert that physical energy into electrical impulses zipping up the auditory nerve into the auditory cortex, where the brain processes them as sounds.

One of the greatest joys in life is enjoying flavors; whether you prefer casserole or caviar, we all get our tasting done in the same way, starting with our taste buds. *Each of our thousands of taste buds contains a sort of pocket-like pore that contains fifty to a* *hundred hair-like taste receptor cells that read food molecules and report back to the brain.* "That chip is salty, that lemon is sour." Now, everybody used to think that our tongues just detected four distinct tastes: sweet, salty, sour and bitter. And you've probably seen the version of this bogus taste map, which incorrectly assigns certain tastes to certain parts of your tongue. But we now recognize a fifth flavor: the savoury, meaty, MSG-y taste, for which there is no English word, it's known as 'umami'. But taste is nothing without smell. Plug your nose, and a bite of cold bacon is just a mouthful of salt. This is a prime example of *sensory interaction*, the principle that one sense can influence another.

Let us take a little questionnaire, shall we?

Do certain words trigger a strong, specific taste in your mouth? Like, does the word 'kitten' taste like candy canes?

Has hearing a sound ever made you see a color? Like does Prince's voice singing Purple Rain actually cause the color purple to flash before your eyes?

Do you ever feel like you're being touched when you smell something?

Most of you said no to all of those questions, but at least one of you out there answered yes. And more likely than not, that person has synesthesia, *a rare and fascinating neurological condition where two or more senses get wrapped together.*

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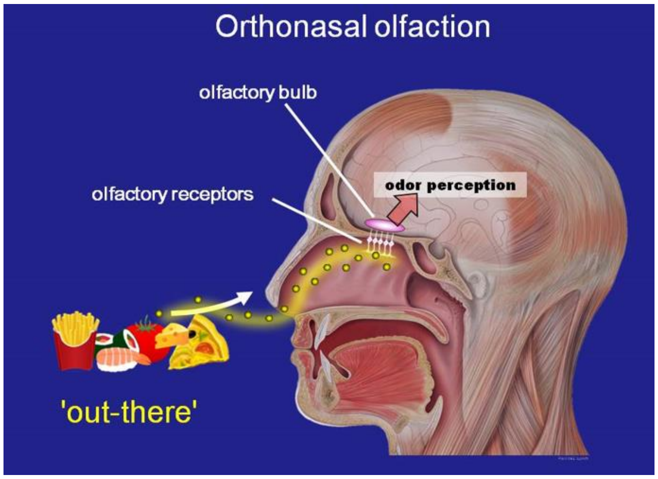
So, back to the comparatively boring topic of smells that only smell... *We differentiate the smells of spring lilacs, grilled cheese, and gasoline when airborne molecules travel up the nose and reach the five to ten million receptor cells at the top of each nasal cavity;* and yes, that means *when you smell poop, there's poop particles in your nose.*

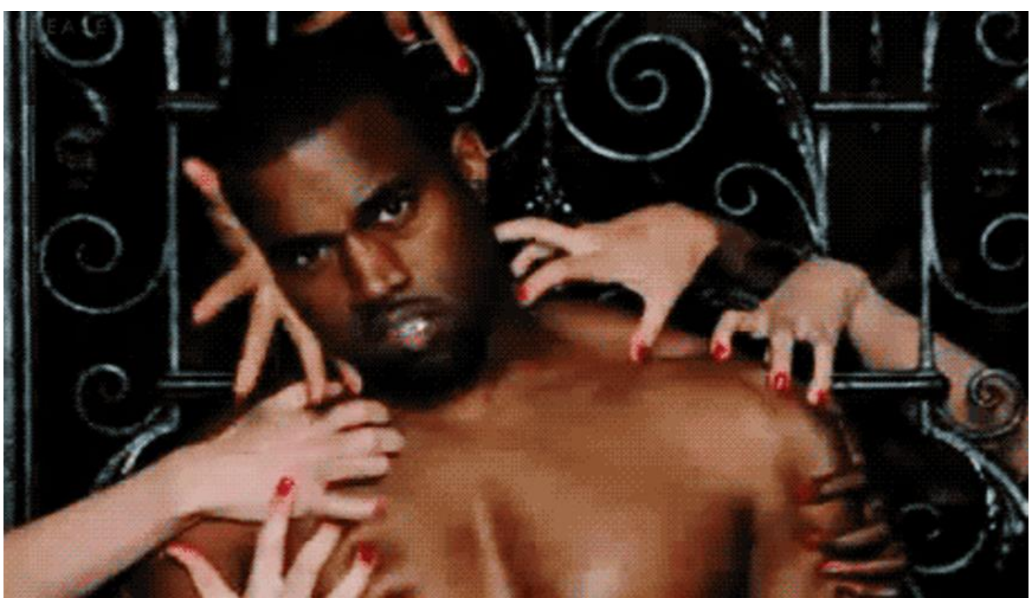
These receptors send information to the brain's olfactory bulb, *then zips it on to the primary smell cortex and parts of the limbic system responsible for emotion and memory*. Unlike our five different taste receptors or two types of retinal receptors, we don't have specifically differentiated smell receptors, rather, odor receptors come together in different combinations. Pressing different keys on your keyboard can allow you to form tons of different words, so too can these distinct combinations of activated smell receptors communicate some ten thousand unique smells.



