mind

Issue 4: The Subconscious | Fall 2020

Cover by Amy Wang

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Letter From the Editors

Dear Reader,

2020 is almost to an end, and to that we raise our glasses. But after an awkward virtual cheers, let's slowly bring them down and ground ourselves for a moment: we've been in 9 months of prolonged social isolation and unprecedented technological adoption. In this time, we've adapted to a world which a year earlier would have been viewed as a distant Black-Mirror-esque techno society that tends more towards the "dys" prefix of -topia. Political and societal tensions have been set aflame in part due to the fragmenting of our collective cognition. With every device delivering a personalized information stream, we now find ourselves in disagreement about even the most basic facts.

Each of us reacted to this changing world in vastly different ways. From compulsively baking banana bread to protesting in the street, we found ourselves making decisions and adjusting to the new reality in ways we didn't completely understand. With emotions running high and motivation running low, it was hard to be our most rational selves this year. This feeling of a chasm between our intentions and our actions was deeply puzzling, and as a team, we felt we had to explore it. This led us to our theme for Mind Issue 4 -- The Subconscious.

To most of us, the subconscious mind is the ultimate black box: experiences go in, decisions come out. So in this issue, our writers attempt to understand and demystify the subconscious mind. We unpack the way pain, sleep, and exercise all affect our daily patterns of thinking. We uncover the nuances behind deja vu, hypnosis, and facial distinction. But we also attempt to give our readers tools to access parts of the subconscious mind. We explore learned helplessness and how to break the cycle with positive affirmations; implicit racial bias and how to unlearn it on a psychological level. We even dive into psychedelics, mindfulness, and the question of free will.

Each of our writers did extensive research during times of immense stress, pouring their hearts and minds into the pages you see before you. We are proud of all the hours of hard work that it took to put this collection together. Thank you to the writers, design team, collaborators and supporters for making this issue possible.

May what lies ahead challenge you to look outside of yourself and search within.

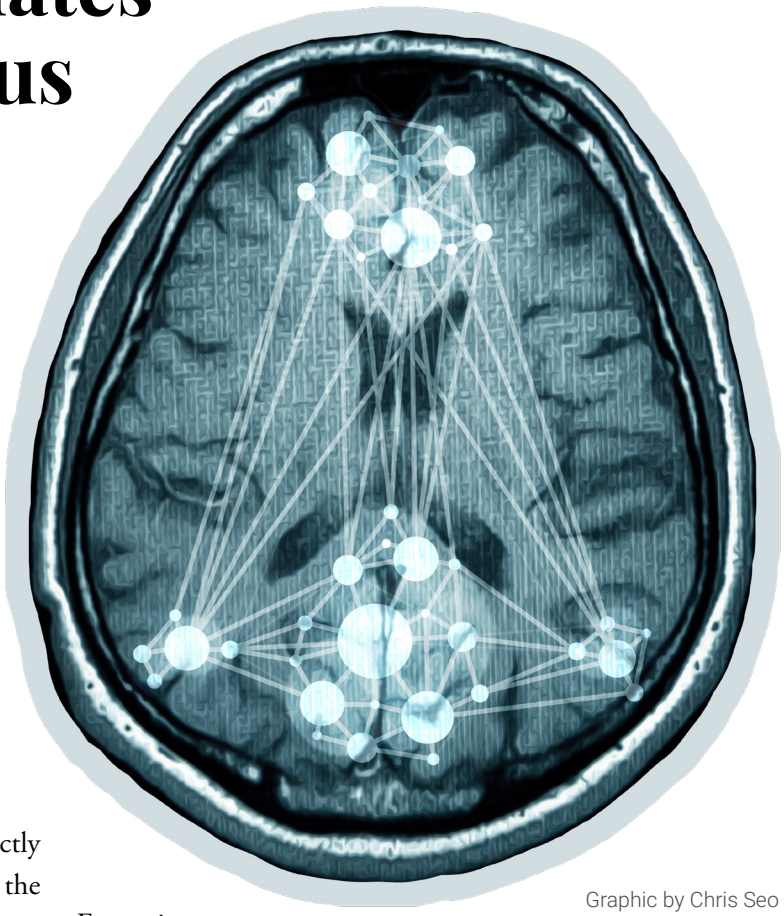
With love,
Lillian and Kyle

understanding the subconscious

Design by Amy Wang

The Neural Correlates of the Subconscious

By Luc LaMontagne



Graphic by Chris Seo

The Mysticism of the Subconscious

Freudian stereotypes and mental clichés have long mysticized the human subconscious. Pinned as a foggy, alien, dark, and subaquatic region of the mind, the subconscious has been gilded with shadows by popular culture. The subconscious is far more conscious than most people believe; with the right practices, the murky water of the mind can be cleared to expose the authentic character of your subconscious. Cognitive neuroscience helps to shed a light on the overlapping neural regions associated with conscious and subconscious functions.

Conscious vs. Subconscious Tasks

The subconscious, the part of the mind that is not directly within focal awareness, informs the conscious, the part of the mind that is. Certain conscious activities can help unveil the subconscious mind, these activities require increased informing by the subconscious mind, and therefore, can be used to reconstruct the subconscious. This works in the same way that a painting provides insight about the paint, or in the way that an entreé provides insight about the ingredients, while the artist or chef is the conscious mind.

Typically, conscious functions include intentional actions such as most skeletal movements, decision making, or subvocalization. These functions require conscious intent and action. Other functions are typically subconscious. These include memory formation, body language interpretation, or pupil dilation. These functions occur naturally when a person is awake and usually accompany conscious activities. Other functions are simultaneously very subconscious and conscious. These include daydreaming, memory recall, and lucid dreaming. The functions that bridge the conscious and subconscious create a mental link that allows comprehension of one's own subconscious. These functions occur in parallel with a neural link between typically conscious and typically subconscious brain regions.

Engaging in different mental activities activates different parts of the brain. Conscious, goal oriented behavior and decision processing primarily activate the prefrontal cortex. For this reason, some scientists believe that a neural correlate of consciousness resides in the prefrontal cortex. While there is little evidence for a neural seat of consciousness, there are regions strongly associated with conscious processes such as the prefrontal cortex, the motor cortex, and Broca's area. In parallel, there is little evidence for a neural seat of subconsciousness, but there are regions strongly associated with subconscious processes such as the parietal cortex, sensory cortices, and subparietal regions.

The functions that are simultaneously very conscious and very subconscious similarly excite both the occipital and subparietal regions, notably memory formation and sensory processing. While memory formation is often associated with the hippocampus and other prefrontal regions, the hippocampus encodes information by creating indices of traceable connections throughout the brain, but primarily within the parietal lobe, and around the hippocampus. Sensory processing primarily excites specific sense-based zones, such as the sensory cortex

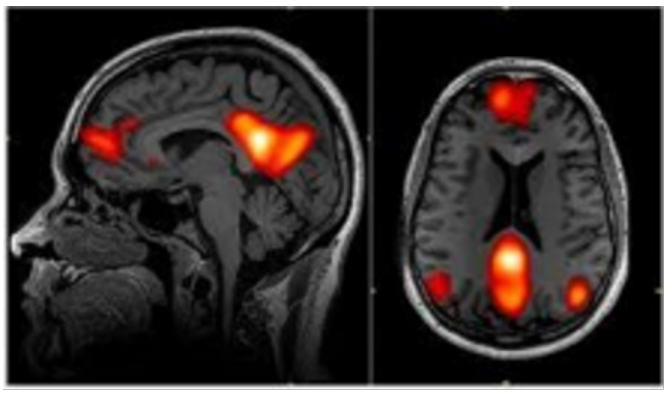
for feeling, or the occipital lobe for sight, etc, and the higher order processing occurs in the parietal lobe.

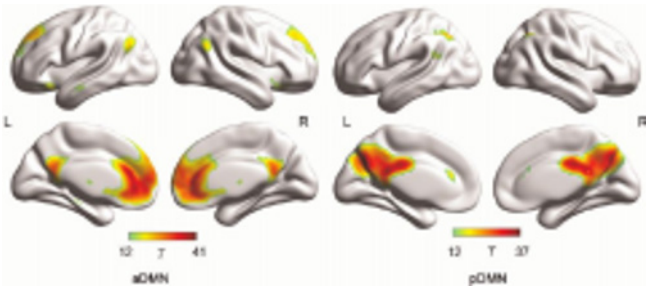
fMRIs and Functional Networks

Functional Magnetic Resonance Imaging, known as fMRI, records Blood Oxygen Level Dependent spikes, known as BOLD signals, that spatially correlate with brain activity. While most of the brain is active at all times, certain regions, both cortical and subcortical, are relatively hyperactive when the brain receives/processes certain inputs. Through fMRI, functional networks can be classified. Function networks are brain regions that experience parallel brain activity while the brain host engages in particular functions. Functional connectivity, "defined as the temporal dependence of neuronal activity patterns of anatomically separated brain regions, reflecting the level of functional communication between regions", contrasts with anatomical connectivity in that they are regions that experience substantial activity at the same time despite proximity or neuronal path strength.

Certain functional networks to know: The Default Mode Network, the Ventral Attention Network, and the Salience Network. Properly understood or even classified functional networks are those recorded during "resting state", the only experimentable state due to fMRI constraints. Despite limited understanding about them, functional networks can still teach us a lot about the mental correlates of brain regions.

The Default Mode Network is engaged when the mind is taskless. This network includes the primary regions associated with conscious and subconscious processing. I argue that the DMN is active when the conscious mind and subconscious mind are communicating.





DMN[2]

The Default Mode Network has two subsystems:

The anterior Default Mode Network (aDMN)

Composed of the "dmPFC, lateral temporal cortex, TPJ and temporal pole" these regions are heavily associated with decision making, emotional stabilization, and language production, etc. These functions fit within the definition of conscious activities such that we take the activities to be about an awareness of external existence.

The posterior Default Mode Network (pDMN)

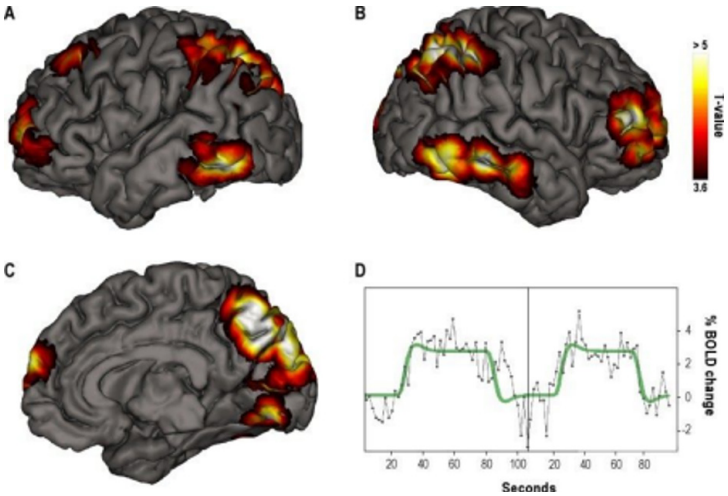
The second consists of "the ventral mPFC, hippocampal formation, parahippocampal cortex, retrosplenial cortex and posterior inferior parietal lobule." These regions are heavily associated with imaginative thought, high level sensory processing, memory encoding, etc. I consider these functions to be subconscious activities because they compose the parts of the mind that do not require attention, despite our ability to be aware of them.

Imagine the conscious mind and the subconscious mind as circles within a venn diagram. There is natural overlap, necessary for brain region communication. This gap might be used when the mind processes internal existence.

The subconscious feeds conscious functions such as the interpretation of stimuli, spontaneous and creative thought, and daydreams. When the default mode is active, a highway between subconscious brain regions and conscious brain regions is formed. Participating in practices that engage use of the prefrontal cortex and subparietal regions strengthens this bond. For that reason activities like daydreaming, which uses attention-exciting prefrontal regions and subconscious-driven-imagination excited subparietal regions, close the gap between the conscious and subconscious mind.

1 https://www.nature.com/articles/srep21001
2 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3393600/

Daydreaming, episodic memory recall, and contemplative processing are all times in which there is heightened connection between the aDMN and the pDMN. These activities engage the primary attention and memory regions. While these phenomena occur when attention and prefrontal functions engage the subparietal cortex, the reverse can occur. The subcortical region, in a state that is primarily subconscious as opposed to conscious, can trigger conscious activity. This occurs in lucid dreaming.



Lucid Dreaming fMRI: [3]
Notice the similarities between this fMRI and the DMN fMRI. They both have BOLD signals from the subparietal and prefrontal cortex.

Practices for Conscious Awareness of the Subconscious

The above listed functions are faculties of the brain that allow increased conscious perception of the subconscious. Being aware of the heightened subconscious-conscious connections during these activities can inform the perceiver. Subconscious connections often seem random or unfounded. Associations should not be dismissed simply based on their nonsenseness. These practices work similarly to dream analysis tactics, using free association like psychoanalysis. A random thought occurring right after thinking about a tangential topic is indicative of a subconscious connection between the concepts.

A few tips:

Smell

Think for instance of a particular smell. Close your eyes and imagine; is that smell coupled with an image? A tree, a meal, or a candle? There is a memory associated with this image that may be coupled with noises, other images and even feelings (I'm cold imagining a snowfall that leaves only the scent of pine in the air).

Or maybe you remember an instance in which a very particular smell made you retrace your memory to an exact instance. The same thing occurs to lesser degrees when all sensory stimuli are interpreted. For example, typically, smell is the sense that conjures memory recall best. Smells are recurrent and, while known smells might mix in new ways, new smells are rare to experience. The cingulate cortex, the region of the brain that processes smells, is conveniently located as a bridge between the prefrontal cortex and subparietal regions. One of the reasons that smell engages the subconscious so directly is because of the anatomical connection and spatial proximity between the cingulate cortex and the sub parietal cortex, despite smelling being a consciousness informing activity.

Daydreaming

Daydreaming is a natural activity that occurs during resting state default mode. Somewhat obviously, people often daydream when they're bored. Daydreaming neural correlates align well with the DMN. With evidence backing the neural association between the aDMN and the pDMN, we must engage with the practice to compare the mental composition of DMN usage.

Close your eyes and imagine a scenario. You may or may not be involved in the situation, there may or may not be a plot. You might just see a singular object or even a simple color. You might not see anything (this may be due to a lack of effort, thought dictating anxiety, or aphantasia). I recommend meditating before daydreaming as it will clear your conscious mind allowing more subconscious input. Analyze the images that arise and how they relate to previous images or the events of your day, especially significant events or the moment before imagination. Draw connections despite obscurity. If you still cannot see a mental image, see the references for an article on

3 https://pubmed.ncbi.nlm.nih.gov/22754049/

aphantasia— mind's eye blindness.

These are examples of phenomena that are both conscious— you're making decisions and implementing your will, and self aware in doing so— and subconscious— you're reconstructing from memory and present state perceptions, the details are implemented by the subconscious.

Why?

The subconscious and conscious crossover can be explained evolutionarily. First off it is advantageous to keep continuous extensive processing from attention. If this processing can be done in the background, it can be done in parallel and allow for increased attention on more relevant functions. Naturally, subconscious processing is advantageous because it allows interpretation and creativity, but most of all learning. The subconscious mind reimagines daily tasks to learn or perfect these functions. This is what is happening when a game of Tetris continues to run though your head after you have turned off the game, or when you keep surfing in your mind after a long day of surfing.

The crossover occurs for a similar reason. In order for the outcomes of subconscious processing to be implemented in the conscious mind, the conscious mind must have access to the subconscious, or vice versa. This occurs in memory recall, daydreaming or other similar dual processes as outlined through this publication. The purpose of other crossover effects are less clear. Our perception of mental reruns or lucid dreaming for example have little evolutionary explanation, and scientists are still seeking answers for these mysteries.

Conclusion

That teacher made a mistake by scolding you for daydreaming in class that one time. While you probably missed some of class by blocking off new input, you were integrating recent information into your subconscious network, your memories, and perspectives. Breaks from studying are necessary for natural information integration. (This is also why people often come up to the answers after "sleeping on" the problems.) You were doing something good for you. You were expanding your conscious awareness of your subconscious and fine tuning your Default Mode Network.

In summary, certain regions of the brain are associated with conscious and subconscious processes. Cognitive Neuroscience and fMRIs allows us to identify functions that use the DMN in a way that exposes the subconscious to the conscious. These functions then can be used to close the mental gap between the conscious and subconscious.

People should try to understand their subconscious better. People think of themselves as simply their conscious mind, or even their conscious mind and their body, but rarely consider how fundamental to the ego the subconscious is. A proper perspective of one's own murky underwater can provide a lens of clarity, showing in great detail even your most sunken depths. It can unlock the ability to get past bad habits, embrace your creative side, confront identity pieces, improve memory, and dissect your own mental health. These are only a few of the many potential results of increasing conscious awareness of one's subconscious. ☐

https://www.researchgate.net/publication/283959707_Neural_correlates_of_different_sel f_domains
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4061803/
https://www.jneurosci.org/content/39/28/5506
https://neurocritic.blogspot.com/2019/07/is-there-objective-test-for-aphantasia.html a. Aphantasia article

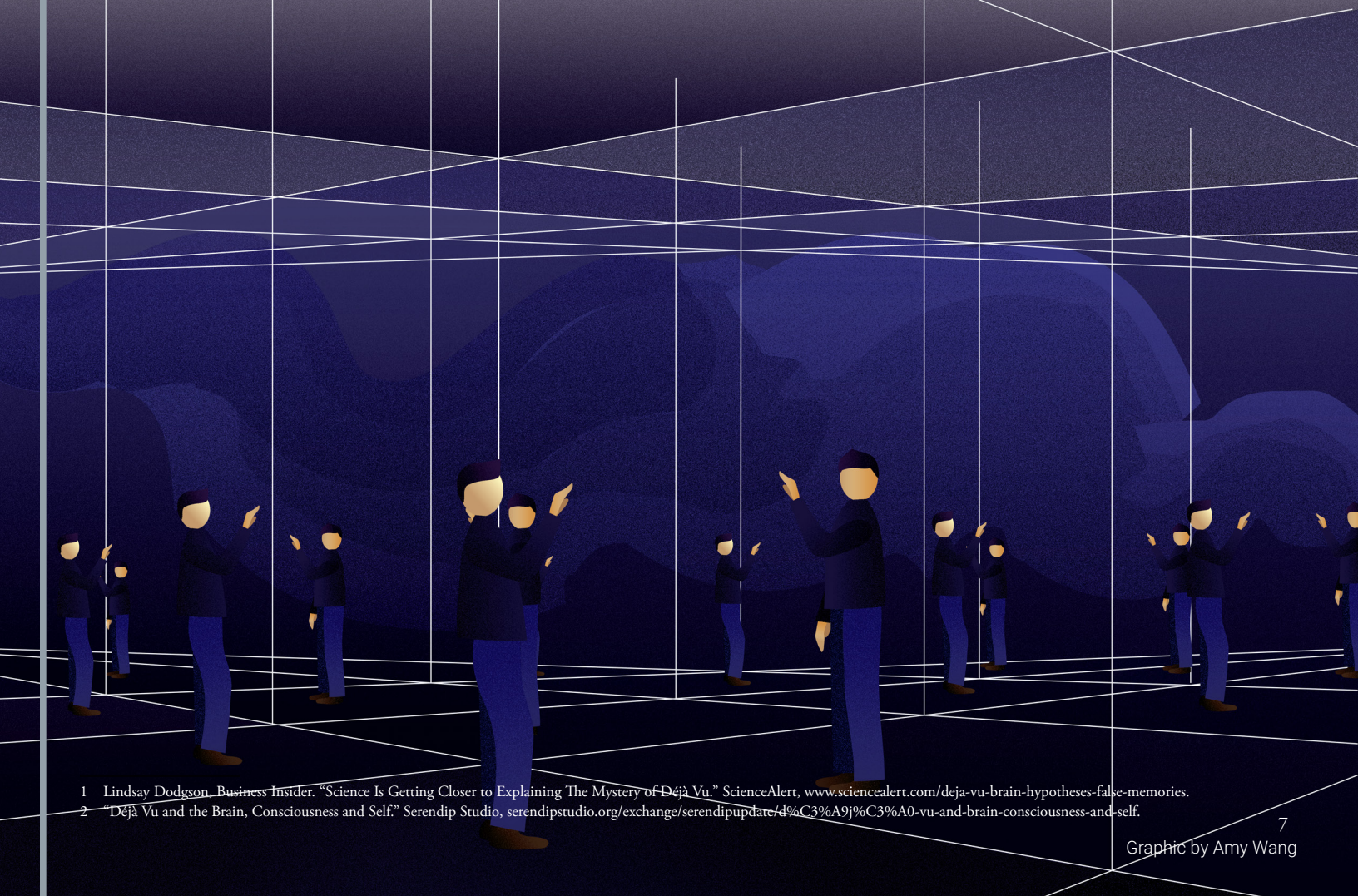
Unraveling the Mysteries of Déjà Vu

By Abe Niu

Do you feel like this has happened before? As in right now, sitting down, reading this magazine for some strange brain club at Berkeley you heard about. It couldn't be possible, right? Well most likely not. However, there's a really small chance you are currently experiencing the eerie feeling of déjà vu. French for "already seen", déjà vu is when one feels that they have lived through the present situation before — and it is something many have experienced at one point or another. The experience is sudden and fleeting, leaving as unexpectedly as it came. The aspects of this phenomenon that make it so intriguing are the same aspects that make this so difficult to study and understand. In this article, I hope to analyze some of the knowledge that we currently have about the déjà vu experience and uncover what these explanations could mean for our subconscious mind.

