HEALTH

A Famous Argument Against Free Will Has Been Debunked

For decades, a landmark brain study fed speculation about whether we control our own actions. It seems to have made a classic mistake.

BAHAR GHOLIPOUR

GRAIKI / GETTY

The death of free will began with thousands of finger taps. In 1964, two German scientists monitored the electrical activity of a dozen people's brains. Each day for several months, volunteers came into the scientists' lab at the University of Freiburg to get wires fixed to their scalp from a showerhead-like contraption overhead. The participants sat in a chair, tucked neatly in a metal tollbooth, with only one task: to flex a finger on their right hand at whatever irregular intervals pleased them, over and over, up to 500 times a visit.

The purpose of this experiment was to search for signals in the participants' brains that preceded each finger tap. At the time, researchers knew how to measure brain activity that occurred in response to events out in the world—when a person hears a song, for instance, or looks at a photograph—but no one had figured out how to isolate the signs of someone's brain actually initiating an action.

The experiment's results came in squiggly, dotted lines, a representation of changing brain waves. In the milliseconds leading up to the finger taps, the lines showed an almost undetectably faint uptick: a wave that rose for about a second, like a drumroll of firing neurons, then ended in an abrupt crash. This flurry of neuronal activity, which the scientists called the *Bereitschaftspotential*, or readiness potential, was like a gift of infinitesimal time travel. For the first time, they could see the brain readying itself to create a voluntary movement.

This momentous discovery was the beginning of a lot of trouble in neuroscience. Twenty years later, the American physiologist Benjamin Libet used the *Bereitschaftspotential* to make the case not only that the brain shows signs of a decision before a person acts, but that, incredibly, the brain's wheels start turning before the person even consciously intends to do something. Suddenly, people's choices—even a basic finger tap—appeared to be determined by something outside of their own perceived volition.

As a philosophical question, whether humans have control over their own actions had been fought over for centuries before Libet walked into a lab. But Libet introduced a genuine neurological argument against free will. His finding set off a new surge of debate in science and philosophy circles. And over time, the implications have been spun into cultural lore.

Today, the notion that our brains make choices before we are even aware of them will now pop up in cocktail-party conversation or in a review of *Black Mirror*. It's covered by mainstream journalism outlets, including *This American Life*, *Radiolab*, and this magazine. Libet's work is frequently brought up by popular intellectuals such as Sam Harris and Yuval Noah Harari to argue that science has proved humans are not the authors of their actions.

It would be quite an achievement for a brain signal 100 times smaller than major brain waves to solve the problem of free will. But the story of the *Bereitschaftspotential* has one more twist: It might be something else entirely.

The *Bereitschaftspotential* was never meant to get entangled in free-will debates. If anything, it was pursued to show that the brain has a will of sorts. The two German scientists who discovered it, a young neurologist named Hans Helmut Kornhuber and his doctoral student Lüder Deecke, had grown frustrated with their era's scientific approach to the brain as a passive machine that merely produces thoughts and actions in response to the outside world. Over lunch in 1964, the pair decided that they would figure out how the brain works to spontaneously generate an action. "Kornhuber and I believed in free will," says Deecke, who is now 81 and lives in Vienna.

To pull off their experiment, the duo had to come up with tricks to circumvent limited technology. They had a state-of-the-art computer to measure their participants' brain waves, but it worked only after it detected a finger tap. So to collect data on what happened in the brain beforehand, the two researchers realized that they could record their participants' brain activity separately on tape, then play the reels backwards into the computer. This inventive technique, dubbed "reverse-averaging," revealed the *Bereitschaftspotential*.

Images from the 1964 experiment show the *Bereitschaftspotential* (left) and one of the finger-tapping subjects. *(Lüder Deecke)*

The discovery garnered widespread attention. The Nobel laureate John Eccles and the prominent philosopher of science Karl Popper compared the study's ingenuity to Galileo's use of sliding balls for uncovering the laws of motion of the universe. With a handful of electrodes and a tape recorder, Kornhuber and Deecke had begun to do the same for the brain.