The emotional power of smell partly has to with how our sense circuitry connects to the brain's limbic system. *The limbic system is right next to our emotional registry, the amygdala, and our memory keeper, the hippocampus.* That's why scents can be so intimately tied with our feelings and memories. And how a whiff of bubble gum can immediately transport you back to your middle school days.

Smelling, hearing, tasting, seeing: all fantastic, but if there's one thing that popular music taught us, is that when it comes to our senses, we're all about touching. We've got songs about magic touches and golden touches, invisible and human touches. Songs about touching ourselves, touching me, touching you, and even what you can't touch.

Touch is extremely important, especially during early development. Baby monkeys that are allowed to see, hear and smell, but not touch their mamas become extremely distraught. That's a mean experiment. Premature human babies gain weight faster if they're held and massaged, and some studies indicated that children that didn't receive enough physical attention as infants are at higher risk for emotional, behavioral, and social problems as they grow.



Your sense of touch is actually a combination of four distinct skin sensations: pressure, *warmth*, *cold*, and *pain*. If you touch various spots of your skin with something soft, you'll feel that you sense different amounts of softness on different parts of your body.

The same goes for a warm mug, or an ice cube, or a needle point. You'll sense that some spots are more or less sensitive to each of the four distinct sensations. *Ultimately, your sense of touch joins forces with sensors in your bones, joints, and tendons to provide your personal kinesthesis*: *the way that body senses its own movement and positioning.* You use your kinesthetic sense whenever you walk, dance, swim, or hula hoop. It's what the cops are testing drunk people for when they ask them to touch their noses with their eyes closed.

The partner sense to your kinesthesis is *your vestibular sense*, *which monitors your head's position and your balance. This sense of equilibrium is ruled by the pretzel-shaped*, *semicircular canals, and the fluid-filled vestibular sacs*, *that connect those canals to the cochlea in your inner ear.* So, if you spin around a bunch and suddenly stop, it'll take a minute for that inner ear fluid to return to normal, which is what makes you feel dizzy. That moving fluid is actually fooling your brain into thinking your body is still spinning. It's a good example of how even our normal functioning senses can fool us.

For now, hopefully you realized that your homunculus, or that little guy in your brain, is actually kinda beautiful, in his own way, because you learned how your sense of hearing, taste, smell, and touch work.

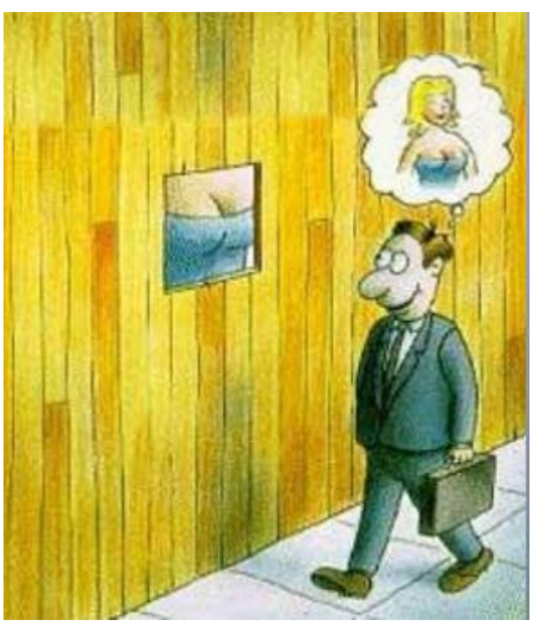
#7 Perceiving is Believing

[Adapted from Crash Course Psychology with Hank Green, written by Kathleen Yale, edited by Blake de Pastino, with psychology consultant Dr. Ranjit Bhagwat]

"Every rose has its thorn"
"Only the good die young"
"Slow and steady wins the race"
and "What you see is what you get".

Except that in reality: several varieties of roses do not have thorns, both the good and the bad on occasion tragically die young, fast and steady beats slow and steady every time, and what you see is, well.... And did you know that your eyes actually see things upside down? It is true.

