

ON MEMORY

How does memory work and how do memories shape us as individuals? I am interested in the science of memory and why people remember what they remember and, in contrast, forget what they forget.

I turned to video as my primary medium to explore this topic. A large quantity of childhood memories involve my two older sisters. This project was an opportunity to examine my sisters' memories, using them as a vehicle to engage my own self-inquiry. I collected footage of my sisters to create an intimate and personal video about my experience and notions revolving around memory.

I have always been concerned about the state of my memory. I often find myself worrying that I will forget moments that really shouldn't be forgotten. Sometimes, when something important is happening to me, I'll catch myself questioning whether or not I will remember the moment after it has passed. I am always looking for a way to reassure myself that my memory still works. For the most part, this desire to preserve memory is irrelevant because neurological science proves that I should not worry about it. Unless I want to train myself to remember sets of zeroes and ones or the terms for a biology test, my brain has it all under control. We can trust ourselves to remember the important moments in life.

Sarah

When I was young my Mom told me that if you find a penny on the ground and give it to the first person you see, you will both have good luck. Remembering this piece of advice has always been easy. I mean, it's pretty good advice. If you do find a penny on the ground, you should give it to the first person you see. Trust me. It's good luck.

To Lucy and Emma—

I mostly felt alone when it came to remembering things. I know for sure that a lot of my memories are true. I think. At least I know that we used to sit in the backyard eating orange creamsicles. We were warm partly because it was mid-September in California, and partly because we thought Mom's quilt covering us was the most beautiful thing we'd seen. Hand stitched, pinks and reds and greens. Some kind of symbol, speaking for warmth and comfort and beauty. Some of my memories don't agree with you. Some of your memories don't agree with me. Sometimes they'll contrast one another and we remember things completely differently. I guess that's actually okay. Memory is definitely not an inert stack of zeroes and ones. Memories are dynamic and creative. On a literal level, making a memory is an act of creating. There's a reason why my memory of the day Leo Soucek Sr. died is different from yours. When discussing memory, we have a tendency to downplay the complexity of the process of memory making into simplified metaphors and analogies. Many scientists and researchers have proven memory to be one of the most elusive and misunderstood human attributes.¹ Every time you remember something, you recreate that memory. That means that, technically, each time you remember something, it is a brand new memory. A little different each time it's remembered. There is no such thing as "a memory for all time". All you've got is the most recent recollection of that experience. The more you remember something, the less accurate it becomes.² The more it becomes about you, the less it becomes about the actual act. I guess that's the reason why my memory of Leo Soucek Sr.'s funeral is different from yours. Sure, we both remember running into Dad's arms after the reception and telling him that we were sorry. I remember the itch of his wool coat and you remember the taste of your tears. I do think though, that we both remember the feeling. I think that was the first time I ever felt truly regretful. I kept picturing us at Dad's funeral. Would I cry the same way I cried here? Would I feel less or more than I'm feeling right now? I should feel more... right?

I do remember the first time I ever kissed a boy. But, more specifically, I remember trying to remember the kiss after it happened. I replayed it over and over again in my head. I am now convinced that my memory of my first kiss is not even close to accurate. It's more a memory of how I felt when trying to remember what it was like to be kissed by a boy for the very first time. The more I used that memory, the more it changed into a projection of my emotions about being kissed. The safest memories, are the memories in the brains of which people can not remember.³ Whenever you create a memory, it's an act of cellular construction. A memory is a structure that connects one thing to another, neurons build together to form a memory. Many different cells in my brain are physically connected to each other, telling each

¹ "Your Brain: The Missing Manual" by Matthew MacDonald (Pogue Press/O'Reilly, 2008)

² Neisser, Ulric (1982). Memory observed: remembering in natural contexts. San Francisco: W.H. Freeman. ISBN 0-7167-1372-1. OCLC 7837605.

³ Escobedo, Jacob. "Neuroscientist Daniela Schiller Is Researching Ways That Bad Memories Can Be Made Less Fearsome | MIT Technology Review." MIT Technology Review. N.p., 17 June 2013. Web. 12 Nov. 2015.

other about the times we flew to DC for Christmas and had to have two Christmases: one with Grandma and Grandpa in Maine and one with Nana and Pop-Pop in DC. Different cells trigger other cells and remind them of these memories. Whenever I hear Kurt Vile, I will never *not* think of you both. Memory, in short, is the process of taking events or facts and storing them in the brain for later use.⁴ They leave a physical trace in your brain. Proteins form together to make you recall certain events and subjects which can be known as stimuli. There are three types of memory: sensory memory, short-term memory, and long-term memory.

