



Abstract

Déjà vu is a common phenomenon that most healthy people experience. Despite its commonness, it is difficult to stimulate in a lab situation, making information on this experience scarce. In order to combat this, researchers have come up with multiple theories on where déjà vu takes place, what occurs, and why it actually happens. Researchers have also begun to study mental disorders that involve déjà vu in order to possibly learn more about the elusive experience. Understanding déjà vu is crucial to gaining a fuller understanding of memory, and how the brain reacts when memories are altered or off kilter; as further technology is developed, scientists will be able to test out all theories surrounding déjà vu and narrow down the true cause.

Introduction

Despite the common manifestation of déjà vu in mental illness, 97% of healthy individuals experience it (Khomutov et al., 2023). Déjà vu is the French word for “seen before” and refers to when an individual feels they are feeling an experience identical to that they have lived before (Texas A&M, 2016).

Oftentimes, this feeling can be described as unnerving, leading some researchers to incorporate déjà vu with what is known as the “dreamy state.” The dreamy state is a term that refers to the many symptoms (which can often be difficult to distinguish between) that lead to the conscious being distorted (Gillinder et al., 2022). Despite the commonality of these emotions, there is very little known about déjà vu and the other processes in the “dreamy state.” The main reason for this is simple: these internal processes are very difficult to study. According to Dr. Michelle Hook of Texas A&M, there is “no clear, identifiable stimulus that elicits a déjà vu experience (it is a retrospective report from an individual); moreover, it is very difficult to study déjà vu in a laboratory” (Texas A&M, 2016). As a result, there is very little that we know about déjà vu as a phenomenon; however, there are many different theories being explored surrounding the feeling.

Where Déjà Vu Takes Place

When it comes to discussions of where déjà vu takes place, a common theory is the optical system. For many, déjà vu is triggered by seeing a specific object, place, person in their visual system. From there, it is thought that these signals were compared to current memories, thus causing déjà vu. However, researchers have found proof of otherwise. In their 2006 study, Researchers Akira O'Connor and Chris Moulin at University of Leeds studied a blind participant who claimed to experience déjà vu. Being blind, the participant's déjà vu was caused by familiar sounds and smells that brought up memories and past experiences such as a particular piece of music playing as he unzipped a jacket (University of Leeds, 2006). This was the first time this particular situation was reported, opening much discussion on the possible location of déjà vu in the brain.

While the hypothalamus was not thought to directly play a role in déjà vu, research has found that a stimulated hypothalamus can also lead to the feeling of déjà vu. Andres Lozano, Professor of Neurosurgery and Canada Research Chair in Neuroscience, led the effort to experimentally treat a man with morbid obesity through a DBS surgery. DBS stands for deep brain stimulation, and this surgery often is used on patients with movement disorders such as Parkinson's disease. Lozano and his team were attempting to identify possible appetite suppressants in the patient's hypothalamus, and found that activating the electrodes caused the patient to experience déjà vu. The patient reported a memory of being with his friends in a park when he was 20, and as the strength of the stimulation was increased, the description of the memory got more detailed. This experiment was repeated again in a double-blind situation, and the results also stated that the participants experienced déjà vu. Researchers said that the feeling of déjà vu increased as the part of the hypothalamus closest to the fornix was stimulated. The fornix is a group of fibers that carry signals within the limbic system that is located close to the hypothalamus in the brain. Despite this seeming to point to the fornix and hypothalamus's participation in the process of déjà vu, there is little research surrounding their involvement in the processes behind other “dreamy state” emotions (Wiley-Blackwell, 2008).

Additionally, there are several theories surrounding which parts of the brain react to déjà vu stimuli. The main theory is that it takes place in the corticolimbic network. The corticolimbic network's main functions are motor programming and control, decision making, mnemonic function and emotional regulation. The main parts of the brain assumed to participate in the emotion of déjà vu are hippocampus, rhinal cortices, parahippocampal gyri, and the amygdala. The hippocampus is a part of the limbic system that deals with episodic memory and spatial reasoning and the rhinal cortices also generally work with memory and object recognition. Specifically with déjà vu, the feeling that you have experienced something before, the hippocampus and rhinal cortices seem to be crucial. Furthermore, the amygdala works with emotions and aggression and the parahippocampal gyri works with memory retrieval and encoding (Gillinder et al., 2022).



Even though it is difficult to place the exact places déjà vu takes place in the brain, these parts of the brain are associated with the “dreamy state” and déjà vu as a result.

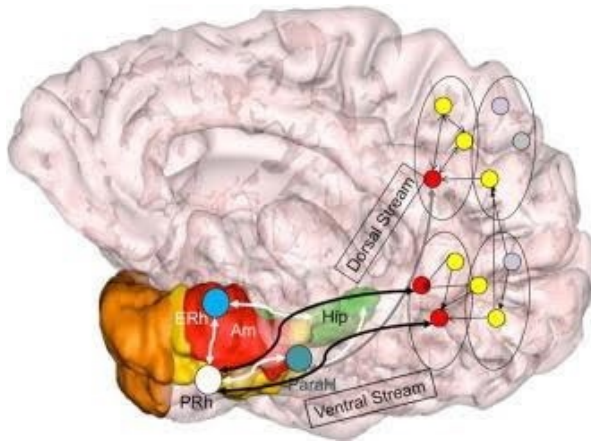


Figure 1. Brain visualization of several different systems in the brain. Dorsal stream connects the parietal areas with parahippocampal cortex. The rhinal cortices attaches to anterior hippocampus, and the parahippocampal cortex attaches to posterior hippocampus. Coloured dots represent neuronal activity areas in the occipital and parieto-occipital cortex (Gillinder et al., 2022).