Due to the subjective and often indescribable nature of the associated feelings, it has been difficult to determine if there are patterns in the types of people who typically experience déjà vu. While there is no information on demographic variations, a survey/research study found that around 60–70% of people experience it, indicating that the feeling is fairly common.[1] The phenomenon occurs mostly in people between the ages 15–25, the stage in life when humans are more subject to notice minor environmental changes.[2] In an attempt to more clearly delineate between associated but different neurological experiences, researchers have come up with three primary types of déjà vu:

déjà vecu (already experienced)
déjà senti (already felt)
déjà visité (already visited)



1 Lindsay Dodgson, Business Insider. "Science Is Getting Closer to Explaining The Mystery of Déjà Vu." ScienceAlert, www.sciencealert.com/deja-vu-brain-hypotheses-false-memories.
2 "Déjà Vu and the Brain, Consciousness and Self." Serendip Studio, serendipstudio.org/exchange/serendipupdate/d%C3%A9j%C3%A0-vu-and-brain-consciousness-and-self.

Graphic by Amy Wang

Déjà vecu is the most common déjà vu experience and involves the sensation of having done something or having been in an identical situation before and knowing what will happen next. Although the experience is usually connected to very normal activities and only lasts a few seconds, it can often be recalled in incredibly detailed fashion. One experiencer says, "There came this strange, almost physical up-welling of visual experience, a visual warping, and at the same time an eerie realization that everything happening now had happened before, maybe many times".[2] In extreme cases, some patients of déjà vécu would withdraw from their current events or activities since they believed that they have participated in them before because of the familiarity, justifying their feelings of familiarity with beliefs bordering on delusion.

Déjà senti is different from déjà vecu in that the episode of recollection feels more like the recovery of long sought after information. The sensation is one of satisfaction at having retrieved a memory although the memory was not actively sought and tends to quickly dissipate from memory. Déjà senti has been strongly associated with the partial seizure experiences reported by temporal lobe epilepsy patients. Caused by unusual electrical activity in small areas of the brain, these partial seizures can last anywhere from a few seconds to 2 minutes long, but generally do not affect awareness.[3] Despite maintaining consciousness, however, you might not be able to react or respond during this time, sometimes from an outsider perspective appearing as if you are zoning out or staring off into space, lost in thought. These partial seizures tend to occur in the temporal lobe because of its centric role in processing memory and emotion, though the specifics are still uncertain. The conscious nature of these episodes has allowed for more detailed descriptions of the feelings associated with a déjà senti event. A patient recalled, "it was as if one of my dreams had simply been sucked out of the actual, physical environment and set to playing again in every detail".[2] Déjà visité is a more rare event in which a person visits a new place and feels that it is familiar. Unlike déjà vecu which is associated with situations and processes, Déjà visité is associated with spatial dimensions and structures. Déjà vu experiences can be in one of the three forms described above or it can be a mixed version with a combined déjà vu effect.

So what causes déjà vu? There is no single concrete answer, but experts have a few possible explanations — mostly revolving around memory.

The split perception theory suggests déjà vu occurs when you see something two different times. The first time you see something, you might take it in out of the corner of your eye or while distracted. Your brain begins forming a memory of what you see even with the limited amount of information you get from a brief, incomplete glance. Say your first view of a flowing river did not involve your complete attention; the next time you see it and fully pay attention to it, you might believe you're seeing it for the first time — except your brain recalls the previous peripheral perception, even if the awareness in your observation was lacking, resulting in déjà vu. In other words, since you didn't give the experience your full attention the first time it entered your perception, it feels like two distinct events, but it's really just one continued perception of the same event.

Another theory suggests déjà vu happens when your brain "glitches," so to speak, and experiences a brief electrical malfunction — similar to what happens during an epileptic seizure.[2] When the part of your brain that tracks present events and the part of your brain that recalls memories are both active, it can cause a brief mix-up. Your brain falsely perceives what's happening in the present as a memory, or something that already happened. This type of brain dysfunction generally isn't cause for concern unless it happens regularly.

Some experts believe another type of brain malfunction may cause déjà vu. When your brain absorbs information, it generally follows a specific path from short-term memory storage to long-term memory storage (consolidation). The theory suggests that short-term memories can occasionally take a direct shortcut to long-term memory storage, making you feel as if you're retrieving a long-ago memory rather than experiencing something that happened in the last second. In this case, your brain is tricking you into an experience which feels by all accounts entirely real, predictable, and tangible, but is really just a byproduct of this neurological shortcut.

Another theory has been proposed by Robert Efron of Boston's Veterans Hospital, who offers the explanation of dual processing, in which you observe something, but the information you take in through your senses is transmitted to your brain along two separate routes. Efron found that the brain sorts incoming

3 "Temporal Lobe Seizure." Mayo Clinic, Mayo Foundation for Medical Education and Research, 18 June 2019, www.mayoclinic.org/diseases-conditions/temporal-lobe-seizure/symptoms-causes/syc-20378214.

signals in the temporal lobe of the brain's left hemisphere. However, signals enter the temporal lobe twice before processing, once from each hemisphere of the brain, but normally with a slight delay of milliseconds between them. Efron proposed that if the two signals were occasionally not synchronized properly, then the disconnect between the signals would be processed as two separate experiences, with the second seeming to be a re-living of the first.[4]

Other explanations for déjà vu have been provided by psychoanalysts, such as the manifestation of wish fulfillment. In this context, déjà vu is the subconscious repetition of a past experience, but with a more positive ending. The realm of parapsychology proposes that déjà vu is a chance for reincarnates to get a sneak peak into a past life. Most scientists scoff at these "magical" explanations for neurological events, citing that they break many of the laws of nature. Some, however, point to more recent findings in physics, such as the possibility of particles that can travel backwards in time (tachyons), time loops and multiple universes. They say that these may give cause for more non-traditional ways of seeing causality and for the possibility of neurological "time travel". This means that, maybe, just maybe, understanding déjà vu as a means of seeing into the past or future cannot be so immediately dismissed. How's that for food for thought?

Perhaps to some, the fleeting nature of déjà vu renders it a fruitless topic not worth researching. It may seem to just be a weird, quirky brain trick that we learn to accept into our lives. Investigation into the implications of this neural event, however, seems to lead towards a more in-depth knowledge of ourselves. A better understanding of déjà vu may lead us closer to an understanding of the complex relationship between ourselves and our memories as well as the workings of our subconscious mind. It may light a path for a clearer view into how we incorporate ourselves into our memory and how our memory is incorporated into our conscious selves. **How can this search for truth be futile?** ◻

4 Efron, Robert. "Temporal Perception, Aphasia and Déjà Vu." academic.oup.com/brain/article-abstract/86/3/403/260382?redirectedFrom=fulltext.

A Time and A Place...

By Lilian Zhang

Picture this: You're in your 80s, retelling your grandchildren the story of how you lived through the COVID-19 pandemic. Online learning became the norm, there was something called Zoom, and a walk in the park seemed a dangerous yet precious undertaking. Hospitals were packed full, stress was peaking. Several painstaking months later, you had heard that the vaccine came out — when was it? Where were you?

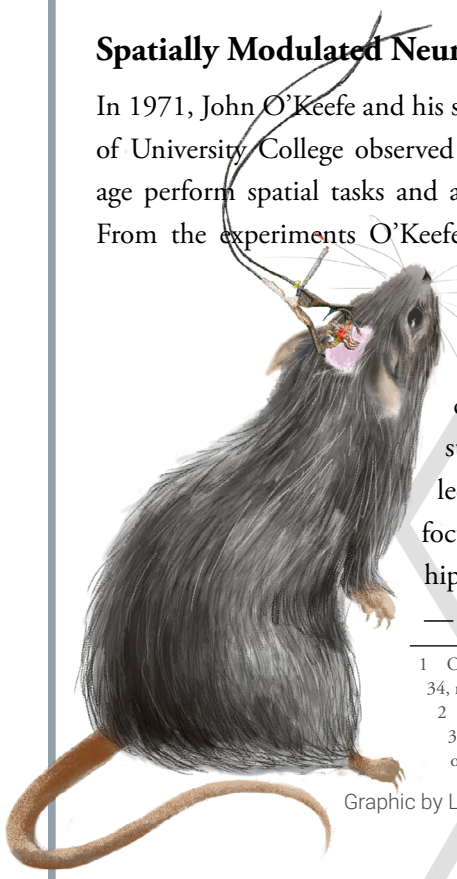
The pathways to this memory — the time, place, and experience — are no longer as sharp as they were when you first told it.

Aging deteriorates memory, often bringing a host of neurodegenerative disorders to chip away at the brain. Spatial memory often declines, with navigation and body positioning becoming difficult to maneuver. Events are harder to place in time and information processing slows down.

But why is it that so many mental faculties begin to decline at once? Spatially modulated neurons may hold part of the answer.

Spatially Modulated Neurons

In 1971, John O'Keefe and his student Johnathon Dostrovsky of University College observed rats with hippocampal damage perform spatial tasks and adjust in novel environments. From the experiments O'Keefe and Dostrovsky performed, they noted that the rats displayed hyperactivity in novel environments and had deficits in performing spatial tasks such as navigating mazes. This led O'Keefe and Dostrovsky to focus their work on the dorsal hippocampus and dentate gyrus — brain structures particularly involved in the formation of memories and spatial cognition. O'Keefe and Dostrovsky recorded electrical activity of these structures during spontaneous behavior (walking, eating, drinking, grooming, and sleeping) and elicited behavior (orienting, sniffing at cotton wool or various odours, biting). In observations of such recordings, O'Keefe began to see patterns of activity: eight units responded "solely or maximally when the rat was situated in a particular part of the testing platform facing in a particular direction".[1] Further exploring these eight units, O'Keefe found that three reached maximal spontaneous firing rates at a particular part of the testing stand while the other five required the animal to be in a moderate state of arousal, situated at a particular part of the testing stand and occasionally receiving appropriate sensory stimulus. A specific set of cells corresponded to external environmental cues.



Graphic by Lilian Zhang

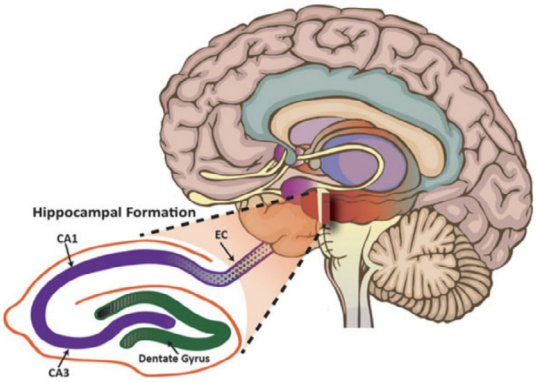


Fig 1: The Structure of the Hippocampus[2]

Spurred by the intriguing initial findings of O'Keefe and Dostrovsky, O'Keefe went on to perform follow-up experiments, recording units now specifically from the CA1 region of the dorsal hippocampus. O'Keefe discovered the presence of "place units" and "displace units," the former firing maximally depending on the rat's position on the testing platform and the latter firing maximally in slow-wave sleep-like states. Place units were further divided into (1) units that fired solely based on location and (2) "misplace units" that fired best when the animal engaged in exploratory sniffing while being positioned at a specific region on the testing platform.[3]

Later termed place cells, O'Keefe had discovered the pyramidal

1 O'keefe, J., and J. Dostrovsky. "The Hippocampus as a Spatial Map. Preliminary Evidence from Unit Activity in the Freely-Moving Rat." Brain Research 34, no. 1 (November 12, 1971): 171–75. https://doi.org/10.1016/0006-8993(71)90358-1.

2 https://www.creative-diagnostics.com/blog/index.php/what-is-hippocampus/

3 O'keefe, John. "Place Units in the Hippocampus of the Freely Moving Rat." Experimental Neurology 51, no. 1 (1976): 78–109. https://doi.org/10.1016/0014-4886(76)90055-8.

neurons shown to be essential in mapping the brain's navigational system. Place cells in someone's brain fire according to a place field, which is a neural representation of the physical environment around them. O'Keefe hypothesized that these cells work to create place fields that represent a cognitive map of the animal's environment based on landmarks, behavior, and stimuli.

34 years later, Edvard and May-Britt Moser built upon this research, discovering neurons leading into the hippocampus that similarly exhibited spatial firing patterns: grid cells. These grid cells that feed information to the hippocampal place cells appeared to also exhibit specific firing patterns encoding the environment — but in hexagons. In examining the input into the hippocampal place cells, the Mosers utilized similar methodology to find cells in the dorsocaudal medial entorhinal cortex (MEC) that fire whenever "the animal's position coincides with any vertex of a regular grid of equilateral triangles spanning the surface of the environment".[4] Though grid cells are spaced differently according to their location on the MEC, the overall mapping creates a hexagonal lattice that fires in novel environments independent of visual input, landmarks, or stimuli.

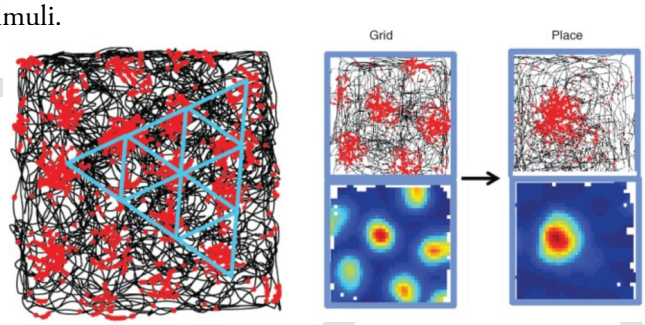


Fig 2: Grid Cell Firing Patterns[5]
Black traces show the rat's trajectory and red dots mark the spike locations of grid cells. The blue equilateral triangle was superimposed to illustrate the hexagonal firing pattern. Rate maps are shown below the grids to show activity of the neurons, red corresponding to high activity and blue corresponding to low.

However, as visual cues and stimuli are provided, this map iscontinuously updated. In examining the origin of grid cell discharge, the Mosers and their team rotated cue cards to test whether changes in grid cell firing could be attributed to external landmarks (allothetic cues) or by information generated by the rat's own movement (idiothetic cues). Remarkably, rotation of the cue card corresponded to the same rotation of the grid. But in darkness, with all visual cues removed, the same grid persists. The Mosers therefore suggest grid cells contribute to a path-integration-based map of spatial environment, whereupon the grid pattern is initially established in a novel environment and continuously updates its metrics with new information on place, distance, and direction.[4]

These experiments would earn Moses and O'Keefe the 2014 Nobel Prize in Physiology or Medicine. Beyond these key discoveries, research into spatially modulated neurons has grown to provide a more comprehensive understanding of the actors modulating spatial processing, uncovering border cells that fire with environmental boundaries and head direction cells that fire according to the orientation of the animal.

Spatial Encodings — and Beyond

Interaction of these spatially-modulated neurons are thought to create encodings of physical space for navigation. Though the exact mechanism is yet unknown, it may not simply involve the entorhinal grid cells feeding input to the hippocampal place cells. Studies into newly weaned rats show that adult-like place fields are established several days before grid-like firing. Further, inactivation of the medial septum that provides input into the MEC disrupts grid cell firing while leaving place fields largely intact. This evidence therefore suggests that grid cells and place cells store complementary spatial representations necessary for detailed encoding. While grid cells consist of context-independent and path-integration based spatial code, place cells may integrate sensory information to encode landmarks and visual cues. The hexagonal pattern of grid cells may serve as a spatial metric through which vectors can be extracted and used for navigation, in contrast to place cells that support direct navigation only up to the size of its largest place fields.[6]

Theoretical models seem to support this hypothesis. Costa and Tort constructed a model of entorhinal-hippocampal circuitry to simulate dynamics of spatial firing patterns of grid and place cells resulting from environmental modifications. Their model suggests two key steps in their bi-directional loop between the hippo-campus and entorhinal cortex: (1) emergence of neural representations of positions through place cells and (2) anchoring these representations to a navigational framework and met-

4 Hafting, Torkel, Marianne Fyhn, Sturla Molden, May-Britt Moser, and Edvard Moser. "Microstructure of a Spatial Map in the Entorhinal Cortex." Nature, June 19, 2005. https://doi.org/10.1038/nature03721.

5 Moser, May-Britt, David C. Rowland, and Edvard I. Moser. "Place Cells, Grid Cells, and Memory." Cold Spring Harbor Perspectives in Biology 7, no. 2 (February 2, 2015). https://doi.org/10.1101/cshperspect.a021808.

6 Bush, Daniel, Caswell Barry, and Neil Burgess. "What Do Grid Cells Contribute to Place Cell Firing?" Trends in Neurosciences 37, no. 3 (March 2014): 136–45. https://doi.org/10.1016/j.tins.2013.12.003.

ric by interaction of place and grid cells. They suggest that grid cells are not essential for place-cell mapping and re-mapping, but instead, grid cell inputs improve the stability of place field representations against noisy data and anchor the place fields to a method of navigating the animal's environment.[7]

The purpose of this information may not be solely for navigation either. Neural activity of the hippocampus and MEC has been shown to encode for variables beyond spatial dimensions. Through a series of sound manipulation tasks (SMT) in which rats changed the frequency of a sound for a reward, David Tank and his team showed that spatial and acoustic representations were mapped with the same neuronal populations and suggest that "well-known spatial patterns in the entorhinal-hippocampal circuit may be a consequence of the continuous nature of the relevant task variables (e.g., location), rather than a primacy of physical space for this network."[8] Patterns previously believed to be solely geared towards environmental mapping and spatial navigation may instead encode for all relevant variables describing the animal's surroundings.

Temporal dimensions are aptly represented as well. In examining whether rats navigated mazes through trained goal locations or trained a sequence of body turns, the hippocampal cells have been shown to fire at characteristic steps within the sequence. Just as place cells fire depending on the landmarks and structure of their physical environment, these same neurons also fire according to temporal landmarks and critical points of an experience.[9]

It seems the organization of experience is crucially encoded through these neurons. In O'Keefe's initial experiments, two of their electrode units displayed activity based on behavior related to the animal's expectation.[1] Later experiments demonstrate the anticipatory nature of CA1 place cells, with firing patterns remaining stable in familiar environments.[10] Further experiments with fear conditioning display remapping of firing patterns by hippocampal place cells in trained environments. The cells display plasticity in response to aversive stimuli within their environment — new associations are established and behaviors are consequently adapted. Studies suggest that the hippocampal encoding of space reflects not only its geometry and physical and temporal aspects of the experience, but also the motivation and behavior appropriate towards the context.[11]

Memory and Learning

These encodings of experience hold critical implications for the role of grid and place cells for memory consolidation and learning. Recent studies have shown the ability of rats to perform "mental time travel," whereupon the rat "revisits" memories during sleep. Following training, during which rats run through a maze and exhibit a specific pattern of hippocampal CA1 place cell firing according to this temporal sequence, neuronal activity is promptly recorded during slow-wave sleep (SWS). In the SWS sequences following the experience, the hippocampal cells repeat the same pattern of firing, though compressed in time. These reactivations may allow for representations of memory to be consolidated and stored in extra-hippocampal regions.[12]

This occurs in awake replay as well. In moments of respite between the rat's busy training schedule, Frank and Karlsson recorded the animal's CA1 place cell activity in moments of activity (immobile for no more than five seconds) and quiescent (still for greater than five seconds).[9] Firing of spatial patterns replayed during awake replay of currently experienced environments, awake replay of remote environments, and quiescent replay of remote environments. The rat was re-running through its training mazes, strengthening its associations and behavior.

Perhaps naturally, learning follows. Researchers hypothesize that the re-firing and re-tracing of place cell patterns serve the function of enhancing the animal's spatial learning, landmark associations, and even behavioral patterns. As the animal is placed into novel environments, place fields similarly remap and form new representations of the new environment. But when an animal is placed back into a learned environment, the

7 Rennó-Costa, César, and Adriano B.l. Tort. "Place and Grid Cells in a Loop: Implications for Memory Function and Spatial Coding." The Journal of Neuroscience 37, no. 34 (August 23, 2017): 8062–76. https://doi.org/10.1523/jneurosci.3490-16.2017.

8 Aronov, Dmitriy, Rhino Nevers, and David W. Tank. "Mapping of a Non-Spatial Dimension by the Hippocampal–Entorhinal Circuit." Nature 543, no. 7647 (March 30, 2017): 719–22. https://doi.org/10.1038/nature21692.

9 Karlsson, Mattias P, and Loren M Frank. "Awake Replay of Remote Experiences in the Hippocampus." Nature Neuroscience 12, no. 7 (June 14, 2009): 913–18. https://doi.org/10.1038/nn.2344.

10 Gereke, Brian J., Alexandra J. Mably, and Laura Lee Colgin. "Experience-Dependent Trends in CA1 Theta and Slow Gamma Rhythms in Freely Behaving Mice." Journal of Neurophysiology 119, no. 2 (February 1, 2018): 476–89. https://doi.org/10.1152/jn.00472.2017.

11 Moita, M. A. P., Svetlana Rosis, Yu Zhou, Joseph E. LeDoux, and Hugh T. Blair. "Putting Fear in Its Place: Remapping of Hippocampal Place Cells during Fear Conditioning." Journal of Neuroscience 24, no. 31 (August 4, 2004): 7015–23. https://doi.org/10.1523/jneurosci.5492-03.2004.

12 Peyrache, Adrien, Mehdi Khamassi, Karim Benchenane, Sidney I Wiener, and Francesco P Battaglia. "Replay of Rule-Learning Related Neural Patterns in the Prefrontal Cortex during Sleep." Nature Neuroscience 12, no. 7 (May 31, 2009): 919–26. https://doi.org/10.1038/nn.2337.

map it has already learned is reinstated.[13] Replay likely allows for the reinforcement and stabilization of these maps, as the experience is re-traced and reliably remembered.