Sensory memory is the shortest-term memory. Sensory memory gives you the ability to retain impressions of sensory information after the original stimuli have ended. This section of memory acts as a buffer for stimuli received through the five senses of sight, hearing, smell, taste and touch, which are retained accurately, but very briefly.⁵ Being able to look at something and remember what it looked like with just a second of observation is all your sensory memory's doing. Remember the time we went to look at puppies and we saw Simon and Theodore? Yes, I was able to retain my first impression of Simon shortly after I met him all thanks to my sensory memory. The stimuli detected by our senses can be ignored on purpose, in which case they disappear almost instantly, or perceived, then they enter our sensory memory. This doesn't require any conscious attention and is totally out of our control. The brain is designed to only process information that will be useful at a later date, and to allow the rest of the information to pass by without being noted. This is beneficial because it eliminates unnecessary information and essentially saves space for only the important and useful information. Sensory memory is an ultra-short-term memory and degrades very quickly, less than a second after the perception of something.⁶ While it lasts for such a short time that it is often considered part of the process of perception, it nevertheless is an essential step for storing information in short-term memory. The sensory memory for visual stimuli is sometimes known as the "iconic memory", the memory for aural stimuli is known as the "echoic memory", and touch is known as the "haptic memory".⁷ Smell may be more closely linked to memory than the other senses because the olfactory bulb and olfactory cortex (where smells are processed) are very close to the hippocampus and amygdala (which are involved in memory processes).⁸ This means that smells may be more quickly and more strongly associated with memories and their associated emotions than the other senses. My memory of mom taking us skating behind our house in Pine Hill will always be linked to the smell of hot chocolate. Every single time we went skating, without fail, there would be a thermos of cocoa. I am not sure how much skating actually got done on my part, but I do know for sure there were times when I would sit next to the frozen pond watching you twirl and move in pretty ways, trying to sip steaming cocoa that almost always burned my tongue. Information is passed from the sensory memory into short-term memory through the process of attention. Attention is the process of selectively concentrating on one aspect of the something while ignoring other things.

Short-term memory acts as a platform for temporary recall of the information which is being processed at any point in time. Sometimes it's referred to as "the post it note" of the brain.

⁴ "Your Brain: The Missing Manual" by Matthew MacDonald (Pogue Press/O'Reilly, 2008)

⁵ Winkler, Istvan; Nelson Cowan (2005). "From Sensory to Long-Term Memory Evidence from Auditory Memory Reactivation Studies". *Experimental Psychology* 52 (1): 3–20.

⁶ T.L. Brink (2008) *Psychology: A Student Friendly Approach*. "Unit 7: Memory." pp. 120

⁷ Pinker, Steven. *How the Mind Works* (W. W. Norton & Company, 1999).

⁸ "Why Sense of Smells Can Trigger Strong Memories." *Mercola.com*. N.p., n.d. Web. 13 Nov. 2015.

Short term memory is thought of as the ability to remember and process information at the same time. It holds a minimal amount of information in mind in a readily available state for a short period of time. If you're having a conversation with me, and while you're listening to me speak you are simultaneously remembering a persuasive argument to throw at me after I finish talking, you would be utilizing your short-term memory. What is actually held in short-term memory isn't complete concepts but links or pointers which the brain can flesh out from its other accumulated knowledge.⁹ Information held by your short-term memory will quickly disappear unless you make a conscious effort to retain it. Short-term memory is a necessary step toward the next stage of retention, which is long-term memory. The transfer of information to long-term memory for more permanent "storage" can be improved by mental repetition of information. Something that might be even more effective than that is giving it a meaning and associating it with other previously acquired knowledge.¹⁰ Motivation is also reason for people to remember certain things: information relating to a subject of strong interest to a person is more likely to be retained in long-term memory. I don't necessarily care about Algebra II right now. It confuses me and I get easily discouraged by difficult and daunting problems. However, I do care about my SAT score and its relation to the college acceptance letters I'll (hopefully) receive in the future. Whether or not I care enough about the SAT to try to change my thoughts about Algebra II is a good question. If I do care, and I somehow find the motivation to devote myself to mastering Algebra II, my memory would have reason to work hard and help me out a bit in preparation for college applications. I care about these math problems.