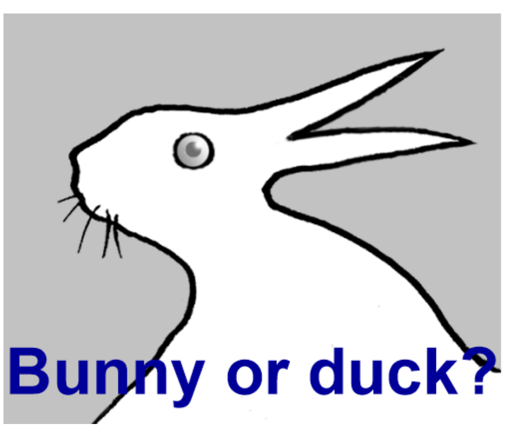
Your expectations are just one factor in your perceptual set: the psychological factors that determine how you perceive your environment. Sometimes, seeing *is* believing, but perceptual set theory teaches us that believing is also seeing.

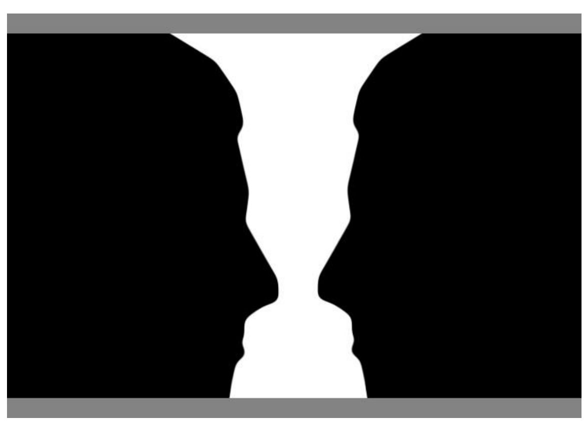


Context is another factor in your perceptual set. If you asked a friend to hold your white bunny, and you instead gave them a white rat, they may hold and stroke it for a few seconds before realizing that what they are stroking was not a bunny at all. And then they might scream.

And that's an example of how *culture* is also an important part of our perceptual set, because in our culture, rats are generally thought to be disgusting creatures As much as our perceptions are affected by context and expectations, they're also swayed by our emotions and motivations. People will say a hill is more steep if they are by themselves, than if they're walking with a friend.

Most of the time, your perceptual set leads you to reasonable conclusions, but they can be misleading or even harmful. They're the basis of tons of entertaining optical illusions. And while all the fooling of our visual perception can be fun, it also helps us understand how it works. Our minds are given a tremendous amount of information, especially through the eyes. But we've come to discover that it is quite complicated, so complicated that we have a name for it: "form perception."





The figure ground relationship is how we organize and simplify whatever scene we are looking at into the main objects, or figures, and the surroundings, or ground, that they stand our against. The classic "faces or vases illusion" is an example. Is it two faces against a white background or a vase against a black background? If you look long enough, you'll see that the relationship between the object and its surroundings flip back and forth, continually reversing. Sometimes white is the figure and black is the ground. That figure-ground dynamic, though, is always there.

The concept applies to non-visual fields as well. Say you're at a party, holding up the wall, and you're creeping on your crush across the room, trying to casually listen in on what he or she is saying. As the focus of your attention, his or her voice becomes the figure, while all the other voices jabbering about sports, beer pong, and everything that doesn't have to do with that one beautiful person all becomes the ground. That large shape on the couch is a person, and that person isn't just any person, but the specific unique person of your dreams. *One way our minds shuffle all of these stimuli into something coherent is by following rules of grouping, like organizing things by proximity, continuity, or closure.*

The rule of proximity for instance, simply states that we like to group nearby figures together. So instead of seeing a random garble of party-goers, we tend to mentally connect people standing next to each other *We're also drawn to organize our world with attention to* continuity*: perceiving smooth, continuous patterns and often ignoring broken ones.* We also like closure, and not just after a break up. What does that mean in terms of vision? *Visually, we want to fill in gaps to create whole objects. This is known as closure.*

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Form perception is obviously crucial to making sense of the world, or, you know. But imagine trying to navigate the world without depth perception. As you gaze upon your one true love, the image hits your retina in two dimensions. Yet somehow, you're still able to see the full three dimensional gloriousness of their form. You can thank your depth perception for that.