What the *Bereitschaftspotential* actually meant, however, was anyone's guess. Its rising pattern appeared to reflect the dominoes of neural activity falling one by one on a track toward a person doing something. Scientists explained the *Bereitschaftspotential* as the electrophysiological sign of planning and initiating an action. Baked into that idea was the implicit assumption that the *Bereitschaftspotential* causes that action. The assumption was so natural, in fact, no one second-guessed it—or tested it.

Libet, a researcher at the University of California at San Francisco, questioned the *Bereitschaftspotential* in a different way. Why does it take half a second or so between deciding to tap a finger and actually doing it? He repeated Kornhuber and Deecke's experiment, but asked his participants to watch a clocklike apparatus so that they could remember the moment they made a decision. The results showed that while the *Bereitschaftspotential* started to rise about 500 milliseconds before the participants performed an action, they reported their decision to take that action only about 150 milliseconds beforehand. "The brain evidently 'decides' to initiate the act" before a person is even aware that decision has taken place, Libet concluded.

To many scientists, it seemed implausible that our conscious awareness of a decision is only an illusory afterthought. Researchers questioned Libet's experimental design, including the precision of the tools used to measure brain waves and the accuracy with which people could actually recall their decision time. But flaws were hard to pin down. And Libet, who died in 2007, had as many defenders as critics. In the decades since his experiment, study after study has replicated his finding using more modern technology such as fMRI.

But one aspect of Libet's results sneaked by largely unchallenged: the possibility that what he was seeing was accurate, but that his conclusions were based on an unsound premise. What if the *Bereitschaftspotential* didn't cause actions in the first place? A few notable studies did suggest this, but they failed to provide any clue to what the *Bereitschaftspotential* could be instead. To dismantle such a powerful idea, someone had to offer a real alternative.

In 2010, Aaron Schurger had an epiphany. As a researcher at the National Institute of Health and Medical Research in Paris, Schurger studied fluctuations in neuronal activity, the churning hum in the brain that emerges from the spontaneous flickering of hundreds of thousands of interconnected neurons. This ongoing electrophysiological noise rises and falls in slow tides, like the surface of the ocean —or, for that matter, like anything that results from many moving parts. "Just about every natural phenomenon that I can think of behaves this way. For example, the stock market's financial time series or the weather," Schurger says.

From a bird's-eye view, all these cases of noisy data look like any other noise, devoid of pattern. But it occurred to Schurger that if someone lined them up by their peaks (thunderstorms, market records) and reverse-averaged them in the manner of Kornhuber and Deecke's innovative approach, the results' visual representations would look like climbing trends (intensifying weather, rising stocks). There would be no *purpose* behind these apparent trends—no prior plan to cause a storm or bolster the market. Really, the pattern would simply reflect how various factors had happened to coincide.

"I thought, *Wait a minute*," Schurger says. If he applied the same method to the spontaneous brain noise he studied, what shape would he get? "I looked at my screen, and I saw something that looked like the *Bereitschaftspotential*." Perhaps, Schurger realized, the *Bereitschaftspotential*'s rising pattern wasn't a mark of a brain's brewing intention at all, but something much more circumstantial.

Two years later, Schurger and his colleagues Jacobo Sitt and Stanislas Dehaene proposed an explanation. Neuroscientists know that for people to make any type of decision, our neurons need to gather evidence for each option. The decision is reached when one group of neurons accumulates evidence past a certain threshold. Sometimes, this evidence comes from sensory information from the outside world: If you're watching snow fall, your brain will weigh the number of falling snowflakes against the few caught in the wind, and quickly settle on the fact that the snow is moving downward.

But Libet's experiment, Schurger pointed out, provided its subjects with no such external cues. To decide when to tap their fingers, the participants simply acted whenever the moment struck them. Those spontaneous moments, Schurger reasoned, must have coincided with the haphazard ebb and flow of the participants' brain activity. They would have been more likely to tap their fingers when their motor system happened to be closer to a threshold for movement initiation.