Long-term memory is intended for storage of information over a long period of time. It seems likely that long-term memory decays very little over time and that it can store a seemingly unlimited amount of information almost indefinitely. The more you know. There are some things we may never forget. I probably won't ever forget the way it feels to hug you after an entire summer apart. There is also something I have noticed. When we are all three together, there is a way I laugh that can't be done unless you're both there. I don't know what it is, but for some reason, it happens and it only happens when we are all together. I will never forget the way it feels to laugh with you both by my side. There is some debate as to whether people actually ever "forget" anything at all, or whether it just becomes increasingly difficult to access certain information from our memory.¹¹ Short-term memories can become long-term memories through the process of consolidation which involves rehearsal and meaningful association.¹² Excellence through repetition. Long-term memory encodes information for storage based on meaning and association. There is also some evidence that to some extent long term memory encodes by sound. For example, when someone can't remember a word but it is "on the tip of the tongue", this is usually based on the sound of a word, and not on its meaning. The establishment of long-term memory involves a process of physical changes in the structure of neurons in the brain. This process is known as long-term potentiation.¹³ At its simplest, whenever something is learned,

⁹ Baddeley, A. D.; Thomson, N.; Buchanan, M. (1975). "Word length and the structure of short term memory" (PDF). *Journal of Verbal Learning and Verbal Behavior* 14

¹⁰ Nikolić, D.; Singer, W. (2007). "Creation of visual long-term memory". *Perception & Psychophysics* 69 (6): 904–912. doi:10.3758/bf03193927.

¹¹ Vogel, Edward, and Tafton Drew. "Why Do We Forget Things?" *Scientific American Global RSS*. University of Oregon, n.d. Web. 19 Nov. 2015.

¹² Baddeley, A.D.; Hitch, G.J.L (1974). "Working Memory". *Q J Exp Psychol* 18 (4): 302–9.

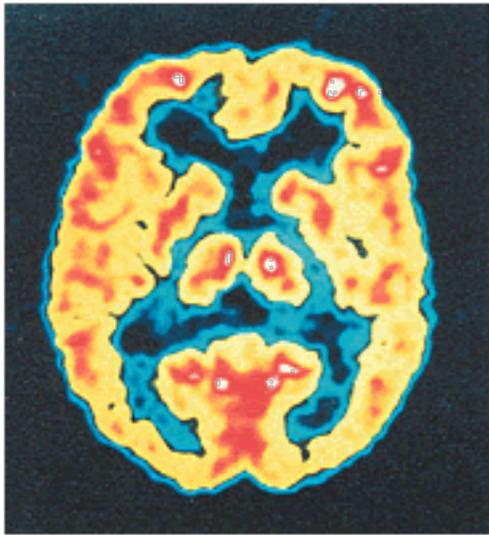
¹³ Paradiso, Michael A.; Bear, Mark F.; Connors, Barry W. (2007). *Neuroscience: Exploring the Brain*. Hagerstown, MD: Lippincott Williams & Wilkins. p. 718. ISBN 0-7817-6003-8.

circuits of neurons in the brain, known as neural networks, are created, altered or strengthened. These neural circuits are composed of a number of neurons that communicate with one another through special junctions called synapses.¹⁴ Through a process involving the creation of new proteins within the body of neurons, and the electrochemical transfer of neurotransmitters across synapse gaps to receptors, the communicative strength of certain circuits of neurons in the brain is reinforced.¹⁵ With repeated use, the efficiency of these synapse connections increases, facilitating the passage of nerve impulses along particular neural circuits, which may involve many connections to the visual cortex, the auditory cortex, and the associative regions of the cortex. This process is different both structurally and functionally from the creation of working or short-term memory. The short-term memory is supported by transient patterns of neuronal communication in the regions of the frontal, prefrontal and parietal lobes of the brain, long-term memories are maintained by more stable and permanent changes in neural connections widely spread throughout the brain. The hippocampus area of the brain essentially acts as a kind of temporary transit point for long-term memories. It is not itself used to store information. But it is essential to the consolidation of information from short-term to long-term memory. It's thought to be involved in changing neural connections for a period of three months or more after the initial learning. Unlike with short-term memory, forgetting occurs in long-term memory when the strengthened synaptic connections among the neurons in a neural network become weakened due to lack of stimulation over time, or when the activation of a new network is superimposed over an older one (causing interference in the older memory.) Although your long term memory is capable of storing many important and meaningful things, dementia is an incurable disease that prevents people from accessing their old memories.