Implications

What if these maps cannot stabilize?It turns out that age-related navigational deficits are highly linked to deficient grid or place cell representations. The vulnerability of the entorhinal cortex to aging and neurodegenerative disorders leads to significant loss in grid-cell representations. Through fMRI time-series data analysis on grid cell firing patte rns in healthy young and older adult rats, Stangl and his team attributed instability in grid-cell representations to a lack of temporal stability — changes in grid orientations in older adults were significantly larger than that of younger adults.[14]

The relationship between the decline of grid-cell-like firing patterns to path integration abilities of older adults was further examined. To compare path integration errors of older versus younger adults, Stangl and collaborators had the participants keep track of their position as they moved along a predefined curve in either a "body-based" or "visual" path integration modalities. The body-based modality allowed participants to be guided along the path by the experimenter without any visual input, therefore testing their ability to integrate body-based self motion cues in updating understanding of their orientation and distance along the path. In contrast, the visual modality allowed participants to gain visual input through a virtual environment in which they moved in first-person perspective while sitting motionless. In comparing errors in determining orientation and distance, the study showed that older adults displayed greater error and difficulty in computing self-position during path integration with both modalities. Furthermore, significant correlation was found in older adults between lower grid-cell-like firing patterns and path integration errors in the body-based modality, suggesting that low grid-cell representation could serve as a marker for spatial cognitive decline.[14]

In knock-in models of Alzheimer's disease (AD), Jun and collaborators find disruption in CA1 place cell remapping and severe impairment in MEC grid cells.[15] Using novel APP-KI mice engineered to replicate AD-associated pathologies, they found that spatial memory and remapping of CA1 neurons were disrupted and spatial tuning to stimuli of MEC neurons severely impaired in old mice. In contrast, the younger mice displayed only mild MEC impairment while CA1 neurons remained largely intact. As Jun and collaborators found impairments only in MEC neurons in the entorhinal-hippocampal circuit, this implies a direction through which neuronal degeneration occurs. Degradation of neuronal cells and dysfunction in spatial memory may proceed from the MEC to the CA1 region, providing an understanding of the path through which age-related cognitive decline may occur.

Research into spatial tuning and remapping of grid and place cells in the entorhinal-hippocampal circuit will therefore provide deeper understanding of neurodegenerative diseases and aging. Since the initial discovery of place cells in the hippocampus, we have found other environment-encoding cells such as grid cells discussed in this article. Though the grid cells of the MEC and hippocampal place cells encode information differently, they may contribute to a loop of information in which grid cells stabilize place fields against noise and provide a metric through which the animal can navigate landmarks from their place cells. By storing all variables — time, behavior, or sensory stimuli — associated with their environment, the animal creates a "map" to memorize and learn its surroundings, replaying the same firing patterns of place cells in its resting states.

With this ability of place and grid cells to encode information along a multitude of dimensions, future work may be done to understand and preserve individuals from age-related decline in other cognitive abilities. Grid-cell representations could serve as markers for the onset of neuronal deterioration, allowing for early detection of dementia and neurodegenerative disorders. In understanding the circuit's pathway for dysfunction, we may learn to halt it in its path.

And with work and research, perhaps one day when we retell a story in our 80s, the time, place and experience will remain as sharp as when we first told it. ◻

13 Csicsvari, Jozsef, and David Dupret. "Sharp Wave/Ripple Network Oscillations and Learning-Associated Hippocampal Maps." Philosophical Transactions of the Royal Society B: Biological Sciences 369, no. 1635 (February 5, 2014): 20120528. https://doi.org/10.1098/rstb.2012.0528.

14 Stangl, Matthias, Johannes Achtzehn, Karin Huber, Caroline Dietrich, Claus Tempelmann, and Thomas Wolbers. "Compromised Grid-Cell-like Representations in Old Age as a Key Mechanism to Explain Age-Related Navigational Deficits." Current Biology 28, no. 7 (March 15, 2018). https://doi.org/10.1016/j.cub.2018.02.038.

15 Jun, Heechul, Allen Bramian, Shogo Soma, Takashi Saito, Takaomi C. Saido, and Kei M. Igarashi. "Disrupted Place Cell Remapping and Impaired Grid Cells in a Knockin Model of Alzheimer's Disease." Neuron 107, no. 6 (June 23, 2020). https://doi.org/10.1016/j.neuron.2020.06.023.

Tempestuous Memories

By Michael Xiong

When I was in 5th grade, my school district hosted a Math Field Day among the local elementary schools. My event included a memorization task, where my competitors and I were asked to examine a drawing and were then tested on its details. Although the specifics have long since escaped me, I remember the frustration. Every question made me regret my prior lack of attention to one part of the image or another. To this day, I still do not understand how this exercise pertained to math.

This was, perhaps, the first time I was confronted with the oddities of our ability to form memories. During the test, my most pressing thought was my wish that I could photograph the image in my mind. A computer would have had no trouble with this, I thought.

Graphic by VienYen HoPham

Of course, I did not then understand the differences in ability between the human brain and a computer, as well as the advantages that the brain possessed. In truth, most computers would have performed horribly on that test. Despite perfectly storing the color value of every pixel on the image, a computer would be even less prepared than I was to answer a question such as "How many people in the image were wearing an orange shirt?"

This simple example points towards something fundamental to how the brain operates. Even if perfect recollection is a tempting ability, it is much more efficient for our brain to paint the past in broad strokes. We have an ability to recognize and categorize experiences that far surpasses any computer. In the ages before we could stroll to the nearest supermarket and purchase a head of broccoli for $0.99, our ancestors relied on their ability to recognize and categorize experiences—one that far surpasses any computer—to identify safe sources of food, water, and shelter. This skill is vital to our survival. Being able to count the number of crumbs that were on my breakfast plate yesterday morning is not.

This idea is demonstrated by the experiences of Solomon Shereshevsky (1896-1958), who became famous for his incredible memory. In one instance, he perfectly recited a list of 70 words that he had last seen fifteen years ago. However, his style of memory processing was not without downfalls. Our knowledge of Shershevsky's experiences comes mainly from his own recounting, recorded in The Mind of a Mnemonist by Aleksandr Luria. Shereshevsky describes his synaesthesia—the association of one sensory input with another (for example, experiencing sounds as images)—as often overpowering. In a conversation, he would become distracted by the imagery created by each word, but take longer to comprehend the meaning of whole phrases. He remembered a single person's different expressions as separate faces, and thus had trouble recognizing people. In essence, his brain was prioritizing the wrong details to store.

Our subconscious memory processing, therefore, is not meant to be completely accurate. Instead, it is enough that we remember the themes and general "gist" of our experiences.

After experiencing especially pivotal or traumatic events, many

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https://staff.washington.edu/eloftus/Articles/sciam.htm
https://www.scientificamerican.com/article/911-memory-accuracy/

people claim that they can recall the details with extreme clarity. Psychologists used to believe that these "flashbulb memories" were incredibly accurate, but we now know that this is far from the case. In one famous study, researchers asked subjects to recount the circumstances in which they first heard of the 9/11 attacks a week after the event. A year later, the same subjects recounted their experiences again. On average, only 63% of the details they provided aligned with their account from one week after the attack. Three years later, this value was 57%. And yet, most subjects were highly confident in their descriptions. The lead investigator, Elizabeth A. Philips, explains that "emotion gives you a stronger confidence in your memory" that may not be reflected in accuracy. Leonard Mlodinow, author of Subliminal, relates this process to the image compression of a computer. Rather than saving each detail perfectly, we save the general framework of events. When we recall these memories, our subconscious processing "fills in" the gaps by making an educated guess of the fine details. Unaware, we believe these details to be fact. This misplaced confidence can be existentially worrying, especially when it concerns eyewitness testimonies.

Elizabeth A. Philips also examines how this association between emotion and memory manifests in the interactions of two brain regions known as the amygdala and the hippocampus. The amygdala is a fundamental part of our emotional response and is crucial for recognizing emotional stimuli. Functional MRI can be used to measure this activity and track its influence. Upon activation, the amygdala signals the hippocampus—the part of the brain responsible for creating memories. This interaction means that more emotional events are more likely to be remembered—accurately or not.

One well-documented case of an inaccurate memory influencing a trial is the testimony of Jennifer Thompson. Thompson was a rape victim who spent her horrific experience doing all she could to memorize the face of her attacker. During a police lineup, however, Thompson mistakenly chose Ronald Cotton as the rapist. Cotton was later exonerated by DNA evidence, but not before Thompson yet again mistakenly identified him—despite her true attacker being presented as another option. Somehow, Cotton's face had overwritten the mental image she had of the rapist. Cotton was in prison for ten and a half years. Ultimately, he and Thompson wrote a memoir about these events together.

We have reason to believe that this is not an isolated incident. Police lineups purposefully include "known innocents": people who the police know with certainty did not commit the crime. Between 20 and 25% of the time, these known innocents will be chosen by the witness. This creates the worrisome possibility that a significant portion of the suspects identified by eyewitness testimony are actually innocent.

Even more extreme than these inaccurate memories are the cases of memories that are completely false. Rather than resulting from filling in the wrong details, these are memories of events that never occurred. In one study by Elizabeth Loftus, family members were asked to write about three real events and one imaginary event that had occurred in the participant's childhood. The subjects then read these events and were asked whether or not they recalled them. The 24 subjects recalled 49 out of the 72 true events, and seven of them claimed to recall the imaginary event. Therefore, the mere pretense that this event had happened to the subjects lead them to create a fictitious memory of the event.

These glaring mistakes show us that there is a subconscious system at play in the formation and organization of our memories. And, contrary to what I believed when I was ten, the imperfections in this system are a blessing rather than a curse. For good reason, our biological machinery is structured to only remember as much as necessary, and to fill in the rest.

But this gives it the potential to be very, very wrong. □

Subliminal: How your unconscious mind rules your behavior, by Leonard Mlodinow
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What We See in the Dark

By Iris Lu

You're in a forest.

Running far, far away from whoever--whatever--is chasing you. The moon peers down on you from the night sky, eerie glow casting shadows on the forest floor--a silent reminder that daytime is still far away.

Whatever is behind you only gets faster.

Blood roars in your ears as you race through the trees, stray branches covering your face and arms with little cuts as you attempt to make an escape.

It's gaining on you.

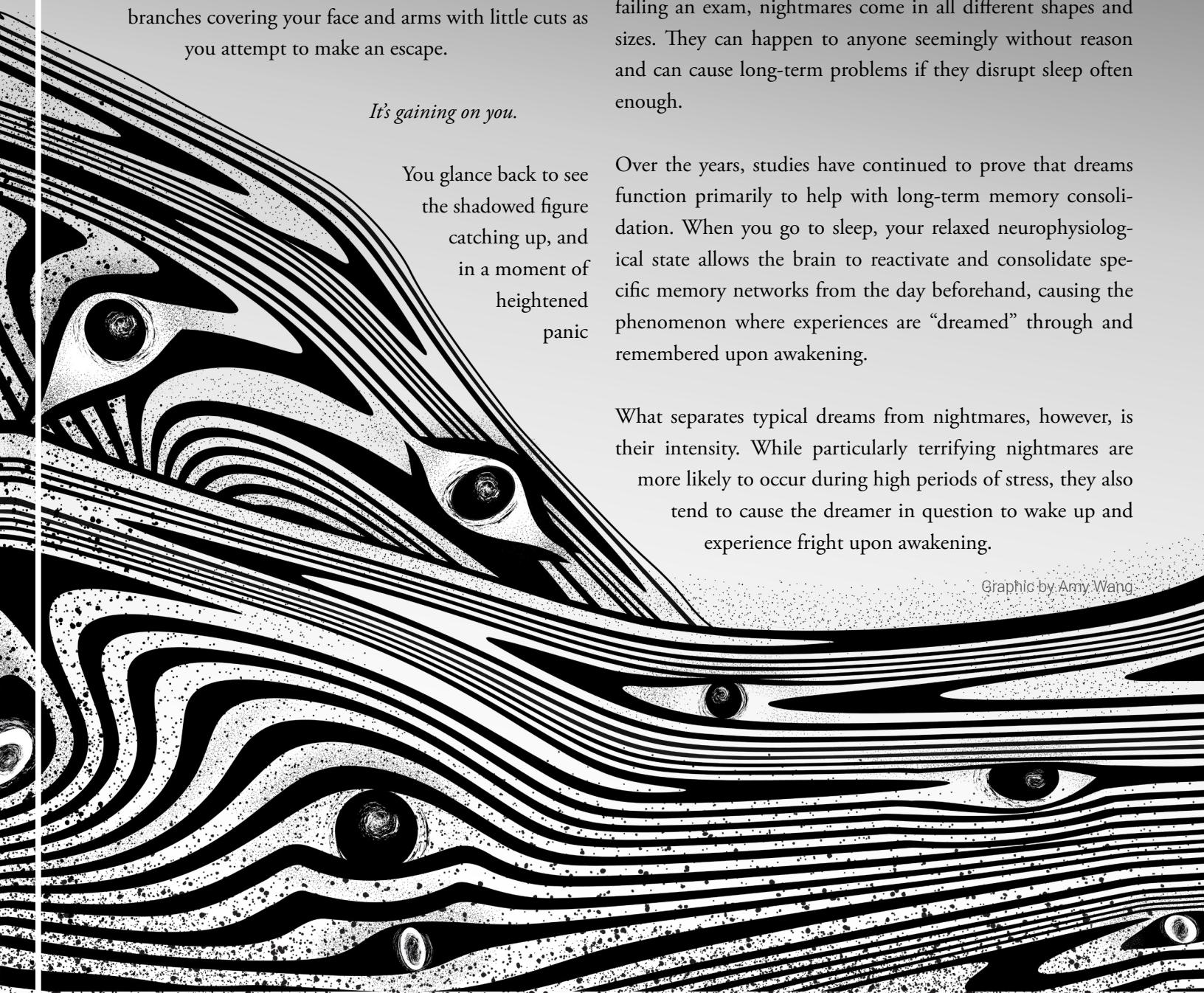
You glance back to see the shadowed figure catching up, and in a moment of heightened panic your foot gets caught in a tree root, causing you to trip and tumble down into the ground. Dread settles deep in your stomach as you turn to see a pair of eyes and sharp teeth with a sinister glint in the darkness, closing in. You open your mouth to yell for help, to scream--

And you wake up with a jolt, safe in your bed at home. *It was just a nightmare.*

From being chased by an axe-murderer through the woods to failing an exam, nightmares come in all different shapes and sizes. They can happen to anyone seemingly without reason and can cause long-term problems if they disrupt sleep often enough.

Over the years, studies have continued to prove that dreams function primarily to help with long-term memory consolidation. When you go to sleep, your relaxed neurophysiological state allows the brain to reactivate and consolidate specific memory networks from the day beforehand, causing the phenomenon where experiences are "dreamed" through and remembered upon awakening.

What separates typical dreams from nightmares, however, is their intensity. While particularly terrifying nightmares are more likely to occur during high periods of stress, they also tend to cause the dreamer in question to wake up and experience fright upon awakening.



Graphic by Amy Wang

But what causes these nightmares, and what makes some people more prone to disruptive sleep? And do these strange, perplexing dreams have deeper meanings in the end?

The Nightmare Begins

Most people experience their first nightmare around the age of 3-6, during the last third of the night where REM (Rapid Eye Movement) levels are the highest. This is the same stage where brain activity reaches it peak as it stimulates the increased production of proteins.

Though the age where nightmares crop up tend to stay the same, the subject of the dreams can vary from child to child. While younger children tend to have similar nightmares about being separated from their guardians or seeing a monster, children that have experienced significant stressors, or traumatic events (e.g a parents' divorce or extreme violence) tend to not only have increased frequencies in nightmares, but different content in them as well.[1] These can range from memories of a traumatic event, to injuries, or the occurrence of natural disasters.

While there is no clear interpretation of what dreams and nightmares mean, some relation does exist between what we experience in our dreams, as well as real life. Young children are more likely to have nightmares of being separated from their guardians as they begin to enter a new environment they may not be familiar with (e.g starting school), and nightmares about seeing a monster can be related to fears of the dark, and can also be influenced by fictional media the child has consumed. At the same time, it has been known for decades that children with recurring nightmares tend to experience them due to psychopathological symptoms,[2] with more violent nightmares being related to a child's traumatic experience and subsequent healing process. But even if someone's mental and physical health improves in the long-run, nightmares remain a possibility.

Even after age 10 and onwards, when most children begin to have significant decreases in nightmare frequency, some may experience nightmares that continue to occur into adulthood-without notable external influences. While the simple answer is that they are caused by exposure to stressors, whether it from school, relationships, or more, there are multiple external factors that can influence an uptick in violent dreams and more.

Idiopathic nightmares, which are nightmares caused by undetermined factors, can be experienced by anyone without specific requirements. Possible causes for these nightmares tend to be too numerous to count, with considerations ranging from genetic factors, personality type, diet, to the level of stress in daily life. Though studies have been conducted on some of these factors, none of these theories have been proven valid enough in the past decade to explain anything worthy of note.

What can be understood, however, is that children that had frequent nightmares when they were younger, tended to have this issue persist even into adulthood, regardless if they were subject to some form of childhood trauma. On the other hand, while trauma may not be directly related to an uptick in nightmares during childhood, it could still remain responsible for a rapid increase in nightmares once reaching adulthood, such as in cases of delayed-onset PTSD.[3]

Antidepressants, for example, more notably SSRIs (selective serotonin reuptake inhibitors), which are typically prescribed to adults 18 and above, tend to come with reviews of intensified dreams and nightmares. These are likely caused by the fact that SSRIs are responsible for increasing serotonin levels in the brain, influencing the suppression of REM sleep. While low levels of REM sleep are typically associated with not having any dreams, or not remembering them upon waking, the low levels of REM sleep can cause the brain to move into REM compensation, causing more intense and vivid dreams or nightmares. The same can be said for blood pressure medications (e.g. beta blockers), which impacts how the brain responds to neurotransmitter norepinephrine, as well as antihistamines (e.g. medicine like benadryl) that can also interfere with REM sleep.[4]

But aside from these external influences, what meanings do nightmares have during our sleep? What is the importance

1 Michael Schredl; Dorothea Blomeyer; Michaela Görlinger (2000). Nightmares in children: Influencing factors. , 4(3), 145–149. doi:10.1007/s11818-000-0007-z

2 Michael Schredl; Leonie Fricke-Oerkermann; Alexander Mitschke; Alfred Wiater; Gerd Lehmkuhl (2009). Longitudinal Study of Nightmares in Children: Stability and Effect of Emotional Symptoms. , 40(3), 439–449. doi:10.1007/s10578-009-0136-y

3 Tore Nielsen, "The Stress Acceleration Hypothesis of Nightmares," Frontiers in Neurology 8 (January 2017), https://doi.org/10.3389/fneur.2017.00201.

4 James M Parish, "Violent Dreaming and Antidepressant Drugs: or How Paroxetine Made Me Dream That I Was Fighting Saddam Hussein," Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine (American Academy of Sleep Medicine, August 15, 2007), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1978339/.

behind remembering them upon waking, compared to typical dreams that we tend to quickly forget shortly after waking up?

Decoding Your Dreams

It is commonly believed that dreams are an amalgamation of concepts, created by drawing inspiration from various thoughts and ideas present in real life experiences. For example, a dream that you are running away from something may represent a person being unable to take things head on, while a bear breaking into your house may symbolize someone who has paid you an unwelcome visit.

One theory, the Activation-Synthesis Hypothesis (coined by Harvard psychiatrists John Allan Hobson and Robert McCarley), helps to simplify these dreams--claiming that they do not have any real subconscious significance. The electrical impulses developed by the brain during REM sleep merely functions to pull random thoughts and imagery from our past, causing humans to construct dreams in order to better consolidate the information they have learned from the previous day.[5] Though certainly not as entertaining a theory when it comes to interpreting dreams and the possible deeper meanings they may have, it has merit in making sense of how the subconscious works in order to digest new information. Perhaps some things are better learned through stories--and others through nightmares.

This notion is similarly followed in the Threat Simulation Theory, coined by Antti Revonsuo in 2000, claiming that dreams, and subsequently nightmares, are biological defence mechanisms created to simulate threatening events so that the human body can learn how to adapt and react in a safe environment. Though not as applicable when regarding dreams as mechanisms for memory consolidation, the six testable propositions Revonsuo includes in the theory can be considered true when taken into account with many popular nightmares.[6]

- **Proposition 1:** The dream experience is a simulation of the perceptual world, mimicking the same experiences one would have while awake, though some things may be rendered as more "random" than it would in real life.
- **Proposition 2:** Normalcies of daily life are absent. The dream world is biased towards the threatening situation they are placed in, ex: not being able to finish escaping when being chased, or being stuck somewhere.
- **Proposition 3:** Traumatic experiences from real life are applied towards cases in dreams, in order to produce a situation in which the brain may properly need to adapt to ensure physical survival.
- **Proposition 4:** Though not necessarily accurate to one's real experiences, it still remains realistic and remains effective for producing threat-avoidance responses in real life.
- **Proposition 5:** The motor skills simulated in dreams will increase the individual's performance in real life, even if the dreams are not remembered. Ex: dreaming of running away will improve your skills at running away in real life
- **Proposition 6:** This threat-simulation system was not innate, but began to become more frequent in individuals as humans began to evolve. Humans who have been exposed to more traumatic events, or high-risk situations tend to have nightmares like these in higher frequency, because they are more needed for survival.

Though this theory may not apply to some members of the population (e.g those who have not experienced particularly traumatic experiences, and thus are not required to simulate threatening events for the sake of survival), there have been cases where this theory, as well as its six propositions have successfully applied to children with cases of severe trauma.

