Neurophysiology of Hypnosis

Hypnosis and Color Perception

In the year 2000, psychologist and neuroscientist Steven Kosslyn did a study to determine if hypnosis can modulate color perception in the brain. Participants were asked to first gaze at an image with a color block pattern, and then look at an image with a similar in grayscale. Then they were given a hypnotic induction and suggestion that they could see color in the grayscale image and gray images, instead of color, in the color block image.

For participants who scored high in hypnotizability, areas of the brain associated with color perception were activated as if they were actually seeing color in the grayscale image. In contrast, participants who scored low in hypnotizability did not have much activity in the areas of the brain associated with color perception. Instead, areas of the brain associated with imagination lit up for these participants.

Kosslyn and his team also found hypnosis correlated with a predominance of left hemisphere activity in a way that just imagining color did not. I've marked these areas in red in the picture of the brain on this slide. The researchers concluded that hypnosis is a distinct mental state that goes beyond simply imagining something.

Hypnosis and Pain Perception

A study by Derbyshire and colleagues in 2004 also saw a difference between the brain's response between hypnotic suggestion and imagination. Of 33 participants, one group was given hypnotic suggestions to feel intense heat from a thermal probe attached to the palm of their hand while they were lying in an fMRI scanner. The researchers would tap their foot on a pedal, pretending to pulse heat every 30 seconds to this probe in the subject’s hand for six minutes. But the heat was actually only delivered three of the six pulses.

The other half of the group was instructed just to imagine the pain of the hot probe as clearly as possible, without a hypnotic induction. The brain imaging studies showed that hypnotically induced pain lit up the same areas of the brain as physical pain, while the imagined pain lit up entirely different regions of the brain.

Hypnosis Reduces Cognitive Conflicts

Meanwhile, another study by Raz, Fan, and Posner in 2005 showed that hypnotic suggestion can reduce conflict in the brain and improve processing time. The study used the Stroop task, where people are asked to look at a list of color words and name the ink color of the word, rather than read the actual word. I've posted an example of this test on the right side of PowerPoint slide number 6 in Module 1D. Try to do the task yourself for a moment and see how tricky it is to name the right color.

As you can see, even though the first word says red, the ink color of the word is blue, so in the Stroop test, they would want you to name the color blue. The reason this test is tricky is because it creates a cognitive conflict in your mind. When reading, we've been taught to prioritize the meaning of the word and ignore its ink color. Encountering this cognitive conflict slows down your processing time and makes you more prone to errors. But subjects in this study who

received hypnotic suggestion to see these words as nonsense and to only name the ink color of the word had much faster processing time and fewer errors. This study suggested that one reason we may be more open to suggestion under hypnosis is because it can reduce cognitive dissonance or cognitive conflict.

Three Neural Hallmarks of Hypnosis

A more recent study at Stanford University School of Medicine by Jiang et al. (2017) identified three distinct neural hallmarks of the hypnotic state. In this study, researchers screened 545 people for hypnotizability. They selected 36 highly hypnotizable subjects and 21 low hypnotizable subjects for comparison. Then the researchers scanned the subjects' brains with an fMRI scanner while they performed the following four tasks:

Let their mind wander and rest for several minutes.

Think about their day in great detail.

Receive a hypnotic induction with a hypnotic suggestion to imagine a vacation.

Receive a hypnotic induction and suggestion to imagine a time that they felt happy.

Hallmark 1: Decreased activity in the anterior cingulate cortex

One neural hallmark that the researchers noticed was decreased activity in an area of the brain called the anterior cingulate cortex. This area of the brain is associated with monitoring incoming emotional and cognitive information from the body and the environment. It evaluates whether we need to pay attention to something or if it's okay to ignore something for the moment. Under hypnosis, this area becomes less vigilant and seems to enable us to engage in tasks without worrying about competing thoughts or background noise.

The anterior cingulate cortex is also part of what's called the salience network in the brain. The salience network is involved in attention, cognitive monitoring, and self-awareness. Its job is to assess what's salient or important for you to pay attention to right now.