Depth perception is what helps us estimate an object's distance and full shape: in this case, a nice shape that is currently too far away from you. It is at least partially innate. Even most babies have it. *We're able to perceive depth by using both binocular and monocular visual cues.* Binocular *cues, as the name gives away, require the use of both eyes.* Because your eyes are about 2.5 inches apart, your retinas receive ever-so-slightly different images. *Monocular cues to help us to determine the scale and distance of an object*. These are things like relative size and height, linear perspective, texture gradient, and interposition . So when you're looking with both of your eyes, your brain compares the two images to help judge distance. The closer the object, the greater the distance between the two images, also known as the *retinal disparity*.

Retinal disparity's pretty easy to see, you just hold your fingers up and then you look past them, and suddenly you have four instead of two fingers. Because those left and right images vary only slightly, retinal disparity doesn't help much when it comes to judging far-off distances.

Relative size allows you to determine that your friend is not wearing the Washington Memorial as a hat, but rather the Washington Memorial is in the distance behind him.

If you've ever made a perspective drawing in art class, you'll remember that parallel lines appear to meet as they move into the distance. The sharper the angle of convergence, and the closer the lines are together, the greater the distance will seem. If you've ever looked out at a mountain range, you'll understand texture gradient as the cue that makes the first ridge appear all rocky and textured, but as your eye follows the ridges into the distance, they become less detailed.

And finally, our interposition, or overlap cue tells us that one object, (the man on the beach below), is far closer to the camera than the woman he appears to be holding. We know it is an optical illusion, so we perceive the man as being closer.

We use motion perception *to infer speed and direction of a moving object.* Your brain gauges motion based partly on the idea that shrinking objects are retreating, and enlarging objects are approaching. *The thing is, your brain is easily tricked when it comes to motion. For instance, large objects appear to move much more slowly than small ones going the same speed*. So it goes.

Perceptual constancy is what allows us to continue to recognize an object regardless of its distance, viewing angle, motion, or illumination. Even as it might appear to change color, size, shape, and brightness, depending on the conditions. Like we know what a football looks like, whether it looks like this, this, this, or this.

Consciousness - Crash Course Psychology #8

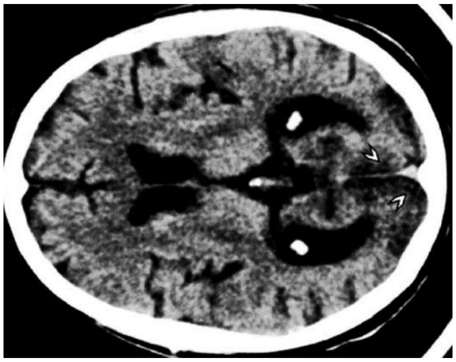
[Adapted from Crash Course Psychology with Hank Green, written by Kathleen Yale, edited by Blake de Pastino, with psychology consultant Dr. Ranjit Bhagwat]

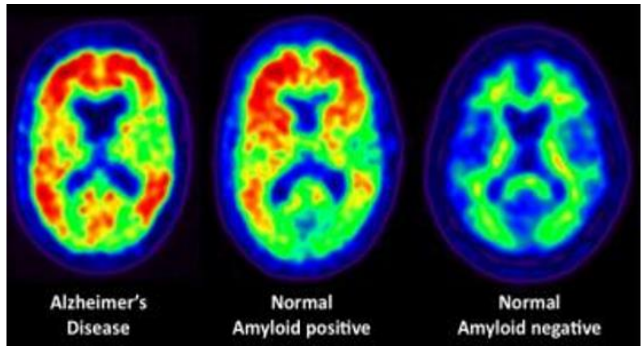
Throughout our daily lives we flit back and forth between various states of consciousness, including waking, sleeping, and various altered states. *These can occur spontaneously, like dreaming, or be physiologically sparked, like a drug-induced hallucination, or be triggered psychologically, through meditation or hypnosis.*

We're going to take the next three episodes to look closely at these different states of consciousness, but let's start with what it really means to be awake. For centuries, scientists learned what they could about the brain solely through clinical observation. And they learned a lot, for sure, but with today's technology, we're actually able to see some of the structures and activity inside a living, working brain - its electrical, metabolic, and magnetic signatures displayed on screens for our wonder and amusement.

The field of *cognitive neuroscience is the study of how brain activity is linked with our mental processes, including thinking, perception, memory, and language.* Like other kinds of neuroscience, it uses neuroimaging technologies to consider links between specific brain states and conscious experiences.

Structural imaging *shows the brain's anatomy, and is useful in identifying large-scale tumors, diseases, and injuries.* In contrast, *functional imaging shows us electromagnetic or metabolic activity in the brain, like blood flow, to let us observe correlations between specific mental functions and activity in particular brain areas.*





Neuroimaging has been revolutionizing the field of psychology, much like telescopes and microscopes did for astronomy and biology. But some of this technology is very new, and there's plenty of disagreement about how to interpret neuroimaging findings. Remember, correlation does not equal causation. So, activity in a certain brain region while having certain kinds of thoughts might be useful to know, but it's not the end of the conversation.