As mentioned before, though frequency of nightmares do tend to differ from person to person, children with more prominent cases of trauma tend to have more frequent, and more violent nightmares that disturb their sleep patterns. While the threat-simulation theory argues that this is a case where the brain inevitably tries to prepare itself in case the same situation occurs again in the future, it is also important to know that the effect of recurrent nightmares is wholly obstructive--it causes significant decreases in sleep, making the dreamer more susceptible to issues in mood, social skills, as well as other psychopathological issues. Though nightmares may be an attempt to help the brain adjust after a traumatic event, it can also cause the dreamer's waking life to be its own nightmare as well.
While the previous two theories tend to focus on making sense

5 Hobson A J and McCarley W R, "The Brain as a Dream State Generator: an Activation-Synthesis Hypothesis of the Dream Process," American Journal of Psychiatry 134, no. 12 (December 1977): pp. 1335-1348, https://doi.org/10.1176/ajp.134.12.1335.
6 Sheri Koopowitz, "1 Revonsuo's Threat Simulation Theory ... - UCT Psychology," UCT Psychology, accessed December 5, 2020, http://www.psychology.uct.ac.za/sites/default/files/image_tool/images/117/Sheri.Koopowitz.pdf.

of dreams and nightmares, and how they tend to affect the human subconsciousness, the last, and more widespread theory, tends to focus on how the human subconsciousness affects dreams instead.

This is the belief of Sigmund Freud--that dreams and nightmares are representatives of the unconscious mind, describing the repressed wishes and impulses one may have had since childhood.[7] If dreams are considered to be fulfillment of wishes, then nightmares are considered to be the fulfillment of twisted desires. Anxieties from these arise only when the brain acknowledges that the desire itself is twisted, intentionally "censoring" it in order to stay within society's moral standards.

Though the idea that nightmares are representative of reprehensible desires is not as widespread, the belief that nightmares are influenced by subconscious emotions certainly is. Having a nightmare of failing a test doesn't necessarily mean that you secretly like failing tests and going against the education system, but it clearly means that you are afraid of important exams. And just like how nightmares of traumatic experiences don't mean those experiences were secretly enjoyable, not all nightmares must have a deeper meaning to them.

In the end, there are too many nightmares with a wide range of causes to truly theorize and understand. Whether it be how you grew up, your personality, or your daily diet, a multitude of factors affect the way you dream and sleep during the night. Just like how every human needs to eat and sleep, some people tend to have nightmares as well. This is where dream journaling can come into context--though they may seem to be strange and disconnected at first, if you begin to apply aspects of your dreams with events from the previous day, some curious patterns may begin to show up.

So the next time you're having a nightmare of someone chasing you through the woods, maybe you'll wake up to consider whether your brain is trying to get you to remember something from the day before, train you for future danger, subconsciously tell you that you're afraid of something, or let you know that for some strange reason, you secretly like being chased.

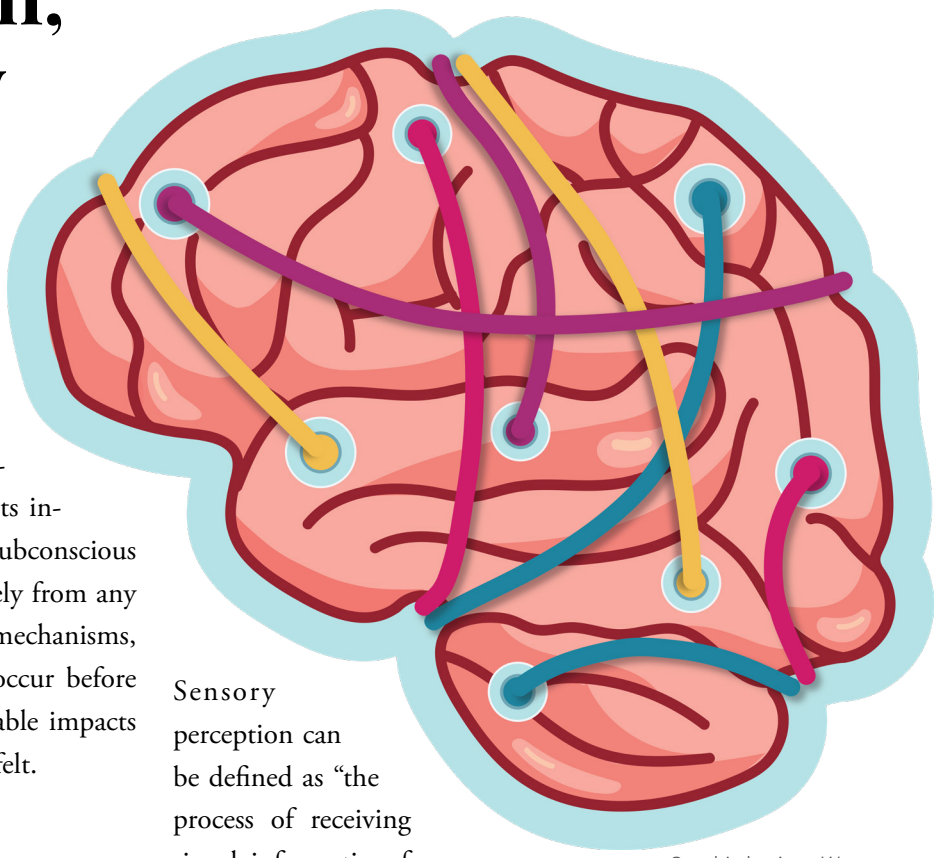
I'll leave that one up to you. ◻

7 Wei Zhang and Benyu Guo, "Freud's Dream Interpretation: A Different Perspective Based on the Self-Organization Theory of Dreaming," Frontiers in Psychology 9 (2018), https://doi.org/10.3389/fpsyg.2018.01553.

Pain, Perception, and Psychology

By Emma Clark

We often hear the utterance, especially in sports, that "pain is a mindset", implying that it can be easily overcome if we just try hard enough. Well, is it? Pain research is a vast and constantly evolving field of neuroscientific, psychological, and sociological research because of its interdisciplinary nature; pain interacts with our subconscious mind, conscious mind, and physical body uniquely from any other sensory experience. Many subconscious mechanisms, from sensory signals to emotional experiences, occur before the actual onset of perceived pain have considerable impacts on how pain is perceived and the severity of pain felt.



Graphic by Amy Wang

Perception

In the scientific literature, the experience of pain is often explained as an interaction between neurophysiological mechanisms and cognitive perceptions. This duality makes pain an incredibly unique neurological occurrence; most current clinical practices for pain management and diagnosis of chronic pain conditions depend heavily on the patient's perception of the level of pain that they're in -- a subjective measure varying greatly from person to person. Since pain is a sensation, and an incredibly unpleasant one at that, doctors typically are more concerned with relieving their patient of this feeling than with what is neurologically occurring to cause them to feel the level of pain in the first place; thus, you can commonly find physicians prescribing painkillers that are unnecessary to the actual recovery process of the condition. The caveat with this approach is that perception itself is a subjective experience that can easily change based upon a breadth of factors, and by only treating a patient based on their perception of their pain at the time of treatment, many implicit factors are given too much attention. Let's dive into what is meant by perception of pain and, more importantly, what actually causes our perception of pain on a neurological basis.

Sensory perception can be defined as "the process of receiving signal information from the body and using it to form a mental experience".[1] On a basic level we understand that like any other sensory experience, the perception of pain is a mental experience resulting from physiological information within the body. However, pain is such a unique sensory experience because of the variation in mental experiences resulting from the same stimuli, like a small burn.

Neurophysiological Mechanisms

The sensation of pain is a nuanced combination of interactions of cognitive factors, because the neurological mechanisms responsible for sensory information translating to pain are so widespread and complex themselves. Pain, unlike other sensory experiences, can be caused by virtually infinite factors. Due to this, different sources of pain cause different types of sensory experiences, likely because our brains' neurophysiological response differs depending on the source of pain.

Nociceptors, sensory neurons that serve as "pain receptors", are the root of physiological pathways of pain. Nociceptors detect stimuli that are abnormally intense, and then send "alarm" signals through the rest of the nervous system, which then

1 Presti, D. E. (2016). Foundational concepts in neuroscience: A brain-mind odyssey (First edition). W.W. Norton & Company.

triggers our reflexes to react to what we perceive as painful.[2] Heat pain is among the most common types of acute pain studied in pain research, since it is more easily measured and controlled than other types of pain through monitoring the exact temperature of stimuli, burn location, and burn intensity. When experiencing acute heat pain, PET and fMRI scans show the primary and secondary somatosensory cortices are activated by nociceptors, which are understood as nerve endings that act as "pain receptors" for the nervous system. This activation demonstrates a relatively straightforward nerve-to-brain communication, but does not paint the whole picture.

When examining heat pain, prefrontal and parietal association areas also show activation. These areas engage cognitive and psychological factors of pain, such as memory and expectation, furthering the idea that perception of pain severity may increase if one was already exposed to a specific type of pain. The primary motor cortex, located in the cerebral cortex of the brain, shows activation less reliably, which suggests it has less of a direct response to acute pain stimuli, like heat, and instead activates in response to pain directly caused or mitigated by motor movements, like joint pain and other types of chronic pain.[3] Chronic pain is distinct from acute pain both because of its distinct neural pathways and its unique nociceptive processes. When nociceptors are constantly activated, it creates a "false alarm" response which heightens the nervous system's responses to all stimuli because of the ongoing nociceptive neural pathways activating simultaneously, creating ongoing, chronic, sensations of pain.[2]

Psychological Factors

Even if pain researchers could fully take apart and understand the black box that is our brain, we can't explain many of the neurophysiological mechanisms that occur during pain without considering the psychological factors that create behavioral responses to pain. Foremost among these are expectation and attention.

When we expect an incoming stimulus to be painful, like watching a needle approach your arm right before receiving a vaccine, it's no surprise that our perception of the pain caused by the stimulus "feels" worse than if we were not anticipating something painful. This phenomenon occurs because the right middle cingulate cortex, right inferior frontal gyrus, and bilateral supplementary motor area are areas of the brain shown to be activated both by anxiety caused by the anticipation of pain and by nociceptors from the actual experience of a painful stimulus. Since these areas are already highly active before the painful stimulus makes physical contact with nociceptors, once the nervous system physically engages, these areas become hyperactive, creating an experience that is perceived as more painful than the experience that the nociceptors alone would create if the pain was unanticipated.

Emotion

Along with our expectations and anxieties about pain, our emotional states when experiencing pain can greatly influence our perception and response. Intuitively, we might think that experiencing a negative emotion would cause our pain tolerance levels to be lower and perceived levels of pain to be higher. This relationship has yet to be clearly agreed upon among pain researchers. A 2016 study used imaging data while subjects were looking at various emotional images prior to experiencing a painful stimulus found that when pain was experienced after areas associated with negative emotion were activated, participants reported lower pain intensities and had slower reaction times than those who were shown images associated with positive emotions.[4] Although some studies have shown that negative emotions during pain have had that effect, others have demonstrated that negative emotional stimuli prior to painful experiences led to lower pain perceptions and slower reaction times to painful stimuli.[5]

The key to understanding this is the difference between emotional state and emotional stimuli. Emotional state refers to a longer-lasting feeling someone experiences, while emotional responses to stimuli are more acute "bursts" of emotion. The longer someone is in an emotional state, positive or negative, the more their perceptions, including those of pain, are influenced by their emotions. Since emotional stimuli presented in the context of a study are meant to create an immediate, acute emotional response, the resulting emotional experience does not have as drastic or long-lasting an impact on the person emotionally, and therefore exerts less influence on their perception of pain.

2 Woolf, C. J., & Ma, Q. (2007). Nociceptors—Noxious Stimulus Detectors. Neuron, 55(3), 353–364. https://doi.org/10.1016/j.neuron.2007.07.016

3 Tracey, I., & Mantyh, P. W. (2007). The Cerebral Signature for Pain Perception and Its Modulation. Neuron, 55(3), 377–391. https://doi.org/10.1016/j.neuron.2007.07.012

4 Peláez, I., Martínez-Iñigo, D., Barjola, P., Cardoso, S., & Mercado, F. (2016). Decreased Pain Perception by Unconscious Emotional Pictures. Frontiers in Psychology, 7, 1636. https://doi.org/10.3389/fpsyg.2016.01636

5 Rhudy, J., & Meagher, M. (2001). The role of emotion in pain modulation. Current Opinion in Psychiatry, 14(3), 241–245.

Conclusion

The sensory experience of pain is an incredibly complex symphony of neurological, psychological, physical, and emotional experiences. As such, it cannot be managed nor understood as simply a conscious mindset. Pain is an experience unique to each individual, yet one that all people have throughout their lives. Even considering the breadth of research from many different angles seeking to understand what pain is, how it's felt, and how to mitigate it, science has yet to conclusively answer any of these questions. Although this science undoubtedly leaves something to be desired, it is perhaps the essential yet ephemeral nature of pain that compels us to continue to work to understand it in all of its convoluted glory. ◻

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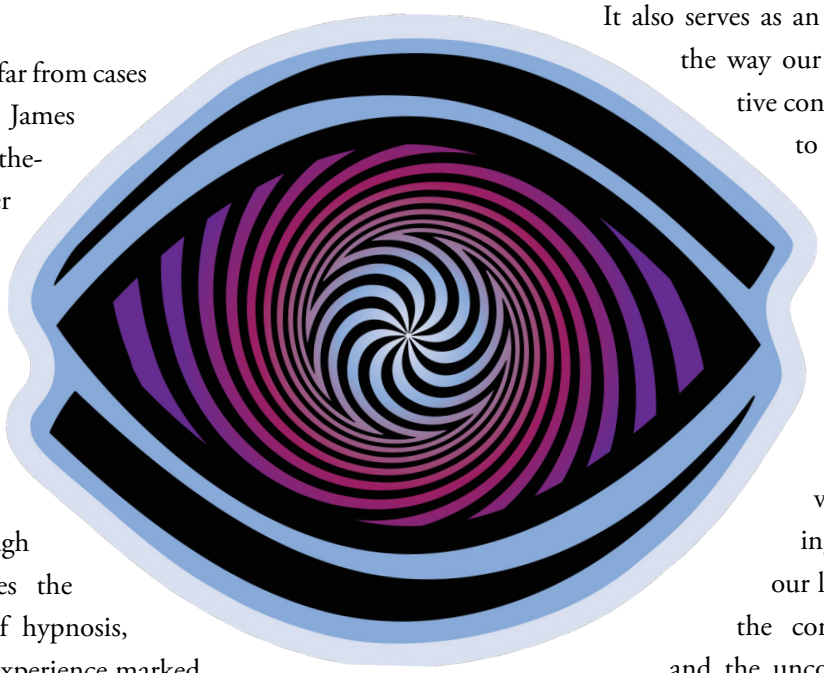
Mesmerising Consciousness

By Nehchal Kaur

I requested Mr Walker, a young gentleman present, to sit down, and maintain a fixed stare at the top of a wine bottle, placed so much above him as to produce a considerable strain on the eyes and eyelids, to enable him to maintain a steady view of the object. In three minutes his eyelids closed, a gush of tears ran down his cheeks, his head drooped, his face was slightly convulsed, he gave a groan, and instantly fell into profound sleep, the respiration becoming slow, deep and sibilant, the right hand and arm being agitated by slight convulsive movements.

Hypnotism has come quite far from cases such as above, described in James Braid's book as a snap-of-the-fingers hypnosis.[1] However it is the elucidated simplicity of the process and the apparent efficacy of its initiation that first captured the minds of people in the 18th century. Hypnosis is a phenomenon operating through suggestibility which makes the person under the effect of hypnosis, often termed as a 'trance', experience marked changes in the contents of their consciousness. They are said to undergo alterations in many of the psychological functions most apparent through reduced peripheral awareness, an increase in focused attention and a heightened response to suggestions.[2]



Graphic by Amy Wang

Trance like states, albeit an everyday experience for many of us; like when we are day-dreaming and are aroused all of a sudden when we hear our name, have been a notable part of many cultural and spiritual practices. However, hypnotically induced trances as a more condensed idea began with Franz Mesmer, of the term - mesmerism or mesmerised, often used to refer to those under hypnosis. As opposed to the conventional view that a hypnotised person is little more than a puppet and the hypnotiser, a puppeteer, hypnotism is a layered phenomenon with an ever-evolving array of experiences attributed to it. It has since journeyed from being a stage-show to a respected clinical practice often utilised as an alternative to chemical analgesics and pain reduction techniques. Hypnosis has thus been studied extensively for the possibilities it offers for therapeutic relief and emotional resolution otherwise inaccessible. It also serves as an interesting tool to explore the way our brains organise for cognitive control, the path that they take to manifest a sense of agency and whether these two play any role in order to give rise to sentience.

The Idea Behind Hypnosis

Psychology has long since viewed consciousness as being differentiated based on our levels of awareness, namely; the conscious, the subconscious and the unconscious. It is the subconscious, which lies just outside day to day awareness through which we operate that hypnosis is said to target, by lowering inhibitions and extracting memories, thoughts and emotions said to be buried deep within the confines of our minds. It is distinguishably seen through three lenses;

Therapeutic

It is this excavation of repressed or forgotten memories or experiences that forms the basis of it being used as therapy in order to resolve emotions and thoughts one does not realise are causing psychological or even physiological problems.

1 http://www.survivorlibrary.com/library/neurypnology_or_the_rationale_of_nervous_sleep _considered_in_relation_with_animal_magnetism_1843.pdf
2 https://core.ac.uk/download/pdf/77614693.pdf

Psychical

Its psychical relevance goes beyond the use of trance-like states that are often discussed in spiritual contexts. Some views also consider the subconscious to be a seat for not only past experiences of our childhoods but also of past lives, all of which become accessible through hypnosis and its different techniques.

Psychological

Hypnosis is known to originate from a person's personal need to heal and from the openness and acceptance of external influence that may act as placebo.

The Experience of Hypnosis

Early accounts of hypnosis typically involve a fantastical view as the theatrics of hypnosis are rife with swinging clocks and whirlpool visuals. Franz Mesmer is known to have sported wizard-like velvet robes while performing group hypnosis called a baquet. He moved around the seated people with drawn hands making 'passes' or gestures in the air to convey the motion of the fluid by his eyes or hands. At some point he would also play his glass armonica. This form of mesmerisation was called 'animal magnetism', which assumed that magnetic fluid flowed in people, the unblocking of which facilitated by others could serve curative purposes.[3] James Braid discounts this theory in his book Neurypnology, but also retains hypnotic amnesia, i.e. failure to recall events that transpired while under hypnosis, as a characteristic of the phenomenon. Hypnosis as an experience though, has since developed into sophisticated undertakings, most notable of which is hypnotherapy; a form of psychotherapy. It is a guided form of hypnosis and has become popular as alternative medicine. Modern hypnotherapy practice espouses an experience less other-wordly and more grounded in reality. The idea behind the repetitive motions of a clock or intently gazing into the eyes of the person who has to undergo hypnosis was to tire the eyes and close the eyelids. The protocol nowadays however, typically begins with an induction which is supposed to have the same effect of bringing the client into a relaxed state and reduce exogenous awareness. It is a set of preliminary instructions like "Will you just take a good long deep breath and close your eyes….Now let that feeling of relaxation go right down to your toes" and so on.

This is followed then by verbal suggestions of imagery administered to enable entry of the person into a form of targeted day-dream with heightened awareness of internal happenings. Barbelo Chr.Uijtenbogaardt, a Dutch hypnotherapist describes the following traits as characteristic of a hypnotic trance. The person in question is

- Conscious
- Remains in control
- Remains in touch with reality

The trace phenomena that correspond with such a state broadly reflect the calmness that the person is experiencing. There are many levels of a trance, relative to the depth of internal vs external awareness and the allowed amount of suggestibility vs resistance shown by the person in question. Each of these are characterised by various observations.

This feeling however, is broadly presumed to be a blank canvas providing a surface for the client to experience various emotions and recollections on. Following this, involuntary muscle twitches, pupil reactions and limb movement, all are known to reflect the experiences that a person is going through in his/her mind.[4]

The How Behind It and the Subsequent Neurophysiological Evidence

Hypnosis is understood to have exemplified the top-down perspective of bodily functioning which says that the mind alters the physiological functions, i.e. the mind controls, the organs react. How exactly this influence is brought about in hypnosis is a divided debate. The state theorists say that hypnosis is a result of an altered state of consciousness. An example of one such theory is that of Hilgard's Neodissociation. It assumes that hypnotic phenomenon occurs because the functioning of mental faculties divides into two distinct streams, one of which is unconscious. An anecdotal incident noted in his book best illustrates this view.

Hilgard hypnotised a blind student and while in trance state suggested that he would become deaf. Henceforth, the student indeed failed to respond to any form of noise but when Hilgard spoke in his ear quietly, asking if there was someone who could hear him and if so, the student should respond by lifting his right index finger. Sure enough, the student raised his finger and also subsequently asked to be brought out of the hypnotic state.

3 https://pubmed.ncbi.nlm.nih.gov/20166775/
4 http://barbelo.nl/wp-content/uploads/Chapter-1-1.pdf

Other theorists pertaining to the non-state view argue that the trance experiences under hypnosis is the result of the process of active imagination that is duly influenced by attitudes, beliefs and expectations.[5] It utilises and reflects normal cognitive processes and there is no change in the form of consciousness exhibited by the hypnotised person. Many neurophysiological studies have aimed at uncovering the precise way in which hypnosis works and have benefited most from exploring differences between the extent of suggestibility that people show. Highs have been known to exhibit both structural (greater volume in the rostrum of corpus callosum) as well as functional (reduced connectivity in frontal structures) differences as compared to those showing low suggestibility. Other research also shows that hypnotic response is enhanced when activity in the prefrontal cortex is selectively reduced.[6]

The prefrontal cortex is associated with many activities involving memory functions, processing internal states as well as attention allocation.[7] Even though neuroscience specifies the diversity of how and when brain areas are recruited, hypnosis as a tool is quite useful to determine how many of the factors that we relate to the consciousness of a human, operate. Most importantly, there has been documented differences between imagined states under normal conditions and those experienced by the subjects during or post hypnosis. For example, imagining reduced pain is significantly different from when subjects report a reduction in pain due to hypnosis, which coincidentally is similar to actual reduction using other methods.[8]

Hypnosis and Consciousness

Being conscious is the reality of being aware while consciousness is the sentience of existence. This idea and extension of the word 'conscious' into consciousness implies that awareness forms the basis of existence. Young's double slit experiment embodies how quantum physics sees the world: inherently probabilistic and thus, tangible only as a result of our observation. Hypnosis, in a similar vein exemplifies how increased attention towards the subconscious mind extracts, makes conscious, and in that sense gives rise to the reality of events, experiences and emotions otherwise inaccessible. Hypnosis is used to breach the demarcations between the conscious and the subconscious.