In addition to the anterior cingulate cortex, the insula is also part of the salience network. The insula is located in the deep midbrain, and tells us about the inner state of our body and emotions-- as well as the emotional state we may sense in another person.

Hallmark 2: Increased communication between the insula and prefrontal cortex

The second hallmark the researchers found of the brain under hypnosis is an increased communication between the insula and the prefrontal cortex. As we just discussed, the insula is involved with somatic awareness and the sensations and information that you're picking up from your body. The prefrontal cortex, or thinking brain, is associated with conscious decision-making, working memory, and our sense of time.

Enhanced connection between the insula and the prefrontal cortex under hypnosis appears to promote increased capacity for self-awareness, self-reflection, and self-regulation. We could think of it as the brain-body connection.

Our prefrontal cortex, or thinking brain, is also part of the central executive network. This brain network in charge of our executive thinking functions, conscious intentions, and voluntary actions. Within this network, the prefrontal cortex connects to an area of the brain in charge of motor activity called the posterior parietal cortex. Together, this communication loop between your thinking brain and the back of your brain is what transforms our intentions or thoughts into a physical action.

Hallmark 3: Reduced connectivity between executive network and default mode network

The third hallmark of hypnosis that researchers observed is reduced connectivity between the central executive network that we just talked about and an area of the brain associated with imagination called the default mode network. Reduced communication between these regions while in hypnosis may explain why we feel a disconnect between a response to a suggestion and how we actually produced the response to that suggestion.

In other words, you can feel your body responding to a suggestion, but it doesn't feel like you voluntarily or consciously caused your body to respond—it feels like the body did it on its own, without your involvement. The default mode network is comprised of the medial prefrontal cortex and the posterior cingulate cortex. The medial prefrontal cortex (mPFC) is involved in emotional regulation and emotional decision-making more than logical decision-making. The mPFC also helps your brain encode new emotional information. When we start treating issues like anxiety and trauma and pain, we want to focus on these mid regions of the brain because they helps to make both new associations both consciously and subconsciously.

The posterior cingulate cortex is associated with daydreaming, recalling autobiographical memories, and regulating the balance between internally and externally focused attention. Because the default mode network is not well connected to the central executive network when we're under hypnosis, again, this may be why we feel this disconnect between our conscious thinking and our subconscious mind.

Understanding this disconnect between the executive network and default mode network also explains hypnotic phenomena such as involuntary movements and ideomotor signaling. For example, the central executive network might hear a suggestion for you to lift your arm, like in an arm levitation induction. We might elicit this response by suggesting that the client's arm could feel lighter and lighter and begin to lift, or imagine a balloon was attached to their finger lifting the hand up.

While your central executive network may hear those suggestions and respond to them as directed, your default mode network and salience network (the network that tells you what to pay attention to and what to ignore) may not hear those suggestions because they were paying attention to something else. Consequently, these two other regions don't understand why your arm's lifting, because they didn't get the message.

Likewise, this disconnect between your executive network and the default mode network might explain why you can really sink deep into some imagery in hypnosis and feel your body respond to it, like we use with chronic pain, for example. Upon receiving a hypnotic induction, you be able to more vividly imagine your pain shrinking, or imagining it turning into a different color that is less intense. Even though your body is responding to those imaginative ideas in your

default mode network, your central executive network's kind of disconnected, So, again, it feels like your body is making these changes on its own without your conscious action or direction.

The reason why I think it's useful for us to look at these neuroscience explanations is because some people may find hypnotic phenomena, like they're arm lifting on its own, a little spooky or disturbing. You want to be able to give these patients a logical explanation and dispel the myth that you have control over their mind or body.

Fortunately, most people find hypnotic experiences to be fun and fascinating. While it feels like magic, there's actually some scientific explanation for why we feel this disconnect between mind and body. As you experienced with the Stroop test that we did earlier in today's lesson, we're going take advantage of this split between our executive network and our daydreaming network so that we can create new responses, new associations, and new experiences in our patients' brains and in their lives.