Possible Reasons for Déjà Vu

When it comes to déjà vu, scientists have a multitude of theories as to why déjà vu occurs in the brain. One of these theories is the electrical malfunction theory. This theory proposes that déjà vu is a result of mismatched synaptic transmissions. Seizures are often caused by many abnormal electrical signals that interrupt the regular transmission of typical electrical signals. However, any differences in connections between nerve cells can cause a seizure in the brain (John Hopkins, 2019). Patients with epileptic seizures have said that they often experience déjà vu before a seizure; seizures are often caused by dysfunctional neuron activity in the brain. As a result, scientists theorize that déjà vu could be caused by lesser malfunctions in neuronal activity (Texas A&M, 2016).

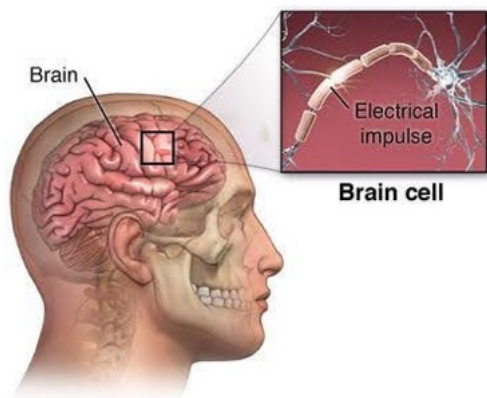


Figure 2. The neuron sets off an electrical impulse in order to communicate with one another. Seizures are caused by abnormal electrical activity (John Hopkins, 2019).

A second theory surrounding the occurrence of déjà vu is the neural pathway mismatch. Brains are equipped to process a certain amount of sensory information, but there is a lot of information in the world. Due to sensory information being classified as short term memory, scientists believe that long term memory is engaged instead, causing the brain to pull information from past memories and experiences (Texas A&M, 2016). In the visual cortex, several pieces of information travel through the neuronal pathways, with all of them reaching the destination at the same time. Due to the visual cortex processing the current information while the sensory cortex processes past information, there is a “mismatch” in the information between the two cortices, causing the brain to believe that this situation is familiar despite it being new.

The third theory is called the “glitch” theory. Scientists believe that déjà vu could be caused by the neurons in the brain mistakenly recognizing a stimulus and firing. This causes the brain to confuse the past and present, and for the body to feel déjà vu. This “glitch” is often compared to a hypnagogic jerk (Texas A&M, 2016). Hypnagogic jerks happen when someone is sleeping and their body involuntary jerks. These two processes are similar in the way that the body is experiencing one thing and the neurons fire for something else (either a different experience or for wakefulness.)

The fourth theory is known as the split perception theory. The idea is that the person perceives the same stimulus twice, but in different states of true perception. The first stimulus is perceived when distracted, quickly or in a period of delusion of some sort, and as a result, the input is weaker than most regular stimuli. This stimulus is then perceived again; this time, the stimulus is grasped fully. This second viewing of the stimulus causes our minds to believe that this stimulus is strangely familiar in some way, but not being able to place why as a result of the unregistered original stimulus. This theory helps to explain why our brains would be unable to place why we feel this moment has occurred before (Brown & Marsh, 2010).

However, when it comes to theories of déjà vu, it is incredibly difficult to study and prove any of these methods with our current technology due to the inability to replicate such emotions in a clinical setting. As a result, scientists have turned to other methods in order to gather information on the elusive experience.

Mental Disorders Related to Déjà Vu

Since déjà vu is challenging to replicate, scientists have turned to other subjects to learn more about the phenomena such as mental disorders. One mental disorder that has been linked to déjà vu is anxiety. In a case study from 2014, a man diagnosed with anxiety and depersonalization who experiences extreme déjà vu was compared. In comparison to other patients who experience déjà vu such as dementia patients, this man was completely aware of his déjà vu happening.

He claims he was constantly living in a loop due to his extreme déjà vu, and lived in constant anxiety. While this case study does draw a possible link between déjà vu and anxiety, the only evidence scientists currently have is regarding the location of the neural signals. Both anxiety and déjà vu take place in the hippocampal formation, which could show a possible connection via location of signals (Wells et al., 2014). However, there has not been enough research for this possible connection to be confirmed.

On the other hand, scientists have conducted a test on patients with temporal lobe epilepsy and déjà vu. Scientists tested 16 patients with temporal lobe epilepsy and tried to evoke the “dreamy state” by stimulating the hippocampus and amygdala. They did this in different ways: six patients had a collective nine dreamy states as a result of seizures, 14 patients had a collective 43 dreamy states due to electrical stimulation, and three patients had a collective five dreamy states as a result of chemical stimulation. Furthermore, the study shows that the amygdala was involved in 73% of stimulation cases, the anterior hippocampus in 83% and the temporal neocortex in 88% (Bancaud, Brunet-Bourgin, Chauvel & Halgreen, 1994). Mental disorders that involve déjà vu as a symptom are incredibly helpful in the study of déjà vu due to the difficulty of stimulating déjà vu, and will continue to aid in the research on déjà vu.

Summary

While déjà vu is generally just described as a feeling of having experienced something before, it is far more than an emotion. Déjà vu is a complicated process that scientists do not fully understand the purpose and reason for. Along with déjà vu, there are several other similar emotions that are often associated with déjà vu known as the “dreamy state.” While we do not know much about the location of déjà vu, scientists believe that this process takes place in the hippocampus, rhinal cortices, parahippocampal gyri, and the amygdala. There are four major theories as to how déjà vu occurs in the brain: the electrical malfunction theory, the neural pathway mismatch theory, and the “glitch” theory. Despite all these theories, it is incredibly difficult to study déjà vu due to the difficulty of stimulating the experience in a lab situation. As science improves, we will get closer and closer to understanding the mechanisms and purpose of déjà vu.

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