Beyond the questions that ask whether hypnotism works and how exactly does it bring about the observed effects, the field also opens up dialogue about what it means to be aware or conscious.

With the advent of neurotechnology and especially brain-computer interfaces, the answer to this question may open up many doors for the applications of upcoming devices. Whether hypnosis simply allows for our imaginations to run wild or whether it is proven to be a key that unlocks otherwise irretrievable information about our past selves, it serves as an example for how our brains react to such revelations. Not only that, trance is known to be induced by the amalgamation of the involuntariness of muscle response that is perpetuated through carefully worded suggestions as well as the perception of reality pertaining to perceptual-cognitive suggestions [2]. These reflect a questionable sense of self-agency that the hypnotised person thinks he has. Thus, consciousness and its important elements of control and awareness become fuzzy concepts when it comes to hypnosis. It serves as a revelation for not just the fact that consciousness is fluid even outside of the sleep-wake transitions but is controllable, its degree like a volume dial.

Hypnotism offers a peephole to how certain influences, be those:

- externally originating (a controlling hypnotiser)
- suggestive (modern day hypnotherapists)
- self-induced (self-hypnosis)

can bring forth to the surface of our consciousness, previously unknown elements that are apparently a part of our own selves. Consider a hypothetical whereby using a neurotechnological device, someone feeds to our heads information that utilises the brain's circuitry to produce a thought or memory inside our heads. It is augmented, however once our brain has 'played it out' using its own synaptic connections, is that false memory or thought now a part of our consciousness? And if it is, can we reliably distinguish between a supplanted memory and a real one? **What about thoughts? Which ones are real?** □

5 https://hypnosisandsuggestion.org/theories-of-hypnosis.html
6 https://academic.oup.com/nc/article/2017/1/nix004/3605468
7 https://www.nature.com/articles/nrn1343
8 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6357291/

Hypnosis:

A journey from pseudoscience to psychotherapy

By Sameer Rajesh

The 18th century was rife with pseudoscience, but perhaps most fascinating was the idea of "animal magnetism", a term referring to a sort of spiritual transfer of energy between living things. It is hard to imagine what this would look like, but the belief in such an energy transference seemed to be rooted in the ideas of possession by a demonic entity–exorcists were thus well versed in the idea of "animal magnetism".

Of course, it is probably true that living things are not really magnetic, nor do we transfer energy between ourselves. But the idea and development of animal magnetism sparked a revolution in early psychology which has persisted. Some physicians and other early psychological theorists conjectured that animal magnetism could be used to connect individuals and influence others. This could be achievable by manipulating the "energy" associated with a pers. The concept was first introduced by a physician named Franz Anton Mesmer, but only decades later would his techniques be referred to by their common name: hypnosis. Mesmer's name would later become the root of the word "mesmerize", related to the process of hypnosis.

For much of the late 19th and 20th centuries, however, hypnosis became regarded as a pseudoscience. It found its place in carnivals and magic shows, but rarely in the clinics where it had originally been practiced. Recently, a shift in this thinking has transpired. While there is little data to suggest that hypnotherapy has clinical viability or that it has any actual benefits, its usage has grown over the last few decades and it is now used in conjunction with other psychiatric therapies for enhancing recovery from certain illnesses.

It would be prudent to define hypnotherapy. Per the APA, "Hypnosis is a therapeutic technique in which clinicians make suggestions to individuals who have undergone a procedure designed to relax them and focus their minds".1 While it is controversial whether these suggestions are made to the subconscious mind or to a conscious state, it is agreed upon that the hypnotized patient is in an abnormal state of awareness and consciousness. Hypnosis as described here is not your average, run-of-the-mill carnival trick. It is a slow, gentle easing of the mind that allows the patient to relax and become more accepting to the caregivers words. Commonly, the caregiver will slowly talk through gentle scenes and soothing imagery to calm the conscious mind. After entering a state of altered consciousness, the caregiver can make deliberate and targeted suggestions to the patient, pushing them to focus subconsciously on solving their psychological problems. For example, a hypnosis session with a chronic pain patient might involve the caregiver instilling in the patient a stronger subconscious confidence over their own pain. Over the second half of the last century, and continuing through the last 20 years, clinical psychology and psychiatry has seen the rise of numerous flavors of hypnotherapy, from solution based hypnotherapy (where hypnosis sessions focus on solving problems rather than eliminating them entirely), to curative hypnotherapy (where the focus is to eliminate the problem), to cognitive behavioral therapy (where the focus is on creating changes in conscious behaviors). In what follows, I will attempt to highlight some of the recent strides made in neurodegeneration (generally, age related neuron death) therapy associated with hypnosis.

Graphic by Vien Yen Ho Pham

Unfortunately, we get old. They say wisdom comes with age, but there are plenty of other things that come with age too–

most relevant to our discussion is the progressive death of neurons and the overall degeneration of the nervous system. Neurodegeneration comes in many forms and has many causes, but all these paths lead to a shared state of vastly reduced quality of life for the patient.

Treatment for the biological component of neurodegeneration is well researched, and though we are still unable to cure many of these diseases, we have come a long way over the last several years. But what about the psychological component? Patients experiencing neurodegeneration are often affected by depression, anxiety, mood swings, and sleep disorders–these are often symptoms that cannot be treated merely by tackling the biological symptoms they present with.

Recently, some neurologists have begun to ask if exploring hypnosis and suggestive therapies connected to the subconscious mind might alleviate these psychological problems. In 2013, for example, a case study was performed on a Parkinson's patient who suffered from severe tremors and other neurological symptoms. After receiving 3 weeks of treatment involving hypnotic intervention, the patient showed marked increase in self-reported quality of life, as well as reduction in tremors and other neurological symptoms.[1] A 2016 review on treatments of REM sleep disorder, a common neurological problem associated with Parkinson's disease, indicated that preliminary studies of the effects of hypnosis as a possible treatment for REM sleep disorder showed promising results.[2] Per the review, the hypnosis sessions involved instruction of mindfulness techniques that encouraged patients to imagine restful sleeping periods. The practitioner guided individuals while they were in an altered state of mind, allowing them to possibly introduce these mindfulness and relaxation techniques to the subconscious mind. Further studies are definitely required, but it is exciting to see that the development of such novel treatment methods has become more relevant, especially after a century of renouncement.

One might question why hypnosis was rejected to begin with, and whether this rejection, in part, stemmed from bad actors. While there are likely cases of bad actors and malpractice in the history of clinical hypnosis, it is far more likely that there was a cultural shift in medicine away from alternative treatments that could not be explained scientifically. For one, the subconscious state of mind is not easily accessible and thus not easily studied. Exploratory techniques that dabbled in altered states of mind as feasible methods of treatment were difficult to accept in part because it is difficult to perform controlled, clinical studies. Hypnotherapy is in no way universally recognized as a gold standard for treatment options; in fact, it is quite the opposite. In the Western world today, hypnotherapy is still not a commonly advertised psychotherapeutic avenue, with many instead opting to receive cognitive behavioral therapy or other mindfulness based approaches to solving psychological problems.

Now, I'm not a snake-oil salesman trying to peddle hypnotherapy to readers. To be accepted clinically, far more studies must be done and the ethical implications of hypnotherapy must be studied. What happens when bad actors begin to suggest to patients in altered states of mind that they commit crimes, or harm themselves or others? Most evidence points towards this not being possible under conventional hypnosis methods, but caution must always be exerted. The question of the medical ethics of hypnotherapy is a deep one, requiring far more study and thought from many different perspectives. What can be said, however, is that by tapping into the minds of patients in altered states of consciousness, hypnotherapy has on occasion proven to be a useful technique for bettering patient quality of life. It has come a long way from its roots of being regarded as a pseudoscience. ☐

1 Elkins, Gary, Jim Sliwinski, Juliette Bowers, and Elmyra Encarnacion. "Feasibility of Clinical Hypnosis For The Treatment of Parkinson's Disease:A Case Study." International Journal of Clinical and Experimental Hypnosis 61, no. 2 (2013): 172–82. https://doi.org/10.1080/00207144.2013.753829.

2 Jung, Youngsin, and Erik K. St. Louis. "Treatment of REM Sleep Behavior Disorder." Current Treatment Options in Neurology 18, no. 11 (2016). https://doi.org/10.1007/s11940-016-0433-2.

[Pair-eye-do-li-a]

By Jandy Le

Graphic by Lilian Zhang

A Pair of Eyes

Look on the road and there's a Miata winking at you, look in your hands and the foam in your latte forms a smiley face, look at your feet and a patch of glass nearby is staring in your direction. Thought you were alone? Personifying inanimate objects happens to be a common experience, whether that be through the mere activity of cloud watching or a more sophisticated act in as in designing appropriate company logos.

Food in the shapes of celebrities have been displayed and priced at thousands of dollars, manufacturers have altered the appearance of cars to attract their target audience, and a multitude of Twitter accounts have the sole purpose of posting images of inanimate objects with facial expressions. The structure of a face can be simplified to just three basic features: two circles depicting eyes and a curve below it symbolizing a mouth. Somehow, this specific facial arrangement seemingly appears everywhere around us, at times even conveying personality or mood — some objects seem happy and excited, while others look more disappointed or even angry. Additional characteristics of the face add to the anthropomorphism: for example, the front headlights of a car can convey a different emotion from the back headlights, and its body can either symbolize a gentle giant or a destructive machine — appearances allowing children to construct storylines from inside their own vehicles on the highway. This subconscious tendency seems wholesome, childlike, and almost irrelevant to everyday life; it's just the contours and lighting playing tricks on the eye anyway, right?[1]

The Phenomenon

The technical term for perceiving patterns in random stimuli, usually visual patterns, is pareidolia, its first two syllables conveniently pronounced "pair eye". A merge between imagination and perception, an exchange of insentience versus life, this universal phenomenon has been observed and identified for a long time; Leonardo da Vinci specifically pointed out this anomaly: "If you look at any walls spotted with various stains or with a mixture of different kinds of stones, if you are about to invent some scene you will be able to see in it a resemblance to various different landscapes adorned with mountains, rivers, rocks, trees, plains, wide valleys, and various groups of hills. You will also be able to see diverse combats and figures in quick movement, and strange expressions of faces, and outlandish costumes, and an infinite number of things which you can then reduce into separate and well-conceived forms."

Used previously as an evolutionary advantage to identify danger, but now more as a social component and fun activity, pareidolia can be traced back to be a survival tactic to distinguish friend from foe, and between safety and danger. Our subconscious now sustains this visual mechanism only as a precautionary measure, yet it is also used in our social, spiritual, and psychological lives.

https://www.bbc.com/future/article/20140730-why-do-we-see-faces-in-objects
https://www.inverse.com/article/49527-what-is-pareidolia

The Subconscious

Human brains are specialized to recognize previously seen patterns and past experiences. We are constantly surrounded by other people; the basic structure of a face is universal amongst all races and ethnicities, within neighborhoods worldwide. Thus, it makes sense that we would try to personify the rest of our environment too.

The underlying subconscious processes start with early visual processing upon initially seeing an object. Since simple facial features — those three main components — are readily recognized in our day-to-day life, in the first split second of viewing an object, the brain utilizes a top-down processing approach in an attempt to construct predictions of the image that we will see, before any other complex processing mechanisms apply context. The brain combs through all its similar past experiences to find the best image match — like a reverse Google search. The best match results in an incomplete, partial image of what we are used to seeing all around us: faces. Any irrelevant details of the object are ignored and instead, our brains further this task by assigning emotions and direction of gaze from the object, which could even be dependent on the viewer's own mood at the moment.

Our high pattern recognition and memory skills come from a part of the visual association cortex, called the fusiform face area. Damage to the fusiform face area can cause an individual to lose the ability to recognize faces, a deficit found commonly in stroke victims. Even though there is only a quick, limited engagement of visual pathways, high activity in the orbitofrontal cortex, which searches through expected outcomes, connects to structures involved with emotion and memory, such as the amygdala and hippocampus, result in this emotional attachment to inanimate objects.

Personal expectation and preface leads to easier recognition of faces, as well. You're cloud-watching with your friends, one of them points to a bumpy feature at the cloud straight ahead. "You see that part, that's the nose!" they exclaim, leading you to an immediate identification again of the familiar eyes and mouth once you reorient yourself. The importance of habituation explains how the more faces you see, the more faces you will spot.

There May Be a Reason

The fact that we see faces all around us brings a sense of commonality and comfort in seeing personified objects. Merely a fun observation for both children and adults today, the fact that faces are the preferred shape of even infants and children's brains who have not been surrounded by as many people, reflects an evolutionary explanation for pareidolia. Human brains are adapted to be aware and react immediately to danger, such as strangers or enemies sneaking up on us. The ability and sensitivity to spot a face in the wild quickly — even one we have not seen before — is a key benefit to survival. It's important to quickly register whether or not a face is human so one can decide a plan of action afterwards as needed. Even the ability to distinguish the emotion of that human face gives an inference as to whether someone is an enemy or ally, whether someone intends to cause harm or good. In addition, pareidolia may be the root that inspired the origins of religion and spirituality. Detecting faces in nature have led people to believe that a spirit or greater being is watching them; it has been shown that religious people are more likely to see faces than atheists are.

The brain also tries to interpret and find intentions behind uncommon, but justifiable, situations; for example, many people rely on natural circumstances such as thunderstorms, in which the shadows mimic large figures, or the menacing, reaching arms of a wildfire, to provide speculation.

Psychological effects of this seemingly meaningless phenomenon in turn also enact psychological effects on mood and behavior. Under the gaze of a watchful eye, people are more likely to act honestly; studies have shown that having a "pair of eyes" in front of a bike rack has been shown to significantly reduce bicycle theft; with this psychological insight, monitoring

http://www.sci-news.com/othersciences/psychology/face-pareidolia-08752.html
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5016824/

measures in the form of supervising "faces" could be implemented to protect citizens from petty crime.

The child-like manner of pareidolia can positively affect the viewer's mood. Like a picture book came to life: those with a higher sense of imagination may sense more anthropomorphized objects around them, perceiving themselves in a more lively environment. The reverse applies as well, in which the viewer's mood impacts their perception of the object. The subjective mechanism of pareidolia has been shown to tie to the current emotional state of the viewer; an object portrays a more optimistic impression to a positive person, compared to a condescending and judgmental object staring down at an agitated viewer. The more positive person may also have a greater tendency for seeing faces, possibly because they are more open to their surroundings and social interaction.

Conclusion

Current research suggests that women are better than men at seeing faces, and that men are likely to identify faces that are much more obvious to the human eye. We could even extend this concept to analyzing people's different interpretations of optical illusions, and how one's visual prediction can reflect their mental and emotional state.

Further study of pareidolia and visual perception in general can be used as an indicator to whether an individual has a healthy mind, with well-functioning social processes and pattern recognition, giving more insight into the workings of the subconscious. ◻

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https://www.artsy.net/article/artsy-editorial-human-faces-look
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accessing the subconscious

Design by Amy Wang

A Nosedive Into the Spiral of Learned Helplessness

By Malachi Keo

I know what it's like to do the impossible, and today, it was getting out of bed. For so many, the impossible doesn't go past the sky into the unknown, but is a common confrontation between a person and her daily do's. When resistance seems futile, the question isn't if a person is steering in the right direction, but if his foot is even on the gas pedal. The resignation to try because of a long list of seemingly inevitable failure is what psychologists have defined as learned helplessness. Whether there is any actual chance of success, the expectation of failure from no perceived control[1] is key to understanding this condition. Here, the neurocircuitry of learned helplessness is described, along with its negative implications on well-being, and its subconscious development and reinforcement in common environments and ways of thinking.

Graphic by Amy Wang

The Experiments Behind Learned Helplessness

Dr. Martin Seligman at the University of Pennsylvania and Dr. Steven Maier at the University of Colorado, Boulder, have since the 1960s, been the greatest minds in shaping the theory of learned helplessness. Prior to understanding its neurological basis, the proposal of learned helplessness challenged fundamental ideas about learning theories and animal cognition.[2]

In their first experiment with dogs, the dogs were divided into three groups and each placed into hammocks with holes for their legs to poke through. This restricted movement, but allowed their legs to come in contact with the ground that could deliver a shock by the experimenters. In the first group, the dogs would be given shocks that could easily stop by pressing a button in front of them with their head. In the second group, the dogs would also be shocked, this time, with a button that didn't work. Even if a dog pressed his button, the shock would continue until its set time. The third group of dogs experienced no kind of shocks at all while in the hammock.[3]

The next day, the dogs were each placed into a shuttlebox—an enclosure where only half the ground could deliver a shock, and the other half be completely shockless. This is the important part: When a shock was delivered, over 90% percent of the dogs in the first and third group jumped over to the shockless side, but just a third of dogs in the second group. What happened?

The only difference between dogs in the first and third group, and dogs in the second group was that the shock was escapable (or not delivered at all). Confirming their hypothesis, and successfully disproving behaviorists wrong, it seemed well that the dogs with inescapable shocks had learned helplessness.

1 Baratta, Maier, "New tools for understanding coping and resilience", 54-57.
2 Seligman, Maier, "Failure to escape traumatic shock", 1-9.
3 Maier, Seligman, "Learned helplessness at fifty: Insights from neuroscience", 349-367.

The Neurocircuitry of Learned Helplessness

The neurocircuitry behind this psychologically complex phenomenon is surprisingly straightforward. As an oversimplification, it likens an ON/OFF switch by the ventromedial prefrontal cortex (vmPFC) to the dorsal raphe nucleus (DRN). Such neurological studies were conducted on rats who underwent similar experimentation as the dogs.

When a shock is delivered, the dorsal raphe nucleus does two things: it inhibits serotonin neurons leading to the dorsal periaqueductal gray[4] and activates serotonin neurons to the amygdala.[5] In order to stop these two events from happening, the ventromedial prefrontal cortex can inhibit the dorsal raphe nucleus. Thus, it is up to the vmPFC to decide whether or not the DRN activates, and consequently, whether the dorsal periaqueductal gray is inhibited and amygdala activated.[6]

So what determines whether the vmPFC activates to inhibit DRN function? When an avoidable shock is computationally detected by the brain, the vmPFC activates, versus when an unavoidable shock is detected, the vmPFC does not activate.[7] In this manner, the two types of shock determine vmPFC activation, like a switch.

What significance does all of this have to create learned helplessness?

The Psychological Consequences of Learned Helplessness

The ventromedial prefrontal cortex not activating causes a change in behavior in the form of increased passivity and anxiety; the dogs and rats stopped avoiding the shocks. When the ventromedial prefrontal cortex did activate, the majority quickly hopped to the safe side of the shuttlebox. Translating these results to human life, the trial of shocks can be seen as a person's past experience with success and failure. In another experiment, Seligman and another scientist, Dr. Donald Hiroto, asked people to first solve unsolvable puzzles, and then later, to solve solvable ones.[8] Most never tried, citing the reason that "nothing worked so why try?" It is unsurprising that from these results, learned helplessness, better defined as the lacking sense of power to change an outcome, has served as a popular animal model for depression.[9]

Participants experiencing learned helplessness in the laboratory showed eight of the nine symptoms of major depressive disorder.[10] According to the *Diagnostic and Statistical Manual of the American Psychiatric Association Fourth Edition*, only 5 are needed to be diagnosed. Learned helplessness contributes to people being less social, more afraid and anxious of new things, a decreased interest in once pleasurable activities, and a sense of defeat.

What is Being Done About Learned Helplessness?

Fortunately, learned helplessness isn't a permanent reality for most people, and even for people with depression, cognitive behavioral therapy (CBT) and medication have helped buffer its effects. One way CBT and programs like the Penn Resiliency Program have minimized this experience in adults and children is through teaching learned optimism.

When a person experiences failure (or success), as a way of moving on, she can explain to herself why it happened. Known as a person's explanatory style, this concept evolved the theory of learned helplessness and its occurrence in individuals as a strong predictor for depression.[11] Together, Seligman, Lyn Abramson, and John Teasdale characterized a person's explanatory style as pessimistic or optimistic by how they perceived the stability, generalizability, and cause of an event.[12] That is, whether the person believes the cause is by something they can't change (stable) or can change (unstable), whether the cause of the event ripples into the rest of her life (global) or just this area (specific), and whether the cause is because of herself (internal) or something else (external).

With this evaluation of explanatory style as the centerpiece for what is now called the reformulated learned helplessness the-

4 Sharp, "Chapter 2.6 - Serotonergic feedback control", (233-247).
5 Urry, van Reekum, Johnstone, Kalin, Thurow et al., "Amygdala and ventromedial prefrontal cortex are inversely coupled…", 4415-4425.
6 Maier, Watkins, "Role of the medial prefrontal cortex in coping and resilience", 52-60.
7 Maier, Watkins, "Stressor controllability and learned helplessness…", 829-41.
8 Hiroto, Seligman, "Generality of learned helplessness in man", 311-327.
9 Vollmayr, Gass, "Learned helplessness: unique features and translational value of a cognitive depression model", 171-178.
10 American Psychiatric Association, "Diagnostic and statistical manual of mental disorders (5th ed.)".
11 Peterson, Seligman, "Causal explanations as a risk for depression: Theory and evidence", 347-374.
12 Abramson, Seligman, Teasdale, "Learned helplessness in humans: Critique and reformulation", 49-74.

ory, the three conducted several studies with participants that voluntarily went to the riskiest place for developing learned helplessness: school. They hypothesized that students that were most likely to develop not just learned helplessness but depression would take on the pessimistic explanatory style, characterized by a stable, global, and internal cause (e.g., "Failing this test is no surprise since I am failing the rest of my classes, no matter how hard I study."). When the school year ended, the scientists were proven right. Students with a pessimistic explanatory style reported higher levels of depression. Not only that, but students explaining bad outcomes with this style also showed relatively low academic achievement. The spiral of learned helplessness deepens people's sense of no control over their life's outcome, especially lowering their self-esteem when they attribute themselves as the sole cause.[13] In future scenarios, many have already convinced themselves that they will fail.