This would not imply, as Libet had thought, that people's brains "decide" to move their fingers before they know it. Hardly. Rather, it would mean that the noisy activity in people's brains sometimes happens to tip the scale if there's nothing else to base a choice on, saving us from endless indecision when faced with an arbitrary task. The *Bereitschaftspotential* would be the rising part of the brain fluctuations that tend to coincide with the decisions. This is a highly specific situation, not a general case for all, or even many, choices.

Other recent studies support the idea of the *Bereitschaftspotential* as a symmetry-breaking signal. In a study of monkeys tasked with choosing between two equal options, a separate team of researchers saw that a monkey's upcoming choice correlated with its intrinsic brain activity before the monkey was even presented with options.

In a new study under review for publication in the *Proceedings of the National Academy of Sciences*, Schurger and two Princeton researchers repeated a version of Libet's experiment. To avoid unintentionally cherry-picking brain noise, they included a control condition in which people didn't move at all. An artificial-intelligence classifier allowed them to find at what point brain activity in the two conditions diverged. If Libet was right, that should have happened at 500 milliseconds before the movement. But the algorithm couldn't tell any difference until about only 150 milliseconds before the movement, the time people reported making decisions in Libet's original experiment.

In other words, people's subjective experience of a decision—what Libet's study seemed to suggest was just an illusion—appeared to match the actual moment their brains showed them making a decision.

When Schurger first proposed the neural-noise explanation, in 2012, the paper didn't get much outside attention, but it did create a buzz in neuroscience. Schurger received awards for overturning a long-standing idea. "It showed the *Bereitschaftspotential* may not be what we thought it was. That maybe it's in some sense artifactual, related to how we analyze our data," says Uri Maoz, a computational neuroscientist at Chapman University.

For a paradigm shift, the work met minimal resistance. Schurger appeared to have unearthed a classic scientific mistake, so subtle that no one had noticed it and no amount of replication studies could have solved it, unless they started testing for causality. Now, researchers who questioned Libet and those who supported him are both shifting away from basing their experiments on the *Bereitschaftspotential*. (The few people I found still holding the traditional view confessed that they had not read Schurger's 2012 paper.)

“It’s opened my mind,” says Patrick Haggard, a neuroscientist at University College London who collaborated with Libet and reproduced the original experiments.

It’s still possible that Schurger is wrong. Researchers broadly accept that he has deflated Libet’s model of *Bereitschaftspotential*, but the inferential nature of brain modeling leaves the door cracked for an entirely different explanation in the future. And unfortunately for popular-science conversation, Schurger’s groundbreaking work does not solve the pesky question of free will any more than Libet’s did. If anything, Schurger has only deepened the question.

Is everything we do determined by the cause-and-effect chain of genes, environment, and the cells that make up our brain, or can we freely form intentions that influence our actions in the world? The topic is immensely complicated, and Schurger’s valiant debunking underscores the need for more precise and better-informed questions.

“Philosophers have been debating free will for millennia, and they have been making progress. But neuroscientists barged in like an elephant into a china shop and claimed to have solved it in one fell swoop,” Maoz says. In an attempt to get everyone on the same page, he is heading the first intensive research collaboration between neuroscientists and philosophers, backed by $7 million from two private foundations, the John Templeton Foundation and the Fetzer Institute. At an inaugural conference in March, attendees discussed plans for designing philosophically informed experiments, and unanimously agreed on the need to pin down the various meanings of “free will.”

In that, they join Libet himself. While he remained firm on his interpretation of his study, he thought his experiment was not enough to prove *total* determinism—the idea that all events are set in place by previous ones, including our own mental functions. “Given the issue is so fundamentally important to our view of who we are, a claim that our free will is illusory should be based on fairly direct evidence,” he wrote in a 2004 book. “Such evidence is not available.”

We want to hear what you think about this article. Submit a letter to the editor or write to letters@theatlantic.com.