Scientists are learning more about the complex neural networks that make human brains so unique.
also had brainstem lesions. In coma patients, the team found that a tiny lesion in a piece of the brainstem, a critical structure that forms the bridge between body and brain, needed to be brought down a whole network: The pontine tegmentum appeared disconnected from the anterior insula and the anterior cingulate cortex, a network that maintains consciousness—maintaining being the operative word.

"It just put the seat of consciousness into conversations," says Demertzi, but she cautions that you can’t draw any major conclusions about the findings from such a correlative approach with a small number of patients. Although a localized source of consciousness has certainly not been found, having even this level of insight into how comatose states come on—and could potentially be reversed—is pretty cool.

WHERE THE BRAIN WANDERS

DEMERTZI IS ONE of the scientists who thinks that consciousness is the product of the brain reacting to the environment, not a sense that arises unprompted from within itself. The question of where consciousness comes from is too hypothetical. Instead, she turns her attention back to those so-called easy problems, and to correcting an imbalance in brain imaging studies.

The way she sees it, so many investigations into brain imaging are related to tasks, or functional experiences: What network in the brain activates when you see a face? How about when you eat or smell something? And when you’re in pain? These studies are important for understanding how big cognitive processes take shape, such as memory, learning, attention, or emotion. This research has also been crucial in reframing the brain as an organ not made of distinct functional areas, but of shifting networks that alternately kick into action or get pushed to the back burner, depending on what’s happening in our environment.

What the brain does on its own time is far more mysterious. Imaging studies that attempt to understand the brain during a neutral resting state show that even when we externally appear to be doing nothing, the brain is busy. "Even during resting state... your mind still wanders," Demertzi says. "It goes here, there, everywhere—into the future and into the past. This is supported somehow. It has neural correlates, this resting state."

BUT THE BRAIN cannot always be this on. We know this because we go to sleep every day partly to let the brain refresh. While we doze, the brain’s immune cells, called microglia, come in to clean up the mess we made during the day. What Demertzi is working on now is understanding whether there are times when consciousness shuts off in a healthy person’s brain, but not as a function of coma or sleep. Yes, the mind sometimes wanders when there’s no specific task going on, but sometimes it also seems to just... stop. Then something snaps you back into the here and now, and you have no
idea where you've been. Colloquially called mind-blanking, no one knows what this looks like neurobiologically. "This, for me, is very, very intriguing, because it would mean that you don't have to be unconscious only when your arousal is low," Demertzi says. "You can really be unconscious while your eyes are open and you move around."

A recent EEG study found that during wakeful mind-blanking, the brain exhibits the kind of low-wave activity that normally happens during sleep. Demertzi wants to see if this holds up in fMRI studies. Her long-term goal is to apply her findings to developing preclinical predictors of who might develop neurodegenerative diseases that also seem to alter someone's conscious experience of the world, such as Alzheimer's.

LIKE DEMERTZI, MOST researchers who are deep in the neuronal weeds think the hard problem of consciousness—why we have self-awareness in the first place—is fundamentally unanswerable, which is incredible to think about. "I don't know why we have it," says Demertzi. "I think, personally, it's an evolutionary accident that we are both cursed and blessed to have."

There's some final frontier that our strong, complex brains can't reason through. They compose music, bring us to outer space, create ground-breaking vaccines in the middle of a pandemic; they make memories and create flavor. But at the deepest level, it seems a brain can't follow its own consciousness to the end of the trail.

Electrodes measure the brain activity of a meditating Buddhist monk in Dengfeng, Zhengzhou, Henan Province, China.
THE BRAIN

Julia Sklar

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Opposite: Santiago Ramon y Cajal’s turn of the 20th-century drawings of microscopic neurons paved the way for modern neuroscience.