There is a flip side. The optimistic explanatory style is characterized by an unstable, local, external cause (e.g., "Even though I bombed this math test, the professor is known for his hard exams, and this says nothing about my skills in football!"). Students who used this style reported lower levels of depression and higher academic achievement.[14] While these certain factors are in respect to explaining bad events, taking the opposite style for good events also predicts depression. A person using the pessimistic explanatory style would attribute a *good* event as unstable, local, and external (e.g., "I only passed this test because the professor made it extra easy"), while a person using the optimistic explanatory style would attribute a good event as stable, global, and internal (e.g., "Hard work always pays off, so I'm glad I studied last night to earn this grade!"). The Penn Resiliency program and psychologists practicing CBT similarly cultivate optimism, so that in the next encounter of a bad event, patients and students might be resilient.

Finally, psychologists conclude that while learned helplessness is a leading animal model of depression, the phenomenon is not unique to depression.[15] People with anxiety, PTSD, or schizophrenia can also experience learned helplessness and are treated for it with different medications, indicating its prevalence in clinical populations with people who haven't been diagnosed with depression. Due to this nonspecificity and the popularity of learned helplessness in translational research, scientists responsible for the taxonomy of psychopathology have begun to break away from a symptom-based approach (e.g., "Having these symptoms means you have this disorder"), and instead, are paying greater attention to the biology that underlies these processes; a process-based approach.[16] So, complementary to a deeper awareness of the mechanics that reinforce feelings of helplessness, there is research using this knowledge to mitigate its negative effect. In fact, Martin Seligman was the figure to establish this new field as president of the American Psychological Association, duly naming it positive psychology. From his perspective, it isn't a bad idea to reclaim the circuitry for learned helplessness as a circuitry for hope. ◻

13 Nolen-Hoeksema, Girgus, Seligman, "Learned helplessness in children: a longitudinal study of depression, achievement, and explanatory style", 235-242.
14 Gillham, Reivich, Jaycox, Seligman, "Prevention of Depressive Symptoms in Schoolchildren", 343-351.
15 Myers-Schulz, Koenigs, "Functional anatomy of ventromedial prefrontal cortex", 132-141.
16 Forgard, Haigh, Beck, Davidson, Henn et al., "Beyond Depression: Towards a Process-Based Approach to Research, Diagnosis, and Treatment", 275-299.

Unlocking the Power of the Subconscious Mind through Autosuggestion

By Oliver Krentzman

"The greatest discovery of my generation is that human beings can alter their lives by altering their attitudes of mind"
- William James

Graphic by Chris Seo

The Power of The Human Mind

Scientists have discovered that the human mind is so powerful that it can convince the body of physical and or psychological illness. Neurasthenia, Hypochondriasis, and Somatization are all disorders that are categorized by a psychological interpretation that leads to a perceived physical symptom. This means that **constantly worrying about getting sick can be the impetus for the body to begin feeling sick.** Caroline Goldmacher-Kern, a New York-based psychotherapist said "The brain is so powerful that it really can convince itself of illness".[1]

If the human brain can convince the body that it is sick… can it also convince the body that it is well and thriving?

This article will seek to explore the impact of the mind over the body and explain how Emile Coué's principle autosuggestion can be used to improve the quality of one's life by rewiring subconscious thought patterns.

What is Autosuggestion?

Autosuggestion (sometimes called affirmation) is a method of self-administered suggestion that has the ability to influence the dominant thoughts permeating throughout the subconscious mind. Autosuggestion was introduced in 1920 by the French psychologist and pharmacist Émile Coué in his book Self-Mastery Through Conscious Autosuggestion.[2] In the book, Coué discusses the conscious mind's ability to influence the subconscious mind. Coué explains that the subconscious mind "may be compared to a horse, improperly harnessed to your carriage, and without bridle or reins; that horse may perform all sorts of foolish tricks and cause your death. But, harness him properly, drive him with a firm hand, and he will go where you want him to. It is the same with your [subconscious mind]. You must direct it for your own good".[2]

During his time as a pharmacist, Coué noticed that his patient's beliefs and expectations related to the effectiveness of a med-

1 https://www.psychologytoday.com/us/articles/201001/hypochondria-the-impossible-illness
2 https://www.amazon.com/Self-Mastery-Through-Conscious-Autosuggestion/dp/1420928163

icine were as important as the medicine itself. This prompted Coué to discover the power of psychosomatic medicine also known as the placebo effect. The placebo effect in medicine is when the mind convinces the body that a treatment is real when in fact it is not. According to a 2019 Harvard Health article, "science has found that under the right circumstances, a placebo can be just as effective as traditional treatments".[3] Coué was interested in the power the human mind has to influence the success of a given treatment. With his discovery of psychosomatic medicine in mind, Coué became motivated to learn other ways that the power of the placebo effect could be utilized.

Coué discovered that by repeating a positive and self-affirming message (with confidence and belief), a person could tap into the power of the placebo effect and convince the subconscious mind that the message being repeated is true. In this way, the conscious mind could begin influencing the subconscious mind to work towards achieving the repeated message. Coué became famous for his saying "Every day, in every way, I'm getting better and better". Coué told his patients, "Learn to cure yourselves; you can. I have never cured anybody; the remedy is within yourselves".[2] Coué set the stage for later scientific discoveries to be made about the neuroscientific and psychological implications of autosuggestion. As we will see, Coué wasn't the only brilliant mind utilizing the power of autosuggestion.

"The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking."
- Albert Einstein

The History & Science of Autosuggestion

There have been many people throughout history who knew of the power of autosuggestion. Although Emile Coué brought this to the mainstream in the Western world, the principles behind autosuggestion have been known for thousands of years. In the book, Rituals and Mantras: Rules Without Meaning, former UC Berkeley professor Johan Frederik Staal, wrote, "during the middle Vedic period—approximately, from 1,000 B.c.E. to 500 B.c.E.— ritual [mantra] became the most prominent expression of Vedic culture and civilization".[4] Mantric expression has been a central practice in other Eastern religions as well such as Buddhism, Jainism, and Sikhism. Mantras, affirmations, and autosuggestions all tap into the same foundation idea: thoughts are important and we can direct them through repetition.

In more recent times, scientific investigations into the applications and overall effectiveness of autosuggestion have been advancing. In a 2014 article, Geoffrey Cohen from Stanford University and David Sherman from The University of California, Santa Barbara presented scientifically-backed applications of autosuggestion. According to the article, autosuggestions can help individuals in a variety of circumstances including, buffering against threats and stress, reducing defensive responses, assisting with intergroup conflict and interpersonal relationships, and overcoming barriers to long-term behavioral changes.[5] The main takeaway from this article is that there is a wide range of applications for autosuggestion which have the potential to positively impact a person's life.

In a 2020 article looking at the applications of autosuggestion on individuals suffering from symptoms of social anxiety, the principal investigator, Dr. Łakuta wrote "research on self-affirmation [autosuggestion] has flourished in the past decade, with numerous studies demonstrating its capacity to improve emotion regulation processes and promote adaptive processes that resemble strategies of the resilient".[6] The findings of this study confirmed that autosuggestion has significant positive long term effects that helped buffer against symptoms of social anxiety. Furthermore, this study supports the notion that autosuggestion has the potential to positively alter thought patterns leading to psychological improvements.

Interestingly, in another study, researchers discovered the neural correlates that are associated with autosuggestion: the Ventral Striatum (VS) and the Ventromedial Prefrontal Cortex (vmPFC).[7] The VS is associated with the reward system, behavioral reinforcement, and learning. The vmPFC on the other hand is thought to be involved in emotion regulation, decision-making, and social cognition.[8] Collectively, these parts of the brain are associated with the reward system and self-related

3 https://www.health.harvard.edu/mental-health/the-power-of-the-placebo-effect
4 https://www.amazon.com/Ritual-Mantras-Rules-without-Meaning/dp/8120814126#:~:text=Rituals%20and%20Mantras%3A%20Rules%20without,linguistics%2C%20anthropology%20and%20Asian%20studies.
5 https://www.annualreviews.org/doi/10.1146/annurev-psych-010213-115137#_i46
6 https://www-tandfonline-com.libproxy.berkeley.edu/doi/full/10.1080/10615806.2020.1746283
7 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4814782/
8 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5862740/

information processing. This discovery is important because continuous activation of these brain regions (through autosuggestion) will inevitably lead to stronger synaptic connections within the local neural circuitry. The strengthening of these connections has the potential to influence dominant conscious and subconscious thought patterns within the brain. These scientific studies among many others continue to validate the effectiveness of autosuggestion as a means for altering subconscious thought patterns leading to positive behavioral changes.

Conclusion

The subconscious mind is one of the most dominant parts of the human psyche. It is particularly powerful because it does not occupy a person's attention, rather it operates behind the scenes when a person is not thinking consciously. The subconscious mind gives rise to a feeling of identity by storing and reminding the conscious mind of beliefs about oneself. **The subconscious mind is malleable and can be influenced by the conscious mind to adopt positive thought patterns and self-affirming beliefs.**

Autosuggestion is a scientifically proven method of planting beliefs into the subconscious mind which has the potential to aid in the realization of a goal or desire. The principles of autosuggestion can be further studied through authors like Emile Coué, Napoleon Hill, Earl Nightingale, and Dr. Joe Dispenza among many others.

Although we may not have the ability to fully control our subconscious minds, we do have the ability to utilize the principles of autosuggestion to begin influencing the subconscious mind. Furthermore, we have the ability to tap into the power of the human brain to cognitively appraise situations and consciously direct the metaphorical ship that is our mind. If used properly, autosuggestion has the potential to significantly improve the quality of one's thoughts, behaviors, habits, values, and destiny.

"A man's mind may be likened to a garden, which may be intelligently cultivated or allowed to run wild; but whether cultivated or neglected, it must, and will, bring forth. If no useful seeds are put into it, then an abundance of useless weed seeds will fall therein, and will continue to produce their kind."
- James Allen, As a Man Thinketh.[9]

9 https://www.amazon.com/As-Man-Thinketh-Complete-Original/dp/1523643536

Is Neuromarketing an Ethical Application of Knowledge?

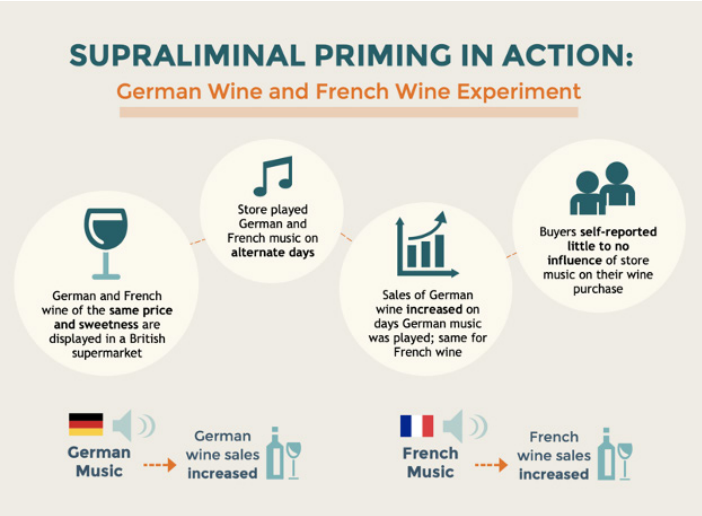
Graphic by Vien Yen Ho Pham

By Vien Yen Ho Pham

Introduction

Scrolling on Facebook, you occasionally run across ads. While rapidly swiping past them, you probably think nothing of it. It's just another annoying advertisement... right? Wrong. There is a whole team of professionals behind that ad dedicating their lives to learning about the neuropsychology of your brain, collecting data on what you like, and delivering an ad that is perfectly targeted to fulfill your needs.

According to Harvard Business School Professor Zaltman, around 95% of our purchasing decisions are driven by our subconscious processes. An experiment conducted by psychologist Adrian North in 1999 strongly illustrates the power of subconscious marketing. In this experiment, a British supermarket offered both French and German wine at the same price and same sweetness level and measured purchasing behavior for a week. The supermarket alternated between playing German music and French music on different days. Interestingly enough, on the days that French music was played, 77% of the wine sold was French. And on German days, 73% of the wine was sold as German. This occurred despite buyers self-reporting that there was little to no influence of the store's music on their purchasing designs.



(From Visme)

Chemical & Biology Processes

Covering the physiological aspects of marketing, there are a few main hormones released in our body as we experience different things.

For example, oxytocin is released when people feel secured and connected. To target those hormones, marketing attempts to replicate the values and environment that consumers lived in 10 years ago.

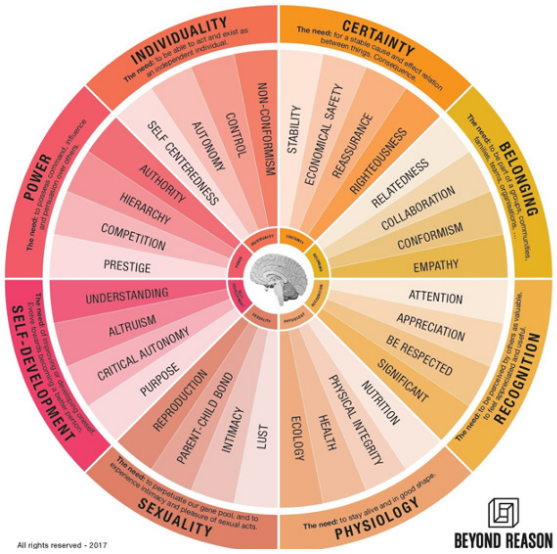
Another common chemical marketers target is mirror neurons and dopamine. Mirror neurons allow us to understand others. These neurons fire when we successfully mirror someone's actions and release dopamine, the feel-good reward hormone. To activate this biological process, marketers show action in an advertisement that the consumer is familiar with. The relationship with the brand is further enhanced when the consumer performs the same action that they saw in the advertisement.

As for a more biological approach, research published in Nature on subconscious information processing suggests that the mechanisms that drive decision making are triggered when our subconscious brain identifies an opportunity that produces a positive emotion. The researchers found that the decision of the consumer can be tracked to the activations of regions in the prefrontal and parietal cortex around 10 seconds before the decision reached awareness, reflecting that our subconscious drives our purchasing decisions. On the subconscious level, our goals relate directly to emotional responses. When we achieve our goals, we release positive emotions, but when we fail to achieve our goals, we release an increased amount of negative emotions. It is important to remember that these emotions can be produced dozens of times per day in small doses, often sub perceptually. This perhaps may be a result of the evolution of the brain in order to protect ourselves from danger, increasing our survival chances. Marketers continue to

learn about the biological processes of consumers in order to best angle their product in an advertisement.

Cognitive Processes

Beyond Reason, a marketing consultant group developed a model of implicit motivations through an analysis of psychological and neurological studies. The model breaks down an individual's motivation into eight main categories: certainty, individuality, belonging, recognition, physiological, sexuality, self-development, and power.



(From Beyond Reason)

These motivations are foundational and serve as an effective resource to evaluate what drives consumer decision making. For example, when deciding between brands, consumers exhibit a level of uncertainty about whether or not a product works well. If the product exhibits trustworthiness, the consumer is more likely to purchase. For example, $1.2 billion makeup and skincare company Glossier poses questions to followers of their Instagram account about the quality of specific products, effectively opening themselves up to criticism. This creates a special bond and trust between the consumers. As a result, 80% of Glossier's advertisements stem from word-of-mouth advertisement rather than paid advertisements, strengthening the trust between consumer and brand.

The skincare line, The Ordinary, also relies on a similar tactic of trust and word of mouth by offering very simple packages, creating ridiculously low price points, and building transparency with their simple ingredients. In 2017, Vox reports they were named one of the biggest skincare lines in the US.

Individuality appeals to the self-centeredness of an individual. By customizing the product according to the consumer's needs, a company taps into the core value of individuality. For example, Air B&B offers a combination of choices ranging from location, duration, price, and type of place. Similarly, shoe companies like Nike allow you to customize your own type of shoe.

Companies end up exploiting these motivations through a few tactics, predominantly through two main methods. The first one is direct exposure to the brand, for example, directly trying a sample of a food. The second is through brand advertisement by encouraging viewers to talk about the brand with friends. Marketing professional and author Allan Dibb discusses that the first method, direct exposure to the brand, is not the most effective marketing experience. When a consumer views an advertisement, the brain creates a perception of the company shown. Then the brain stores the information subconsciously for future use. The emotional perception of the brand can influence the purchasing decision of the consumer more than direct exposure.

For a successful advertisement, the advertisement needs to display how exactly the product is different from others while also positively meeting the consumer's needs. To be successful, as Gemma Mullin puts it, "brands should be moving from novelty to familiarity and eventually an established habit." For example, the technology of Apple is extremely novel as they market one of the most cutting edge pieces of technology out there available to consumers, displaying the uniqueness of the brand. However, despite the novelty, the brand is familiar to millions of Americans, and finally, Apple puts the brand into familiarity by creating the daily necessity of the iPhones.

A Question to the Readers

Perhaps this may make you rethink everything you own. The decision making process had some sort of intention through it. The question is posed, ***is this behavior from companies manipulative, or simply thoughtful marketing to suit your needs?*** ☐

Bigotry in the Brain:

Why it Seems like We Can Never Agree

By Annabel Davis

2020, a year compiled of unprecedented turmoil and uncertainty. From everything to the life altering Covid-19 pandemic, the Black Lives Matter movement, the United States Election, to even the estranged murder hornets and alien life that somehow appeared earlier in the year, it seems as though fear and chaos has become a regular fixture in our lives. But within this chaos, one thing throughout it all that has remained apparent is division, especially division based in bigotry.

Conscious and unconscious thoughts that encompass bigotry come from what is known as Implicit Bias; or the indirect expression of prejudice or stereotyping, often in one's response to members of a particular social group" (Greenwald & Banaji, 1995, 2017). This is why people will tend to form the opinions they have later on in life. Implicit bias may be based on any aspect of a person's "social identity, from race or ethnicity to sexuality or nationality, or even arbitrary group categories." The things that we notice in our society that suggest -negative implicit bias- go into what we know as prejudice and bigotry. Direct actions based on these biases are inherently explicit, however, the hard wiring in our brain show more implicit tendencies when it comes to decision making and constructing opinions.

Understanding how implicit biases are encoded in the mind and brain can help us predict the way it will influence behavior and inform ways to reduce its impact; but knowing how to reduce this impact first requires the knowledge of how implicit bias for things such as bigotry are formed in the brain and how we can recognize the root of these dispositions.

Implicit bias may reside in what is known as semantic associative memory (automatic associations between concepts that often go together), emotional memory (affective reactions to threat or reward - Pavlovian), and instrumental memory (how one approaches and how one avoids due to behavioral association); all of these relate and formulate automatic behavioral responses (habits) (Desaunay et al., 2017).

Each of these coexisting parts of implicit bias depend on different neural processes. For conscious thought, these memories work in tandem to conduct our thoughts, emotions, and behaviors. But what is important to remember is that these memory systems function with little conscious input from the individual — "forming and influencing our behaviors without our awareness or intention." To understand the effects on an individual one must understand the workings of implicit social cognition (Amodio, 2019; Amodio, 2008; Amodio & Ratner, 2011).

The subconscious involves all information that cannot be consciously processed. An individual's subconscious can process information and make them act out of fear, without the individual fully understanding why they are acting that way (Subconscious vs Unconscious mind, n.d).

In terms of bigotry, it makes sense to look at implicit racism or unconscious racism, considering the need for racial justice and equity in our present moment, but then to apply this more apparent subject to other sectors of biases of bigotry such as homophobia, xenophobia, sexism, and so forth. Explicit racism more so describes behaviors such as speech or actions that demonstrate a conscious recognition of racist attitudes and beliefs. However, implicit or unconscious racism includes implicit biases or tendencies that persist within an individual, regardless of their awareness of these biases. Implicit/unconscious racism is what then leads to explicit racism based upon implicit biases that are learned throughout an individual's conscious experience.

David Amodio, an associate professor of psychology at New York University, has extensively researched unconscious racism in the brain and found that often, "people's implicit biases aren't based on personal experiences or beliefs, but rather reflect

Graphic by Amy Wang

societal messages, such as the images of blacks or other minorities seen in the media."

What we know as stereotypes are produced through this same kind of affective bias. Affective bias is how one processes negative things relative to positive events and the tendency to differentiate between the two (Pulcu & Browning, 2017). When we look into long term memory, we see that it's formed from both non-declarative (implicit) and declarative (explicit) concepts/modules. Declarative memories are a bit easier to understand as its made up of what you would expect of a memory such as facts and events, which have been found to be stored in the medial temporal lobe (ie. hippocampus). But non-declarative or implicit memories are formed in a much more nuanced way; with procedural memory (skills and habits) are stored in the striatum, conceptual priming in the neocortex, classical conditioning (how emotional responses are formed) stored in the amygdala, and non-associative learning which is stored in more random structures such as reflex pathways.

These systems make apparent a stark truth about how and why we form severely biased mental models; the formation is deeply wired into several different systems of memory and learning, meaning it takes work and understanding to fully change an individual's perspective on an implicitly held belief. Take for example, racial prejudice as a commonly held implicit bias, because of how racial prejudice would then be processed from factors from how they were taught (or many other learning events likely out of one's control), it takes time and effort to strengthen one's ability to change implicit racial biases. Even so, this does not mean that it is impossible to change a racist person's mind, but what it does mean is that it takes time and persistence to overturn this kind of prejudice.