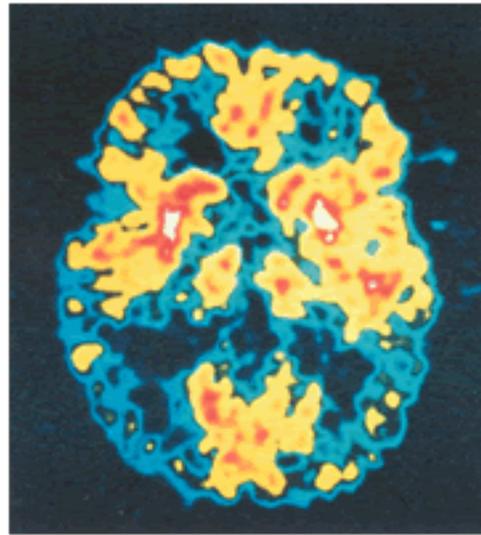
¹⁴ Nikolić, D.; Singer, W. (2007). "Creation of visual long-term memory". *Perception & Psychophysics* 69: 904–912. doi:10.3758/bf03193927.

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BRAIN SCANS HELP IDENTIFY ALZHEIMER'S



NORMAL



ALZHEIMER'S

Brain scans done with Positron Emission Tomography (PET) show how Alzheimer's affects brain activity. The left image shows a normal brain, while the right is from a person with Alzheimer's. The blue and black areas in the right image indicate reduced brain activity resulting from the disease.

Images courtesy of Alzheimer's Disease Education and Referral Center, National Institute on Aging

Do you remember how mom always used to talk about her fear of developing Alzheimer's disease? I don't know if you've noticed this too, but I don't think she talks about it as much anymore. Either she's forgotten, or she really does believe she'll have some type of dementia. Maybe she believes it enough, so much, that it's become too real to joke about anymore. I don't know if there is anything scarier than thinking about your mom developing a slow and fatal disease of the brain. I guess the scariest thing wouldn't be the thoughts, but the act of it happening. The disease comes on gradually as two abnormal protein fragments called plaques and tangles accumulate in the brain and kill brain cells.¹⁶ They start in the hippocampus, the part of the brain where memories are first formed. Over a long period of time, many years, the plaques and tangles slowly destroy the hippocampus and it becomes harder and harder to form new memories.¹⁷ Simple recollections from hours or a few days ago cease to exist in the brain. Yeah, she probably won't remember what we had for breakfast this morning. After that more plaques and tangles spread into different regions of the brain, killing cells and compromising different functions of the brain. This spreading around is what causes different stages of Alzheimer's. From the hippocampus the disease spreads to the region of the brain where language is processed, after that happens it gets increasingly harder to find the right

¹⁶ Burns A, Iliffe S (5 February 2009). "Alzheimer's disease". *BMJ* 338: b158. doi:10.1136/bmj.b158. PMID 19196745.

¹⁷ Berchtold NC, Cotman CW. Evolution in the Conceptualization of Dementia and Alzheimer's Disease: Greco-Roman Period to the 1960s. *Neurobiology of Aging*.

words. It moves to the front of the brain where logic is processed. She'll lose the ability to solve problems, grasp concepts, and make plans. Next the plaques and tangles invade the part of the brain where emotion is regulated. She'll gradually lose control over moods and feelings. We'll probably still be able to go to the farmer's market with her, we'll just have to remind her that she wants to. Then the disease moves to where the brain makes sense of things it sees, hears, and smells. That's pretty much it, it's up to the disease now I guess. Eventually the plaques and tangles go to the back of the brain and are able to erase a person's oldest and most precious memories. For the first time in all of the years of my life I think I will know myself better than my mother knows me. I am not sure though. Near the end, the disease compromises a person's balance and coordination and in the very last stage, the disease destroys the part of the brain which regulates breathing and the heart.

Sometimes our memories don't really agree with each other. I remember one thing, you remember another. That's okay. It's an intricate, complex and individualized process. It doesn't rely on any one factor or influence to shape itself. What's important to me, may not be important to you. Ultimately, you will remember things the way you felt or the way you thought you felt.

I remembered what she said. I just found a penny on the ground and I gave it to the first person I saw. Now we both have good luck. Thanks, Mom.

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