We've already talked a lot about how function is often localized in the brain and how everything psychological is simultaneously biological--so it stands to reason our thoughts and emotions could in part be illustrated by a bright flare on a dark screen. *We've also collected a fair amount of evidence that we don't just have one layer of consciousness - a single tape playing various tunes - but rather, something more like two layers,* each supported by its own personal bio-psycho-social pit crew.

I'm talking about one of the dual process models of consciousness--the idea that our conscious, deliberate mind could be saying: "Look - a squirrel!" while our implicit, automatic mind is simultaneously subprocessing like a computer: color: brown, tail: bushy, movement: climbing, distance: 20 meters, All of this can weigh upon my behavior upon seeing the little guy.

By some estimates, all your senses are scooping up nearly 11 million bits of information, EVERY SECOND. And yet, you consciously register only about 40 at a time. So how do we keep focused and filter out all the chatter to actually get stuff done?   With selective attention, of course!

Selective attention is how we focus our consciousness on one particular stimulus or group of stimuli, effectively tuning out the rest. Your consciousness is like a spotlight on a busy stage. There are other things going on around you that your automatic, subprocessor brain is covertly registering. But for those moments when you shine your spotlight, most of the other stimuli fall away.

Try it at home! Right now, you're consciously watching this lesson on consciousness. You probably don't notice the feel of your socks on your feet, or the tongue that's inside your mouth, always filling up your mouth with tongue! But as soon as I mention it, the spotlight of your attention turns to them, you feel those socks on your feet, and you're like wow! It's weird that there's a tongue in my mouth!

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The classic auditory example of selective attention is the cocktail party effect. You could be in a room with 47 people jabbering away, and yet be able to concentrate your hearing on one conversation, tuning out the rest of the voices and background music. *But, if the couple next to you were to speak* *your name, suddenly your cognitive radar would light up and your attention would whip around to the sound of your name.*

This roving spotlight of selective attention is pretty handy most of the time, for spies and laypeople alike. But it can also be dangerous, if you're being dumb, and say, texting and driving. *When you shift your primary selective attention from driving to OMG, LOL, YOLO, you also unwittingly activate your selective inattention*, which means that you failed to see that cyclist whom you almost ran over, which would not only have ruined her life but also yours so DON'T TEXT AND DRIVE!

In fact, *when your full attention is directed elsewhere, you'd be astounded by the scope of obvious things you fail to notice. It's called inattentional blindness.* You may have even already been subject to one of the most famous experiments of inattentional blindness...the Invisible Gorilla or, sometimes, the Moonwalking bear. Just google either of those things if you want to be tested on your awareness and then come back.

Given the prompt to count the number of passes one team makes, your consciousness is focused on following the players and the ball, nothing else. You don't see the players in black, they're the distraction... also you certainly don't see the dancing gorilla...or bear...whichever one. The original version of this experiment found that about 50% of people didn't notice that there was A GORILLA WALKING THROUGH THE ROOM! THAT is how powerfully selective our attention can be.

But you know who understands and exploits inattentional blindness better than anyone? Magicians! Except they call it misdirection. Famous modern magician Teller, of Penn and Teller, says, "Every time you perform a magic trick you're engaging in experimental psychology." And we can't help but be rubes. *Magicians also prey on our change blindness, the psychological phenomenon in which we fail to notice changes in our environment.* And no, I don't mean climate change. I mean the failure to recognize the difference between what was there a moment ago, versus what is there now.

In a well-known and often-copied experiment, sometimes called the "person swap," an experimenter will stop someone in a park and ask for directions. And then, during some staged interruption, the original experimenter will leave and be replaced with a totally different person. Half the time, the subject doesn't even notice. Fun!

One of the many perks of studying psychology is you learn all kinds of new ways to mess with people! But while *change blindness* makes for some really cool parlor tricks, this failure to notice certain things *can be dangerous -- say, faulty memories lead to false eyewitness testimonies in court,* or when friends get deadlocked in a he-said, she-said disagreement.

So, my friends, use The Force. But use it wisely. As one of my favorite psychologists once advised: “A Jedi uses the Force for knowledge and defense, never for attack.” Actually, that was Yoda.

Anyway, the bottom line is, we are far less aware of what’s going on around us than we think we are. And that’s just when we’re awake! Imagine what might slip your notice when you’re half-asleep, drunk, hypnotized, or hallucinating! That’s what we’re gonna talk about next time.