Now, where is the proof that racial bias ACTUALLY exists rather than just randomly connecting these patterns to form an assumption? Dr. David Amodio has conducted and reviewed several studies that support the existence of implicit evaluative race bias and implicit stereotyping, such as a study looking at racial biases of self reporting participants but also more explicitly one of white American participants viewing white and Black faces and seeing implicit associations based on fMRI, eye blinking, and internal and external motivation scaling. In his research including studies such as this, Dr. Amodio has found that implicit evaluative racial bias is directly associated with amygdala activation, but not areas involved in semantic associations or general world knowledge. This essentially means that there is inherently a more emotional response associated with racial bias in the brain rather than what is stored as fact or knowledge. Implicit stereotyping is, however, associated with activations in the left temporal and frontal lobes, but not with the same emotional amygdala activity - meaning more so that these activations are related to semantic memory and are more associated with what we know as a form of factual or worldly knowledge in a way, whether it is correct or not.

The studies investigated by researchers like Dr. David Amodio, combined with an understanding of subconscious processing beg the question: how are implicit biases actually regulated in the brain? If Amodio's results are valid, does this mean that there are differences between stereotyping and affective bias? And may these findings inform how self-regulation of prejudice-reduction can be achieved? It's worth exploring the neurological data to find out.

The actual neural regulation involved shows heavy association to Major lateral prefrontal cortex (PFC) effects, where in the Left PFC it manages goal representation, action, and influences the tuning of one's perception, while the Right PFC manages the actual inhibition of action. This inhibition of action and tuning of one's perception actually plays a huge role in regulating stereotypes and assumptions. In a more traditional interpretation of this information, it suggests that this plays into the general internal regulation of affective semantic systems in the brain. Essentially, it demonstrates evidence for the fact that the PFC controls initial emotional responses, or the "gut feelings" that show up in making assumptions or stereotypes, by "down-regulating" the amygdala. Furthermore, the Medial PFC plays an even bigger role in this type of regulation because it has direct associations with controls such as social knowledge representations, interpersonal response regulation, and the overall humanization process. Humanization in this context means more so the emphasis of empathy in relating a humanistic perspective to another person, or in other terms recognizing a common humanity (Corissa, 2016).

It appears that stereotypes are regulated through the process of changing one's goals and inhibiting possible unwanted actions from occurring. The aforementioned right lateral PFC is then what is involved in inhibiting these stereotype rooted

responses that are the basis of racial bias and general bigotry (Amodio & Swencionis, 2018). The Medial PFC is involved in the regulation of affect based responses, where affective bias is generally controlled by interacting with one's social cognition or humanization in this case.

These studies may demonstrate an ability for people to self-regulate their emotional biases and actually rewire the pathways in their brain. This process of regulation would require seeing a person in a new perspective that focuses on their "humanization". Specific intervention would involve engagement and highlight the "humanness" of individuals through the promotion of social interaction. To regulate stereotypes and stereotype based biases/behavior, it would involve monitoring one's stereotypes that they hold and perform a readiness to then regulate/withhold any expression regarding said stereotype (Amodio & Swencionis, 2018). It does not help to directly attempt to suppress any initial thoughts or feelings in this way as it would disregard the actual neural circuitry and hard wiring of an individual, possibly causing more harm than good (Geggel, 2016).

Overall, we do not need to act on implicit bias nor should we use it as an excuse for racial prejudice or general bigotry. This notion that implicit bias is "natural" falls into a naturalistic fallacy which is an informal logic based fallacy, arguing that if something is 'natural' it must be good when that is not really always the case.

An interesting notion from the study of implicit bias and how the intervention involves gradual learning and rewiring shows the growth within social rights overtime and the growth of a humanistic mindset (Amodio & Swencionis, 2018). From a culture that has been historically entangled in racism and has continued to perpetuate racist ideologies in many forms whether that be explicit or implicit; there must be a goal to validate and recognize this same history and see how this may have affected our current thinking and implicit bias through systemic means of racism and bigotry.

There is responsibility to use information such as what is concluded by studies such as these to work on bettering ourselves by recognizing our own implicit biases, and even recognizing bias behavior in our peers. Then choosing to educate ourselves and others on topics such as race and how race is impacted today in this case, or other forms of social education that one may lack. As said before when trying to re-wire these implicit bias pathways/structures in our brains, we must tend to it with continued diligence, patience, and empathy rather than a abrupt emotional response - otherwise the ability to learn and to try to intervene gets overruled over by the amygdala and only creates further aggression in favor of the preconceived implicit bias that we aim to diminish. After this kind of education, one then must actively choose to do something differently, in order to strengthen the regulation of structures such as the Medial PFC that helps to diminish the initial amygdala response and eventually forms the desired behavior.

From the evidence provided by these studies we know that there is no need to act on implicit bias, let alone use it as an excuse for racial bias or bigotry, especially any kind that may lead to violence. Again memory systems function with little conscious input from the individual — "forming and influencing our behaviors without our awareness or intention" (Amodio & Devine, 2005). But people's implicit biases are not based on personal experiences or beliefs, but instead in societal implication and messages that continue a narrative of bigotry.

There are many further implications for this information especially in neurotechnology. There are many possibilities in what could be designed to even recognize behavior or implicit bias in a person. There could be a design for a tailored system of education and different forms of therapy that help rewire and strengthen one's ability to intervene in implicit bias. Although the application of this in a technological sense could be great, we need societal movement towards at the very least diminishing racist behavior, if not eradicating it. We need to establish greater empathy for the collective in order to continue a "positive cultural change"(Warren, 2020).

Practicing this diligence towards race and towards bigotry help confront racist conditioning and other negative forms of implicit bias (Amodio, 2010). There is much to practice when confronting these behaviors and changing one's ways, and imagining exactly how is often a very difficult thing to do and is definitely not an easy option, but it is the necessary option. This means actively thinking about your own actions and beliefs and working to diminish any racial biases that you may have, or if you see these behaviors in others, finding ways to have these difficult conversations with a focus on patience,

persistence, and empathy (BBC 3, 2015).

Inherently, we have a responsibility to act against racism and bigotry as it continues to have negative consequences for minority groups both physically and mentally. There is a need to dismantle our own prejudices and biases in order to then dismantle systemic oppression that we have become complicit in maintaining (Warren, 2020). These are no simple tasks that we must confront but from what we know about our own brains and our own minds, we must recognize, educate, and act to change these biases and have the willingness to do so in order to create the change necessary to end this divide and promote our humanity. ◻

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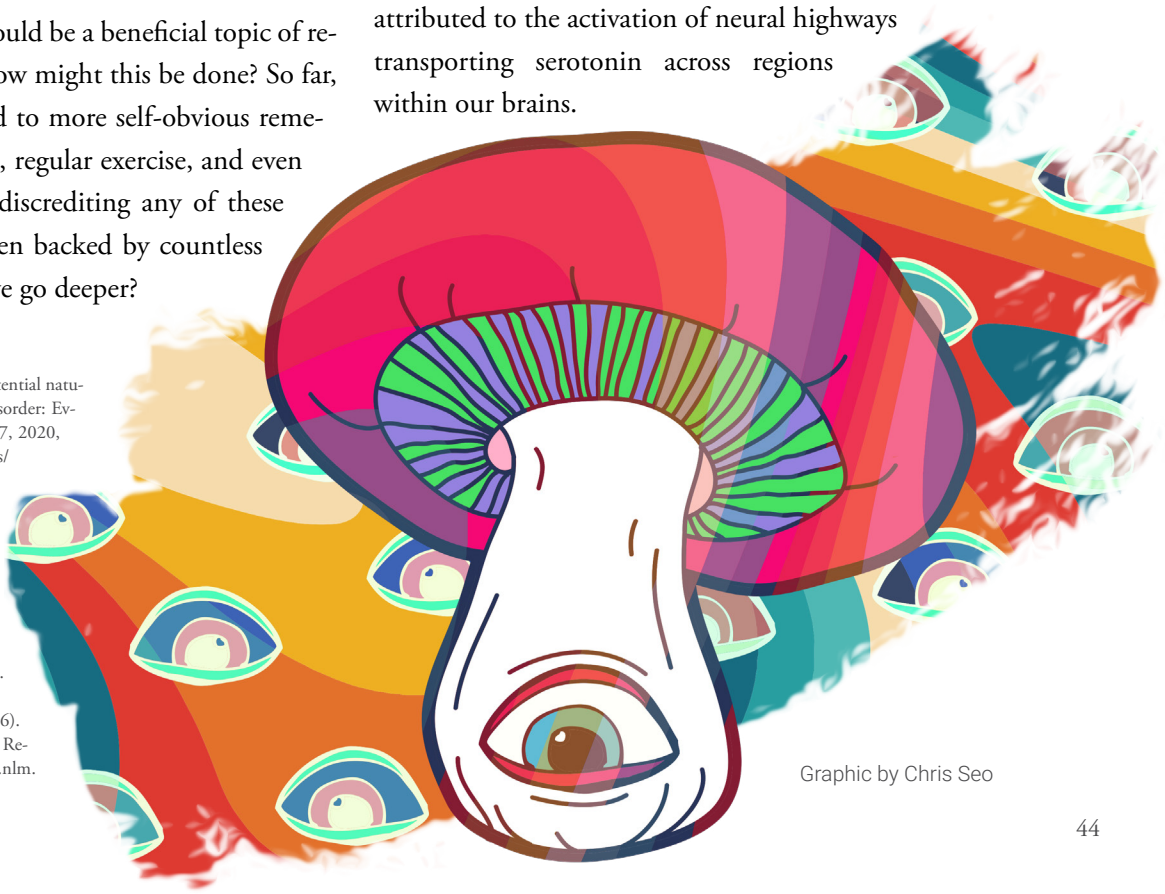
Microdosing Psychedelics > Adderall?

By Kris Lim

Whether it be in relation to a neurological disorder such as ADHD or damage to the functional hardware of the brain responsible for attention and focus, it is not uncommon for a patient suffering from deficiencies in these particular areas to be treated with pharmaceutical amphetamines such as Adderall, Ritalin, and Vyvanse. However, while these medications provide temporary solutions, it is no secret that current treatment falls far short from perfect. Many studies have found that current treatment of attention issues offer only limited relief from symptoms and typically involve serious side effects.[1] They apply unhealthy strain to the cardiovascular system, cause damage to the central nervous system, and even affect individual's internal reward systems as well as overall personalities, to name a few consequences. Furthermore, a recent systematic review of 22 studies found that 5 - 35% of college students surveyed had misused prescription stimulants primarily for neurocognitive enhancement (Weyandt et al., 2018). With consistent increases in non-medical uses of these potentially dangerous amphetamines in students, professionals, athletes and more, it seems that the research and development of a healthier and more natural alternative to these drugs would be a beneficial topic of research. So the question arises: how might this be done? So far, research has been largely limited to more self-obvious remedies such as sleep, a healthy diet, regular exercise, and even meditation. However, without discrediting any of these practices - all of which have been backed by countless studies and experiments - can we go deeper?

In 1971, an international treaty developed by the United Nations prohibited the production, distribution, and consumption of psilocybin mushrooms and other psychedelic substances.[2] Today, while the ban on psychedelic mushrooms seems to be reducing in popularity, it is of no surprise that after an international ban, there is some residual skepticism of the safety of these substances in the context of physical alterations of the mind and potential addiction. Not to mention, a strong social stigma around these substances that they may induce a never-ending spiral into existentialism or even reconstructing the state of your mind permanently. However, as peculiar as it may be, research has shown that "there is no indication of increased drug abuse, persisting perception disorders, prolonged psychosis, or other long-term deficits in functioning".[3] While the rigid limitations surrounding psychedelics as a whole have limited empirical experimentation, Daniel's study has since been confirmed by a plethora of others. In regular doses, psilocybin has been found to produce pronounced changes in visual and auditory perception, accompanied by vivid imaginative experiences and intense emotions.[4] These occurrences can be attributed to the activation of neural highways transporting serotonin across regions within our brains.



Graphic by Chris Seo

1 Kuo, F., & Taylor, A. (2004, September). A potential natural treatment for attention-deficit/hyperactivity disorder: Evidence from a national study. Retrieved October 27, 2020, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1448497/

2 McClure, J. (2020, July 15). Why are Shrooms Illegal?: DoubleBlind. Retrieved October 27, 2020, from https://doubleblindmag.com/why-are-shrooms-illegal/

3 Daniel, J., & Haberman, M. (2018, March 23). Clinical potential of psilocybin as a treatment for mental health conditions. Retrieved October 27, 2020, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6007659/

4 Polito, V., & Stevenson, R. (2019, February 6). A systematic study of microdosing psychedelics. Retrieved October 27, 2020, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6364961/

On the other hand, microdosing involves the ingestion of a sub-threshold dose along a regimented schedule. The miniscule dose prevents subjects from feeling particularly "high" but "proponents claim a wide variety of psychological and social benefits from regular microdosing, including increases in vitality, creativity, productivity, social ability, focus, analytic thinking, positive mood, memory, mindfulness and general wellbeing".[4] One prior study conducted an observational investigation with 98 microdosing individuals over a period of 6 weeks. Among other results, the study reported discernable decreases in depressive and stressful moods accompanied by heightened abilities of focus and information retention. While research into microdosing is very limited, the FDA recently approved for a clinical trial of psilocybin for treating depression.

Further research has also "consistently found that psychedelics are among the least harmful substances, with far less personal and societal risks than legal drugs such as alcohol and tobacco".[4] In the scope of cognitive enhancers, it seems that the naturally occurring chemical compound, psilocybin, commonly found in psychedelic mushrooms, if taken in microdoses along a carefully regimented schedule, can be used as an alternative to traditional prescription drugs for those diagnosed with neurological conditions. Its effects on neurological pathways in creating uninhibited cognition may be an effective measure of treating diagnosed issues with attention and focus, not only matching their benefits but also remedying the problem with minimal health defects

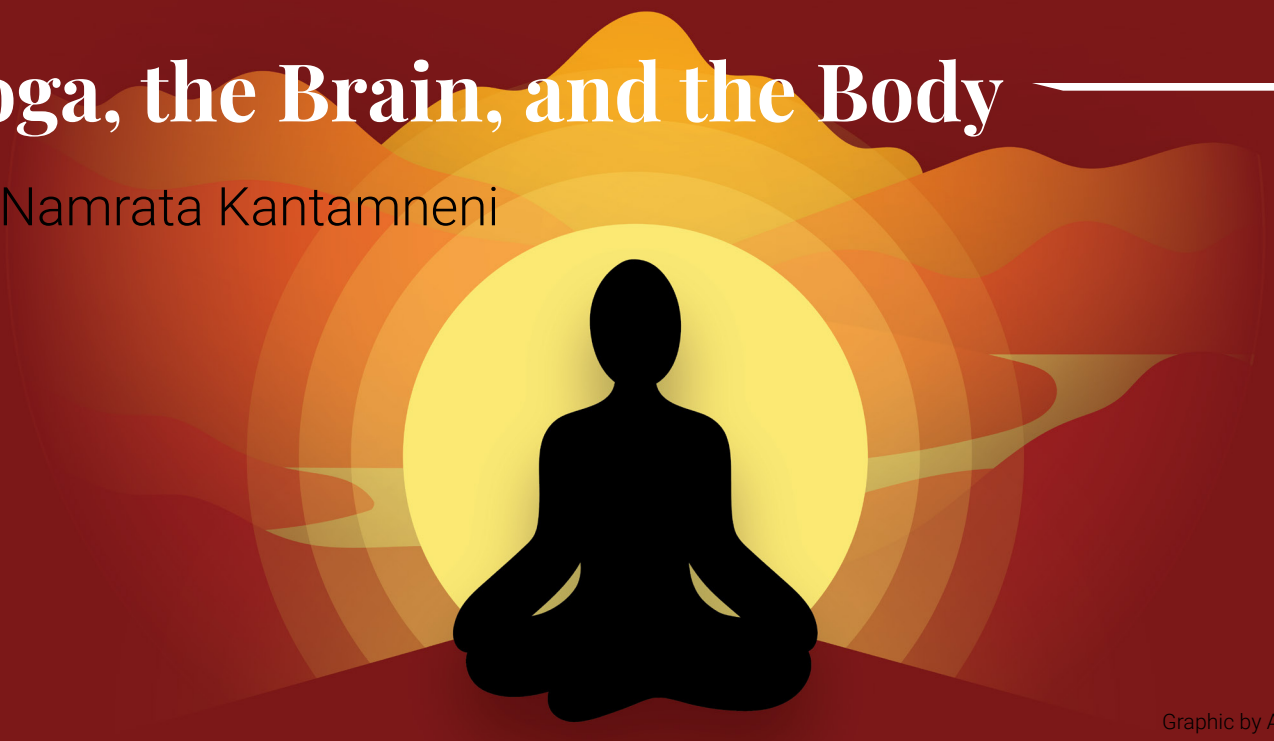
Overall, with the dangerous health risks, increasing non-medical use, and addictive quality of prescription cognitive stimulants, it is time we start looking into alternative methods of treating pervasive disorders such as ADHD. Not only have negative side effects been reported for individuals diagnosed with ADHD, but individuals (primarily students) as young as middle school and high school with no cognitive dysfunction are abusing these amphetamines at alarming and increasing rates as it seems like they are missing out on an advantageous edge. Schools are just one of many institutions in which these harmful drugs are abused, especially due to the lack of proper education of their degenerative health effects. While the recreational use of psychedelics has long been stigmatized and perceived as dangerous as well as unproductive, multiple studies seem to consistently support that their consumption is safe and even beneficial. I believe that their potential applications in the medical scene may lead to a prospective breakthrough. Notably, in terms of sociocultural impact and attempting to negate the misuse of ADHD treatments (eg Adderall) by students and other non-affected individuals – simply replacing medication may not be effective in preventing misuse to the same extent as public health centered education. However, the reduction in negative health effects by transitioning to psychedelic mushrooms seems to be a far better alternative than addiction to amphetamines and prolonged health defects associated with Adderall so that in the unfortunate case of misuse, individuals will be longitudinally less affected by negative side effects of Adderall as previously mentioned.

With their numerous health benefits and low risk at low concentrations, psychedelics can be used as potential remedies to conditions such as depression, anxiety, and as a means of weaning of addiction. Research has time and time again showcased that the self reflection and introspection that the drug itself kindles can be a promising means to an end for many psychological and neurological conditions. ◻

4 Polito, V., & Stevenson, R. (2019, February 6). A systematic study of microdosing psychedelics. Retrieved October 27, 2020, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6364961/

Yoga, the Brain, and the Body

By Namrata Kantamneni



Graphic by Amy Wang

Memories come in fleeting gaps.

They are recognized by the emotions they produce, as evidenced by aptly-named "flashbulb memories". We remember details in fuzzy, hazy, and sparsely encoded instances characterized by heightened emotion. We then try to reconstruct memories from these sparsely encoded samples, only to blur together several memories or construct completely false details.

For me, many of these scattered childhood memories involve yoga with my father.

And even though I haven't caught onto yoga like he has, my childhood memories with him surround yoga. Fleeting memories come and go of us waking up early and performing a yoga ritual before the sun comes up. We start with a series of standing poses. Then to the sitting ones. As we progress through a myriad of poses, Sanskrit vocabulary slowly fills my head and makes its way into our daily conversations, resulting in a spattering of Telugu, English, Hindi, and Sanskrit. We end the session by lying flat on the ground in shavasana (corpse pose). This is arguably the hardest pose, though it is the easiest to accomplish physically. Perfect shavasana requires a state of detachment between the mind and the physical body. Personally, I am excited when we get to shavasana, since it is an excuse for me to sleep (especially since I am still half-asleep during these early morning yoga sessions).

I'm not a morning person, and so these early morning yoga sessions are met with great resistance from my end (even today, I somewhat resist these early morning yoga sessions; I am a night owl, through and through, despite my father's best efforts at anything otherwise). But eventually, I became used to these early morning sessions and now I (hesitantly) welcome them.

When hearing the word "yoga," people typically associate it with some of its popular uses: a series of stretches to make the body more limber and flexible, a method for clearing the mind of the clutter in our everyday lives, an intensive exercise meant to get us in more shape. However as we delve into the deeper meaning of yoga, it seems to be not just a physical activity, but rather a mental one.

"Yoga" in Sanskrit means "union". A deeper delve reveals that this "union" is a union on multiple levels. The first is the union of mind and body. A higher level is the union of one's individuality with the universe, a union requiring the elimination of "I", or ego.[1]

To this effect, there are many different forms of non-exercise-based yoga aimed at achieving this state of union. For instance, karma yoga is yoga through our actions in our everyday lives.[2] Dhyana yoga, on the other hand, is yoga through

1 https://isha.sadhguru.org/yoga/new-to-yoga/what-is-yoga/
2 https://fitsri.com/yoga/karma-yoga

contemplative meditation.[3] I have even heard that music can be a form of yoga, so long as it moves the listener or musician towards the state of "oneness" as yoga is defined as! Whether music is in fact a form of yoga is for you, the reader, to judge. But today, I will focus on the modern-day version of yoga: a series of stretching-based exercises designed to relax the mind and make the body more limber. This is what most of us are familiar with and associate yoga with.

Exercise-based yoga has long been touted for numerous health benefits, from physical to mental as well as spiritual. In fact, yoga has been used as a method of pain management and is increasingly being adopted as an alternative to drug-based methods of pain management.

Dr. Chris Karas, M.D., defines two such aspects of pain targeted by yoga: the central pathway of pain perception and the physical pain felt by the periphery organs. According to Dr. Karas, yoga's focus on mindfulness targets the former. This makes yoga distinct from other similar exercises which often focus only on the physical aspect of pain. Dr. Karas' view on the mental aspect of yoga has been shown in numerous studies. One such study showed an association between yoga and smaller right amygdala volume in the brain[4]. The amygdala is part of the limbic system of the brain, which is the primitive monkey portion responsible for rash decision making, including that midnight carb binge. The amygdala specifically is responsible for the fear response; this is what is triggered during panic attacks and scary clown sightings (yes, clowns are scary; you can't convince me otherwise). And yoga shrinks the size of this amygdala, thus reducing our fear response and making us calmer in a world full of scary clowns.

And not only does yoga reduce our fear response, but it also activates the rational portion of your brain, the prefrontal cortex. This part developed last in the evolutionary pathway and is one of the last structures to fully develop in childhood development (often not fully developing till the late teenage years, hence the need for age limits on driving cars and drinking alcohol). It has been found that that meditative aspect of yoga activates parts of the prefrontal cortex and can have long lasting impacts on the prefrontal cortex.[5] Thus yoga improves the steady, rational part of our mind which does not jump from one thought to another, unlike the monkey-like limbic system.

In addition, yoga also targets the second aspect of pain, the physical pain. According to Dr. Karas, naturally occurring spinal degeneration causes pain due to a degeneration of core musculature as we age, revealing the underlying degeneration of the bone which manifests as pain. This pain is a commonly occurring pain. And according to Dr. Karas, the most effective way to treat this pain is through core strengthening and flexibility, which yoga offers. Yoga has been shown as an effective method of lower back pain management.[6] In fact, not only has yoga been proven as helpful for the innocuous sources of pain such as everyday back pain, but also for more severe diseases including multiple sclerosis[7], Parkinson's disease[8], fibromyalgia[9], and depression.[10] Perhaps in addition to "an apple a day", we should add "a yoga regiment a day" to keep the doctor away!

So perhaps we could all use a little more yoga in our lives. Perhaps the hardest part of this is getting into a routine. Perhaps we can get that little ounce of motivation by having a yoga partner, like my father. According to Dr. Karas, this regular adherence to a yoga routine is perhaps the hardest part for most people. My anecdotal evidence from an on-and-off relationship with yoga confirms this: as a 20-year-old college student, my 3 a.m. – 12 p.m. sleep schedule gives me a lot of excuses for avoiding the daily early morning yoga sessions with my father.

But I haven't given up. I will try and try again. And perhaps there is hope yet for a slacker like me!

I really hope so, because as much as I despise early mornings, I cherish the early morning yoga sessions with my father. And someday, I hope to pass them on. □

3 https://chopra.com/articles/dhyana-the-seventh-limb-of-yoga
4 https://pubmed.ncbi.nlm.nih.gov/29417491/
5 https://www.yogajournal.com/meditation/brain-on-meditation
6 https://pubmed.ncbi.nlm.nih.gov/19468897/
7 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4684133/
8 https://pubmed.ncbi.nlm.nih.gov/30124146/
9 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6746047/
10 https://www.psychologytoday.com/us/blog/minding-the-body/201704/is-yoga-effective-antidepressant

Does Free Will Actually Exist?

The Answer May Surprise You

By Hunter Alves

When was the last time you consciously decided on every turn and direction on your drive home or to work *(or bike ride, for those that sadly don't have a license like your dear author…)*? When your mind was solely focused on the mechanical task at hand and not thinking of something else? Maybe you got distracted thinking about something simple like what you're going to eat later that day, or something slightly more attention grabbing like slipping into a mini existential crisis about post-grad plans and what you're going to do for the rest of your life… No matter what it could be, it's probably been a while if we are being honest with ourselves - which could be scary to think. It kind of feels like we are running on "autopilot" in this situation and other straightforward tasks as well. We are still interacting with the world on some level, but are not consciously aware of each and every action we make unless we deliberately focus our attention on it.

Thinking of our brains running on mini automated programs throughout the day may fracture the standardized perception of reality in one's mind. The sci-fi genre is well known for serving as a distraction to the trials and tribulations of life, allowing us to imagine worlds different than our own (or so we think) with a prime example of a film that has been able to accomplish this feat with ease is The Matrix. It's no wonder since it has all the paradigmatic components of a quality sci-fi film - a compelling hook, stellar cast *[my obligatory shout-out to Keanu Reeves]*, and mind-bending visuals alone make it a memorable visual experience. It is set in a dystopian future in which artificial intelligence has taken over the world and humanity is unknowingly trapped within a simulated reality known as the Matrix. As the machines use humans' bodies as their energy source to power the whole simulation, they distract humans from the truth; a select few of individuals have been able to escape the Matrix in the hopes to put an end to their AI enemy. While this is not intended to be an exposé on the cinematic masterpiece that is *The Matrix*, the themes explored in this film are very applicable to our own lives even though we are not undergoing a full-blown AI takeover ourselves.

In the movie, the dichotomy between fate and free will is set in the context of technology; either your actions are controlled by an AI, or they are truly your own. Offscreen, we can perceive free will to mean that our actions are self-determined - where we have some choice in how we choose to act and conduct ourselves, while fate indicates that there are elusive forces beyond our control that govern our future. Keeping these stereotypical definitions in mind, in this piece I argue that these traditional definitions are less different than we think. That our subconscious mind is the underlying program which controls our decisions and gives us the illusion of free will. Yet this time, there's no escaping this Matrix. We can't just wake up from it like Neo did.

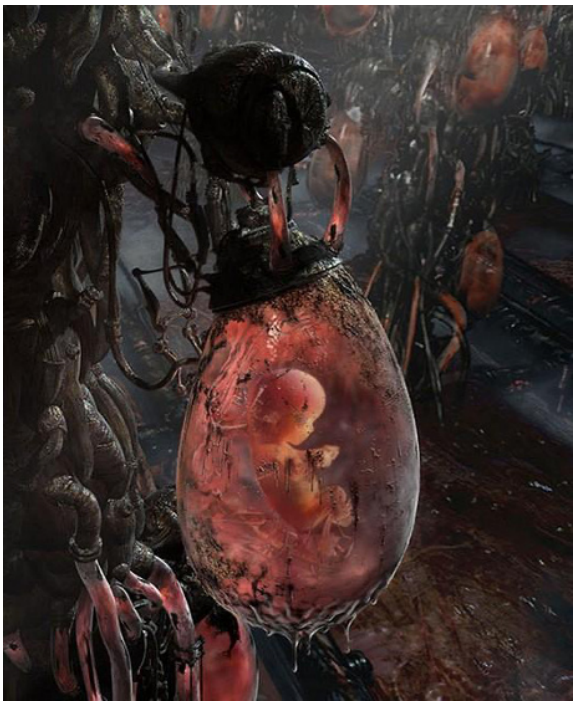
Is there a distinction between the conscious and subconscious mind?

As we live and breathe, our brains are constantly functioning - there is never a single moment when our minds shut off. When faced with a new stimulus, our conscious mind is what allows us to adapt and respond. It is also what allows us to constantly develop new goals or personal desires. Once actions or feelings become more habituated, those tasks then get handed off to the subconscious mind.

From the example of driving a car, when someone first learns, they pay attention to every single detail of how to operate the machinery.Years later, the skills that were initially foreign feel like second nature and the act of driving is much easier. That is because our subconscious mind has turned it into one of **many** learned programs that we accrue over time. With practice and repetition, we no longer need to pay attention to every minute detail like changing gears or using the brakes and stop thinking consciously, since we seamlessly allow our subconscious to take the reigns.

Graphic by VienYen HoPham

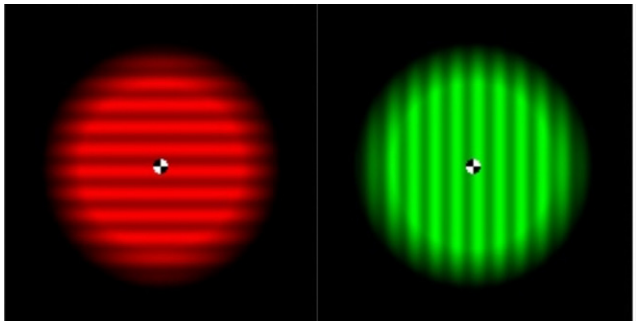
At birth, we do not possess any form of logic or reasoning and have to function in the world using primitive mechanisms to meet our needs. The most formative years of our lives are between age zero and eight, and during this time we begin to navigate life through making identifications and associations. We soak up every new piece of stimuli like a sponge, and it is only through experience that we can begin to shape our perceptions of good vs bad and develop opinions and beliefs. Within these formative years our subconscious mind programming begins as well as it can act as a memory bank - storing any information that we remember for our future survival. Any stimulus that we engage with using our five senses immediately gets inserted into it, acting like data downloading onto a server. In the film, as newborn babies are immediately attached to the Matrix's program, babies in our reality function in a similar way.



The Matrix

Previous research has framed the subconscious to function as a memory reservoir that remains dormant and only activates for mundane tasks or to communicate with our conscious brain when we deliberately need to recall information for the task at hand. It is constantly functioning 24/7 while we are asleep and awake and never shuts off, so isn't it possible for it to have a much greater role in our lives beyond simple navigation and memory recall? Although we may want to believe that we make our own choices based off of our personal beliefs and opinions, there must be some room for the conscious mind to unknowingly be guided by the subconscious mind and shape our "self-determined" actions that we make on a daily basis.

A study conducted by Roger Koenig and Professor Joel Pearson at the Future Minds Lab at the UNSW School of Psychology explored the idea of our brains being able to make choices before we are even consciously aware of them. Their research suggests that everyday thoughts and decisions that we would like to imagine are based on "free choice", can actually be visualized and predicted based on patterns of brain activity in visual, frontal and subcortical areas. Their findings determined that it took approximately 11 seconds before the person consciously chose what they wanted to think about while the subconscious mind had already made a decision regarding the task almost instantaneously (Koenig). The experiment comprised of asking participants to "freely" choose between imagining one of two visual patterns of either red horizontal or green vertical stripes. While recording brain blood-oxygen-level dependent (BOLD) data and being placed in an fMRI machine for the duration of the experiment, they were given up to 20 seconds to consciously imagine one of the two images after being given directions for the task. Once the participants felt as though they had made their decision on which image to visualize, they pressed a button and then had 10 seconds to generate the image as vividly as possible. They were subsequently prompted with two questions: "what did you imagine?" and "how vivid was it?" and responded through pressing different buttons.



Future Minds Lab

Throughout the time of experimentation, the researchers used machine learning to analyze the neuroimages from the patients' results and successfully predicted the pattern participants chose to think about, as well as how vividly they were each able to imagine it.

This study suggests that there are always subconscious traces of thought that exist, acting as sort of "unconscious hallucinations", Professor Pearson says. As participants needed to decide between two choices, their subconscious thoughts were simply waiting to become conscious when the experience they were

involved in resembled some sort of "non-conscious traces of the thoughts" that were already there (Gilbert). Our executive brain areas choose the thought-trace that is stronger, and will be increasingly more likely to pick that choice. As we continuously process stimuli on an ongoing basis which our subconscious is able to retain and collect, using the idea that we are constantly using previous similar information to guide present decisions, as it primes all of our thoughts before we consciously make them, are we ever truly making a decision based on free will? With the subconscious mind acting as our own personal AI overlord, do we really have any free thoughts roaming in our head? And if we did, how would we tell the difference?[1]

Concluding Thoughts

I do understand that the validity of my argument surrounding the concept of free will being considered illusory might be questioned as this is discussed in the context of what occurs within a single brain and not any physical external forces. Although being controlled by our own subconscious mind does not entirely negate the notion of free will, it definitely complicates most of what we believe to be true about our reality as that is largely based on our subconscious programming - which has room to be shaped and changed. Consciously questioning this perspective has valid implications on how we may view other topics of interest such as implicit biases or our general outlook on reality itself. By fully understanding the inner dynamics of our conscious and subconscious minds, we can wake up like Neo and uncover how to rewire our subconscious programming to escape our Matrix. ◻

Inside the Minds of NMEP 2020

We asked our Fall 2020 class of new members,

"Why are you fascinated by the brain and why do you want to study it?"

I'm fascinated by the idea of **intelligence** in general, and thought learning about our minds would be the best way to learn about what **gives rise** to intelligence

- Ansh Verma

I have always been fascinated by **simple and complex processes** of the brain and the **literal energy** it takes to do so. Also, we have such little information which excites me even more to know further **potential**

- Ayaon Yadav

Neuroplasticity - especially for neurotech, like how can we use electrical stimuli to restore or enhance neural function to treat **neurodegenerative diseases**

- Ashwin Rammohan

I'm interested in how **a single organ** can drive all of our decisions and interactions with others and how so many different **aspects of our society** can be broken down and understood via different aspects of our brains and cognition

- Emma Clark

I'm really curious about the biological basis behind **consciousness** and reverse engineering cognition

- Debleena Chatterjee

If we study it we can find ways to make ourselves **less stupid**

- Aditya Murali

The brain pretty much operates through specific neurons firing at specific times and together these neurons can control everything we do as humans. Could we perhaps figure out how get a **computer** to **artificially fire** these neurons instead of us?

- Anirudh Natrajan

Studying the brain allows us to connect our understandings to many different fields that are important to understanding the nature of humans, like **philosophy** and **ethics**. Beyond pure human knowledge, understanding the brain can help us develop better technologies to help those who suffer with neurological conditions

- Sonika Vuyyuru

A few years ago I learned about this cool trick to memorize numbers and random words called a **memory palace**. It seemed cool to me so I spent a lot of time practicing it and then tried it on lots of things I saw in the world. I realized that having good memory is something you develop and no ones born with

- Kathan Shah

I'm interested in the brain because it appears to be the **root of everything** plus affects our perception of the world (and seeing how **marketing** utilizes some of these concepts)

- Vien Yen Ho Pham

Understanding our own minds can provide insight into how we **perceive the world around us** -- altering this perception could lead a better living experience for some

- Lilian Zhang

It came out of interest for both **cognitive psychology** and the importance of **neural networks in ML**

- Rishi Arjun

I'm actually much more interested in the **mind**, but studying the brain is one of the most effective ways of studying the mind. I am studying the mind through brain processes because I want to help alleviate the modern plague of **mental illnesses** and/or advance humanity by working to **bridge the neuro-tech gap.**

- Luc LaMontagne

The fact that **we know so little** about something that's so relevant. I think the fact that new stuff about the brain is being discovered all the time is really cool, and I appreciate how those discoveries lead directly to a better understanding of how we **function**

- Nidhir Guggilla

It's such a powerful organ and so **complex**. It has such unbelievable capabilities to affect our emotional and mental states and create a **conceptual world** that has no tangible basis in the physical world. It's also unimaginable when people get neurological disorders or neurodegenerative disorders and I hope to work to that effect to use neurotechnology to address **dysfunction and degeneration in the brain**

- Anisha Iyer

Contributors

Abraham Niu | Author
Abraham Niu is a junior at UC Berkeley studying Cognitive Science and Data Science. He is extremely interested in the intersections between healthcare and technology, and he hopes to pursue a career within this space if his plans of becoming a famous Youtuber and/or Ben and Jerry's Flavor Guru don't pan out. In his spare time, he enjoys snowboarding, meddling with music, listening to podcasts, and playing basketball.

Amy Wang | Design Lead
Amy is a third year studying Neurobiology and Data Science. In addition to being design lead, she is also co-lead of the Education division in NT@B. Her academic interests range from magnetogenetic neuromodulation to machine learning, and when she's not frantically putting together MIND at the end of every semester, she loves exploring coffee shops, baking, and competing on the Cal Figure Skating team.

Annabel Davis | Author
Annabel Davis is a third-year undergraduate at UC Berkeley, studying Cognitive Science, Social Welfare, and Global Health. They are endlessly intrigued by the intersection between cognition and the societal implications on cognition and technology as well as Conscious Theory. Outside of studying, Annabel works part time with Social Work in the Bay Area and will often be found on long mindful walks blasting 2000's music and questioning the purpose of existence. She hopes to one day work in the Medical Field or in Global Health Policy for low income populations.

Chris Seo | Design
Chris is a sophomore studying computer science. He loves to cook and take photos in his free time.

Emma Clark | Author
Emma Clark is a junior at UC Berkeley studying cognitive science and data science. She is incredibly passionate about the intersections of public health, technology, and neuroscience and exploring innovative approaches to understanding interactions among these fields. In her free time, Emma is an avid hiker and camper and loves cooking and baking for her friends and family. Eventually, she hopes to pursue a MPH and work in community public health investigating social determinants of physical and mental health.

Hunter Alves | Author
Hunter Alves is a graduating senior at UC Berkeley studying Immunology and Pathogenesis. She is fascinated with understanding memory and the pathology of neurodegenerative diseases, and is focused on pursuing a career as a neurosurgeon. Since quarantine, Hunter has rediscovered her love for boxing and tennis to destress, and has developed a habit of spending too much time baking cakes for friends' birthdays (with celebrations happening socially distanced, of course :))

Iris Lu | Author
Iris Lu is a sophomore intending to study Integrative Biology at UC Berkeley. While she hopes to pursue optometry in the future, the intersection of neuroscience and technology remain a diverse area of interest with lots to explore. She loves to hike, catch up on sleep, and take too many personality quizzes for her own good!

Jandy Le | Author
Jandy Le is a junior at UC Berkeley studying Human Biology and Public Health. Although she is pursuing a pre-health track, she loves learning about the applications of data science and technology into healthcare fields. Her hobbies include crocheting, trying new recipes, and exploring the Bay!

Kris Lim | Author
Kris Lim is a sophomore at UC Berkeley majoring in Cognitive Science and Computer Science.

Kyle Giffin | Publications Lead
Kyle Giffin is a senior at UC Berkeley studying Cognitive Science and Data Science, and he is fascinated by the future of neuro-technological influence. He is co-editor and colead of the publications division for Fall 2020. In his free time, you can find him climbing, hiking, or running the hills of Berkeley. Kyle won a pi competition in 3rd grade and has since been on a slow downward trend.

Lillian Zhang | Author & Design

Lilian Zhang is a third year undergrad at UC Berkeley studying Chemical Biology. While also interested in physical chemistry, Lilian is fascinated with neuroscience and memory consolidation, and currently is researching the neurobiology of sleep in jellyfish. In her free time, she loves to read, paint, and jog. Deeply and unfortunately indecisive by nature, Lilian hopes to pursue PhD in either computational chemistry or neuroscience!

Lillian Shallow | Publications Lead

Lillian Shallow is in her third year at UC Berkeley studying Microbial Biology, Public Health, and Spanish. She is co-editor and co-lead of the Publications Division for Fall 2020. Her primary hobby is planning her retirement along the Andalusian coast, but besides that she loves to read short stories and volunteer in her community. Lillian plans to pursue a career in development and health infrastructure in the Global South.

Luc LaMontagne | Author

Luc LaMontagne is a junior at UC Berkeley studying Cognitive Science and minoring in BioEngineering. He is fascinated by the mind, and thinks the best means for understanding it is through neuroscience and technology. He hopes to pursue a career in the neurotech industry in order to facilitate a greater understanding of the mind, and to increase the bandwidth between the brain and computers. He has an affinity for maps, and is usually listening to his Discover Weekly. He can be found by the ocean, reading on the beach, surfing, or sailing with the Cal Sailing Team.

Malachi Keo | Author

Malachi Keo is a third year undergraduate at UC Berkeley, studying Molecular and Cell Biology and Psychology. With a love for science and art, he's made it part of his career and life to understand the emotion of awe, and how to maximize its experience. Currently, Malachi researches stress on the brain and social inequality. He is ambitiously compassionate. As Season 3 winner of MasterChef Canada, Mary Berg, once said "I don't want to leave anyone behind. I don't want to win that way."

Michael Xiong | Author

Michael Xiong is a second year Chemistry Biology student. He is really interested in the biochemistry behind the brain. Michael has been staying sane during quarantine by exercising and being way too obsessed with books. In all honesty, Michael has been faring pretty well because he's bad at socializing and life is less stressful this way.

Namrata Kantamneni | Author

Namrata Kantamneni is a junior at UC Berkeley studying Computer Science & Neurobiology. When she isn't coding neural nets, she loves suturing fruits, calligraphy, sketching architectural designs, messing with electric circuitry, & going on long runs. At any given moment, she can be found whistling, playing the flute, singing, or drumming to the 24/7 music in her head whilst doodling or running in the woods. She aims to pursue an MD/Ph.D. & work as either neurosurgeon, plastic surgeon, or emergency medicine physician.

Nehchal Kaur | Author

Nehchal Kaur is an M.Sc. Cognitive Systems student at Ulm University, Germany. She has an intense curiosity for the brain, the mind and everything in between and hopes that her love for music can serve to be a useful tool for this investigation. When she's not hiding in her room behind thick black glass frames and a big Hawaiin guitar, she is mostly staring up at the sky making annoying, existential comments.

Oliver Krentzman | Author

Oliver Krentzman is a senior studying Cognitive Science at UC Berkeley. With a passion for understanding the brain and its processes, Oliver's main interests are within the fields of cognitive neuroscience, psychopharmacology, ethnobotany, and biochemistry. Outside of academics, Oliver enjoys spending time in nature, reading self development books and lifting weights. After undergrad, Oliver plans to pursue a PhD in Neuroscience focusing on developing the scientific understanding of consciousness.

Sameer Rajesh | Author

Sameer Rajesh is a sophomore at UC Berkeley intending to major in Molecular and Cell Biology. When he's not waiting for someone to drop the latest protein structure determination algorithm (his wait has finally ended, thank you Google), he can be found watching Netflix, reading popular science, or playing ultimate frisbee with his friends. Sameer hopes to become a physician and work in either neurology or neurosurgery.

VienYen HoPham | Author & Design

VienYen HoPham is a second year undergraduate at UC Berkeley studying Molecular & Cellular Biology. Her interests lie within the intersection between cognitive processes and neurobiology. In her free time, she enjoys hiking, working out, creating graphic designs, and exploring new music. She hopes to work in the healthcare industry in the future.

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